TAPHONOMIC AND POLLUTION RESPONSES OF MARSH/ESTUARINE BENTHIC FORAMINIFERA IN CHEZZETCOOK INLET, NOVA SCOTIA AND NEW BEDFORD HARBOR, MASSACHUSETTS

by

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ABSTRACT

This thesis considers two separate problems: 1) taphonomic alterations in marsh foraminifera and 2) foraminiferal responses to a variety of industrial and domestic activities. The field areas were centered in two locations; Chezzetcook Inlet, Nova Scotia, and New Bedford Harbor, Massachusetts.

Marsh foraminiferal distributions from cores collected seasonally for a year at 4 sites along Chezzetcook Inlet, Nova Scotia suggest that living foraminifera do not migrate vertically within the core and that infaunal species do not affect the total population downcore. Also, there appears to be little to no taphonomic alteration of marsh foraminifera within these cores. The total species composition at the surface was very similar to that in the subsurface. There seemed to be little evidence that infaunal habitat or taphonomic biasing affected the total assemblage downcore in replotted data from Nanaimo, British Columbia; it appears that there are environmental changes and is amplified by coincident lithology changes. Assemblage changes throughout the core appear to be the result of changes in environmental conditions at the time of deposition. Consequently, the top 1 cm of these cores is a representative aliquot and accurately reflects environmental conditions occurring at the time of deposition.

New Bedford Harbor has been affected by intense industrial activities over the last 50 to 60 years. This has led to heavy metal, PAH, PCB, and organic enrichment contamination of sediments. Foraminiferal distributions in surficial samples showed recovery in the lower part of the harbor as well as in some parts of the Upper Harbor where contamination of sediments was at its worst. The return of calcareous species such as Haynesina orbiculare and Elphidium spp. suggests recovery of the environment. Deformities of tests in foraminifera occurred in cores where PCB concentrations were highest suggesting that foraminifera are responding to increased levels of contamination. As concentrations of pollutants decreased toward the top of the core, deformities decreased to almost zero. The various foraminiferal responses reinforce the fact that foraminiferal assemblages are useful in detecting pollution changes through time and they can be applied to just about any marginal marine setting which makes them an excellent cost-effective tool as biomonitors for industrial and municipal pollution.

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CHAPTER I

INTRODUCTION

1.1 General Introduction- Marsh Taphonomic/Seasonal Studies

Benthic foraminifera are one-celled protists that form an external skeleton (test) composed of several types of material, i.e., cemented debris particles (agglutinated), calcareous, and porcelaneous (Loeblich and Tappan, 1964). The ecology of marsh foraminifera has been extensively studied along the coasts of North America since the early work of Phleger and Walton (1950) in Barnstable Harbor, Massachusetts. Since that time, many studies have documented the distributional patterns of foraminifera relating them to a number of varying physical parameters such as salinity (Parker and Athearn, 1959; Murray, 1971; Scott and Medioli, 1980a; de Rijk, 1995), temperature (Scott and Medioli, 1986), geographic region (Scott et al., 1990) and pH (Phleger and Bradshaw, 1966). Scott (1976a) and Scott and Medioli (1978; 1980a) documented in Chezzetcook Inlet (Nova Scotia) and Tiajuana Lagoon (California), that vertical zonation of marsh foraminiferal assemblages are well defined and the limits of the zones are controlled principally by the elevation in relation to mean sea level. They reported that although floral assemblage distributions may vary, the relationship between foraminiferal assemblages and elevation above sea level remain fairly constant. Since the studies by Scott and Medioli (1978; 1980a) were published, vertical zonations of foraminifera within salt marshes have been well documented in many parts of the world, for example: in South Carolina (Collins, 1996, Collins et al., 1995), British Columbia (Patterson, 1990), and the Texas Gulf Coast (Williams, 1994) and subjected to rigorous statistical treatment (Horton, 1999). However, De Rijk (1995) found a stronger correlation with salinity, rather than elevation to explain foraminiferal distributions in the high marsh zone of the Great Marshes of Massachusetts and concluded that no single model of foraminiferal distributions in marshes can be applied ubiquitously. Considering, however, that only the high marsh zone was examined in her study, the validity and significance of her results are questionable.

Modern distributions of salt marsh foraminifera are successfully utilized for comparison with those of fossil foraminifera in many paleoenvironmental interpretations (e.g. sea-level changes, paleo-seismic events). With Rose Bengal staining techniques used by Walton (1952), seasonal distributions of living salt marsh foraminifera have been described (e.g. Matera and Lee, 1972; Buzas, 1974; Scott and Medioli, 1980b). Preservation of foraminiferal tests (or lack thereof) must be taken into account because it may be affected by taphonomic processes, i.e., test dissolution, bacterial degradation of cements (Murray, 1973). Infaunal habitats and taphonomic effects may be related in the fossil foraminiferal distributions (Goldstein and Watkins, 1998; Ozarko et al., 1997; Jonasson and Patterson, 1992; Buzas et al., 1993). All of these studies observed an overall decrease downcore in both calcareous and agglutinated foraminifera suggesting poor test preservation potential lending itself to taphonomic biasing. In this thesis, studies are presented to determine how much taphonomic biasing takes place, to determine how to compensate for these biases and to make subsurface distributions reliable and useful.

1.2 Introduction- Pollution Studies

Benthic foraminiferal distributions are affected by a number of ecological parameters, i.e., biological, chemical, etc., (Murray, 1973). Even in anthropogenically altered environments, some opportunistic species persist where other organisms such as molluscs and ostracods might show a barren zone (Schafer et al., 1975). Their tests are often preserved and as a result, benthic foraminiferal distributions are used as proxies in assessing impacted marine environments. Since the early work of Bandy et al. (1965) where the relationship between foraminiferal trends and ocean pollution near the Hyperion Outfall in Los Angeles were studied, numerous studies have focused on the effects of various kinds of pollution sources in a wide range of marginal marine environments (Alve 1995, and references therein). Several workers in this field suggest that benthic foraminiferal distributions provide one of the most sensitive and inexpensive markers for indicating deterioration of marginal marine environments. The importance and significance of foraminifera for environmental applications was emphasized in a theme issue in Journal of Foraminiferal Research (Scott and Lipps, 1995).

With the ever increasing pressures placed on coastal areas (e.g. rise in population, increases in pollution), resulting in habitat loss and degradation, new, simpler and less expensive approaches to coastal zone monitoring are becoming necessary. Many different methods of monitoring marine environments are known and have been applied in coastal systems (i.e. chemical analysis, organic loading determination, nutrient inputs, measurements of pH in both water column and sediments, bioaccumulation in indigenous organisms (e.g. Lake et al., 1995; Bergen et al., 1993). To properly assess marsh/estuarine environments, both spatially and temporally, present day baseline characteristics must be determined from that specific area because assemblages may vary from one locality to another. Benthic foraminifera are useful biological indicators for assessing and characterizing coastal environments due to the fact that they live on and in the substrate, in contact with the surrounding water mass, and react to changes, thereby recording prevailing conditions at any given time. Foraminiferal tests are readily preserved in the sediment, thus becoming excellent proxies for paleoenvironmental interpretations. For these reasons, benthic foraminiferal assemblages are used in this study.

1.3 Relationship of two major focus areas

The studies of taphonomy and seasonal signals helps to strengthen the usefulness of all foraminifera as paleoenvironmental indicators. Seasonal vertical migration (if any) of marsh foraminifera will be documented and the effects infaunal habitats have on total (live + dead) marsh benthic foraminiferal assemblages in cores collected in Chezzetcook Inlet (Nova Scotia) will be illustrated. The potential for preservation of foraminiferal distributions in subsurface sediment from these cores, as it affects the fossilized assemblage, will also be determined.

These data fit together to strengthen the use of foraminifera as paleo-indicators in the development of a method to characterize polluted, transitional, and non- polluted coastal areas using benthic foraminifera. The seasonal focus can then be used to document the pollution history of New Bedford Harbor (Massachusetts) using benthic foraminifera as proxies and determine if foraminiferal assemblages reflect responses to anthropogenic changes (i.e., heavy organic carbon loading, PCB and heavy metal dumping) (Figure 1.1)

1.4 Study Locations- Chezzetcook

Chezzetcook Inlet is an estuary located along the eastern shore of Nova Scotia and is approximately seven kilometers in length and two kilometers in width at its widest spot and hosts extensive intertidal mudflats and salt marsh systems. There is a complex of channels which cut across the mudflats helping to drain the intertidal areas. The main channel originates in the East Head of the marsh and continues its way down the estuary where it empties into a large central area just south of Conrad Island. The basic morphology of Chezzetcook Inlet has remained relatively intact since 1858 as all the islands and channels are still present (Atkinson, 1999). Scott (1977) and Scott and Medioli (1980a) described the physical parameters of the inlet in great detail and these were assumed to have changed little over the last 20 years. Vertical zonation of the vegetation is a distinctive characteristic of salt marsh systems and Chezzetcook is no exception. *Spartina patens* characterizes high marsh areas while *S. alterniflora* characterizes low marsh areas. Chezzetcook Inlet is a relatively pristine estuary affected only by low density urbanization and not by industrial sources which makes it an ideal location to investigate foraminiferal assemblages.

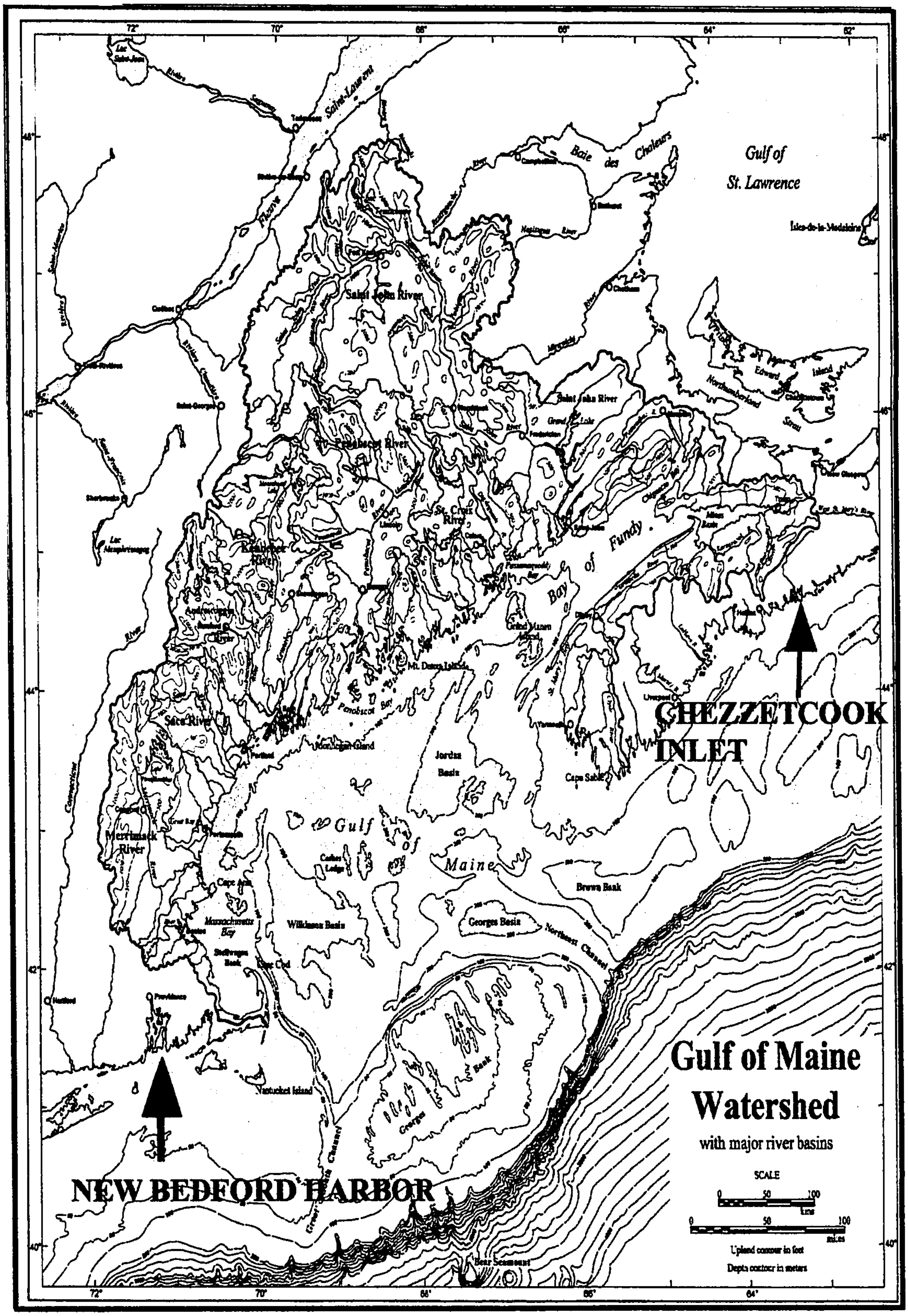


Figure 1.1- Generalized map showing the locations of the two study sites in relation to each other (modified after the website www.gulf of maine.org/watershed/index. html on Nov. 6, 2002, 3:30 pm).

1.5 Study locations- New Bedford Harbor

New Bedford Harbor, Massachusetts, is one of the deepest embayments in the Buzzards Bay System and is divided into the upper, lower, and outer Harbor. The upper and lower harbor, also known as the Acushnet River estuary, is the largest industrialized and urbanized harbor on Buzzards Bay. It is a sub-tidal, weakly stratified and partially mixed estuary. Freshwater input is generally low, causing a net landward movement of bottom water throughout the year (Summerhayes et al., 1985). It is separated from the Outer Harbor by a hurricane barrier that was constructed in 1964 to protect the cities and towns surrounding the area from storm flooding. This barrier has led to restricted tidal flushing, allowing contaminants to settle in the upper and lower parts of the harbor. The harbor has been a major manufacturing center and fishing port over the last 300 years and as a result of this activity, the ecology and marine resources of the harbor have been severely impacted or altered. In fact, New Bedford Harbor (NBH) was classified as a United States Environmental Protection Agency (US EPA) Superfund site due to contamination of marine sediments with polychlorinated biphenyls (PCBs). Currently, NBH is under recovery and a pilot dredging project was initiated to remove PCB-contaminated sediments from the harbor. A subsequent monitoring plan was designed and implemented to determine the biological and chemical effects that this project has had (Latimer et al., 1997). The outer harbor, located outside the hurricane barrier, is well flushed and both the water quality and marine sediments are relatively unimpacted. The hurricane barrier has effectively sheltered the outer harbor from contaminants affecting the upper and lower harbor, which has allowed for a more focused clean up as well as to provide a baseline for naturally occurring faunal assemblages that can be used for comparison to the impacted areas of the harbor. NBH is an ideal area for this study because its industrial activities have been extensively documented over the past 400 years (Figure 1.2).

1.6 Previous Work

1.6.1 Foraminiferal Studies - Marshes

The distributional patterns of present day marsh foraminifera from Chezzetcook Inlet have been described by Scott and Medioli (1978, 1980a,b) and Scott et al., 1977. Those studies showed that the vertical zonation of foraminiferal assemblages along the marsh surface were primarily controlled by the elevation in relation to mean sea level and all the factors controlled by it. However, there is still some argument as to the reliability of marsh foraminiferal assemblages for paleoecological interpretations. Much of the debate hinges on the fact that the relationship between the living surface and the total (living plus dead) populations are not entirely understood. Murray (1973) suggests that only living populations can be used to determine environmental conditions, equating the use of total foraminiferal populations to incorporating information on the "graveyard residents in population statistics on humans" (Murray, 1973, p. 274). Buzas (1968) felt that observations over longer periods of time must be used to determine the total aspects of a population and that examination of the living assemblage at any one time did not accurately represent the environmental conditions on the population. Scott and Medioli (1980b) investigated both living and total assemblages over a three year period in

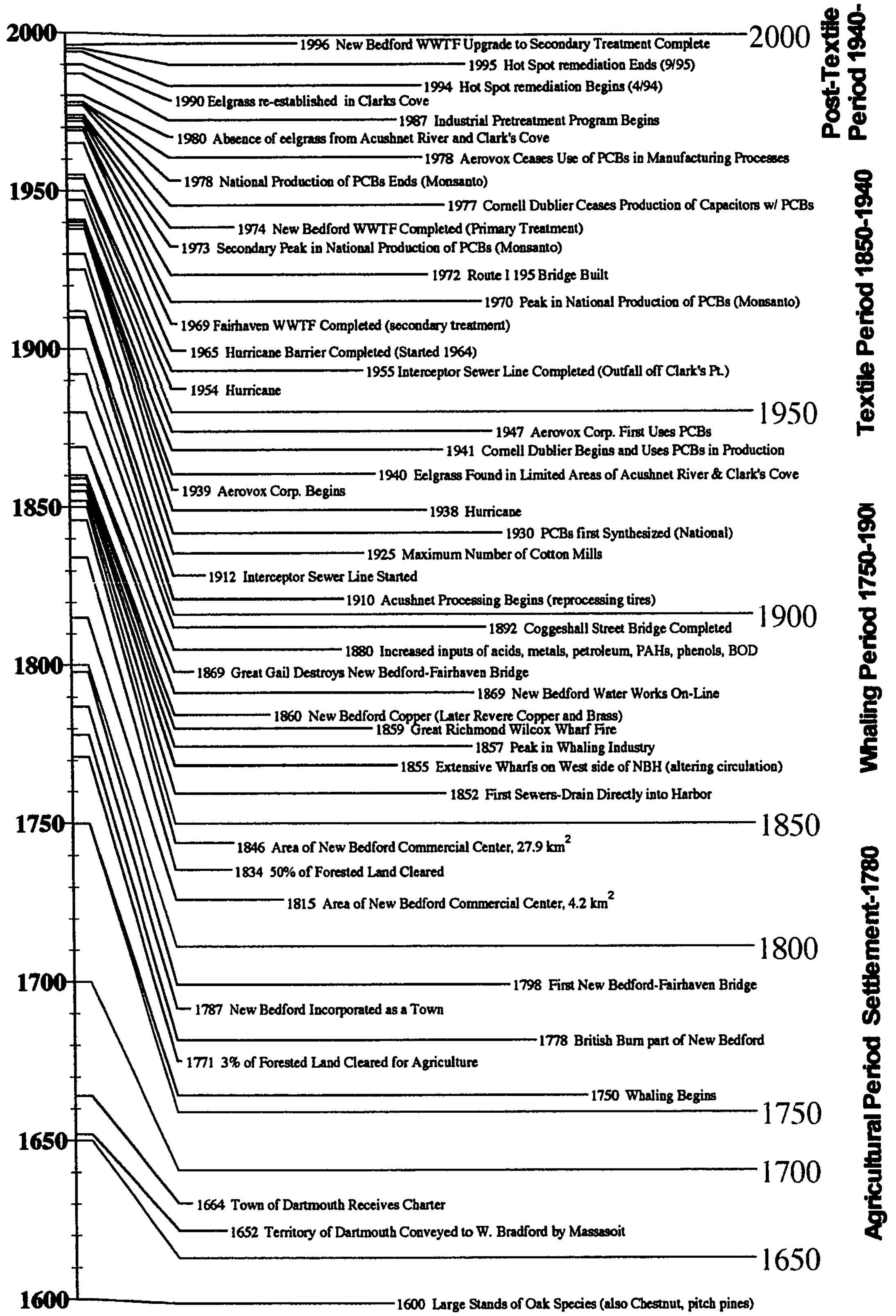


Figure 1.2- Chronology of the industrial activities of New Bedford Harbor, Massachusetts (modified from Latimer et al., 1997).

Chezzetcook Inlet and found a high degree of variability in the living populations and assemblages of foraminifera. However, the total assemblage did not change significantly over the same time period because the total population integrated any small scale seasonal and spatial variations into a definable assemblage. The total population seems to reliably reflect long term conditions which serve as a good indicator for paleoenvironmental studies (Scott and Medioli, 1980b).

Several previous studies on salt marsh foraminifera have reported species that live infaunally (e.g. Akers, 1971; Matera and Lee, 1972). However, the significance of infaunally-dwelling foraminifera, and to some degree taphonomic effects, have primarily dealt with deep sea marine sediments (e.g. Corliss, 1985; Corliss and Emerson, 1990, Loubere, 1989; Denne and Sen Gupta, 1989). Traditionally, modern distributions of marsh foraminifera have been determined using the top 1 cm of sediment and this interval has been used as an analog of their fossil distributions. There is debate as to which near surface aliquot best reflects fossil faunas because of the effects of infaunal habitat and taphonomic processes on biofacies distribution have not been widely addressed and are poorly understood. The last decade or so, however, has seen an increase in attempts to address this problem in marsh environments. In studies of Georgian salt marshes, living *Arenoparrella mexicana* were reported down to depths of 30 cm and selective preservation was suggested to affect both calcareous and agglutinated foraminifera (Goldstein 1988; Goldstein et al., 1995a; Goldstein and Harben 1993). Jonasson and Patterson (1992) also found that selective preservation of both agglutinated and calcareous species of foraminifera exists in subsurface sediments. Goldstein et al

(1995b) reported that this selective preservation downcore decreased the diversity and abundance of foraminiferal assemblages and significantly altered fossil faunas which are different from those at the surface. Goldstein and Harben (1993) suggested that subsurface death assemblages should be evaluated to increase the accuracy and reliability of paleo-environmental interpretations. In their study of marsh foraminifera from Nanaimo, British Columbia, Ozarko et al. (1997) discovered that high marsh faunae lived slightly deeper infaunally compared to those faunas in the low marsh and that a surface interval of 10 cm provided a more accurate, less biased modern analog of fossil faunas which significantly reduced the impact of selective preservation and infaunal habitat. Goldstein and Watkins (1998) also found that the assessment of the top 10 cm of sediment rather than the top 1 cm would provide a more accurate baseline for paleoenvironmental studies. Saffert and Thomas (1998) found that there were no consistent decreases in diversity and abundance downcore and that this variation in total abundances reflected in part variations within the populations over time and not simply by differential preservation of various species. Collins (1996) examined three cores from a South Carolina marsh to evaluate the living and total assemblages down to 30 cm. Although he found that certain species lived down to depths of 20 cm and more, the majority lived in the upper few centimeters. The living population appeared to have little effect on the total fauna at any one interval within the cores so that the total assemblages remained unchanged vertically.

Another factor in determining which below surface interval provides the best analogue for fossil faunas is the possibility of seasonal vertical migration of certain marsh foraminifera. Extreme differences in temperatures from one season to the next, which may cause freezing of the marsh surfaces, may cause certain species to migrate vertically and this may alter the total population down core. These problems are addressed in this thesis.

1.6.2 Foraminiferal Studies – Pollution Indicators

Traditionally, foraminifera have been used primarily for stratigraphic and paleoecological indicators. Their potential for assessing the environmental impact of industry and urban development on benthic ecosystems has been acknowledged only recently. Early studies of this nature have dealt with mostly organic waste contamination (e.g. sewage or pulp and paper mills) but there has been an increase in studies addressing various kinds of thermal and chemical pollution.

Bandy et al. (1965) investigated the relationship between ocean pollution and foraminiferal distributions by studying the Los Angeles outfall area (Hyperion) and mainland shelf of Santa Monica Bay. They discovered marked differences in the foraminiferal distributions. They found that one or two species of foraminifera were anywhere from 5 to 50 times more abundant in the Hyperion outfall region than in unaffected areas of the shelf, whereas away from the outfall source, abundance of these species decreased while foraminiferal diversity increased. This seems to suggest that some living species of foraminifera adapt quite easily to conditions at sewage outfalls which makes them good indicators for this type of pollution (Bandy et al., 1965). Their abundance, diverse adaptation, and response to sewage fields near ocean outfalls make foraminifera ideal for calibrating pollution effects.

The Bandy et al. (1965) study provided a baseline for Stott et al., (1996) who returned to the same area 30 years later, after recovery had taken place, to determine if there was a change in the foraminiferal fauna due to a decrease in contamination concentrations. Stott et al. concluded that foraminiferal populations had shown a marked improvement around the site with both diversity and abundance returning to almost normal conditions.

Sieglie (1968) used foraminiferal assemblages as indicators of high organic carbon content in sediments and polluted waters. Assemblages related to high organic carbon content in sediments were correlated in species abundance and diversity with assemblages in sewage outfall areas and concluded that foraminiferal assemblages provide a powerful tool as biological markers for areas polluted by sewage outfalls. This relation has been used as an index to the extent of contamination by the discharge of polluted waters in southern California.

Schafer (1973) suggested that the distribution of benthonic foraminifera is a useful measure for the effects of effluent discharge on the adjacent marine benthic environment at Chaleur Bay, New Brunswick. This study incorporated several outfall sites to provide information on the sensitivity of estuarine species to the various kinds of effluents (including organic carbon, toxic chemical, and thermal). He discovered that species diversity generally decreases near outfall areas while species abundance of one or two opportunistic species increases. The differences in species abundance and diversity from unaffected areas to affected areas may serve as an indicator for effluent discharge. The *Elphidium incertum/clavatum* group (*E. excavatum* group in this thesis) generally dominated the living fauna near sewage outfalls, which may make it a very good indicator species.

Schafer et al. (1975) investigated the distribution of foraminifera, molluscs, and ostracods in a moderately polluted part of the Canso Strait. They found that these groups display relatively high, moderate, and low tolerances respectively to industrial effluents. Again, stressed environments near pollution sources were characterized by large numbers of the *Elphidium incertum/clavatum* group (as above); this was attributed to the group's ability to compete successfully and to reproduce in modified or artificial environments. Also important was the observation that the molluscs and ostracods had much larger barren zones, meaning that foraminifera can supply higher resolution records of highly impacted areas.

Ellison et al. (1986) studied trace metal contamination in the Patapsco River and Baltimore Harbor, Maryland. They suggested that since foraminifera are known to be responsive to environmental change in other aquatic settings (e.g. Schafer, 1973), and thus are useful indicators of pollution, their distribution can also be used to document the pollution history of a particular estuary. Large populations of a few opportunistic species are good indicators of disturbed marine environments, where they flourish at high and moderate toxic levels of pollution (Ellison et al., 1986). Consequently, as species diversity begins to increase as pollution decreases (i.e. away from the source), these foraminifera mark the extent and level of contamination.

Yanko et al. (1994) studied the responses of benthic foraminifera to various pollution sources along the Mediterranean coast. They found that industrial pollution such as coal and heavy metals had a deleterious effect upon the foraminifera as evidenced by the reduced population diversity and density. Deformation, stunting and pyritization of tests were directly related to trace metal contamination whereas a positive response occurred in the presence of domestic sewage. The added nutrient supply allowed the foraminifera to realize their full growth potential. As a result, they suggested that benthic foraminifera may be useful in detecting anthropogenic pollution as well as natural organic pollution and provide a wide potential in a variety of fields where the monitoring of the present marine environment is required

Foraminifera have relatively short life spans (month to year), so they respond quickly to environmental changes, either natural or anthropogenic. Many tolerant or opportunistic species benefit from certain types of contamination, directly through increased nutrition (organic carbon based substances, bacteria, etc.) or indirectly, through reduced competition and predation (Alve, 1995). This often results in greater than normal concentrations of certain species. Occasional theratologic tests occur naturally, but significantly high numbers of them generally indicate polluted conditions. Alve (1995) also suggested that to assess the impact on the biota, generalized comparisons between unpolluted and polluted areas might be useful if the areas have homogenous hydrographical properties. However, each estuary is unique and these parameters often vary. The historical effects of pollution of an estuary may be gauged by studying the foraminiferal assemblage changes in dated sediment cores.

Although there have been no previous distributional studies of Recent foraminifera in New Bedford Harbor, there have been ecological studies on benthic foraminifera in adjacent estuaries and sounds. These studies provide a baseline of the distributional patterns of foraminiferal assemblages in New Bedford Harbor.

In his paper on the foraminifera of Narragansett Bay, Rhode Island, Said (1951) recorded 55 species of which only 25 were abundant. All foraminifera observed were benthonic. *Elphidium incertum* (*clavatum*) (*E. excavatum* this study) was by far the most abundant form. *Rotalia beccarii* (*Ammonia beccarii* this study) flourishes in the southern parts of the bays. Arenaceous forms are few but occur abundantly in gravelly bottoms and deeper waters. Basically, all foraminiferal species recorded in this area are the typical fauna characteristic of the areas south of Cape Cod.

Schafer (1968) noted specimens of *E. clavatum*, *E. incertum* "complex" (*E. excavatum* this study) and *B. fridgida* were the most abundant forms found in western Long Island sound and adjacent nearshore waters. *Elphidium subarcticum*, *A. beccarii*, and *Eggerella advena* also occurred persistently. He suggested that the distributional patterns of these foraminifera may be due to substrate type, perhaps in accordance with their respective feeding habits. Water depth may be an important factor in the distribution of benthic foraminifera as *A. beccarii* is most abundant between 6- 10 meters. *E. clavatum* is abundant everywhere in Long Island Sound as it apparently tolerates pollution and can survive and reproduce in waters surrounding New York City (Schafer, 1968).

In her study of benthic foraminifera of the continental shelf from the Gulf of Maine to Maryland, Parker (1948) found that material sampled in the littoral and sub-littoral zones was dominated by various species of *Elphidium* with *Rotalia beccarii* (*Ammonia beccarii* this study) and *Eggerella advena* present in appreciable quantities. She also found that samples taken in sand yielded the richest fauna and that the bottom samples of the littoral zone showed a very high percentage of *Elphidium* throughout this area.

Parker (1952a) also studied the distribution of foraminifera in the Long Island Sound-Buzzards Bay area where she recorded 36 species in the area. She defined three foraminiferal facies associations in the area. Facies one, consisting of agglutinated forms such as *Ammobaculites dilatatus* and *A. cf. exiguus*, was confined to the Housatonic and Connecticut Rivers where salinity is lower, Facies 2 and 3 are composed mainly of calcareous forms and are found in the Long Island Sound, Buzzards Bay, Block Island Sound, and southwest of Cuttyhunk areas. Faunal associations in and around these areas include some agglutinated forms as well as the increase in calcareous species such as *Rotalia* (*Ammonia*) *beccarii* and *Elphidium* spp. A few species are restricted to either facies 2 or 3, and the relative abundance of species differs in the two facies. Out of the 36 species that Parker listed from Long Island Sound, 7 were indicated as persistent in their occurrence.

Lidz (1965) listed *Ammonia beccarii*, *Buccella frigida*, and *Elphidium* spp. as the most important species found in fine sediments in Nantucket Bay.

Buzas (1965) found twenty-three species belonging to fifteen genera (all benthonic) in Long Island Sound. Generally, *Elphidium clavatum (E. excavatum* f. *clavatum* here), *E. pauciloculum, E. varium, Buccella frigida*, and *Eggerella advena* make up about 90 percent of the total foraminiferal fauna. He also showed that the total and living population patterns were very similar in his transects where the number of species tended to increase from west to east. The nearshore areas contained the greatest number of individuals whereas the offshore areas contained far fewer. Buzas found that *E. clavatum* was the most abundant in nearshore areas where water depths were less than 20 meters, while *E. advena* was most abundant in water depths over 20 meters. *B. frigida* was abundant at depths between 10-40 meters. Upon careful examination of data, Buzas determined that particle size had no influence on the numbers of foraminifera in Long Island Sound. He suggested that the foraminiferal species in Long Island Sound are selective feeders, and their depth zonation is, therefore, related to the distribution of the material upon which they feed.

In their study of three type estuaries in eastern Canada, Scott et al. (1980) developed a framework of estuarine classification based on benthic foraminiferal distributions which allows for comparison with other studies. In relation to foraminiferal distributions, three zones were recognized in these estuaries (upper, transitional, and marginal marine) with the exception of Chezzetcook Inlet in which four zones were recognized (Figure 1.3). The first zone (upper) is the area in which the riverine environment is first affected by marine processes, as a river comes in contact with the marine influence. Thecamoebians and agglutinated forms (including marsh species)

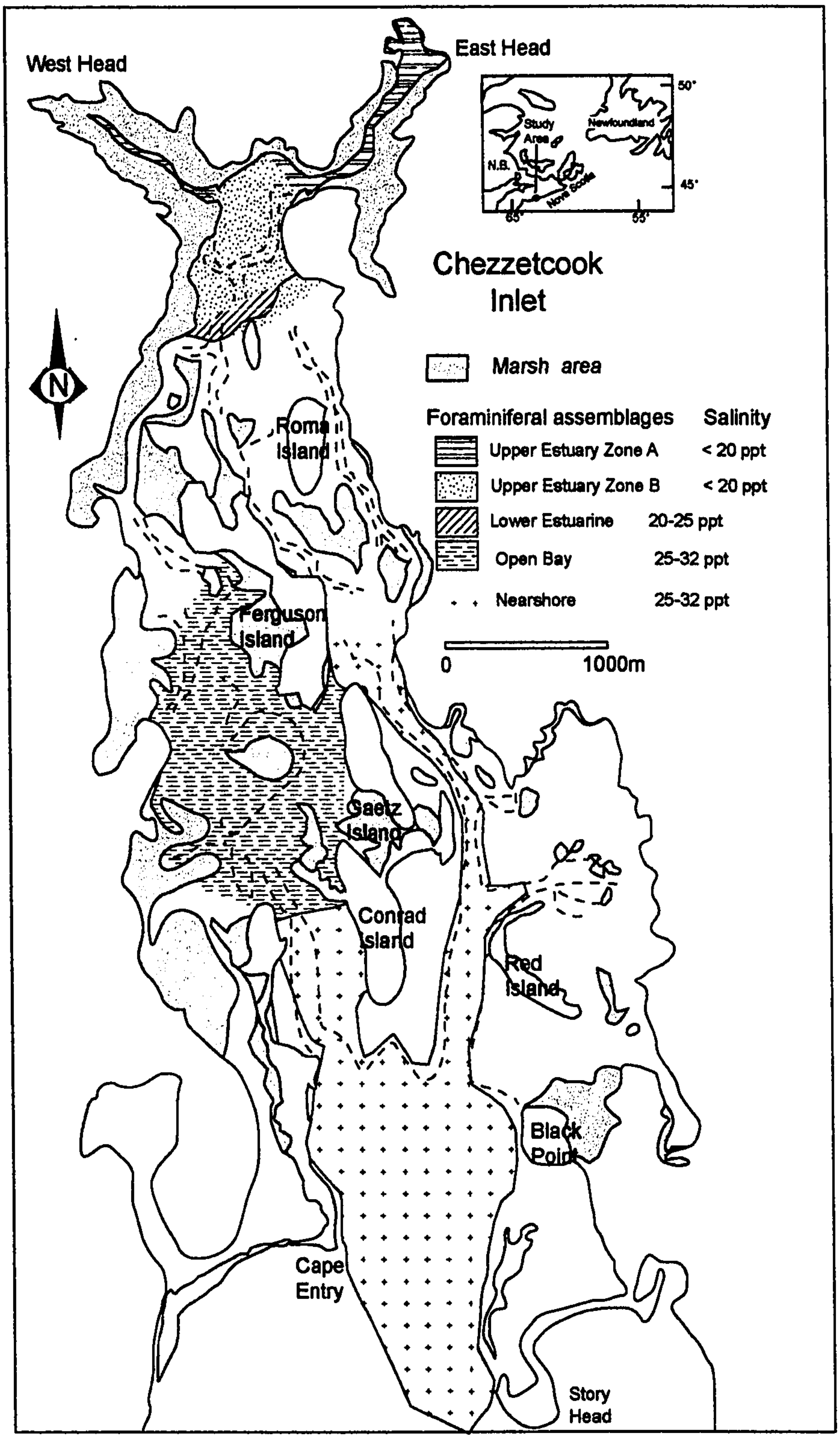


Figure 1.3- Estuarine zones in relation to foraminiferal assemblages in Chezzetcook Inlet, Nova Scotia (after Scott et al., 2001).

characterize this zone. *Miliammina fusca* and *Ammobaculites dilatatus* are the more common species. The transitional zone is characterized by an increase in calcareous forms such as *Elphidium williamsoni*, *E. excavatum*, and *Ammonia beccarii*. An agglutinated form, *Eggerella advena*, as well as *Haynesina orbiculare* (a calcareous form) also increase. The marginal marine zone is characterized by the dominance of open ocean species (*Elphidium* spp., *H. orbiculare*, and *Buccella frigida*) and the disappearance of agglutinated forms. *A. beccarii* is characteristic of the intertidal areas of the Maritimes and has been shown to require warm temperatures to reproduce (~15-23°C) (Bradshaw, 1957, 1961). The availability of $CaCO_3$ increases with higher salinities and temperatures and as a result, the lower latitudes are dominated by calcareous species (Greiner, 1970).

1.6.3 Sediment Chemistry Studies

There have been many studies on sediment contamination in NBH either through direct examination of sediments or by measurements of bioaccumulation in indigenous organisms. The construction of the hurricane barrier in 1964-66 led to increased siltation of the harbor with sediment enriched in organic matter. Apparently, contamination of bottom sediments with heavy metals is worse here than anywhere else in the United States and according to Farrington et al. (1983) also one of the most polluted with PCBs. EPA historical records show that NBH has been used as a discharge point for metal-rich industrial waste for about 100 years. These findings have led others to study the sediments of NBH to follow their course through the estuarine system.

Summerhayes et al. (1985) studied sedimentation and waste dispersal in the estuary of the River Acushnet, which discharges into the upper part of the estuary. They found that the Acushnet estuary is a sediment trap that is gradually being filled with dominantly silt and clay fractions. The sediments of the harbor and of the approaches near Clark's Point are unusually rich in organic matter because of the discharge of sewage into the sea at these places. Large amounts of metal have been discharged (through runoff, sewage, and dumped) into the harbor, including mainly Cu, Cr, Pb, and Zn, with lesser amounts of other metals. The various metals rapidly become part of the bottom sediment, particularly the clay fraction. Most of the metals have stayed in the harbor and they combine to form more than one percent of the sediment. These metals occur as finely divided solids, as adsorbed phases and as organometallic complexes, mostly in the clay fraction, so they tend to be distributed in the same way as the clay. These metals are transported out of the harbor with the clay fraction and show an exponential decrease into Buzzards Bay (Summerhayes et al., 1985).

Weaver (1984) found that the sediments underlying NBH contained elevated levels of PCBs. Testing revealed that two industrial operations were discharging wastewater containing PCBs. Both the direct discharge of contaminated water to the Acushnet River estuary and PCB contamination of the NBH municipal wastewater treatment facility were identified. Widespread contamination of these areas has resulted in the accumulation of PCBs in many marine organisms. As a result, thousands of hectares have been closed to the harvesting of shellfish, finfish, and lobsters. In a status report on PCB pollution in NBH (Weaver, 1982), contamination extended from the northernmost extreme of the Acushnet River estuary to the sediments in the vicinity of the New Bedford Harbor municipal wastewater outfall. Sediments contained levels up to 19 percent of PCBs and concentrations in the hundreds of thousands ppm were common in the tidal flats near Aerovox Inc. Elevated levels of PCBs were found in sludge, grit and effluent from the municipal wastewater treatment plant. PCBs were used in the manufacture of electronic capacitors during the years 1947-78 in buildings presently occupied by Aerovox Inc. and Cornell Dubilier. All analyzed soil and sediment samples collected on the Aerovox property have been found to contain elevated levels of PCBs (Weaver, 1984). The NBH municipal landfill has been used as a repository for domestic, commercial, and industrial wastes since the early 1920s. Monitoring for PCBs has not revealed the presence of any significant groundwater problems in the area of the landfill (Weaver, 1984).

Bergen et al. (1993) deployed blue mussels to monitor the levels of bioavailable contaminants during a pilot dredging project in New Bedford Harbor. The purpose was to quantify PCBs in dissolved and particulate seawater samples collected at four locations in the harbor and five independent mussel deployments which occurred at two of these stations during all phases of the project. Their study found a large concentration gradient of PCB congeners that existed in the seawater of NBH. PCB concentrations in deployed blue mussels and the dissolved phase of the seawater decreased by the same amount over the study area. Concentration factor analysis showed that PCB concentrations in mussels were best modeled as if these compounds had been accumulated from the dissolved phase of the seawater (Bergen et al., 1993). This relationship was consistent with and similar to those previously observed in two laboratory experiments and demonstrated the utility of the blue mussel for assessing PCB bioavailability, which provides information that is useful for relating PCB tissue residues with seawater concentrations (Bergen et al., 1993).

These and other studies showed that the sediment in NBH is elevated in many types of contaminants and, as a result, a pilot dredging operation was initiated to rid the harbor of some of these contaminated sediments. Subsequently, a multidisciplinary study by the USEPA was employed to delineate the benthic response to the dredging operation. Foraminifera were a part of this study and were used to illustrate benthic faunal responses and to determine if recovery took place after the removal of contaminated sediments.

CHAPTER II

FIELD AND LABORATORY METHODS

2.1 Chezzetcook Field Methods

2.1.1 Seasonal Migration, Preservation Potential, and Taphonomic Processes- Short Core Collection

Four sampling sites were selected from Chezzetcook Inlet to include the full gradient of low to high marsh foraminifera described by Scott and Medioli (1980a, b) (Figure 1.1). Short cores from these four sites were collected over a one year period. Site 1 cores were collected in October 1996, January 1997, April 1997, June 1997 and September 1997. Although cores were collected a few meters apart at Site 2, upon examination of the foraminiferal assemblages, this site was sub-divided into 2a and 2b due to the fact that a change in the foraminiferal assemblage occurred demonstrating the heterogeneity of assemblages in marsh sediment. As a result, cores were collected at site 2a in October 1996, and January 1997 and cores at Site 2b were collected in June 1997 and September 1997. Both January and April core collection was impossible due to snow and ice cover at Site 3 and as a result, cores were collected in October 1996, June 1997, and September 1997. Although a core at site 2a in April was collected, once it was found that the spring bloom did not occur at this site for April, the core was not examined. Aluminum tubes, 10 cm in diameter and approximately 45 cm in length, were hand pushed into the sediment at these sites except at site 1 where vegetation was so thick that it caused compaction. To avoid the problem, a shovel was used to cut a piece of marsh that was approximately 1 m^2 and 25 cm deep. The cores were approximately 30 cm in length and were used to establish seasonal variations, if any, in vertical foraminiferal distributional patterns. The winter of 1997 was very cold with ice remaining in the marsh well into March and as a result, the cores collected in June were used to represent spring, while the September cores represented summer conditions. The vegetation cover was also noted at each site. Once each core was collected, compaction due to vegetation was measured (at sites 2a, 2b, and 3) and the cores were capped (except at site 1 where each sample was placed in a bucket) and transported back to the laboratory at Dalhousie University where they were subsequently split. One half of each core was archived while the working section was photographed, described, foraminiferal processing and organic loss on ignition samples were taken within a day of collection.

2.1.2 Foraminiferal Test Degradation Determination

2.1.2.1 Surface Sample Collection

To quantify foraminiferal test degradation at room temperature over time, surface samples were collected at the same three sites that the cores were taken. On October 29, 1996, 350 cm^3 of surface sediment for each site (including a subsurface sample at site 1) were collected and placed in buckets and allowed to stand at room temperature. On September 25, 1997, 150 cm^3 of sediment was collected and placed in resealable bags at room temperature. Each week, for 15 weeks, 10 cm^3 of sediment were taken from each bag, which were then processed and the bags were then resealed. The sediment that was collected in buckets was stirred after 10 cm^3 of sediment was taken for examination each week, for 35 weeks. Foraminiferal test abundance and diversity was determined for each week and the results plotted. The sediment that was collected in bags was used to represent anaerobic conditions while sediment in the buckets were used to represent aerobic conditions.

2.1.2.2 1992 Archived Core

As well as surface samples left at room temperature over time, an archived core from Chezzetcook collected in 1992 near site 1 was used to determine if there was any foraminiferal test degradation when the core was left at room temperature (20°C). Two separate intervals (65-80 cm and 175-190 cm) were selected from the core and every other week, 5 cm^3 of sediment was processed and foraminiferal assemblages were determined. This experiment was carried out for 52 weeks. Any decrease in foraminiferal diversity and/or abundance was noted

2.2 Laboratory Methods

2.2.1 Processing of Foraminifera

Once split, short cores were sampled at 1 cm intervals for foraminiferal and organic matter analysis. Ten cm^3 of sediment at each interval were taken for foraminiferal examination. These samples were then washed through a 63μm sieve and placed in sample containers with a buffered formalin solution and Rose Bengal stain and then allowed to stand overnight. Samples were then washed free of the solution and stain and preserved in denatured ethanol. Samples were kept in suspended conditions, not dried, and due to the high organic content of the samples, a wet splitter was used to separate the sample into equal aliquots as described by Scott and Hermelin (1993). Foraminifera were examined and counted in a petri dish using a binocular microscope until at least 300 specimens were counted. These methods follow closely those described in Scott et al. (2001).

2.2.2 Organic Matter Percentage Analysis

At each interval of the first collection of cores taken in October 1996, a fraction of sediment was taken for organic matter analysis. The samples were placed in aluminum pans and dried in an oven at 50 °C. Upon cooling, the samples were crushed with a ceramic mortar and pestle and weighed. The samples were then placed in a muffle furnace and roasted for two hours at 400 °C. Once the samples cooled to room temperature, they were weighed once again and the organic loss on ignition was determined.

2.2.3 Data Analysis

After the samples were counted, the results were plotted for each core with living and total plotted separately and foraminiferal assemblages were interpreted graphically as well as subjected to simple statistical analysis to reinforce these results. The three or four dominant species of each corewere plotted on a 1:1 plot designed to discover if the surface sample interval (0-1 cm) was identical to that of the average of the 1-10 cm interval.

2.2.4 Replotted Data from Nanaimo, British Columbia

Data from Ozarko et al. (1997) were re-plotted because they had reported that the examination of foraminiferal faunas from a surface interval of 10cm provided a much less biased modern analog of fossil faunas used for paleoenvironmental comparison; however, their plots were based on computer generated "clusters" resulting in many small and discontinuous marsh zones. The raw data are re-plotted here to make them comparable with the Chezzetcook data.

2.3 New Bedford Harbor Field Methods

2.3.1 Introduction

All samples collected in NBH were collected by USEPA contractors who were specially trained in handling contaminated sediments. No collection of sediment was done by Dalhousie personnel.

2.3.2 Surface Sample Collection

The surface samples were collected from transects in New Bedford Harbor using different types of grab samplers (van Veen and petit Ponar) deployed from a Boston whaler. Both the van Veen and petite Ponar samplers are clam-shell dredge samplers that are lowered in the "jaws open" configuration until they hit the seafloor. The jaws are drawn shut as the hauling wire is retracted by the ships wench (Scott et al., 2001). Once the jaws are shut, the sample is effectively isolated from turbulence created by the retrieval process. The 12 surface samples from transect 1, which extends from the inner to outer harbor, were collected on October 18, 1996 with a petite Ponar device. Transect 2, taken near Apponagansett Bay, includes 6 samples which were collected on October 30, 1996 with a van Veen sampling device except for sample NBH 331 which was collected on December 8, 1997 with a petite Ponar sampler. The 14 samples near Clark's Outfall were collected using a petite Ponar sampler on two different days; 9 on the 8^{th} of December and 5 on the 4^{th} of December, 1997. This transect was plotted by taking the distance of each sample from the outfall.

Once the surface samples were collected, they were taken back to the Environmental Protection Agency laboratory in Rhode Island. Here, approximately 10 cc of sediment from each sample were placed in vials for foraminiferal analysis and most of the remaining sediment was analyzed for several types of pollutants. These samples were refrigerated and stored for approximately 3 months and were then subsequently sent to Dalhousie University for foraminiferal processing. Once processed, these samples were examined and results were plotted accordingly.

2.3.3 Core Collection

The 7 cores in New Bedford Harbor for this study span over the Inner (Upper to Lower) Harbor and Apponogansett Bay and were collected over a three year period. Core 1 was collected on May 23, 1996 using a Davey hand sampler. Cores 2, 3, and 6 were collected in 1996 on October 25 and 18 (for cores 3 and 6), using a simple hand sampler which is basically pushed through the sediment. Core 7 was collected on October 30, 1996 by a Benthos gravity corer which uses a weight to reach the seafloor and is used in deeper water. The final two cores, 4 and 5, were collected on June 10, 1998 by a hand piston corer (used to obtain longer cores). Once the cores were collected, they were capped on site and brought back to the EPA laboratory in Rhode Island where they were subsequently split. One half of the core was refrigerated and used for foraminiferal analysis and the other half was used for dating and geochemical analysis.

2.4 Laboratory Methods

2.4.1 Foraminiferal Analysis

Once the cores were split, one half of the core was sampled at selected intervals for foraminiferal examination. Both the core and surface samples were processed and examined in the same fashion as those collected in Chezzetcook. After the samples were counted, foraminiferal totals were plotted and interpreted graphically.

2.4.2 Dating and Geochemical Analysis

The remaining half of each core and fractions of surface samples were used for the determination of heavy metals, organic cabon, PCBs, and PAHs while Pb-210 dating was determined for all cores collected using the radionuclides Pb-210. Ra-226, and Cs-137 by direct gamma assay. For samples where unsupported Pb-210 activity was below detection limits, sedimentation rates were either extrapolated from those calculated for sediment depths immediately above or were estimated based on pollen stratigraphy and historical evidence. The materials and methods used by the EPA to obtain these results are detailed in Appendix Table 1a-i.

2.4.3 SEM Determination

Foraminiferal specimens from both Chezzetcook and New Bedford Harbor were selected for scanning electron micrographs. Foraminifera were picked and placed on a metal stub. An environmental scanning electron microscope (ESEM), a low vacuum device, was used and as a result, no coating was necessary for the specimens which allowed for preservation of the sample. The photographs of specimens were numbered, labeled and assembled into a plate. Some pictures were also taken using a Scanning Light Microscope (Scott and Vilks, 1991).

CHAPTER III

SALT MARSH (CHEZZETCOOK AND NANAIMO) RESULTS

3.1 **Chezzetcook short cores**

3.1.1 Quantitative Analysis

3.1.1.1 Site 1 (Station 4b from Scott and Medioli (1980a,b))

All 5 cores (Figure 3.1) exhibited low diversity but high numbers of foraminifera and arcellaceans. *Spartina patens* was the dominant plant species at this site with cores consisting of dark brown peaty mud with extensive roots throughout. Organic matter percentages were relatively high throughout the cores and ranged from 14.8- 68.7 %.

3.1.1.1a October 1996 collection

Total: Numbers were generally high for all 29 samples examined at 1cm intervals down this core, ranging from 1580 to 5136 inds/10 cm^3, with total numbers remaining relatively constant throughout the core (Appendix Table 2; Figure 3.2) *Trochammina macrescens* forma *macrescens* dominated the assemblage throughout this core (40-80 %) with low percentages of *Pseudothurammina limnetis* (0.5-20 %) steadily decreasing downcore. There were low percentages of *Miliammina fusca* (3-10%) except between interval 7-18 cm where it formed a significant component of the assemblage (15-30%). Low percentages of *Tiphotrocha comprimata* were present throughout, with the highest values at the bottom of the core (15-30%).

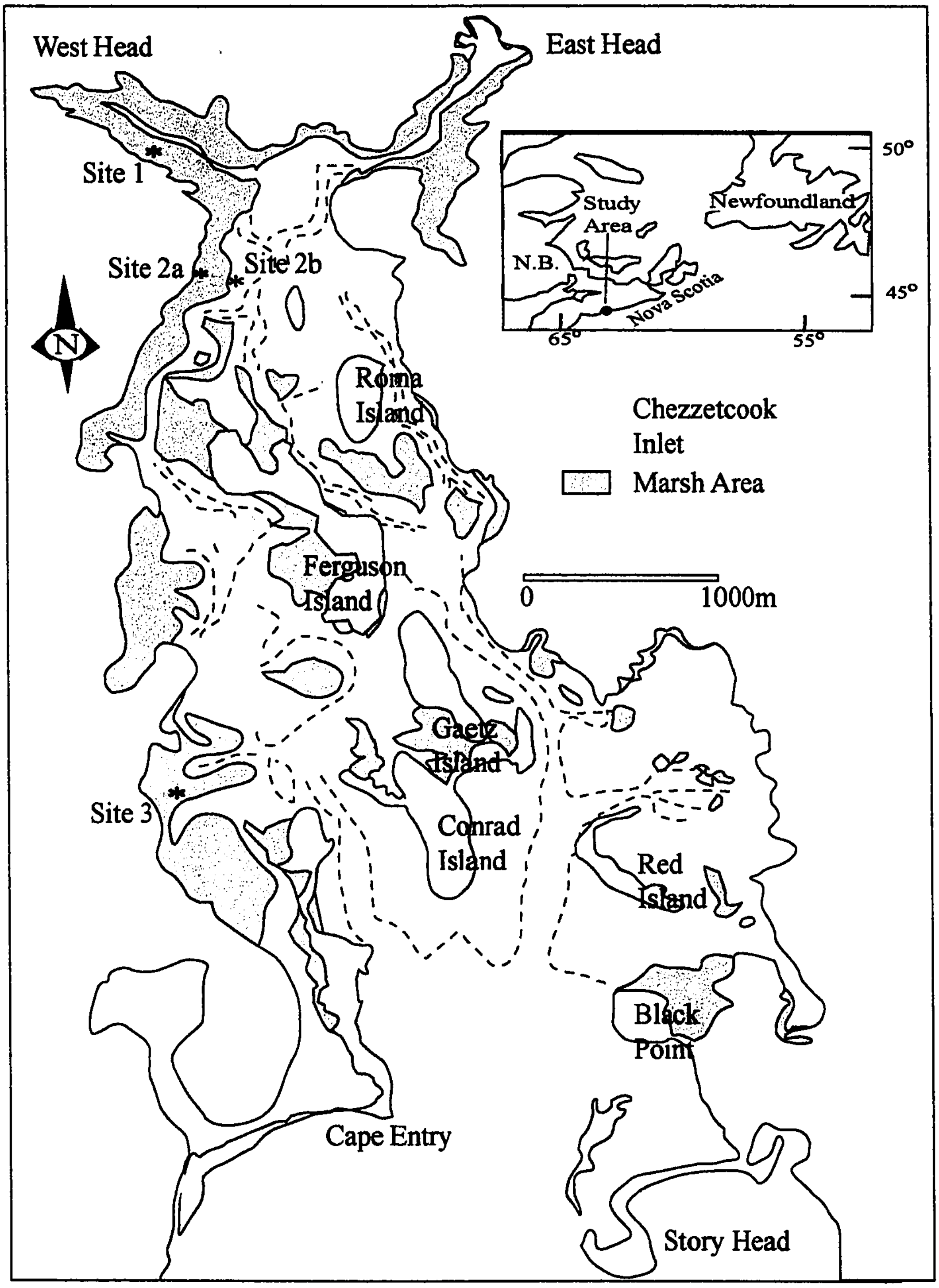


Figure 3.1- Location map of Chezzetcook Inlet on the Atlantic Coast of Nova Scotia, showing the positions of surface and core sampling sites (after Scott et al. 2001)

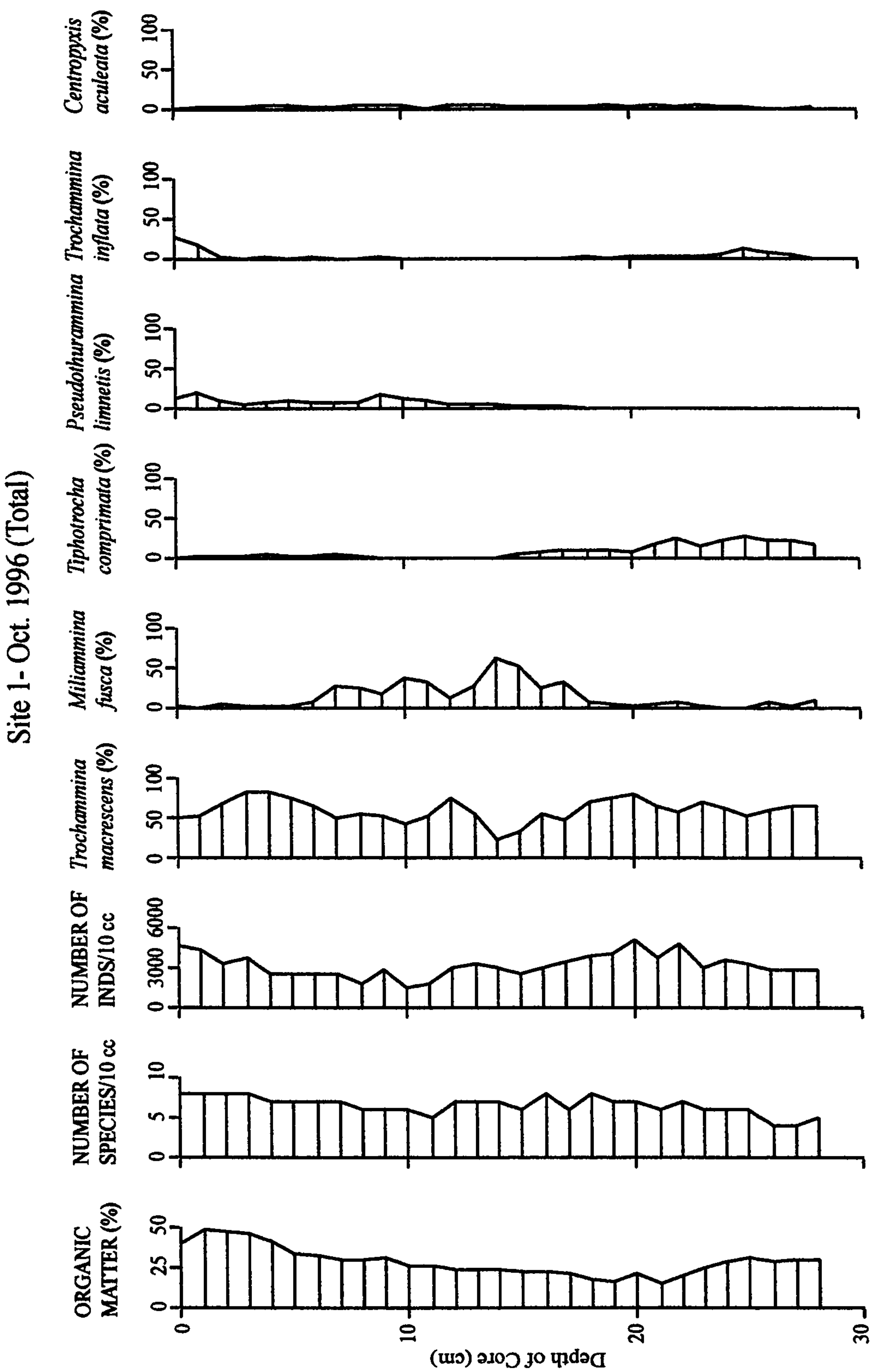


Figure 3.2- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

Living: Specimens were identified as far down the core as 15-16 cm and numbers ranged from 8 to 2382 inds/10 cm^3 (Appendix Table 2; Figure 3.3). Highest numbers of individuals occurred in the top 3 cm. Below the 2 cm level, living populations dropped to less than 100 but were detectable down to 15 cm. *Trochammina macrescens* forma *macrescens* generally dominated the assemblage. There were moderate percentages of *Pseudothurammina limnetis* in the upper 12 cm, with highest values found between 6- 11 cm. Low percentages of living *Miliammina fusca* were found throughout the core with highest percentages found at the 14- 16 cm interval and low percentages of *Tiphotrocha comprimata* (1-5%) found down to 11 cm.

3.1.1.1b January 1997 Collection

Total: There were no living specimens in this core at the time of collection (hence no diagram). Numbers ranged from 1400 to 5423 inds/10 cm^3 for the 24 samples examined at 1 cm intervals downcore (Appendix Table 3; Figure 3.4). *Trochammina macrescens* forma *macrescens* strongly dominated the assemblage throughout the core (55 to 90 %) with low percentages of *Tiphotrocha comprimata* (0.5 to 6.3 %) that varied little in values throughout the entire core. Low percentages of *Miliammina fusca* occurred near the surface (2 to 12 %) with peak values occurring between 11 and 20 cm (15 to 36.7 %). *Centropyxis aculeata* and *C. constricta*, both arcellaceans, comprised 4 to 8 % of the entire assemblage and these values were constant throughout the entire core.

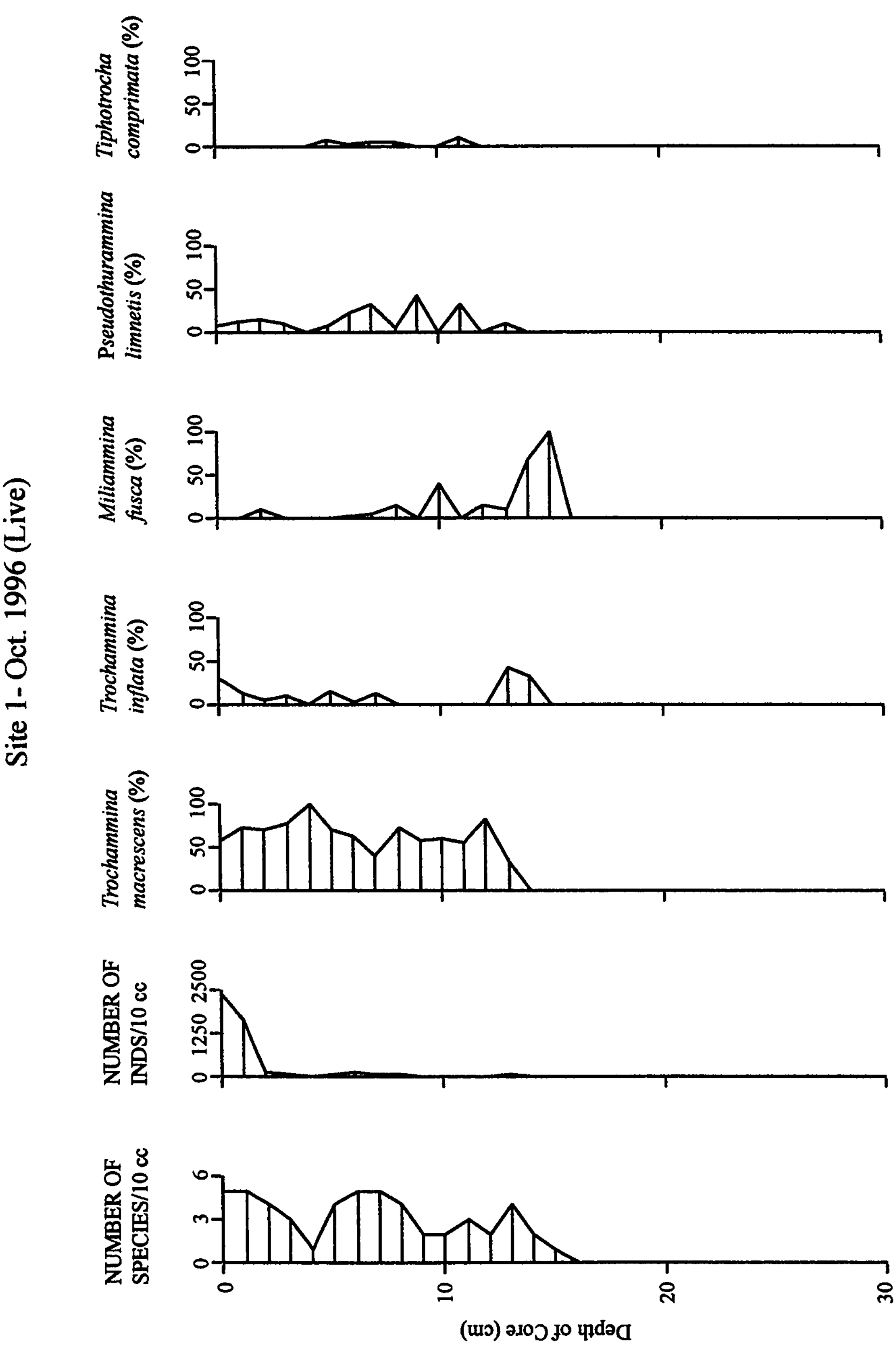


Figure 3.3- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

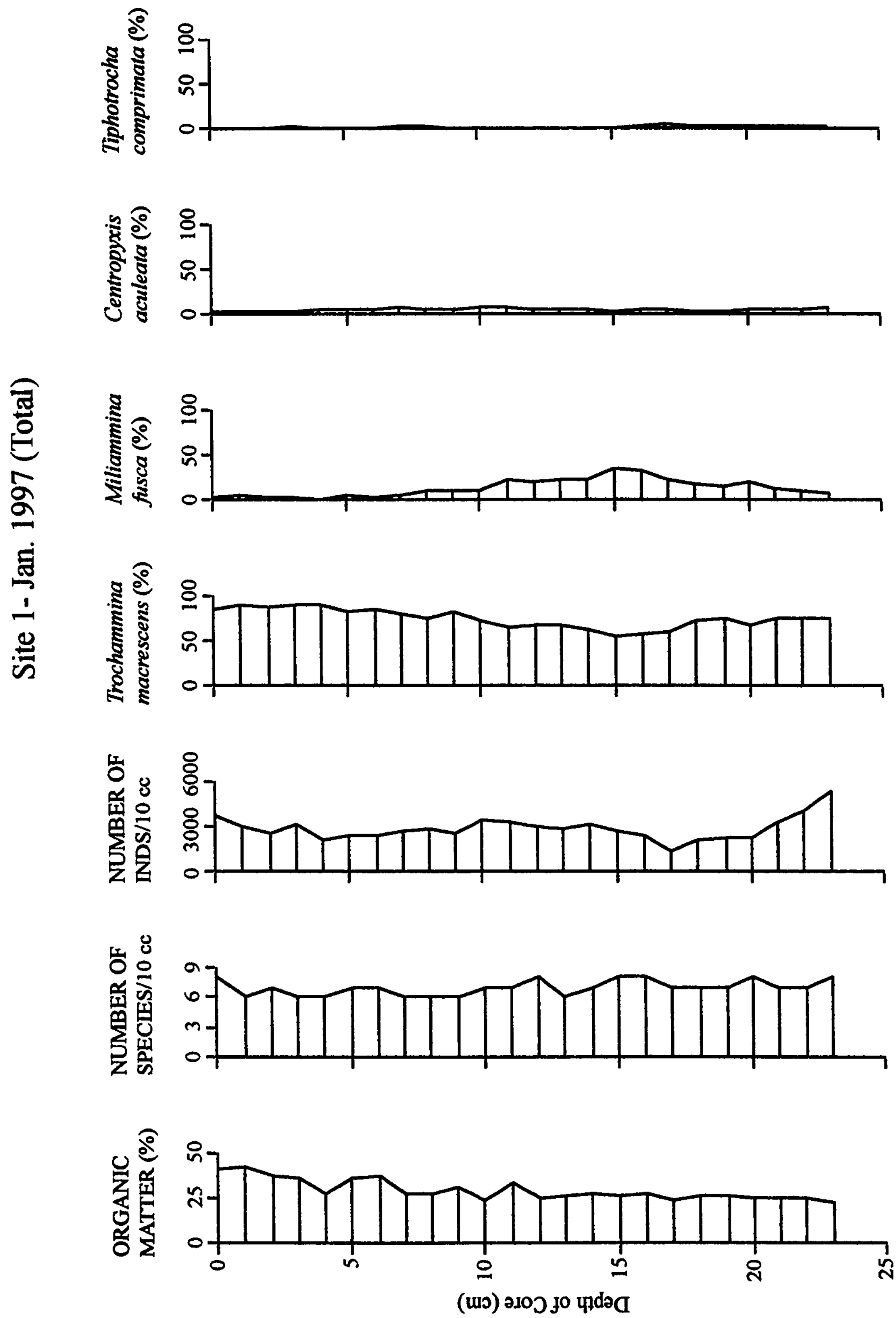


Figure 3.4- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

3.1.1.1c April 1997 Collection

Total: Numbers ranged from 1992 to 6952 inds/10 cm^3 for the 22 samples examined at 1 cm intervals down the core remaining relatively constant throughout except between 8 to 11 cm (Appendix Table 4; Figure 3.5). *Trochammina macrescens* forma *macrescens* dominated the assemblage throughout the core (49.8 to 92.9 %) with low percentages of *Tiphotrocha comprimata* (2 to 14.3 %) that increased slightly downcore. There were low percentages of *Centropyxis aculeata* (1.7 to 8.8 %) with little variation in values throughout the core. *Miliammina fusca*, except at peak values of 11.2 to 30. 5 % between 10 and 17 cm, showed little variation.

Living: Numbers were very low and ranged from 24 to 440 inds/10 cm^3 with specimens present only to the 3 cm level (few specimens of *Trochammina macrescens* forma *macrescens*) (Appendix Table 4; Figure 3.6). Most living representatives were concentrated at the surface. *Trochammina macrescens* forma *macrescens* dominated the assemblage while *Tiphotrocha comprimata*, *Miliammina fusca*, and *Trochammina inflata* occurred only at the surface (0-1 cm). *Trochammina macrescens* forma *macrescens* is the only species that occurs below the surface with very low numbers.

3.1.1.1d June 1997 Collection

Total: Numbers were generally high ranging from 2664 to 5864 inds/10 cm^3 for the 28 samples examined at 1 cm intervals down the core, (Appendix Table 5; Figure 3.7) with

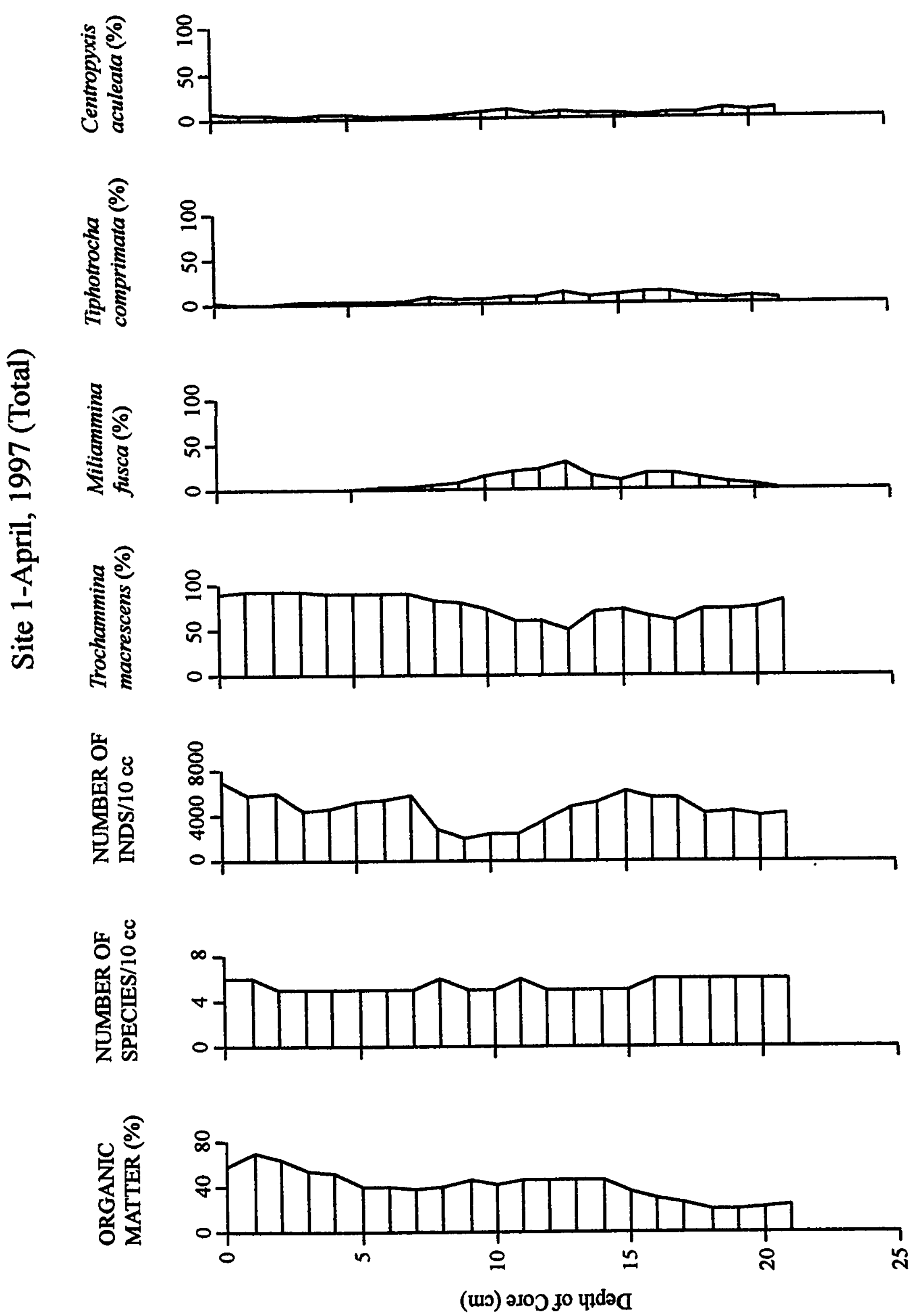


Figure 3.5- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

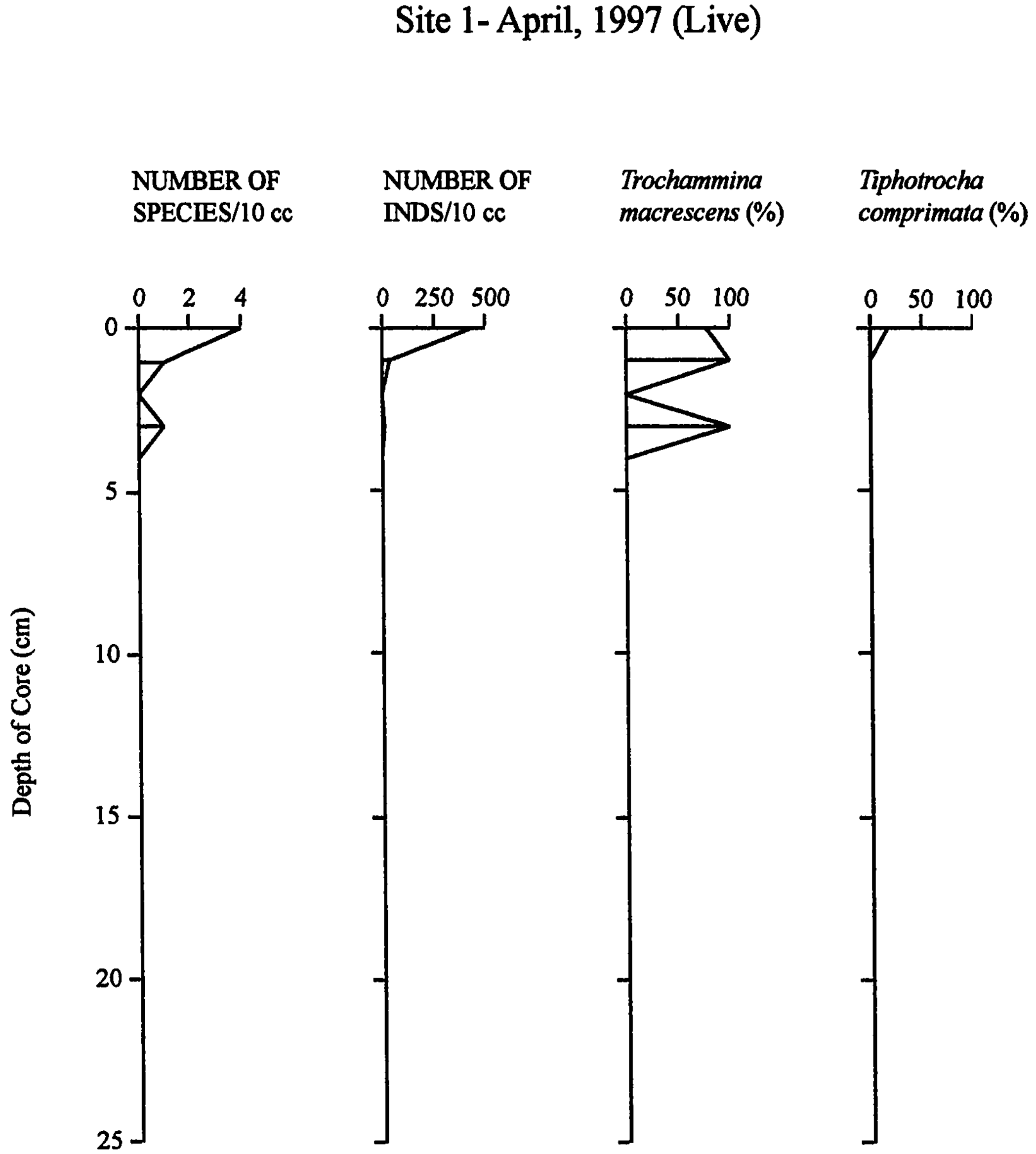


Figure 3.6- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

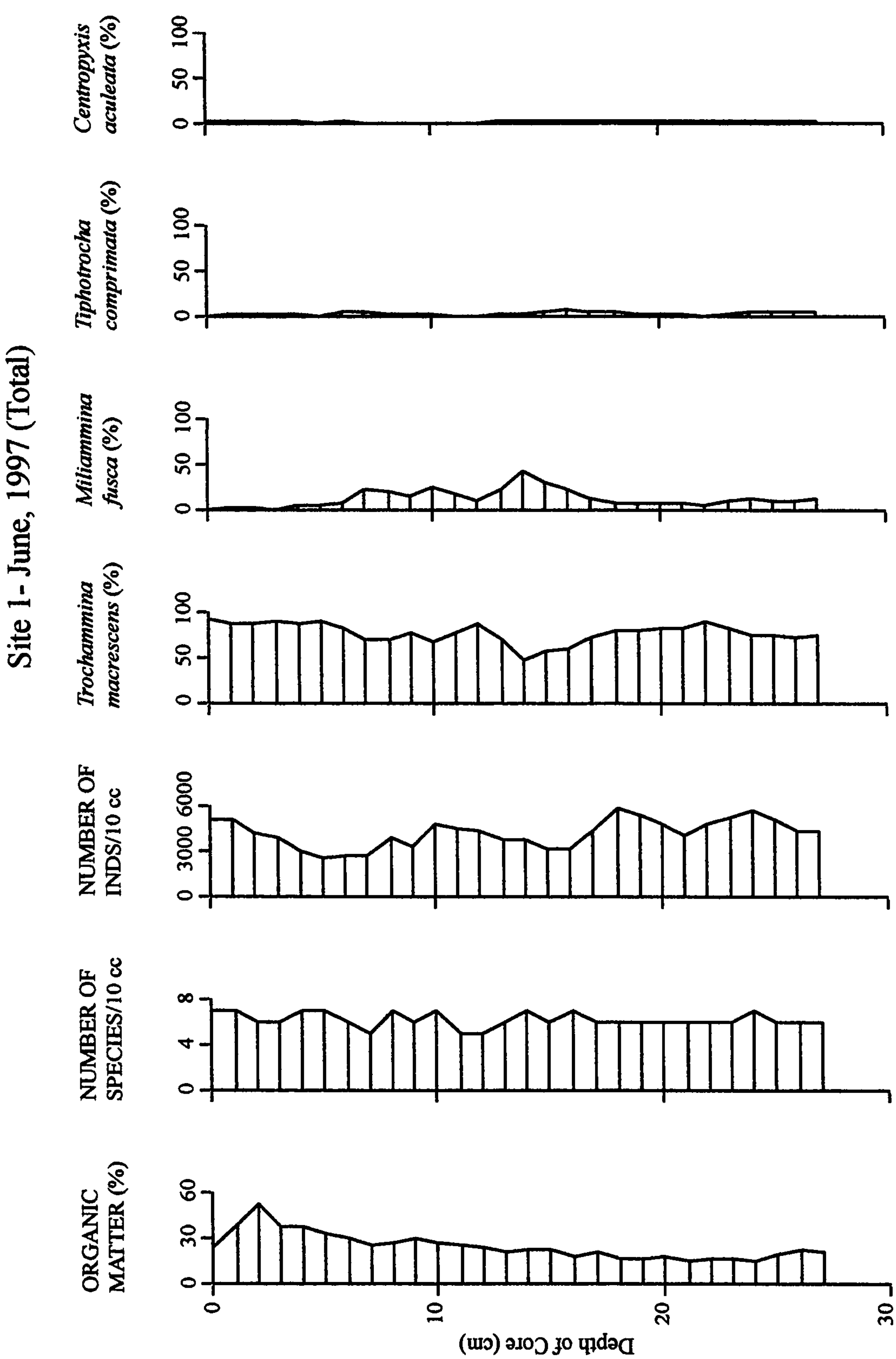


Figure 3.7- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

lowest numbers occurring between 4-7 cm. *Trochammina macrescens* forma *macrescens* strongly dominated the assemblage (48.8 to 92.8 %) with low percentages of *Tiphotrocha comprimata* with little variation in values (1.2 to 8.6 %) throughout the entire core. Low percentages of *Miliammina fusca* also occurred throughout the core except at peak values between 13-16 cm where it co-dominated with *Trochammina macrescens* forma *macrescens*. *Centropyxis aculeata* and *C. constricta* comprised 0.3 to 6 % of the total assemblage and remained constant throughout the entire core.

Living: Specimens were identified down to only 7 cm with highest values occurring near the surface (0-2 cm) and ranging from 8 to 2216 inds/10 cm^3 (Appendix Table 5; Figure 3.8). The faunal assemblage had low diversity with only 4 species identified and was dominated by *Trochammina macrescens* forma *macrescens* (93.5 to 100 %). Low percentages of *Miliammina fusca* and *Tiphotrocha comprimata* occurred in two intervals (0-2cm and at 4 cm). *Trochammina inflata* occurred only in the 1-2cm interval and comprised 0.5 % of the living assemblage. *Trochammina macrescens* forma *macrescens* was the only form to occur below 4 cm and only 8 specimens were identified at the 5-6 cm and 7-8 cm interval.

3.1.1.1e September 1997 Collection

Total: Numbers ranged from 2600 to 12024 inds/10 cm^3 for the 26 samples examined at 1 cm intervals down the core, with peak values occurring between 9-16 cm (Appendix

Site 1- June, 1997 (Live)

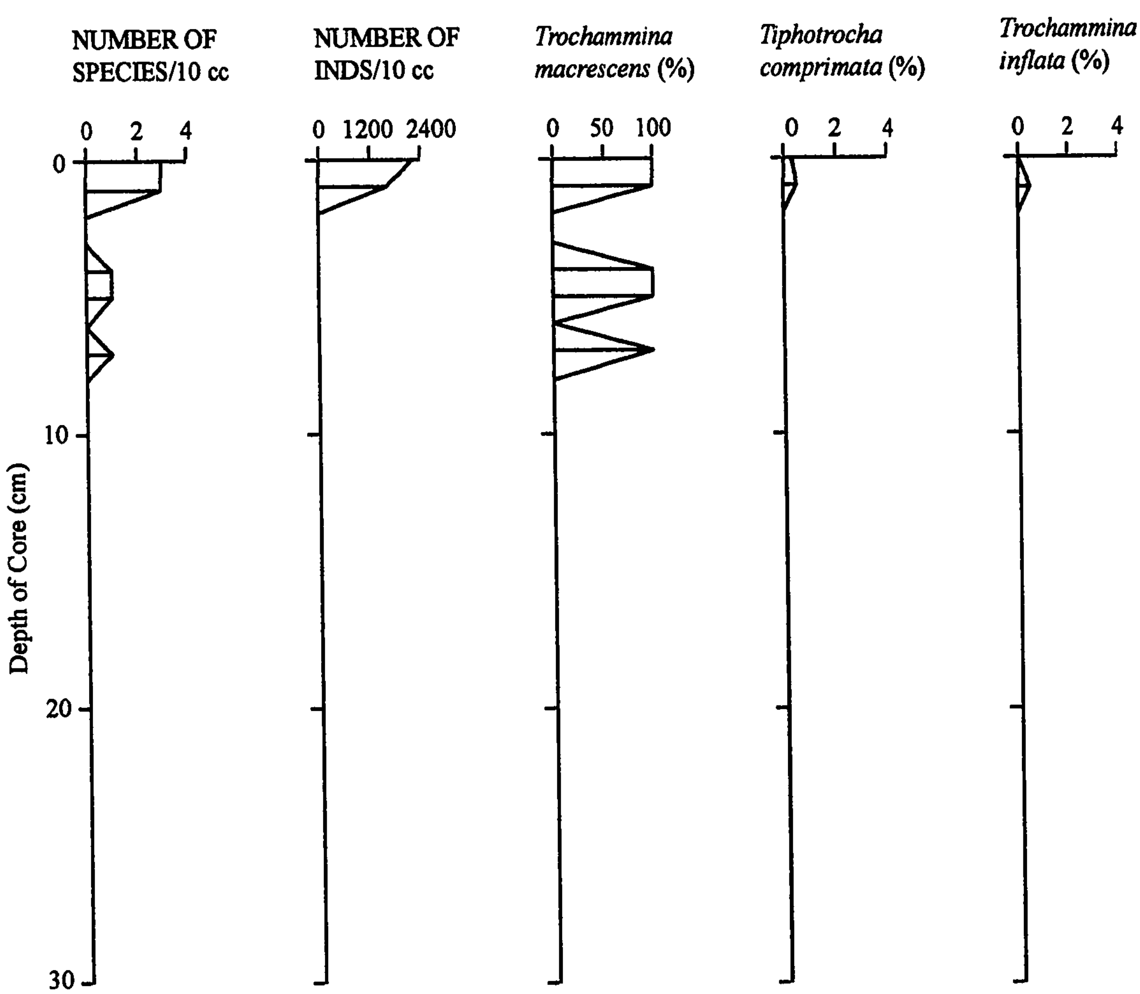


Figure 3.8- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 1-, Chezzettcook. (**note**: both *Tiphotrocha comprimata* and *Trochammina inflata* have very low numbers)

Table 6; Figure 3.9). *Trochammina macrescens* forma *macrescens* strongly dominated the assemblage (47.1 to 94.3 %). Low percentages of *Tiphotrocha comprimata* (1.5 to 27.2 %) and *Miliammina fusca* (0.1 to 16.7 %) steadily increased downcore. The combined percentages of *Centropyxis aculeata* and *C. constricta* also increased downcore, ranging from 0.7 to 37.3 %. The highest percentages of *Tiphotrocha comprimata*, *Miliammina fusca*, *Centropyxis aculeata*, and *C. constricta* occurred where total abundance is lowest (18-22 cm).

Living: Foraminifera were identified in the top 3 cm with the highest number occurring at the surface (0-1 cm), and numbers ranged from 120 to 2240 inds/10 cm^3 (Appendix Table 6; Figure 3.10). *Trochammina macrescens* forma *macrescens* dominated the assemblage occurring in all 3 samples and represented the entire assemblage at the 2-3 cm interval. Only 3 species were identified as living with only 16 specimens of *Pseudothuriammina limnetis* occurring at the surface while *Tiphotrocha comprimata* occurred in the top 2 cm.

3.1.1.1f Statistical Analysis

The relative percentage of the three most abundant species from the five cores that were collected from this site were plotted comparing the relative percentage of each species from the surface interval (0-1 cm) to that of the average relative percentage of a selected interval (in this case 1- 7cm) (Figure 3.11). The relative percentages of the

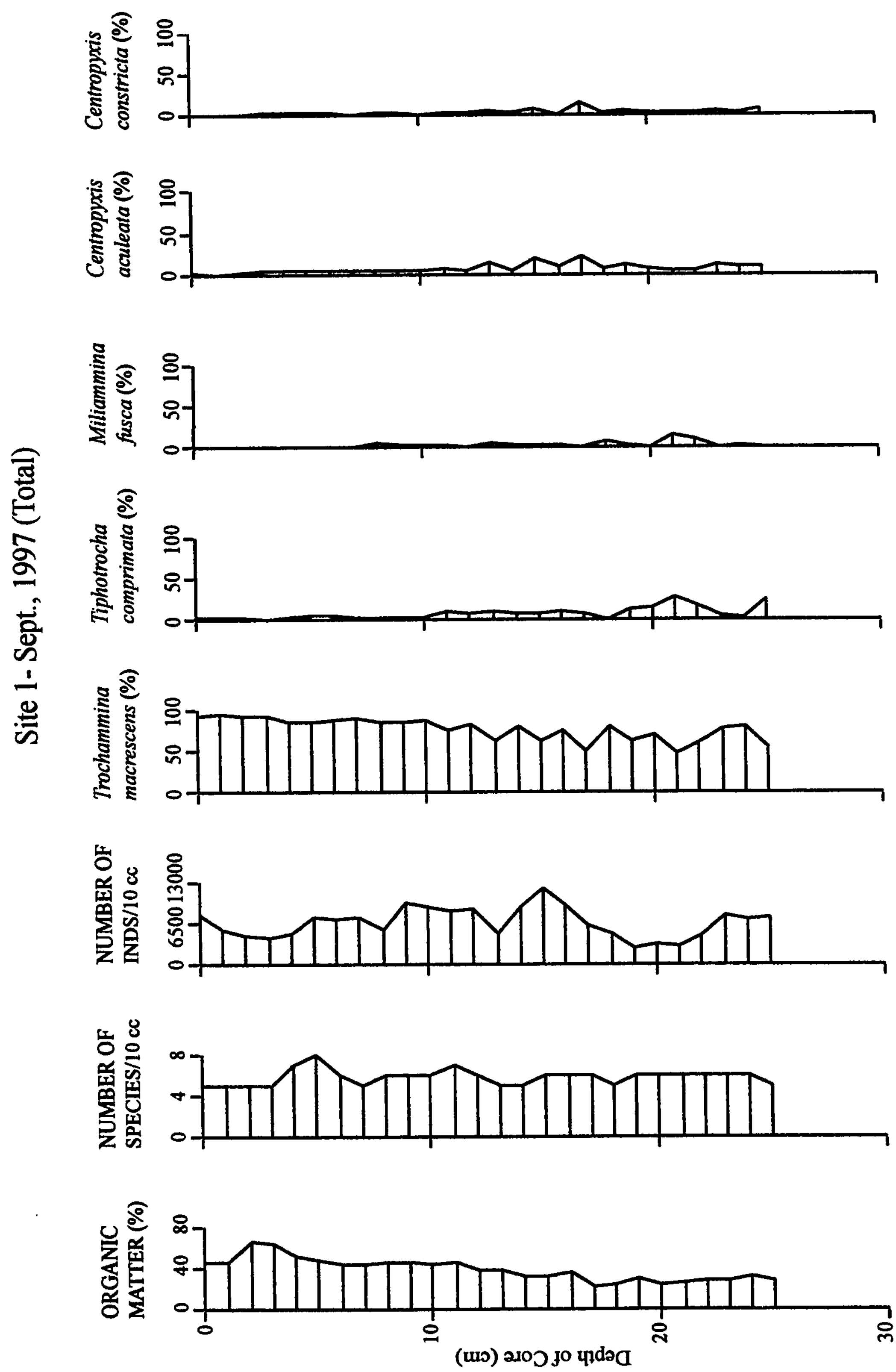


Figure 3.9- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

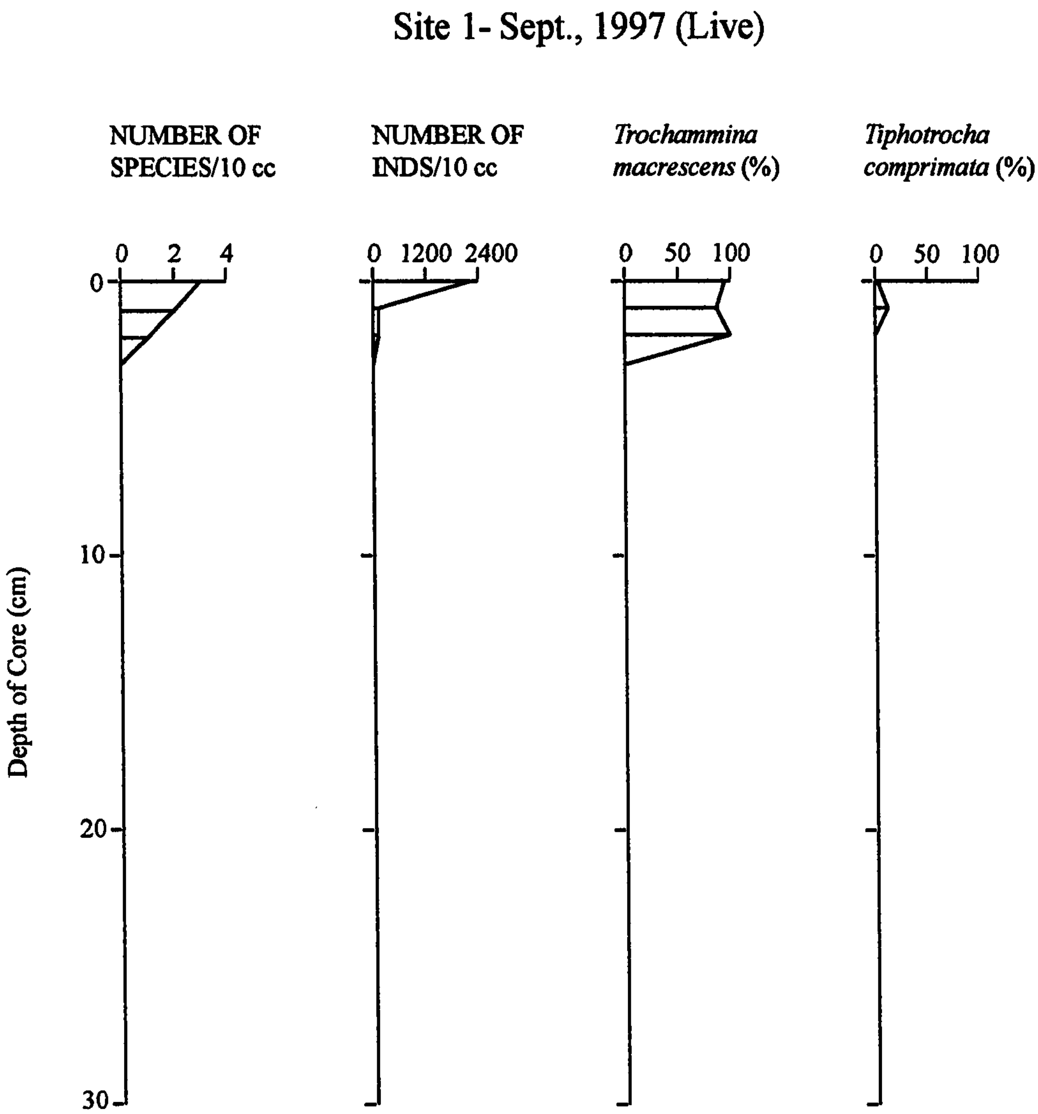


Figure 3.10- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 1, Chezzettcook.

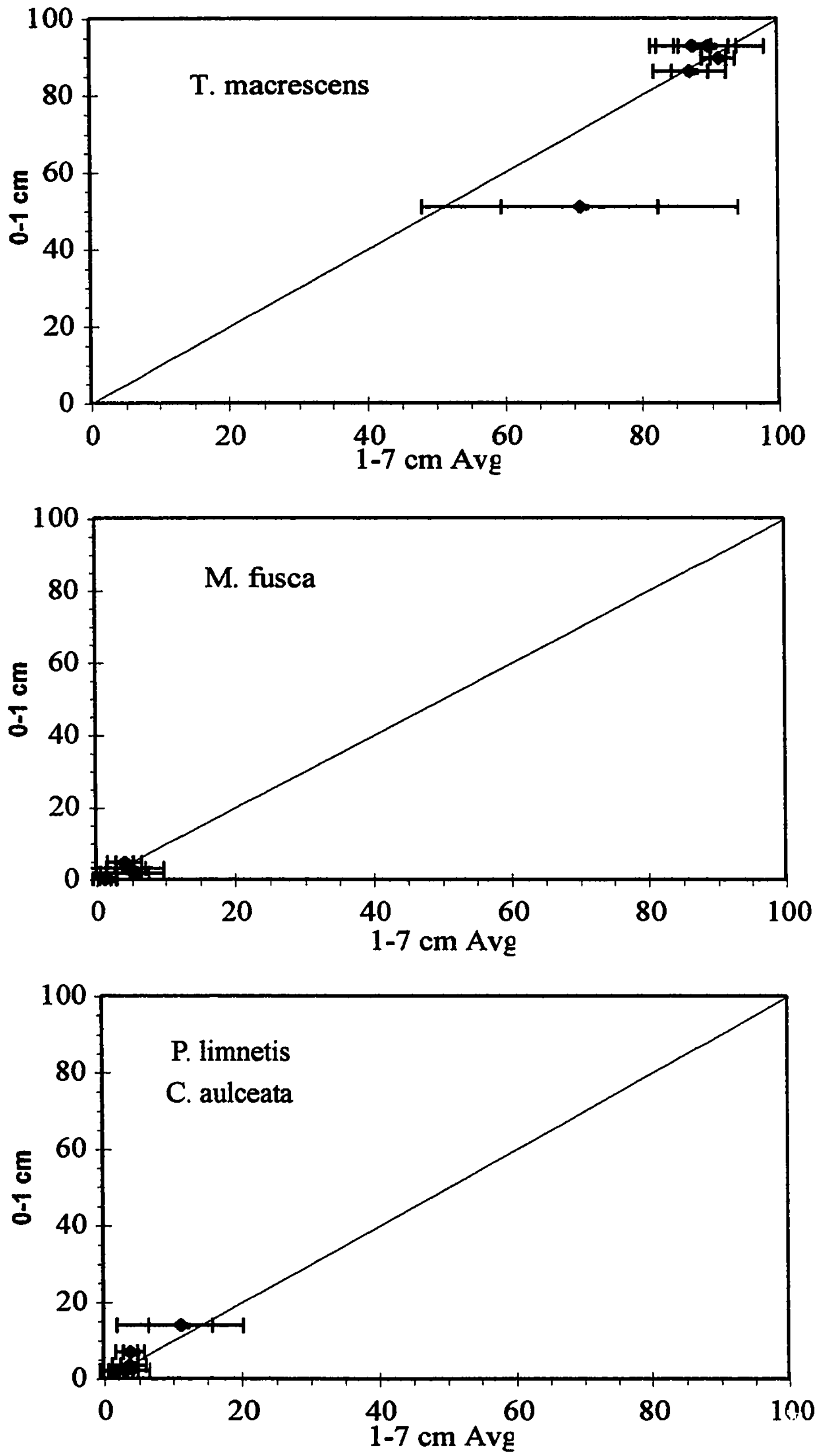


Figure 3.11- 1:1 plots of the three most abundant species from site 1 comparing the relative percentage of the surface (0-1 cm) and the average from 1- 7cm. Vertical bars are 1 and 2 standard deviations.

abundant species were averaged from the 1- 7 cm interval to determine if the variation of percentages were due to biofacies changes or simply variations in the relative percentages due to the heterogeneity of the marsh system. If the surface interval percentages were identical to the average percentages of the selected interval, the points would plot on the 1:1 line and any changes downcore would be attributed in natural variations and not a change in biofacies. Figure 3.10 shows that the points from the surface and the interval from 1- 7 cm fall on the 1:1 line within 1 standard deviation in almost all of the cases with the exception of one sample where the point falls within two standard deviations (*T. macrescens*). The other species that occur in moderate to low percentages (*T. och*racea and *P. limnetis* or *C. aculeata*) are very close to the 1:1 line suggesting that these assemblages are very similar. This shows that despite changes in the relative percentage of species downcore, once the average is taken, the overall assemblage does not vary significantly and as a result, the surface interval provides an adequate representation of the environmental conditions occurring at the time of deposition.

3.1.1.2 Site 2a (Station 3d from Scott and Medioli (1980a,b))

The two cores from site 2a and the 2 cores collected at site 2b exhibited slightly higher diversities but lower abundances of foraminifera than at Site 1. (**Note**: site 2a was in the *Spartina patens* zone, while site 2b, which was very close to site 2a, was on a mudflat). At Site 2a, the abundance of plant species was not as high as it was at Site 1 (and negligible at Site 2b), but *Spartina patens* did dominate the floral assemblage comprising 75 % while *Spartina alterniflora* comprised 25 %. Organic matter percentages were lower here than at the first site ranging from 6- 19% with the sediment consisting of dark grey mud with roots extending down through the cores.

3.1.1.2a October 1996 Collection

Total: Numbers ranged from 265 to 9088 inds/10 cm^3 for the 30 samples examined at 1 cm intervals down the core, with highest values occurring between 2 and 9 cm (Appendix Table 7; Figure 3.12). *Miliammina fusca* strongly dominated the assemblage (60.2 to 92.8 %) remaining relatively constant down to 23 cm where the percentage dropped between 21.8 to 55.8 %. There were low percentages of *Trochammina macrescens* forma *macrescens* (3 to 9.5 %) except for the interval 13-19 cm where numbers ranged from 12.6 to 23.8 %. Low percentages of *Trochammina ochracea* were also present down to 22 cm and then the species, co-dominated with *Miliammina fusca,* and eventually dominated the assemblage (up to 39.4 %) as total numbers decreased to less than 1000. Organic linings formed a significant component of the assemblage (up to 33.7 %) between 25 and 29 cm. This increase of *Trochammina ochracea* and organic linings corresponded to the decrease in total numbers and decrease in organic matter percentage near the bottom of the core. *Elphidium williamsoni* was present with low percentages (0.3 to 2 %) down

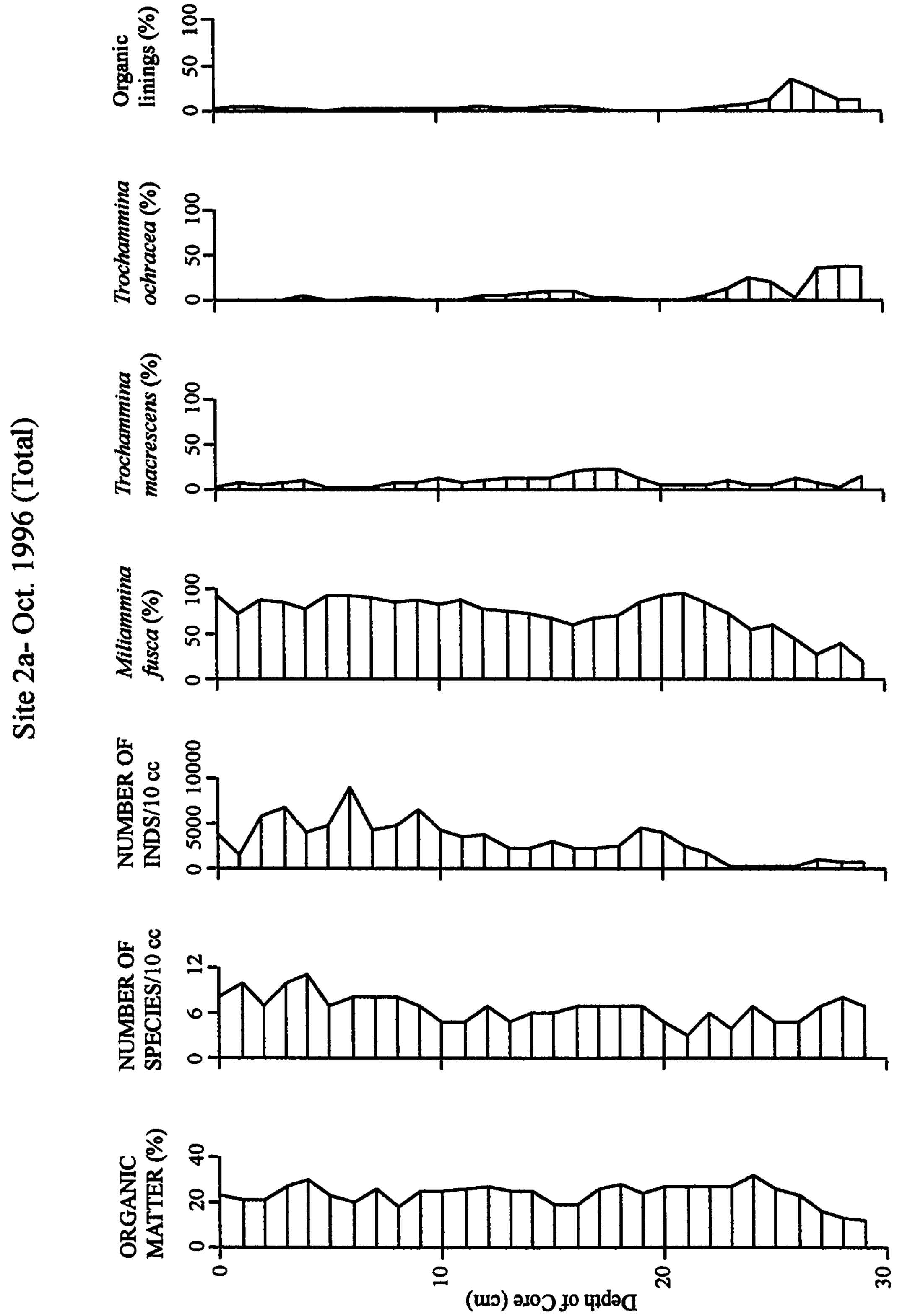


Figure 3.12- Profile of organic matter, number of species and individuals and percent abundance of foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 2a, Chezzettcook.

to 6 cm. *Eggerella advena* was also present with low percentages (0.1 to 3 %) and little variation throughout the core.

Living: Foraminifera were identified in each sample down to 19 cm with abundances ranging from 8 to 2736 inds/10 cm^3 (Appendix Table 7; Figure 3.13). Percentages varied with *Miliammina fusca* dominating in the upper 12 cm and at 19 cm and *Trochammina macrescens* forma *macrescens* dominating between 15 and 17 cm. *Miliammina fusca* and *Trochammina macrescens* forma *macrescens* co-dominated from 13 to 15 cm. Representatives of *Elphidium williamsoni* occurred in low percentages down to 5 centimeters. Four specimens of *Pseudothurammina limnetis* were identified at the surface (0-1 cm). Representatives of *Eggerella advena* were identified at intervals 1-3 cm, at 4-5 cm, and 6-7 cm. Between 5-8 cm, specimens of *Ammobaculites dilatatus* and *Ammotium salsum* were identified while *Trochammina inflata* was found in low percentages from 3-5 cm, 7-8 cm, 9- 10 cm, and 12- 13 cm.

3.1.1.2b January 1997 Collection

Total: Numbers ranged from 955 to 4232 inds/10 cm^3 for the 27 samples examined at 1 cm intervals down the core (Appendix Table 8; Figure 3.14). *Miliammina fusca* strongly dominated the assemblage (61.3 to 91.2%) with little variation in values except between

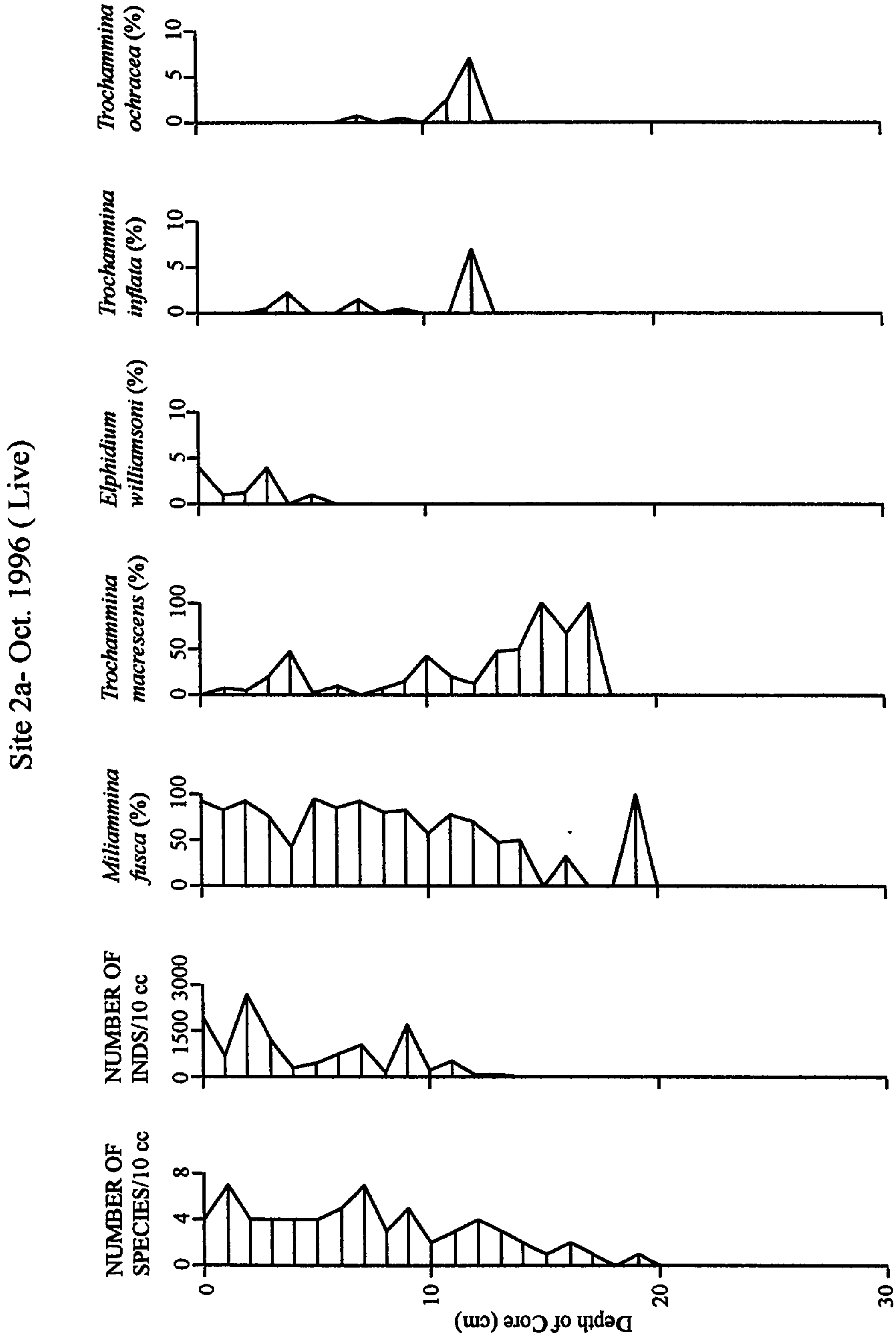


Figure 3.13- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 2a, Chezzettcook. (**note:** *Elphidium williamsoni* and *Trochammina inflata* have reduced numbers.)

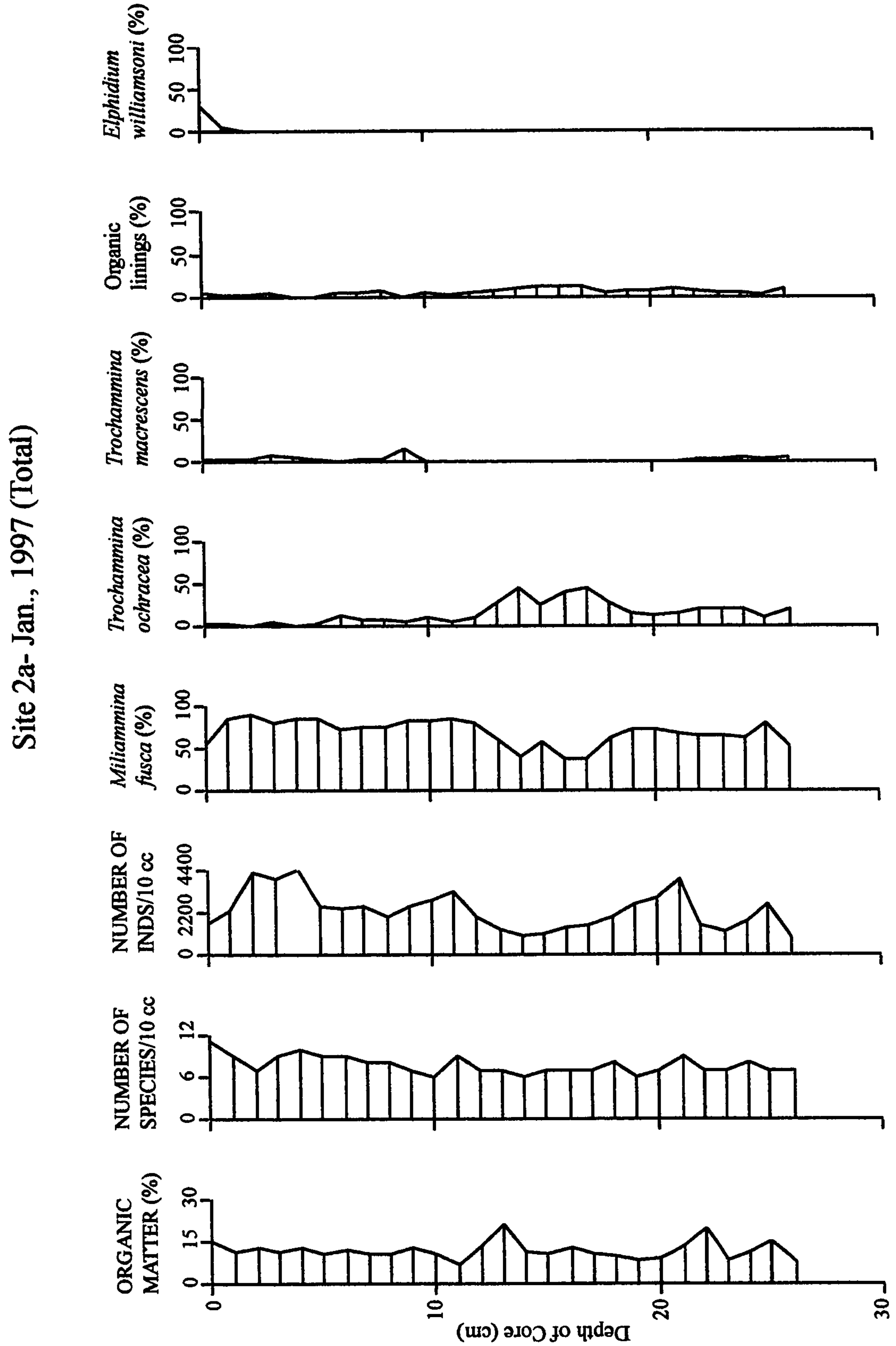


Figure 3.14- Profile of organic matter, number of species and individuals and percent abundance of foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 2a, Chezzettcook.

13-17 cm where percentages ranged from 41.9 to 57.7 %. *Elphidium williamsoni* co-dominated the assemblage at the surface (31.1 %) but quickly dropped off to 0.3 to 5 % between 1-7 cm. Low percentages of *Trochammina macrescens* forma *macrescens* were present throughout the entire core (0.4 to 8.8 %) with a peak value of 16.8 % occurring at 9- 10 cm. *Trochammina ochracea* also occurred in low percentages but gradually increased downcore and its peak values corresponded to the lowest values for *Miliammina fusca*. There were low percentages of *Ammobaculites dilatatus*, *Ammotium salsum*, *Eggerella advena*, and organic linings throughout the core; there was a general increase in percentages of organic linings occurring in the middle of the core (14-15 cm down to 23 cm).

Living: Specimens were identified to the 15-16 cm level and abundances ranged from 4 to 1080 inds/10 cm^3 with highest numbers occurring at the surface and steadily decreasing down core (Appendix Table 8; Figure 3.15). *Miliammina fusca* strongly dominated the assemblage throughout the entire core (42.3 to 100 %) except between 0-2 cm where it co-dominated with *Elphidium williamsoni*. Low percentages of specimens of *Trochammina macrescens* forma *macrescens* were identified at intervals 4- 6 cm and 7-8 cm (6.1 to 10.5 %). Calcareous species were also identified at the surface in small numbers. *Elphidium excavata* forma *excavatum*, *Elphidium excavata* forma *clavata*, *Ammonia beccarii*, and *Haynesina orbiculare* all had living representatives at the surface but disappeared below this level except for 8 specimens of *Haynesina orbiculare* that

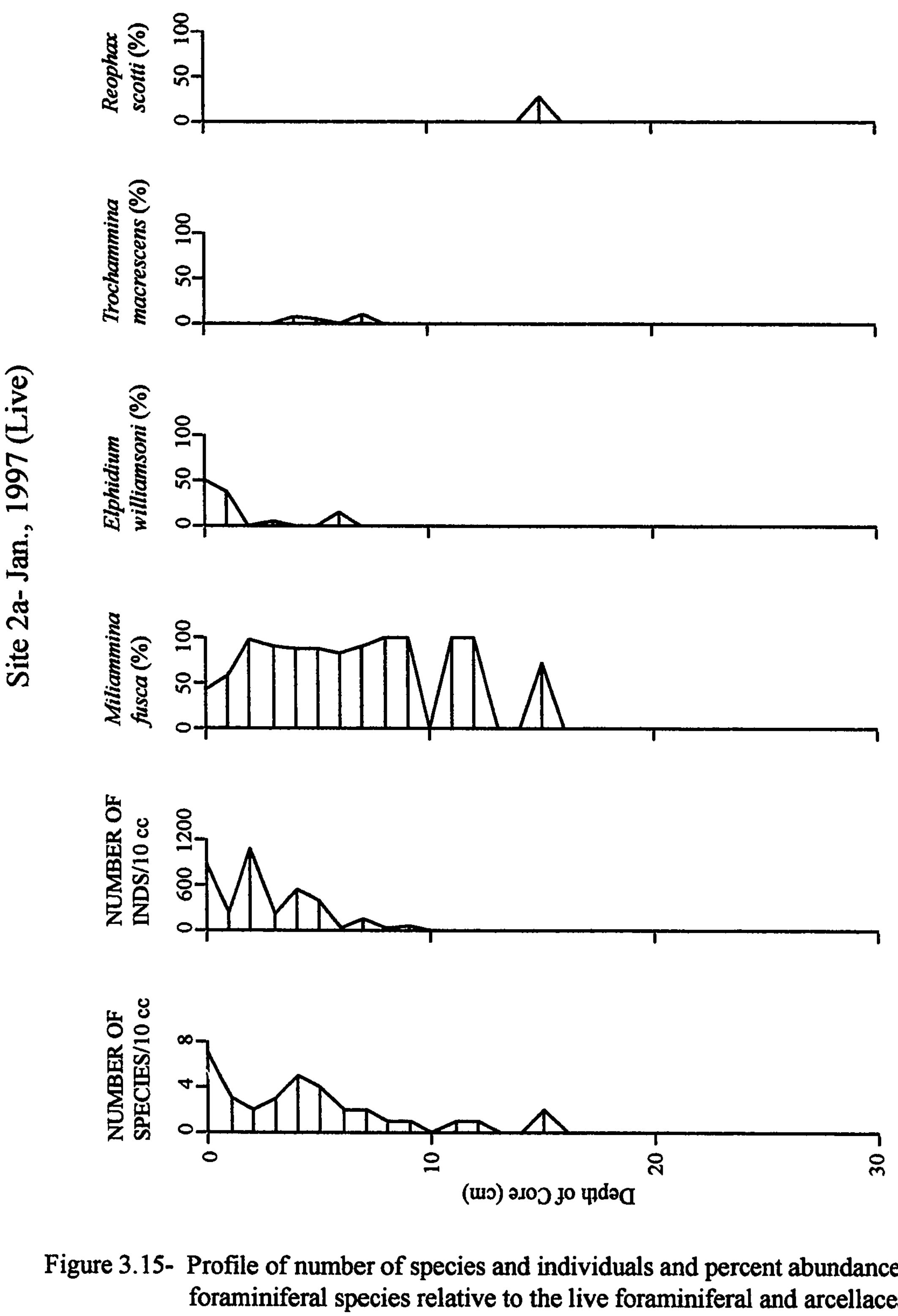


Figure 3.15- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 2a, Chezzettcook.

occurred at 1-2 cm. Three specimens of *Reophax scotti*, a rare species in this marsh, were found to be living at interval 15-16 cm while living *Haplophragmoides manilaensis* were identified between 3- 6 cm.

3.1.1.3 Site 2b (Station 3e from Scott and Medioli (1980a,b))

3.1.1.3a June 1997 Collection

Total: Numbers ranged from 368 to 8752 inds/10 cm^3 for the 30 samples examined at 1 cm intervals down the core, with peak values occurring between 14- 22 cm (Appendix Table 9; Figure 3.16). Both *Miliammina fusca* and *Trochammina ochracea* co-dominated the assemblage from 0- 7 cm with *Trochammina ochracea* steadily decreasing down core (0.3 to 10.2 %) below this interval. *Miliammina fusca* strongly dominated the assemblage from 7-29 cm (72.4 to 95.8 %) remaining relatively constant throughout this interval. Low percentages of *Trochammina macrescens* forma *macrescens* were present throughout and relatively constant (2-5.2 %), with peak values occurring between 2-4 cm. Organic linings were identified throughout the core (0.9 to 30.4 %), with highest values occurring between 0- 6 cm. There were low percentages of *Ammobaculites dilatatus* and *Eggerella advena* throughout the core; *Eggerella advena* showed little variation in numbers (0.1 to 5.7 %) with peak values at 3- 6 cm.

Living: Specimens were identified to the 10-11 cm interval and abundances ranged from 4 to 312 inds/10 cm^3 with highest numbers occurring between 1-4 cm and 7-9 cm

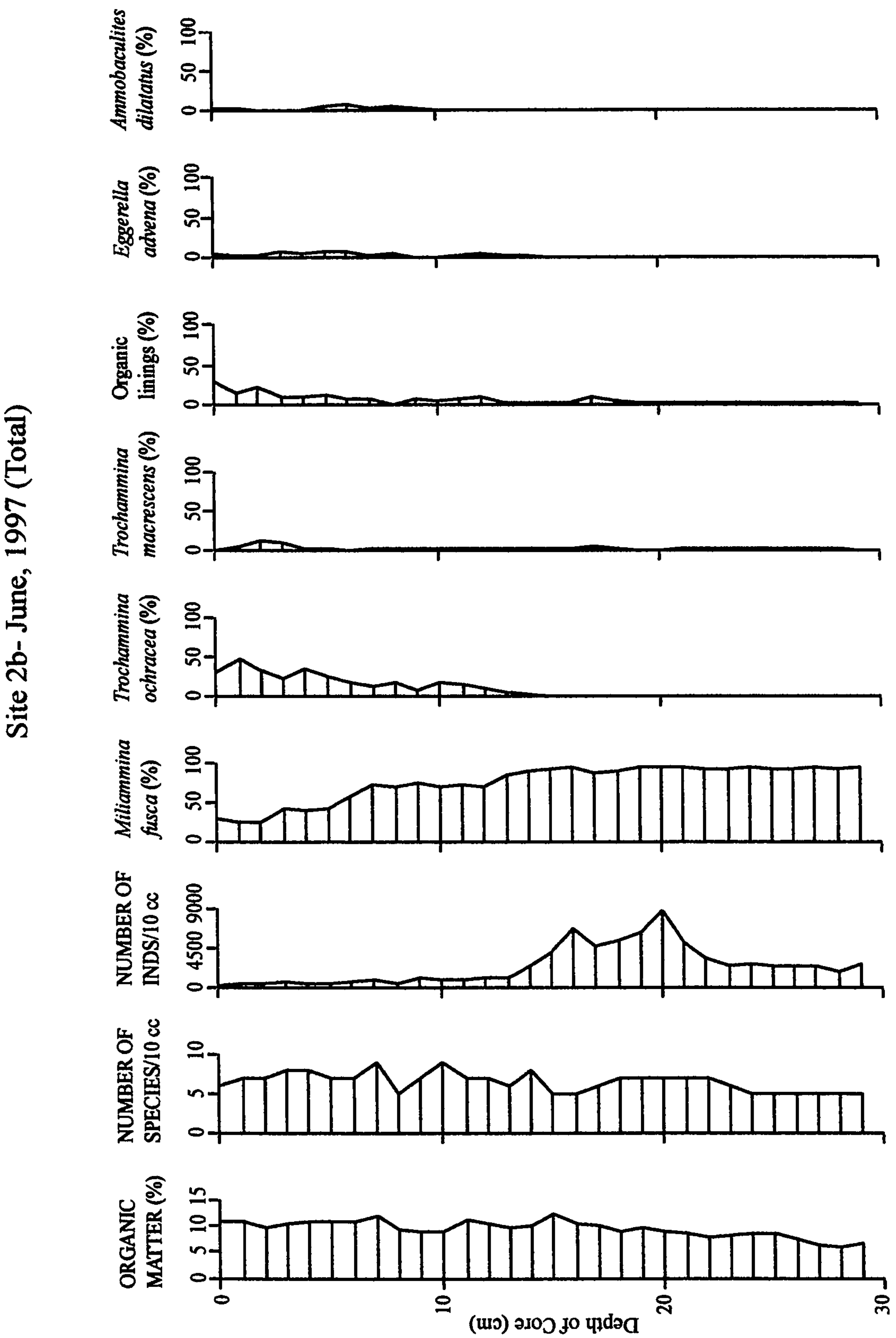


Figure 3.16- Profile of organic matter, number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 2b, Chezzettcook.

(Appendix Table 9; Figure 3.17). *Miliammina fusca* dominated the assemblage at 0-1 cm and 5-10 cm (87.5 to 100 %) while *Trochammina ochracea* dominated from 1-3 cm (51.6 to 64.5 %) and co-dominated with *Miliammina fusca* at intervals 3-5 cm. Low percentages of *Ammobaculites dilatatus* were identified at intervals 1- 2 cm, 3-4 cm, and 8- 9 cm (2.6 to 9.3 %) while moderate percentages of *Trochammina macrescens* forma *macrescens* were present between 2- 5 cm (10.3 to 12.9 %) and at interval 7- 8 cm (6.6%). Specimens of *Elphidium williamsoni* were identified down to 3 cm with a peak value of 12.5 % occurring at the surface (0-1 cm). 8 specimens of *Reophax scotti* were found to be living at interval 4- 5 cm.

3.1.1.3b September 1997 Collection

Total: Numbers ranged from 264 to 3672 inds/10 cm^3 for the 26 samples examined at 1 cm intervals down the core, with highest numbers occurring in the middle of the core (Appendix Table 10; Figure 3.18). *Miliammina fusca* strongly dominated the assemblage from 1-25 cm (52.7 to 92.8 %) but co-dominated with *Trochammina ochracea* at the surface. Moderate percentages of *Trochammina ochracea* occurred throughout the entire core (2.6 - 14.7 %), with peak values occurring between 0-2 cm (23.4 to 30.3 %), 9- 10 cm (17.3 %), and 18- 20 cm (21.4 to 23.5 %). Low percentages of *Trochammina macrescens* forma *macrescens* were present throughout the entire core remaining relatively constant (1.1 to 10.3 %) as did *Eggerella advena* (0.2 to 6.8 %) and

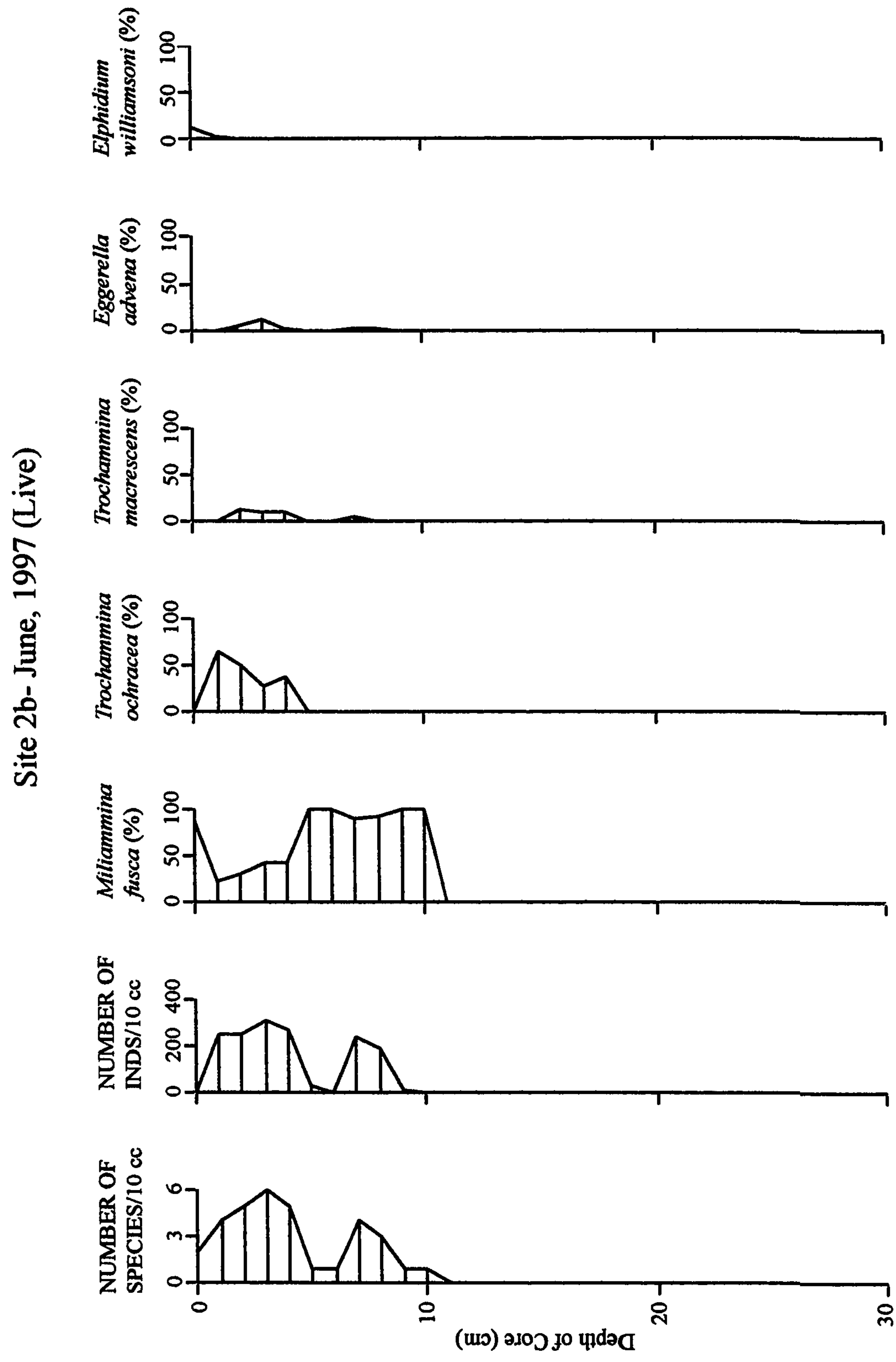


Figure 3.17- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 2b, Chezzettcook.

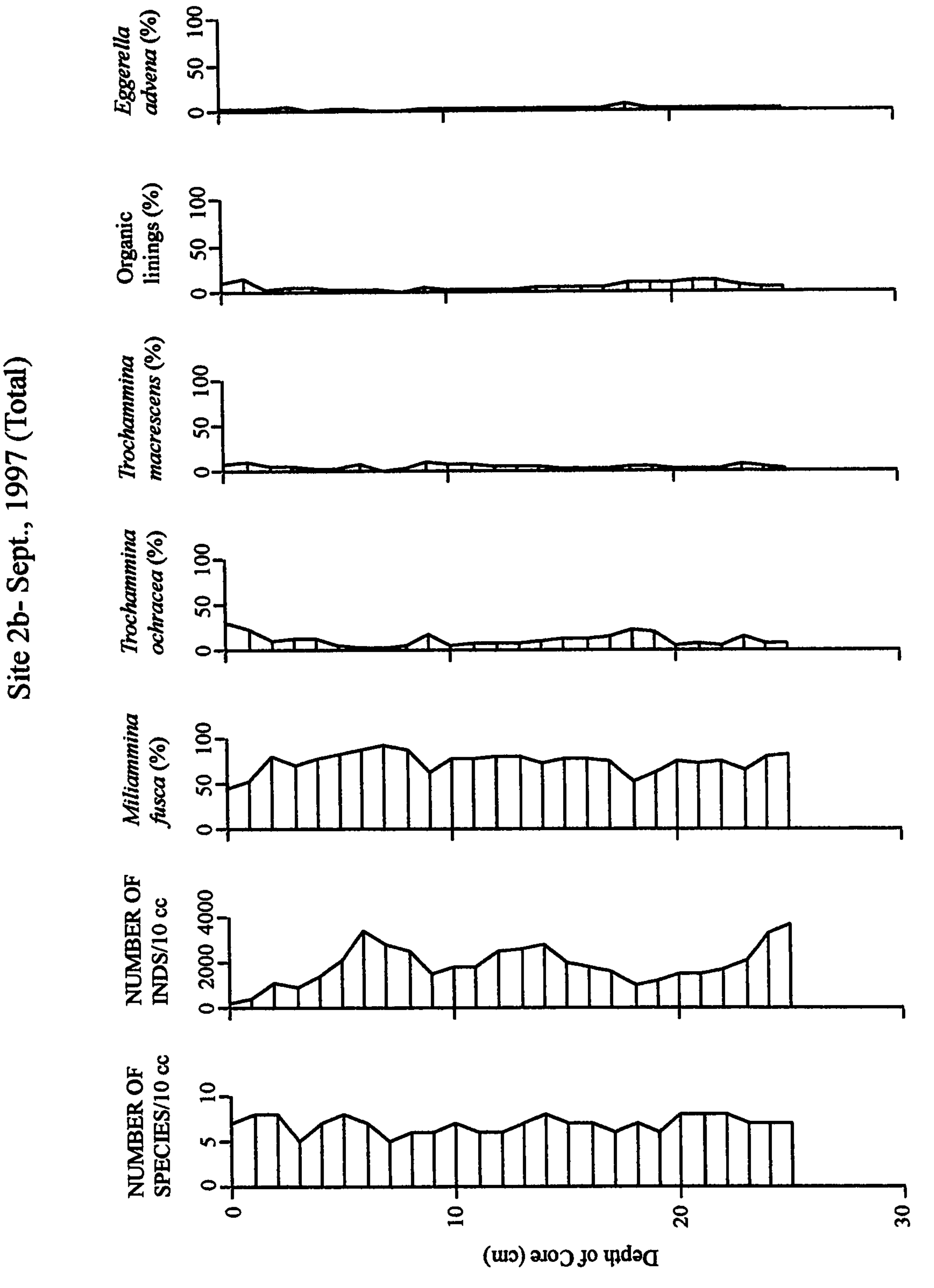


Figure 3.18- Profile of number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and assemblage in sediments from Site 2b, Chezzettcook.

Ammobaculites dilatatus (0.2 to 4.4 %). Organic linings were present throughout the entire core in moderate percentages (0.3 to 13.7 %).

Living: Specimens were identified down to the 10-11 cm interval and abundances ranged from 3 to 1200 inds/10 cm^3 with peak values occurring between 5-7 cm (Appendix Table 10; Figure 3.19). *Miliammina fusca* dominated the assemblage between 1-8 cm and 10-11cm. 3 specimens of *Elphidium williamsoni* were identified at the surface which comprised the entire assemblage, however, this species disappeared below the surface. Specimens of *Trochammina macrescens* forma *macrescens* were identified down to 10 cm (1.9 to 17.5 %), with peak values occurring between 9-11 cm (28.6 to 30.8 %). At the 1-2 cm interval, *Trochammina ochracea* co-dominated the assemblage (34.5 %) and at the 9-10 cm interval (46.2 %) with low percentages occurring between these intervals (1.9 to 6.2 %). Low percentages of *Eggerella advena* (1.3 to 2.5 %) occurred from 2-6 cm while 8 specimens of *Ammobaculites dilatatus* were present at 1-2 cm and 16 specimens were identified at the 5-6 cm interval.

3.1.1.3c Statistical Analysis

The relative percentages of the four most abundant species from site 2a and 2b were plotted versus the average relative percentages of the same species from the interval 1- 10 cm (Figure 3.20). There is considerably more variability in these sets of cores than the previous site as seen by the large standard deviations as well as the variability of the

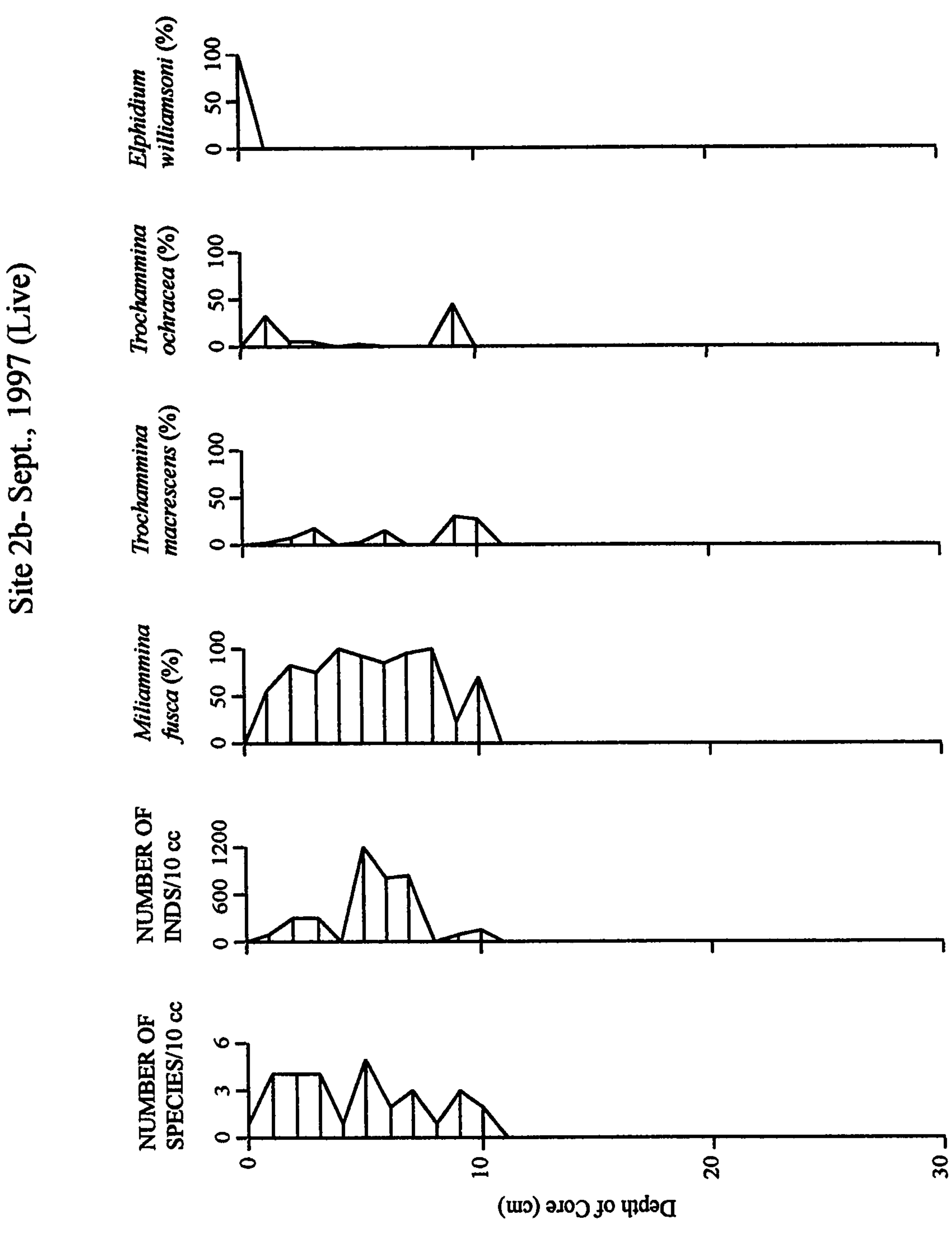


Figure 3.19- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 2b, Chezzettcook.

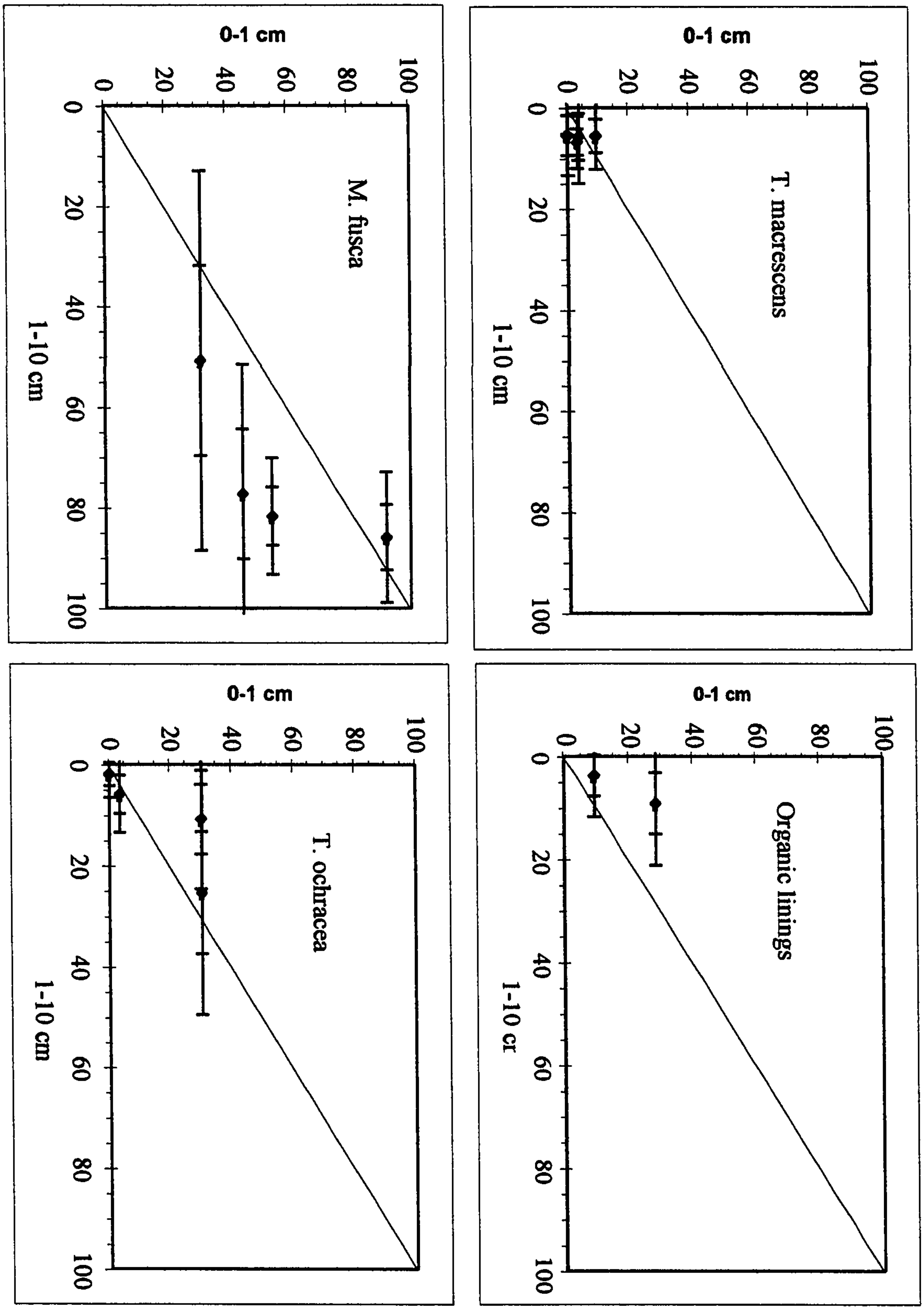


Figure 3.20- 1:1 plots of the four most abundant species from site 2a and 2b comparing the relative percentages at the surface (0-1 cm) and the average from 1- 10 cm. Vertical bars represent 1 and 2 standard deviations.

dominant species (i.e. *M. fusca* plots). Some points fall within one standard deviation but most fall on the line within two standard deviations. There are some that do not plot on the line suggesting substantial variability however when these plots are coupled with the foraminiferal plots from this site, the dominant species appear to co-vary. Total numbers vary throughout the core which also is responsible for the variations in assemblages from the surface and in the subsurface. Overall, the trend is relatively consistent and indicative of mudflat or transitional marsh assemblages. As a result,the surface interval does provide an adequate representation of conditions occurring at the time of deposition.

3.1.1.4 Site 3 (Station 7d from Scott and Medioli (1980a,b))

The three cores that were collected at this site exhibited high diversity but relatively low abundance with the exception of the October 1996 core which showed both a high abundance and high diversity. Organic matter percentages were lower here than at the other three sites ranging from 4- 17% with highest numbers occurring in the top half and steadily decreasing down core. All three cores consisted of dark grey mud with some roots in the lower half of the core.

3.1.1.4a October 1996 Collection

<u>Total</u>: Numbers ranged from 601 to 4448 inds/10 cm^3 for the 30 samples examined at 1 cm intervals down the core (Appendix Table 11; Figure 3.21). *Miliammina fusca* strongly

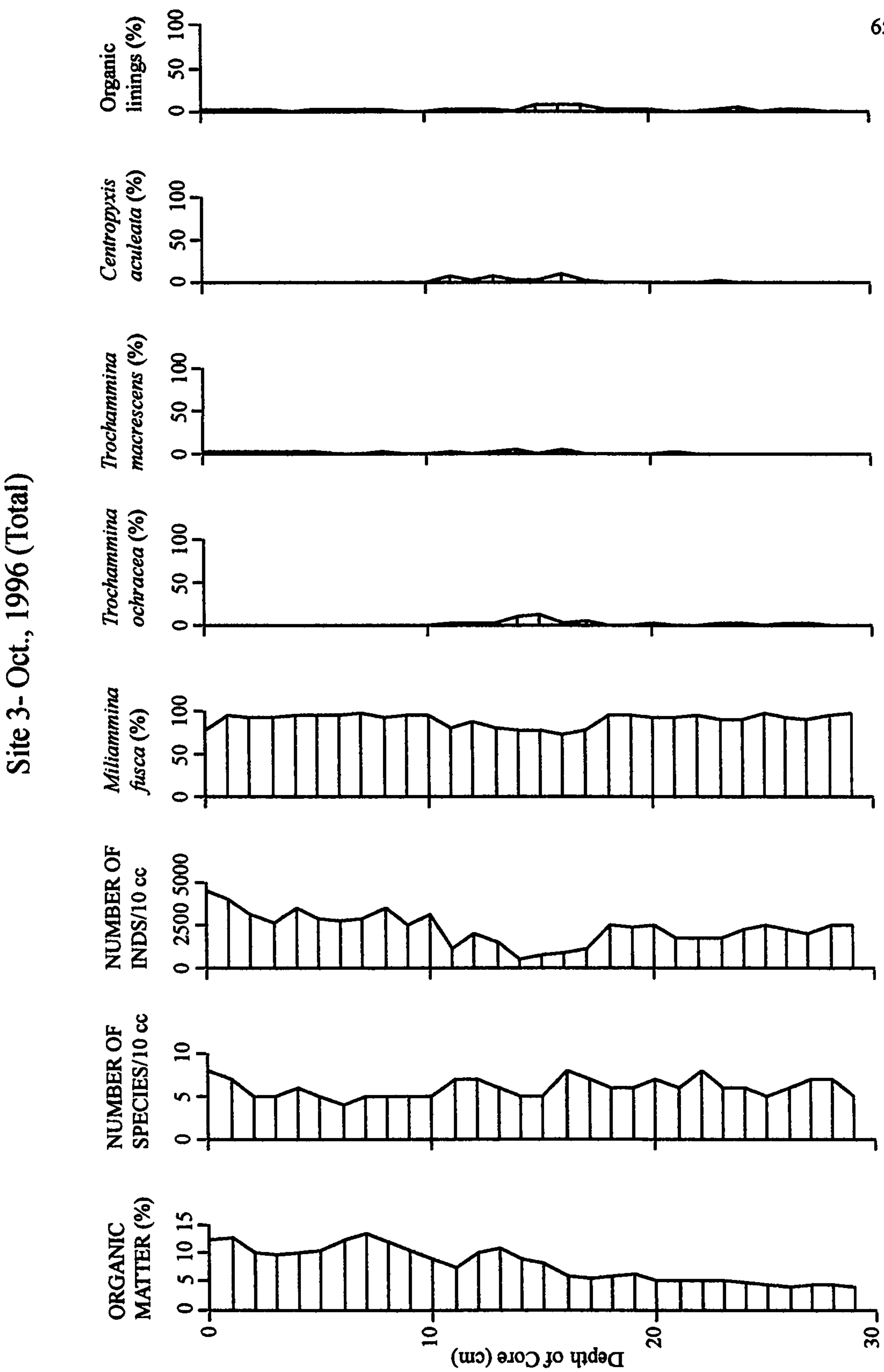


Figure 3.21- Profile of number of species and individuals and percent abundance of some arcellacean and foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 3, Chezzettcook.

dominated the assemblage remaining relatively constant down core except between interval 11 - 17 cm (72.6 to 97.8 %). Very low percentages of *Trochammina ochracea* (0.2 to 13.2 %), *Trochammina macrescens* forma *polystoma* (0.3 to 6.7 %), and organic linings (0.3 to 7. 3 %) existed throughout the entire core with peaks occurring between 11-17 cm. Small percentages of *Centropyxis aculeata*, an arcellacean, were also identified within the same interval. Specimens of *Elphidium williamsoni* were present in the top 2 cm and disappeared down core. Another calcareous species, *Helenina anderseni*, was also identified at the surface and again, disappeared downcore.

Living: Specimens were identified to the 10- 11 cm interval and abundances ranged from 16 to 856 inds/ 10 cm^3 with only 4 different species of foraminifera found living (Appendix Table 11; Figure 3.22). Highest numbers of individuals occurred at the surface and significantly decreased downcore. *Miliammina fusca* dominated the assemblage throughout the core (76.5 to 100 %) except at the surface where *Elphidium williamsoni* dominated (72 %) and at the 1-2 cm interval where it co-dominated with *Elphidium williamsoni* (42.9 %). There was no occurrence of any living calcareous species below this interval. There were moderate percentages of *Trochammina macrescens* forma *polystoma* occurring at intervals 0-1 cm, 2- 3 cm, and 4- 5 cm (9.3 to 20 %). 8 specimens of *Helenina anderseni* were identified only at the surface (0- 1 cm).

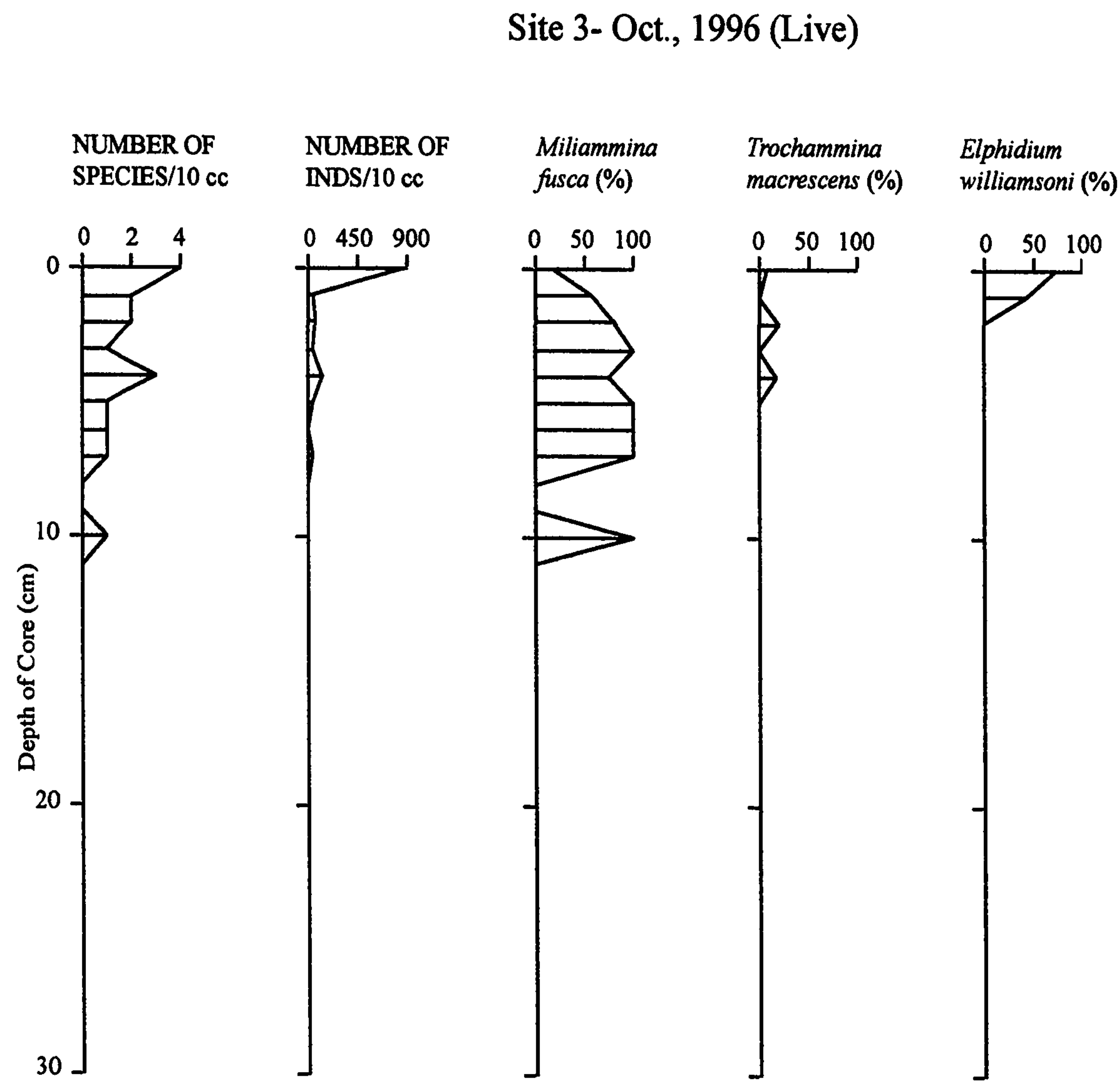


Figure 3.22- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal and arcellacean assemblage in sediments from Site 3, Chezzettcook.

3.1.1.4b June 1997 Collection

Total: Numbers were highly variable throughout and ranged from 280 to 3256 inds/10 cm^3 for the 30 samples examined at 1 cm intervals down the core (Appendix Table 12; Figure 3.23). *Miliammina fusca* dominated the assemblage down to 23 cm (49.2 to 96.3 %). At the interval 23-24 cm, the assemblage is co-dominated by *Miliammina fusca* (43.3 %) and organic linings (31.1 %) while between 24- 28 cm, the core is co-dominated by *Miliammina fusca* and *Trochammina ochracea* and the final 2 cm of the core is dominated by *Trochammina ochracea* (40 to 41.9 %). Moderate percentages of organic linings (2.8 to 10.6 %) occurred throughout the core with peak values occurring at 0-3 cm (15.5 to 21.9 %) and 23- 30 cm (12.5 to 31.1 %). Low percentages of *Trochammina ochracea* were present throughout the core (0 to 5.5 %), with peak values occurring between 0-3 cm (14.8 to 19.9 %) and 23- 30 cm (11.1 to 47.4 %). Very low percentages of *Trochammina macrescens* forma *polystoma* occurred throughout the entire core (0 to 4.5 %) except at peak values which again occurred between 23- 30 cm (5 to 14.4 %). The peak values for these faunal changes corresponded to low numbers of individuals. Low percentages of *Ammobaculites dilatatus* were identified down to 9 cm (0.5 to 8 %).

Living: Specimens were identified down to the 14- 15 cm interval and abundances ranged from 32 to 584 inds/10 cm^3 and were highly variable throughout this interval (Appendix Table 12; Figure 3.24). *Miliammina fusca* dominated the assemblage throughout the core (68.3 to 100 %) except at the surface where it co-dominated with *Trochammina ochracea*

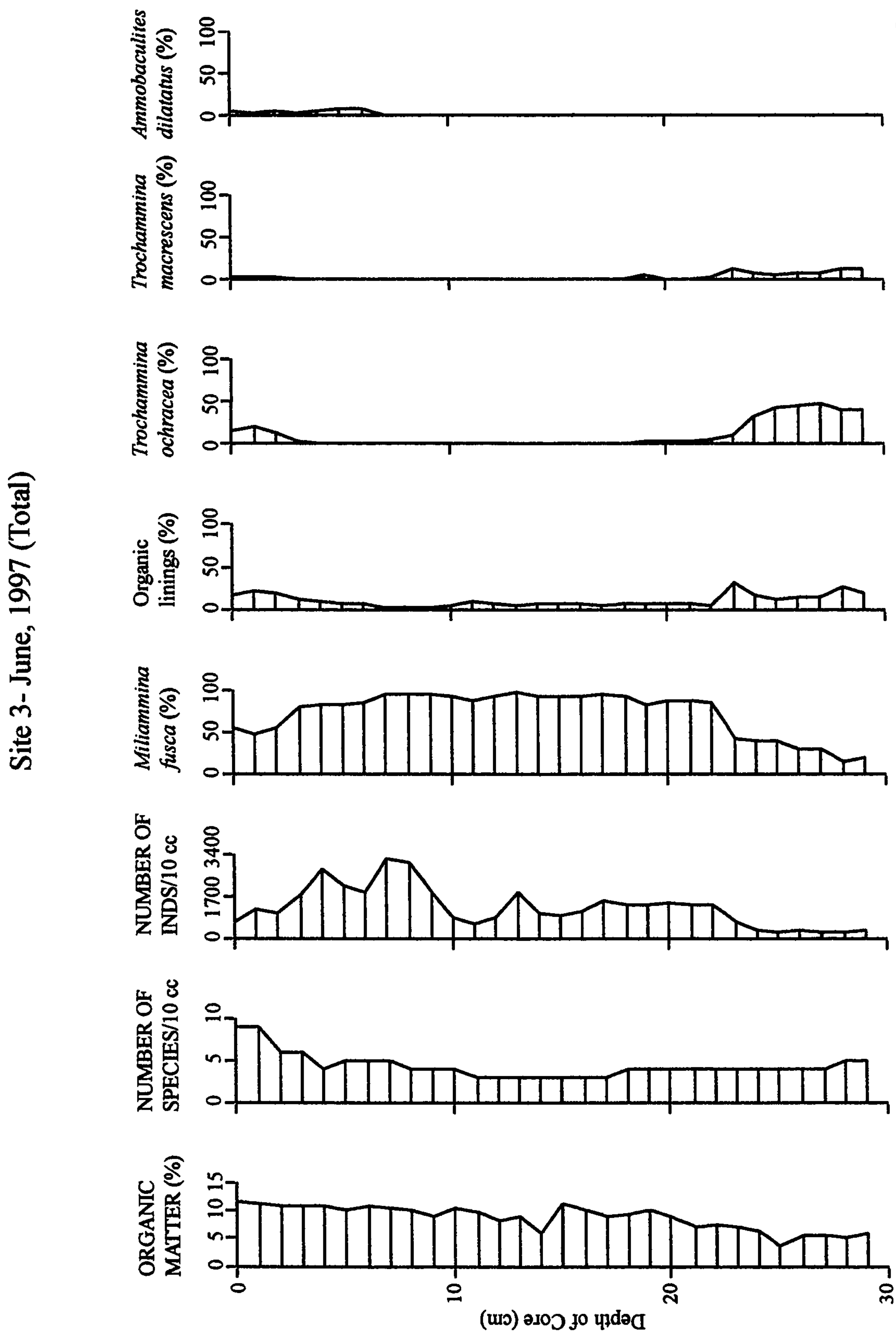


Figure 3.23- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal and arcellacean assemblage in sediments from Site 3, Chezzettcook.

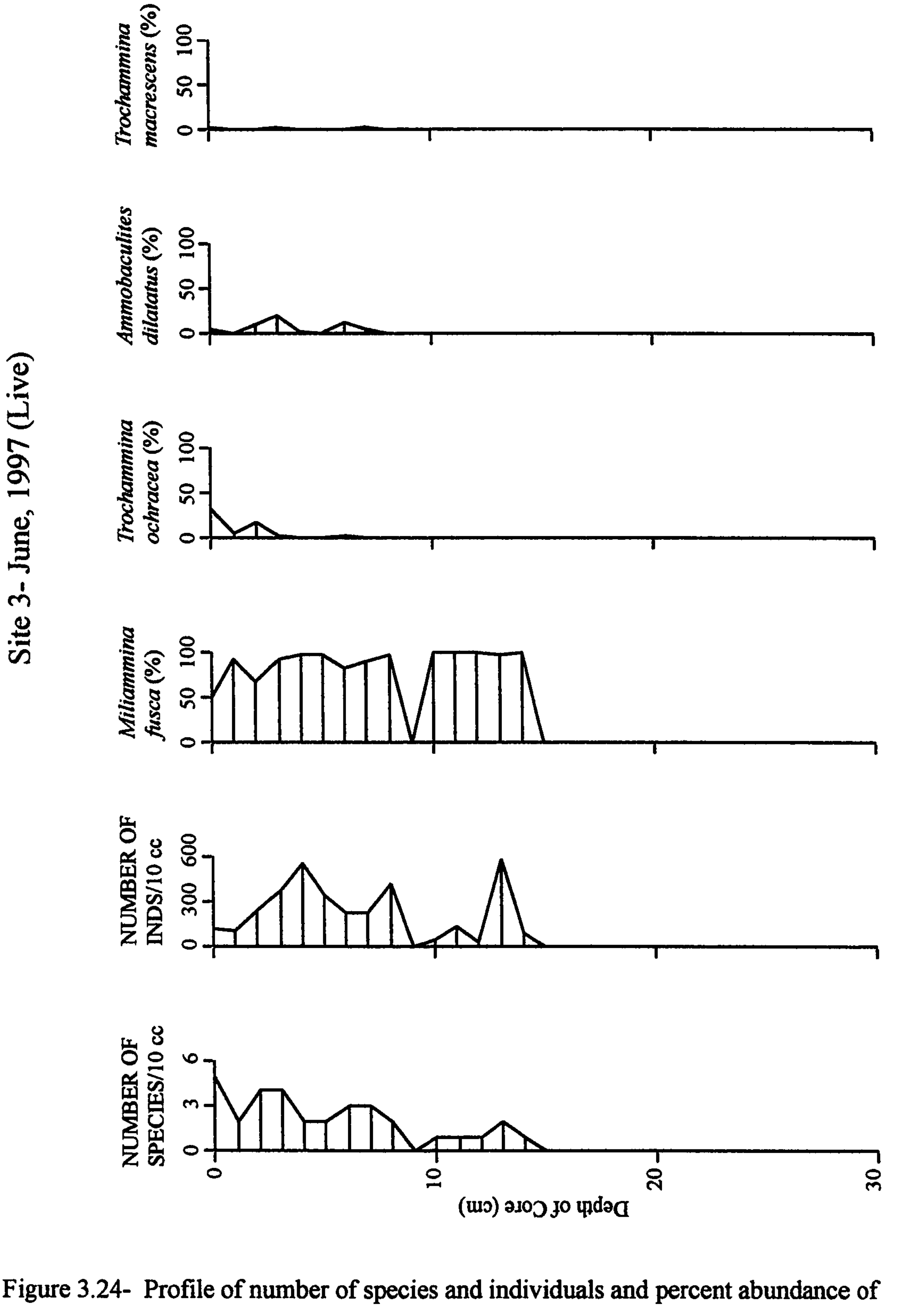


Figure 3.24- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal assemblage in sediments from Site 3, Chezzettcook.

(32.3 %). Very low percentages of *Trochammina ochracea* were identified down to the 8- 9 cm interval (0- 3.4 %), with peak values occurring in the upper 2 cm (7.1 to 32.3 %). Moderate percentages of *Ammobaculites dilatatus* were found down to the 7- 8 cm interval (2.3 to 21 %) and low percentages of *Trochammina macrescens* forma *polystoma* were also identified down to the 7- 8 cm interval (0 to 3.6 %). 8 specimens of *Elphidium williamsoni* were counted only at the surface.

3.1.1.4c September 1997 Collection

Total: Numbers ranged from 296 to 2216 inds/10 cm^3 for the 30 samples examined at 1 cm intervals down the core (Appendix Table 13; Figure 3.25), with peak values occurring within the middle of the core. This core was very similar to the previous core as *Miliammina fusca* dominated the assemblage down to 22 cm (52 to 94.5 %). The assemblage is co-dominated by *Miliammina fusca*, *Trochammina ochracea*, and organic linings in the upper 2 cm and is co-dominated by *Miliammina fusca* and *Trochammina ochracea* between 22-24 cm. The assemblage changed below 24 cm and was dominated by *Trochammina ochracea* (45.9 to 56.1 %). Low percentages of organic linings (1.3 to 12 %) occurred throughout the core with peak values at 0-2 cm (15.9 to 30.8 %) and 26-27 cm (19 %). Moderate percentages of *Trochammina ochracea* were present throughout the core (1.4 to 8.8 %), with peak values occurring between 0- 10 cm (11.8 to 19.9 %) and 22- 30 cm (32.8 to 54.4 %). There were also very low percentages of *Trochammina*

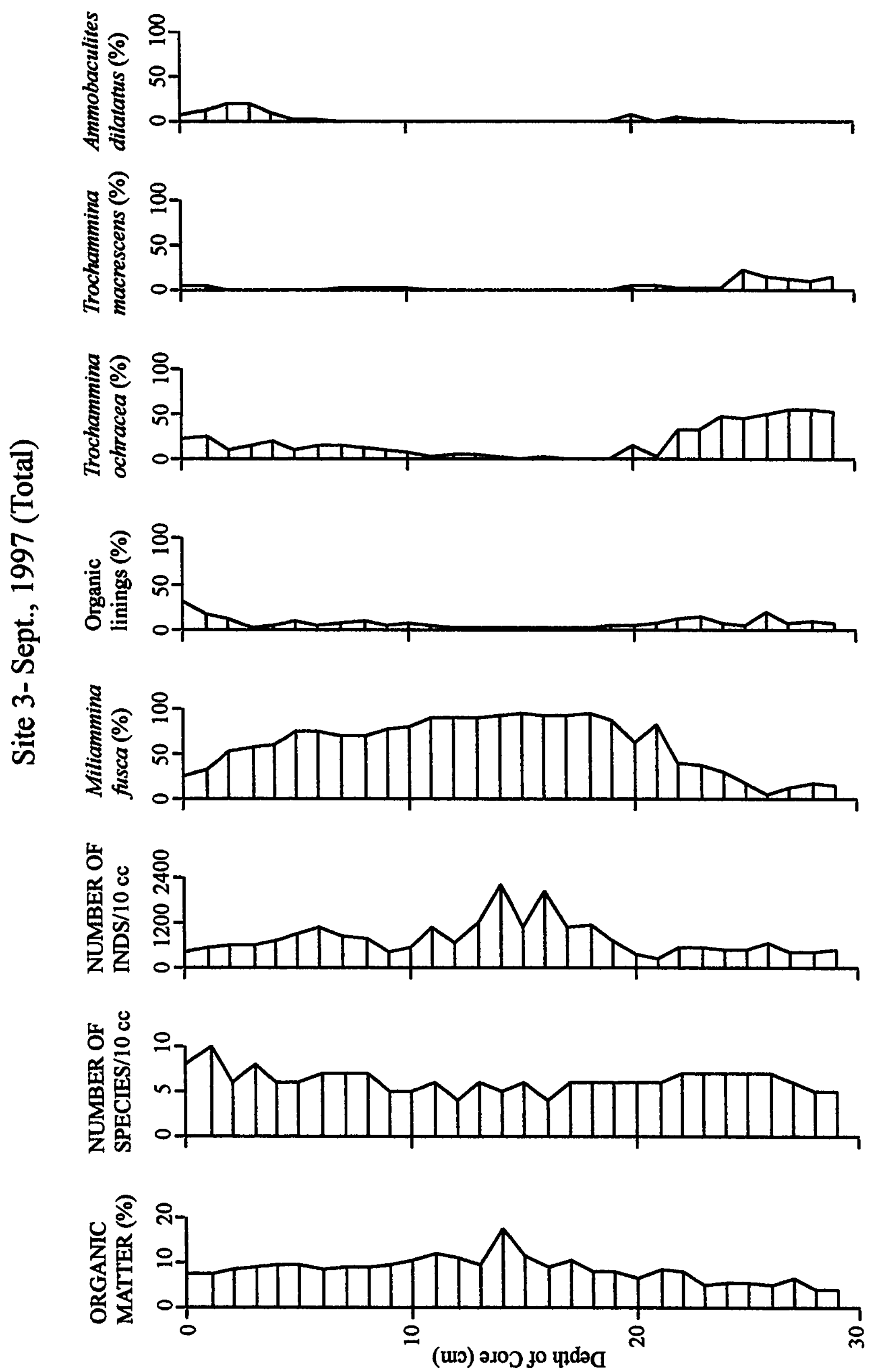


Figure 3.25- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Site 3, Chezzettcook.

macrescens forma *polystoma* existing throughout the entire core (0 to 7.2 %) except at peak values which occurred between 25- 30 cm (10.5 to 23 %). The peak values for these faunal changes corresponded to low numbers of individuals. Low percentages of *Ammobaculites dilatatus* were identified throughout the core (0 to 8.2 %) with peak values occurring from 0- 5 cm (9.6 to 20.7 %).

Living: Percentages of species were highly variable and were identified to the 12- 13 cm interval with low abundances ranging from 0 to 36 inds/10 cm^3 (Appendix Table 13; Figure 3.26). *Miliammina fusca* dominated the assemblage at interval 4- 5cm (66.7 %) and from 7- 13 cm (100 %). The assemblage was co-dominated at the surface (0- 1cm) by *Ammobaculites dilatatus*, *Miliammina fusca*, and *Trochammina ochracea*. At the interval 1- 2 cm, 5 specimens each of *Ammobaculites dilatatus*, *Eggerella advena*, *Elphidium williamsoni*, *Miliammina fusca*, *Trochammina macrescens* forma *polystoma*, and *Trochammina ochracea* were identified. *Elphidium williamsoni* dominated between 2- 4 cm (100 %) and were absent below this interval.

3.1.1.4d Statistical Analysis

The 1:1 plot from site 3 with the three most dominant species were slightly less variable than site 2a and 2b but there was still some variability especially with the dominant species *M. fusca* (Appendix Table 22a-c; Figure 3.27). The variability of the surface to the subsurface is attributed to the emergence of calcareous species at the

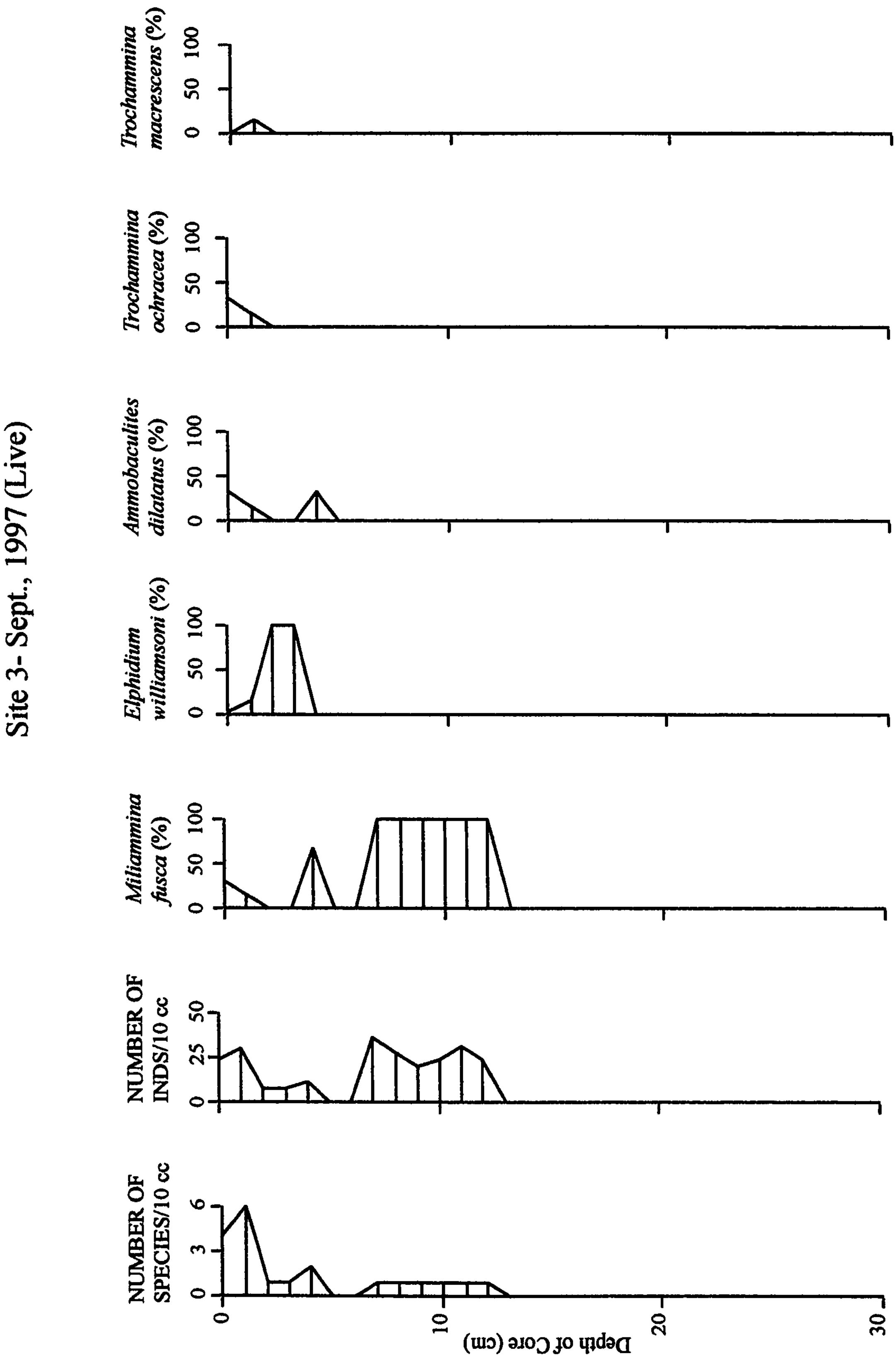
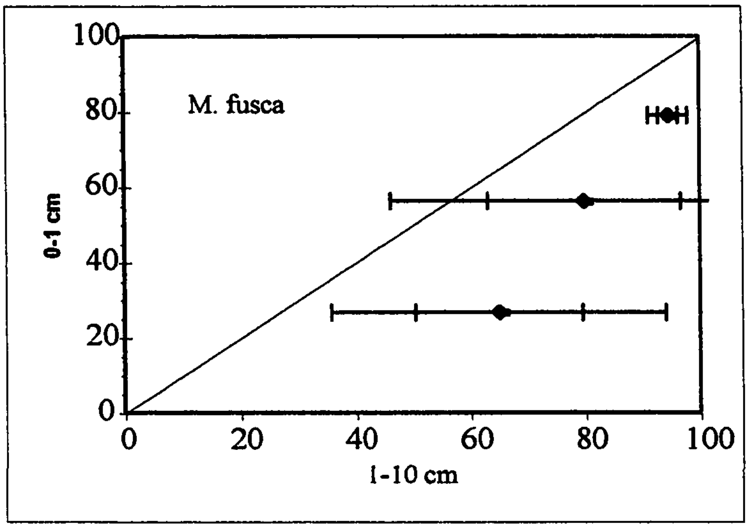
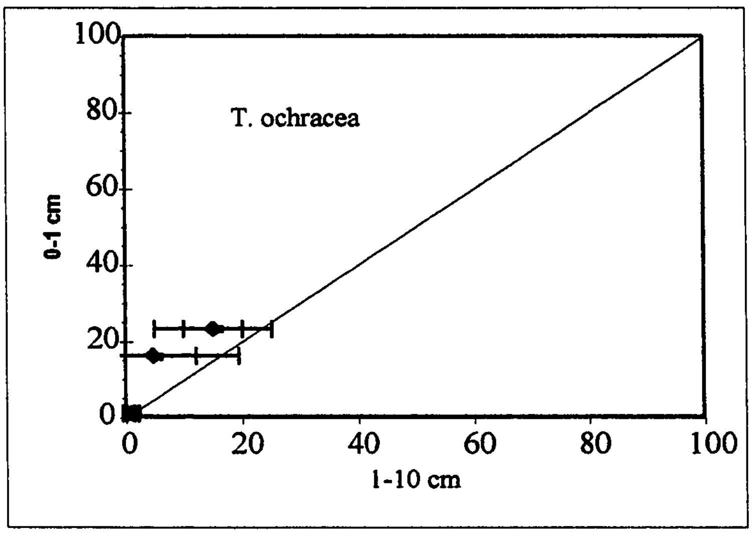


Figure 3.26- Profile of number of species and individuals and percent abundance of foraminiferal species relative to the live foraminiferal assemblage in sediments from Site 3, Chezzettcook.





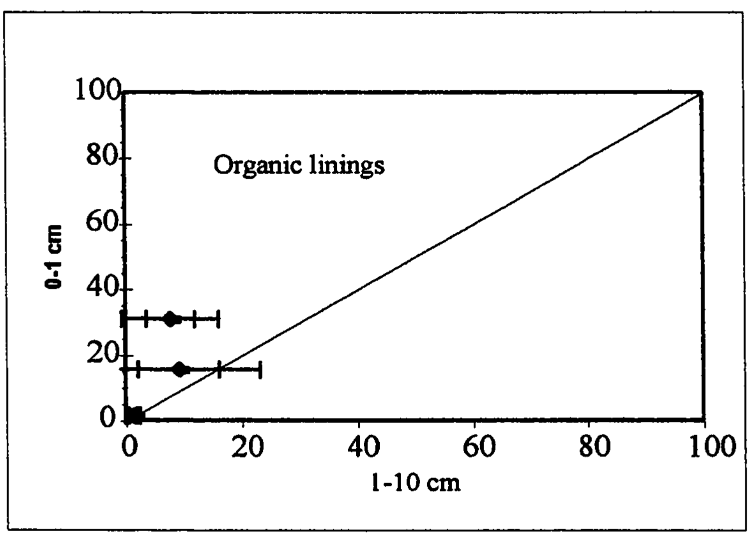


Figure 3.27- 1:1 plots of the three most abundant species from site 3 comparing the relative percentages at the surface (0-1 cm) and the average from 1- 10 cm. Vertical bars represent 1 and 2 standard deviations.

surface than disappearing below this interval due to lowered ph conditions (resulting in organic linings) as well as the presence of *T. ochracea* at the surface in moderate to high percentages and the variability of total individuals. As a result, the relative perecentage of *M. fusca* is quite variable for all three cores. However, if these factors are taken into account, the foraminiferal assemblage from the surface aliquot still provides an adequate representation of environmental conditions occurring at the time of deposition.

3.2 Nanaimo Short Cores (from Ozarko et al., 1997)

3.2.1 Quantitative Analysis

3.2.1.1 Site 1

All four cores (Figure 3.28a and b) exhibited similar foraminiferal trends with *Miliammina fusca* generally dominating the total assemblage with moderate percentages of *Haplophragmoides wilberti*, *Trochammina inflata*, and *Jadammina* (*Trochammina* here) *macrescens*. The living assemblage was variable in all four cores with specimens living down to 30 cm. These following diagrams differ from Ozarko et al. (1997) because they are graphical representations of the actual data, not of statistically generated clusters.

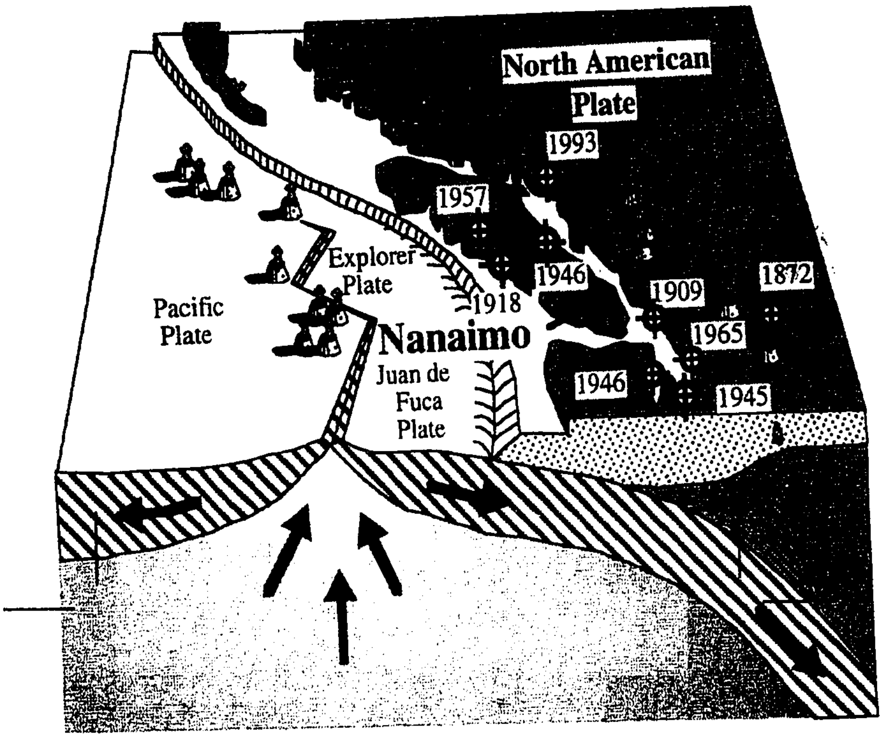


Figure 3.28a- Tectonic setting of Nanaimo, British Columbia. (Modified after Ozarko et al., 1997).

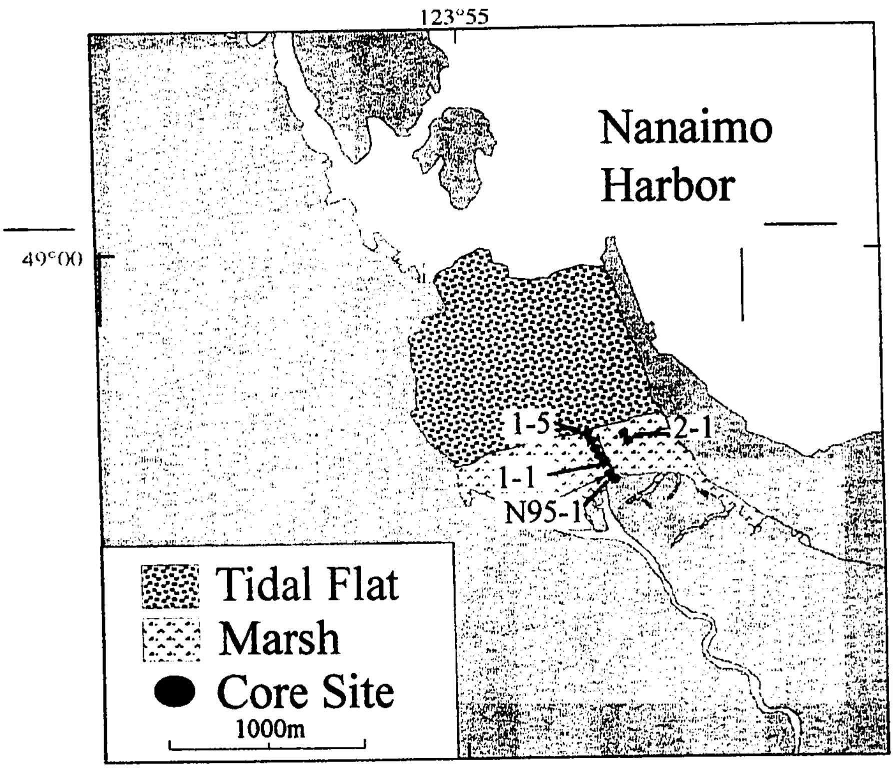


Figure 3.28b- Location map of cores (1-1 to 1-5; 2-1, 2-2, N95-1, and N95). (Modified after Ozarko et al., 1997).

3.2.1.1a Core 1-1

Total: Numbers ranged from 131 to 376 inds/cm^3 for the 23 samples examined at selected intervals down the core, with highest numbers occurring in the upper two thirds of the core (Figure 3.29). **Note: Numbers of individuals for these cores are plotted using 1 cm^3 and not 10 cm^3**. *Miliammina fusca* dominated the assemblage at intervals 0- 5 cm (50.1 to 85.8 %) and from 10- 14.5 cm (60- 70.5 %). *M. fusca* co-dominated the assemblage with *Haplophragmoides wilberti* from 6- 9 cm (29.8- 32.9%) as well as co-dominating with both *Trochammina inflata* and *H. wilberti* from 19cm to the bottom of the core. Moderate percentages of *Jadammina macrescens* occurred throughout the entire core (3.5 – 28.3 %), with peak values occurring in the bottom few centimeters where total numbers were lowest. *T. inflata* occurred in moderate percentages in the upper half of the core (4- 24.2 %).

Living: Percentages were variable and specimens were identified throughout the entire core with numbers ranging from 2 to 127 inds/cm^3 with peak values occurring in the upper two centimeters with persistent occurrences found through the upper two thirds of the core that steadily decreased down core (Figure 3.30). *Miliammina fusca* dominated the assemblage in the upper two centimeters (84.2- 85 %) and had moderate percentages throughout the rest of the core. *Trochammina inflata* and *H. wilberti* co-dominated the assemblage except between 17.5- 20.5 cm where the assemblage was dominated by *T. inflata* (58.1- 91.4 %). Moderate percentages of *J. macrescens* occurred throughout the

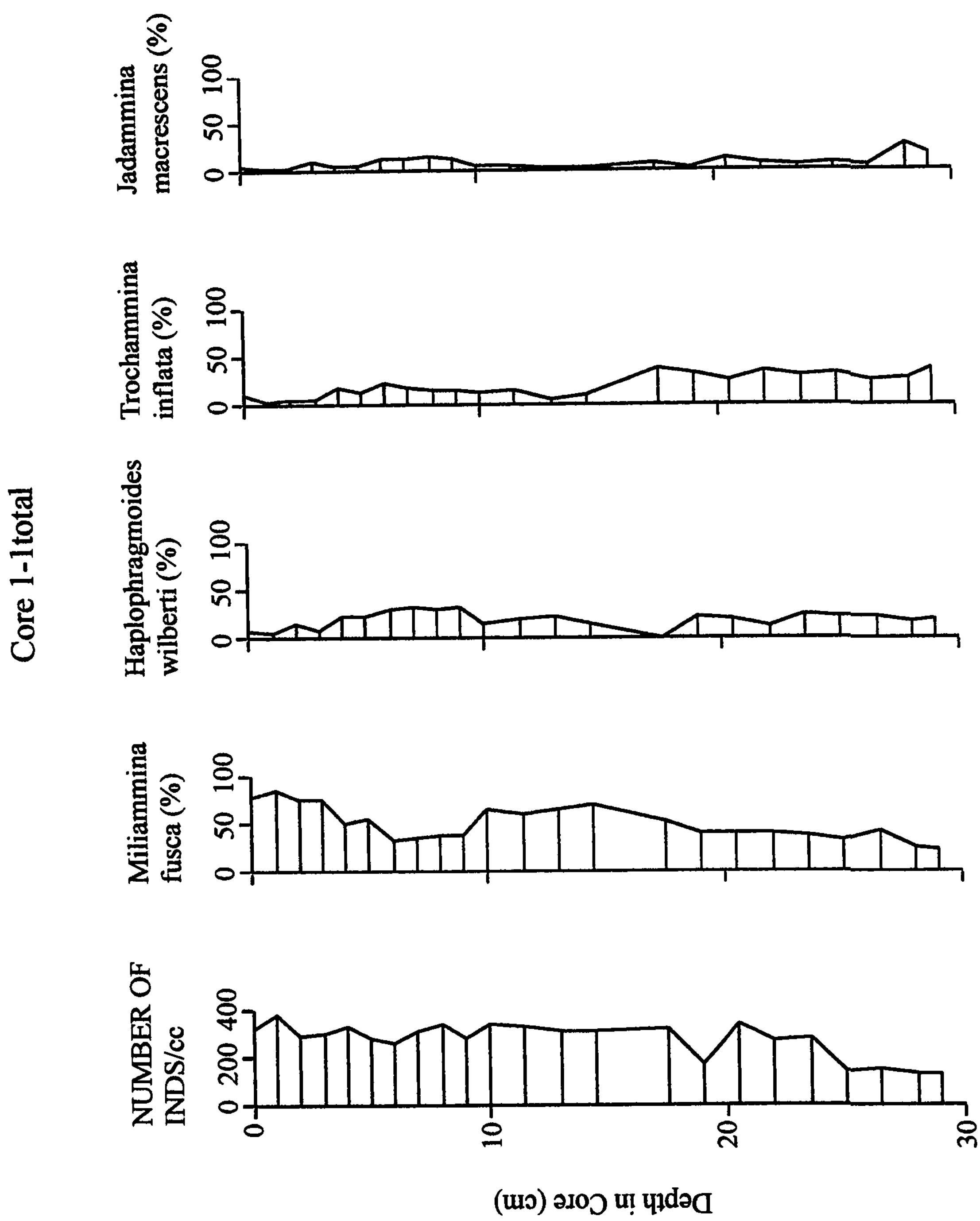


Figure 3.29- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1-1, Nanaimo.

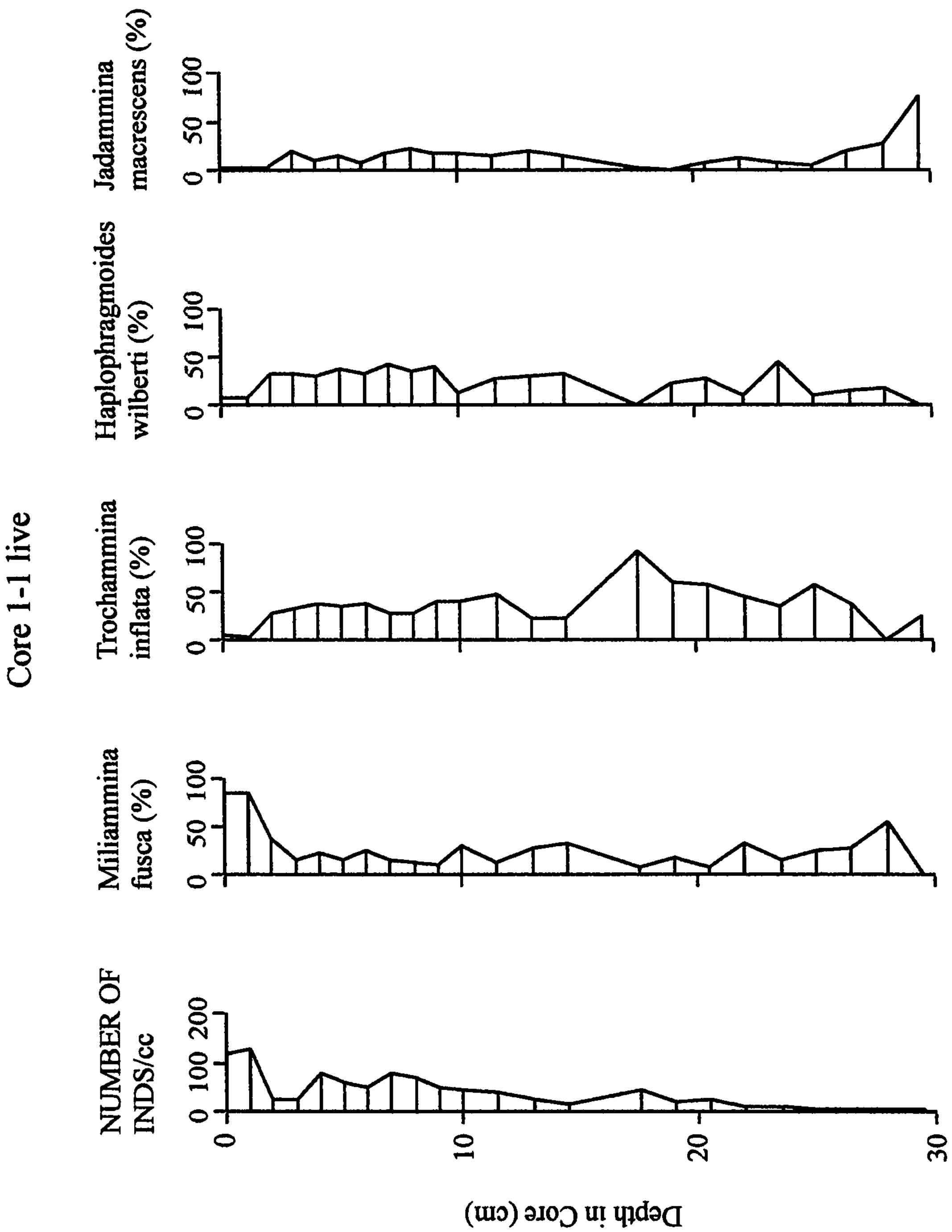


Figure 3.30- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 1-1, Nanaimo.

core (1.4- 18.8 %) with a peak value of 75.6 % occurring at the bottom of the core where numbers were lowest.

3.2.1.1b Core 1-2

Total: Numbers ranged from 66 to 339 inds/cm^3 for the 20 samples examined at selected intervals down the core, with highest numbers occurring in the upper two thirds of the core (Figure 3.31). *Miliammina fusca* dominated the assemblage down to 20.5 cm (55.4- 80.5 %) and co-dominated with *Trochammina inflata* (34.9- 52.6 %) from 22 cm down to the bottom of the core (18.1- 43.5%). Moderate percentages of *Jadammina macrescens* (2.1- 10%) and *Haplophragmoides wilberti* (5.6- 23.9 %) occurred throughout the entire core (3.5 – 28.3 %) remaining relatively constant. *T. inflata* occurred in moderate percentages in the upper half of the core (5.9- 17.4 %).

Living: Percentages were variable and specimens were identified throughout the entire core with numbers ranging from 1 to 89 inds/cm^3 with peak values occurring in the upper three centimeters with persistent occurrences through the upper two thirds of the core that steadily decreased down core (Figure 3.32). *Trochammina inflata* dominated the assemblage from 8- 23.5 cm (52.9- 84.5 %). From 0- 4 cm, the assemblage was co-dominated by *T. inflata* (29.6- 38.4 %) and *Miliammina fusca* (31.5- 53.3 %). From 5- 7 cm, the assemblage was co-dominated by *T. inflata* (36.6- 46.1 %) and *Haplophragmoides wilberti* (31.3- 38.4 %). Moderate to high percentages of *M. fusca* (2.9- 9.2 %) occurred

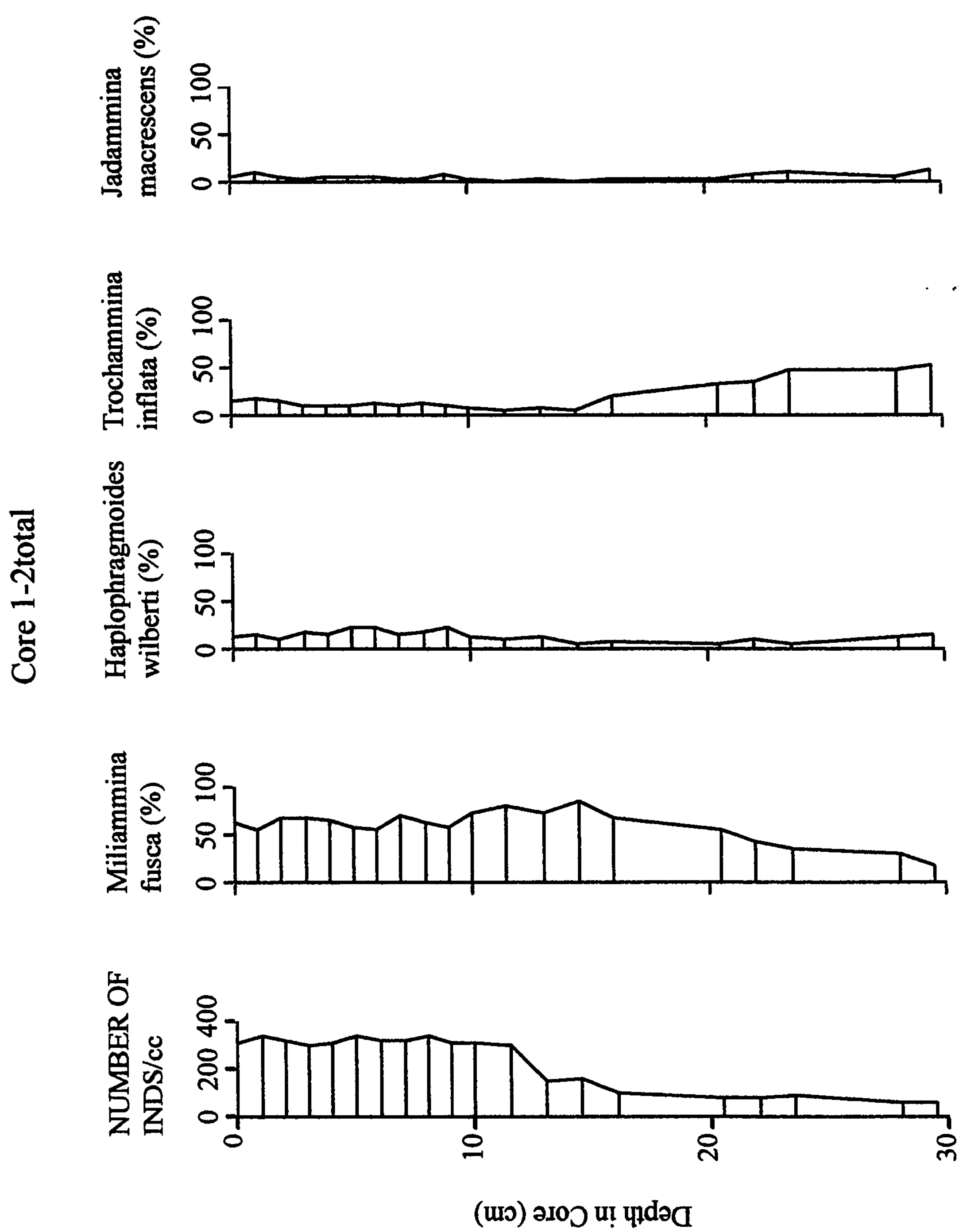


Figure 3.31- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1-2, Nanaimo.

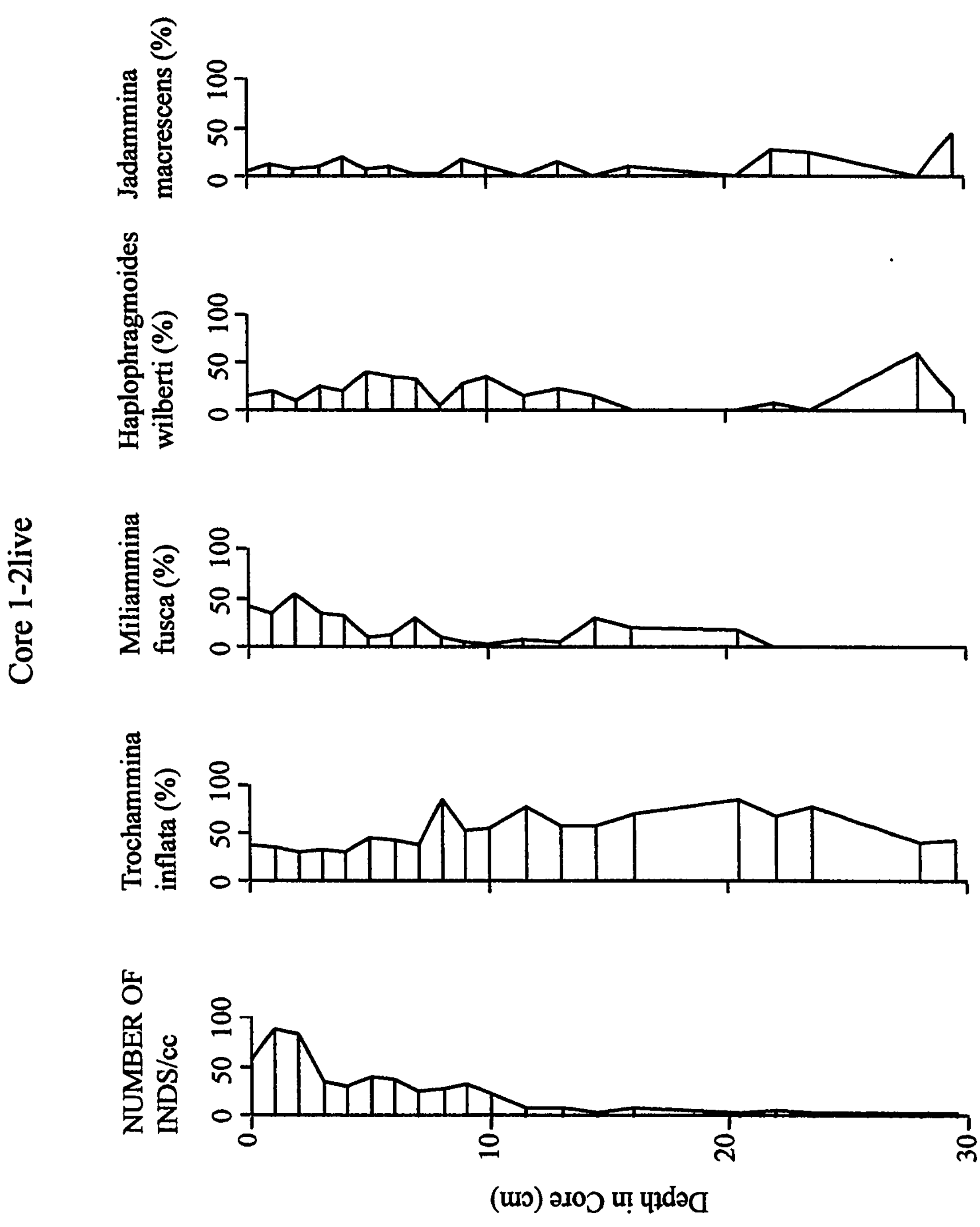


Figure 3.32- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 1-2, Nanaimo.

from 5- 20.5 cm and disappeared below this interval. Moderate percentages of *Jadammina macrescens* (2.3- 19.7 %) were identified down to 20.5 cm and increased up to 26.6 % at 22 cm and co-dominated with *T. inflata* at the bottom of the core (42.8%) where lowest values occurred. Moderate to high percentages of *H. wilberti* also occurred throughout the core (4.6- 34.1 %) and co-dominated with *T.inflata* (40%) at 28 cm (60%).

3.2.1.1c Core 1-3

Total: Numbers ranged from 37 to 349 inds/cm^3 for the 19 samples examined at selected intervals down the core, with highest numbers occurring in the top 11 centimeters and from 23.5 cm to the bottom of the core (Figure 3.33). *Miliammina fusca* dominated the assemblage from the surface of the core to 11.5 cm (69.3- 91.1 %) and co-dominated with *Trochammina inflata* (22.7- 24.2 %) and *Haplophragmoides wilberti* (16.6- 30%) at 13- 14.5 cm (21.6- 40.1%). Low percentages of *Jadammina macrescens* (0.8- 4.9%) and *Reophax nana* (0- 1.3 %) occurred from the surface of the core down to 11.5 cm. Below this interval, percentages of both *J. macrescens* and *R. nana* increased ranging from 3.8 –74.6 % and 1.1- 46.2 % respectively. *H. wilberti* occurred throughout the entire core in moderate percentages (4.6 – 18.9 %) remaining relatively constant. *T. inflata* occurred in moderate percentages in the upper half of the core (2.4- 14.7 %) and steadily increased down to the bottom of the core (11.4- 32.8 %). From 17.5 cm to the bottom of the core, M. fusca occurred in low to moderate percentages ranging from 1.1- 12.6 %.

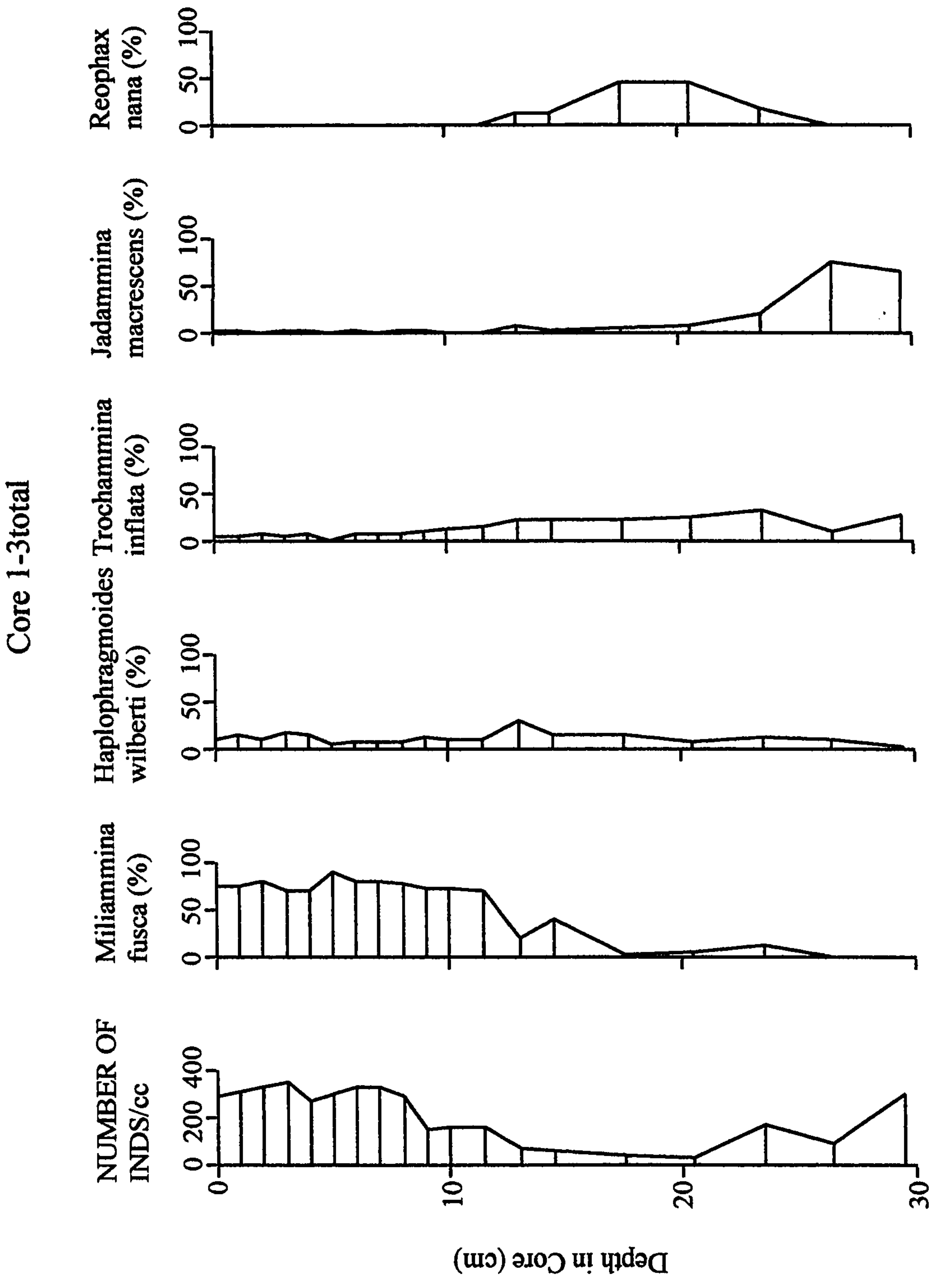


Figure 3.33- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1-3, Nanaimo.

<u>Living</u>: Specimens were identified throughout the entire core with numbers ranging from 1 to 80 inds/cm^3 (except at interval 26.5 cm where no living specimens were identified) with highest values occurring in the upper third of the core with persistent occurrences through the upper two thirds of the core that steadily decreased down core (Figure 3.34). *Miliammina fusca* dominated the assemblage from the surface down to 11.5 cm (47- 67.3 %) except at the 4 cm interval where it co-dominated the assemblage (27.6 %) with both *Trochammina inflata* (30.1 %) and *Haplophragmoides wilberti* (37.7 %). Below this interval, *M.fusca* were identified at 14.5 cm (22.1 %) and at 23.5 cm (11%). Moderate to high percentages of *H. wilberti* (6.3- 33.3 %) occurred throughout the entire core except at 13 cm where it dominated the assemblage (64.4 %) and at the 26.5 cm interval where there were no living specimens identified. *T. inflata* dominated the assemblage at 23.5 cm (66.3 %) and occurred in moderate to high percentages throughout the rest of the core ranging from 6.3- 43.8 %. Low percentages of *Reophax nana* were identified at 6-8 cm (5- 10%) and 10-11.5 cm (4.3-5.5 %) with a high occurrence at the 13 cm interval (35.6 %) and dominating the assemblage from 17.5- 20.5 cm (66.5- 88.3 %). Moderate percentages of *Jadammina macrescens* (1.7- 18.5 %) occurred from the surface of the core down to 9 cm and was identified at the bottom of the core (44%) where it co-dominated the assemblage with *J. macrescens* (44%).

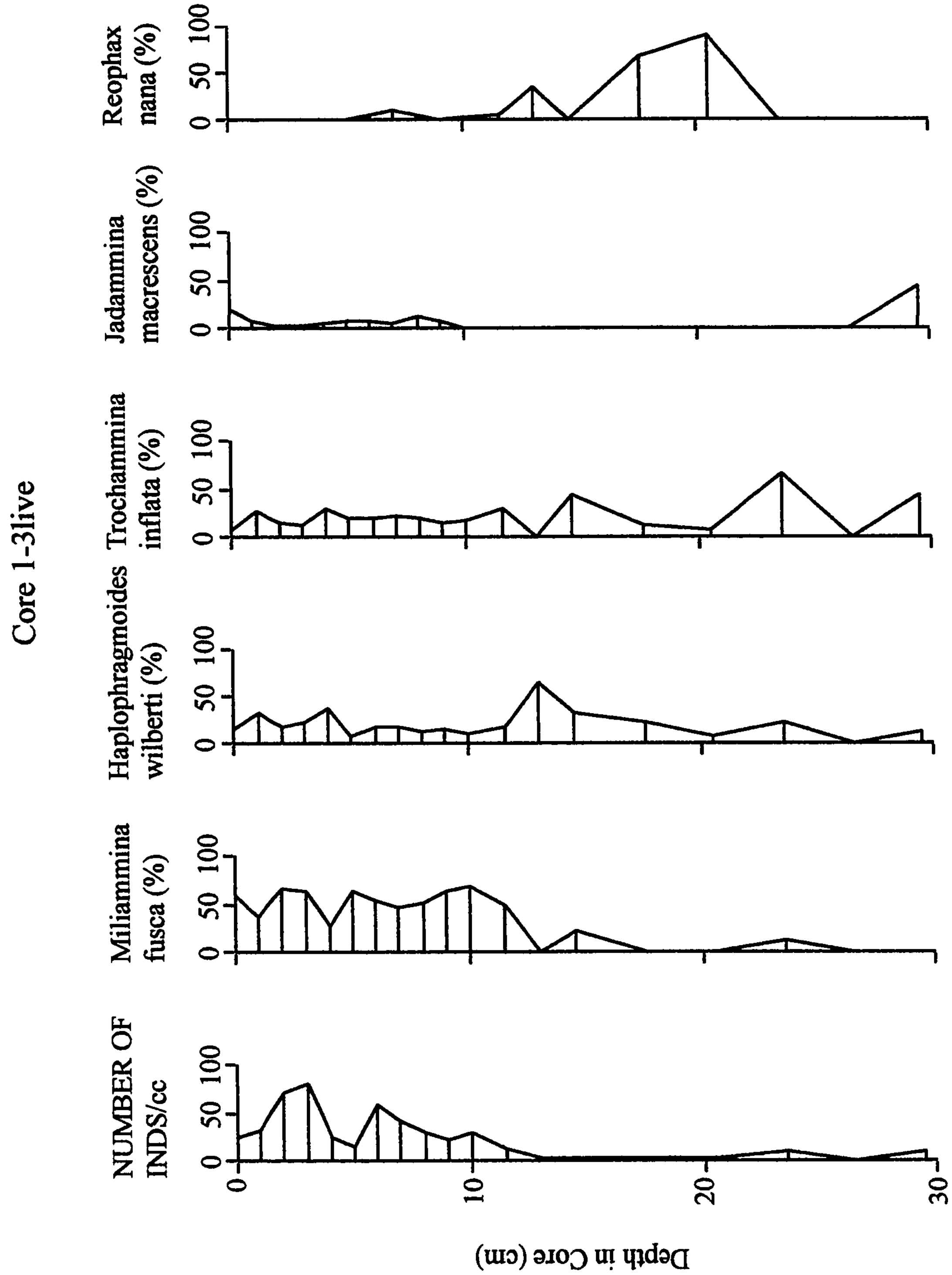


Figure 3.34- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 1-3, Nanaimo.

3.2.1.1d Core 1-4

Total: Numbers ranged from 21 to 164 inds/cm^3 for the 12 samples examined at selected intervals down the core, with a peak value occurring at 4 cm and percentages remaining relatively constant down core (Figure 3.35). The assemblage was dominated by *Miliammina fusca* from 4- 5 cm (44.5- 52.8 %) and dominated by *Haplophragmoides wilberti* at 6-7cm (41.10 51.9 %). From 0- 3 cm, the assemblage was co-dominated by *M. fusca* (25.3- 43.2 %) and *H. wilberti* (24.5- 45.2 %). From 8- 11.5 cm, the assemblage was co-dominated by *Trochammina inflata* (30.3- 48 %) and *H. wilberti* (37.3- 49 %). Low to moderate percentages of *Jadammina macrescens* (1.9- 15.3 %) occurred throughout the core. *T. inflata* occurred in moderate percentages in the upper two thirds of the core (13.1- 27.3 %) and *M. fusca* were identified in moderate percentages from 6 cm to the bottom of the core (4.4- 27.1 %).

Living: Specimens were identified down to 8 cm with numbers ranging from 1 to 38 inds/cm^3 with highest values occurring from 1- 4 cm (Figure 3.36). *Haplophragmoides wilberti* dominated the assemblage from 0-1 cm (50- 76.7 %) and 4-8 cm (38- 80.9%) and occurred in moderate percentages from 2-3 cm (5.3- 23.4 %). Moderate to high percentages of *Miliammina fusca* (5.3- 32.4 %) occurred from 0- 6 cm except at 2 cm where it dominated the assemblage (65.5%). Moderate to high percentages of *Trochammina inflata* (6.9- 31.6 %) were identified down to 8 cm. *Jadammina*

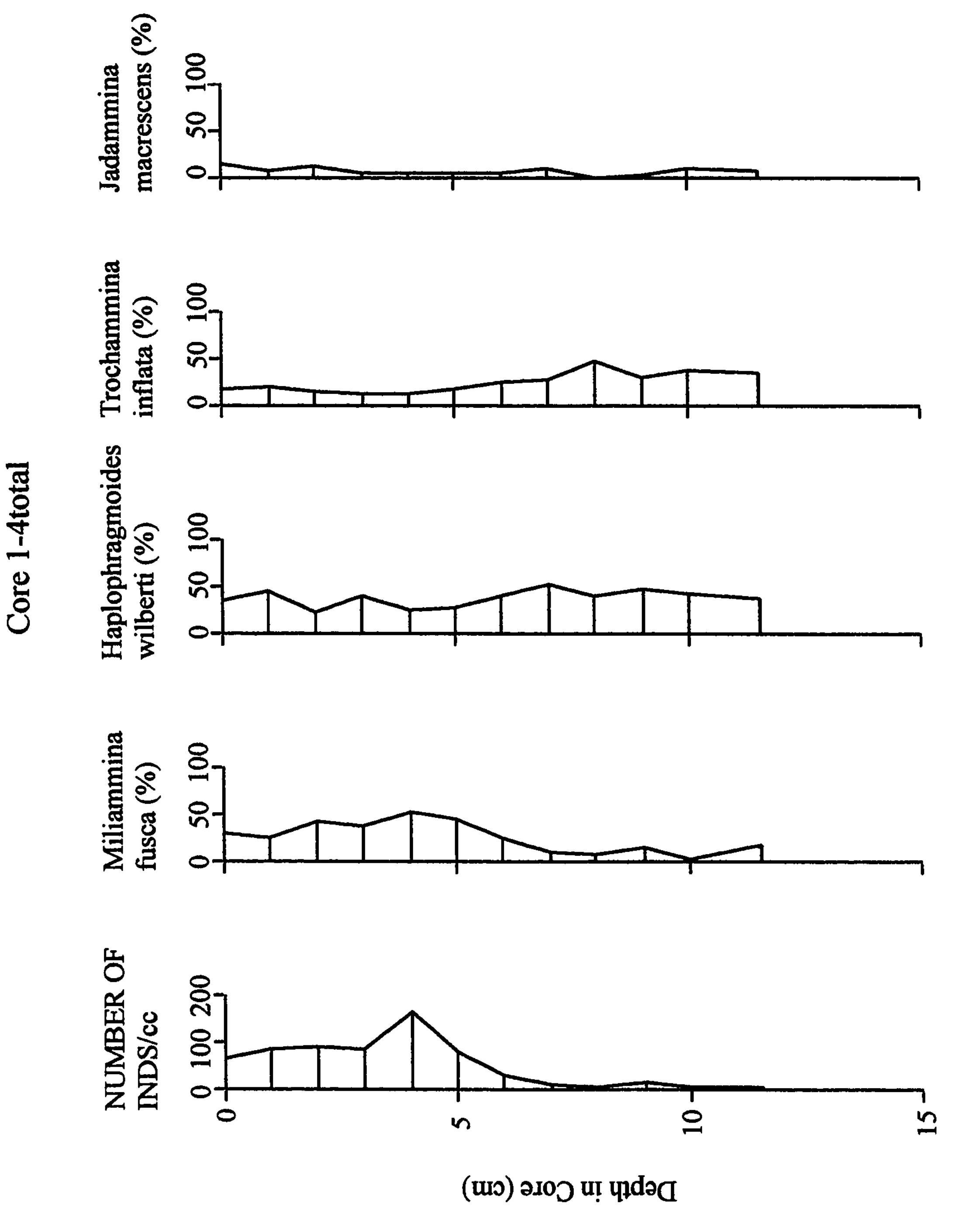


Figure 3.35- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1-4, Nanaimo.

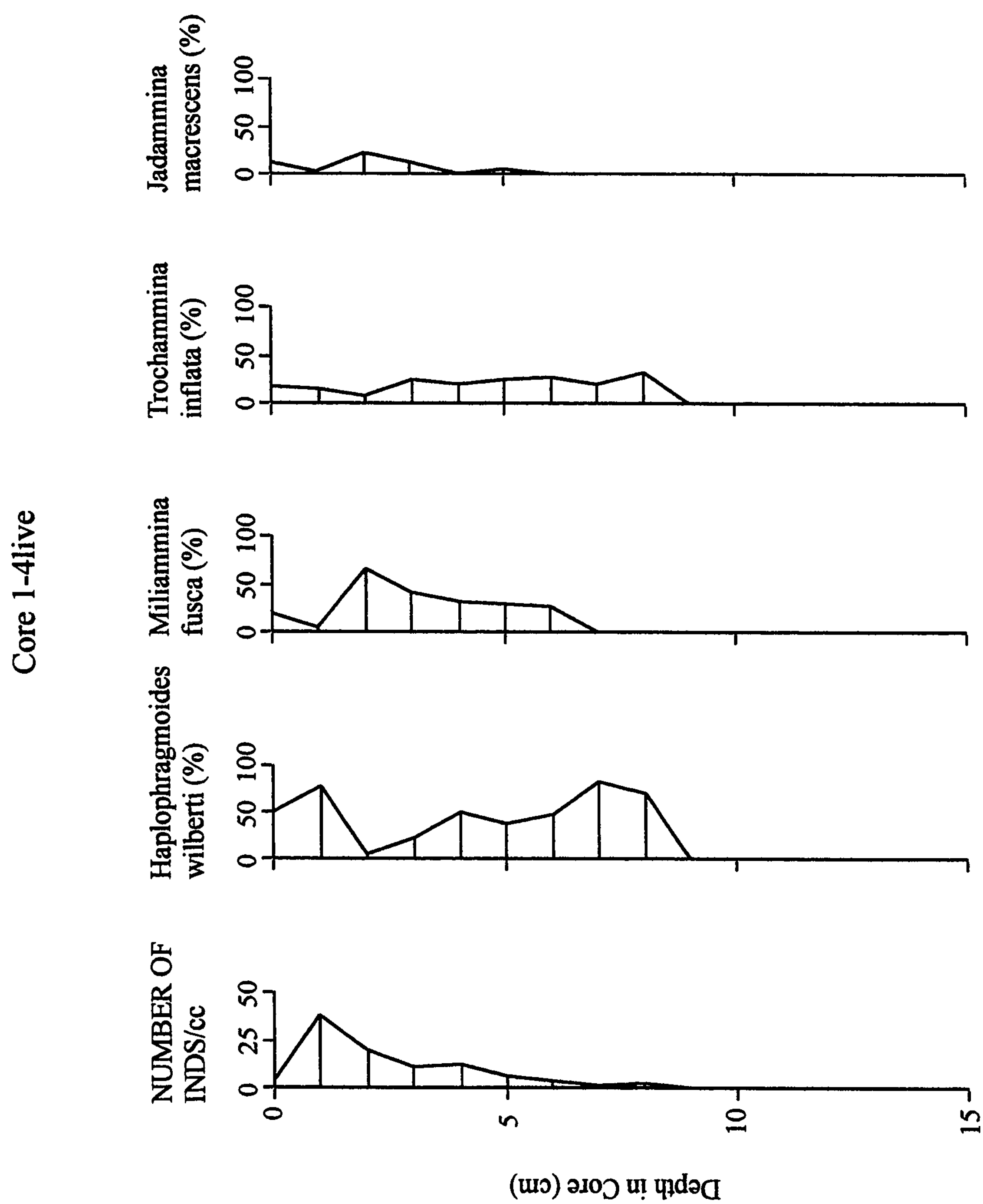


Figure 3.36- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 1-4, Nanaimo.

macrescens individuals were found down to 5 cm ranging from 2.6- 22.4 %. Specimens of *Reophax nana* were identified at 5 cm comprising 6.3 % of the assemblage.

3.2.1.2 Site 2

Both cores from this site exhibited similar foraminiferal trends with *Miliammina fusca* dominating the total assemblage with low percentages of *Haplophragmoides wilberti*, *Trochammina inflata*, and *Jadammina macrescens*. The living assemblage was variable in both cores with *T. inflata* dominating the assemblage in the lower part of the core and *M. fusca* generally dominating in the upper half of the cores with specimens living down to 29 cm.

3.2.1.2a Core 2-1

Total: Numbers ranged from 61 to 367 inds/cm^3 for the 19 samples examined at selected intervals down the core, with highest numbers occurring in the upper two thirds of the core (Figure 3.37). *Miliammina fusca* dominated the assemblage in the entire core with percentages remaining relatively constant ranging from 70.8- 94.3 %. Low to moderate percentages of *Haplophagmoides wilberti* (0.8- 17.8 %), *Trochammina inflata* (1.6- 12.4 %) and *Jadammina macrescens* (0.4- 13.3 %) occurred throughout the core with percentages remaining constant.

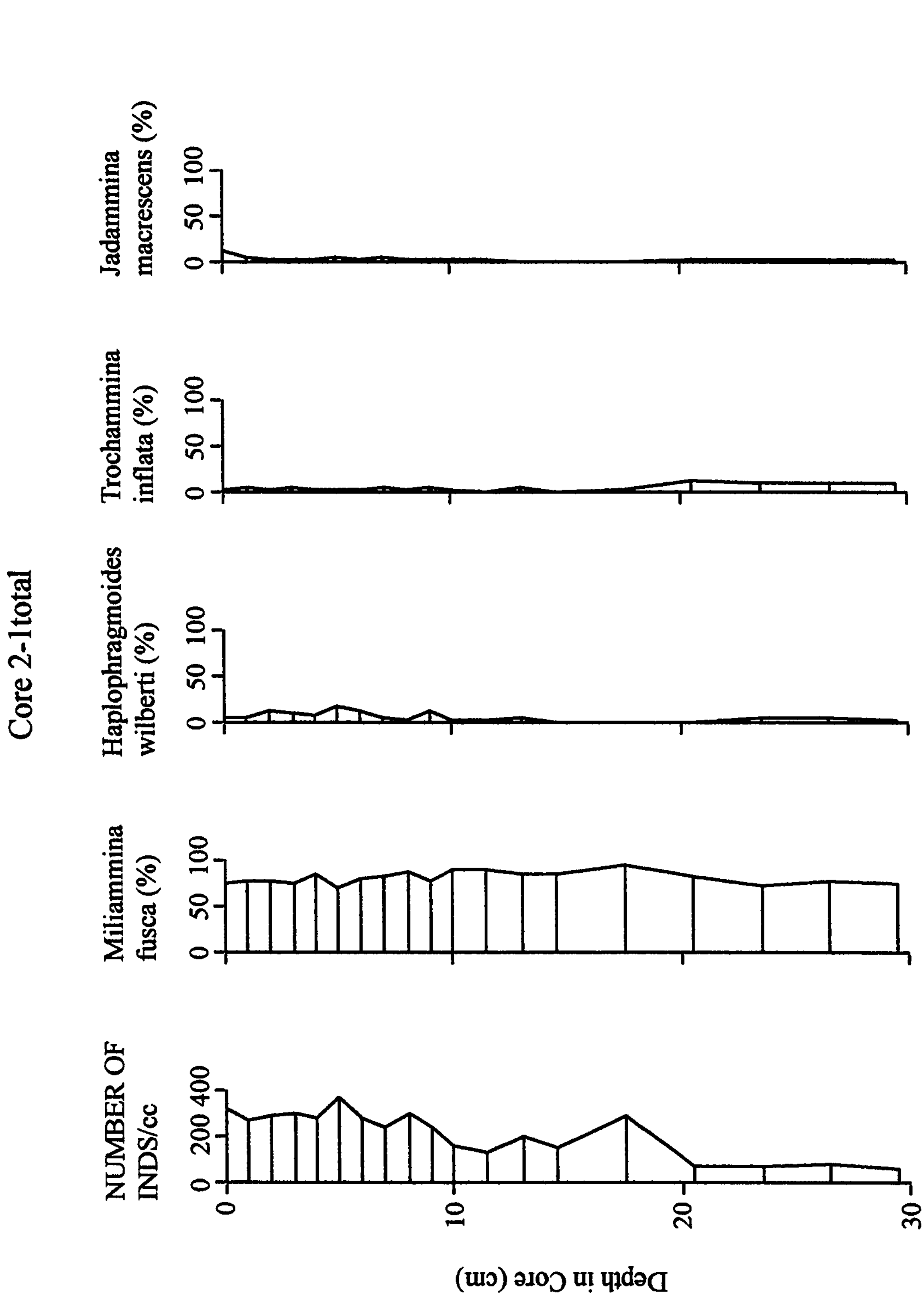


Figure 3.37- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 2-1, Nanaimo.

Living: Percentages were variable and specimens were identified throughout the entire core, except from 17.5- 20.5 cm, with numbers ranging from 1 to 45 inds/cm^3 with peak values occurring in the upper ten centimeters that steadily decreased down core (Figure 3.38). *Miliammina fusca* dominated the assemblage from 0- 14.5 cm (52.9- 100 %) except at 7 cm where the assemblage was co-dominated with *Jadammina macrescens* (both at 41.7 %). Moderate to high percentages of *Haplophragmoides wilberti* occurred from 0- 9 cm (8- 29.4 %). Low to moderate percentages of *Trochammina inflata* (0- 25 %)and *J. macrescens* (0- 16 %) were identified down to 10 cm. Specimens of *Reophax nana* were identified from 23.5- 29.5 cm ranging from 50- 100 %, co-dominating with *M. fusca* (50%) at 23.5 cm and co-dominating with *T. inflata* (50%) at 26.5 cm.

3.2.1.2b Core 2-2

Total: Numbers ranged from 36 to 506 inds/cm^3 for the 15 samples examined at selected intervals down the core, with highest numbers occurring in the middle of the core (Figure 3.39). *Miliammina fusca* generally dominated the assemblage ranging from 36.2- 80.4 % except at 8- 9 cm (37.1- 46.6 %) where it co-dominated with *Trochammina inflata* (37.2- 46 %). Moderate percentages of *Haplophagmoides wilberti* (5.8- 25.6 %) occurred throughout the core with percentages remaining relatively constant. Moderate to high percentages of *T. inflata* (6- 29.6 %) and *Jadammina macrescens* (5.3- 17.1 %) were also identified throughout the core.

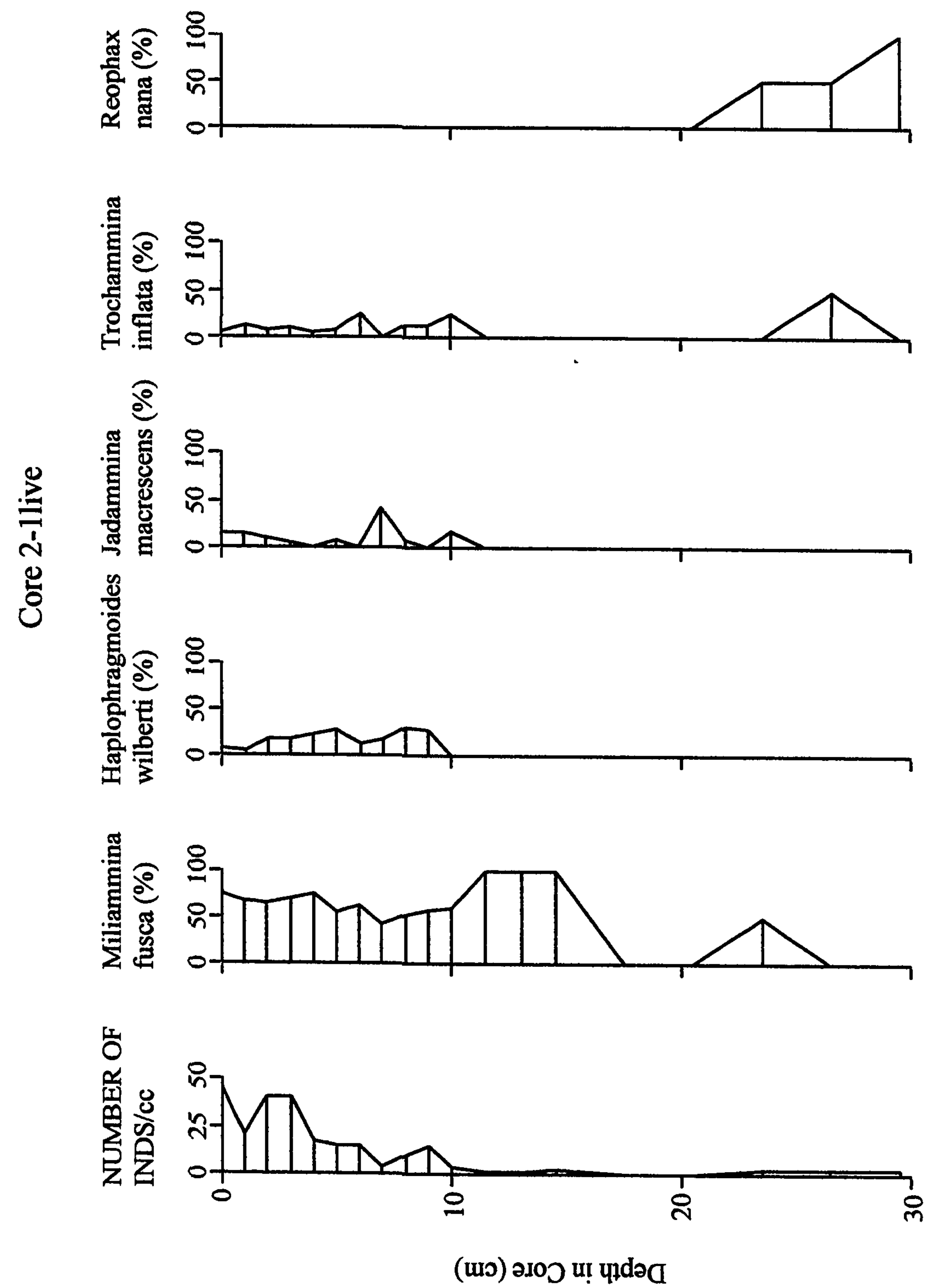


Figure 3.38- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 2-1, Nanaimo.

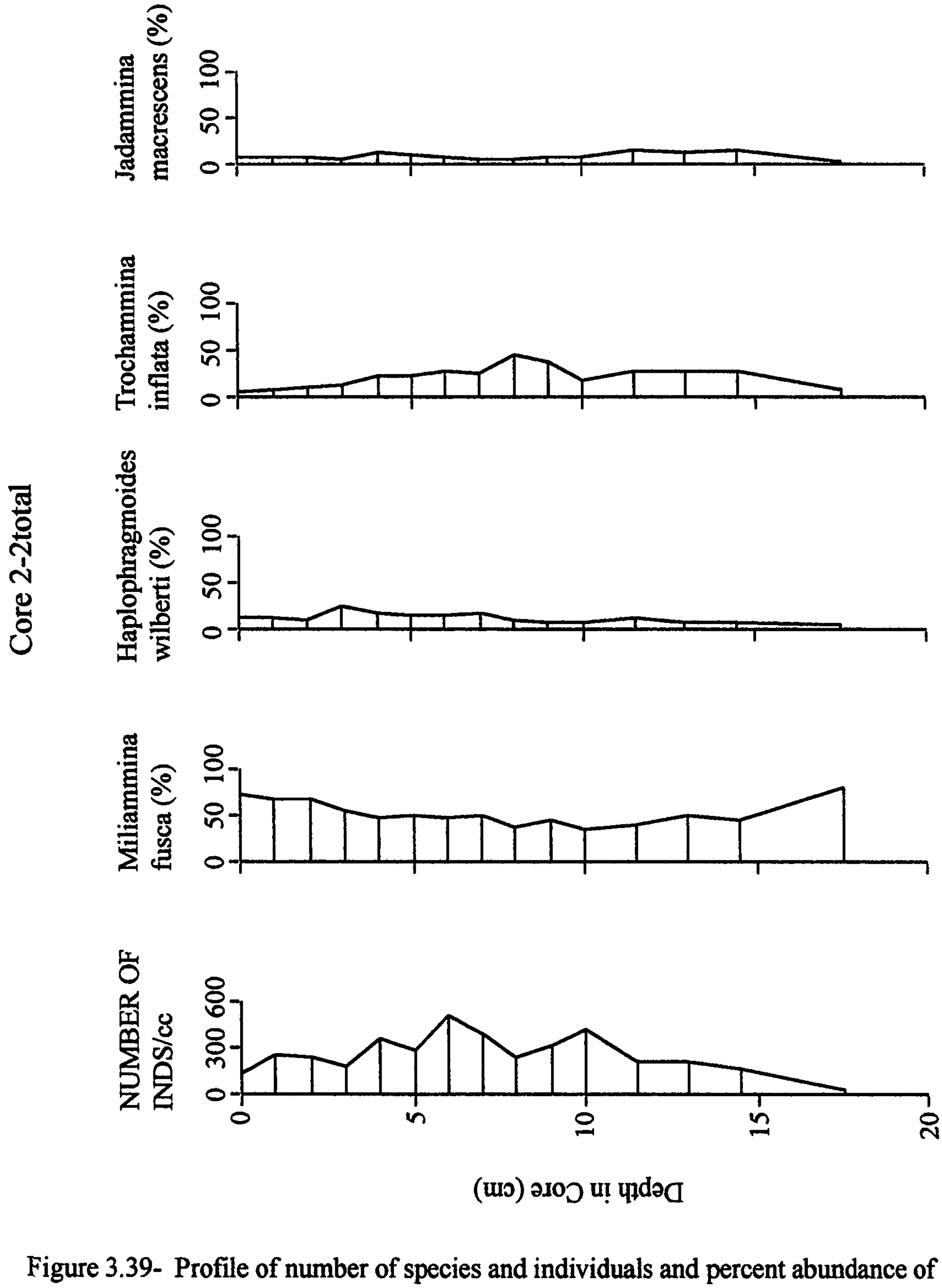


Figure 3.39- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 2-2, Nanaimo.

<u>Living</u>: Percentages were variable in the upper half of the core and specimens were identified throughout the entire core with numbers ranging from 1 to 46 inds/cm^3 with peak values occurring in the upper two thirds of the core and steadily decreased down core (Figure 3.40). *Trochammina inflata* dominated the assemblage at 4 cm (44.5 %) and from 8- 17.5 cm (64.7- 100 %). The assemblage was co-dominated by *T. inflata* (30- 32.9 %)and *M. fusca* (38.3- 32.9 %)at 0 cm and 2 cm. *T. inflata* (31.3%), *M. fusca* (31.3%), and *Haplophragmoides wilberti* (39.5%) co-dominated the assemblage at 3 cm. *T. inflata* (32.8- 48.1 %) and *H. wilberti* (32.8- 44.9 %) co-dominated the assemblage from 5- 6 cm. *M. fusca* had persistent occurrences throughout the core ranging from 6.3- 35.3 % with a peak value of 51.4 % at 1 cm where it dominated the assemblage. *H. wilberti* occurred in moderate percentages (6.3- 23.4 %) down to 8 cm and dominated the assemblage with a peak value of 55.7 % at 7 cm. Low to moderate percentages of *Jadammina macrescens* (0- 23.3 %) were identified down to 8 cm.

3.2.1.3 Site N95

Both cores exhibited similar foraminiferal trends with *Jadammina macrescens* generally dominating the total assemblage with moderate percentages of *Trochammina inflata*, *Trochamminita salsa*, and *Miliammina fusca* and low percentages of

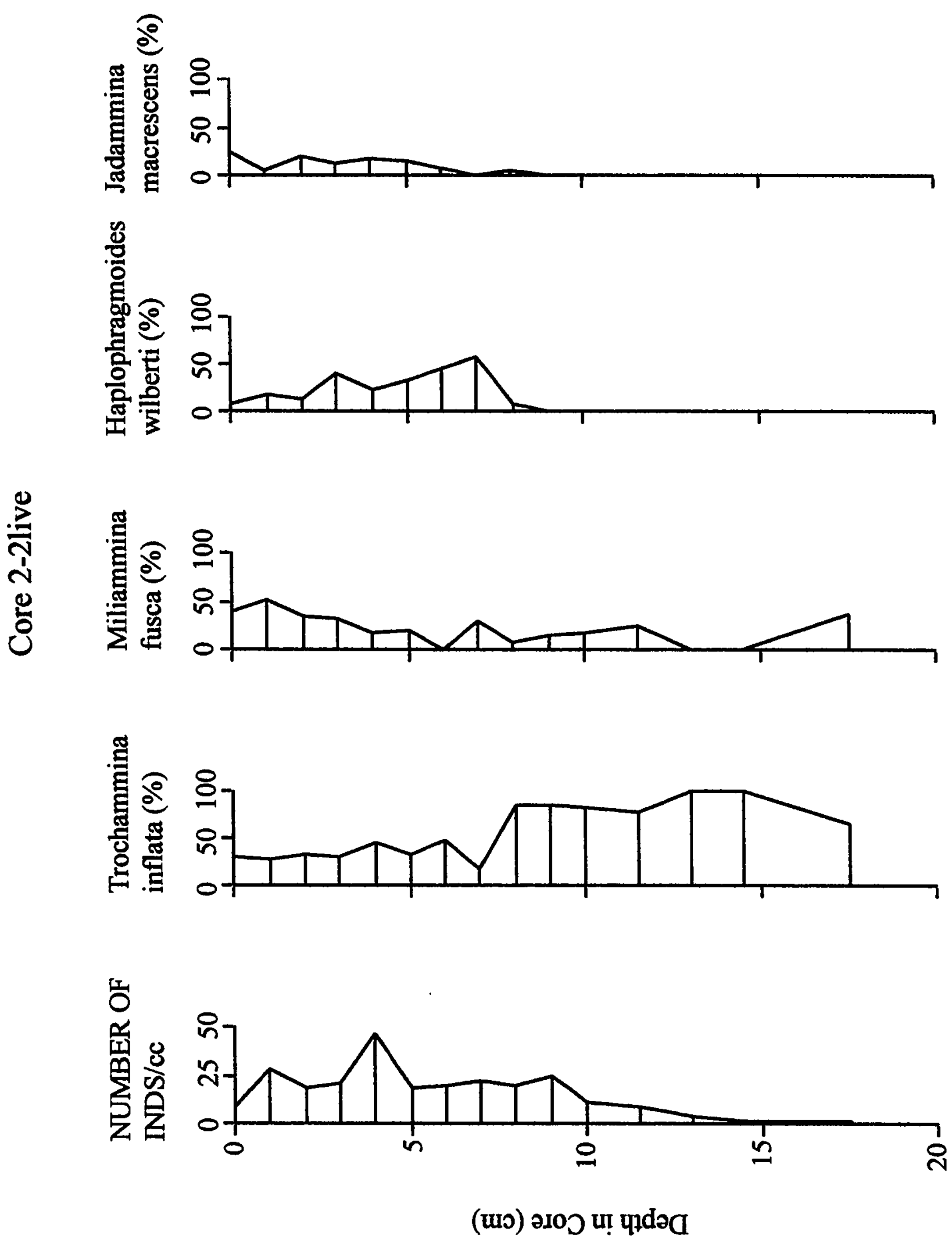


Figure 3.40- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core 2-2, Nanaimo.

Haplophragmoides wilberti. The living assemblage was relatively constant with *J. macrescens* generally dominating with moderate percentages of *T. inflata* and *T. salsa* and low percentages of *M. fusca* and *H. wilberti* with specimens living down to 28 cm.

3.2.1.3a Core N95-1

Total: Numbers ranged from 207 to 439 inds/cm^3 and were relatively constant for the 20 samples examined at selected intervals down the core (Figure 3.41). *Haplophragmoides wilberti* dominated the assemblage from 1- 5cm (33.3- 45.5 %) and co-dominated with *Trochammina inflata* (20.8%) at the surface (26.3 %) and co-dominated with *Miliammina fusca* (42.1 %) at 6 cm (33.7 %). Below this interval, low percentages of *H. wilberti* occurred for the remainder of the core (3- 7.8 %). High percentages of *M. fusca* occurred from 7- 12 cm (21.2- 55.7 %) where it dominated at 7 and 9 cm. Moderate to high percentages of *M. fusca* were present from 0- 5 cm (14.8- 26.2 %) and in the lower half of the core (4.6- 15.4 %). Moderate to high percentages of *Jadammina macrescens* occurred in the upper half of the core ranging from 9.6- 35.6 %). From 14 cm to the bottom of the core, *J. macrescens* dominated the assemblage (38.7- 63.9 %). *T. inflata* (7.3- 22.8 %) and *Trochamminita salsa* (5.4- 22.3 %) exhibited similar profiles throughout the core and remained relatively constant.

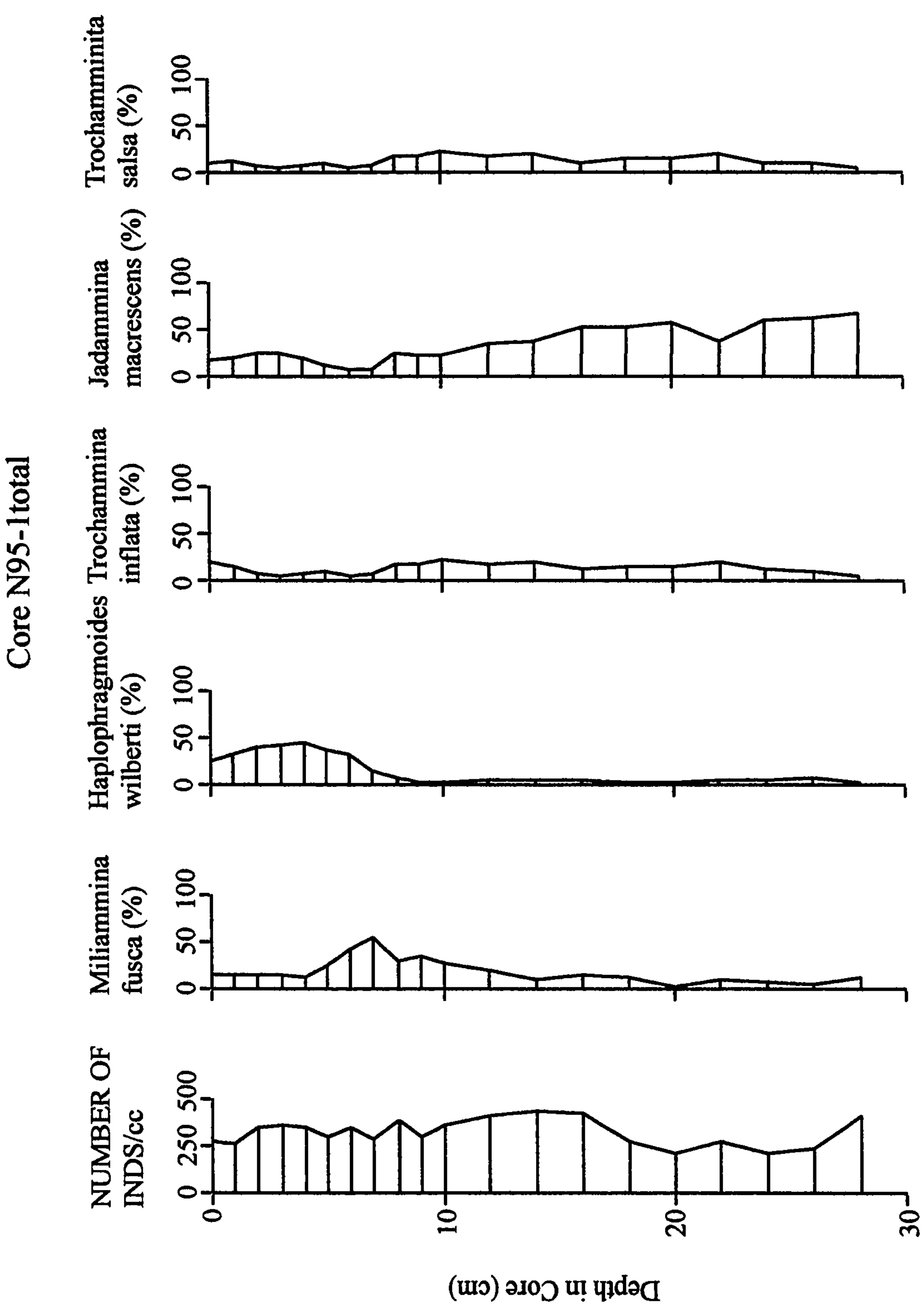


Figure 3.41- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core N95-1, Nanaimo.

Living: Specimens were identified throughout the entire core with numbers ranging from 7 to 90 inds/cm^3 with peak values occurring in the upper two thirds of the core (Figure 3.42). The entire core was generally co-dominated by two or three species. *Trochammina inflata* (17.9- 38.9 %), *Jadammina macrescens* (6.8- 50 %), and *Trochamminita salsa* (4- 32.1 %) occurred in moderate to high percentages throughout the core. High percentages of *Haplophragmoides wilberti* (19.2- 43.6 %) were present from 0- 7 cm and below this interval, low percentages of *H. wilberti* occurred ranging from 2.9- 12.1 %). There were low to moderate percentages of *M. fusca* (0- 16.9 %) throughout the core except at 7 cm where *M. fusca* co-dominated the assemblage with *T. inflata* and *H. wilberti*.

3.2.1.3b Core N95-2

Total: Numbers ranged from 125 to 326 inds/cm^3 and were relatively constant for the 20 samples examined at selected intervals down the core (Figure 3.43). *Jadammina macrescens* (45.6- 70 %) dominated the assemblage from 0- 20 cm and occurred in high percentages in the remainder of the core ranging from 21.7- 54.2 %). *Trochammina inflata* (3.7- 20.8 %) and *Trochamminita salsa* (3.1- 20.2 %) displayed similar profiles with low to moderate percentages throughout the core. *M. fusca* occurred in low to moderate percentages down to 20 cm (2.3- 26.5 %) and dominated the assemblage below this

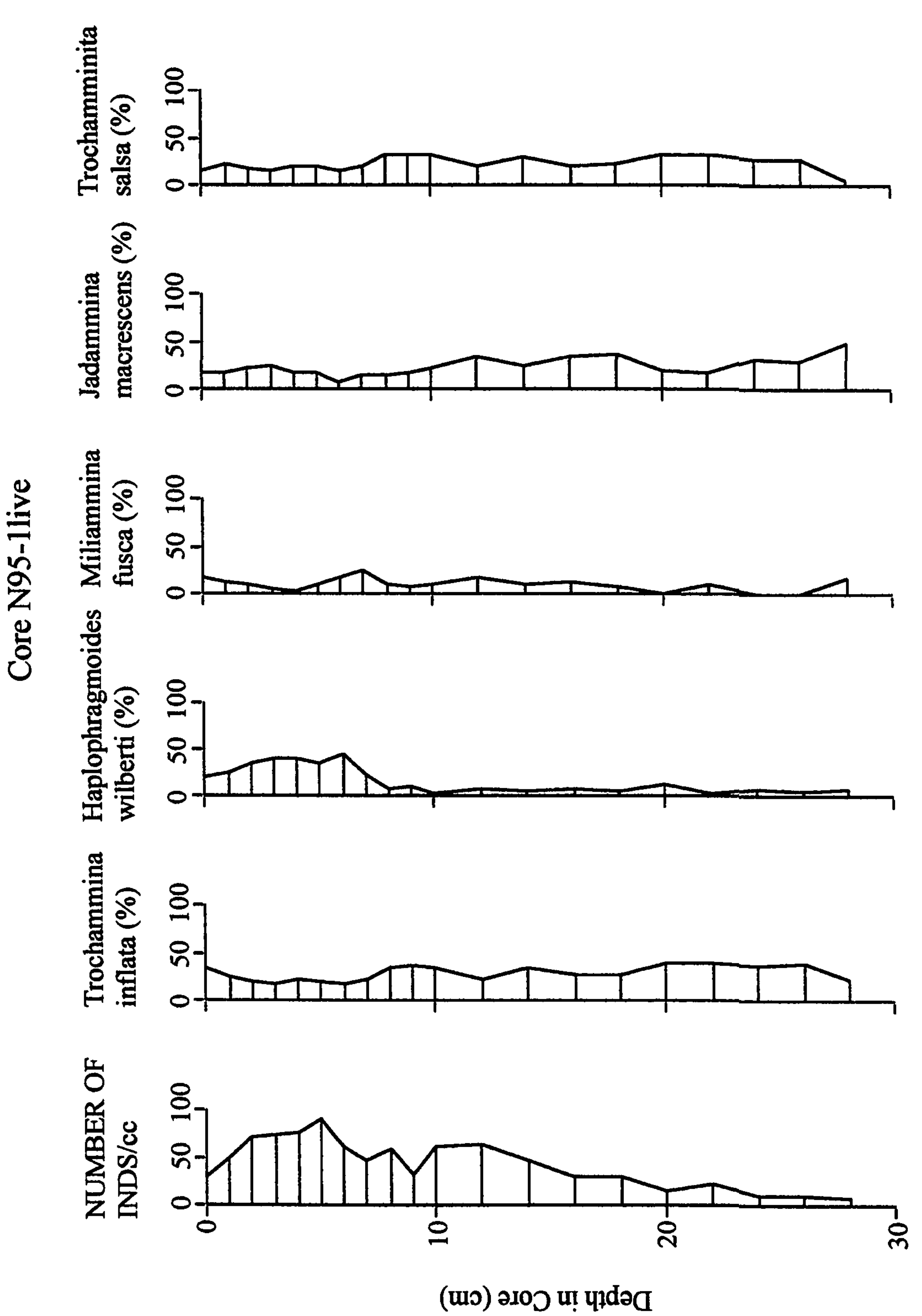


Figure 3.42- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core N95-1, Nanaimo.

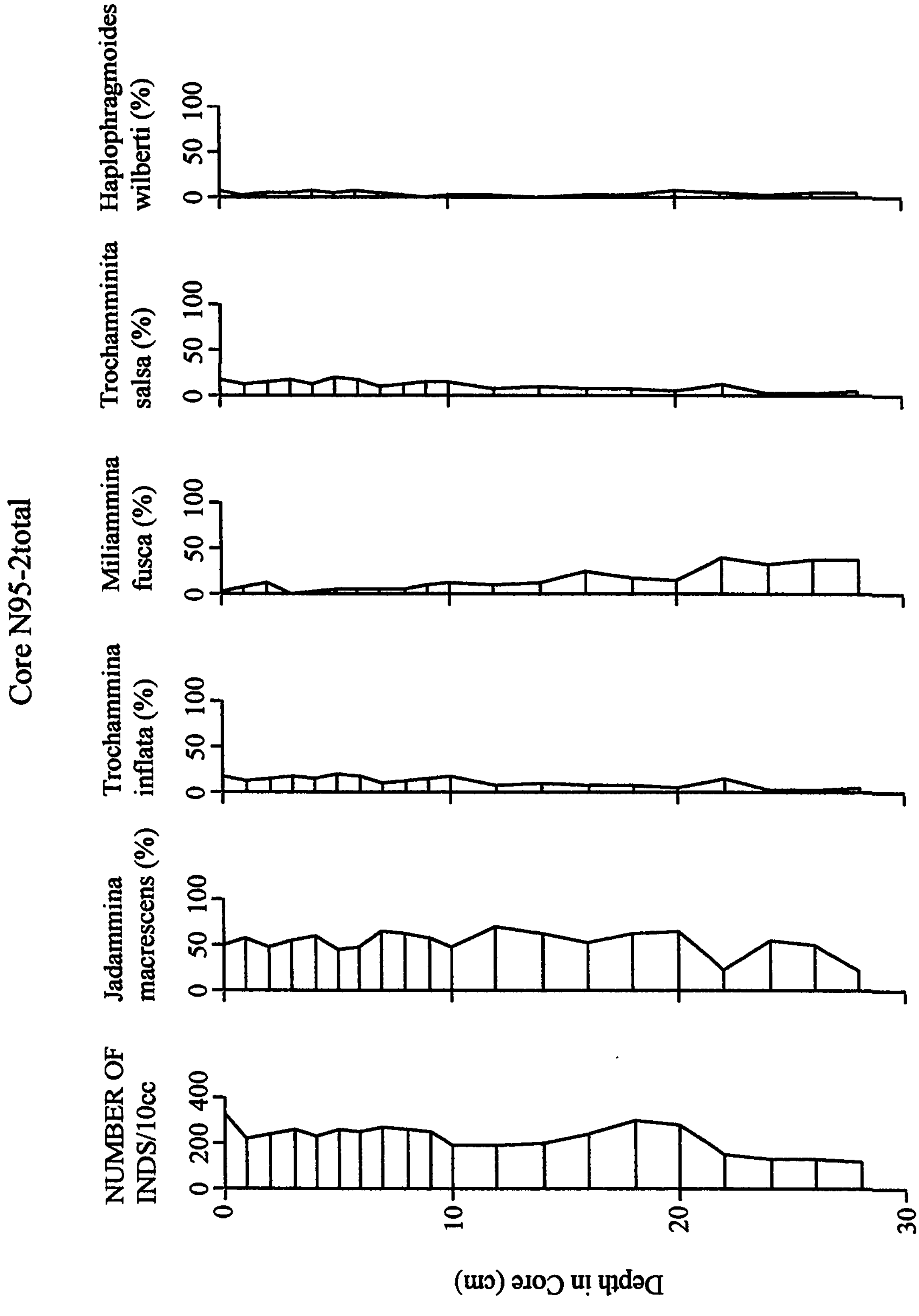


Figure 3.43- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core N95-2, Nanaimo.

interval ranging from 32.8- 41.5 %. Low percentages of *Haplophagmoides wilberti* (2.1- 9.2 %) occurred throughout the core with percentages remaining relatively constant.

Living: Specimens were identified throughout the entire core with numbers ranging from 3 to 61 inds/cm^3 with peak values occurring in the upper third of the core (Figure 3.44). *Jadammina macrescens* (6.8- 50 %) generally dominated the assemblage ranging from 33.3- 59.9 % except at 0, 10, and 22 cm where species occurred in low percentages. *Trochamminita salsa* (10.3- 34.7 %) and *Trochammina inflata* (14.1- 38.1 %) occurred in moderate percentages throughout the core. Low to moderate percentages of *Haplophragmoides wilberti* (0- 16.3 %) and *M. fusca* (0- 13.9 %) occurred throughout the core except at 10 cm where *M. fusca* (32.6 %) co-dominated the assemblage with *T. inflata* (30 %).

3.3 Degradation Results

3.3.1 Material in buckets

The four samples that were collected and stored in buckets were from Site 1 (surface and subsurface), Site 2a, and Site 3 (surface samples). All samples showed similar results; foraminiferal numbers remained relatively unchanged at room temperature after all the material was analysed (35 weeks for the surface samples and 52 weeks for the subsurface sample). The total foraminiferal assemblage at each site was quite constant with one species dominating all others. All living foraminifera disappeared by week 14 and the living faunal assemblage was quite variable in the material from each site.

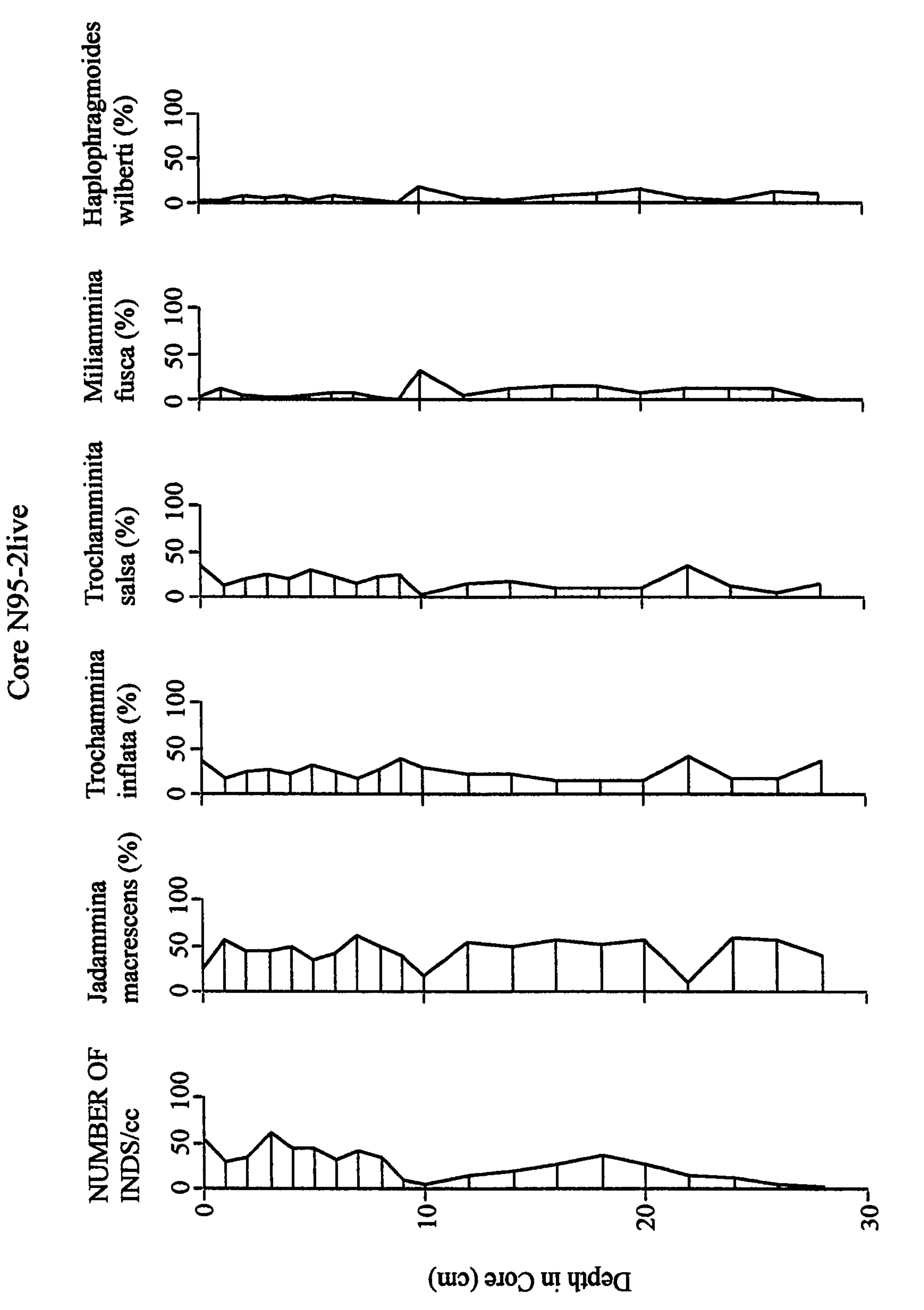


Figure 3.44- Profile of number of species and individuals and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage in sediments from Core N95-2, Nanaimo.

3.3.1.1 Site 1 Surface Samples

Total: In the 33 weeks surface sample material was examined, numbers ranged from 1596 to 5056 inds/10 cc's with highest numbers, surprisingly, occurring after week 15 (Appendix Table 14; Figure 3.45) and as a result, there were no signs of degradation of foraminiferal tests. *Trochammina macrescens* forma *macrescens* dominated the assemblage in all 35 weeks (63.1- 90.8 %). Low to moderate percentages of *Pseudothurammina limnetis* (0.4 to 18.1 %), *Miliammina fusca* (0 to 10.6 %), and the thecamoebian *Centropyxis aculeata* (0.5 to 10.4 %) occurred throughout the 35 week time interval. *Tiphotrocha comprimata* (0.5 to 5.8 %) occurred in low percentages.

Living: Foraminifera were identified up to week 12 ranging from 44 to 1744 inds/ 10 cc's with highest values occurring at week 0 and weeks 4-6 (Appendix Table 14; Figure 3.46). However, after week 8, numbers of living dropped well below 100 inds/10 cc. *T. mac. f. macrescens* assemblage (53.3- 100 %) except at week 10 where *T. comprimata* dominated (54.5 %) and co-dominated with *P. limnetis* at week 7. Low percentages of *P. limnetis*, *T. comprimata*, *Trochammina inflata*, and *M. fusca* occurred up to week 12.

3.3.12 Site 1 Subsurface Sample

Total: In the 52 weeks samples were examined, numbers ranged from 1720 to 5608 inds/ 10 cc's with highest numbers occurring near the end of the study period (Appendix Table 15; Figure 3.47). *Trochammina macrescens* forma *macrescens* dominated the assemblage

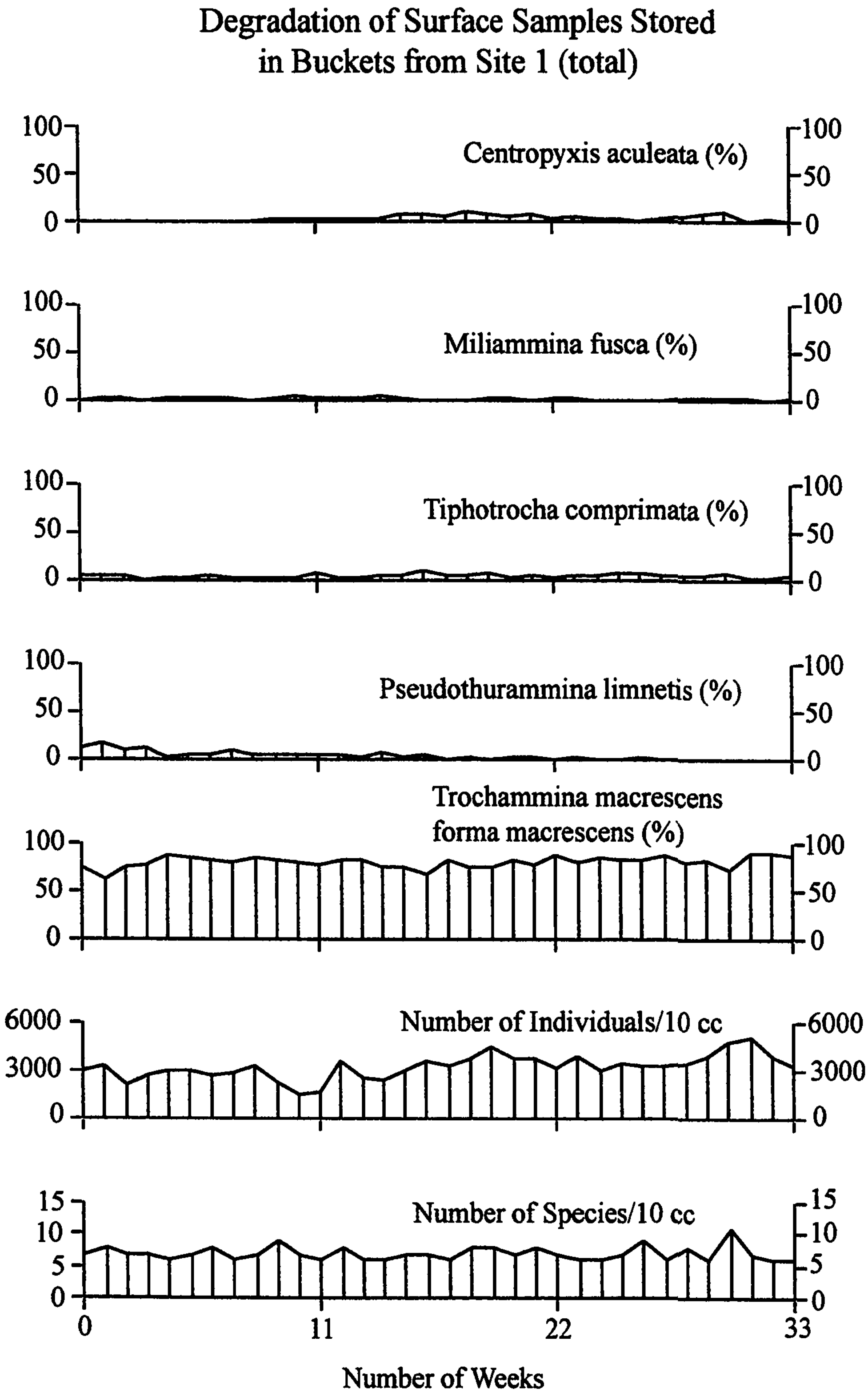


Figure 3.45- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 33 week period in surface sediment collected at Site 1, Chezzetcook Inlet.

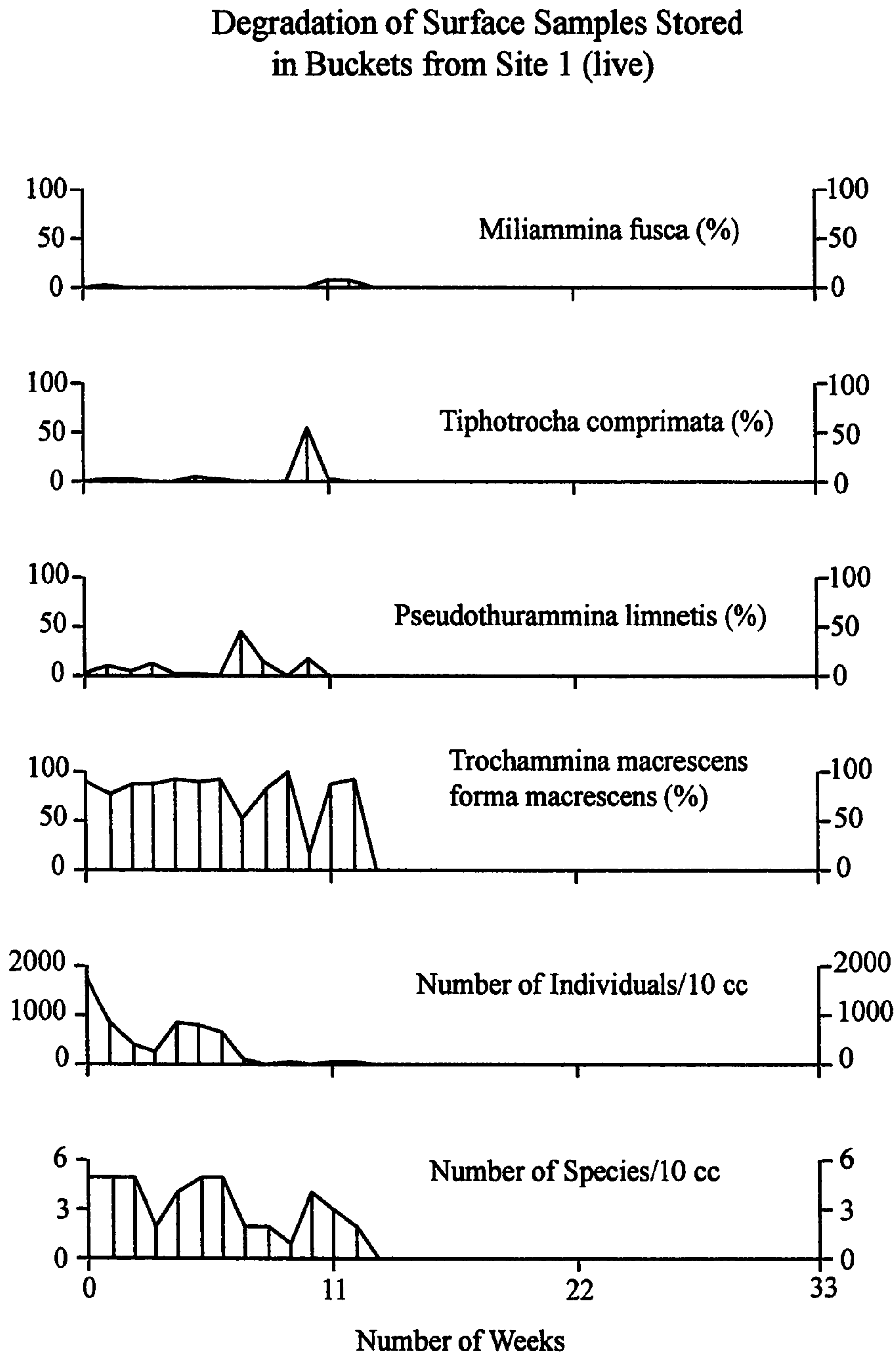


Figure 3.46- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 33 week period in surface sediment collected at Site 1, Chezzetcook Inlet.

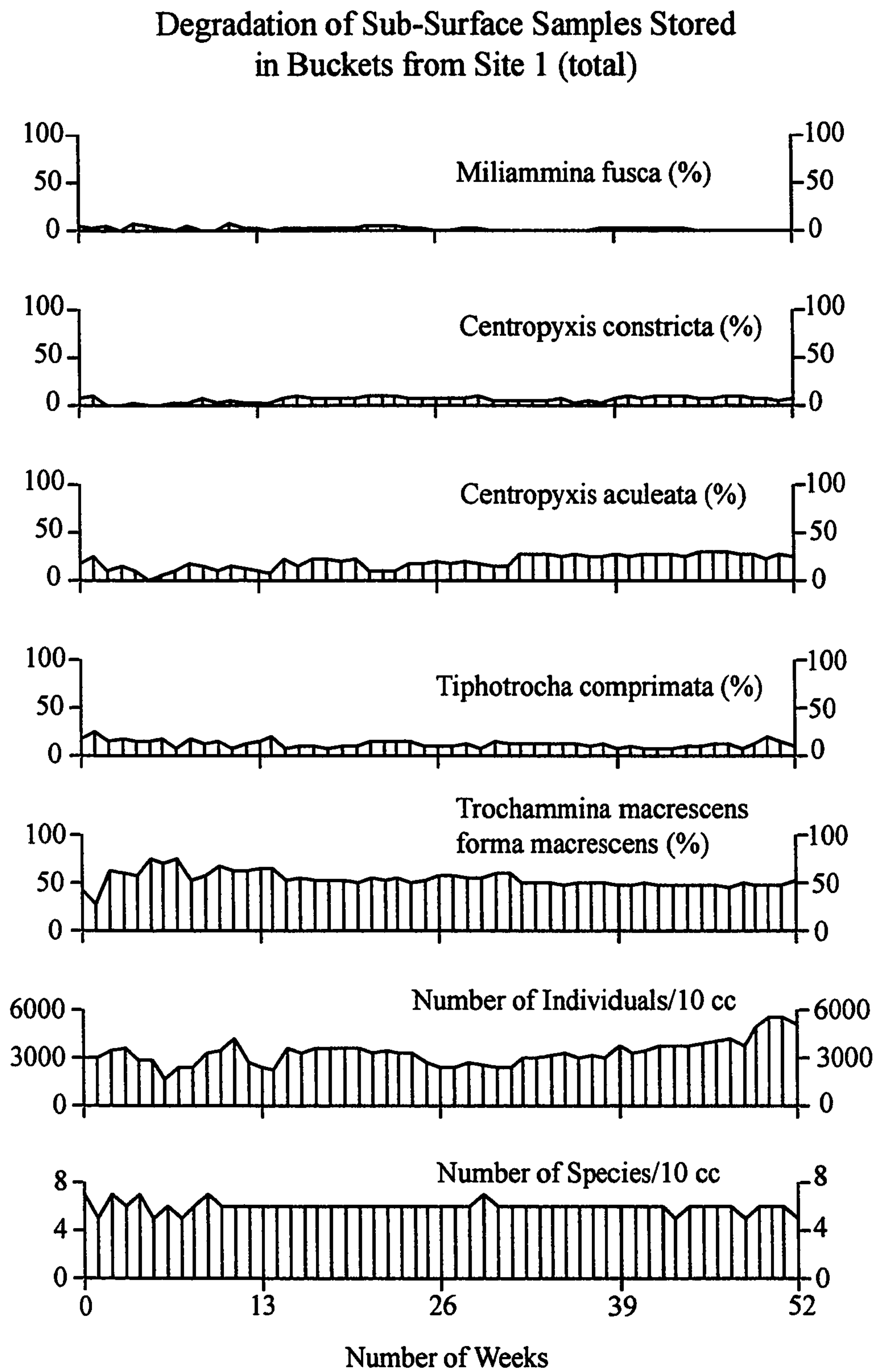


Figure 3.47- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 52 week period in sub-surface sediment collected at Site 1, Chezzetcook Inlet.

(43- 75.9 %) except in week 1 (27.4 %) where it co-dominated with *Tiphotrocha comprimata* (25.3 %) and *Centropyxis aculeata* (24.9 %). Moderate percentages of *T. comprimata* (7.7- 21.2 %) and *C. aculeata* (1.7- 30.4 %) were present throughout the 52 week interval with *C. aculeata* increasing in total percentage toward the end of the study period. Another thecamoebian, *C. constricta* was present in low percentages ranging from 0 to 11.5 %. *Miliammina fusca* (0.1- 8.9 %) occurred in low percentages which rounded out the assemblage. Overall, there were no signs of degradation, as the foraminiferal assemblage remained relatively constant.

3.3.1.2 Site 2a Surface Sample

Total: In the 35 weeks samples were examined, numbers were high and remained relatively constant ranging from 2624 to 4804 inds/ 10 cc's (Appendix Table 16; Figure 3.48). *Miliammina fusca* wholly dominated assemblage (74.7- 91.7 %) with moderate percentages of *Trochammina macrescens* forma *macrescens* (2.6- 10.9 %) occurring over the 52 week time interval. Low percentages of *T. ochracea* (0- 4.9 %) were present throughout the time period. *Elphidium williamsoni*, a calcareous species, occurred in low percentages ranging from 0 to 10.3 % with peak values occurring near the start of the study interval. *E. williamsoni* basically disappeared after week 15 with only one or two specimens occurring after this time in each week. This pattern holds true for all calcareous species that were found at this site (i.e. *Haynesina orbiculare*, *E. excavatum*

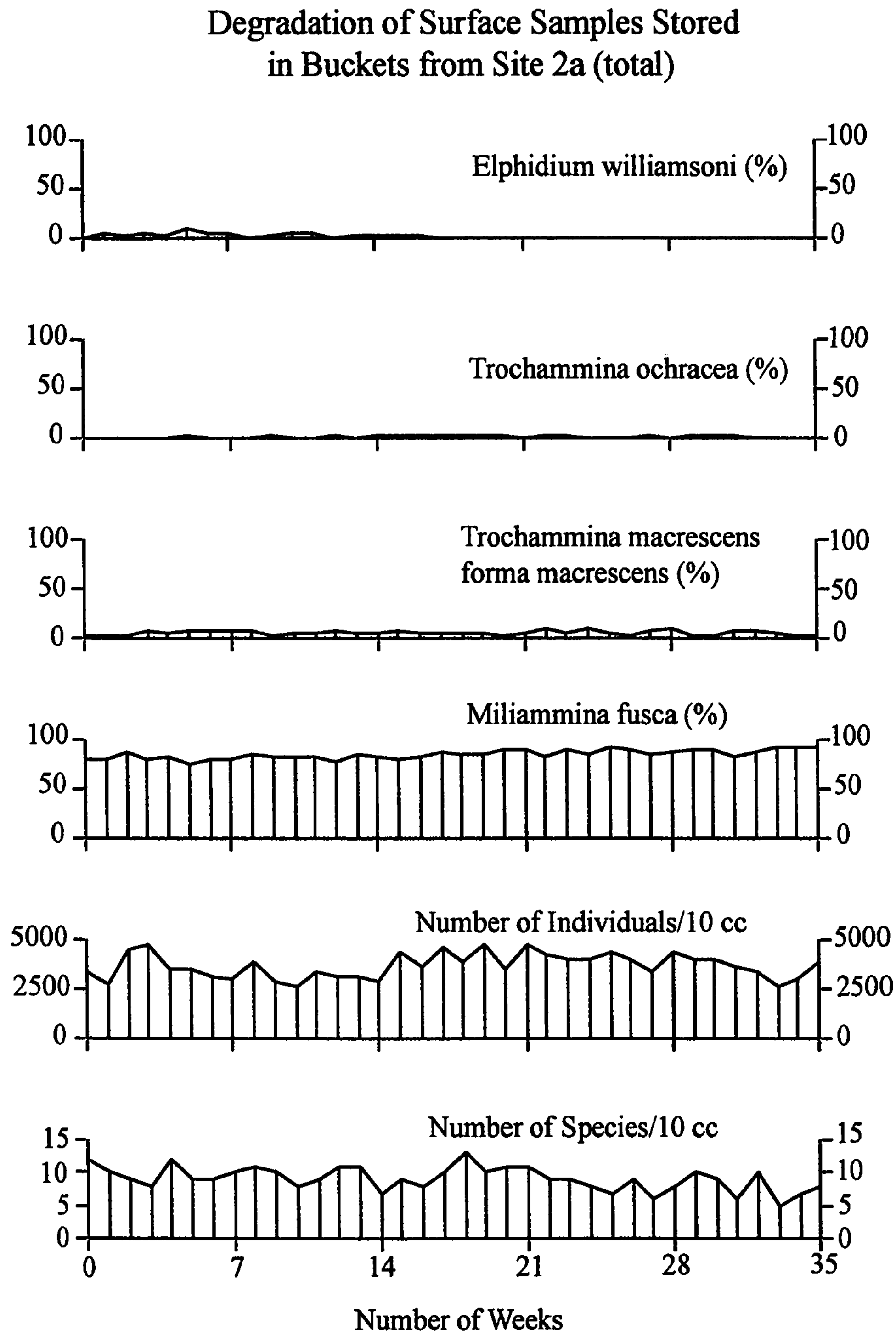


Figure 3.48- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 35 week period in surface sediment collected at Site 2a, Chezzetcook Inlet.

forma *excavatum* and *E. excavatum* forma *clavatum* all disappeared after week 15 with one or two specimens occurring after this time).

Living: Numbers were quite variable and were identified up to week 14 ranging from 8 to 1800 inds/ 10 cc's (Appendix Table 16; Figure 3.49). Unlike site 1, living numbers remained relatively high until week 12. *Miliammina fusca* generally dominated the assemblage (17.4- 89.3 %) except between weeks 5-7 where it co-dominated with *E. williamsoni* and weeks 10, 11, and 14 where *E. williamsoni* dominated the assemblage. Living representatives of *E. exc.* f. *exc.*, *E. exc.* f. *clav.*, and *H. orbiculare* were present in low numbers up to week 12 which rounded out the assemblage.

3.3.1.3 Site 3 Surface Sample

Total: In the 35 weeks surface sample material was examined, numbers ranged from 740 to 1744 inds/ 10 cc's (Appendix Table 17; Figure 3.50). This site displayed a higher diversity than at the previous two sites. The assemblage remained relatively constant with *Miliammina fusca* dominating (31.9- 55.8 %). There were moderate percentages of *Elphidium williamsoni* (3.1- 19.5 %), organic linings (5.6- 31 %), *Ammobaculites dilatatus* (5.1- 21.1 %), and *Ammotium salsum* (1.4- 13.9 %) which occurred throughout the entire 35 week interval. Low percentages of *Ammonia beccarii* (0-11.1 %) were also present. Again, total numbers remained relatively constant and did not display any signs of degradation.

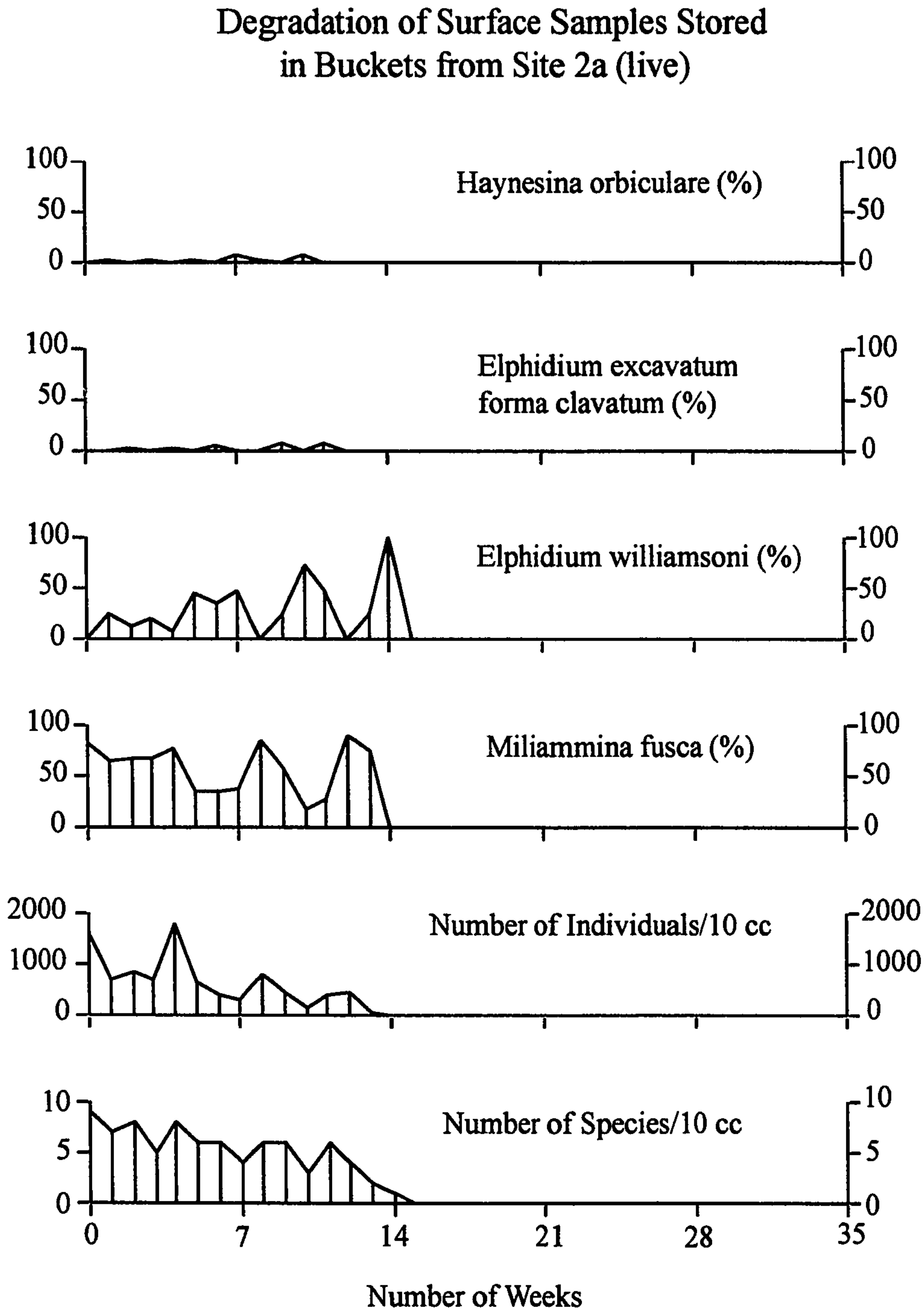


Figure 3.49- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 35 week period in surface sediment collected at Site 2a, Chezzetcook Inlet.

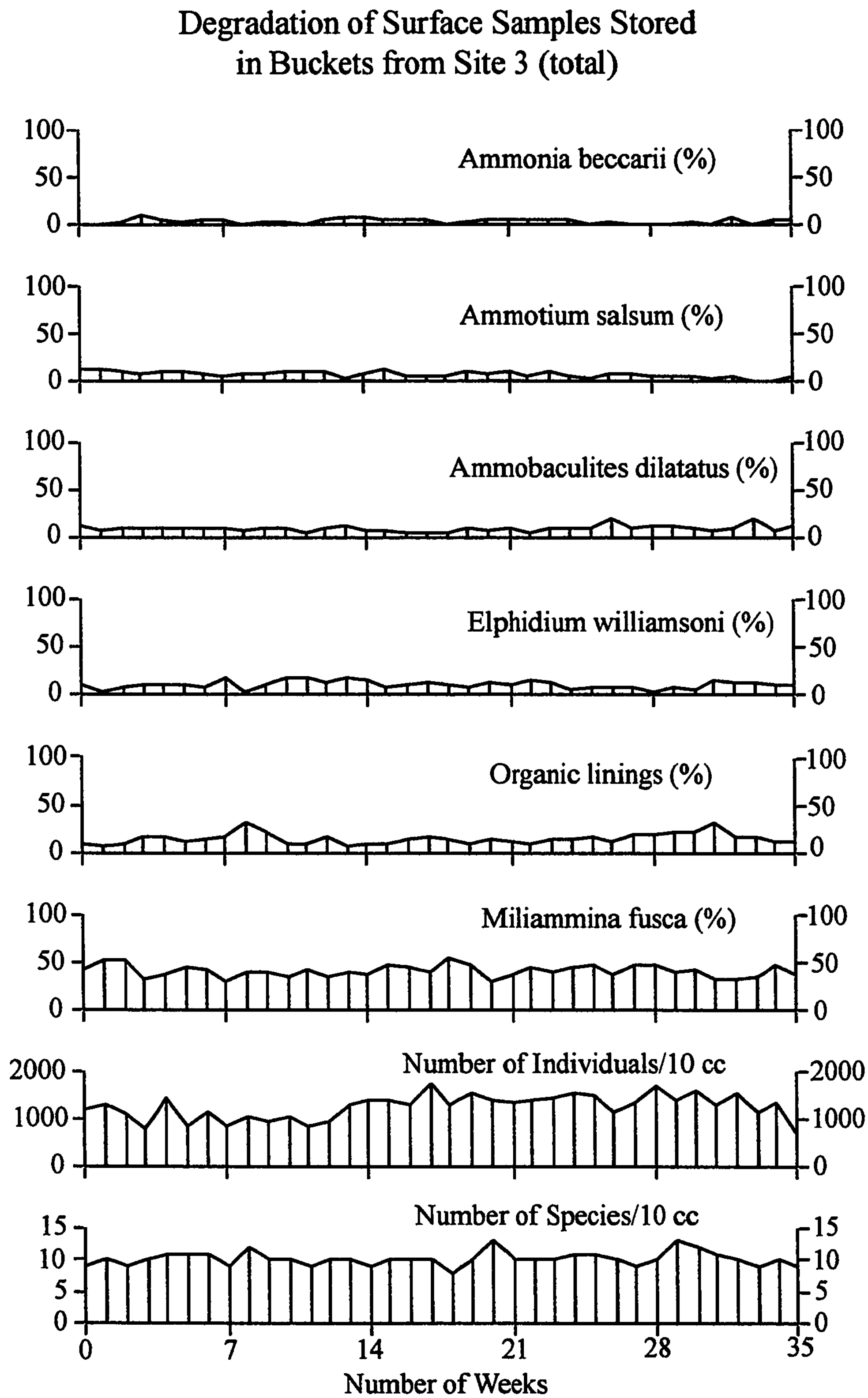


Figure 3.50- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 35 week period in surface sediment collected at Site 3, Chezzetcook Inlet.

Living: Numbers were identified up to week 13 ranging from 76 to 452 inds/ 10 cc's (Appendix Table 17; Figure 3.51); as in site 2, living numbers remained high to the end of week 13. *M. fusca* dominated the assemblage in the first few weeks and co-dominated with both *E. williamsoni* and *E. exc.* f. *clav* up to week 9. After this, calcareous species *(A. beccarii, E. williamsoni* and *E. exc.* f. *clav.*) dominated the assemblage up to week 13. Moderate percentages of *A. beccarii* (0- 17.4 %) occurred up to week 12 and dominated the assemblage at week 13 (47.5 %). There were low percentages of *A. dilatatus* (0- 15.1 %) up to week 13 and low numbers of A. *salsum* (0- 18.3 %) were also present up to week 11. Living representatives of *Pseudothuriammina limnetis* (5.3 %) occurred only at week 0.

3.3.2 Material in Bags

The three samples that were collected and stored in resealable bags were from the same sites that the cores and surface samples were collected. Like the material from the buckets, all samples showed similar results; foraminiferal abundances remained relatively unchanged at room temperature after all the material was used (in this case 15 weeks). The total foraminiferal assemblage at each site was quite constant with one species generally dominating with a few others completing the assemblage. Live foraminiferal abundances were very low at sites 2a and 3 (less than 100 specimens) and quite variable at all three sites.

Degradation of Surface Samples Stored
in Buckets from Site 3 (live)

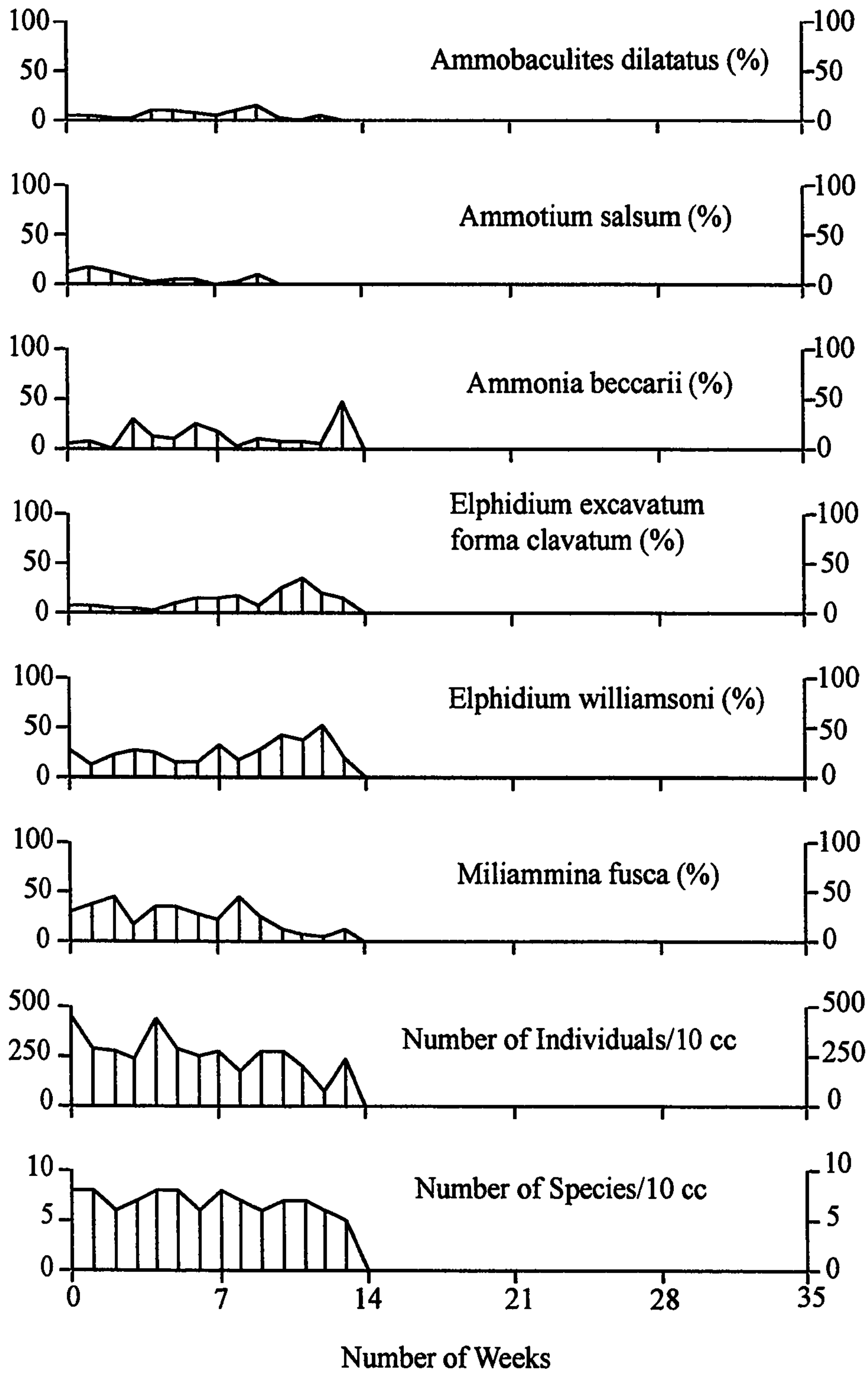


Figure 3.51- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 35 week period in surface sediment collected at Site 3, Chezzetcook Inlet.

3.3.2.1 Site 1 Surface Samples in Bags

Total: In the 15 weeks that material was examined, numbers were very high ranging from 2400 to 11088 inds/ 10 cc's (Appendix Table 18; Figure 3.52). There were no signs of degradation after the 15 weeks as numbers remained extremely high (11, 088 inds/ 10 cc's). *Trochammina macrescens* forma *macrescens* dominated the assemblage in all 15 weeks (70.8- 94.6 %). Low percentages of *Tiphotrocha comprimata* (1.2- 7.1 %) and the thecamoebian *Centropyxis aculeata* (0.6- 13.4 %) occurred which rounded out the assemblage. Very low values of *Miliammina fusca* (0.2- 2.9 %) were present throughout the 15 week period.

Living: Foraminifera were identified up to week 14 ranging from 16 to 1896 inds/ 10 cc's, with peak values occurring in the first two sampling times, however at weeks 4, 7, 8, 13, and 15, there were no specimens identified (Appendix Table 18; Figure 3.53). This response was similar to the site 1 samples not sealed with most of the living populations disappearing after week 7-8. *T. mac. f. mac.* dominated the assemblage (80- 100 %). Specimens of *M. fusca* occurred only in weeks 1 and 2 (3.4 and 20 % respectively). Low percentages of *Tiphotrocha comprimata* (3.8- 7.9 %) were identified at weeks 0-1 and 5 and 6. Specimens of *T. inflata* were identified at week 1 (5.1%) and *C. aculeata* specimens were counted at weeks 0-1.(1-1.7 % respectively).

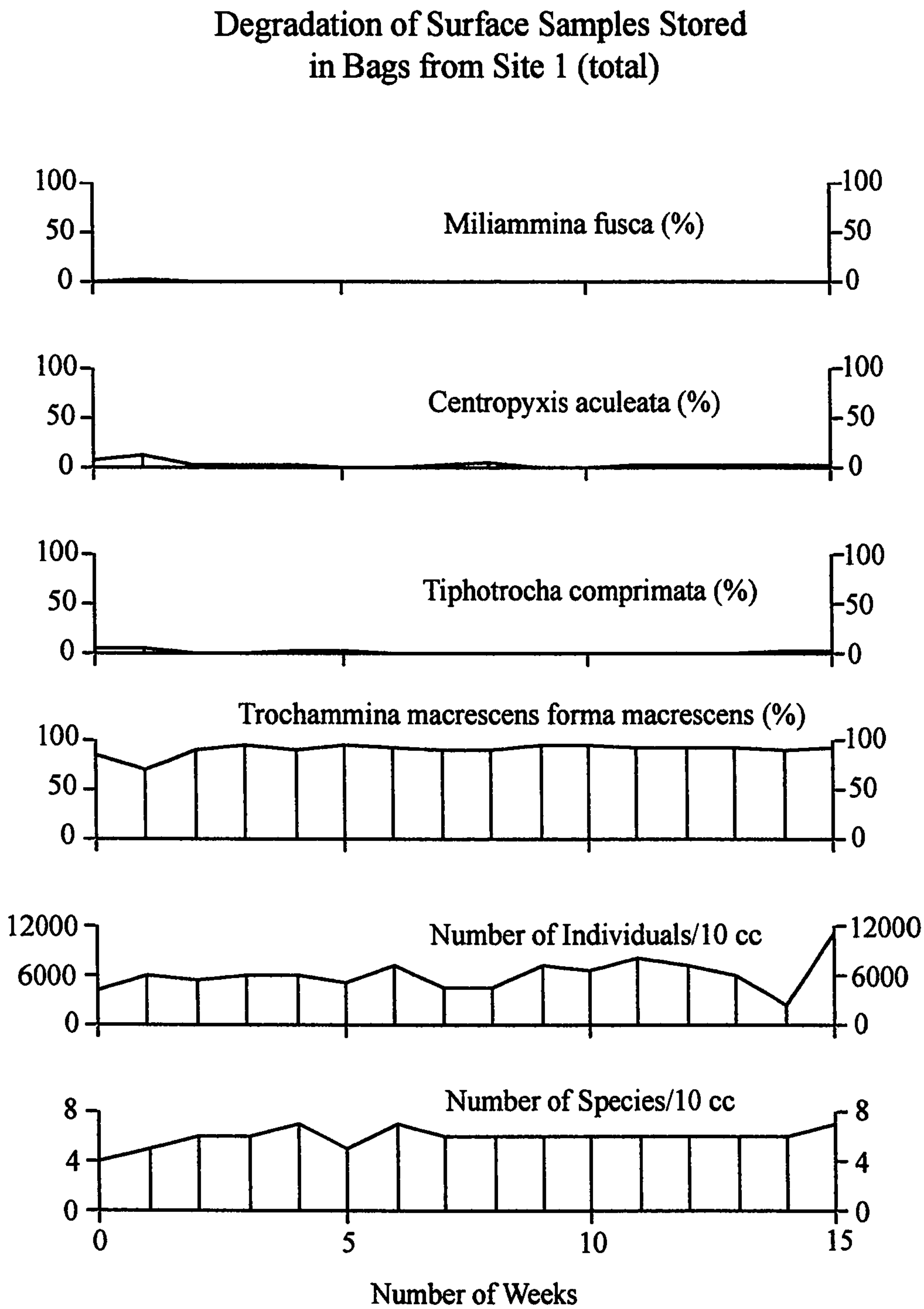


Figure 3.52- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 15 week period in surface sediment collected at Site 1, Chezzetcook Inlet.

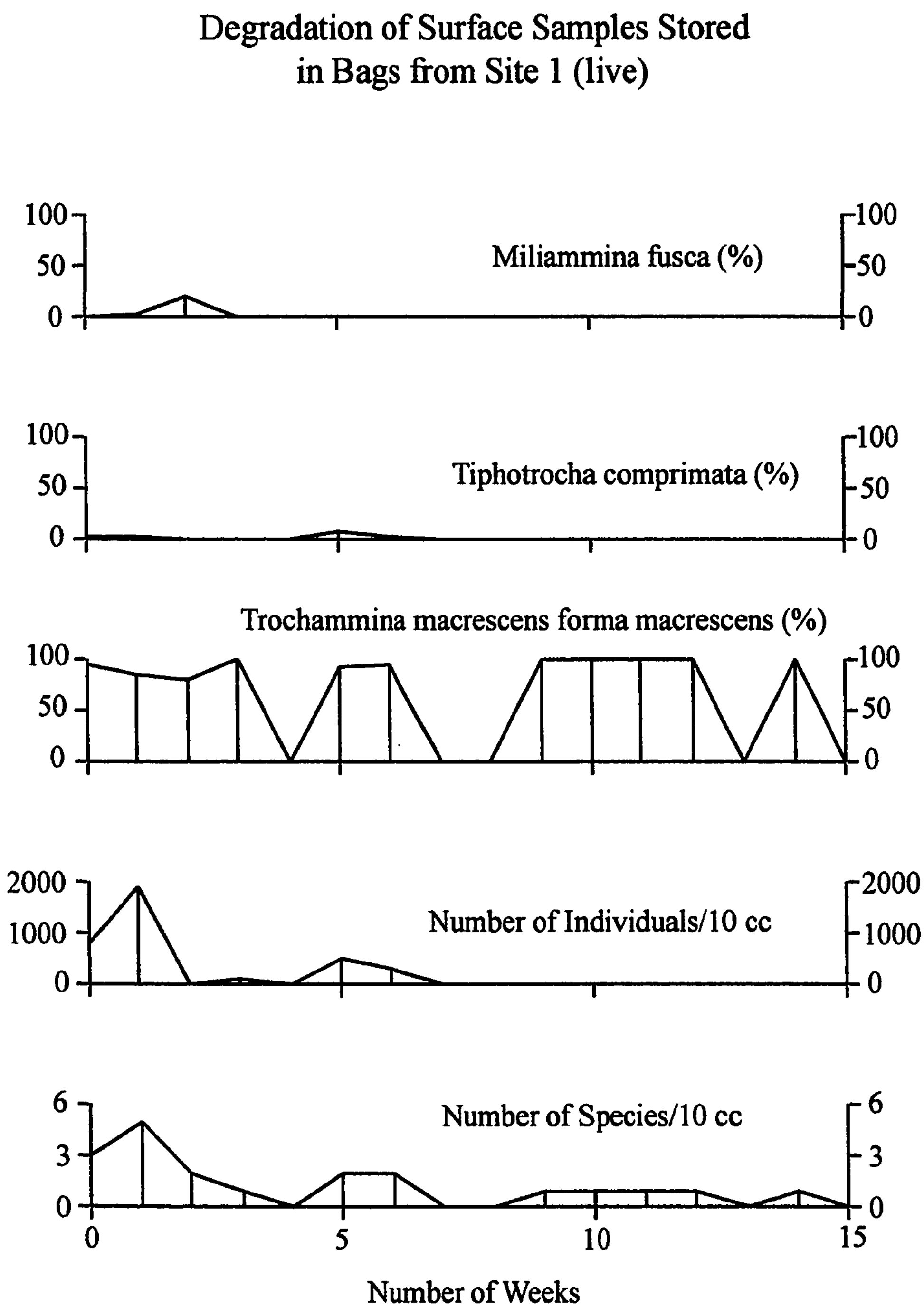


Figure 3.53- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 15 week period in surface sediment collected at Site 1, Chezzetcook Inlet.

3.3.2.2 Site 2 Surface Samples in Bags

Total: In the 15 weeks that samples were examined, numbers ranged from 60 to 448 inds/ 10 cc's (Appendix Table 19; Figure 3.54). *Miliammina fusca* generally dominated the assemblage (49- 83.3 %) at weeks 0- 10 and 14- 15 and co-dominated with *Trochammina macrescens* forma *macrescens* (41.6- 46 %) at weeks 11- 13 (39.6- 44.4 %). Moderate percentages of *T. ochracea* (0- 21.4 %) and organic linings (0- 20.8 %) were identified over the 15 week interval. Low percentages of *Eggerella advena* (0- 7.7 %), with a peak value of 9.4 % occurring at week ten, were also identified over the study period. Again, there were no signs of degradation after 15 weeks as total numbers remained relatively constant.

Living: Abundances were very low and were identified up to week 8 ranging from 0 to 25 inds/ 10 cc's (Appendix Table 19; Figure 3.55). As well, at weeks 0, 2, 4, and 7, no living representatives were identified. *Miliammina fusca* dominated the assemblage (60- 100 %). Living *Ammobaculites dilatatus* were identified at week 1 (40 %) and *T. macrescens* forma *macrescens* (16.7 %) specimens were counted at week 3. Low percentages of *T. inflata* (16 and 14.3 %) were identified at weeks 5 and 6 respectively.

3.3.2.3 Site 3 Surface Sample

Total: In the 15 weeks that samples were examined, numbers ranged from 162 to 840 inds/ 10 cc's (Appendix Table 20; Figure 3.56). *Miliammina fusca* dominated the

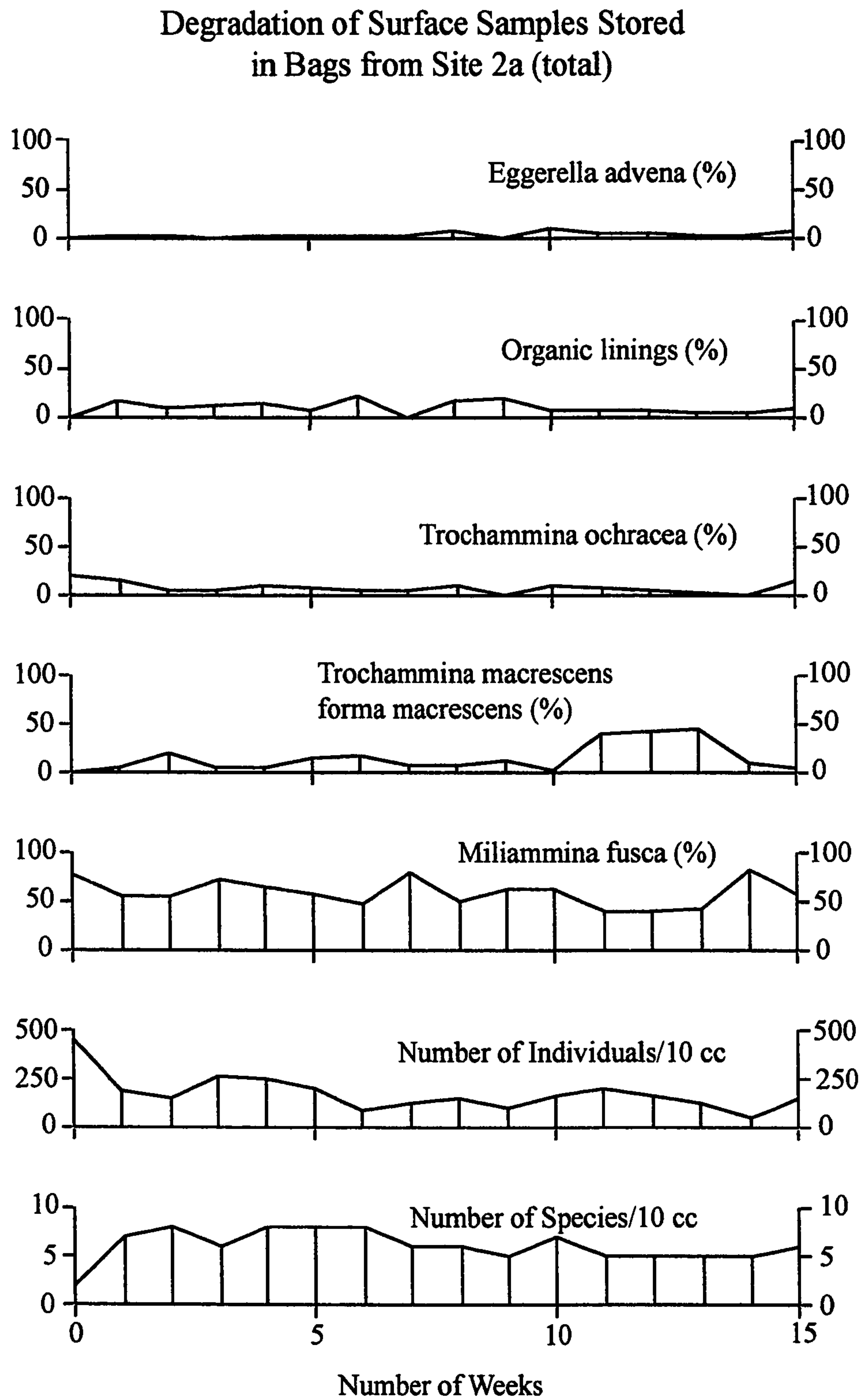


Figure 3.54- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 15 week period in surface sediment collected at Site 2a, Chezzetcook Inlet.

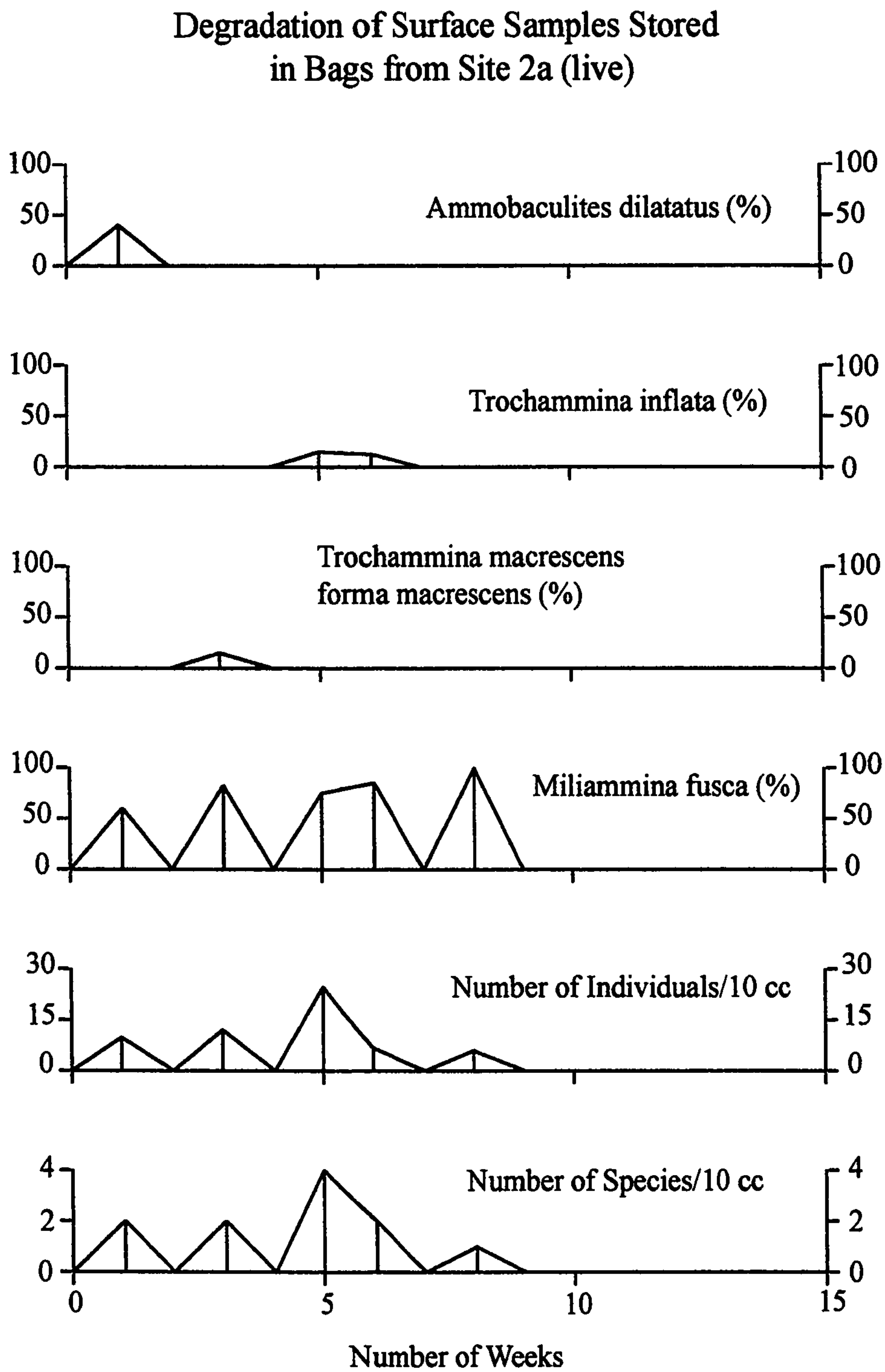


Figure 3.55- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 15 week period in surface sediment collected at Site 2a, Chezzetcook Inlet.

Degradation of Surface Samples Stored in Bags from Site 3 (total)

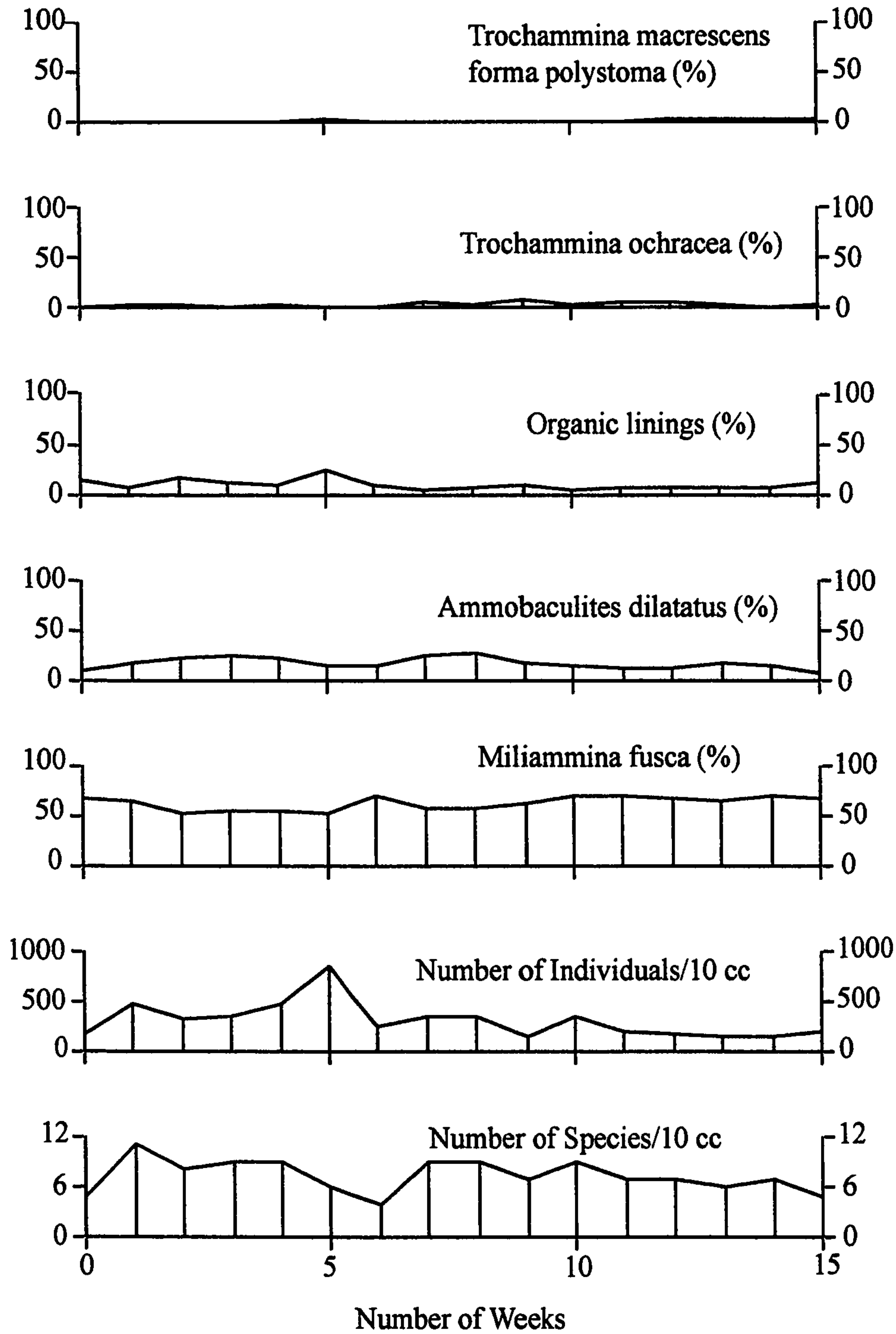


Figure 3.56- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage over a 15 week period in surface sediment collected at Site 3, Chezzetcook Inlet.

assemblage (52.4- 71.1 %) throughout the 15 week interval. Moderate percentages of *Ammobaculites dilatatus* (9.8- 27.3 %) and organic linings (3.5- 24.8 %) were identified over the study period. Low percentages of *Trochammina ochracea* (0- 8.2 %) were also identified over the 15 weeks. Again, there were no signs of degradation after 15 weeks as total numbers, save for a few weeks, remained relatively constant.

Living: Numbers were very low and were identified up to week 8 and ranging from 8 to 64 inds/ 10 cc's (Appendix Table 20; Figure 3.57) with no living representatives counted at week 7. *A. dilatatus* dominated the assemblage at weeks 2 and 3 (80 and 75 %) respectively and co-dominated with *M. fusca* at weeks 0 and 1 (60 and 50 %). *M. fusca* dominated the assemblage at weeks 5, 6, and 8 (87.5, 100, and 100% respectively). Specimens of *Elphidium williamsoni* were identified at week 4 and co-dominated the assemblage with *A. dilatatus* (24 %) and *M. fusca* (36 %) at this interval.

3.3.3 Core2-1992 (near Site 1) Interval 60-70 cm

Total: In the 85 weeks that sampling took place between intervals 60- 70 cm, numbers were quite high ranging from 2720 to 10768 inds/ 10 cc's (Appendix Table 21; Figure 3.58). *Trochammina macrescens* forma *macrescens* completely dominated the assemblage (94.2- 98.9 %) in all 85 weeks. Very low percentages of *Miliammina fusca* (0-

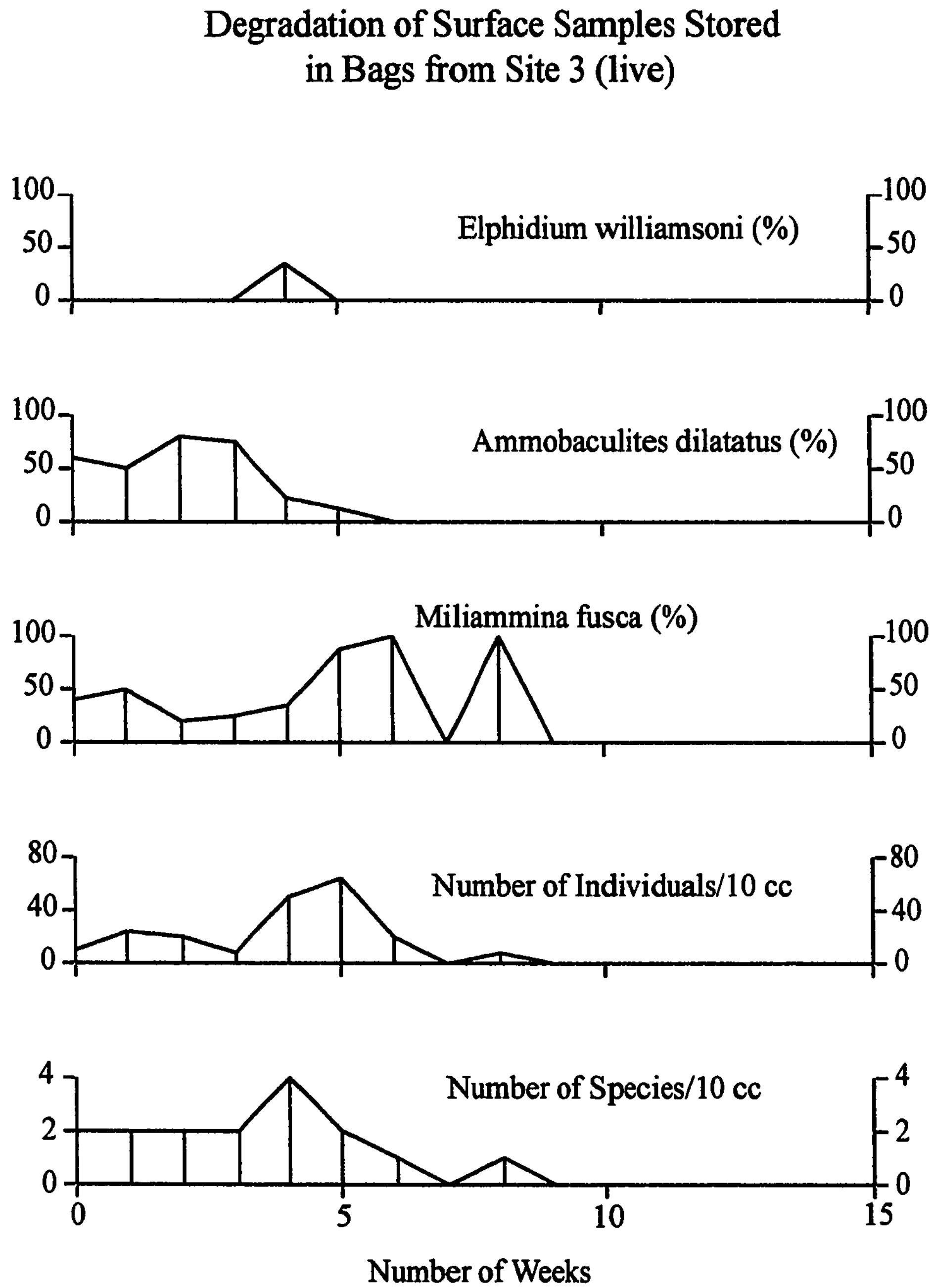


Figure 3.57- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the live foraminiferal assemblage over a 52 week period in surface sediment collected at Site 3, Chezzetcook Inlet.

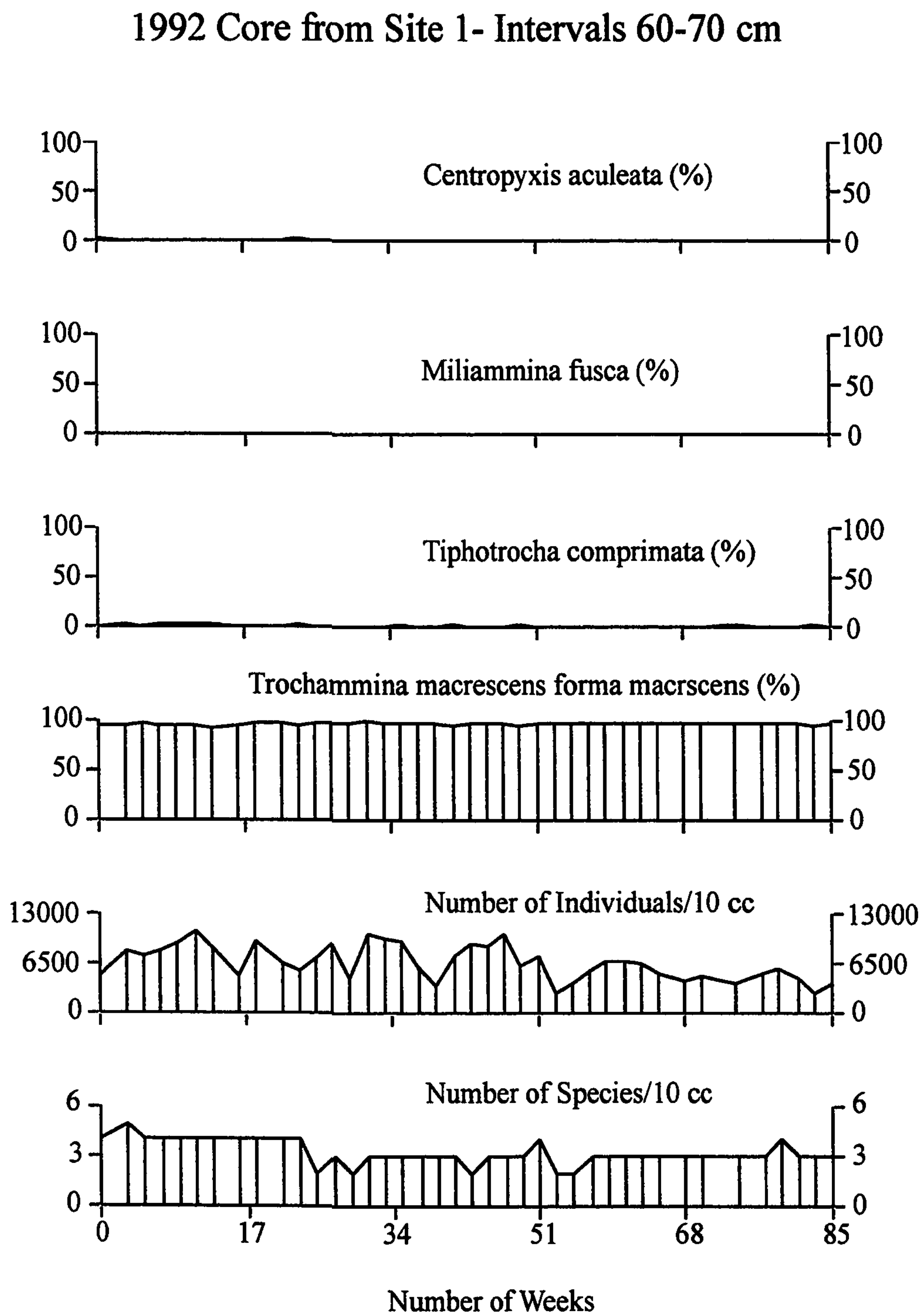


Figure 3.58- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from a 1992 core collected near Site 1, Chezzetcook Inlet.

2.4 %) and *Tiphotrocha comprimata* (0-4.6 %) were present throughout the 85 week study period. Low values of *Centropyxis aculeata* (0- 3.2 %), a thecamoebian, were identified down to week 31. There was a slight decrease in abundance after week 53 however, numbers remained relatively high and as a result, there were no signs of degradation of foraminiferal tests spanning the 85 weeks.

3.3.4 Core 2-1992 (near Site 1) Interval 175-185 cm

Total: In the 85 weeks that sampling took place between intervals 175- 185 cm, numbers ranged from 496 to 8704 inds/ 10 cc's (Appendix Table 22; Figure 3.59) with peak values occurring between weeks 16- 33. *Trochammina macrescens* forma *macrescens* dominated the assemblage (68.5- 96.8 %) in all 85 weeks. Moderate percentages of *Tiphotrocha comprimata* (1.9 -29.7 %) were identified throughout the 85 week period. Low percentages of *Trochammina inflata* (0- 8.9 %) were present in the study interval. Very low values of *Centropyxis aculeata* (0- 3.8 %) and *Miliammina fusca* (0- 2.5 %) were only identified down to week 35 and week 51 respectively. Although total numbers decreased after week 35, there were no signs of foraminiferal degradation as the tests remained relatively robust; there were nearly 1000 individuals remaining after week 85.

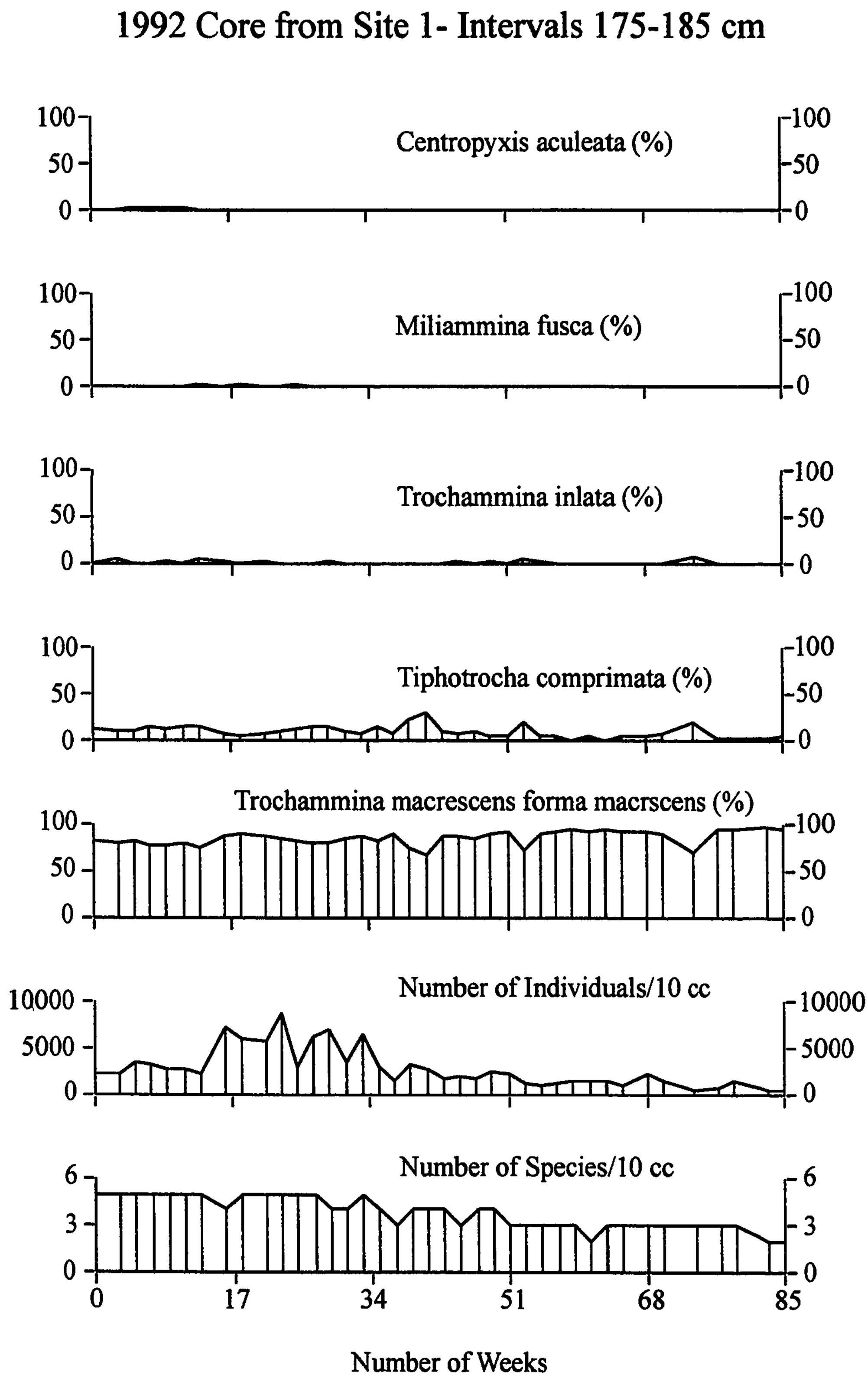


Figure 3.59- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from a 1992 core collected near Site 1, Chezzetcook Inlet.

CHAPTER IV

NEW BEDFORD HARBOR RESULTS

4.1 Geochemical Results

4.1.1 Surficial Transects

4.1.1.1 Transect 1- Upper Harbor to Lower Harbor

For the 12 samples examined in this transect (Figure 4.1), the concentrations of pollutants in sediments were highest in the Upper Harbor (Appendix Table 23; Figure 4.2). Al, Fe, and Mn are major components of the earth's crust and values are much higher than other metals; they are considered natural and not plotted in the figures. Organic carbon values ranged from 3 to 8.7 % with peak values occurring in the first three stations of the transect (i.e. Upper Harbor). Several heavy metals showed elevated concentrations in the sediment and these are plotted in figure 4.1. These metals, along with the total PCB and total aliphatic hydrocarbon (PAH) concentrations showed a distinct and similar trend. Their concentrations were highest in the first 3 or 4 stations and then values decreased to lowered levels.

4.1.1.2 Transect 2- Apponagensett Bay

For the 6 samples examined at this site, concentrations of metals, PCBs, and PAHs were relatively low (Appendix Table 24; Figure 4.3) with the lowest values occurring in the first station and steadily increased to the last station. Organic carbon values were quite low ranging from 0.8 to 2.7 %. The area is considered unimpacted because the concentration of contaminates was low in this transect.

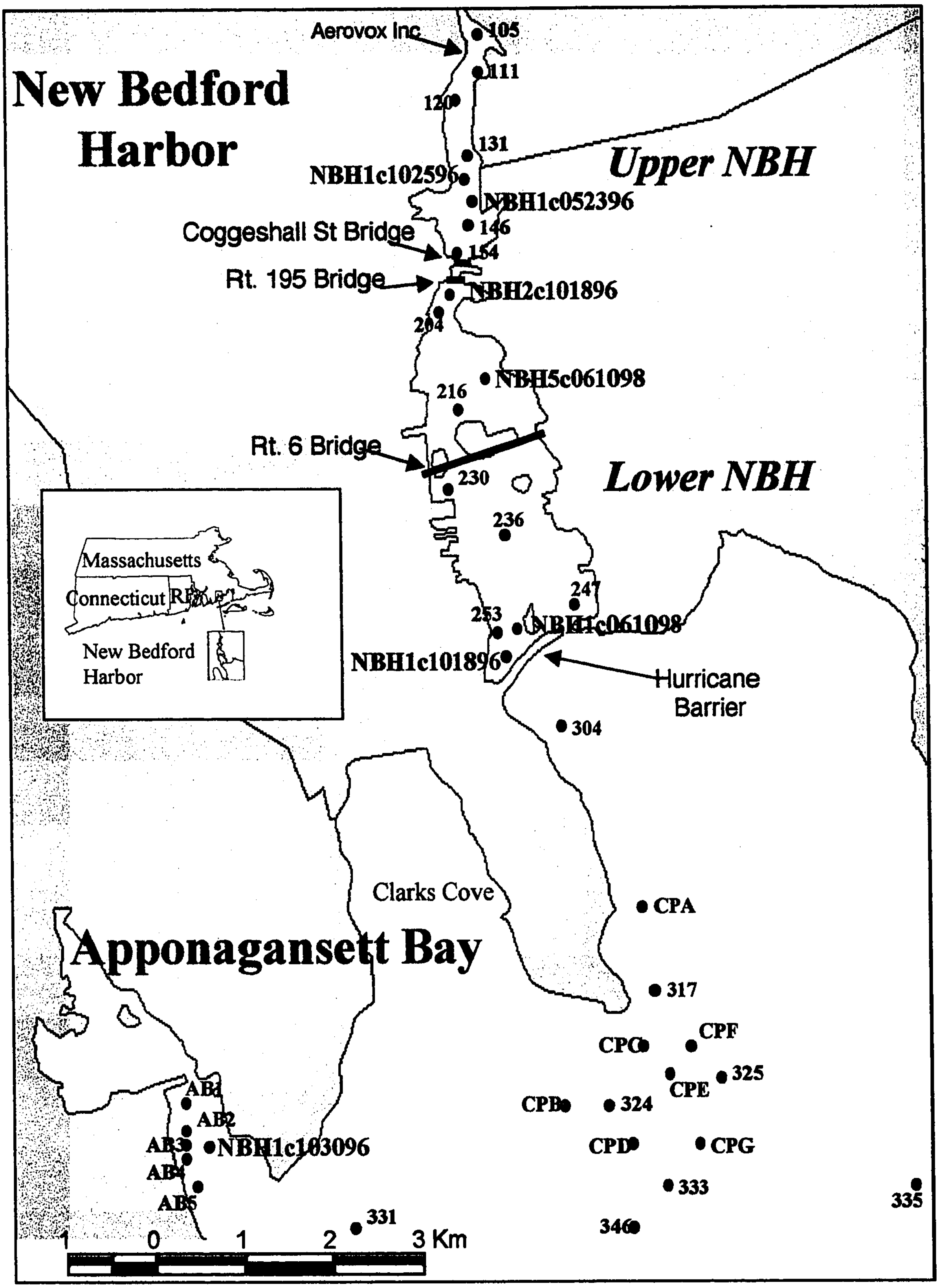


Figure 4.1- Location map of New Bedford Harbor, Massachusetts, showing the positions of surface stations and core sampling sites.

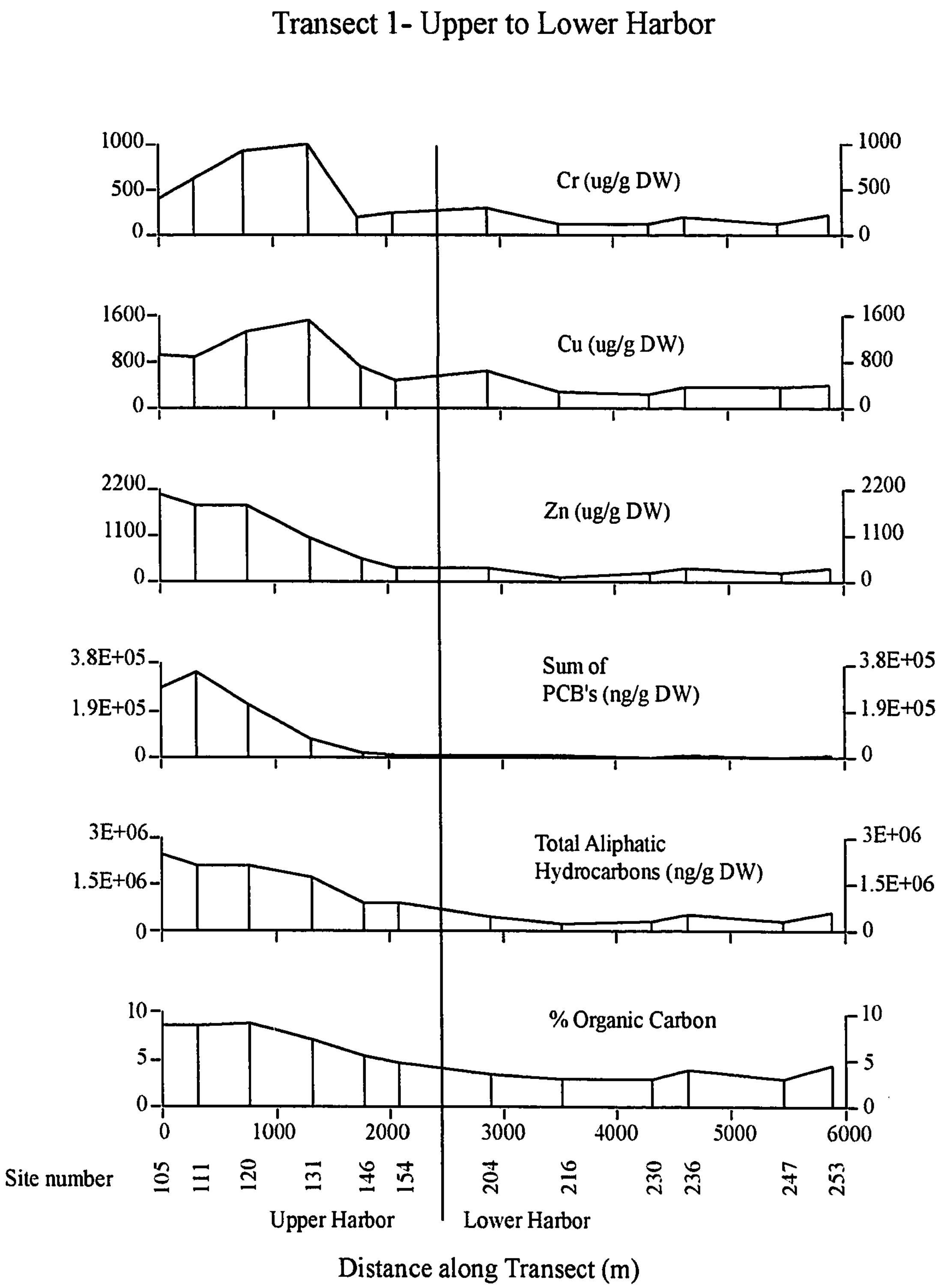


Figure 4.2- Profile of metal, PCB, hydrocarbon, and OC concentrations for transect 1 from upper to lower harbor, NBH.

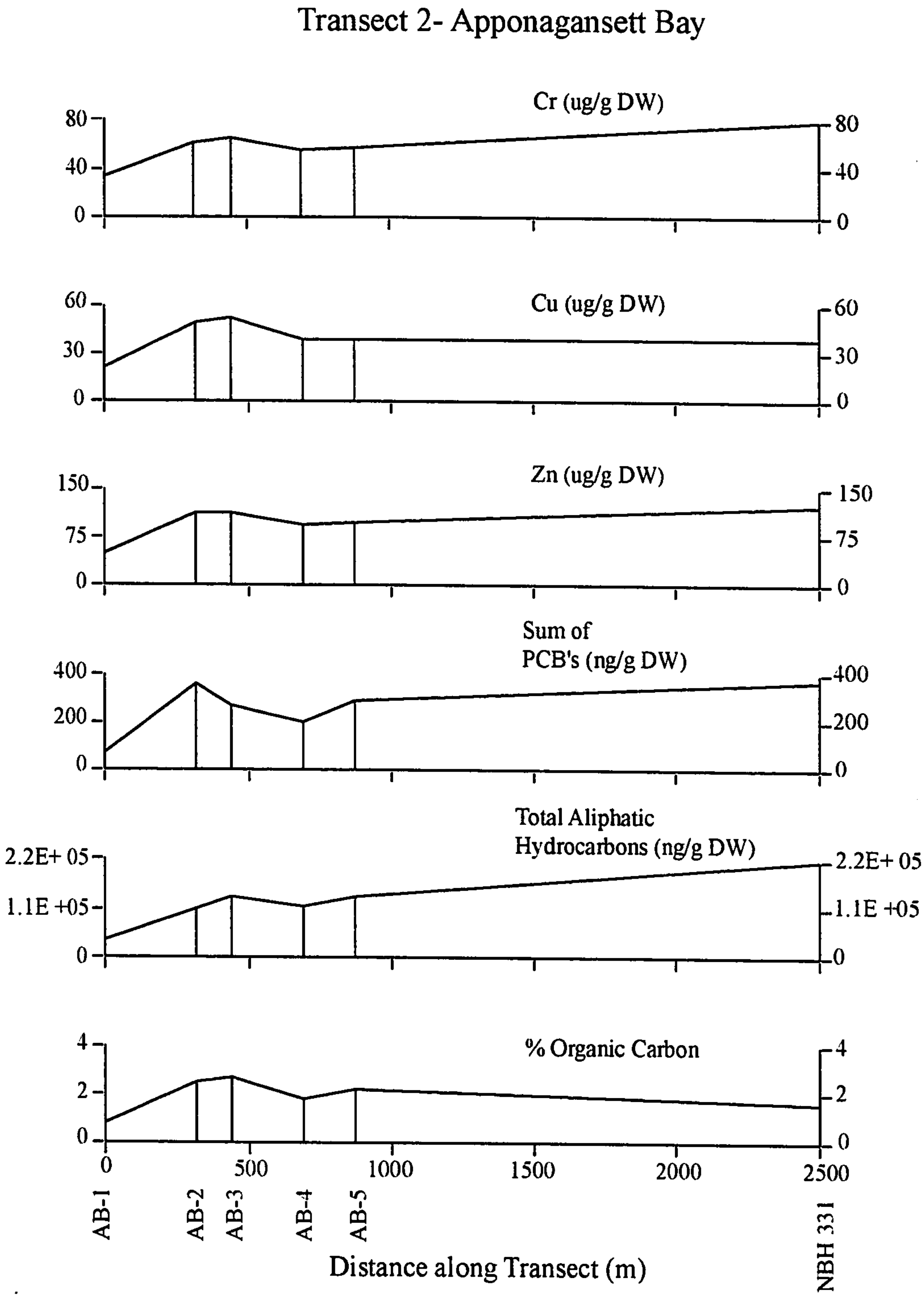


Figure 4.3- Profile of metal, PCB, hydrocarbon, and OC concentrations of surface samples from Apponagansett Bay.

4.1.1.3 Clark's Point Outfall Samples

For the 14 samples examined at this site, sediment chemistry concentrations were quite variable (Appendix Table 25; Figure 4.4). **Samples collected around Clark's Point outfall were plotted as distance from the outfall, not as a transect.** Metal concentrations near Clark's Pt. outfall were low with one high peak value of chromium reaching 1020 ug/g DW at site CP-D, which is an outlier in this set of samples. PCB concentrations were relatively low when compared to the inner harbor and peak values of PAHs were high at the stations near the outfall area probably the result of urban runoff and high organic content. This site was variable with relatively low metals and PCBs but higher in other pollutants.

4.1.2 New Bedford Harbor Cores

4.1.2.1 Upper Harbor

The two cores that were collected and analyzed from the upper harbor displayed the same type of trend; reference levels of pollutants in the lower parts of the cores, increasing to peak values below the surface then decreasing to present day at the surface although surface concentrations are still above background values. The oldest part of the first core is dated at the base as 1836 AD while the oldest part of the second core is dated at the base 1875 AD with Pb-210 dates extrapolated to dates older than 100 yBP.

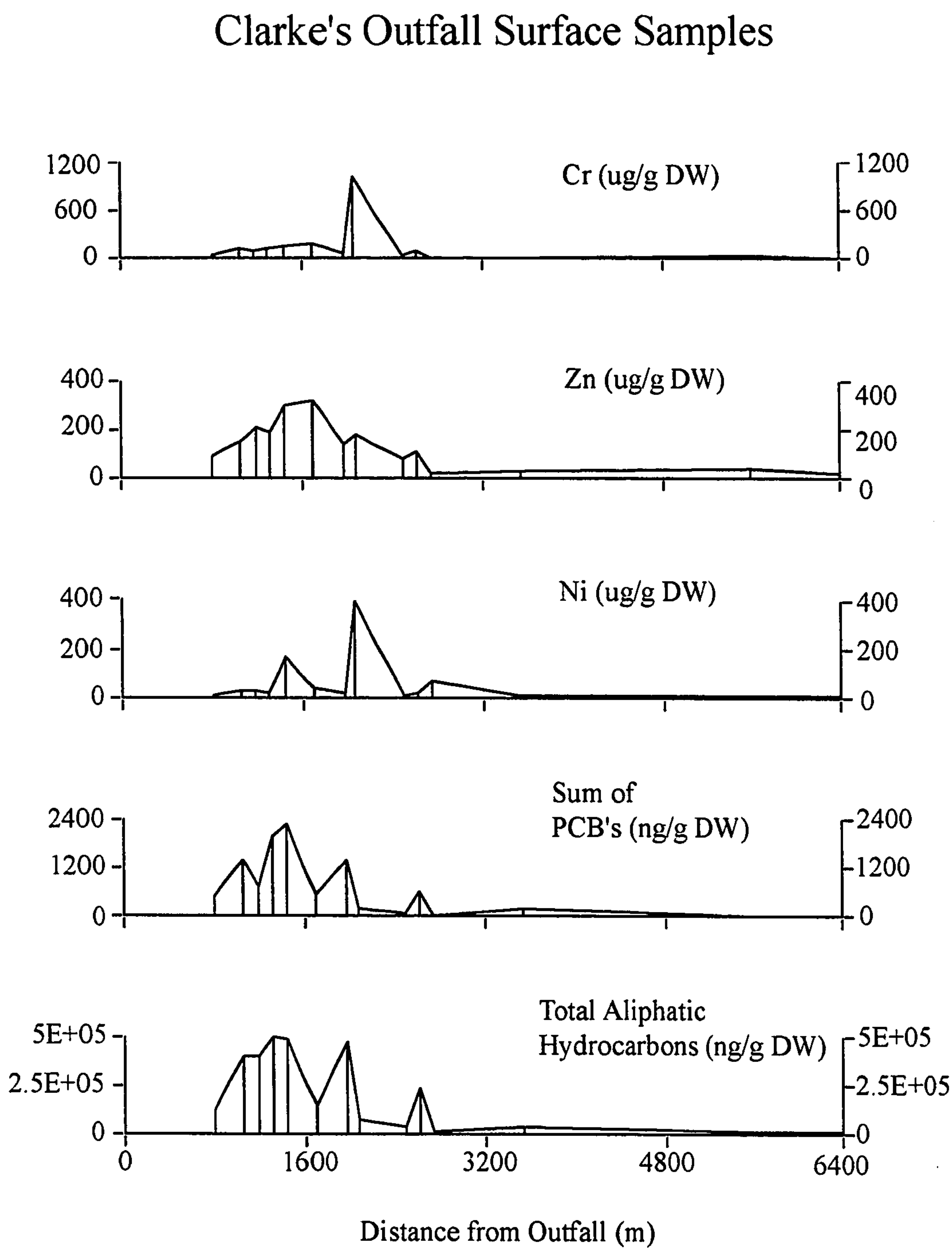


Figure 4.4- Profile of metal, PCB, and hydrocarbon concentrations of surface samples from Clarke's Outfall, NBH.

4.1.2.1a Core 1c052396

Organic carbon concentrations were low in the bottom half of the core (~2%) but increase to 5% at around 23 cm (Appendix Table 26; Figure 4.5). The increase in organic carbon corresponded to the increase of pollutants above reference levels until they reached peak values near 10 cm which has been dated at 1971. Total aliphatic hydrocarbons (PAHs), PCBs, and heavy metals all displayed similar trends of increasing to peak concentrations and decreasing towards the surface. Peak values of PAH, which occur at 10 cm, reached $6.25 * 10^6$ ng/g DW while peak concentrations of PCBs were 177, 000 ng/g DW. Heavy metals such as Zn, Cu, and Cr reached peak concentrations of 2500, 2360, and 1740 ug/g DW respectively; other contaminant metals followed similar patterns. The core has been dated using the profiles of excess Pb-210 activity. The date at the base has been determined to be 1836 AD.

4.1.2.1b Core 1c102596

Organic carbon percentages showed a similar trend to the previous core; low values (~2%) in the lower part of the core and increasing (up to 7%) near the 30 cm level, corresponding to a similar increase of pollutants (Appendix Table 27; Figure 4.6). The pollutant profiles increased from reference conditions near the 30 cm interval until they reached peak values at 15 cm and then decreased toward the top of the core. Peak PCB concentrations, which has been determined to have occurred in 1971 when a peak in national production of PCBs took place, were slightly lower in this core. PAH concentrations reached a peak value of $3.42 * 10^6$ ng/g DW while PCB concentrations

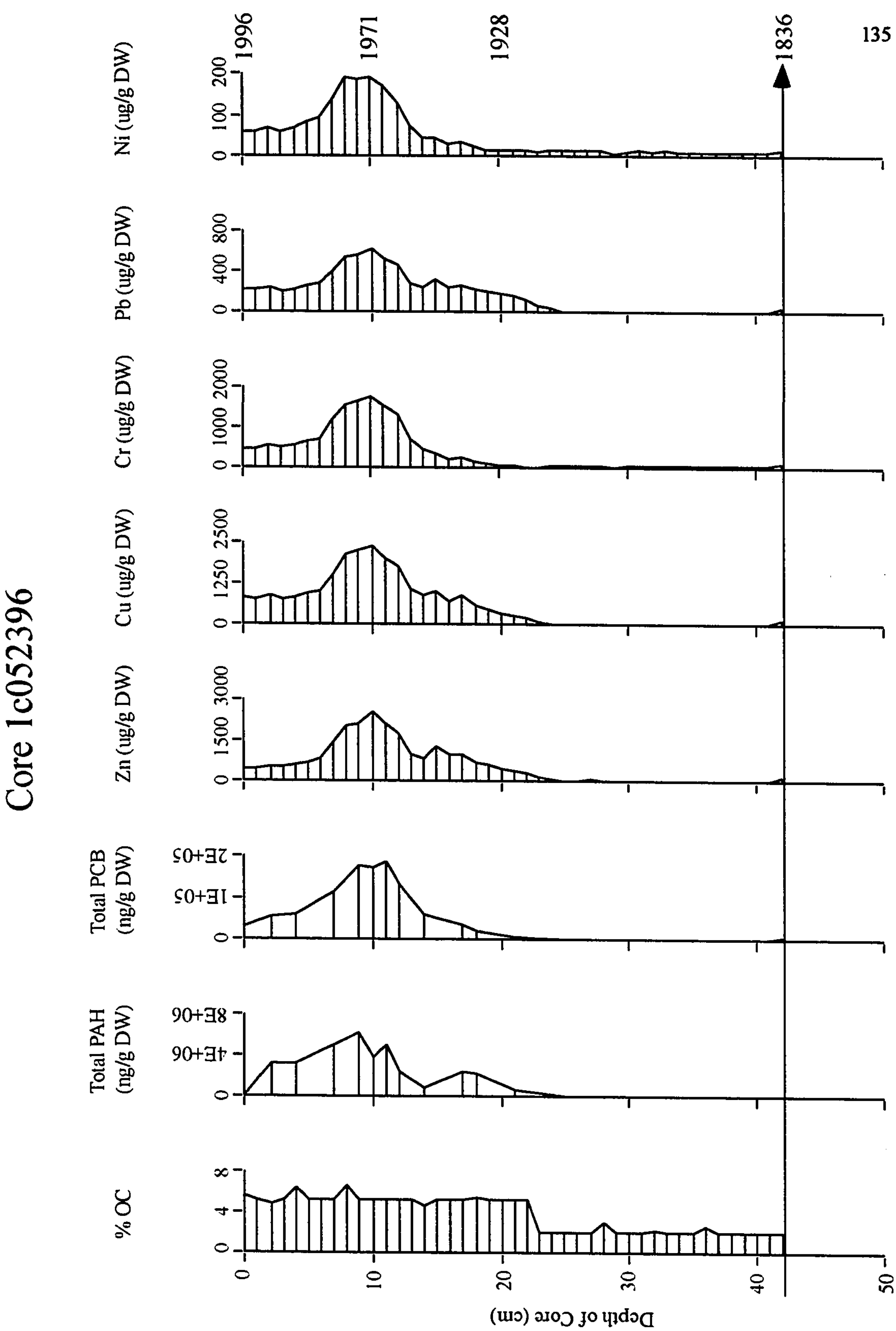


Figure 4.5- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 1c052396, NBH.

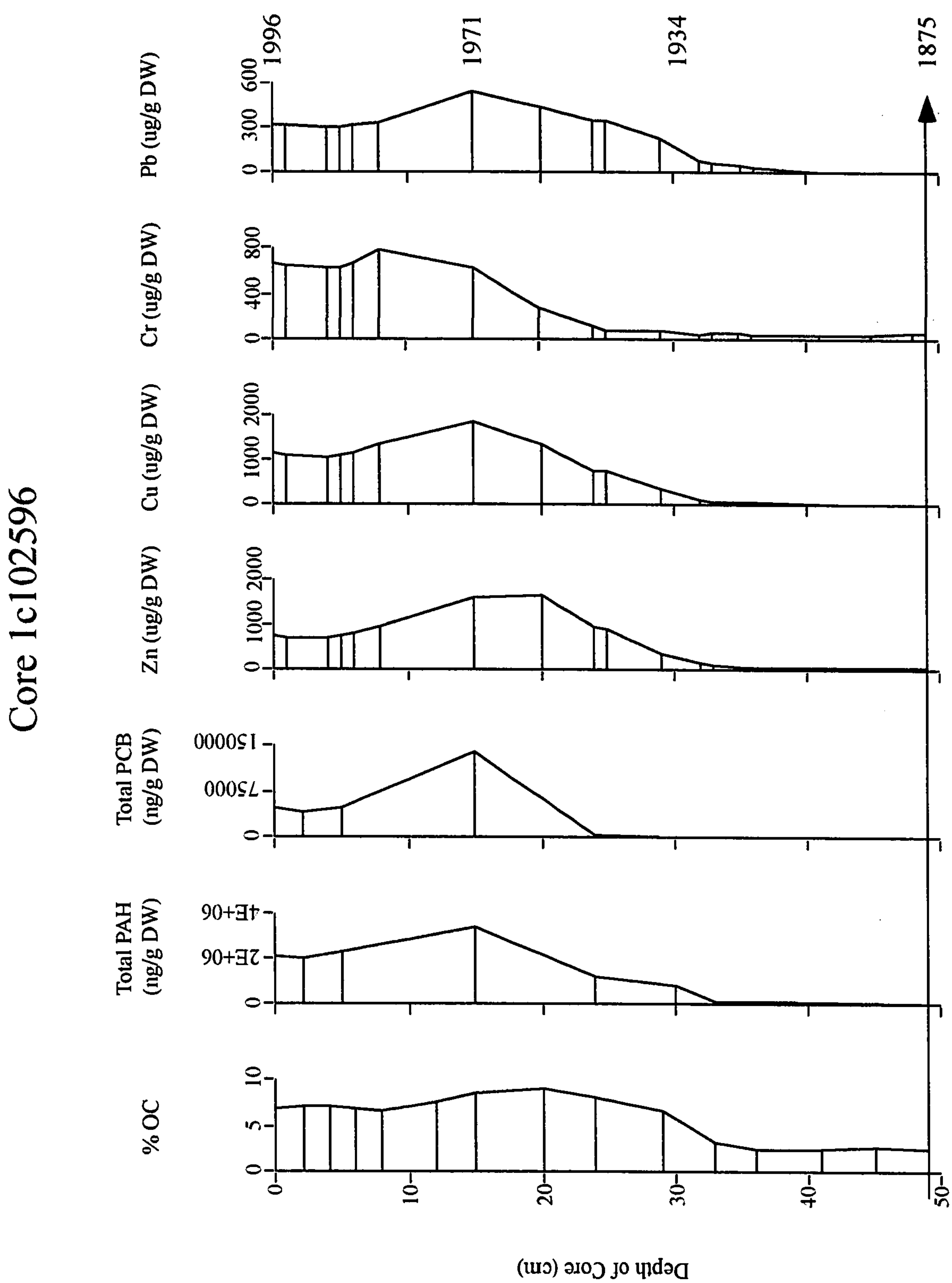


Figure 4.6- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 1c102596, NBH.

reached 142, 000 ng/g DW. Zn and Cu reached peak values between 1910 and 1931, Cr from 1960 to present, Ni from 1931 to present, Cd between 1931 and 1973, and Ag between 1910 and present. The date assigned to the base of the core is 1875 AD.

4.1.2.2 Lower Harbor

4.1.2.2a Core 2c101896

Organic carbon percentages increased above the 35 cm interval and remained relatively constant to the top of the core (~7%) (Appendix Table 28; Figure 4.7). PAH concentrations were an order of magnitude higher in this core than the first few cores and reached a peak value near 60 million ng/g DW at 45 cm and remained high throughout the rest of the core. PCB concentrations were low in this core attaining a peak value of 33000 ng/g DW at 40 cm and quickly decreasing to near background levels to the top of the core. Patterns for most metals are similar- close to background values near the base, elevated up core with slight decrease at the surface. Zn and Cu displayed background levels below 48 cm but increased above this interval. A peak value of Zn (1140 ug/g DW) occurred at 37 cm and decreased slightly to the top of the core. Cu concentrations were higher downcore than the surface ranging from 1020 to 1450 ug/g DW. Dating of this core is problematic but the date assigned to the base of the core is 1935 AD.

4.1.2.2b Core 5c061098

All pollutants displayed the similar trend in this core by departing from a background level at the 20 cm interval and increasing up to the surface of the core

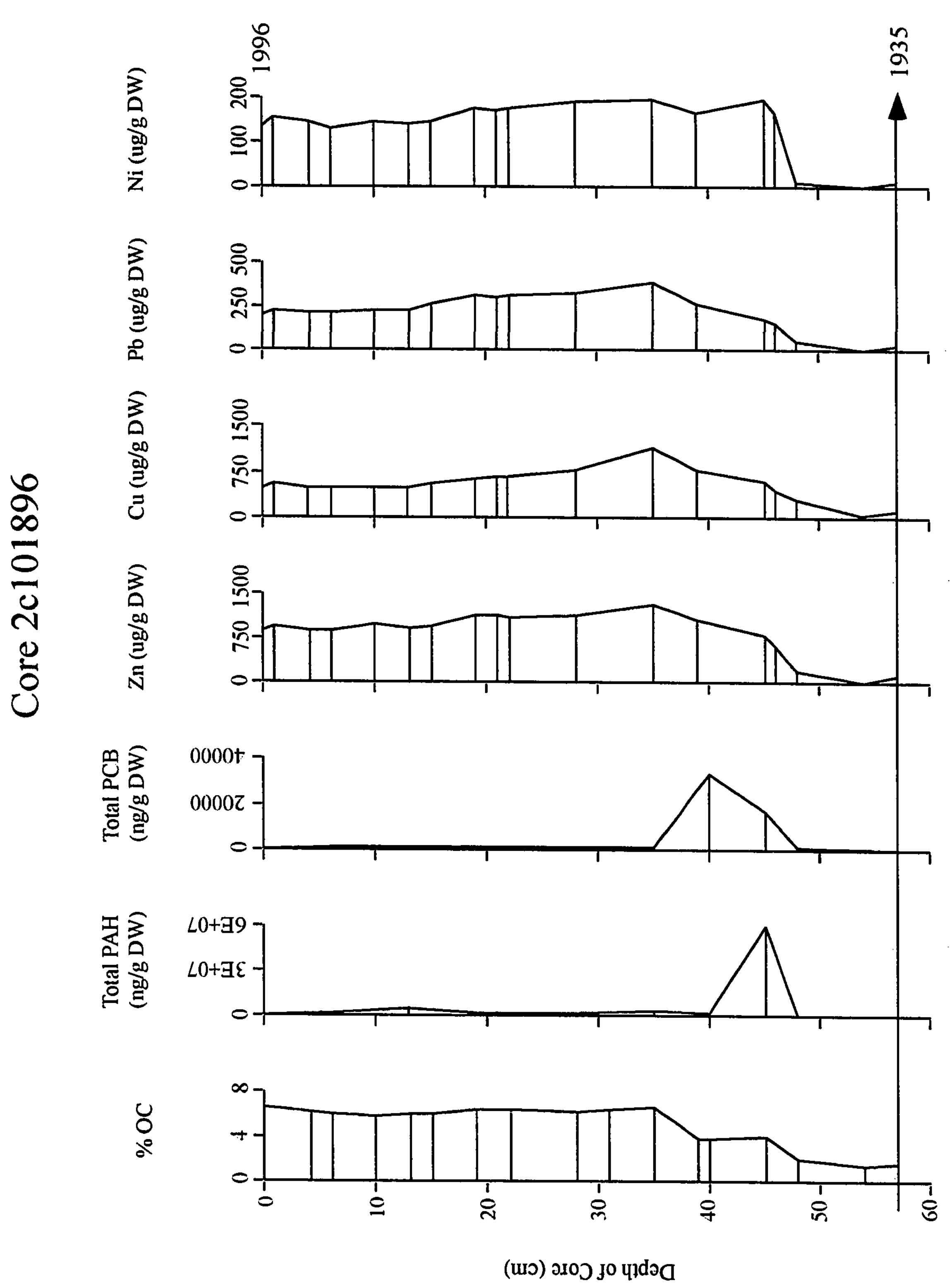


Figure 4.7- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 2c101896, NBH.

(Appendix Table 29; Figure 4.8). Organic carbon percentages remained relatively constant through the core (~2 %) up to the 11 cm level and increased up to almost 9 % up to the top of the core. PAH concentrations departed from background levels at 40 cm, which has been dated at 1925 AD, reaching peak values of $2.98 * 10^6$ ng/g DW at the surface. PCB concentrations were relatively low in this core but have peak values occurring at the surface reaching 17600 ng/g DW. Heavy metal concentrations were lower in this core with Cu the only metal exceeding 1000 ug/g DW. Peak values of Cu occurred at the surface and reached 2053 ug/g DW. Zn was the only other metal to have elevated concentration levels which peaked at 631 ug/g DW at the surface however, other metals were above background values at 40 cm (Pb), 6 cm (Cr), 16 cm (Ag), and 3 cm (Ni, Cd). The two models applied to interpret the Pb-210 data, the constant initial concentration (CIC) and constant rate of supply (CRS) models, were used down to 16 cm (dated at 1928 AD). From this horizon to the base of the core, an average sedimentation rate was calculated based on the date assigned to the 16 cm horizon plus the two horizons for which pollen analysis could be related to historical information where the oak/ragweed ratio decreased at the 50-51 cm interval, which corresponds with the clearance of 40-50% of the watershed (approximately 1834 in NBH) and at 90-91 cm where ragweed comprised greater than 1% of the total pollen, corresponding to initial settlement. Using this long-term average sedimentation rate, the base of the core was dated at 1245 AD. The chemical profiles for this core suggested that a portion of the top of the core was lost during collection. Through geochronological markers and constraints, it was suggested that the top of the core be dated at 1973 AD.

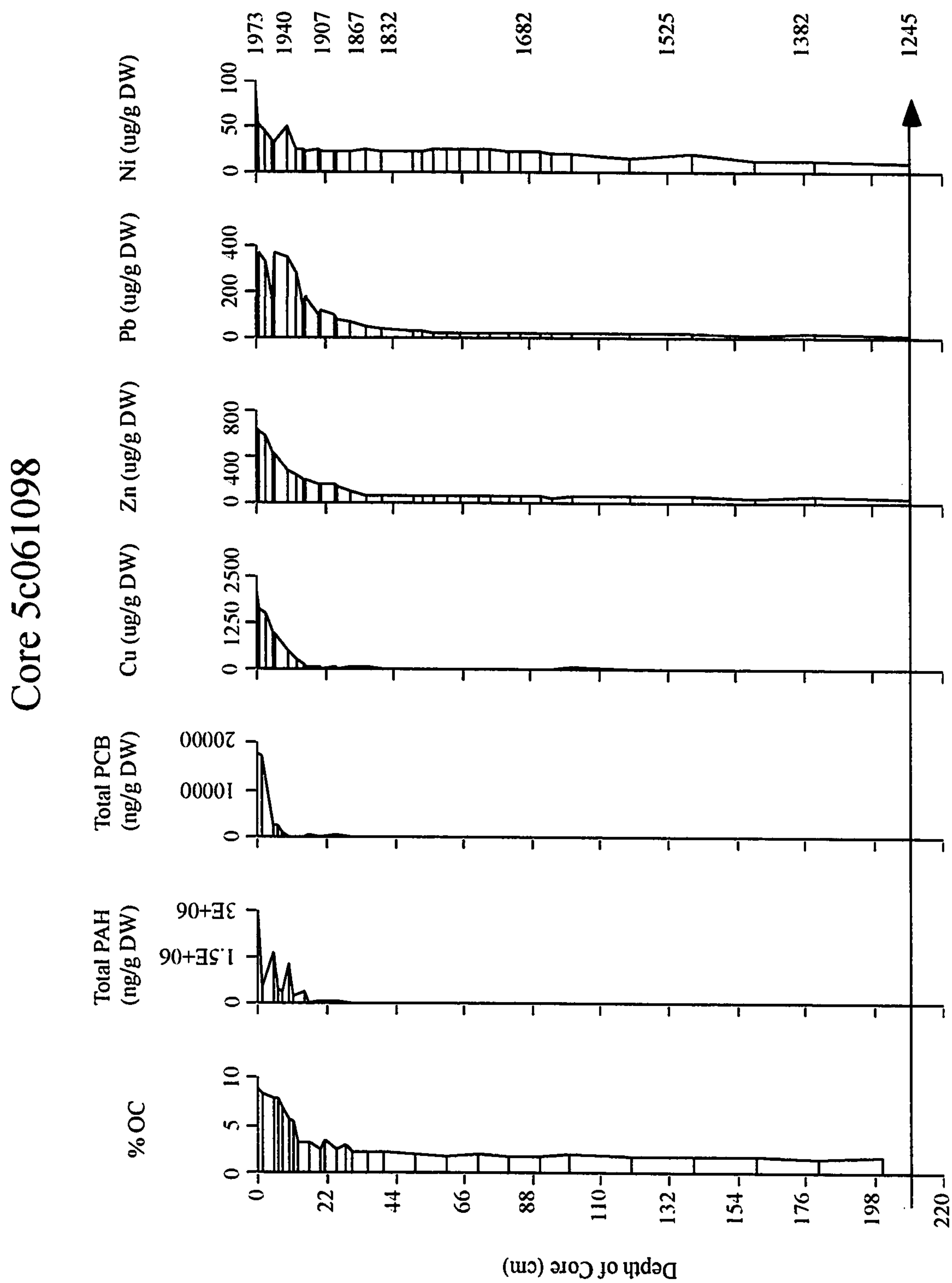


Figure 4.8- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 5c061098, NBH.

4.1.2.3 Hurricane Barrier Cores

4.1.2.3a Core 1c061098

Profiles of pollutants in this core showed an increase from lower (higher than background) levels that increased to peak values near the middle of the core and decreased to the top of the core (Appendix Table 30; Figure 4.9). The only exception to this was PAHs which showed a peak interval occurring in the upper part of the core reaching concentrations up to 406 million ng/g DW. PCB and Cu concentrations reached peak values of 24000 ng/g DW and 1240 ug/g DW respectively at 74 cm where a Pb-210 age of 1971 has been assigned. Organic carbon percentages peaked at the same interval (7.5%) and at the surface (7.6%). Only selected intervals have been analyzed for geochemistry and as a result, these pollutant profiles may change once more intervals are tested. The base of the core (130 cm) has been dated by Pb-210 as 1964 AD.

4.1.2.3b Core 1c101896

The final core in the Lower Harbor near the hurricane barrier displayed some interesting trends (Appendix Table 31; Figure 4.10). All pollutants showed a peak over a 10 cm interval occurring between 60- 70 cm, with peak values occurring at 68 cm, which has been assigned a Pb-210 date of 1972 AD. Within this interval, pollutant concentrations were relatively low compared with other cores. Total PAHs reached nearly 1 million ng/g DW, PCBs reached 16000 ng/g DW, and heavy metal concentrations such as Zn, Cu, and Cr peaked at values of 268, 470, and 212 ug/g DW respectively (5 to 10 times their background levels). Above this interval, pollutants

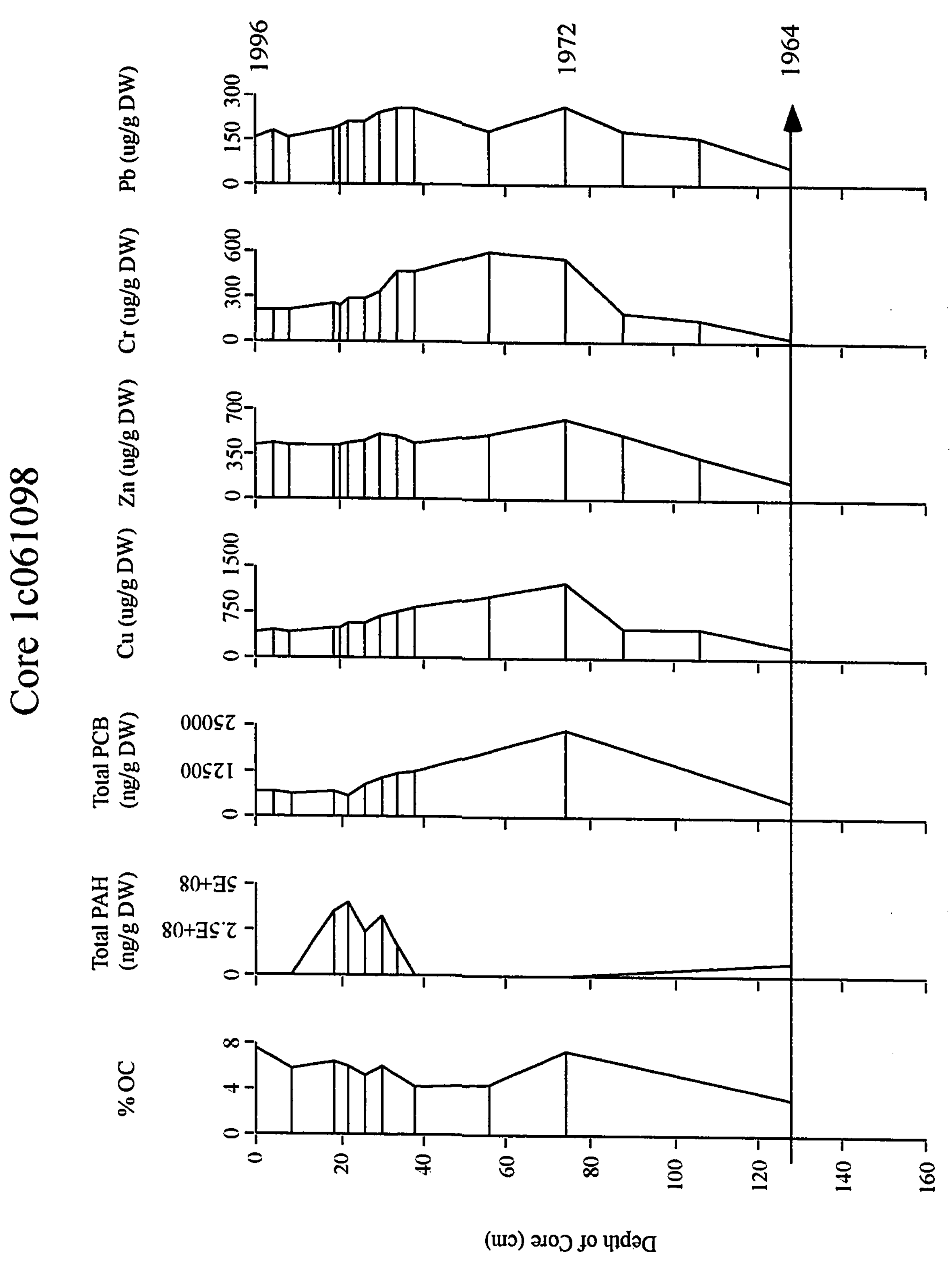


Figure 4.9- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 1c061098, NBH

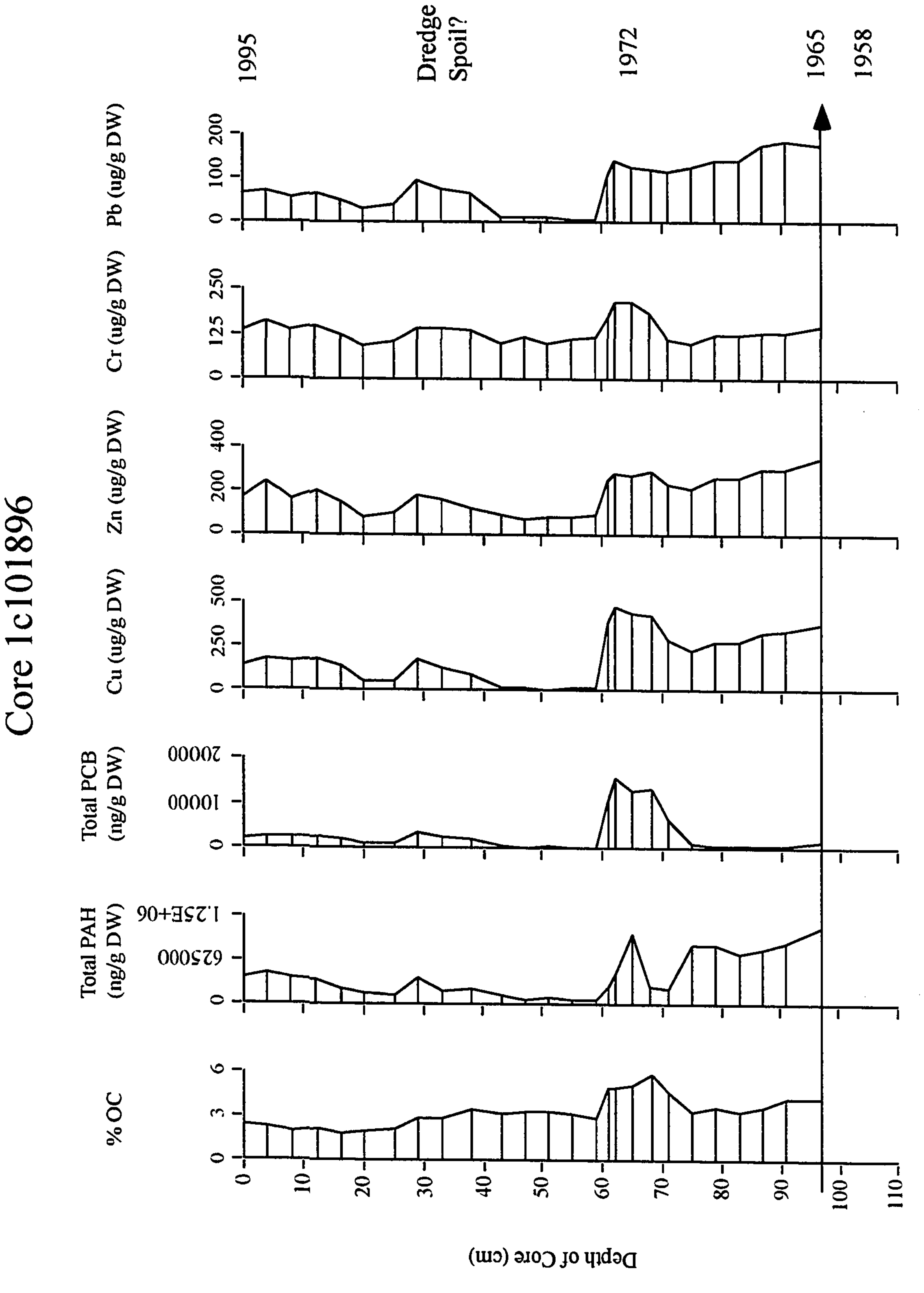


Figure 4.10- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 1c101896, NBH.

decreased to nearly background levels except for PAHs which remained relatively high. Organic carbon percentages also showed peak numbers occurring between 60- 70 cm reaching up to 5 % and decreasing to 2% to the surface of the core. The base of the core was assigned an age of 1958 AD.

4.1.2.4 Apponogansett Bay

4.1.2.4.a Core 1c103096

Organic carbon, heavy metals, PCBs and PAH concentrations were all quite low in this core. Organic carbon percentages ranged from 1.5 to 2.2 % in the lower half of the core and increased slightly above 23 cm ranging from 2.4 to 3.3 % (Appendix Table 32; Figure 4.11). Both PCBs and total PAHs peaked at the 8 cm interval with concentrations of 45.5 and 260,000 ng/g DW respectively. Heavy metal concentrations were low but showed slight increases above background at about the mid 1800s but never as high as NBH. The base of the core has been dated at 1672 AD with Pb-210 and extrapolation below the Pb-210 range.

4.2 Foraminiferal Results

4.2.1 Surficial Transects

4.2.1.1 Transect 1- Upper Harbor to Lower Harbor

For the 12 samples examined from this transect, total numbers of individuals were variable, ranging from 90 to 3088 inds/10 cm^3 (Appendix Table 33; Figure 4.1, 4.12)

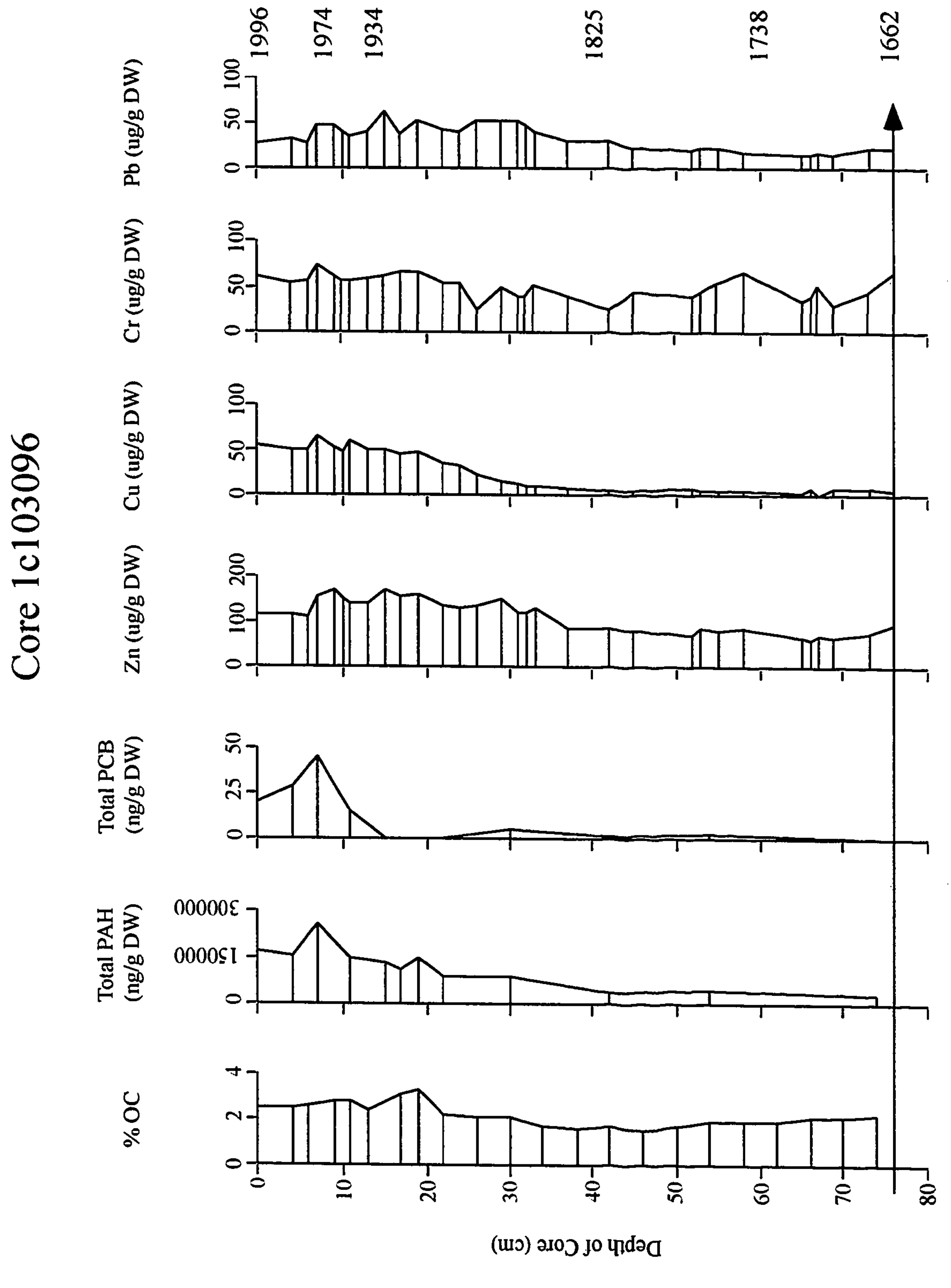


Figure 4.11- Profile of metal, PCB, hydrocarbon, and OC concentrations for core 1c103096, NBH.

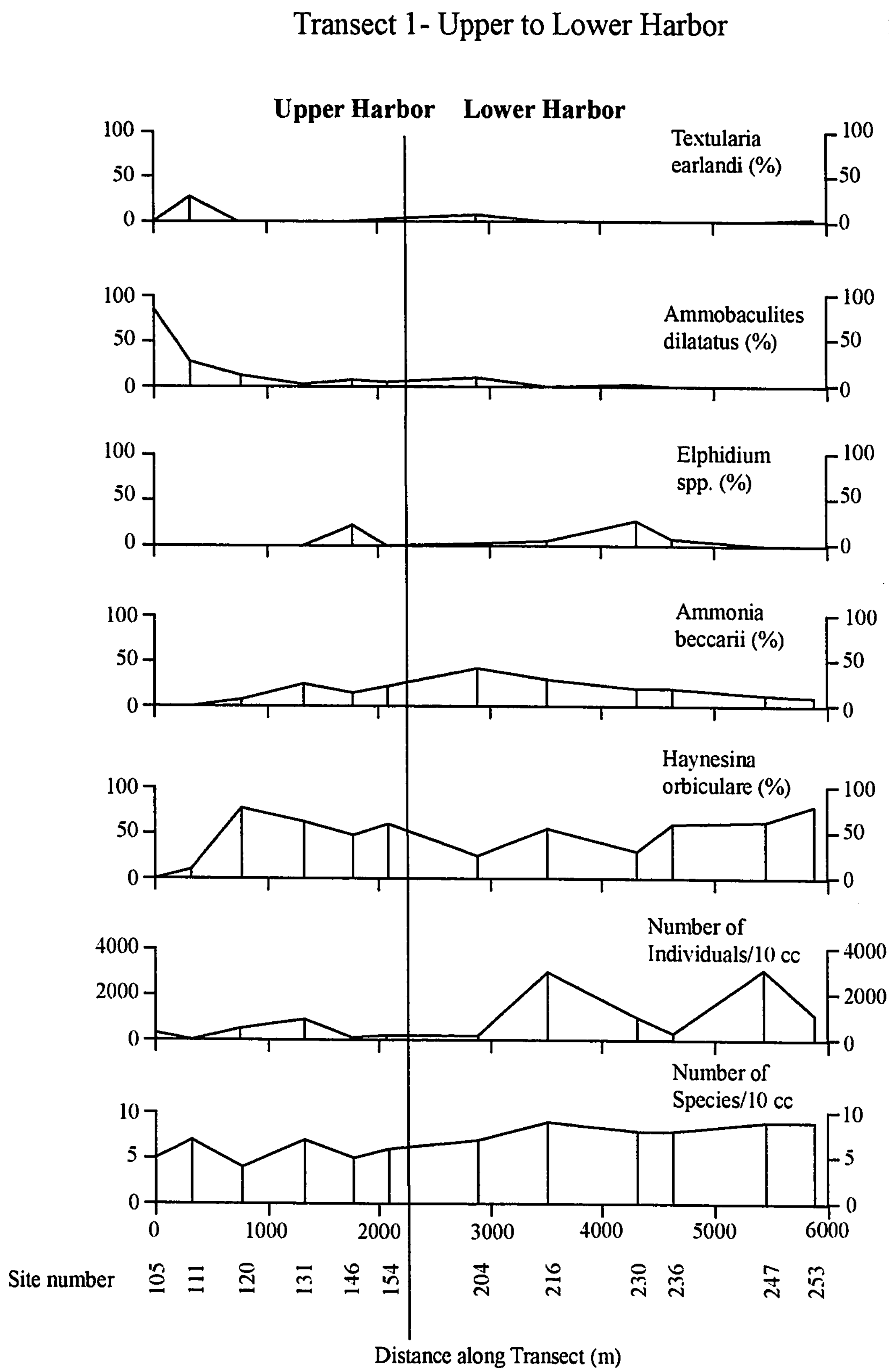


Figure 4.12- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Transect 1, NBH.

with highest numbers occurring in the Lower Harbor. Numbers of species varied from 5 to 10 with highest stable diversities in the Lower Harbor. The total faunal assemblage was dominated by *Haynesina orbiculare* with *Ammobaculites dilatatus* forming a significant component of the assemblage except at station NBH 105 where *A. dilatatus* dominated the assemblage (84%). High percentages of *Ammonia beccarii* were also identified in the upper samples of the transect (7.1- 23.6 %). A large percentage of *Textularia earlandi* was found only at the second station (NBH 111). *Elphidium excavatum* forma *clavatum*, a calcareous species, was identified at only one station in the upper part of the harbor (NBH 146).

The lower part of the transect was characterized by two large peaks in total abundance and was dominated by *H. orbiculare* at most stations. *A. beccarii* was also present in relatively high numbers (9.2- 41.4 %) throughout the lower harbor while there was a consistent but low percentage of *A. dilatatus* in these samples. At station NBH 230 in the Lower Harbor, *E. excavatum* f. *clavatum* formed a significant percentage of the total assemblage but was almost absent in all of the other samples. The entire transect was generally dominated by *H. orbiculare* with some agglutinated foraminifera present in significant percentages in the upper harbor while the outer section of the transect was dominated by calcareous species with agglutinated foraminifera present in low numbers.

4.2.1.2 Transect 2- Apponagansett Bay

In the 6 samples examined from this transect, total numbers ranged from 80 to 2328 ind/10 cm^3 (Appendix Table 34; Figure 4.13) with highest numbers occurring at the

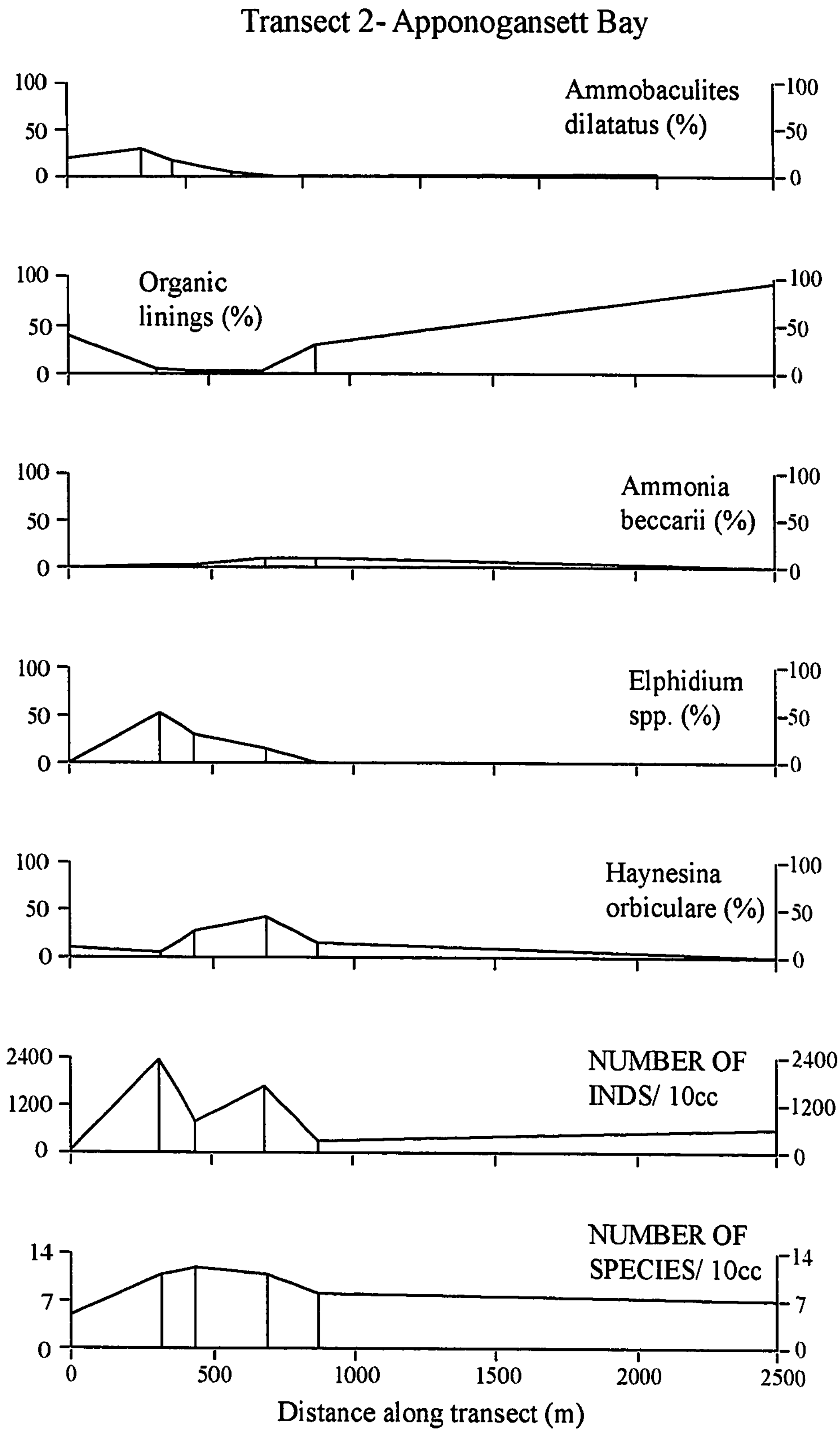


Figure 4.13- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Transect 2, Apponogansett Bay.

second and fourth stations. Organic linings dominated the assemblage at AB-1 and NBH-331 stations and co-dominated with *Textularia earlandi* at the AB-5 station in the transect. *Ammobaculites dilatatus* (20 %) and *Miliammina fusca* (20 %) (both agglutinated foraminifera) formed a significant percentage of the assemblage while the calcareous species *Haynesina orbiculare* (10 %) completed the assemblage at the first station. *Ammonia beccarii* (10.3 %) and *H. orbiculare* (15.4%) were the only other species that formed a significant percentage of the assemblage at AB-5 station. Stations AB-2, AB-3, and AB-4 were dominated by calcareous species with agglutinated foraminifera forming moderate components of the assemblage. AB-2 exhibited the largest values of individuals with *Elphidium excavatum* forma *clavatum* dominating the assemblage with 47.8 %. Both *Elphidium. excavatum.* f *clavatum* and *H. orbiculare* co-dominated at AB-3 while *H. orbiculare* (40.8 %) dominated at AB-4 with *A. beccarii* and *Elphidium excavatum* f. *clavatum* rounding out the assemblage. Overall, the middle part of the transect (i.e. AB-2 to AB-4) was dominated by calcareous species while organic linings and agglutinated foraminifera dominate the assemblages at AB-1 and NBH-331 while forming moderate percentages in the middle three stations.

4.2.1.3 Clark's Point Outfall

Surface samples collected near Clark's Point showed some interesting trends. There was a plume formed from the effluent discharged in the Outer Harbor. Samples CPC, CPE, CPF, NBH324, and NBH325 were relatively barren (Appendix Table 35; Figure 4.14 & 4.15), showing a lack of calcareous tests, but a high abundance of organic

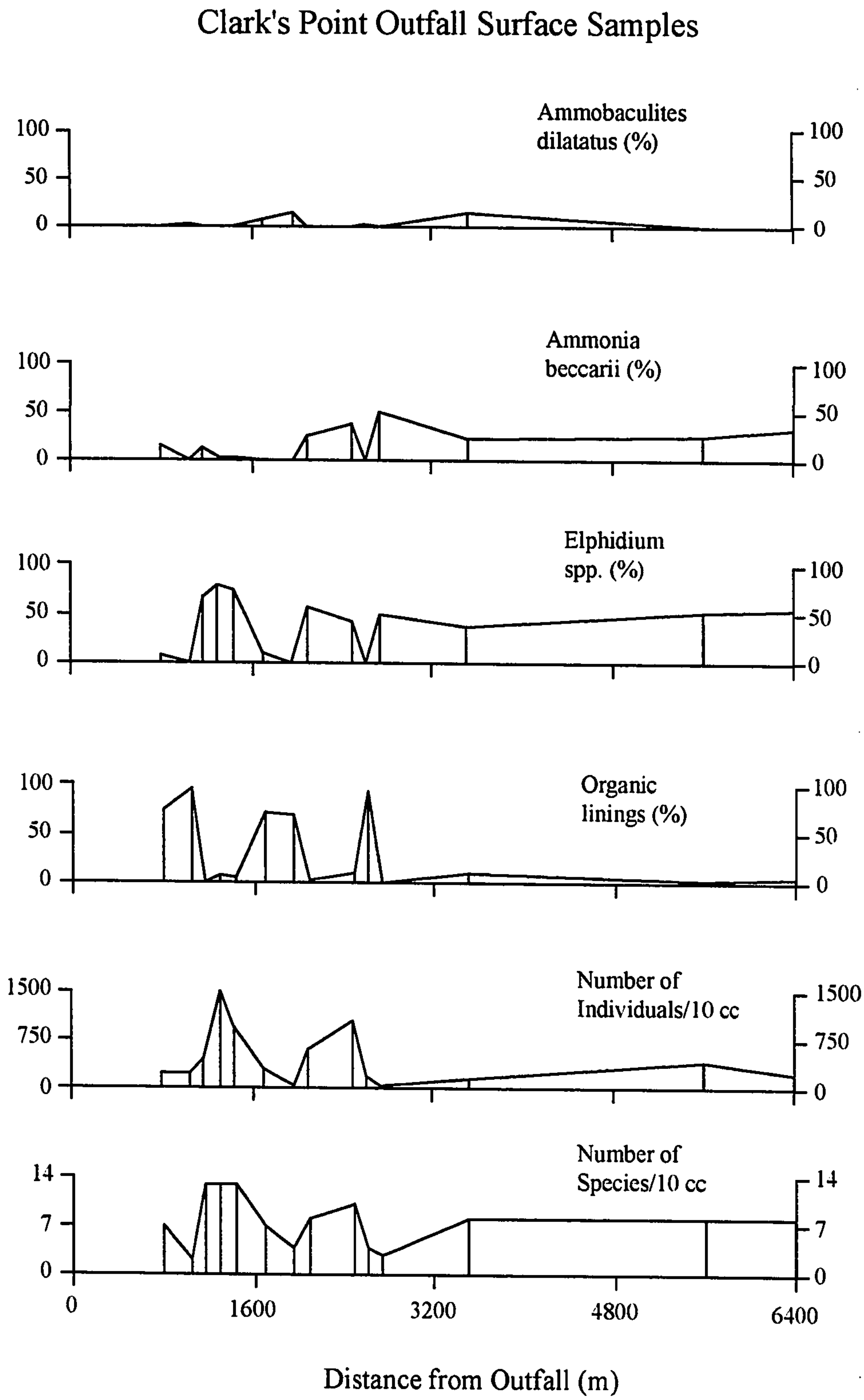


Figure 4.14- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Clarke's Outfall, NBH.

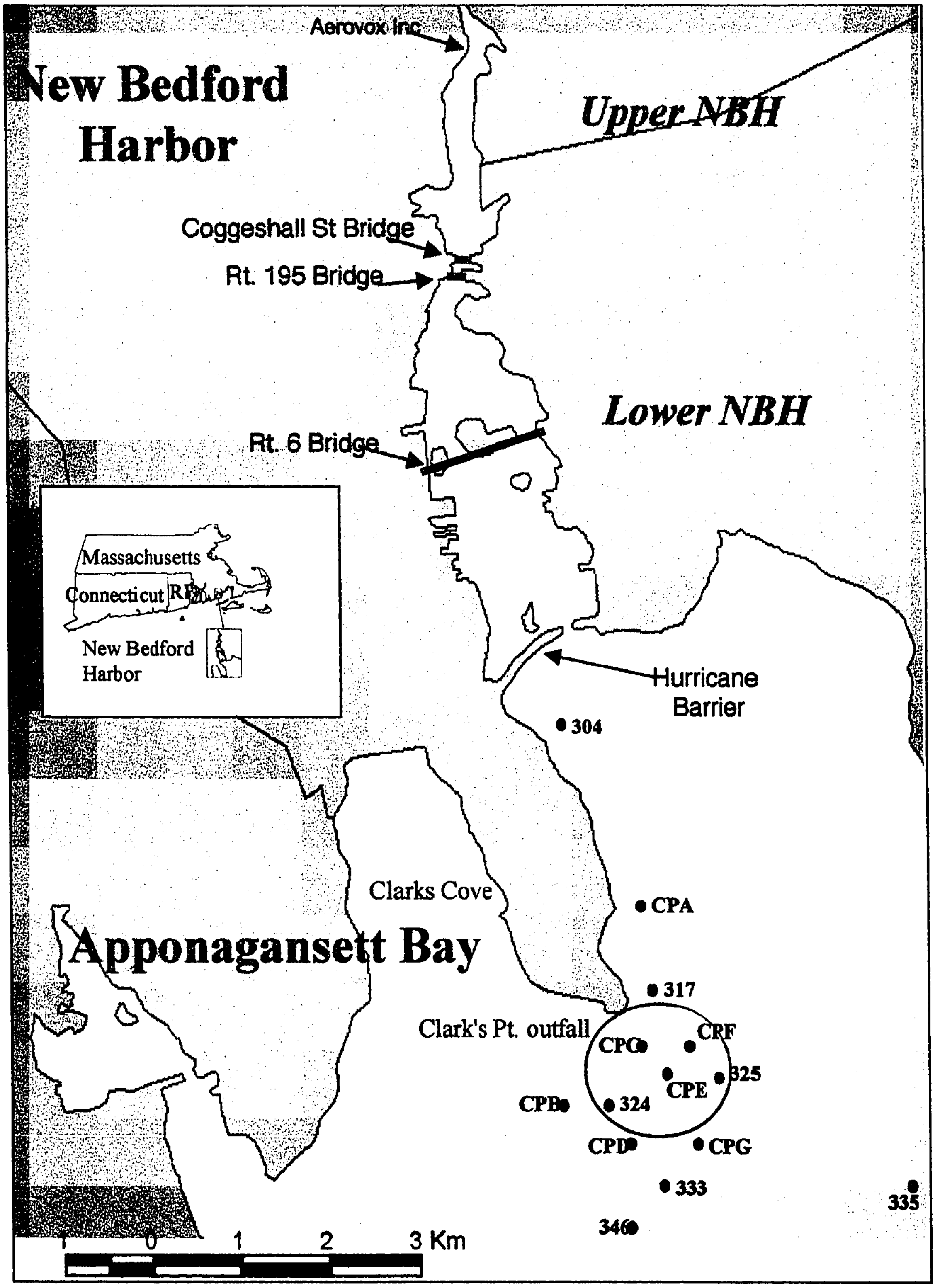


Figure 4.15- Surface samples near Clark's Pt. outfall showing the plume that is formed in response to increased organic carbon (circled).

linings indicated there was a diagenetic response; i.e. the foraminifera are present but quickly dissolve after death. The plume was very well defined as surrounding samples showed a rich diversity and high abundance of calcareous tests. The plume appears to have formed to the south and slightly to the east as samples CPB, CPD, and CPG were not affected by the plume indicated by their rich assemblages of calcareous foraminifera. The plume appeared not to extend far from the source as only samples close to the outfall site were affected while samples CPD and CPG showed a typical foraminiferal assemblage for this environment. The sample at station NBH333 had a low abundance of foraminifera, however, the entire assemblage was composed of calcareous species.

4.2.2 New Bedford Harbor Cores

4.2.2.1 Upper Harbor

The 2 cores that were collected and examined from this area exhibited very low diversity and abundances of foraminifera. These cores consisted of grey mud with shells scattered throughout (refer to Figure 4.1 for core locations).

4.2.2.1a Core 1c052396

Total: Abundances were quite low at this site ranging from 115 to 325 inds/10 cm^3 for the 21 samples examined at 2 cm intervals throughout the core (Appendix Table 36; Figure 4.16), with highest values occurring in the lower half of the core. *Trochammina inflata* dominated the assemblage in the upper half of the core from 0- 22 cm (37.7 to 72.9 %) with *Ammobaculites dilatatus* comprising a significant component of the

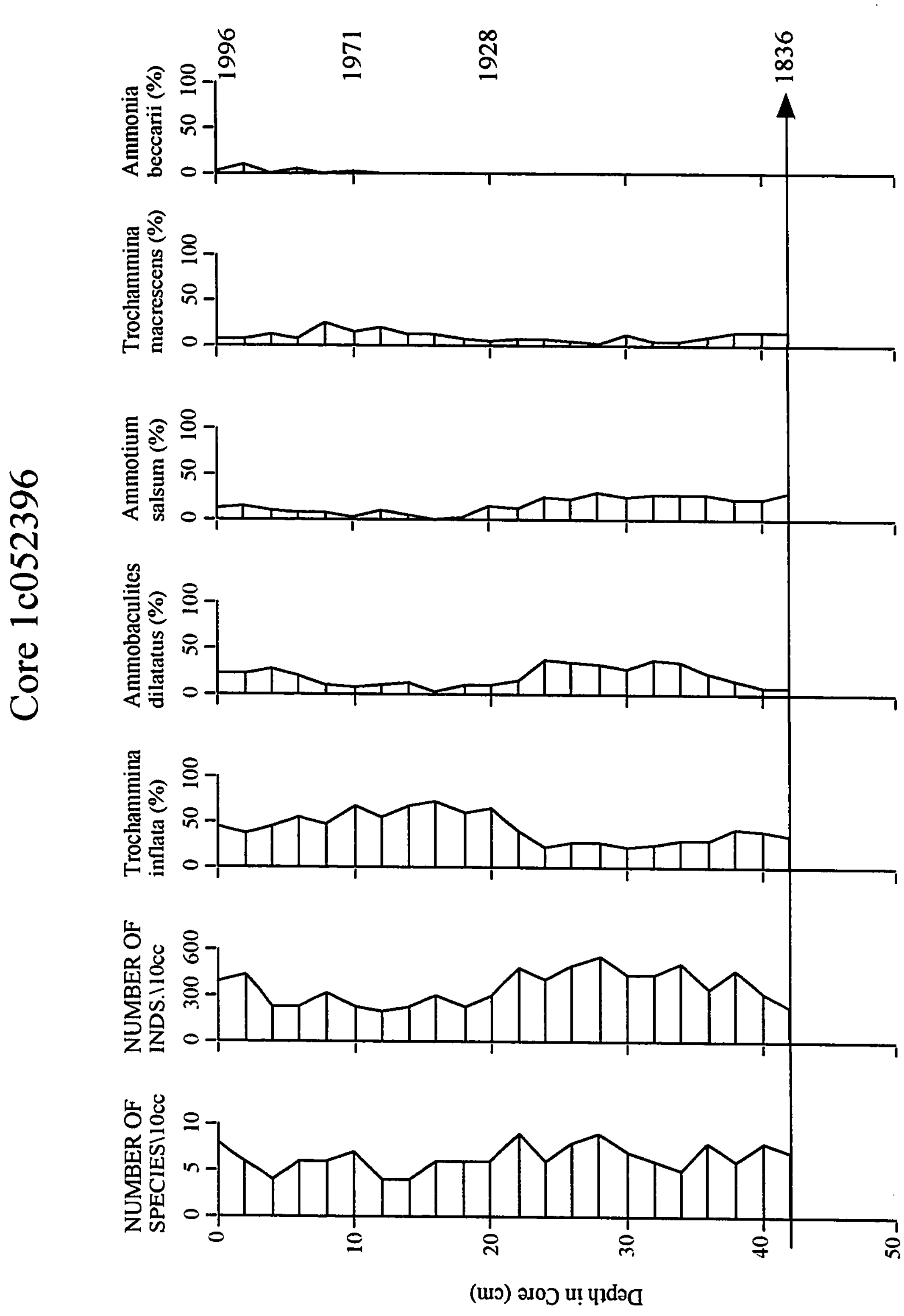


Figure 4.16- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1c052396.

assemblage (4-29.4 %) with low, constant percentages of *Ammotium salsum* (1.7- 16.8 %). Below this interval, the assemblage was co-dominated by *Trochammina inflata* (24.3- 43.1 %), *Ammobaculites dilatatus* (8.6- 37.3 %), and *Ammotium salsum* (23.8- 30.3 %). There were low percentages, with little variation in values throughout the core, of *Trochammina macrescens* spp. (4.5- 14.3 %) except at peak values of 15.1 to 26.8 % between 8 and 14 cm and values of 16.6 to 17.2 between 38-42 cm. *Ammonia beccarii*, a calcareous species, was identified down to 10 cm in low percentages (3- 12.3 %).

4.2.2.1b Core 1c102596

Total: Abundances were generally quite low at this site ranging from 17 to 555 inds/10 cm^3 for the 50 samples examined at 1 cm intervals with peak values occurring in the upper 10 cm of the core and again at the 29- 31 cm level (Appendix Table 37; Figure 4.17). The upper part of the core was co-dominated by two calcareous species, *Ammonia beccarii* (28.6- 70.1 %) and *Haynesina orbiculare* (21.3- 53.1 %) down to 10 cm except in interval 3-5 cm which was dominated by *Ammobaculites dilatatus* (45.2- 47.1 %). Both *A. beccarii* and *H. orbiculare* disappeared below the 13 cm interval. However, *H. orbiculare* reappeared at the 25- 26 cm interval (5.2 %), and both *H. orbiculare* and *A. beccarii* were identified and were present between 32 and 34 cm. Peak abundances of *Trochammina macrescens* and *T. inflata* occurred between 10- 30 cm and dominated the assemblage in this interval. There were moderate percentages of *Textularia earlandi* (2.2- 25.8 %) throughout the entire core except in the 14-22 cm interval where abundance

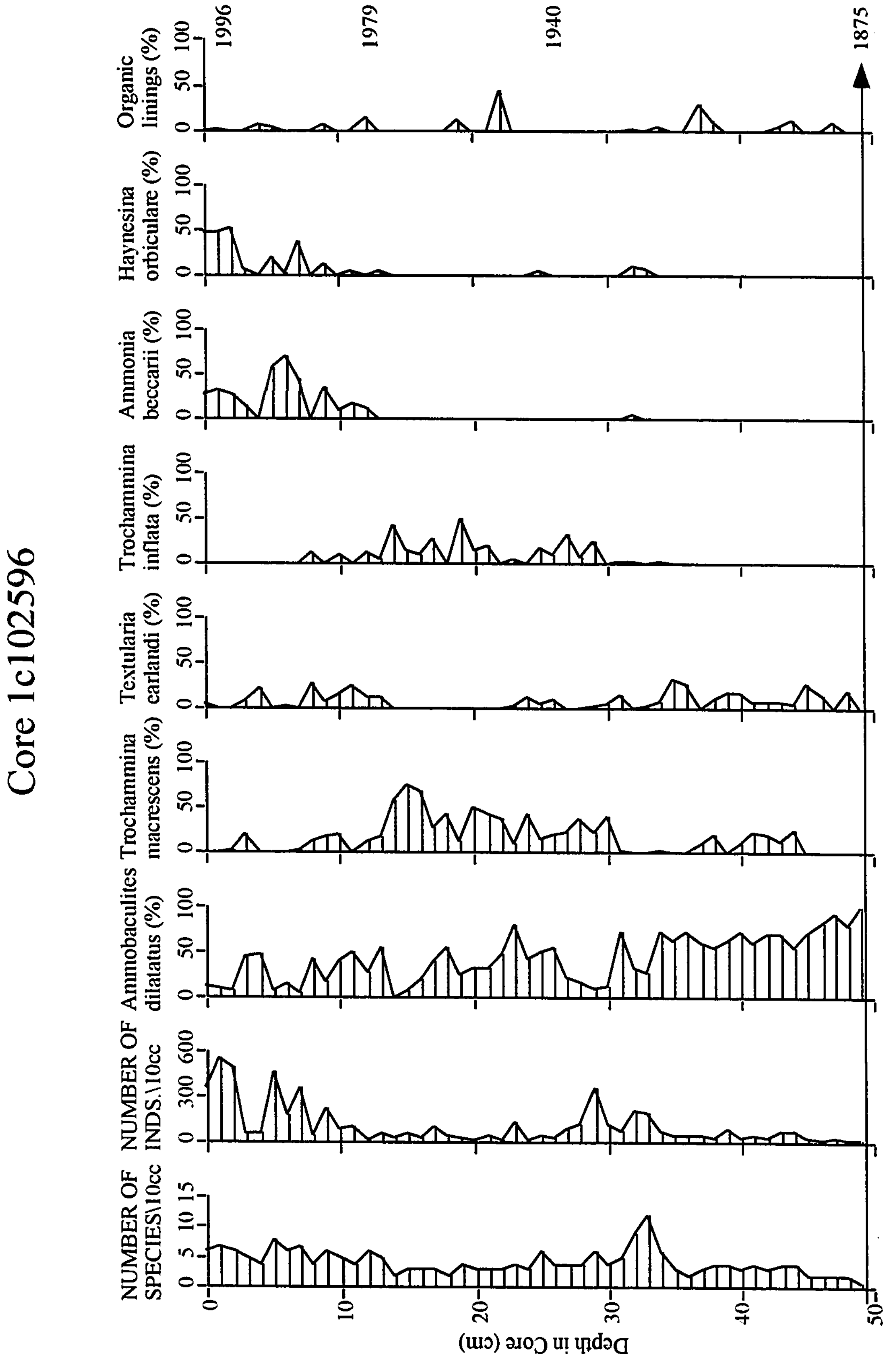


Figure 4.17- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1c102596.

of *T. macrescens* was highest. Low percentages of organic linings were found throughout the core with peak abundances occurring at 22 cm (43.1 %) and at 37 cm (30 %). From 30 cm to the base of the core, *A. dilatatus* dominated with reduced percentages of all other species.

4.2.2.2 Lower Harbor

The 2 cores that were collected and examined from this area were quite variable in both diversity and abundance as well as in length. Both cores contained greenish grey mud that became coarser grained downcore.

4.2.2.2a Core 2c101896

Total: Abundances were extremely low at this site ranging from 0 to 45 inds/10 cm^3 for the 58 samples examined with highest values occurring in the top 10 cm of the core (Appendix Table 38; Figure 4.18). The core was dominated by agglutinated foraminifera however, there were a few intervals where organic linings were present. The assemblage was dominated by *Textularia earlandi* from 0- 2 cm (66.7- 82.5 %). Below this interval, the assemblage was dominated by *Ammobaculites dilatatus*, *Trochammina macrescens*, or *T. earlandi* individuals except for a few selected intervals downcore. Organic linings co-dominated the assemblage at 9-10 cm with *A. dilatatus* and *T. earlandi* and at 42- 43 cm with *A. dilatatus* with total percentages of 33.4 % and 50% respectively.

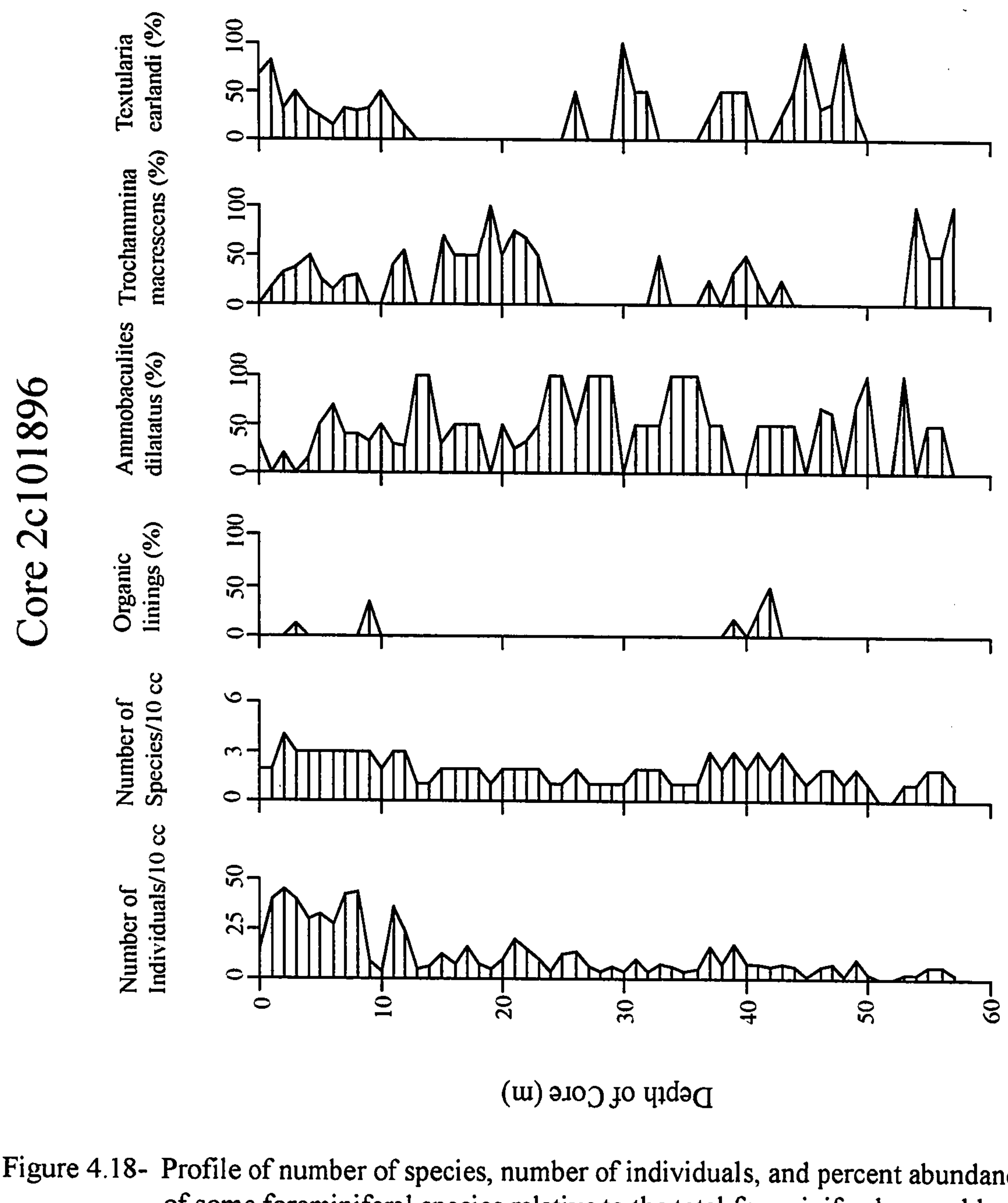


Figure 4.18- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 2c101896, NBH.

4.2.2.2b Core 5c06101898

<u>Total</u>: Abundances ranged from 20 to 1040 inds/10 cm^3 with highest values occurring in the top third of the core (Appendix Table 39; Figure 4.19). *Ammobaculites* cf. *crassus* dominated the top ten centimeters of the core. *Textularia earlandi* dominated at the surface (54.8 %) and co-dominated with *A.* cf. *crassus* at 1-3 cm, forming a significant percentage of the assemblage down to 15 cm. *T. earlandi* showed background percentages of the assemblage in the rest of the core except between 71-80 cm (5.6 – 14.4 %) and 85- 89 cm (7.1 – 7.7 %). *Haynesina orbiculare* co-dominated with *A.* cf. *crassus* (32.3 %) at the 5 cm interval and formed a significant percentage of the assemblage down to 85 cm and again from 183 to 195 cm. From 15 – 90 cm, *Elphidium excavatum* forma *clavatum* and organic linings alternated in dominating the assemblage with *A.* cf. *crassus* occasionally co-dominating with one or both of these. From 101- 113 cm, *E. excavatum.* f. *clavatum.* formed a minor component of the assemblage while organic linings and *A.* cf. *crassus* co-dominated this interval. The bottom half of the core alternated with *E. exc.* f. *clav.*, organic linings, and *A.* cf. *crassus* all co-dominating the assemblage. Deformities were identified down to 45 cm and were low at this site ranging from 0 to 5.2 %. Although the surface of this core was lost, there is a surface sample close to this core from transect 1 which shows recovery of *H. orbiculare* and *A. beccarii*

4.2.2.3 Hurricane Barrier Cores

The two cores collected near the hurricane barrier exhibited a 15 cm interval of increased abundance and diversity in the lower third of the core dominated by calcareous

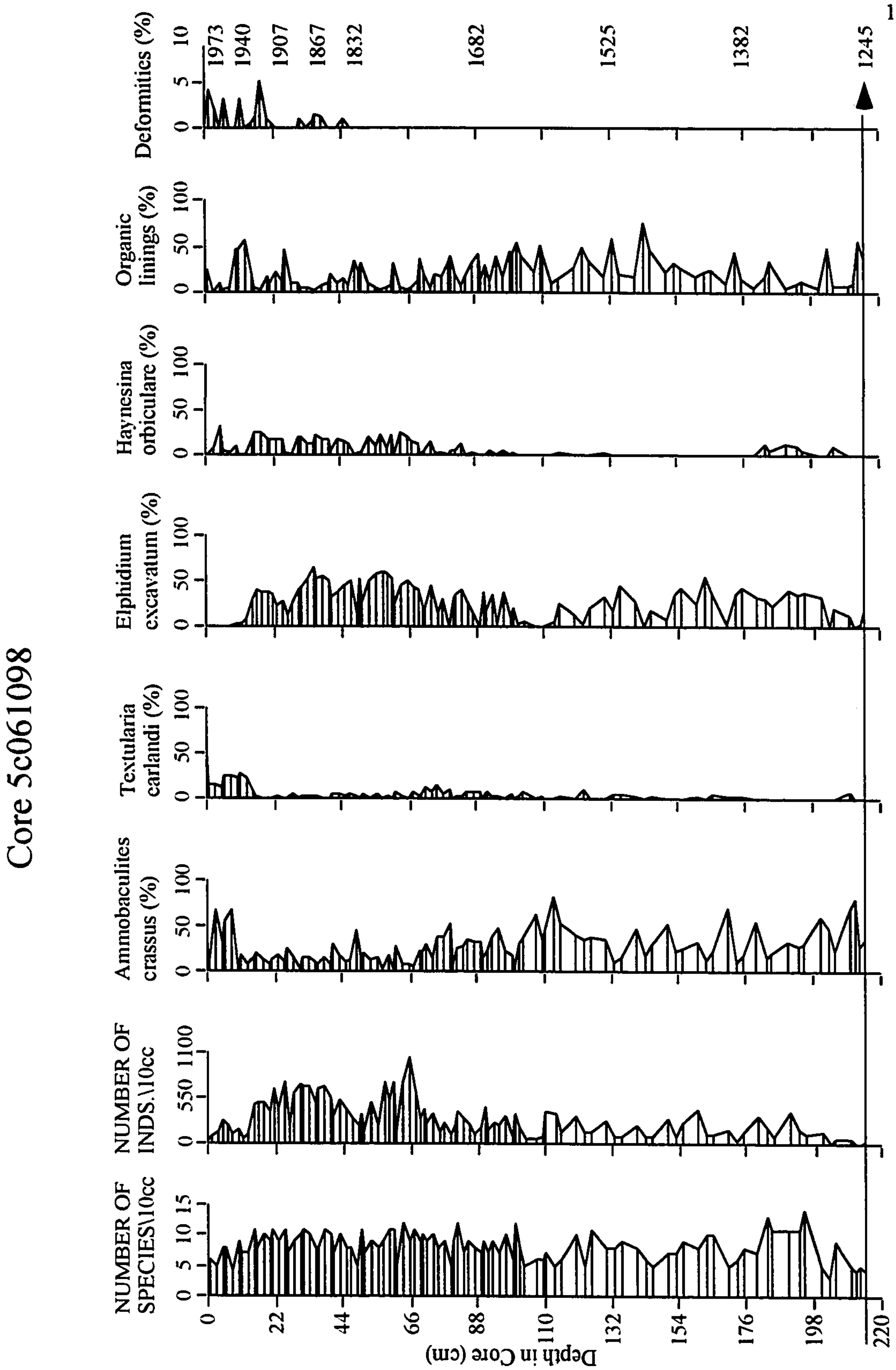


Figure 4.19- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 5c061098, NBH.

species. Both cores contained greenish grey mud with shells concentrated in the lower half of the cores.

4.2.2.3a Core 1c061898

Total: Abundances were generally low at this site ranging from 24 to 3168 inds/ 10 cm^3 with peak values of 892- 1420 inds/ 10 cm^3 and 656- 3168 inds/10 cm^3 between intervals 42- 47 and 86- 107 cm respectively (Appendix Table 40; Figure 4.20). *Haynesina orbiculare*, a calcareous species, dominated the upper 85 cm of the core except between intervals 0-13 cm and 64-74 cm where organic linings dominated. Below this interval, *Ammonia beccarii* dominated the core to 108 cm and co-dominated with *Elphidium excavatum* forma *clavatum* and an agglutinated foraminifera, *Textularia earlandi,* down to 120 cm. From 120 cm to the bottom of the core, the assemblage was co-dominated by *A. beccarii* and *E. exc.* forma *clavatum* with low percentages of *Buccella frigida.* The core exhibited deformities (most notably *H. orbiculare*) from the 25 cm interval and persisted down to 131 cm ranging from 0.2 to 12.5 % of the entire assemblage with peak values occurring near the 40 cm level. Deformities were highest when *H. orbiculare* was the dominant species in the assemblage. The core consisted of black mud with fine sand and contained a 20 cm long shell hash which appeared at the 88 cm level. Below this interval, the core consisted of olive grey muddy sand with shells scattered throughout while the bottom 20 cm became notably coarser grained as it contained several pebbles.

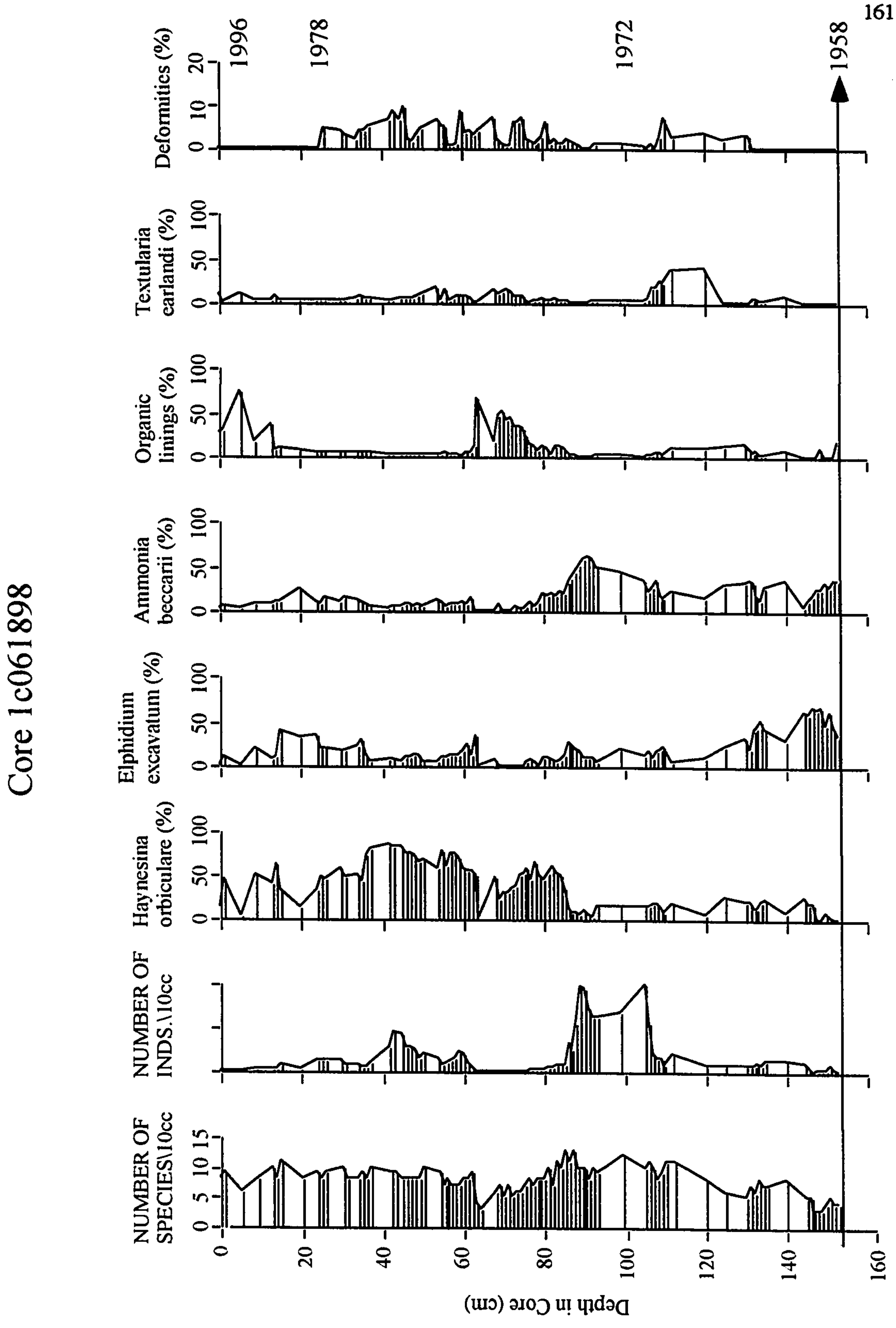


Figure 4.20- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1c061898, NBH.

4.2.2.3b Core 1c101896

Total: Abundances were low at this site, ranging from 5 to 1568 inds/10 cm^3 for the 88 samples examined with peak values occurring between 61- 71 cm (1128 to 1568 inds/10 cm^3) and again at 103- 105 cm (876 inds/10 cm^3) (Appendix Table 41; Figure 4.21). The assemblage was co-dominated by *A. dilatatus*, *Elphidium spp.*, and *H. orbiculare* in the top 2 cm. Below this interval, the assemblage was dominated by *T. earlandi* down to 20 cm with moderate percentages of *A. dilatatus* also present (0- 50 %) except at 13-14 cm where the assemblage was co-dominated by *T. macrescens* and *T. ochracea.* Between 20- 61 cm and 71-101 cm, the assemblage was dominated by organic linings or co-dominated by *T. macrescens* or *T. earlandi.* Between 61-71 cm, there was a complete change in the foraminiferal assemblage where the highest numbers of individuals were found. In this interval, the assemblage was dominated by calcareous species that were, except the surface, absent before. *Elphidium* spp., *H. orbiculare*, and *A. beccarii* all co-dominated the assemblage. There was an almost complete loss of organic linings in this interval (0-1.5 %). For the remainder of the core, there were some fluctuations (between calcareous forms and organic linings) in the assemblage as the calcareous species dominated at selected intervals including the bottom of the core where again, organic lining percentages were almost negligible. When total numbers were low, the core was dominated by organic linings and some agglutinated foraminifera, however, at peak values, the core was dominated with calcareous species.

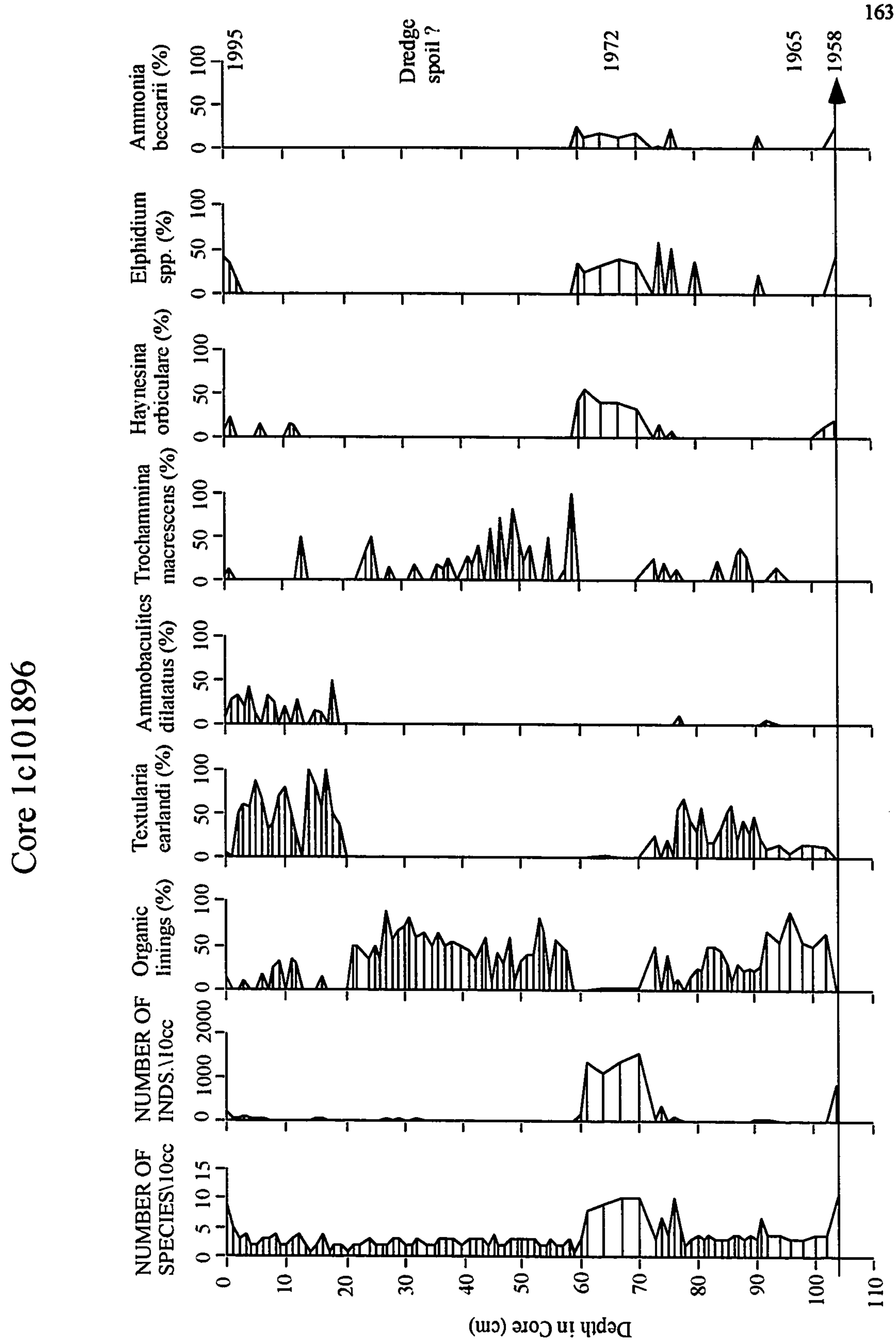


Figure 4.21- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1c101896, NBH.

4.2.2.4 Apponogansett Bay

4.2.2.4a Core 1c103096

Total: Abundances ranged from 12 to 4140 inds/ cm^3 for the 78 samples examined in this core (Appendix Table 42; Figure 4.22) with highest values occurring between 3-13 cm. Below this interval, total numbers remained relatively constant. There were significant percentages of *Ammobaculites dilatatus* (0.4- 28.1 %) throughout the core except for higher values at 0- 2 cm where it dominated the assemblage (71.3- 86.9 %). *Ammonia beccarii* was present in moderate percentages from 2-13 cm ranging from 0.8 to 13.2 cm. The only other occurrence of *A. beccarii* was found in the middle of the core comprising a small part of the assemblage. The dominant assemblage for the remaining part of the core alternated between *Elphidium spp.* and organic linings. There were low to moderate percentages of *Haynesina orbiculare* (0- 23.8 %), *Textularia earlandi* (0- 22.1 %), and *Trochammina ochracea* (0- 22.1 %) throughout the core except at the bottom as *T. ochracea* (66.7 %) dominated the assemblage which corresponded with the lowest total numbers.

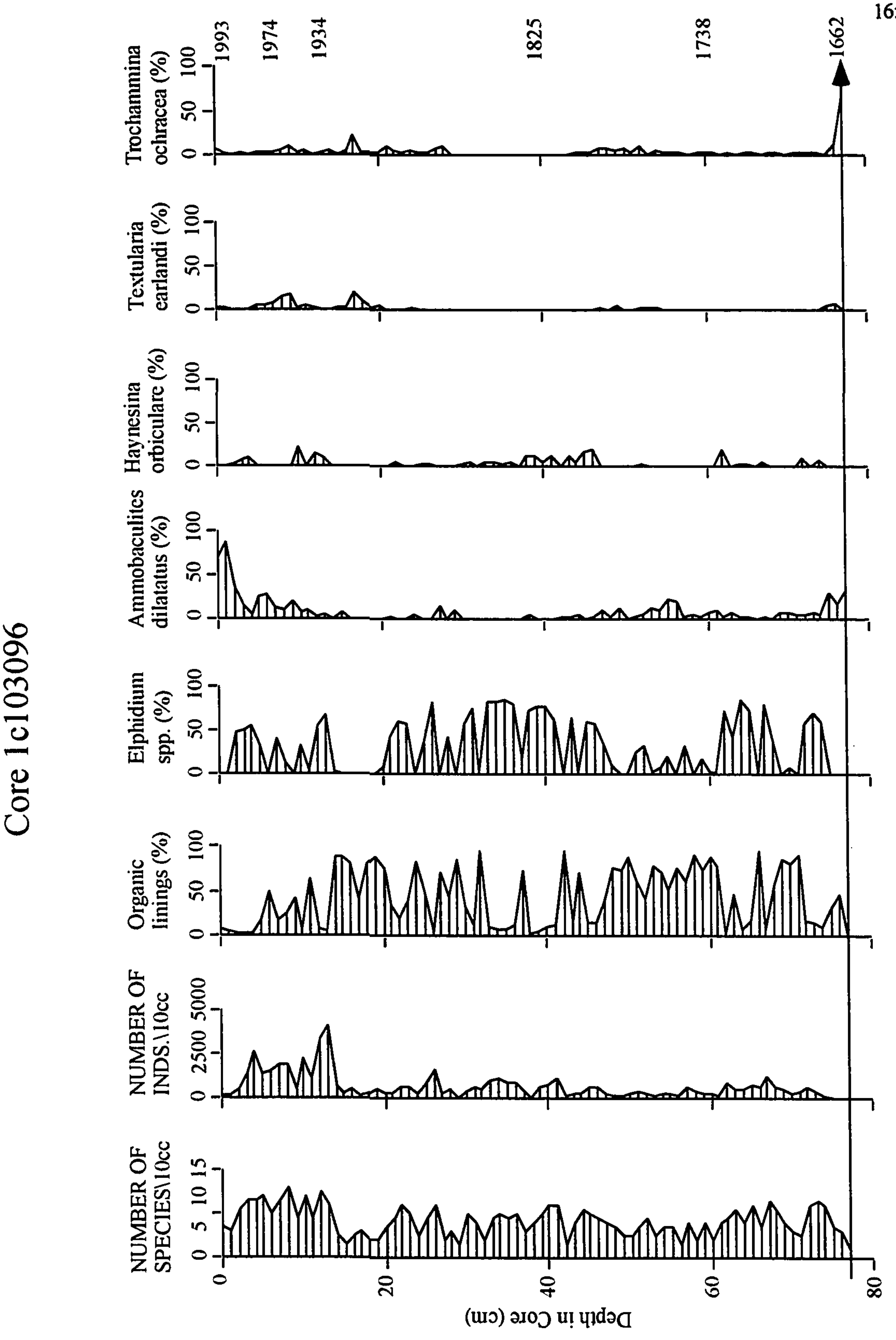


Figure 4.22- Profile of number of species, number of individuals, and percent abundance of some foraminiferal species relative to the total foraminiferal assemblage in sediments from Core 1c103096, NBH.

CHAPTER V

SALT MARSH (CHEZZETCOOK AND NANAIMO) DISCUSSION

5.1 Habitat and Natural Taphonomic Problems

5.1.1 Introduction

Recent studies have established that salt marsh foraminifera live both epifaunally and infaunally with living specimens occurring (rarely) down to 35 cm (Goldstein et al., 1995a,b; Ozarko et al., 1997; Goldstein and Harben, 1993). This is an important piece of information for use of foraminifera as paleo-environmental indicators and for accuracy of faunal records. Marsh assemblages occur in zones related to the elevation above mean sea level (Scott and Medioli, 1980, 1986; Scott et al., 1990; Gehrels, 1994). Past changes in relative sea level can be inferred in salt marsh sediments from these zonations. Live foraminiferal assemblages are extremely patchy and tend to display seasonal variations and as a result, the total (live + dead) distributions of foraminiferal assemblages serve as a better basis for paleoenvironmental interpretations than either the live or dead foraminiferal assemblages (Scott and Medioli 1978, 1980). The total assemblage may be affected by a number of factors such as diagenesis, bioturbation, and perhaps by living infaunal occurrences which ultimately may modify the total assemblage. In assessing the foraminiferal record for accuracy in terms of sea-level reconstruction or any paleoenvironmental study, a better understanding of taphonomic processes, preservation potential, and infaunal habitats are required. To investigate these problems, short cores from four sites were collected from Chezzetcook Inlet every three months (when possible) to determine what effect, if any, these factors play in the faunal record. Data from Ozarko et al. (1997) were also re-plotted because they had reported that the upper 10cm must be used for paleoenvironmental comparison; however, their plots were based on computer generated "clusters", not real data. The raw data are re-plotted here to make them comparable with the Chezzetcook data.

5.1.2 Preservation Potential and Taphonomic Implications

Most calcareous and some agglutinated foraminifera are not preserved in the subsurface sediment (Jonasson and Patterson, 1992; Goldstein and Watkins, 1998; Blais-Stevens and Patterson, 1998). Agglutinated foraminifera are the most widespread marsh type as they tend to be more resistant to dissolution in the low pH conditions that occur in marsh sediments. Calcareous species are not likely to withstand the low pH conditions and be found in older marsh deposits thus reducing resolution of paleomarsh elevation from the number of biofacies found in the marsh (Jonasson and Patterson, 1992). Despite this reduction in elevation-based biofacies downcore, it is still possible to interpret fossil marshes in terms of those species found at present time because most of these are based on well preserved agglutinated species. One question that remains is which near surface aliquot would accurately reflect fossil faunas because of selective preservation and infaunal habitats in the subsurface.

Loubere (1989) suggested that there are three factors which control the downcore distribution of total assemblages of benthic foraminifera: 1) changing environmental conditions at the sediment surface which may result in changes in the composition of the living populations, 2) the different habitat depth of the populations, and 3) taphonomic processes and selective fossilization potential of the tests. Infaunal species numbers will increase down to their maximum habitat depth and then remain constant below that depth while epifaunal species would have constant numbers in the entire sediment column under conditions of stable habitat (Loubere, 1989). The four sites discussed here came from different marsh settings within the same marsh; site 1 (five cores) from high marsh, site 2a (two cores) from the middle marsh, site 2b (two cores) from a low marsh mudflat, and site 3 (three cores) from the upper low marsh. The collection of these cores over a period of a year enabled the delineation of the effects that infaunal habitat and selective preservation (if any) had on the total assemblage as well as to determine if foraminifera migrated seasonally within the sediment.

5.1.3 Chezzetcook Inlet

5.1.3.1 Site 1- High Marsh

The five cores collected over one year showed considerable variability in the living assemblage, however the total assemblage remained consistent and was typical of a high marsh assemblage (Scott and Medioli, 1980b) with *Trochammina macrescens* dominating throughout all cores, and *Tiphotrocha comprimata*, *Miliammina fusca*, and *Pseudothurammina limnetis* comprising a small percentage of the total assemblage.

The increase in the total relative abundance of *M. fusca* between 7 and 18 cm in core 1 can not be attributed to an increase in infaunal specimens as there was a sharp decline in the total number of living specimens in this interval The peak in relative percentage of *M. fusca* in this interval appears to be caused by a decrease in total numbers suggesting selective preservation of foraminiferal tests or changes in environmental conditions at the time of deposition resulting in a different faunal density than is observed at the surface (more likely the latter). Below 2 cm, living representatives decreased to almost zero and have no effect on the total assemblage down core. The increase in the relative percentage of *T. comprimata* below 18 cm is probably the result of a change in environmental conditions at the time of deposition and not from infaunal habitats or selective preservation because each seasonal core from this site tends to display an increase in relative percentage of *T. comprimata* in the bottom third of the core. Overall, the density of total foraminifera remained relatively consistent as do the relative percentages of commonly occurring foraminifera. This would suggest that there was no taphonomic alterations of the assemblage.

Core 2, collected in January, had no living representatives. Again, the peak in relative abundance of *M. fusca* from 10- 18 cm is the result of a change in environmental conditions at the time of deposition; i.e. a slight change in elevation. The number of individuals near the bottom of the core is actually higher than at the surface however the relative percentages remained consistent again suggesting no taphonomic alterations of the total assemblage.

Core 3, which was collected in April, was collected to show a spring bloom as shown by Scott and Medioli (1980a) but had living representatives down only to 3 cm with surface numbers quite low. As a result, living foraminifera had no impact on the total numbers infaunally as *T. macrescens* dominated the assemblage throughout the entire core, with *T. comprimata*, *M. fusca*, and thecamoebians (*Centropyxsis aculeata* and *C. constricta)* as minor constituents in the total assemblage. Between 8 and 12 cm, total numbers decreased and *M. fusca* increased in relative percentage while *T. comprimata* increased slightly in this interval and remained this way to the bottom of the core. There was no evidence in this core of selective preservation, only minor changes in environmental conditions at the time of deposition.

The fourth core which was collected in June, had living representatives down to 8 cm, however, there was only 8 living specimens found in intervals below 2 cm. There were high numbers of living foraminifera in the first two centimeters of this core, but this had no effect on the relative abundance of the total assemblage as it remained relatively constant throughout the entire core. The high living percentage of *M. fusca* below 2 cm represented only a few specimens in an impoverished living assemblage. The remaining species relative abundances did not appear to be affected by living infaunal representatives. The density of total foraminifera was somewhat variable throughout the core with highest numbers actually occurring in the middle of the core. This was likely the result of slight changes in environmental conditions at the time of deposition as the relative abundance of species remains consistent throughout.

The fifth and final core collected at this site displayed similar trends to the core collected in April. Living representatives were found down to 3 cm with highest numbers at the surface. Most of the living representatives were *T. macrescens* and they dominated the total assemblage though the entire core. At the 10 cm interval, total numbers increased and the emergence of *T. comprimata* and *M. fusca* started to influence some of the relative total percentages of the assemblage, while below the 18 cm interval, these two species became more dominant as total numbers decreased suggesting a change in environmental conditions at the time of deposition. However, the bottom of the core was similar to the surface of the core with *T. macrescens* comprising nearly 100 % of the total assemblage while *T. comprimata*, *M. fusca,* and thecamoebians rounded out the rest of the assemblage. The density of total foraminifera remained relatively constant throughout the entire core suggesting that there is little to no taphonomic alteration occurring in this core.

Overall, there seemed to be little evidence that infaunal habitats at this site affected the total assemblage downcore. Highest numbers of living representatives generally occurred in the first few centimeters and dropped to only a few living specimens below this interval. The density of the total assemblage of each core remained relatively constant , and in some cases higher in the subsurface than at the surface, suggesting changes in environmental conditions at the time of deposition and not selective preservation as the relative total percentage of each species remained consistent throughout the entire core. The total species composition at the surface was very similar to that in the subsurface. These cores in the highest marsh area generally have the highest numbers of foraminifera as well as the lowest diversity. Living foraminifera did not appear to migrate vertically from season to season as there was no increase in living foraminifera in the subsurface in the winter months. As the temperature drops in the winter, living representatives should vertically migrate down into the subsurface creating an artificial increase in the infaunal habitat however this does not occur.

The 1:1 plots of the three most dominant species at this site for all five cores is in agreement with the foraminiferal plots. The average relative percentages from 1- 7 cm for these species plot on the 45 degree line within one standard deviation suggesting that these averages are the same as the surface relative percentages and as a result, the assemblages are the same at the surface and at the sub-surface. The plots are very consistent from one core to the next which is typical at a high marsh site. As a result, the top 1 cm of these cores is a representative aliquot and accurately reflects environmental conditions occurring at the time of deposition.

5.1.3.2 Site 2a- Middle Marsh

The two cores showed considerable variability in the living assemblage with the total assemblage remaining relatively consistent. The infaunal assemblage had a deeper living zone in these cores than in the cores from site one. The total assemblage was similar to that observed by Scott and Medioli (1980b) for a middle marsh assemblage with *M. fusca* dominating the total assemblage in all cores with *T. macrescens*, *T. ochracea*, and organic linings constituting a minor percentage of the total assemblage.

Although moderate densities of living infaunal specimens occur in the first core collected at site 2, there appears to be no effect on the total assemblage distributions. Living representatives were found down to 19 cm with highest numbers occurring in the top 10 cm. The high percentages of living *T. macrescens* from 13 to 18 cm does not contribute much to the total assemblage as it represents only a few specimens in an impoverished living assemblage. Highest densities of infaunal specimens were present in the upper 9 cm and this is the only interval where infaunal foraminifera had an effect on the total assemblage. The density of the total assemblage was highest within this interval however, relative percentages of species remained relatively consistent. Below 13 cm, total density decreased and an increase in *T. macrescens* percentage occurred, probably representing a change in environmental conditions because a few centimeters below this interval, total numbers increased again and *M. fusca* completely dominated the total assemblage. Total numbers decreased considerably below 22 cm with a decrease in *M. fusca* percentages and both *T. ochracea* and organic linings increasing in relative percentages. Again, this change is the result of slight changes in environmental conditions. Scott and Medioli (1980b) sampled this marsh and showed that there was considerable variability of assemblages within a few centimeters of each sampling site. As a result, only minor or slight changes in depositional conditions would be needed to alter the assemblage. Low percentages of living calcareous specimens were also identified in this core down to 5 cm which generally made up the assemblage. The calcareous specimens either live infaunally at depth or their tests quickly dissolve after death because of the acidity of the marsh sediments. The presence of organic linings in the lower half of the core indicates that calcareous species were present at one time but after death and burial, the tests had dissolved and only organic linings remained.

The high densities of living *Elphidium williamsoni* in the upper few centimeters of the second core along with high numbers of living *Miliammina fusca* down to 12 cm at this site are reflected in the total percentage for this species. The peaks in relative abundance of living species below this interval are not reflected in the total percentage as they represent only a few specimens. Total numbers were variable throughout the core with peaks occurring in the 2-4 cm interval and near the 20 cm interval. *M. fusca* generally dominated the total assemblage except between 14- 17 cm where it co-dominated with *Trochammina ochracea*. Although there were minor fluctuations in the total abundances within this interval, the overall trend is fairly consistent although a case could be made that *M. fusca* is being preferentially degraded. However, below this interval, total numbers increased and *M. fusca* once again dominated the total assemblage suggesting that a possible change in conditions at the time of deposition is the likely cause. Goldstein and Harben (1993) suggested that *M. fusca* was more prone to degradation than many other marsh species however, Scott (1977) and Scott et al. (1995), in their core studies of Chezzetcook Inlet, did not see any taphonomic effects onthis species in any cores. Foraminiferal composition varied slightly between the surface and bottom of this core, however, if organic linings are taken into account as representing calcareous species in the subsurface, then relative abundances are quite consistent.

5.1.3.3 Site 2b- Low Marsh Mudflat

This site is close to site 2a in physical characteristics but shows the high degree of variability over just a few centimeters of elevation. The living assemblage of the first core displayed considerable variability along with low abundances down to 10 cm. The high densities of living *Trochammina ochracea* from 1- 5 cm in this core along with high numbers of living *Miliammina fusca* between 1-4 cm and 7-9 cm intervals are reflected in the total percentage for this species. Below this interval, there was a ten-fold increase in total numbers suggesting a change in the environment at the time of deposition. This total assemblage appeared to be similar to a low marsh assemblage dominated by *M. fusca* with low numbers of organic linings, *T. macrescens*, and *T. ochracea*. These high numbers throughout the rest of the core show that *M. fusca* does not degrade in the subsurface. Although there are differences in the faunal composition between the top and bottom of the cores, they most likely result from changes in environmental conditions at the time of deposition and not from infaunal or taphonomic causes.

The second core collected at this site displayed living specimens down to 10 cm and showed considerable variability. This core showed similar trends to the previous core but total numbers increased at about 5-6 cm, not at 14 cm as in the previous core. Although densities of living infaunal specimens between 5-7 cm in this core moderate to high, there appears to be no effect on the total assemblage distributions. Total numbers increased in this interval but these numbers remained consistent throughout the remainder of the core where there were no living representatives. Relative percentages of the common species remained consistent. Overall, total densities were higher in the subsurface than at the surface suggesting good preservation potential of these marsh species. The relative percentages of the foraminifera observed in this core remained consistent displaying a typical transitional marsh assemblage with *M. fusca* dominating and *T. ochracea*, *T. macrescens*, *E. advena*, and organic linings rounding out the total assemblage.

At sites 2a and 2b, there appeared to be little evidence that infaunal habitats affected the total assemblage downcore. The highest numbers of living representatives occurred not only in the first few centimeters but down to 7 cm; however, the numbers dropped to a few living specimens below this interval. Also, the density of the total assemblage of each core remained relatively constant , and for site 2b, higher in the subsurface than at the surface, suggesting changes in environmental conditions at the time of deposition and not selective preservation as the relative total percentage of each species remained consistent throughout the entire core. The total species composition at the surface was very similar to that in the subsurface. These cores in the transitional marsh area generally had deeper living specimens than in the high marsh. In some cores, extremely high numbers of *M. fusca* occurred in the subsurface suggesting good preservation of that species. The 1:1 plots for this site display a high variability within the relative percentages of species which make up the assemblages at this site. Some points fall on the 45 degree line within one standard deviation while others needed two standard deviations. There are some percentages that do not fall on the line suggesting that the subsurface assemblages are different than at the surface. However, upon examination the foraminiferal plots, there are changes in the total number of individuals which affect relative percentages. *M. fusca* and *T. ochracea* tend to co-vary which is causing large variations in the relative percentages at the surface and subsurface. As well, the emergence of organic linings due to calcareous species occurring at the surface tends to alter relative percentages of certain species. Again, combining both the foraminiferal plots with the 1:1 plots for this site, it is apparent that there is considerable variability at the surface and subsurface but if the co-dominance or co-variance of *M. fusca* and *T. ochracea* as well as the decrease of total individuals near the surface, which is typical at this site in the marsh system, is taken into account, assemblage changes can be explained by the heterogeneity of the marsh. These changes in assemblages however, are still representative of the general location within the marsh. As a result, the top 1 cm of these cores appears to be a representative aliquot and accurately reflects environmental conditions occurring at the time of deposition.

5.1.3.4 Site 3- Upper Low Marsh

The three cores collected showed variability in the living assemblage. Living numbers were lower here than any other site but were found down to depths of 14 cm. Total numbers were variable as well at this site but this was due to changes in environmental conditions at the time of deposition. This low marsh site was in an area very similar to the transitional marsh site and as a result, the total assemblage sometimes alternated from a low marsh (where *M. fusca* completely dominated) to a transitional marsh assemblage (co-dominated by *M. fusca*, *T. ochracea*, and organic linings). In the final two cores, there was a complete change in the total assemblage occurring near the 22 cm interval where four species co-dominate the total assemblage.

The maximum living density occurs in the surface interval (0-1 cm) and this is the only interval that living foraminifera have an effect on the total assemblage; in this case, because when the calcareous species die, they dissolve and leave no fossil record. The peaks in relative abundance of living *Miliammina fusca* below the surface represent very few specimens and these are not reflected in the total percentage. The relative abundance of species in the total assemblage remained extremely constant throughout the entire core with *M. fusca* dominating the faunal assemblage. Total numbers decrease between 14-17 cm accompanied with a slight increase in relative percentages of *T. ochracea* and *T. macrescens* and a decrease in the relative percentage of *M. fusca.* This is probably the result of a change in surface conditions at the time of deposition rather than taphonomic causes because the relative percentage of *M. fusca* increases to well over 90 % below this interval for the remainder of the core. Overall, the density of total foraminifera decreased slightly downcore however, the relative percentage of the total assemblage of each species remained consistent. As a result, if the decrease in density is a result of taphonomic processes, all species are being affected equally.

The increase in total numbers of foraminifera between 4- 8 cm cannot be attributed to an increase in infaunal specimens as total numbers of living individuals were low in comparison to the total numbers of both living plus dead. In the upper 3 cm, the total assemblage was dominated by *M. fusca* with major percentages of *Trochammina ochracea* and organic linings rounding out the assemblage and total numbers were low. The same observations are made at the bottom part of the core with *T. macrescens* forma *polystoma* forming a minor percentage of the total assemblage. Between these intervals, total numbers were higher and *M. fusca* generally constituted the entire assemblage. The sharp decline in total numbers and relative percentage of *M. fusca* in the bottom quarter of the core suggested that *M. fusca* was degrading or not being preserved however, the same assemblage is seen at the top of the core as well as high numbers of *M. fusca* are found throughout the rest of the core. This change is attributed to a change in surface conditions at the time of deposition and not from taphonomic causes. Overall, the density of total foraminifera is variable throughout the entire core with highest numbers occurring in the middle section of the core with *M. fusca* dominating the total assemblage. There were low total numbers found at the surface and near the bottom of the core but the assemblages are the same suggesting a slight change in environmental conditions at the time of deposition. As a result, there is little difference between the surface and subsurface assemblages of foraminifera in this core suggesting that the 0-1 cm aliquot is a good indicator of environmental conditions at the time of deposition.

The total numbers of living individuals in the third core (collected in September 1997) are again quite variable and living specimens are found down to 12 cm but do not contribute to the total assemblage because of their low numbers in relation to the total numbers of all individuals. The profile of the total assemblage in this third core was similar to the previous core with highest total numbers occurring in the middle third of the core. The upper few centimeters resembled a transitional marsh assemblage with *M. fusca*, *T. ochracea*, and organic linings co-dominating the total assemblage. A similar distribution was seen from 22 cm down to the bottom of the core. Between these intervals, total numbers were quite high and the total assemblage was dominated by *M. fusca*. These changes in assemblages appear to be the result of environmental changes at the time of deposition because the same profile is observed in the second core at this site as well as the similarity of total numbers and total assemblages at the surface and near the bottom of the core.

Site 3 was observed to be highly variable over a three year period by Scott and Medioli (1980b) in the living assemblage- two years the calcareous species completely dominated the summer living populations while in year three they were absent so natural surface variability is extremely high at this site in particular. The 1:1 plots for this site are slightly more consistent than at the previous site. The variability of the dominant species *M. fusca* is the result of lower total numbers as well as the co-dominance with other species such as organic linings and *T. ochracea*. As well, there is a change in environmental conditions occurring at the time of deposition below 5 cm in both the June 1997 core and the September 1997 core which is also skewing the results of the 1:1 plots. The assemblage appears to change near the 5 cm interval with *M. fusca* completely dominating below this interval with a large increase in total numbers. However, in the bottom 5- 10 cm of these two cores, total numbers decrease to that at the surface with *M. fusca*, organic linings, and *T. ochracea* dominating the assemblage much like at the surface and down to 5 cm.

5.1.3.5 Chezzetcook Intersite Comparisons

The data from all four sites over a period of a year show good preservation of benthic foraminifera in sediments with the exception of calcareous species. In this study, the distinction between a high marsh and transitional\low marsh biofacies was possible.

This is in agreement with many studies from northern marshes where fossilized assemblages could be used as reliable sea-level indicators because the modern assemblages were found in a narrow and tightly constrained vertical zonation, especially the almost monospecific assemblage of *Trochammina macrescens* forma *macrescens* as seen in Nova Scotia by Scott and Medioli (1980a), in Maine by Gehrels (1994), and amazingly in New Zealand (Hayward et al., 1999). Infaunal habitats did not alter the total assemblage down core nor was there any evidence of seasonal vertical migration. This is in agreement with Collins (1996) who studied cores from the South Carolina coastline and concluded that the living fauna at depth appeared to have little influence in composition of the total fauna. Total densities remained relatively constant in most cores; however, a few cores exhibited decreased abundances. The relative percentage of each species appear to remain consistent downcore and both surface and subsurface assemblages were similar suggesting that the 0-1 cm aliquot is a reliable environmental indicator of surface conditions at the time of deposition.

5.1.4 Nanaimo Inlet

5.1.4.1 Site 1

The four cores collected in this transect showed variability in the living assemblage with species identified down to 30 cm. The total assemblage remained relatively constant with *Miliammina fusca* generally dominating the core while *Haplophragmoides wilberti*, *Trochammina inflata*, and *Jadammina macrescens* comprised moderate percentages of the total assemblage. All four cores in this transect display similar trends as *M. fusca* dominated the upper two thirds of the core while both *H. wilberti* and *T. inflata* increased in relative percentages in the lower part of the cores.

Overall in this transect, there seemed to be little evidence that infaunal habitat or taphonomic biasing affected the total assemblage downcore; it appears that there are environmental changes and that is amplified by coincident lithology changes. The surface assemblages appear to be similar to that within the subsurface down to a point where a change in total numbers as well as changes in relative percentages of species occurs which is likely the result of depositional changes due to the fact that the lithology changes occur near the interval where assemblages change. As a result, the top 1 cm of each core in this transect is a representative aliquot and reflects environmental conditions at the time of deposition. The slight variations of relative percentages of the dominant species can be attributed to the heterogeneity of the marsh system and not changes in biofacies at each interval as suggested by Ozarko et al., 1997. The slight changes in the relative abundance of *M. fusca*, *H. wilberti*, and *T. inflata* at the surface of each core is the result of the decrease in relative elevation in relation to sea level on the transect, however, within each core, the relative percentage of each species remained relatively constant.

5.1.4.2 Site 2

The two cores collected in this transect showed variability in the living assemblage with species identified down to 29 cm in this first core and at 17 cm in the second core with highest numbers identified in the top 10 cm. The total assemblage remained constant throughout the two cores with *Miliammina fusca* dominating the assemblage and *Haplophragmoides wilberti* comprising moderate percentages with *Trochammina inflata*, and *Jadammina macrescens* comprising low percentages of the total assemblage.

In both cores of this transect, the total species composition remained relatively consistent with total numbers actually higher in the middle of the second core. The first core experienced a decrease in total numbers in the subsurface however, the relative abundance remained constant suggesting that there was no selective preservation or taphonomic alteration occurring in these cores in this transect. Again, the top 1 cm appeared to be a good representative aliquot which would accurately reflect environmental conditions occurring at the time of deposition.

5.1.4.3 Site N95

The two cores collected from this transect showed no signs of taphonomic alterations or biasing as total abundance remained consistent throughout. In the first core, the high densities of living *H. wilberti* in the upper 5 centimeters may be reflected in the total percentage for this species as *H. wilberti* dominated the total assemblage in the top third of the core. There is a definite change in the total foraminiferal assemblage below this level as *J. macrescens* became the dominant species. This is probably the result of a change in conditions at the time of deposition or the inherent natural variability within the marsh and not a taphonomic phenomenon because total abundance remained consistent.

The living assemblage in core 2 had no effect on the total assemblage distributions as peak living numbers occurred in the upper 10 cm but the abundance and relative percentages of total species remained consistent throughout the entire core. The only change in assemblage distributions occurred below 20 cm where total abundance decreased and *M. fusca* increased in relative percentage. However, there is a change in lithology at this interval suggesting a change in depositional conditions and not the result of taphonomic biasing. As a result, the top 1 cm of these cores appears to be a representative aliquot and accurately reflects environmental conditions occurring at the time of deposition. This is in contrast to suggestions by Ozarko et al. (1997) that the upper 10 cm of surface sediment must be used; it illustrates once again that the real data, as opposed to computer generated clusters, especially for small data sets such as this one, give a truer picture of environmental conditions at the time of deposition.

5.2 Artificial Taphonomy

5.2.1 Material in buckets, bags, and an archived core (1992)

In an attempt to determine if material that has been collected and left at room temperature over a period of time would still be useful for foraminiferal investigation, surface and subsurface sediment from Chezzetcook Inlet was collected and stored in resealable bags and buckets to artificially mimic aerobic and anaerobic conditions. As well, an archived core was taken out of the refrigerator and left at room temperature. 10 cc of material from each sample was processed every week and the abundance and relative percentage of each species was plotted. This was to determine the robustness of the foraminiferal tests and to determine if any of the foraminiferal tests had degraded.

There was no evidence of test degradation in any of the material examined. The biggest surprise was the fact that in most surface samples, there were live foraminifera up to week 13. Another interesting find was the fact that not only did agglutinated species remain, but also calcareous forms were identified throughout the experimental period suggesting that these marsh foraminifera are extremely durable and robust. This is in contrast to results of Scott (pers. comm.). He studied material taken from an exposed cliff section from Fort Beausejour and found no foraminiferal tests, however, when material was collected in an area that was not exposed, there were numerous foraminifera identified. Also, in cores examined from Halifax Harbour, Nova Scotia and Chignecto

Bay, New Brunswick, there were foraminifera identified when these were first collected however, after being left out for a period of time, it was discovered that there were no foraminiferal tests remaining. There are a few possible explanations for this result; 1) that the processing techniques used were too rigorous and damaged the tests in the Halifax and Chignecto cores; 2) the cores collected in those areas had different sedimentary and chemical properties which enhanced test degradation; or 3) this study could not mimic the natural environmental conditions necessary for test degradation that was seen at the exposed cliff section in Fort Beausejour. The total abundance remained relatively constant in each of the samples examined, and as a result, it was concluded that these marsh foraminifera from Chezzetcook Inlet were very robust and that material taken from this area could be left out at room temperature for quite some time and still be used in foraminiferal analysis. There was no evidence of artificial taphonomic alterations in this material and as a result, it could be used in the determination of surface environmental conditions at the time of deposition.

CHAPTER VI

NEW BEDFORD HARBOR DISCUSSION

6.1 Foraminiferal Assemblages and Their Pollution Responses in New Bedford Harbor

New Bedford Harbor has been affected by many types of pollution for the past 300 years (1700- 2002) and has seen degradation of its system through increases in population growth and industrial development, especially over the last 50-60 years. Benthic foraminifera have been shown to be responsive to environmental change in other marine settings as well as useful indicators of pollution (e.g. Schafer, 1973; Murray, 1973; Alve, 1995). Their distribution in both surface and core samples further documents the pollution (and remediation) history of New Bedford Harbor. The various responses of foraminiferal assemblages (e.g. test deformities, absence of tests) have shown that benthic foraminifera are sensitive *in situ* monitors of marine pollution and as a result, are the proxies used in this study.

6.1.1 Surface Samples

6.1.1.1 Transect One- Upper to Lower Harbor

In the surface transect for NBH lowest numbers of foraminifera occur in the upper harbor where pollutant concentrations are at their highest (figure 4.11). PCB and total aliphatic hydrocarbon (PAH) concentrations are extremely high in the upper few samples, as are many heavy metals. Upper Harbor samples are dominated by agglutinated forms such as *Textularia earlandi* and *Ammobaculites dilatatus,* that are also present in other areas where there are strong pollution effects (e.g. Scott et al., 1976,1980; Ellison et al., 1986). The pollutant concentrations decrease in the Lower harbor where there is an increase in both diversity and abundance of foraminifera. PCB levels decrease to relatively low levels and PAHs decrease by an order of magnitude. Heavy metal concentrations are reduced to a quarter of their initial concentrations from the upper part of the harbor but these levels are still relatively high. The occurrence of calcareous species such as *Ammonia beccarii* and *Haynesina orbiculare* suggests that the area is becoming more hospitable for calcareous forms to be present. The removal of contaminated sediments and the subsequent remediation of these sediments is allowing these calcareous species to return and their tests to be preserved. Conditions are becoming favorable for the preservation of calcareous tests not only in the Lower Harbor, but halfway up the Upper Harbor where pollution was at its worst. Thus, the foraminifera are responding to a combination of adverse conditions and lower salinities with the dominance of agglutinated forms in the upper part of the transect, and as conditions improve in the lower harbor, the less tolerant calcareous forms occur in the living population and are preserved.

6.1.1.2 Transect Two- Apponagansett Bay

This transect was chosen because Apponagansett Bay has not been affected by the magnitude of industrial activities that NBH has had, and as a result, was the control site used for comparison of the other sites. All pollutant concentrations were near background levels except for PAHs. This is no surprise as these hydrocarbons are derived from more gnereal sources such as urban runoff and not necessarily industrial activities. The uppermost stations of the transect is dominated by *Ammobaculites dilatatus*, an agglutinated foraminifera, and organic linings. This species is generally indicative of lower salinity conditions which occur here as well as higher %OC values. The next two stations are co-dominated by *A. dilatatus* and calcareous species such as *Elphidium spp.* and *Haynesina orbiculare.* There is also an increase in both diversity and abundance at these stations. This would seem to be the typical fauna found in this location compared with other sites that have been investigated (e.g. Schafer, 1973; Buzas, 1973; Alve, 1995). There is an increase in organic linings at the fifth site as well as a decrease in numbers and this trend continues out to the furthest site where the assemblage is completely dominated by organic linings. This would suggest that although there is little in the way of toxic pollutants, this area is naturally stressed in terms of preservation, probably by organic matter and biological oxygen demand as calcareous tests are readily dissolved by low pH values.

6.1.1.3 Clark's Point Outfall Samples

The twelve surface samples collected near Clark's Point Outfall show a definite response to the wastewater or sewage effluent that is discharged at the outfall site. The samples closest to the outfall show higher concentrations of PAHs. PCB concentrations are negligible at this site as are heavy metal concentrations. Samples CPC, CPE, CPF, NBH324, and NBH325 are relatively barren showing a lack of calcareous tests (such as *Elphidium excavatum* forma *clavatum*) but there is a high abundance of organic linings indicating a diagenetic response; i.e. the foraminifera are living there but the $CaCO_3$ dissolves after they die. These organic linings are the result of the dissolution of calcium carbonate tests due to a lowering of pH in the sediment from the discharge of high amounts of organic carbon from the Clark's Point outfall. The outfall plume is very well defined as surrounding samples show a rich diversity and high abundance of calcareous tests. The plume forms to the south and slightly to the east as samples CPB and CPD are not affected as suggested by their rich foraminiferal assemblages. Also the plume does not extend far from the source as only samples close to the outfall site are affected while samples CPD and CPG show a typical foraminiferal assemblage for this environment (figure 6.1). This response is similar to the ones observed by Bandy et al. (1965) near the Hyperion Outfall in Orange County, California where a barren zone was created as well as Schafer (1973) near pollution sources in Chaleur Bay, New Brunswick (Canada).

An exception to this response is sample NBH333. Despite the fact that this site is not affected by heavy metals or other industrial wastes, the number of individuals is quite low. This may be the result of the very coarse sandy nature of the bottom sediments at this site indicating oligotrophic conditions (lack of organic matter). This is in accordance with Phleger (1960) and Murray (1968) who suggest that fine sand and silty sand substrata yield high numbers of living species and individuals. The fine-grained sediments generally contain higher percentages of organic matter, and thus more potential food, than coarse grained sediments. Low organic content here appears to keep populations low because of the lack of a food source.

Overall, an outfall plume was delineated surrounding Clark's Point that showed a lack of calcareous tests along with large numbers of organic linings from samples CPC, CPE, CPF, NBH324, and NBH325 suggesting that the effluent that is discharged is high in organic content and has a deleterious effect on the preservation of calcareous tests.

6.1.2 New Bedford Harbor Cores

6.1.2.1 Upper Harbor

6.1.2.1a Core 1c052396

There appears to be a few factors that have caused a change in assemblages in this core around the 22 cm interval corresponding to 1926. Prior to this date, this was an upper estuarine assemblage consisting of almost entirely of *Ammobaculites dilatatus* and *Ammotium salsum* with small percentages of reworked marsh species from surrounding contemporaneous marshes including *Trochammina inflata* and *T. macrescens*. This is good evidence that as the area was developed, surrounding salt marshes were destroyed which probably led to the introduction of reworked marsh species. With the introduction of pollutants such as Zn, Cr, Cu, PAHs, and PCBs, conditions became stressed with organic carbon percentages doubling, resulting in lower numbers of individuals with the assemblage dominated by reworked marsh species. The pollutant levels peaked at around 1971 and then began to decline. 1971 marks the introduction of a calcareous species, *Ammonia beccarii*, at this site indicating more favorable conditions for the preservation of calcium carbonate tests. There were no signs of calcareous species in older sediments suggesting a change in the environment brought about either through remediation of the area or a change in conditions at the time of deposition (i.e. salinity and temperature changes). Overall, there are two distinct responses in this core; one is the result of pollution where the assemblage became dominated by reworked marsh species with the elimination of all endemic species after the introduction of pollutants around 1926 followed by a change in environmental conditions near the top of the core signaling remediation with the introduction of a lower estuarine calcareous species. The lack of organic linings in the lower part of the core suggests no calcareous species were living there.

6.1.2.1b Core 1c102596

There appears to have been a fundamental change in the environment in this Upper Harbor site since 1979, not related to direct pollution effects. Prior to 1979 there are few organic linings suggesting that calcareous species were not present in significant numbers even in the background level period (1875-1940). The low abundance assemblage between ~1940 and 1979 appears to be largely reworked marsh species (again from surrounding contemporaneous marshes) that were not living there (*Trochammina macrescens* and *T. inflata*) and before that an upper estuarine, very brackish assemblage consisting of almost 100% *Ammobaculites dilatatus*. This assemblage does not recover with remediation but is replaced by a calcareous assemblage after 1979 which suggests not only recovery but a fundamental change in salinity/temperature structure of the upper estuary that now allows calcareous species where there were none less than century ago. There could be many reasons for this, among them reduced ground water flow as a result of increased population pressure that decreases the freshwater input, blockage of freshwater inlets in the upper estuary or an increase in temperature of the area caused by a local "heat island" as the population increased; all these factors separately or together could act to allow calcareous species to exist in lower salinities. Whatever the reason there are two distinct responses in core 1c102596-one pollution related between 1940 and 1979, where basically the assemblage was eliminated, so that only reworked marsh species were present, and second, an environmental response that may or may not also be related to human pressures; that is the fundamental environmental shift from an upper estuarine regime to a lower estuary one signaled by the intrusion of calcareous species after 1978.

6.1.2.2 Lower Harbor

6.1.2.2a Core 2c101896

This core contained very few individuals and was basically a reworked marsh fauna with an upper estuarine form, *A. dilatatus* co-dominating the assemblage (figure 4.13). The chemical profile suggests that this area was likely dredged and used as a dump area. This core was collected near Rt. 195 bridge so there was a lot of activity in the area with high organic carbon content. Although this core does not show any definitive results, it does illustrate the high degree of variability between sites that shows why "one core" studies are not valid.

6.1.2.2b Core 5c061098

Upon careful examination of the chemical profiles of this core, it was discovered that some of the top portion was lost in the collection of the core. As a result, the top of the core was dated at 1973. All pollutants tend to be increasing up to the surface of the core. There appears to be a change in the faunal assemblage around the 15 cm interval corresponding to 1940. Prior to this interval, the assemblage was dominated by *Elphidium excavatum* and *Haynesina orbiculare* alternating with organic linings. Abundance and diversity both decreased above this interval with *Ammobaculites exiguus* and *Textularia earlandi* dominating the assemblage. There is also the presence of deformities occurring in the top 22 centimeters and increasing in frequency above 15 cm (1940). These deformities are generally stunted *Haynesina orbiculare*. Yanko et al. (1992, 1994) have noted that most stunted foraminiferal tests are characteristic of areas that are contaminated with heavy metals. Schafer (1973), Buckley et al. (1974), and Schafer et al. (1991) showed that *Elphidium excavatum* was able to tolerate and compete successfully in polluted, near shore environments. However, *Elphidium excavatum* in this core disappears above 15 cm and most of the deformities are in *H. orbiculare*. This was the only core location (if the surface samples from the transect are considered0 that indicated conditions to be similar between now and pre-industrial times. The *Elphidium/Haynesina* assemblage appears to be typical for most shallow parts of the Long Island Sound system (e.g. Buzas, 1965). Although the core has lost the top 8 cm, the surface transect shows that conditions are becoming favorable again as this area recovers with the typical calcareous fauna dominating the assemblage in surface samples near this site. Samir and El-Din (2001), in a study in two Egyptian Bays, suggested that heavy metals were responsible for abnormalities in foraminiferal tests and that the mode of deformation depends upon the degree of pollution and type of pollutants. Deformed specimens with double apertures, compressed tests, and abnormal growth are associated with the highest levels of heavy metals and forms with protuberances and siamese twins are associated with lower concentrations of heavy metals. Heavy metal concentrations are highest at this site and as a result, nearly all of the deformities observed were compressed and stunted tests in agreement with Samir and El-Din (2001) (see Plate 1). Thus, the foraminifera are responding strongly to pollutants in this area and with the removal of some of the contaminated sediment, they are returning to pre-industrial times in the surface transect, indicating recovery in this area. A similar type of study was done by Stott et al. (1996) who revisited stations of Bandy et al. (1964) from the Orange County Outfall (California, USA). In the 1964 study there was evidence of a degraded fauna with many species, such as *Trochammina pacifica*, which have subsequently been linked to pollution (e.g. Patterson,1990). Since 1964 there have been attempts to reduce pollution at the outfall site and Stott et al. (1996) sought to determine if they could detect recovery by reexamining Bandy et al.'s stations for foraminifera. They did see a fauna that was similar to a non-impacted shelf fauna suggesting some recovery had taken place. This indicates that foraminifera can be used for monitoring remediation as well as degradation.

6.1.2.3 Lower Harbor

6.1.2.3a Core 1c061098

Two push cores were collected near the hurricane barrier located on the lower west side of the lower harbor (figure 1.2). Both cores exhibited similar foraminiferal and geochemical trends; however, there were some marked differences. The first core shows some interesting foraminiferal responses to various types of activities that have taken place in New Bedford Harbor. Because the Pb-210 signals showed mixing in the upper part of the core, very few intervals within the core were used in geochemical analysis and as a result, foraminiferal assemblages were used to at least determine the barrier placement stage in these cores; it is easy to see the sharp contrast to open bay (no barrier) with closed bay (barrier), which we know is 1964. Organic matter percentage increases rapidly above the 140 cm interval. This is due to the construction of the hurricane barrier that started in 1964 and was completed in 1965. Circulation patterns and tidal flushing were severely reduced after the hurricane barrier was built and as a result, organic matter percentages increased which resulted in the dissolution of calcareous specimens. There is a large increase in foraminiferal abundance between 90-110 cm; this spike may be due to the construction of the I-195 highway which took place in 1972 which may have introduced a disturbance by input of road material that would have temporarily raised oxygen levels and allowed $CaCO_3$ species to exist. This is around the same time that peak production in PCBs took place resulting in high concentrations of PCBs (figure 1.3) There is a decrease in organic matter and an increase in sand suggesting a high energy environment. This disturbance seems to be overriding any effects that PCBs or other pollutants had on the foraminifera by increasing the oxygen levels as calcareous species are in high abundance. Above this interval, there is a dissolution event as organic carbon again increases, reducing the amount of available oxygen in the environment.

Another foraminiferal response observed in this core is the emergence of deformed specimens. They first appear around the 130 cm interval (1964), probably the result of high pollutants and the loss of tidal flushing after the barrier emplacement. Deformities continue up core to the 28 cm interval. This corresponds to PCB levels decreasing from a peak value to a lower level (1978). The deformed specimen profile and the calcareous species, *Haynesina orbiculare,* profile are similar because nearly all of the deformities occur in *H. orbiculare.* Again most of these deformities are stunted tests from *H. orbiculare*, however, there are some twinned and protuberance tests found in this core suggesting slightly lower levels of heavy metals (see Plate 1). Near the top of the core, another dissolution event occurs as organic linings dominate the assemblage. This may be the result of an increase in PAHs or in organic carbon percentages that takes up available oxygen, thereby lowering the pH in the sediment and causing dissolution. The only sign of recovery in this core is the disappearance of deformities after 1978; however, abundances above this interval are still low and the assemblage has not returned to pre-industrial times.

6.1.2.3b Core 1c101896

This core was collected only a few meters away from core 1c061898 (figure 1.2). Both the foraminiferal and geochemical data show a similar response as in the previous core. Between the 60-70 cm interval, total abundance increases dramatically as does concentration of metals, hydrocarbons, and PCBs (Fig. 4.17 and 4.7). Within this interval, PCB concentrations peak at two different intervals. This corresponds to peaks in national production of PCBs in 1970 and 1973. Again, there is an increase in sand probably from the construction of the I-195 highway, which is creating a disturbance that appears to be masking the effects that these pollutants have on the benthic biota. There is a typical foraminiferal fauna occurring at the bottom of the core (1958) however, these calcareous forms disappear above the 105 cm interval and organic linings dominate the assemblage. Increases in organic carbon above this interval suggest that the construction of the hurricane barrier resulted in the increase in organic linings by decreasing circulation and increased stagnation.

The difference in these two cores occurs above the 60 cm interval. There seems to be two dumping events that have taken place after the highway was built because the foraminiferal fauna is misplaced. The foraminiferal assemblage is dominated by organic linings and a marsh species, *Trochammina macrescens.* This continues until the 20 cm interval where another dumping event appears to have taken place and continues up to the 4 cm interval. The assemblage is dominated by *Ammobaculites dilatatus* and *Textularia earlandi* (both upper estuarine species). These two dumping events are marked by an almost barren assemblage as numbers of individuals are quite low. These "dumping" events can be detected because the foraminifera here are severely displaced. It is quite possible we could trace the source of the dredge spoil from the from the foraminifera present.

There appears to be an increase in both the abundance and diversity of foraminifera above the 4 cm interval. Calcareous species are appearing, suggesting that conditions are becoming more favorable for these species to return and that the system may be getting restored to pre-impact times with an assemblage similar to that described by Buzas (1965). The upper few centimeters of this core displayed a typical fauna for this area. There appears to be remediation occurring here as a result of the pilot dredging operation that took place in 1994 to remove contaminated sediments from the area. Heavy metal concentrations are relatively low at this site and as a result, there were no deformities observed in this core.

These two cores provide an opportunity to see affects of several perturbations on foraminiferal assemblages: barrier building (1964) which decreased circulation, road building (1972) which increased oxygen levels, pollution (1960's- present), remediation and dredging which can be detected by displaced foraminifera. Each of these events can be delineated by these foraminiferal assemblages.

All cores from NBH recorded the effects of remediation, at least to some extent, with the most pronounced event starting in 1978 when use of PCBs was terminated. The examination of the assemblages in the cores below the 1978 levels and the comparison with those of the core surfaces and the surface transect made the event very clear. In two cores from the Upper Harbor (1c102596 and 5c061898) agglutinated species were most prominent prior to 1978; one of these species, Textularia earlandi, has been reported as common in other upper estuarine environments subjected to heavy industrial and domestic input (San Diego Bay, USA, Scott et al., 1976). High levels of deformities in cores 5c061898 and 1c061898, in the period of PCB use, indicated a strong response to those chemicals. No deformities were recored in core 1c102596 because the species deposited in that corre during the time of PCB use were all reworked marsh species, which had not been subjected to the PCBs. Although the rrecord after 1978 in 5c061898 is apparently missing, the surface transect assemblages show that remediation has taken place at the site due to the increase in both diversity (appearance of calcareous species) and abundance.

6.1.2.4 Apponagansett Bay

6.1.2.4a Core 1c103096

This core was used as a control site because this area was not affected by industrial activities. Throughout the entire core, organic linings and calcareous species such as *Elphidium excavatum* and *Haynesina orbiculare* dominate the entire assemblage. The only change in the assemblage occurs at the top of the core with total numbers decreasing to almost zero and *Ammobaculites dilatatus*, an agglutinated foraminifera, completely dominates the assemblage. This was also observed in the surface samples in transect 2 and suggests a freshwater influx somewhere allowing this upper estuarine form to be present. Pollutant concentrations are at background levels and the foraminiferal assemblage is responding to naturally induced stresses and not human induced stresses. This site is eutrophic, thus calcareous species would have a hard time preserving their tests due to the lack of oxygen necessary for test formation as well as test preservation. One interesting aspect of this core is the alternation of calcareous preservation and organic linings only. Is this a seasonal response? That is, do low temperatures in the winter enhance carbonate dissolution or conversely does high organic production in the summer enhance dissolution? The core profile alternates systematically but the time resolution does not allow intra-year comparison but these alterations are suggestive of intra-year changes in preservation characteristics.

6.2 Comparisons and Applications in Other Estuaries

Foraminiferal distributions in polluted marine environments have been investigated over the last 30- 40 years. They have been shown to respond to various industrial activities, however, the dynamics of foraminiferal ecology and their responses to various industrial activities are far from understood for a number of reasons. The two main reasons are the fact that many different kinds of pollutants are being discharged into the marine environments and as a result, the foraminiferal response varies with the different mixtures of pollutants and secondly, marginal marine settings are complex and in many cases unique which makes delineating faunal properties from pollution effects difficult. The same type of pollution can affect various environments differently. Pollution effects on the biota in estuaries can best be evaluated by comparing the natural, pre-pollution assemblages with those of the present. The presence of empty tests in sediment cores that penetrates through the impact intervals provides this type of information. Although foraminifera respond differently in various marine environments, there are similar patterns such as deformities, increased abundance, and/or a decrease in diversity or the emergence of an opportunistic species which occur which allows for comparisons of other estuaries around the world.

Cores from the Patapsco River and Baltimore Harbour in Maryland were analysed and the retreat of *Ammobaculites crassus* downstream in response to increased heavy metal levels was identified. This species also developed a large population in the lower part of the estuary probably because of the lack of competition. As concentrations of heavy metals increased, the population was reduced leaving the area almost barren. The upper parts of the cores indicated a recent return to more natural conditions in the estuary with a moderate assemblage of *A. crassus* identified. This is a similar response to the one observed in New Bedford Harbor with *A. crassus* or *A. dilatatus* appearing in cores that were impacted with heavy metals and larger populations returning in the upper part of the cores reflecting improving conditions. Alve (1991) and Alve and Nagy (1986) investigated several different fjords in Norway that were affected by heavy metals and/or organic enrichment. The silled-fjord types that were studied were more sensitive to organic enrichment than New Bedford Harbor that has a connection with the open sea. She determined that a faunal shift had taken place due to heavy metal loading and that species abundance had decreased upcore and the appearance of an opportunistic species, *Eggerelloides scabrus*, revealed an extremely polluted environment. Despite the fact that the foraminiferal species in Norway are different than the ones examined in New Bedford Harbor, responses to pollution impacts are similar. The increase in PCBs and heavy metals in NBH caused a sharp decline in species abundance and diversity with often only one or two species identified in the sediment. The agglutinated foraminifers *A. dilatatus* and/or *A. crassus* were often the only species found in cores and surface samples in the highly polluted areas. In Norway, agglutinated foraminifera tended to remain while the calcareous species were more sensitive to pollution.

Cores and transects from Halifax Harbor (HH), Nova Scotia and New Bedford Harbor were compared for differences in pollution types and the different foraminiferal responses. The differences between these sites are not simply due to different pollution problems. NBH is a shallow, relatively warm-water system, while HH is deep water, in places strongly stratified, estuarine system. As demonstrated by Scott et al., (1980) there are distinct classifications that can be based solely on foraminiferal assemblages for deep and shallow water embayments. For example, *Ammonia beccarii* is not found subtidally anywhere in Nova Scotian waters, except for the Northumberland Strait, which is a part of the Gulf of St. Lawrence, in which, during the summer, the water warms to 20°C which is the reproductive temperature requirement for A. beccarii (Bradshaw, 1961). This difference alone makes the comparison of these two systems difficult. In both sites, however, the dissolution of calcareous tests is a fundamental problem caused by the same phenomenon: high OC fluxes that lower the pH in the sediments with consequent dissolution of the tests of calcareous foraminifera. In Nova Scotia, this process might be enhanced further by colder water increasing the solubility. Organic loading, however, is a factor in both places.

The most fundamental difference between the two areas, however, is the level of pollution in NBH versus that in HH. The organic loading may be higher in HH but the concentrations of the industrial metals, despite 250 years of unchecked pollution, do not even reach the background levels observed in NBH.

There were no barren or even really low-number assemblages in HH comparable to those in some parts of NBH, such as interval of core 1c102596 representing the time interval between1940 and 1980, or the upper part of core 5c061898. Although deformed specimens have been observed in HH, they were never observed in the high percentages encountered in NBH cores 1c061898 or 5c061898. Because of its shallow topography, many of the low oxygen indicators observed in HH, such as *Fursenkoina fusiformis,* were not observed in NBH. Possibly, the low oxygen indicator in NBH may be *Ammonia beccarii*, as it is for many other localities with warmer water (Scott et al., 2001). Surprisingly, a species almost completely missing from NBH is *Eggerella advena*, a well-known industrial pollution indicator (Schafer et al. 1975 and in HH). This species would expected to be present in NBH, but it was probably displaced by some of the shallow water calcareous forms.

Bandy et al., (1964, 1965) studied two outfalls in the California area and delineated a barren zone closest to the outfall effluent while an aureole of increased abundance of foraminifera existed on the periphery of the outfall points. Again, within this area, diversity decreased, but the abundance of a few species increased. This is similar to what occurred at Clark's Point, NBH where an aureole was created around the outfall site whereby a barren zone was created and around the periphery of the outfall extent, abundance of foraminifera were elevated.

These studies represent different marine settings however, some similarities do exist when comparing them with NBH. The most important aspect is to establish pre-impact assemblages and then determine what effects, if any, did heavy metals and other pollutants have had on the biota. The various foraminiferal responses reinforces the fact that foraminiferal assemblages are useful in detecting pollution changes through time and they can be applied to just about any marginal marine setting which makes them an excellent cost-effective tool as biomonitors for industrial and municipal pollution.

CHAPTER VII

CONCLUSIONS

7.1 Marsh Foraminiferal and Arcellacean Distributions

A. The tidal vertical zonation in Chezzetcook Inlet is very well defined with a high to low marsh assemblage readily delineated

B. In cores examined at three sites in Chezzetcook Inlet, living foraminifera did not appear to migrate vertically from season to season as there was no bulge in living foraminifera in the subsurface in the winter months.

C. No evidence indicates that infaunal habitats affected the total assemblage downcore. Preservation of agglutinated marsh foraminifera was very good in subsurface sediments in Chezzetcook Inlet. The total species composition at the surface was very similar to that in the subsurface. There was little evidence of natural taphonomic alteration of assemblages in cores collected in Chezzetcook Inlet. Consequently, the top 1 cm of these cores is a representative aliquot and accurately reflects environmental conditions occurring at the time of deposition.

D. Infaunal habitat or taphonomic biasing did not affect the total assemblage downcore in replotted data from Nanaimo, British Columbia; it appears that there are environmental changes and that is amplified by coincident lithology changes. Assemblage changes throughout the core appear to be the result of changes in environmental conditions at the time of deposition.

E. Foraminiferal assemblages in surface and subsurface sediment collected in Chezzetcook Inlet and stored at room temperature in buckets and bags showed no signs of degradation suggesting that these marsh foraminifera are robust and can withstand oxidizing and/or ambient conditions. Foraminiferal distributions from an archived core collected in 1992 near site 1 in Chezzetcook also showed no signs of degradation which suggests that there is also no artificial taphonomic processes occurring in the sediment once it is collected.

7.2 Estuarine Foraminiferal Assemblage

A. New Bedford Harbor has been affected by intense industrial activities over the last 50 to 60 years. This has led to heavy metal, PAH, PCB, and organic enrichment contamination of sediments. Foraminiferal assemblages have been shown to respond to the pollution and recovery as well as the various activities within sediment cores.

B. Foraminiferal distributions in surficial samples showed recovery in the lower part of the harbor as well as in some parts of the Upper Harbor where contamination of sediments was at its worst. The return of calcareous species such as *Haynesina orbiculare* and *Elphidium spp.* suggests recovery of the sediment.

C. Deformities of tests in foraminifera occurred in cores where PCB concentrations were highest suggesting that foraminifera are responding to increased levels of contamination. As concentrations of pollutants decreased toward the top of the core, deformities decreased to almost zero.

D. The twelve surface samples collected near Clark's Point Outfall show a definite response to the wastewater or sewage effluent that is discharged at the outfall site. There is an outfall plume that is very well defined as surrounding samples show a rich diversity and high abundance of calcareous tests while samples collected near the outfall site show a lack of tests with organic linings dominating the foraminiferal assemblages.

E. It is still unclear if domestic influence or natural phenomenon caused the alteration of calcareous tests with organic linings in two cores. This pattern goes well below the level where industrial activities would have had any impact on the assemblages.

F. The various foraminiferal responses reinforces the fact that foraminiferal assemblages are useful in detecting pollution changes through time and they can be applied to just about any marginal marine setting which makes them an excellent cost-effective tool as biomonitors for industrial and municipal pollution.

SYSTEMATIC TAXONOMY

Faunal Reference List:

The systematic arrangement of the foraminiferal genera are in accordance with Loeblich and Tappan (1964, 1988) except where otherwise noted. The classification of the thecamoebians is in accordance with Medioli and Scott (1983). The list includes species mentioned in tables and figures and these species are listed alphabetically by genus. Each synonomy includes the original reference, those used in species identification as well as some generic changes for each species.

Foraminifera

Ammobaculites dilatatus Cushman and Brönnimann, 1948a
Plate 1, Figure 1

Ammobaculites dilatatus CUSHMAN and BRÖNNIMANN, 1948a, p.39, pl. 7, figs. 10, 11. PARKER and others, 1953, p. 5, pl. 1, figs. 13-15. BOLTOVSKOY, 1984, figs. 11, 12. SCOTT and MEDIOLI, 1980a, p. 35, pl. 1, figs. 9, 10.

Ammobaculites c.f foliaceus (Brady). PARKER, 1952a, p. 444, pl. 1, figs. 20, 21.

Ammobaculites foliaceus (Brady). SCOTT and MEDIOLI, 1980a, p. 35, pl. 1, figs. 6-8.

Ammobaculites c.f **A. crassus** Cushman and Brönnimann, 1948a
Plate 1, Figures 2-5

Ammobaculites exiguus CUSHMAN and BRÖNNIMANN, 1948b, p. 38, pl. 7, figs. 7, 8.

Ammobaculites exiguus CUSHMAN and BRÖNNIMANN. SCOTT and MEDIOLI, 1980a, p. 35, pl. 1, figs. 9, 10.

Remark: This species was difficult to identify due to the fact that it looked very similar to *A. dilatatus* and/or *A. exiguus*. The species was separated from these other two due to the fact that the initial chambers contained a gap and wasn't closed in. We initially thought that this was a deformed *A. dilatatus* but it only occurred in one core and there was no evidence of other deformities so we called it *A.* c.f. *crassus*.

Ammonia beccarii (Linné, 1758)

Nautilus beccarii LINNE, 1758, p. 710.

Ammonia beccarii (Linné). SCOTT and MEDIOLI, 1980a, p. 35. Pl. 5, figs. 8,9.

"Rotalia" beccarii (Linné) var. tepida CUSHMAN, 1926, p. 79, pl. 1. PHLEGER and PARKER, 1951, p. 23, pl. 12, fig. 7.

Ammotium salsum Cushman and Brönnimann, 1948b

Ammobaculites salsus CUSHMAN and BRÖNNIMANN, 1948b, p. 16, pl. 3, figs. 7-9. PARKER and others, 1953, p. 5, pl. 1, figs. 17-25. PHLEGER, 1954, p. 635, pl. 1, figs. 7, 8.

Ammotium salsum CUSHMAN and BRÖNNIMANN. PARKER and ATHEARN, 1959, p. 340, pl. 50, figs. 6, 13. SCOTT and MEDIOLI, 1980a, p. 35, pl. 1, figs. 11-13.

Buccella frigida Cushman, 1922b

Plate 1, Figure 9

Pulvinulina frigida Cushman,1922b, p. 144.

Eponides frigida (Cushman) var. *calida* Cushman and Cole, 1930, p. 98, pl. 13, Fig. 13a-c; Phleger and Walton, 1950, p. 277, pl. 2, Fig. 21.

Eponides frigidus (Cushman). Cushman, 1941, p. 37, pl. 9, Fig. 16.

Buccella frigida (Cushman). Anderson, 1952, p. 144, figs. 4a-c, 5, 6a-c; Schafer and

Cole, 1978, p. 27, pl. 8, figs. 1,2; Scott et al., 1980, p. 226, pl. 4, figs. 10,11;

Miller et al., 1982, p. 2364, pl. 2, figs. 9,10.

Cyclogyra involvens (Ruess, 1850)

Operculina involvens REUSS, 1850, p. 370, pl. 46, fig. 30.

Cornuspira involvens (Reuss). REUSS, 1863, p.39, pl. 1, fig. 2. CUSHMAN, 1929, p. 80, pl. 20, figs. 6, 8.

Cyclogyra involvens (Reuss). BOCK, 1971, p. 12, pl. 3, fig. 2.

Eggerella advena (Cushman, 1922)

Verneuilina advena CUSHMAN, 1922, p. 141.

Eggerella advena (Cushman). PARKER, 1952a, p. 447, pl. 2, fig. 3. SCOTT and MEDIOLI, 1980a, p. 40, pl. 2, fig. 7.

Elphidium excavatum (Terquem) forma **clavatum** Cushman, 1930
Plate 1, Figures 12, 13

Elphidium incertum (Williamson) var. *clavatum* CUSHMAN, 1930, p. 20, pl. 7, fig. 10.

Elphidium incertum (Williamson) and variants. PARKER, 1952b, p. 448, pl. 3, fig. 16.

Elphidium incertum (Terquen) forma *clavata* Cushman. MILLER and others, 1982, p. 124, pl. 1, figs. 5-8; pl. 2, figs. 3-8; pl. 3, figs. 3-8; pl. 4, figs. 1-6; pl. 5, figs. 4-8; pl. 6, figs. 1-5.

Elphidium excavatum (Terquem) forma **excavatum** (Terquem, 1876)
Plate 1, Figures 10, 11

Polystoma excavata TERQUEM, 1876, p. 429, p. 2, fig. 2.

Elphidium excavatum (Terquem). CUSHMAN, 1930b, p. 21, pl. 8, figs. 1-7.

CUSHMAN, 1944, p. 26, pl. 2, fig. 40. BENDA and PURI, 1962, p. 325, pl.1, fig. 16. HANSEN and LYKKE-ANDERSON, 1976, p. 10, pl. 6, figs. 1-6.

Elphidium excavatum (Terquem) forma *excavata* (Terquem). MILLER and others, 1982, p. 128, pl. 1, figs. 9-12; pl. 2, figs. 1, 2; pl. 3, figs. 1, 2; pl. 4, figs 13-16; pl. 5, figs.15, 16; pl. 6, figs. 6-8, 14.

Elphidium excavatum (Terquem) forma **gunteri** Cole, 1931

Elphidium gunteri COLE, 1931, p. 34, pl. 4, figs. 9, 10. PARKER and others, 1953, p. 8, pl. 3, figs. 18, 19. PARKER, 1954, p. 508, pl. 6, fig. 16. PHLEGER, 1954, p. 639, pl. 2, figs. 3, 4. BANDY, 1956, p. 194, pl. 30, fig. 19. LEHMANN, 1957, p. 348, pl. 3, figs. 1-4. LANKFORD, 1959, p. 2098, pl. 2, fig. 7. BENDA and PURI, 1962, p. 335, pl. 1, fig. 11. SCOTT and others, 1991, P. 385, PL. 2, fig. 15.

Elphidium excavatum (Terquem) forma **lidoensis** Cushman, 1936

Elphidium lidoensis CUSHMAN, 1936, p. 86, pl. 15, fig. 6.

Elphidium excavatum (Terquem) forma *lidoensis* Cushman. MILLER and others, 1982, p. 134, pl. 1, figs. 17-20; pl. 4, figs. 7-12; pl. 5, fig. 9; pl. 6, figs. 15, 16.

Elphidium excavatum (Terquem) forma **selseyensis**
Plate 1, Figure 16

(Heron-Allen and Earland), 1911 emended (Brand), 1941

Designated by Brand, 1941, p. 66, as: *Polystominella striatopunctata* variety selseyensis

Heron-Allen and Earland, 1909, p. 695, pl. 21, figs. 2a-2c.

Polystominella striatopunctata (Fichtel and Moll) variety HERON-ALLEN and EARLAND, 1909, p. 695, pl. 21, figs. 2a-2c.

Polystominella striatopunctata (Fichtel and Moll) variety *selseyensis* HERON-ALLEN and EARLAND, 1911, p. 448.

Elphidium incertum (Williamson) and variants. PARKER, 1952a, p. 448, pl. 3, figs. 14, 17; pl. 4, figs. 1, 2.

Elphidium excavatum (Terquem) forma *selseyensis* Heron-Allen and Earland. MILLER and others, 1982, p. 132, pl. 1, figs. 13-16; pl. 5, figs. 10-13; pl. 6, figs. 9-13.

Elphidium poeyanum (d'Orbigny, 1839)

Polystominella poeyana d'Orbigny, 1839, p. 55, pl. 6, figs. 25, 26.

Criboelphidium kugleri CUSHMAN and BRÖNNIMANN, 1948a, p. 18, pl. 4, fig. 4.

Criboelphidium poeyanum (d'Orbigny). BOCK, 1971, p. 57, pl. 21, figs. 1, 2.

Elphidium kugleri (Cushman Nd Brönnimann). HANSEN and LYKKE-ANDERSEN, 1976, p. 12, pl. 9, figs. 4-8.

Elphidium poeyanum (d'Orbigny). CUSHMAN, 1930b, p. 25, pl. 10, figs. 4, 5. PARKER and others, 1953, p. 9, pl. 3, fig. 26. BANDY, 1954, p. 136, pl. 30, fig. 6. PARKER, 1954, p. 509, pl. 6, fig. 17. PHLEGER, 1954, p. 639, pl. 2, figs. 8, 9. LEHMANN, 1957, p. 348, pl. 3, figs. 13, 14. LANKFORD, 1959, p. 2098, pl. 2, fig. 5. HANSEN and LYKKE-ANDERSEN, 1976, p. 13, pl. 9, figs. 9-12; pl. 10, figs. 1-5.

Elphidium williamsoni Haynes, 1973

Plate 1, Figures 14, 15

Polystomella umbilicatula Williamson, 1858, p. 42-44, figs. 81,82.

Elphidium williamsoni Haynes, 1973, p. 207-209, pl. 24, fig. 7, pl. 25, figs. 6,9, pl. 27, figs. 1-3.

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

Cribrononion umbilicatulum (Williamson). Scott and Medioli, 1980b, p. 40, pl. 5, fig. 4.

Cribrononion williamsoni (Haynes). Scott et al., 1980, p. 228.

Epistominella exigua (Brady, 1884)

Pulvinulina exigua BRADY, 1884, p. 696, pl. 103, figs. 13, 14.

Epistominella exigua (Brady). Parker, 1954, p. 533; Scott , 1987, p. 327, pl. 2, figs. 8,9.

Fursenkoina fusiformis (Williamson, 1858)

Bulimina pupoides (d'Orbigny) *fusiformis* WILLIAMSON, 1858, p. 64, pl. 5, figs. 129, 130.

"Bulimina" fusiformis (Williamson). HÓGLUND, 1947, p. 232, pl. 20, fig. 3, test-figures 219-233.

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

Fursenkoina fusiformis (Williamson). GREGORY, 1970. SCOTT ET AL., 1980, p. 228, pl. 3, figs. 9, 10.

Glomospira gordialis (Jones and Parker, 1860)

Trochammina squamata var. *gordialis* JONES and PARKER, 1860, p. 304.

Glomospira gordialis CUSHMAN and MCCULLOCH, 1939, p. 70, pl. 5, figs. 5, 6.

SCOTT and others, 1991, p. 385.

Haplophragmoides manilaensis Anderson, 1953

Haplophragmoides manilaensis ANDERSON, 1953, p. 22, pl. 4, fig. 8. SCOTT and others, 1991, p. 385, pl. 1, figs. 18, 19.

Haplophragmoides bonplandi TODD and BRÖNNIMANN, 1957, p. 23, pl.2, fig. 2. SCOTT and MEDIOLI, 1980a, p. 40, pl. 2, figs. 4, 5.

Haynesina orbiculare (Brady, 1881)
Plate 1, Figures 8, 17-19

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

Protelphidium orbiculare (Brady). SCOTT and others, 1977, p. 1579, pl. 5, figs. 5, 6. SCOTT and MEDIOLI, 1980a, p. 43, pl. 5, fig. 7

Haynesina orbiculare (Brady). BANNER and CULVER, 1978, p. 188.

Helenina anderseni (Warren, 1957)

Pseudoeponides andersoni WARREN, 1957, p. 39, pl. 4, figs., 12-15. PARKER and ATHEARN, 1959, p. 341, pl. 50, figs28-31.

Helenina anderseni (Warren). SCOTT and MEDIOLI, 1980a, p. 40, pl. 5, figs. 10, 11.

Hemisphaerammina bradyi Loeblich and Tappan, 1957

Hemisphaerammina bradyi Loeblich and Tappan in LOEBLICH AND COLLABORATORS, 1957, p.224, pl. 72, fig. 2, SCOTT and MEDIOLI, 1980a, p. 40, pl. 1, figs. 4, 5.

Hemisphaerammina sp. COLE and FERGUSON. 1975, pl. 1, fig. 4.

Islandiella teretis (Tappan, 1951)

Cassidulina laevigata d"Orbigny. Brady, 1884, p. 428, pl. 54, figs. 1-3.

Cassidulina teretis Tappan, 1951, p. 7, pl. 1, figs. 30a, c.

Islandiella teretis (Tappan) Vilks, 1969, p. 49, pl. 3, fig. 5.

Miliammina fusca (Brady, 1870)
Plate 1, Figures 6, 7

Quinqueloculina fusca BRADY, 1870, p. 286, pl. 11, figs. 2, 3.

Miliammina fusca (Brady). PHLEGER and WALTON, 1950, p. 280, pl. 1, figs. 19a, b. PARKER and ATHEARN, 1959, p. 340, pl. 50, figs. 11, 12. SCOTT and MEDIOLI, 1980a, p. 40, pl. 2, figs. 1-3.

Pseudothurammina limnetis (Scott and Medioli, 1980a)

Thurammina (?) *limnetis* SCOTT and MEDIOLI, 1980a, p. 43, pl. 1, fig. 4.

Pseudothurammina limnetis SCOTT and others, *In* Scott et al., 1981, p. 126. SCOTT and others, 1991, p. 386, pl. 2, fig. 4.

Quinqueloculina seminulum (Linné, 1758)

Serpula seminulum LINNÉ, 1758, P. 786.

Miliolina seminulum (Linné). WILLIAMSON, 1858, p. 85, pl. 7, figs. 183-185.

Quinqueloculina seminula (Linné). CUSHMAN, 1929, p. 59, pl. 9, figs. 16-18. PARKER, 1952a, p. 406, pl. 3, figs. 21a, b, 22a, b, pl. 4, figs. 1, 2.

Quinqueloculina seminulum (Linné). D'ORBIGNY, 1826, p. 303. GREGORY, 1970, p. 187, pl. 6, fig. 1. SCOTT, 1977, p. 175, pl. 7, figs. 3-5. SCOTT ET AL., 1980, p. 229, pl. 3, figs. 3-5.

Reophax arctica Brady, 1881

Reophax arctica BRADY, 1881, p. 405, pl. 21, fig. 2a, b. PARKER, 1952a, p. 395, pl. 1, figs. 6, 7. GREGORY, 1970, p. 168, pl. 2, fig. 3. COLE and FERGUSON, 1975, p. 40, pl. 1, fig. 9. SCOTT, 1977, p. 175, pl. 3, fig. 5. SCHAFER and COLE, 1978, p. 29, pl. 2, fig. 5.

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

Reophax arctica (Brady). SCOTT ET AL., 1980, p. 226, pl. 2, fig. 1.

Reophax nana Rhumbler, 1911

Reophax nana RHUMBLER, 1911, p. 182, pl. 8, figs. 6-12. SCOTT and MEDIOLI, 1980a, p. 43, pl. 2, fig. 6.

Reophax scorpiurus (Montfort, 1808)

Reophax scorpiurus Montfort, 1808, p. 330. Loeblich and Tappan, 1953, p. 24, pl. 2, figs. 7-10. Leslie, 1965, p. 169, pl. 1, fig. 6, 7.

Reophax scotti Chaster, 1892

Reophax scotti CHASTER, 1892, p. 57, pl. 1, fig. 1.

Rosalina columbiensis (Cushman, 1925)

Discorbis columbiensis CUSHMAN, 1925, p. 43, pl. 6, fig. 13. PARKER, 1952a, p. 418, pl. 6, figs. 7a, b, 8a, b, 9a, b. PARKER, 1952b, p. 446, pl. 4, figs. 17a, b, 18a, b, 19a, b, 20a, b. GREGORY, 1970, p. 218, pl. 11, figs. 6, 7.

Rosalina columbiensis (Cushman). UCHIO, 1960, p. 66, pl. 8, figs. 1, 2. SCOTT, 1977, p. 176, pl. 8, figs. 6, 7. SCOTT ET AL., 1980, p. 230, pl. 4, figs. 6, 7.

Spiroplectammina biformis (Parker and Jones, 1865)

Textularia agglutinans (d'Orbigny) var. *biformis* PARKER and JONES, 1865, p. 370, pl. 15, fig. 23, 24.

Spiroplectammina biformis (PARKER and JONES). CUSHMAN, 1927, p. 23, pl. 5, fig. 1. GREGORY, 1970, p. 179, pl. 4, fig. 1, 2.

Tiphotrocha comprimata (Cushman and Brönnimann, 1948a)

Trochammina comprimata CUSHMAN and BRÖNNIMANN, 1948a, p. 41, pl. 8, figs. 1-3. PARKER and others, 1953, p. 14, pl. 3, figs. 3, 4.

Tiphotrocha comprimata (CUSHMAN and BRÖNNIMANN). SCOTT and MEDIOLI, 1980a, p. 44, pl. 5, figs. 1-3.

Trochammina inflata (Montagu, 1808)

Nautilus inflatus MONTAGU, 1808, p. 81, pl. 18, fig. 3.

Trochammina inflata (Montagu). PARKER, 1952a, p. 459, pl. 3, fig. 1. PHLEGER, 1954, p. 646, pl. 3, figs. 22, 23. SCOTT and MEDIOLI, 1980a, p. 44, pl. 5, figs. 1-3.

Trochammina macrescens Brady, 1870

Trochammina inflata (Montagu) var. *macrescens* BRADY, 1870, p. 290, pl. 11, fig. 5. SCOTT, 1976a, p. 320, pl. 1, figs. 4-7.

Jadammina polystoma BARTENSTEIN and BRAND, 1938, p. 381, figs. 1, 2. PARKER and ATHEARN, 1959, p. 341, pl. 50, figs. 21, 22, 27. SCOTT, 1977, p. 173, pl. 4, figs. 9-11.

Trochammina macrescens Brady. PARKER, 1952a, p. 460, pl. 3, fig. 3. SCOTT and MEDIOLI, 1980a, p. 44, pl. 3, figs. 1-12.

Remarks: In this study, *Trochammina macrescens* s. l. includes two ecophenotypes, *Trochammina macrescens* and *Jadammina polystoma*. The ecophenotypes form an intergradational serious based on suture curvature and are distinguished by the presence or absence of supplementary apertures. The author adopts the following terminology as used in Scott and Medioli, 1980a; the form without supplementary apertures is identified as *Trochammina macrescens* forma *macrescens* and correlates with low salinity, and the one with supplementary apertures as *Trochammina macrescens* forma *polystoma,* correlating with higher salinity as to avoid confusion and argument.

Trochammina ochracea (Williamson, 1858)

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

Trochammina squamata PARKER and JONES, 1865, p. 407, pl. 15, figs. 30, 31. PARKER, 1952a, p. 460, pl. 3, fig. 4. SCOTT and MEDIOLI, 1980a, p. 45, pl. 4, figs. 6, 7.

Trochammina squamata (Williamson). PARKER and JONES, and related species. PARKER, 1952a, p. 460, pl. 3, fig. 5.

Trochammina ochracea (Williamson). CUSHMAN, 1920, p. 75, pl. 15, fig. 3. SCOTT and MEDIOLI, 1980a, p. 45, pl. 4, figs. 4, 5.

Thecamoebians

Centropyxis aculeata (Ehrenberg), 1832 *ab* (Ehrenberg, 1830)

Arcella aculeata EHRENBERG, 1832, (ab Ehrenberg, 1830, p. 60, nomen nudem), p. 91.

Leptodermella salsa CUSHMAN and BRÖNNIMANN, 1948b, p. 15, pl. 3, figs. 3, 4.

Leptodermella variabilis PARKER, 1952a, p. 452, pl. 1, figs. 11, 12.

Centropyxis excentricus (Cushman and Brönnimann). SCOTT, 1976b, p. 320, pl. 1, figs. 1, 2. SCOTT and others, 1980, p. 224, pl. 1, figs. 1-3.

Centropyxis aculeata (Ehrenberg). STEIN, 1859, p. 43. MEDIOLI and SCOTT, 1983, p. 39, pl 7, figs. 10-19. SCOTT and others, 1991, p. 384, pl. 1, figs. 7-9.

Centropyxis constricta (Ehrenberg, 1843)

Arcella constricta EHRENBERG, 1843, p. 41-, pl. 4, fig. 35, pl. 5, fig. 1.

Difflugia constricta (Ehrenberg). LEIDY, 1879, p. 120, pl. 18, figs. 8-55.

Urnulina compressa CUSHMAN, 1930, p. 15, pl. 1, fig. 2. PARKER, 1952a, p. 460, pl. 1, fig. 9. SCOTT and others, 1980, p. 224, pl. 1, figs. 13-15.

Centropyxis constricta (Ehrenberg). DEFLANDRE, 1929, p. 340, test-figs. 6-67. MEDIOLI and SCOTT, 1983, p. 41, pl. 7, figs. 1-9. SCOTT and others, 1991, p. 384, pl. 1, fig. 4.

Difflugia oblonga Ehrenberg, 1832

Difflugia oblonga EHRENBERG, 1832, p. 90. EHRENBERG, 1838, p. 131, pl. 9, fig. 2. MEDIOLI and SCOTT, 1983, p. 25, pl. 2, figs. 1-17, 24-26.

Difflugia capreolata Penard. Scott and others, 1980, p. 224, pl. 1, figs. 4-7.

Lesquereusia spiralis (Ehrenberg, 1840a)

Difflugia spiralis EHRENBERG, 1840a, p. 199.

Lesquereusia spiralis (Ehrenberg). PENARD, 1902, p. 36, text-figs. 1-10. PATTERSON and others, 1985, p. 135, pl. 2, figs. 9, 10. SCOTT and others, 1991, p. 386, pl. 1, fig. 10

Pontigulasia compressa (Carter, 1864)

Difflugia compressa CARTER, 1864, p. 22, pl. 1, figs. 5, 6.

Pontigulasia compressa RHUMBLER, 1895, p. 105, pl. 4, figs. 13a, b.

Pontigulasia compressa (Carter). AVERINTSEV, 1906, p. 169. SCOTT and others, 1980, p. 224, pl. 1, figs. 10-12. MEDIOLI and SCOTT, 1983, p. 34, pl. 6, figs. 5-14.

PLATE I

Figure 1.	*Ammobaculites dilatatus* Cushman and Bronnimann.
Figures 2-5.	*Ammobaculites* c.f. *crassus* Cushman and Bronnimann
Figures 6-7.	Deformed *Miliammina fusca* (Brady)
Figure 8.	*Haynesina orbiculare* (Brady)
Figure 9.	*Buccella frigida* Cushman
Figures 10, 11.	*Elphidium excavatum* forma *excavatum* (Terquem)
Figure 12.	*Elphidium excavatum* forma *clavatum* (Cushman)
Figure 13.	Deformed *Elphidium excavatum* forma *clavatum* (Cushman)
Figures 14, 15.	Deformed *Elphidium williamsoni* Haynes
Figure 16.	*Elphidium excavatum* forma *selseyensis*
Figures 17-19.	Severely deformed *Haynesina orbiculare* (Brady)

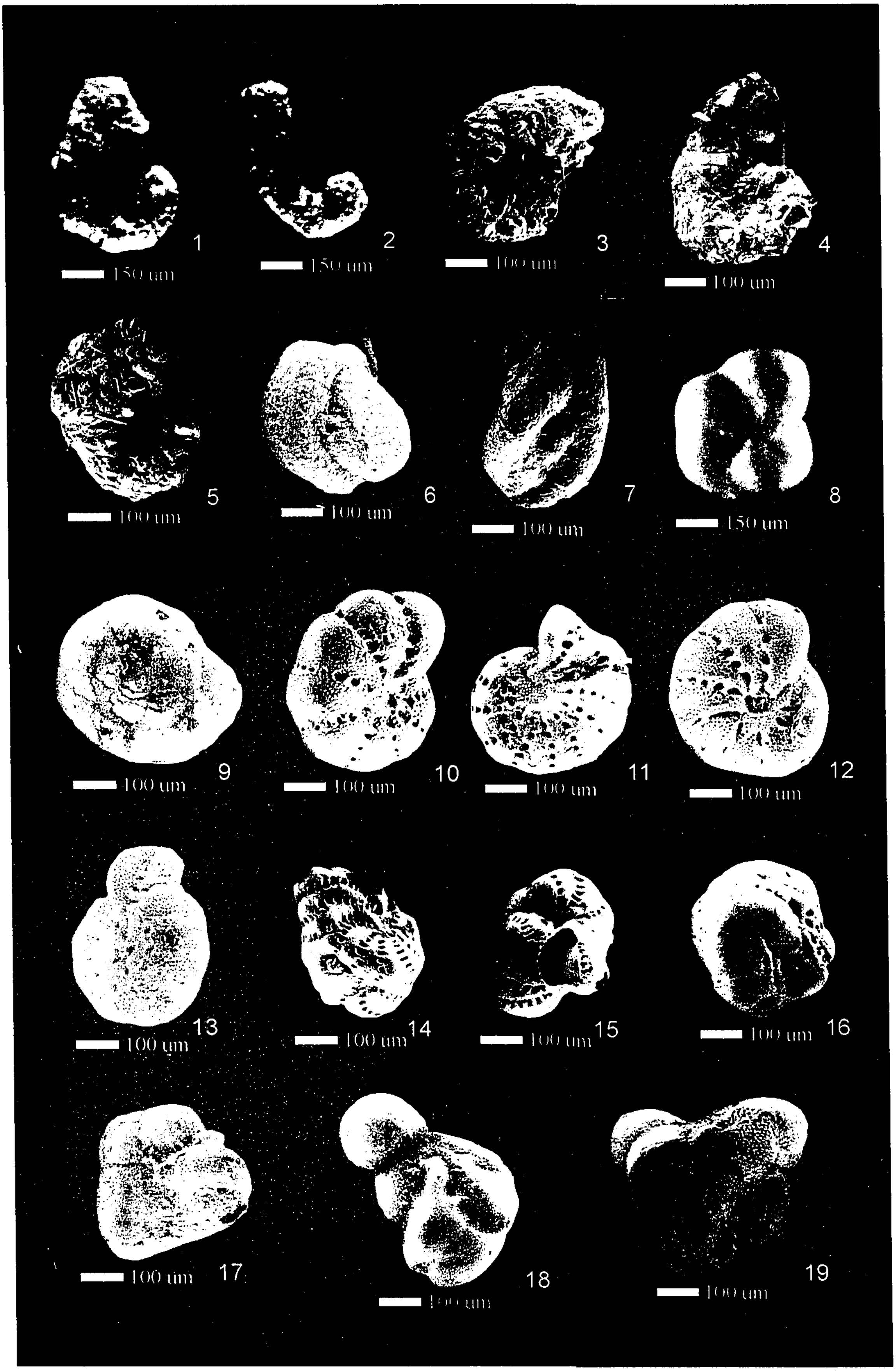

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Plate 1

APPENDIX TABLE 1a-i - Laboratory operating procedures for radionuclide dating and core chronologies and inorganic analysis of surficial and core marine environmental samples taken from New Bedford Harbor. This includes metal preparation and analysis, polyaromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB) analysis, and the cleanup and chemical class separation of semi-volatile organic compounds.

1. OBJECTIVES

The objective of LOP is to describe the procedure that performs a complete digestion of sediments for determination of the concentrations of metals. Because of the digestion is complete, the concentrations measured are the total metals concentrations in the sediment, including both contaminant and natural background components. Complete digestion of the mineral matrix is accomplished by the use of concentrated nitric and hydrofluoric acid. Residual HF is neutralized after digestion with boric acid, any residue filtered and the filtrate diluted. The resultant solution may be analyzed for metals by atomic absorption or emission techniques.

2. MATERIALS AND EQUIPMENT

- Concentrated nitric acid
- Hydrofluoric acid
- Boric acid
- Teflon digestion vessels with peel-off labels
- Freezer
- Virtis lyophilizer
- Laboratory scale
- Protective clothing:
- Labcoat
- Polyethylene apron
- Neoprene gloves
- Safety goggles (not glasses)
- Face shield
- MDS-81
- Fume hood
- 50 ml volumetric flask
- Deionized water
- Clean, acid-stripped polyethylene bottle

3. PROCEDURE

3.1 Sample preparation

3.1.1 Sediments should be thawed and homogenized using appropriate equipment prior to subsampling for analysis.

3.1.2 Obtain the tare weight of each Teflon digestion vessel liner. Add approximately 1.0-2.0 g of wet sediment (corresponding to 0.5-1.0 g dry) to each vessel and reweigh, obtaining the wet gross weight.

3.1.3 If sediment samples are to be dried, place vessels upright in freezer until sediments are frozen solid. Freeze-dry sediments according to manufacturer's instructions.

3.1.4 Remove the vessels from the freeze dryer and weigh again, obtaining the dry gross weights for the samples. Wet weight, dry weight and the dry-to-wet ratio are calculated from the tare and gross weights.

3.2 Microwave digestion

3.2.1 Before digesting the sediment samples, the chemist **must** be wearing appropriate protective clothing: lab coat, polyethylene apron, neoprene gloves, safety goggles (not glasses) and face shield.

3.2.2 Add 5.0 ml of concentrated nitric acid (HNO_3) to each vessel liner. Swirl slightly to wet sediment and check for reaction with sediment, e.g. foaming or bubbling. When no reaction is evident, add 4.0 ml of concentrated hydrofluoric acid (HF) and 1.0 ml of concentrated hydrochloric acid (HCl) to each vessel. Place liners into digestion vessels, insert a rupture membrane into each cap and tighten cap. Do not overtighten.

3.2.3 Place vessels in carousel. Insert vent tube into each vessel neck and tighten nut. Insert free end of tube into vent trap in center of carousel. Attach pressure sensing line to control vessel, making sure that the lever on the side of the digestion oven is in the "NEUTRAL" position. Return the carousel to oven. Insure that venting fan is operating.

3.2.4 Program the MDS-2100 for the parameters given below:

Stage	1	2
% power	100	100
PSI	120	150
Time	30:00	15:00
TAP (time at ppressure)	20:00	10:00
Fan speed	100	100

Power setting is for 12 vessels. If fewer vessels used, reduce power by 5% per vessel. Initiate digestion by pressing start. Note: Individual sediments can always react in unanticipated ways. If vessels vent, remove vented vessels, reduce power accordingly and complete digestion.

3.2.5 After program is completed, allow pressure in the control vessel to drop to 20 psi, then vent. Remove carousel from MDS-2000, place in hood, remove vent tubes and CAREFULLY vent remaining vessels manually. If venting is too vigorous, allow to cool longer and vent again. Repeat until no more venting occurs.

3.2.6 Loosen caps, remove from vessels and rinse caps with deionized water, catching rinse water in vessel liner. Add 30 ml of 5% boric acid solution tro neutralize any residual HF.

3.3 Sample filtration (if neccessary) and dilution

3.3.1 Add 15 ml of deionized water to each digestion vessel. If insoluble precipitate exists, vacuum-filter sample through Whatman 42 filter paper into a clean, acid-stripped 125-ml polyethylene bottle; if no filtration neccessary, pour vessel contents directly into bottle. Rinse vessel (and filtrate where appropriate) with deionized water, combining rinse with solution in bottle.

3.3.2 Transfer bottle contents to a clean, acid-stripped 100-ml volumetric flask. Rinse bottle with deionized water, adding rinse to volumetric flask. Dilute with deionized water to the volumetric mark and mix thoroughly.

3.3.3 Pour the sample solution into a clean, acid-stripped polyethylene containers and label appropriately. Typically, a sample might be contained in its initial 125-ml bottle, two 60-ml bottles, or could be distributed into 3 15-ml ICP sample tubes, 10 1-ml polyethylene vials for GFAA analyses and one 60-ml bottle for ICP-hydride analyses.

4. QA/QC

Quality Assurance and quality control activities will follow those stated in the AED Quality Assurance Project Plan for Routine Chemical Analyses of Environmental Samples, June 25, 1996

Appendix Table 1b

1. OBJECTIVES

The conditions given below describe the instrumental parameters used for atomic absorption and emission analysis of environmental samples at AED.

2. MATERIALS AND EQUIPMENT

- ARL Model 3410 ICP spectrophotometer
- Perkin-Elmer 5000 atomic absorption spectrophotometer
- Leeman PS200 Mercury Analyzer

3. PROCEDURE

Where conditions for a particular element and instrument are not specifically provided, the instrument manufacturer's recommended operating conditions and parameters are used.

3.1 Inductively Coupled Plasma Operating Conditions

Element	Analytical Wavelength (nm)	Bkgd. Correction Wavelengths (nm)	Detection Limit (ug/ml)
Cu	324.754	325.836	0.020
Zn	213.856	213.820	0.005
Cr	205.552	205.619	0.020
Pb	220.353	220.309, 220.374	0.100
Ni	231.604	231.657	0.040
Cd	228.802	228.839	0.010
Mn	257.610	257.638	0.010
Fe	259.940	259.902	0.020

RF Power: 650 W forward, < 8 W reflected
Argon gas flows: Coolant 6.5 L/min
Plasma 1.0 "
Nebulizer 0.7 "

Sample solution pumping rate : 1.6 ml/min

3.2 Graphite Furnace Atomic Absorption Operating Conditions

Element	Wavelength (nm)	Slit (nm)	Ash Temp (^{0}C)	Atomize Temp (^{0}C)	Matrix Modifier
Ag	328.1	0.7	1000	1900	0.01 mg Pd
As	193.7	0.7	1300	2100	0.01 mg Pd
Cd	228.8	0.7	1000	1800	0.01 mg Pd
Cu	324.8	0.7	1000	2300	
Cr	357.9	0.7	1400	2600	
Fe	248.3	0.2	1400	2600	
Mn	279.5	0.2	1300	2200	
Ni	232.0	0.2	1400	2500	
Pb	283.3	0.7	1000	1900	0.01 mg Pd
Sb	217.6	0.7	1100	2000	0.01 mg Pd
Se	196.0	2.0	1000	2100	0.01 mg Pd
Sn	286.3	0.7	1400	2300	0.01 mg Pd

Analyses are performed using forked L'Vov platforms, maximum power heating, zero-gas flow during atomization and Zeeman background correction. Peak areas are used for calibration and quantitation. All analyses utilize 15 ul sample injections + 5 ul matrix modifier. Triplicate injections are measured for each sample.

3.3 Mercury Analyzer Operating Conditions

Element	Wavelength (nm)	Reducing Agent	Carrier Gas
Hg	253.7	$SnCl_2$	Argon

Analyses are performed according to the manufacturers recommendations in *PS200 Automated Mercury Analyzer Manual*.

4. QA/QC

The accuracy and validity of instrumental analyses performed on samples using the above parameters are assured by analysis of the following types of samples:

4.1 Standard reference materials - SRMs are used, when available, to assess the accuracy of the analysis and to verify that the initial calibration is still valid for the samples being analyzed. SRMs are analyzed at the beginning, end, and every 10 samples of each sample sequence. Concentrations determined for SRMs should be preferably +/-10% and absolutely +/-15% of the certified concentration. A commonly used SRM is *1643c Trace Elements in Water* commercially available from National Institute of Standards and Technology.

4.2 Spike additions - Spike additions are used to determine whether the sample matrix is interfering with the analytical measurement. One spike is run during each sample sequence. Acceptable values are 80-120% spike recovery.

4.3 Analytical duplicates - Analytical duplicates are used to determine the precision of the measurement. Two sample cups are filled from the same sample bottle and run during a sample sequence. Acceptable values are less than 10% relative percent difference provided that the concentrations are greater than 5x the detection limit.

Appendix Table 1c

1. OBJECTIVES

The conditions given below describe the instrumental parameters used for atomic absorption and emission analysis of environmental samples at AED.

2. MATERIALS AND EQUIPMENT

- ARL Model 3410 ICP spectrophotometer
- Perkin-Elmer 5000 atomic absorption spectrophotometer
- Leeman PS200 Mercury Analyzer

3. PROCEDURE

Where conditions for a particular element and instrument are not specifically provided, the instrument manufacturer's recommended operating conditions and parameters are used.

3.1 Inductively Coupled Plasma Operating Conditions

Element	Analytical Wavelength (nm)	Bkgd. Correction Wavelengths (nm)	Detection Limit (ug/ml)
Cu	324.754	325.836	0.020
Zn	213.856	213.820	0.005
Cr	205.552	205.619	0.020
Pb	220.353	220.309, 220.374	0.100
Ni	231.604	231.657	0.040
Cd	228.802	228.839	0.010
Mn	257.610	257.638	0.010
Fe	259.940	259.902	0.020

RF Power: 650 W forward, < 8 W reflected
Argon gas flows: Coolant 6.5 L/min
Plasma 1.0 "
Nebulizer 0.7 "

Sample solution pumping rate : 1.6 ml/min

3.2 Graphite Furnace Atomic Absorption Operating Conditions

Element	Wavelength (nm)	Slit (nm)	Ash Temp (^0C)	Atomize Temp (^0C)	Matrix Modifier
Ag	328.1	0.7	1000	1900	0.01 mg Pd
As	193.7	0.7	1300	2100	0.01 mg Pd
Cd	228.8	0.7	1000	1800	0.01 mg Pd
Cu	324.8	0.7	1000	2300	
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Fe	248.3	0.2	1400	2600	
Mn	279.5	0.2	1300	2200	
Ni	232.0	0.2	1400	2500	
Pb	283.3	0.7	1000	1900	0.01 mg Pd
Sb	217.6	0.7	1100	2000	0.01 mg Pd
Se	196.0	2.0	1000	2100	0.01 mg Pd
Sn	286.3	0.7	1400	2300	0.01 mg Pd

Analyses are performed using forked L'Vov platforms, maximum power heating, zero-gas flow during atomization and Zeeman background correction. Peak areas are used for calibration and quantitation. All analyses utilize 15 ul sample injections + 5 ul matrix modifier. Triplicate injections are measured for each sample.

3.3 Mercury Analyzer Operating Conditions

Element	Wavelength (nm)	Reducing Agent	Carrier Gas
Hg	253.7	$SnCl_2$	Argon

Analyses are performed according to the manufacturers recommendations in *PS200 Automated Mercury Analyzer Manual.*

4. QA/QC

The accuracy and validity of instrumental analyses performed on samples using the above parameters are assured by analysis of the following types of samples:

4.1 Standard reference materials - SRMs are used, when available, to assess the accuracy of the analysis and to verify that the initial calibration is still valid for the samples being analyzed. SRMs are analyzed at the beginning, end, and every 10 samples of each sample sequence. Concentrations determined for SRMs should be preferably +/-10% and absolutely +/-15% of the certified concentration. A commonly used SRM is *1643c Trace Elements in Water* commercially available from National Institute of Standards and Technology.

4.2 Spike additions - Spike additions are used to determine whether the sample matrix is interfering with the analytical measurement. One spike is run during each sample sequence. Acceptable values are 80-120% spike recovery.

4.3 Analytical duplicates - Analytical duplicates are used to determine the precision of the measurement. Two sample cups are filled from the same sample bottle and run during a sample sequence. Acceptable values are less than 10% relative percent difference provided that the concentrations are greater than 5x the detection limit.

Appendix Table 1d

1. OBJECTIVES

The objective of LOP is to describe the procedure that performs a complete digestion of sediments for determination of the concentrations of metals. Because of the digestion is complete, the concentrations measured are the total metals concentrations in the sediment, including both contaminant and natural background components. Complete digestion of the mineral matrix is accomplished by the use of concentrated nitric and hydrofluoric acid. Residual HF is neutralized after digestion with boric acid, any residue filtered and the filtrate diluted. The resultant solution may be analyzed for metals by atomic absorption or emission techniques.

2. MATERIALS AND EQUIPMENT

- Concentrated nitric acid
- Hydrofluoric acid
- Boric acid
- Teflon digestion vessels with peel-off labels
- Freezer
- Virtis lyophilizer
- Laboratory scale
- Protective clothing:
- Labcoat
- Polyethylene apron
- Neoprene gloves
- Safety goggles (not glasses)
- Face shield
- MDS-81
- Fume hood
- 50 ml volumetric flask
- Deionized water
- Clean, acid-stripped polyethylene bottle

3. PROCEDURE

3.1 Sample preparation

3.1.1 Sediments should be thawed and homogenized using appropriate equipment prior to subsampling for analysis.

3.1.2 Obtain the tare weight of each Teflon digestion vessel liner. Add approximately 1.0-2.0 g of wet sediment (corresponding to 0.5-1.0 g dry) to each vessel and reweigh, obtaining the wet gross weight.

3.1.3 If sediment samples are to be dried, place vessels upright in freezer until sediments are frozen solid. Freeze-dry sediments according to manufacturer's instructions.

3.1.4 Remove the vessels from the freeze dryer and weigh again, obtaining the dry gross weights for the samples. Wet weight, dry weight and the dry-to-wet ratio are calculated from the tare and gross weights.

3.2 Microwave digestion

3.2.1 Before digesting the sediment samples, the chemist **must** be wearing appropriate protective clothing: lab coat, polyethylene apron, neoprene gloves, safety goggles (not glasses) and face shield.

3.2.2 Add 5.0 ml of concentrated nitric acid (HNO_3) to each vessel liner. Swirl slightly to wet sediment and check for reaction with sediment, e.g. foaming or bubbling. When no reaction is evident, add 4.0 ml of concentrated hydrofluoric acid (HF) and 1.0 ml of concentrated hydrochloric acid (HCl) to each vessel. Place liners into digestion vessels, insert a rupture membrane into each cap and tighten cap. Do not overtighten.

3.2.3 Place vessels in carousel. Insert vent tube into each vessel neck and tighten nut. Insert free end of tube into vent trap in center of carousel. Attach pressure sensing line to control vessel, making sure that the lever on the side of the digestion oven is in the "NEUTRAL" position. Return the carousel to oven. Insure that venting fan is operating.

3.2.4 Program the MDS-2100 for the parameters given below:

Stage	1	2
% power	100	100
PSI	120	150
Time	30:00	15:00
TAP (time at	20:00	10:00

ppressure)		
Fan speed	100	100

Power setting is for 12 vessels. If fewer vessels used, reduce power by 5% per vessel. Initiate digestion by pressing start. Note: Individual sediments can always react in unanticipated ways. If vessels vent, remove vented vessels, reduce power accordingly and complete digestion.

3.2.5 After program is completed, allow pressure in the control vessel to drop to 20 psi, then vent. Remove carousel from MDS-2000, place in hood, remove vent tubes and CAREFULLY vent remaining vessels manually. If venting is too vigorous, allow to cool longer and vent again. Repeat until no more venting occurs.

3.2.6 Loosen caps, remove from vessels and rinse caps with deionized water, catching rinse water in vessel liner. Add 30 ml of 5% boric acid solution tro neutralize any residual HF.

3.3 Sample filtration (if neccessary) and dilution

3.3.1 Add 15 ml of deionized water to each digestion vessel. If insoluble precipitate exists, vacuum-filter sample through Whatman 42 filter paper into a clean, acid-stripped 125-ml polyethylene bottle; if no filtration neccessary, pour vessel contents directly into bottle. Rinse vessel (and filtrate where appropriate) with deionized water, combining rinse with solution in bottle.

3.3.2 Transfer bottle contents to a clean, acid-stripped 100-ml volumetric flask. Rinse bottle with deionized water, adding rinse to volumetric flask. Dilute with deionized water to the volumetric mark and mix thoroughly.

3.3.3 Pour the sample solution into a clean, acid-stripped polyethylene containers and label appropriately. Typically, a sample might be contained in its initial 125-ml bottle, two 60-ml bottles, or could be distributed into 3 15-ml ICP sample tubes, 10 1-ml polyethylene vials for GFAA analyses and one 60-ml bottle for ICP-hydride analyses.

4. QA/QC

Quality Assurance and quality control activities will follow those stated in the AED Quality Assurance Project Plan for Routine Chemical Analyses of Environmental Samples, June 25, 1996

Appendix Table 1e

1.0 OBJECTIVES

The objective of this document is to define the laboratory operating procedure for the preparation of columns for the cleanup and chemical class separation of semi-volatile organic compounds from marine samples. This procedure is also details procedure for silica gel preparation and testing. The extract fractions will be analyzed by gas chromatography (GC) (AED LOP 2.04.003) or gas chromatography/mass spectrometry (GC/MS) (AED LOP 2.04.002).

2.0 NECESSARY MATERIALS AND EQUIPMENT

- 9.5-mm ID X 45-cm glass chromatography column with 100 ml reservoir
- Top-loading balance capable of weighing to 0.01 g
- Turbo-Vap (Zymark) apparatus, with heated water bath maintained at 25-35 °C
- Glass Turbo-Vap flasks, 200 ml
- Nitrogen gas, compressed, 99.9% pure
- Tumbler, ball-mill
- Glass graduated cylinders, 100- and 500-ml
- Glass beakers, 50-ml
- Concentrator tubes, 10ml
- Borosilicate glass vials with Teflon-lined screw caps, 2-ml
- Micropipets, solvent rinsed or muffled at 450 °C
- Reagents:
    - Pentane, pesticide grade or equivalent
    - Methylene Chloride (CH_2Cl_2), pesticide grade or equivalent
    - Hexane, pesticide grade or equivalent
    - Heptane, pesticide grade or equivalent
    - Deionized water, pentane-extracted
    - BioSil A silicic acid, 100-200 mesh
- Glass wool, silanized

3.0 PROCEDURE

3.1 <u>Silica gel preparation and testing.</u>

3.1.1 Approximately 150 grams of fully activated silica gel is accurately weighed and transferred to a glass jar.

3.1.2 The silica gel is deactivated by adding 7.5% (weight basis) of pentane-extracted deionized water. The water is weighed accurately and an appropriate amount is added dropwise, ~ 1 ml at a time, to the silica gel. After each water addition, the jar is hand-shaken vigorously.

3.1.3 The silica gel is tightly sealed and then placed on a ball-mill tumbler (CEL-GRO rotator) and allowed to tumble two to three days. The tumbler is set at the maximum speed (8 rpm, dial set at 8).

3.1.4 After tumbling, the jar is removed from the tumbler and tested for proper compound separations using the steps in section 3.2 and 3.3 below. The column standard used contains CB030 and CB198 as the F1 internal standards and 2,5-dichloro-*m*-terphenyl as the F2 internal standard. The final volume of each fraction is adjusted to 1.0ml. Prior to injection on the GC-ECD (LOP 2.04.003) 5uls of γ-chlordene (REC0329212) are added to 100uls of each fraction to calculate the recovery of each internal standard. A single point calibration using the column standard (100uls of standard spiked with 5 uls of γ-chlordene is used for calculating the percent recoveries of each internal standard. The percent recoveries of the internal standards must be between 50-110%. The occurrence of the F2 standards in the F1 must be less than 2%. The occurrence of the F1 standard in the F2 must be less than 2%. If the silica gel does not pass the requirements it is returned to the drying oven and the process is repeated (step 3.1).

After passing the quality control requirements the jar is sealed again and stored in a cool dry place (room 138 cabinet).

3.2 <u>Column preparation.</u>

3.2.1 The glass columns are set up in ring stands in a fume hood.

3.2.2 Glass wool sufficient to create a 1 cm thick plug in the column is placed into the reservoir of the column. A glass rod is used to push the glass wool to the bottom of the column.

3.2.3 11.5 g of the 7.5% deactivated silica gel is weighed out in a beaker. Approximately 50 ml of CH_2Cl_2 is added to the beaker to form a slurry. The slurry is then carefully poured into the column. The beaker is rinsed with additional CH_2Cl_2, as are the inner walls of the reservoir to ensure all silica is introduced to the column.

3.2.4 The column is allowed to drip, with the eluate being collected and discarded. When the level of the CH_2Cl_2 just reaches the top of the silica gel, 50 ml of pentane is slowly added to the column. Under no circumstances is the column allowed to go dry! This eluate is also collected and discarded.

3.3 <u>Chemical class separations.</u>

For samples:

3.3.1 The sample extract, in a 10ml concentrator tube, is introduced to the column just as the pentane rinse level reaches the silica gel. The concentrator tube is then rinsed with an additional 1.0 ml of pentane which is also introduced to the column just before the silica gel is exposed. As the sample rinse level reaches the silica gel, 55.0 ml of pentane is added to the column. This eluate is collected as part of the F-1 as well The eluate is collected in a solvent-rinsed 200ml TuboVap® tube as the F1.

For testing silica gel:

1mL of column standard is introduced to the column just as the pentane rinse level reaches the silica gel. The concentrator tube is then rinsed with an additional 1.0 ml of pentane which is also introduced to the column just before the silica gel is exposed. As the sample rinse level reaches the silica gel, 55.0 ml of pentane is added to the column. This eluate is collected as part of the F-1 as well The eluate is collected in a solvent-rinsed 200ml TuboVap® tube as the F1.

For testing silica gel:

3.3.2 As the pentane level reaches the top of the silica, 36.0 ml of a 70:30 (volume:volume) pentane:CH_2Cl_2 mixture is introduced to the column. The F-2 fraction is collected in a second solvent-rinsed TurboVap® tube. After collection,the flasks are kept tightly capped with aluminum foil. At no time should the column flow rate exceed 6 ml/min.

3.3.4 After the F-2 fraction has been collected from the column, the flasks are placed in the TurboVap® with the water bath heated to approximately 30 ^{o}C (5 ^{o}C below the boiling points of the solvents used). Nitrogen gas is introduced to the flasks and will reduce the volume to approximately 5 ml. The samples are then solvent-exchanged to heptane, transferred to a 10ml concentrator tube and brought to a final volume of 1.0 ml in heptane.

3.3.5 The fractions are then transferred to borosilicate glass vials fitted with Teflon-lined screw caps. The vial file is stored in the refrigerator in room 138. 10ul of $^{\gamma}$-chlordene is added to100ul of sample prior to injection to measure recovery of standards.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC follows the *Quality Assurance Project Plan for Routine Chemical Analyses of Environmental Samples*, June 25, 1996.

Appendix Table 1f

1. OBJECTIVES

The objective of this document is to define the laboratory operating procedure for the microwave assisted extraction of semi-volatile organic compounds from marine sediment samples. The extracts will be further cleaned up by silicic acid chromatography (AED LOP 2.03.005) prior to analysis by gas chromatography (AED LOP 2.04.003) and/or gas chromatography/mass selective detector (AED LOP 2.04.002).

2. MATERIALS AND EQUIPMENT

-Equipment for homogenizing sediment
-Electric drill with polyethylene propeller attachment
-Stainless steel or teflon coated utensils like spoon or spatula
-Apparatus for determining dry/wet ratio
    Top-loading balance capable of weighing to 0.01 g
    Aluminum weighing pans
    Stainless steel spatula
-Drying oven maintained at 105-120°C

-Microwave Extraction System (CEM MES-1000)
-100 mL lined extraction vessels
-Turbo Vap (Zymark) apparatus with heated water maintained at 25-35°C
-Compressed Nitrogen gas (99.9% pure)
-Glass Turbo Vap flasks (200 ml)
-Glass graduated cylinders (50- and 500-ml)
-Separatory funnels (250 or 150 ml)
-Erlenmeyer flasks (200ml)
-Glass concentrator tubes (10 ml)
-Microliter syringes or micropipets, solvent rinsed
-Borosilicate glass vials with Teflon-lined screw caps (2-ml)

Reagents

-Hexane, pesticide grade or equivalent
-Acetone, pesticide grade or equivalent
-Sodium sulfate-anhydrous, reagent grade.
-Heated to 650°C for at least 4 hours,then cooled and stored in a tightly sealed glass container at room temperature.
Internal Standards (IS) CB030, CB198, 2,5-dichloro-m-terphenyl (Ultra Scientific) and naphthalene-d_8, chrysene-d_{12}, anthracene-d_{10}, benzo(a)anthracene-

d_{12}, phenanthrene-d_{10} and perylene-d_{12} (Supelco) added to each sample prior to extraction.

3. PROCEDURE

3.1. Sample Homogenization

3.1.1 Homogenize sample by physically mixing with a stainless steel or Teflon coated utensil or using a polyethylene propeller attached to an electric drill.

3.2. Dry Wt./Wet Wt. Ratio Determination

It is very important to predetermine the moisture content in each sample before microwave extraction . This data is used to standardize the moisture content in each of the sample.

3.2.1. Weigh about 1.0 to 2.0 grams into a preweighed aluminum pan for dry/wet weight determinations. Place in a drying oven and record weight at 24 and 48 hours.

3.2.2 Using the dry/wet ratio, back calculate the wet weight needed for each sample. Set the dry weight constant, also called the "target dry weight" (between 0.8 and 1 gram dry, target dry weight). Use the sample with the <u>lowest</u> dry/wet ratio (highest percent moisture) and back calculate the wet weight for that sample (see A). Since the moisture content is not the same for all the samples, the wet weight will also be different (see B). Adjust the wet weight of all samples to be equivalent to the standardization sample by adding hexane rinsed DI water(see C).

(A) Target Dry Wt/ (dry/wet ratio sample A) = $\text{Grams}_{\text{wet sample A}}$

(B) Target Dry Wt/(dry/wet ratio sample B) = $\text{Grams}_{\text{wet sample B}}$

(C) $\text{Grams}_{\text{wet sample A}}$ - $\text{Grams}_{\text{wet sample B}}$ = Grams H_20 added to sample B

Refer to OPERATION MANUAL "INSTRUCTIONS FOR USE OF LINED EXTRACTION VESSELS" for assembly and safety guidelines.

Refer to the MES-1000 Operation Manual for instructions on connecting the pressure sensing tubing and fiberoptic probe to the control vessel.

Both of the above documents can be found on the bookshelf in the AED organic chemistry prep lab, room 139.

The following are brief steps of the instructions, use and connecting the pressure sensing tubing and fiberoptic probe to the control vessel and refer to the manual for detailed instructions on the above.

3.3 Assembly and Preparation of Extraction Vessels. **Refer to the manual for detailed description of assembly and preparation of extraction vessels. This is recommended for beginners.**

3.3.1. Unscrew and remove the gray vent fitting from the cover of a Lined Extraction Vessel. Install a single rupture membrane in the vent fitting. Screw the gray vent fitting onto the threaded stem of the cover.

3.3.2. Weigh samples directly into the lined extraction vessels. Samples must be placed in the bottom of the liners so that they will be completely covered by solvent. The sides of the liner must not have sample deposits on them. Standardize the wet weight for all the samples by adding hexane rinsed DI water.

3.3.3. Add Internal Standards (IS) as required: CB030 and CB198 for PCB analysis; 2,5-dichloro-m-terphenyl for pesticides; and naphthalene-d_8, chrysene-d_{12}, anthracene-d_{10}, benzo(a)anthracene-d_{12}, phenanthrene-d_{12} and perylene-d_{12} (Supelco) for PAHs to be added to each sample prior to extraction. The amount of IS added is dependent on the expected contaminant concentrations and should produce an instrumental response reasonably close to the mean analyte response.

3.3.4. Weigh 15 g of sodium sulfate in a clean muffled 50 ml beaker. Slowly add half the amount to the sample and mix throughly with a teflon spatula. Now add the remaining half and mix into the sediment. (The extraction vessels should not be placed directly in the fume hood). Add 30 mL of 50/50(v:v) hexane/acetone solvent mixture, stir gently with teflon spatula and insert the liner into a clean, dry, particle-free vessel body.

NOTE: The lined extraction vessels with the sample and solvent are weighed before and after the microwave extraction.

3.3.5. Place the vessel cover with the gray vent from step 3.3.1 on top of the vessel liner, and screw on the vessel cap in a clockwise direction until hand tight. Place the vessel into the turntable.

3.3.6. Insert the open end of a 3mm O.D vent tube through the gold ferrule nut, and thread the gold ferrule nut onto the gray vent fitting. Screw the gold ferrule nut to the gray vent.

3.3.7. Repeat step 3.3.6 for remaining sample vessels.

NOTE: For fewer than 12 vessels, each unused vent tube must be sealed with a cap.

3.3.8. Place turntable with assembled vessels into the microwave system and onto the drive lug.

3.3.9. Carefully slide the fiberoptic temperature probe into the control vessel thermowell (always hold the probe approximately 2 inches behind the tip). Secure the fiberoptic temperature probe and the pressure sensing tubing into the collection container standoff using the retaining ring.

3.4.0. The control vessel should be in the right center of the cavity and the 6 mm vent tube to the left side of the cavity. Connect the 6 mm diameter vent tube to the bulkhead fitting.

3.4.1. Connect the pressure sensing tubing to the control vessel and into the collection container.

3.4.2. Turn the handle of the two way valve to vertical (neutral) position. This valve is located on the outside (left middle bottom of the microwave).

3.4.3. With the door open, press "F4" to rotate the turntable. Allow the turntable to turn 3 or 4 times to ensure that the pressure sensing tube and the fiberoptic probe do not get entangled.

3.4. Follow these steps to program the Microwave for extraction. After startup, the display will show the main menu.

(1) F1 to RECALL STORED/DATA
(2) F3 to RECALL METHOD/DATA
(3) F1 to LOAD THE PROGRAM
(4) F3 to REVIEW
F2 to print the method
For sediment extractions select "PAH Method" using the arrow keys and hit enter. The PAH method parameters are shown below.
To select a stored method use the arrow key and choose the correct method. To program a new method select F2.

	Stage				
POWER (%)	70	0	0	0	0
PRESSURE (psi)	180	0	0	0	0

RUN TIME (min)	30	0	0	0	0
TIME @ P (min)	15	0	0	0	0
TEMP (°C)	120	0	0	0	0

F4 to START to begin the procedure using the programmed parameters. The operator's Safety Checklist screen will appear. Press the appropriate key to answer the questions.

F2 to print a table for run time, pressure and temperature or F3 to have the printer print time versus pressure and temperature for the completed procedure.

4.0 After the extraction, the top solvent layer from the extraction vessel is carefully poured into a pre-solvent rinsed 250 mL separatory funnel containing 80 mL of hexane rinsed DI water. The vessels are rinsed twice with a hexane/acetone mixture and once with 10 mL of hexane. Back extract the DI/acetone:hexane phase in the separatory funnel 3X with hexane: use 10 ml hexane for first extraction and then 5ml each for second and third extractions. After each addition of hexane has been shaken, draw off the bottom layer into a 250ml erlenmeyer flask or use the lined extractin vessel. Decant the hexane layer into a 250ml erlenmeyer flask by pouring it out the top of the separatory funnel. This way the transfer of water into the hexane extract will be minimized.

4.1. Transfer the water layer from the 250 ml erlenmeyer flask or the lined extraction vessel back into the separatory funnel for every addition of hexane. Rinse the 250ml flask with 5ml hexane and add the rinses to the separatory funnel.

4.1.1. Combine the hexane extracts and dry over sodium sulfate to remove any traces of water.

4.1.2 Transfer the extract into a clean rinsed 200 mL Turbo-Vap tube. Place the flask into the Turbo-Vap® apparatus and turn on the unit. Adjust the associated nitrogen pressure regulator to read approximately 5 psi. When the hexane volume is down to approximately 2ml, rinse the sides of the turbovap down using a hexane squeeze bottle. Reduce the sample volume to approximately 1ml.

4.2. Fractionate the sample using column chromatography with silicic acid, AED LOP 2.03.005

5. QA/QC

Routine chemical analyses follow the document *Quality Assurance Project Plan for Routine Chemical Analyses of Environmental Samples*, July 25, 1996.

5. TROUBLE SHOOTING

To prevent cross contamination of samples the microwave vessels are precleaned by taking them through the entire PAH program with the solvents listed in the method above.

Sometimes microwave detects solvent vapors inside the microwave cavity. When such a problem is detected, please contact Saro or Rick for trouble shooting. **Please do not try to restart the microwave.**

1.0 OBJECTIVES

The objective of this document is to define the standard procedure for analyzing marine environmental samples for PAHs using GC/MSD in electron impact/positive ion mode.

2.0 MATERIALS AND EQUIPMENT

HP Model 5890 Series II Gas Chromatograph
HP Model 5971A Mass Selective Detector
HP Model 7673 Autosampler
HP MS Chemstation (DOS Series) Software
IBM Compatible Personal Computer

3.0 PROCEDURE

3.1. Instrument Parameters

Column: 60 m x 0.25 mm ID x 0.25 um DB-5MS (J&W Scientific)
Carrier: Helium at 25 psi; 0.8-1.0 ml/min
Injector: 270∞C; splitless mode, purge on at 0.8 min
Interface: 300∞C; direct, source 200∞C
Temperature Program: 1 min, 40∞C; 20∞C/min to 120∞C; 10∞C/min to 310∞C and hold 16 min. This is suitable for Polycyclic Aromatic Hydrocarbons.
MS Parameters: Set by Autotune using perfluorotributylamine (PFTBA) as the calibration compound; Manual Tune is then used to force the 131 and 219 abundances to 20 to 40 percent of the 69 base peak; the electron multiplier is then set to meet the requirements of the particular method. This procedure is done in a series of loops, as new parameter settings for a specific lens will affect the behavior of the others.

3.2. Periodic Performance Checks

3.2.1 Adequate decafluorotriphenyl phosphine DFTPP spectrum, based on a 50 ng injection.

The following mass abundance criteria are used to evaluate the mass spectrum of DFTPP. A spectrum for evaluation is obtained by adding three spectra (one at the cedter of the peak, one three scans pre-center and one three scans post-center) and subtracting an appropriate background spectrum.

DFTPP ACCEPTANCE CRITERIA (by CLP 3/90)

Mass	Abundance
51	30-80% of mass 198
68	Less than 2% of mass 69
70	Less than 2% of mass 69
127	25-75% of mass 198
197	Less than 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	Greater than 0.75% of mass 198
441	Less than mass 443 but present
442	40-110% of mass 198
443	15-24% of mass 442

3.1.2. Calibration Check - results for a mid-level standard are evaluated by the applicable Quality Assurance Project Plan; generally analyte concentrations must be within 25 percent of the true value for a single target compound, and the average error for all compounds in the method must be less than 15 percent.

3.3. Calibration

The calibration method is a 5 point, internal standard, least squares fit, forced through the origin. The levels are chosen to cover a range from 4 to 10 times the instrument detection limit for the lowest point, up to the point at which saturation and/or non-linear behavior is observed. For

PAHs in marine sediment or tissue, the current levels are 1.0, 5.0, 10.0, 15.0, and 20.0 ng/ul. Acceptance criteria for each level are the same as listed for the calibration check (3.1.2).

3.4. Sample Analysis

A 250 uL aliquot of the sample extract is blown down to 20-25 uL with nitrogen or helium. If required, an internal injection standard is added (4-chloro-p-terphenyl). Once the daily performance checks are satisfied, the extracts are injected using the autosampler. Periodic solvent blanks, standards, etc. are inserted at the judgement of the analyst.

3.5. Identification

Samples are routinely analysed either by selected ion monitoring (SIM) mode or full scan mode depending on required detection limits. Compounds are identified by monitoring a characteristic ion within a 12 second retention time window. Additional ions may be monitored at the discretion of the analyst.
Confirmation is obtained by inspection of the full mass spectrum, unless samples were analyzed using SIM in which case relative abundance of a qualifier ion confirms peak identity.

4.0 QA/QC

The accuracy and validity of analyses performed on samples analyzed by this method are assured by including quality assurance samples which address accuracy, precision and method detection limits. Accuracy is measured by analyzing standard reference materials, procedural blanks, and matrix spikes. Precision is measured by the analysis of laboratory duplicates. One of each of the above samples is included with each batch of 20 samples. Method detection limits are determined using a method described in 40 CFR Ch.1, Pt. 136, Appendix B, and are performed at regular intervals (generally every 6 months) or at the start of large projects.

5.0 TROUBLE SHOOTING

Troble shooting procedures are addressed in section 3.0 Procedures above.

1. OBJECTIVES

The objective of this document is to define the standard procedure for analyzing marine environmental samples for polychlorinated biphenyls (PCBs) and chlorinated hydrocarbon pesticides using gas chromatography and electron capture detectors.

2. MATERIALS AND EQUIPMENT

-Hewlett-Packard 5890 Gas Chromatographs
-Hewlett-Packard electron capture detectors, model 19233 (Ni 63)
-30 m DB-5MS fused silica capillary columns (0.25μ film thickness, 0.25mm i.d.).
-Perkin-Elmer/Nelson GC data collection and analysis software (ACCESS*CHROM)

-Ultra high purity helium carrier gas
-95/5% Argon/Methane (P5) auxilliary gas

3. PROCEDURE

3.1 Check gas supply and gas lines

3.1.1 Check gas cylinder pressures. Replace tank if pressure is less than 100 psig.
3.1.2 Check head pressure gauge on front panel of instrument. Gauge should read 18 psig; adjust to correct setting if reading is high; check for leaks if pressure is low. This setting provides for a carrier gas flow of approximately 1.5 ml/min.

3.1.3 Replace injection port septum. Check septum nut and column fittings for leaks with leak detector and tighten as necessary.

3.1.4 Check the auxiliary gas flow. A flow of 35 ml/min is required.

3.1.5 Check septum purge and split flows. Adjust to 1 and 35 ml/min, respectively, as necessary.

3.2. Instrument output signal

3.2.1 Display the analog output signal from the detector on the LED panel of the GC. Record the value in the instrument log book, and check for consistency with previous readings. On instruments with dual detectors, ensure the signal is correctly assigned to the detector selected for the analysis.

3.3. Instrument operating parameters

3.3.1. Temperature programs and run times are stored as workfiles in each GC's integrator. The following conditions are required for the analysis of PCBs and pesticides:

Injection port temperature	275°C
Detector temperature	325°C
Initial column temperature	100°C
Initial hold time	1 min
Rate 1	5°C/min
Ramp 1 final temperature	140°C
Ramp 1 hold time	1 min
Rate 2	1.5°C/min
Ramp 2 final temperature	230°C
Ramp 2 hold time	20 min
Rate 3	10°C/min
Final column temperature	300°C
Final hold time	5 min
Stop time	100 min
Injection port purge open time	1 min

3.3.2. Load an appropriate workfile into the integrator.

3.3.3. Enter the autosampler parameters into the integrator using option 11. Indicate which injection port is being used, the number and positions of the samples in the autosampler tray, the number of injections per bottle, and the amount injected (1 ul).

3.3.4. Check the signal assignments and levels again. If they are correct, store the workfile in the integrator.

3.4 Data system setup

3.4.1. Setting up the instrument queue is accomplished by following instructions laid out in the Perkin-Elmer Nelson manual.

3.4.2. Order the samples, standards, and rinses according to the following guidelines:

-place hexane rinses before standards
-bracket groups of no more than ten (10) samples with check standards.

-procedural and field blanks should be run prior to samples to minimize risk of carryover contamination.

3.4.3 Type in sample weight and internal standard amounts for each sample to be used in final concentration calculations. Double check all manually entered values for accuracy.

3.5 Instrument startup and data collection

3.5.1. After the instrument has been scheduled, arrange the samples and standards to be run in the autosampler trays. Check the order for accuracy against a copy of the sequence. Load the trays into the autosampler.

3.5.2. Visually recheck tank regulator gauges and instrument settings to ensure proper settings.

3.5.3. Start GC operation and data collection by pressing 'start' on the integrator.

3.6 Peak identification and quantitation

3.6.1. Peak identification is accomplished by automated routines. Identifications are based on comparison of retention times of actual standards to unknown peaks. Multilevel standards are calibrated to generate a linear regression curve of response according to the manufacturer's instructions. After a calibration curve has been generated, the samples are analyzed. Analytes are quantified based on the peak heights for the analytes and internal standard, the amount of the internal standard, and the response factors generated from the calibration curve. Chromatograms and data reports are generated for each sample and standard.

4. QA/QC

Measurement quality criteria for routine chemical measurements follow the document, *Quality Assurance Project Plan for Routine Chemical Analyses of Environmental Samples*, July 25, 1996.

4.1 Chromatograms of standards are compared to posted references. Peak identifications, resolution and shapes are inspected. Calculated standard amounts are checked for accuracy and documented. Other abnormalities, such as spurious or extra peaks, rising or falling baselines, and negative spiking are examined. Response factors and overall instrument response are compared to previous runs and documented. Blanks are checked for the presence of interferences or analytes of interest. Unknown samples are compared to standards to verify peak identifications.

Radionuclide dating & core chronologies

Ages of sediment core sections and sedimentation rates were calculated from profiles of excess ^{210}Pb activity. Excess or unsupported, ^{210}Pb activity was calculated as the difference between the measured activities of total ^{210}Pb and parent nuclides ^{214}Pb or ^{226}Ra, the parent nuclide activities serving to estimate the supported ^{210}Pb activity. Vertical profiles of excess ^{210}Pb were fit to two different model to determine sedimentation rates: the constant rate of supply (CRS) model assumes a constant flux of ^{210}Pb from the water column to the sediments regardless of sedimentation rates, whereas the constant initial concentration (CIC) model assumes a rate of supply of ^{210}Pb to the sediments proportional to the sedimentation rate, resulting in a constant mass concentration of ^{210}Pb in freshly deposited sediments. The CRS model requires determining the entire inventory of excess ^{210}Pb in the sediment column by integrating the activity profile over depth, as well as either measuring the dry weight density of the sediments directly or (as in this study) estimating the density from the dry/wet weight ratios of the sediments. The model also allows for variation of sedimentation rates over time. The CIC model, on the other hand, fits with individual data points to a linear decay model, assuming a constant (mean) sedimentation rate; in some cases, the CIC model has been applied to non-linear ^{210}Pb data by assuming separate portions of the sediment column with different, albeit constant, sedimentation rates within each portion.

The estimated age or sedimentation rate provided by the models were used to estimate the date of deposition for each segment. The accuracy of the estimates was evaluated by examination of estimated dates for two features of the chemical profiles: the maximum concentration of lead and the deepest sample with concentrations of total chlorinated biphenyls above background. Comparisons of chemical data from sediment core samples obtained from similar locations in Chesapeake Bay at different times and by different investigators have shown concentrations of total lead in sediments have declined since the use of leaded gasoline was phased out in the mid-1970's. This led to the suggestion that the Pb peak in sediment core profiles could be useful as a stratigraphic marker. Analogous to 137Cs, thereby providing a second tracer to confirm ^{210}Pb chronologies. (Owens M. and Cornwell J.C. (1995). Sedimentary evidence for decreased heavy-metal inputs to the Chesapeake Bay. *Ambio* **24** (1), 24-27). One point of evaluation for each model then was whether the date estimated for the core section with the maximum concentration of lead was approximately 1973. Similarly, chlorinated biphenyls were first synthesized in 1930 and their use in manufacturing in New Bedford began as early as 1941 or earlier, so the date estimated for the first sample in each core with a concentration of total PCBs elevated above background should be no earlier than 1930 if a model chronology was to be accepted. Of course, neither model can be applied to sediments which are too old to have any measurable ^{210}Pb activity remaining, i.e., approximately 4-5 half-lives or about 100 years. For samples below the depth at which unsupported ^{210}Pb activity decreased below detection limits, sedimentation rates were either extrapolated from those calculated for sediment depths immediately above or were estimated based on historical evidence. Previous work has shown sedimentation rates outside the harbour within the harbour in the earlier half of the 20th century were around 0.2-0.3 cm/yr (Summerhayes C.P., Ellis J.P., and Stoffers P. (1985). Estuaries as sinks for sediment and industrial waste-a case history from the Massachusetts Coast. In *Contributions to Sedimentology*, Vol. 14 (ed. H. Fuchtbauer, A.P. Listzyn, J.D. Milliman, and E. Seibold), pp.47. Schweizerbart.), so rates estimated for deeper samples were constrained within this range.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm	
% Organic matter	39.9		48.1		47.3		45.7		40.8		33.7		32.4		29		30.1		30.7		25.7	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	5	8	5	8	4	8	3	8	1	7	4	7	5	7	5	7	4	6	2	6	2	6
Number of Individuals\10cc's	2382	4650	1608	4314	160	3384	72	3704	32	2608	104	2592	168	2648	120	2528	76	1836	56	2824	20	1580
Haplophragmoides manilaensis	0	0	0	0	0	1.2	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemisphraemmina bradyi	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0
Miliammina fusca	2	3	0.7	2.2	10	5.7	0	2.8	0	2.5	0	3.1	4.8	9.4	6.7	28.8	15.8	25.5	0	19	40	37.5
Organic linings	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	8.3	13.9	12.7	20	15	11.1	11.1	6.9	0	8.6	7.7	10.8	23.8	9.7	33.3	9.5	5.3	9.2	42.9	18.4	0	12.4
Tiphotrocha comprimata	0.8	2.2	0.7	3.5	0	4.5	0	2.8	0	6.1	7.7	4.6	4.8	4.8	6.7	6	5.3	3.4	0	2.2	0	2.3
Trochammina inflata	30.5	29.4	13.4	18.9	5	4.5	11.1	1.5	0	3.4	15.4	2.2	4.8	3.9	13.3	2.2	0	2.2	0	2.8	0	1
Trochammina macrescens f. macrescens	58.4	50.9	72.4	53.3	70	69	77.8	82.9	100	82.9	69.2	74.4	61.9	64.2	40	49.7	73.7	55.3	57.1	53.3	60	42.5
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0.1	0	1.7	0	3.3	0	1.7	0	4.6	0	4	0	3.6	0	3.2	0	4.4	0	4.2	0	4.3
C. constricta	0	0.09	0	0.3	0	0.7	0	1	0	0.3	0	0.9	0	0	0	0.6	0	0	0	0	0	0

Depth in Core (cm)	11-12cm		12-13cm		13-14cm		14-15cm		15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm	
% Organic matter	26.5		23		23		23.1		21.7		22.6		20.8		17.1		16.1		21.1		15.3	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	3	5	2	7	4	7	2	7	1	6	0	8	0	6	0	8	0	7	0	7	0	6
Number of Individuals\10cc's	36	1824	48	2984	72	3320	48	2976	8	2560	0	3000	0	3512	0	3976	0	4000	0	5136	0	3784
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemisphraemmina bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0
Miliammina fusca	0	33.8	16.7	14.7	11	29.6	66.7	62.4	100	52.5	0	26.7	0	32.1	0	9.5	0	7.2	0	3.7	0	6.6
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	33.3	9.9	0	5.1	11	6	0	6.2	0	3.8	0	2.9	0	3.6	0	0.4	0	0.2	0	0.8	0	0
Tiphotrocha comprimata	11.1	1.8	0	0.8	0	2.2	0	1.8	0	5.3	0	8.3	0	11.6	0	11.7	0	10.4	0	7.6	0	19.5
Trochammina inflata	0	0.2	0	0.5	44	1.9	33.3	2.2	0	1.9	0	2.1	0	0.7	0	4	0	2.4	0	3.9	0	4
Trochammina macrescens f. macrescens	55.6	54.3	83.3	74.5	33	55.7	0	23.1	0	33.1	0	54.9	0	48.5	0	70.4	0	75.8	0	79.4	0	65.3
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	2.3	0	0
C. aculeata	0	0	0	3.8	0	3.9	0	3.8	0	3.4	0	3.2	0	3.4	0	2.8	0	3.8	0	2.2	0	4
C. constricta	0	0	0	0.5	0	0.7	0	0.5	0	0	0	0.8	0	0	0	0.6	0	0.2	0	0	0	0.6

Depth in Core (cm)	22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm	
% Organic matter	19.2		25		27.9		30.8		29		29.9		29.7	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	7	0	6	0	6	0	6	0	4	0	4	0	5
Number of Individuals\10cc's	0	4768	0	3072	0	3648	0	3328	0	2880	0	2816	0	2960
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemisphraemmina bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	9.1	0	3.9	0	2.4	0	1.4	0	7.5	0	4.8	0	11.6
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	27	0	16.9	0	23	0	29.3	0	22.5	0	24.4	0	18.1
Trochammina inflata	0	2.5	0	3.6	0	6.8	0	12.5	0	9.4	0	6.3	0	1.4
Trochammina macrescens f. macrescens	0	57.2	0	70.6	0	63.2	0	53.4	0	60.6	0	64.5	0	65.7
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	3.5	0	4.4	0	3.7	0	3.1	0	0	0	0	0	3.2
C. constricta	0	0.6	0	0.5	0	0.9	0	0.2	0	0	0	0	0	0

Appendix Table 2- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 1, October 1996.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm	
% Organic matter	41.3		42.1		37.6		36.3		27.9		36		37.5		27.3		27.2		31.4		23.8		34.2		24.8		26.6		27.5	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	8	0	6	0	7	0	6	0	6	0	7	0	7	0	6	0	6	0	6	0	7	0	7	0	8	0	6	0	7
Number of Individuals\10cc's	0	3760	0	3008	0	2520	0	3160	0	2196	0	2472	0	2440	0	2808	0	2928	0	2640	0	3416	0	3320	0	3096	0	2952	0	3208
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	4.7	0	5.1	0	4.4	0	3.3	0	2.2	0	5.5	0	3.9	0	5.7	0	12.3	0	12.1	0	11.9	0	22.7	0	22.2	0	23	0	23.4
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothurammina limnetis	0	1.9	0	2.1	0	2.5	0	1.3	0	0	0	0.6	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.5
Tiphotrocha comprimata	0	1.5	0	1.9	0	1	0	2.5	0	0.9	0	1.9	0	1.6	0	3.7	0	3.3	0	0.6	0	0.7	0	1.9	0	2.1	0	0.5	0	1.2
Trochammina inflata	0	0.6	0	0.3	0	0.6	0	0	0	1.1	0	0.3	0	1.6	0	0.6	0	2.2	0	0.3	0	0.5	0	0.2	0	1.8	0	2.2	0	3.2
Trochammina macrescens f. macrescens	0	86.2	0	88.9	0	86.7	0	88.9	0	90	0	82.8	0	85.6	0	80.6	0	75.7	0	81.5	0	72.4	0	65.3	0	67.7	0	68	0	63.8
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0.5	0	0.5	0	0	0	0
Reophax scotti	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	3.4	0	1.8	0	3.2	0	3.5	0	3.8	0	5.4	0	4.4	0	6.8	0	4.1	0	4.3	0	6.2	0	6.3	0	4.1	0	4.8	0	4.8
C. constricta	0	1.5	0	0	0	1.6	0	0.6	0	2	0	3.3	0	2.2	0	2.6	0	2.5	0	1.2	0	1.3	0	3.1	0	1.1	0	1.4	0	2.9

Depth in Core (cm)	15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24	
% Organic matter	26.3		27.8		23.6		26.7		26.1		25.5		25.5		24.7		22.9	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	8	0	8	0	7	0	7	0	7	0	8	0	7	0	7	0	8
Number of Individuals\10cc's	0	2728	0	2400	0	1400	0	2168	0	2344	0	2276	0	3288	0	4040	0	5423
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0.2	0	0.2	0	0
Haplophragmoides manilaensis	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	36.7	0	32.3	0	22.3	0	18.1	0	15.4	0	20.4	0	12.9	0	10.5	0	8.8
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothurammina limnetis	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4
Tiphotrocha comprimata	0	2.3	0	3.3	0	6.3	0	3.3	0	3.1	0	3.5	0	2.7	0	4.2	0	4
Trochammina inflata	0	3.2	0	3	0	1.1	0	0.7	0	0.7	0	2.1	0	1.2	0	2.2	0	1.3
Trochammina macrescens f. macrescens	0	55.5	0	57.7	0	61.7	0	73.8	0	74.7	0	67.1	0	75.2	0	75.4	0	74.3
Trochammina ochracea	0	0.6	0	1.3	0	1.1	0	1.5	0	0.7	0	1.1	0	0	0	0	0	0.1
Reophax scotti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	1.4	0	5.1	0	5.1	0	2.2	0	3.3	0	4.8	0	4.8	0	4.8	0	6.5
C. constricta	0	0.1	0	0.9	0	2.3	0	0.4	0	2.2	0	0.8	0	3	0	2.7	0	4.4

Appendix Table 3- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 1, January 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm	
% Organic matter	24.3		37.9		51.9		36.5		36.3		33.3		29.6		25.4		27.3		28.9		26.4		24.5		23.9		20.8		22	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	3	7	4	7	0	6	0	6	3	7	1	7	0	6	1	5	0	7	0	6	0	7	0	5	0	5	0	6	0	7
Number of Individuals\10cc's	2216	5136	1656	5160	0	4192	0	3912	14	3032	8	2664	0	2800	8	2672	0	3920	0	3320	0	4768	0	4528	0	4344	0	3728	0	3752
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0.7	1.7	2	3.9	0	4.6	0	2	2	5.8	0	6.3	0	8.9	0	22.4	0	21.8	0	17.1	0	25.3	0	19.2	0	12.2	0	23.6	0	43.3
Organic linings	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0.2	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	1.4	0	1.6	0	2	0	0.8	0	0.3	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tipholrocha comprimata	0.3	1.2	4	2.9	0	3.6	0	3.3	4	3.4	0	1.8	0	5.1	0	5.1	0	3.3	0	3.9	0	3.9	0	2.3	0	1.5	0	2.6	0	3
Trochammina inflata	0	0.5	0.5	1.2	0	0.4	0	0	0	0.5	0	0.6	0	0.6	0	0.3	0	0.8	0	1.2	0	0.2	0	0	0	0	0	1.1	0	2.1
Trochammina macrescens f. macrescens	99	92.8	93.5	87	0	87.8	0	89.2	94	88.1	100	90.4	0	82.9	100	71.6	0	70.8	0	77.3	0	69	0	76.8	0	88.43	0	69.7	0	48.8
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0.6	0	0	0	0.8	0	0.2	0	0.2	0	0	0	0	0	0	0	0.2
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	1.9	0	3.3	0	1.5	0	2.9	0	1.6	0	0.3	0	2	0	0.6	0	1.2	0	0	0	0.8	0	1	0	1.1	0	1.7	0	1.5
C. constricta	0	0.5	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0.8	0	0.9	0	1.3	0	1.1

Depth in Core (cm)	15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm	
% Organic matter	21.8		17.1		20.4		16.8		16.7		17.2		14.8		16.7		16.4		15.3		19.7		21.5		20.8	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	0	7	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	7	0	6	0	6	0	6
Number of Individuals\10cc's	0	3230	0	3168	0	4352	0	5864	0	5344	0	4840	0	4040	0	4840	0	5248	0	5680	0	5048	0	4416	0	4400
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	31.4	0	24	0	14.2	0	8	0	8.4	0	8.6	0	8.7	0	6	0	10	0	13.2	0	12	0	10.7	0	12.9
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tipholrocha comprimata	0	6	0	8.6	0	6.6	0	5.2	0	4.5	0	3.8	0	3.4	0	1.8	0	3.8	0	5.5	0	6.3	0	7.4	0	6.7
Trochammina inflata	0	1.5	0	0.3	0	1.7	0	1.8	0	1	0	0.7	0	0.6	0	0.3	0	0.8	0	1.3	0	1.6	0	2	0	1.8
Trochammina macrescens f. macrescens	0	58	0	60.9	0	72.4	0	80.2	0	81.4	0	82.5	0	83.6	0	90.1	0	82.3	0	75.4	0	75	0	73.9	0	75.3
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	1.7	0	3	0	3.3	0	3.3	0	3.3	0	3.3	0	2.8	0	1.3	0	2.1	0	3	0	3	0	3.1	0	2.2
C. constricta	0	1.5	0	2.3	0	1.8	0	1.5	0	1.3	0	1.2	0	1	0	0.5	0	1.1	0	1.5	0	2.1	0	2.9	0	1.1

Appendix Table 4- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 1, April 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm	
% Organic matter	44.6		45.4		65		62.8		50.7		47.7		44.1		43.8		46.2		44.6		44.3		45.1		38.2		37.4	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	3	5	2	5	1	5	0	5	0	7	0	8	0	6	0	5	0	6	0	6	0	6	0	7	0	6	0	5
Number of Individuals\10cc's	2240	7896	#	5480	168	4536	0	4292	0	4992	0	7384	0	7344	0	7408	0	5688	0	9664	0	9200	0	8568	0	8728	0	4856
Miliammina fusca	0	0	0	0.3	0	1.6	0	0.1	0	1.8	0	1.6	0	2.2	0	1.2	0	5.5	0	3.2	0	3.6	0	3.7	0	1.8	0	5.8
Organic linings	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0.7	0.4	0	0	0	0	0	0	0	0.1	0	0.5	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	3.6	3.9	#	3.9	0	3.3	0	1.5	0	4	0	6.8	0	5.2	0	4.5	0	4.1	0	3.5	0	2.7	0	11.1	0	8.7	0	11.4
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.7	0	1.2	0	1.2	0	0.6	0	1.1	0	0
Trochammina macrescens f. macrescen	95.7	92.8	#	94.3	100	92.8	0	93.4	0	85.7	0	85.9	0	86.9	0	90.4	0	85.4	0	86.4	0	87.2	0	75	0	82	0	62.6
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0
C. aculeata	0	2.1	0	0.4	0	1.4	0	3.7	0	5.4	0	3.4	0	4.1	0	3.2	0	3.1	0	3.8	0	4.1	0	6.9	0	4.3	0	14.3
C. constricta	0	0.8	0	0.3	0	0.9	0	1.3	0	2.7	0	1.5	0	1.3	0	0.6	0	1.3	0	1.7	0	1.2	0	2.6	0	2.1	0	5.9

Depth in Core (cm)	14-15cm		15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm	
% Organic matter	31.4		31.7		35.6		21.7		23.7		28.9		24.2		26		28.5		27.1		31.8		28.6	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	5	0	6	0	6	0	6	0	5	0	6	0	6	0	6	0	6	0	6	0	6	0	5
Number of Individuals\10cc's	0	9056	0	12024	0	9426	0	6304	0	4968	0	2600	0	3428	0	3024	0	4728	0	7776	0	7360	0	7440
Miliammina fusca	0	4.5	0	3.2	0	3	0	2.4	0	8.2	0	4.3	0	0.9	0	16.7	0	10.5	0	1.4	0	4.1	0	2.2
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	9.7	0	8.3	0	10.7	0	8.6	0	0	0	14.5	0	16.7	0	27.2	0	18.1	0	5.8	0	3.8	0	26.6
Trochammina inflata	0	0	0	0.4	0	1.2	0	0.5	0	1.2	0	2.2	0	1.9	0	2.1	0	2.3	0	0.2	0	0.9	0	0
Trochammina macrescens f. macrescen	0	80.6	0	63.6	0	74.8	0	51.1	0	81.3	0	61.8	0	71.6	0	47.1	0	61.3	0	77.4	0	79.3	0	54.6
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	3.1	0	18	0	9.1	0	21.8	0	6.2	0	12.3	0	7.2	0	4.8	0	4.6	0	10.5	0	8.7	0	10.1
C. constricta	0	2.1	0	6.6	0	1.2	0	15.5	0	3.1	0	4.9	0	1.7	0	2.1	0	3.2	0	4.7	0	3.2	0	6.6

Appendix Table 5- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 1, June 1996.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm	
% Organic matter	56.8		68.7		63.4		53.9		51.5		40		39.6		37.6		39.1		46.3		42.2		45.8	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	4	6	1	6	0	5	1	5	0	5	0	5	0	5	0	5	0	6	0	5	0	5	0	6
Number of Individuals\10cc's	440	6952	40	5904	0	6024	24	4424	0	4688	0	5240	0	5376	0	5744	0	2888	0	1992	0	2488	0	2472
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	1.8	0.2	0	1.6	0	1.3	0	0.2	0	0.6	0	1.8	0	2.5	0	3.7	0	6.1	0	7.7	0	15.4	0	20.7
Pseudothurlammina limnetis	0	0.1	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.8	0	2.4	0	0	0	0.6
Tiphotrocha comprimata	18.2	2.6	0	1.9	0	2	0	4.2	0	3.1	0	3.8	0	4	0	4.5	0	8	0	5.6	0	5.5	0	8.4
Trochammina inflata	1.8	0.5	0	0.1	0	0.1	0	0	0	0.3	0	0.56	0	0.3	0	0	0	1.1	0	0	0	1	0	1
Trochammina macrescens f. macrescens	78.2	89.6	100	91.6	0	92.2	100	92.9	0	91.1	0	89.8	0	90.3	0	89.4	0	82.3	0	80.3	0	72	0	60.8
Trochammina ochracea	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	6.9	0	4.3	0	4.4	0	2.5	0	4.9	0	4	0	2.8	0	2.1	0	1.7	0	4	0	6.1	0	8.4

Depth in Core (cm)	12-13cm		13-14cm		14-15cm		15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm	
% Organic matter	46		46.2		44.5		35.4		30		25.7		20.7		19.2		21.2		23.4	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	5	0	5	0	5	0	5	0	6	0	6	0	6	0	6	0	6	0	6
Number of Individuals\10cc's	0	3608	0	4856	0	5280	0	6184	0	5600	0	5560	0	4336	0	4376	0	4048	0	4288
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0.1	0	0.7	0	0.4	0	0.4	0	0.4	0	0.2
Miliammina fusca	0	23.9	0	30.5	0	16.5	0	11.2	0	17.7	0	18.7	0	12.5	0	9.7	0	6.1	0	2.2
Pseudothurlammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	9.8	0	12.5	0	8.8	0	10.7	0	12.7	0	14.3	0	9.6	0	7.3	0	9.1	0	5.2
Trochammina inflata	0	0.9	0	1.1	0	0.5	0	0.3	0	0.3	0	0.3	0	0.2	0	0.5	0	0.8	0	0.4
Trochammina macrescens f. macrescens	0	60.8	0	49.8	0	69.9	0	73.2	0	66.1	0	61.5	0	72.2	0	73.9	0	75.9	0	83.2
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	4.7	0	6.1	0	4.4	0	4.7	0	3	0	4.4	0	5.2	0	8.2	0	7.7	0	8.8

Appendix Table 6- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 1, September 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm	
% Organic matter	11.25		10.43		10.58		13.21		14.8		11.17		9.66		12.62		9.08		12.46		12.1		12.85		13.15		12.12		12.22	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	4	8	7	10	4	7	4	10	4	11	4	7	5	8	7	8	3	8	5	7	2	5	3	5	4	7	3	5	2	6
Number of Individuals\10cc's	1980	3784	716	1608	2736	5744	1256	6680	328	4112	504	4936	784	9088	1056	4312	168	4872	1704	6656	296	4336	592	3640	112	3872	136	2448	32	2400
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0.2	1.6	0.3	3.1	0.4	0.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	3.4	1.7	0	0	0	0.1	0	0.8	0	0	0.1	0.3	2.3	0.7	9.5	0.7	0.5	0.1	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0.6	1.2	0.3	0.4	0	0.1	2.4	0.6	0	0	1	0.1	0.8	0.7	0	0.5	0	0.1	0	0.2	0	0.4	0	1.7	5.9	1.6	0	1.3
Elphidium williamsoni	4	1.6	1.1	2	1.3	1.8	4.1	2	0	0.5	1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemisphraemmina bradyii	0	1.1	1.1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	93.4	92.1	83.3	73.4	92.8	87.1	74.2	84.6	43.9	77.7	94.2	92	84.7	92.8	92.4	90.5	81	86	81.7	88.8	56.8	83.8	77	87.7	71.4	77.7	47.1	74.8	50	72
Organic linings	0	1	0	4.2	0	4.3	0	3	0	1.9	0	0	0	1.8	0	1.5	0	1	0	0.7	0	0.7	0	1.8	0	3.1	0	2.9	0	3
Pseudothuriammina limnetis	0.2	0.2	0	0.5	0	0	0	0.1	0	0.4	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	1.1	1.1	6.2	0	0.7	0	1.9	0	0.6	0	1	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0.6	0	0	0	0.3
Trochammina inflata	0	0	0	0	0	0	0.6	0.1	2.4	0.2	0	0	0	0	1.6	0.4	0	0	0.5	0.1	0	0	0	0	7.1	0.2	0	0	0	0
Trochammina macr. f macr.	2.4	3	9.4	9.5	5.6	5.6	21	7.9	48.8	10.1	3.2	4.9	10.2	3.7	1.6	3	9.5	7.9	16.9	8.5	43.2	13.3	20.3	7.7	14.3	11	47.1	13.4	50	14
Trochammina ochracea	0	0	0	0	0	0	0	0	0	7	0	1.5	0	0.8	0.8	3	0	3.1	0.5	1.6	0	2	2.7	2.4	7.1	5.8	0	7.2	0	9.3
Reophax scotti	0	0.1	0	0.2	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm		29-30cm	
% Organic matter	9.27		9.29		12.8		13.93		12.06		13.23		13.16		13.39		13.48		15.62		12.67		11.3		8.11		6.4		6.02	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	1	6	2	7	1	7	0	7	1	7	0	5	0	3	0	6	0	4	0	7	0	5	0	5	0	7	0	8	0	7
Number of Individuals\10cc's	8	3080	24	[illegible]	8	2456	0	2624	8	4624	0	4120	0	2520	0	1768	0	419	0	293	0	265	0	309	0	1072	0	813	0	808
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0
Ammotium salsum	0	0	0	0	0	1.6	0	0.6	0	0.3	0	0	0	0	0	0	0	0	0	0.7	0	0.8	0	1.6	0	1.6	0	0.6	0	2.4
Eggerella advena	0	2.6	0	3	0	1.6	0	0	0	0.2	0	0.2	0	0	0	0	0	0	0	2	0	0	0	0	0	1.6	0	3	0	8.9
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemisphraemmina bradyii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	67	33.3	60.2	0	67.4	0	71	100	85.5	0	92.4	0	94	0	85.7	0	72.3	0	55.3	0	60.8	0	46.6	0	27.4	0	40.3	0	21.8
Organic linings	0	4.9	0	4.3	0	2.3	0	0.6	0	0.3	0	0.2	0	0	0	1.6	0	4.1	0	7.5	0	11.7	0	33.7	0	23.8	0	10.5	0	11.5
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0.7	0	0.7	0	0.6	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0
Trochammina macr. f macr.	100	14.8	66.7	21.4	100	23.8	0	23.8	0	12.6	0	6.4	0	5.4	0	6.6	0	10.5	0	7.2	0	6.4	0	13.3	0	8.9	0	3.3	0	16.8
Trochammina ochracea	0	10.1	0	9.9	0	2.6	0	3	0	0.9	0	0.8	0	0.6	0	5.4	0	13.1	0	27	0	20.4	0	4.9	0	36	0	39.4	0	37.6
Reophax scotti	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	1

Appendix Table 7- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 2a, October 1996.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm	
% Organic matter	14.8		11.4		12.7		10.8		12.3		10		12		10.2		10.6		12.5		10.7		6.3		13		20.4	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	7	11	3	9	2	7	3	9	5	10	4	9	2	9	2	8	1	8	1	7	0	6	1	9	1	7	0	7
Number of Individuals\10cc's	888	1620	264	2184	1080	4096	232	3808	544	4232	392	2408	48	2384	152	2440	56	1964	88	2408	0	2712	8	3208	4	1956	0	1332
Ammobaculites dilatatus	1.8	1	0	0.4	0	0	0	1.1	0	0.6	2	2.7	0	2.3	0	2	0	2.2	0	1.7	0	0	0	1.7	0	2.5	0	0.6
Ammonia beccarii	0.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0.4	0	0.4	8.8	2.8	0	3	0	3.4	0	2.6	0	1.2	0	3.3	0	0.6	0	1.5	0	2	0	0.6
Eggerella advena	0	0	0	0.4	0	0.2	0	0.2	0	0.2	0	0.7	0	0	0	1.3	0	0.4	0	0	0	0.3	0	0.2	0	1.4	0	1.2
Elphdium excavatum forma excavatum	1.8	1	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0
Elphidum williamsoni	51.4	31.1	39.4	5	2.2	0.6	6.9	0.4	1.5	0.2	0	0	16.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	3.4	0.4	2.9	1.3	4.1	1	0	1	0	0.3	0	0.8	0	0	0	0	0	0.2	0	0	0	0
Haynesina orbiculare	0.9	0.5	3	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	42.3	54.8	57.6	84.2	97.8	91.2	89.7	80.5	86.8	85.8	87.8	84.7	83.3	72.5	89.5	76.4	100	76.2	100	83.7	0	82.3	100	85.5	100	80.4	0	61.3
Organic linings	0	3.5	0	2.2	0	2.7	0	3.6	0	0.4	0	0	0	4.4	0	4.6	0	6.1	0	0	0	4.4	0	2.7	0	3.1	0	6
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	3.5	0	3.3	0	2.9	0	8.2	8.8	7	6.1	2.7	0	2.3	10.5	4.9	0	4.1	0	16.8	0	1.8	0	0.5	0	0.4	0	2.1
Trochammina ochracea	0	3.5	0	3.7	0	2	0	5.2	0	0.9	0	4.7	0	13.1	0	7.9	0	9	0	7	0	10.6	0	7.2	0	12.3	0	28.2
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0.2	0	0	0	0	0	0	0	0.2	0	0.3	0	0.7	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0

Depth in Core (cm)	14-15cm		15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm	
% Organic matter	10.9		10.3		12.8		10.6		9.5		8.3		8.8		13.2		19.3		8.1		10.9		15.1		7.1	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	2	7	0	7	0	7	0	8	0	6	0	7	0	9	0	7	0	7	0	8	0	7	0	7
Number of Individuals\10cc's	0	955	11	1053	0	1368	0	1460	0	1898	0	2504	0	2888	0	3808	0	1532	0	1216	0	1680	0	2496	0	917
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	2	0	2.3	0	1.6	0	0.8	0	0.3	0	0	0	0.4	0	2.1	0	4.6	0	1	0	3.2	0	3.5
Eggerella advena	0	0.8	0	2	0	3.2	0	2.2	0	0.8	0	1.6	0	2.5	0	2.7	0	1	0	1.6	0	3.3	0	1.3	0	5.2
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	41.9	72.7	57.7	0	38	0	37.5	0	62	0	73.2	0	73.7	0	67.2	0	64.2	0	64.5	0	63.8	0	80	0	53.2
Organic linings	0	9.2	0	10.6	0	12	0	11	0	5.5	0	7.7	0	7.2	0	10.3	0	7.3	0	3.9	0	3.8	0	1.6	0	9.6
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0.1	0	0.6	0	0.8	0	0	0	1	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.2	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	0.8	0	1.2	0	2.3	0	1.6	0	1.7	0	0.6	0	1.9	0	2.3	0	3.1	0	4.6	0	5.7	0	2.9	0	6.2
Trochammina ochracea	0	46.9	0	25.8	0	41.5	0	44.9	0	28.3	0	16.6	0	14.1	0	15.8	0	21.4	0	20.4	0	21	0	10.9	0	21.8
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0.5	0	0	0	0
Reophax scotti	0	0.3	27.3	0.6	0	0.6	0	1.1	0	0.4	0	0	0	0.3	0	0.4	0	0	0	0.3	0	0	0	0.3	0	0.5

Appendix Table 8- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 2a, January 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm	
% Organic matter	10.9		10.6		9.8		10.5		10.9		10.9		10.8		11.8		9.4		8.8		8.8		11.2		10.3		9.8		10	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	2	6	4	7	5	7	6	8	5	8	1	7	1	7	4	9	3	5	1	7	1	9	0	7	0	7	0	6	0	8
Number of Individuals\10cc's	8	368	248	592	248	568	312	720	272	684	32	504	8	696	240	928	192	468	16	1136	4	992	0	996	0	1192	0	1296	0	2584
Ammobaculites dilatatus	0	4.3	9.7	4.1	0	0	2.6	2.2	0	2.4	0	6.3	0	8	0	2.6	6.3	5.1	0	4.2	0	1.6	0	1.2	0	2	0	1.2	0	0.6
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	4.3	0	1.4	3.2	2.8	12.8	7.8	2.9	3.6	0	6.3	0	5.7	1.7	1.7	2.1	3.4	0	0.4	0	0.4	0	1.2	0	4.6	0	1.2	0	0.9
Elphidium williamsoni	12.5	1.1	3.1	1.2	1	0.8	2.3	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	87.5	31.6	22.7	27.1	31.3	26	43.8	43.6	44.1	41	100	44.4	100	57.5	90	72.4	91.7	70.1	100	75.4	100	70.2	0	72.3	0	69.8	0	85.2	0	90.7
Organic linings	0	28.3	0	13.5	0	21.1	0	8.9	0	9.6	0	11.1	0	5.7	0	5.6	0	0	0	6.7	0	4	0	5.6	0	9.4	0	1.2	0	1.2
Textularia earlandi	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0.4	0	0.4	0	0.7	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0.4	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.3
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	0	0	5.4	12.9	14.1	10.3	10	11.8	4.8	0	3.2	0	2.3	6.6	3.4	0	2.6	0	3.5	0	4.8	0	4.4	0	3.3	0	4.8	0	2.8
Trochammina ochracea	0	30.4	64.5	47.3	51.6	33.8	28.2	24.4	38.2	38.1	0	27	0	19.5	1.7	12.5	0	18.8	0	9.5	0	17.7	0	14.9	0	10.1	0	6.2	0	2.8
Reophax scotti	0	0	0	0	0	0	0	2.2	2.9	1.2	0	1.6	0	1.1	0	0.4	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.6
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm		29-30cm	
% Organic matter	12.3		10.5		9.9		9		9.7		8.8		8.7		7.8		8.1		8.5		8.4		7.5		6.2		6.1		6.7	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	5	0	5	0	6	0	7	0	7	0	7	0	7	0	7	0	6	0	5	0	5	0	5	0	5	0	5	0	5
Number of Individuals\10cc's	0	4088	0	6768	0	4744	0	5400	0	6256	0	8752	0	5264	0	3480	0	2576	0	2736	0	2584	0	2600	0	2536	0	1960	0	2744
Ammobaculites dilatatus	0	0.8	0	0.4	0	0.3	0	0.3	0	0.1	0	0.1	0	0.1	0	0.2	0	0.3	0	0.3	0	0.3	0	0.6	0	0.3	0	0.4	0	0.3
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0.3	0	0.1	0	0	0	0.2	0	0.2	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	91.6	0	94.3	0	88.4	0	89	0	94.8	0	95.8	0	94.8	0	93.1	0	93.2	0	93.9	0	93.2	0	92.9	0	94.3	0	93.1	0	95.3
Organic linings	0	2	0	1.1	0	9.9	0	3.7	0	1.7	0	1.3	0	1.4	0	2.1	0	2.5	0	2	0	2.8	0	2.5	0	2.5	0	1.6	0	0.9
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0.2	0	0.1	0	0.3	0	0.1	0	0.2	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	3.5	0	2.7	0	5.2	0	4.7	0	2.3	0	2	0	2.6	0	3.4	0	2.8	0	2.6	0	2.5	0	2.8	0	2.5	0	3.7	0	2.3
Trochammina ochracea	0	2.2	0	1.5	0	2	0	1.8	0	0.8	0	0.6	0	0.8	0	0.7	0	0.9	0	1.2	0	1.2	0	1.2	0	0.3	0	1.2	0	1.2
Reophax scotti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 9- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 2b, June 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	1	7	4	8	4	8	4	5	1	7	5	8	2	7	3	5	1	6	3	6	2	7	0	6	0	6	0	7	0	8
Number of individuals\10cc's	3	264	116	410	320	1120	320	928	24	1424	1200	2128	816	3400	832	2792	8	2528	104	1528	168	1792	0	1816	0	2552	0	2576	0	2768
Ammobaculites dilatatus	0	3	6.9	4.4	0	0.4	0	0	0	1.7	1.3	1.9	0	0.7	0	0.3	0	0	0	0	0	1.8	0	0.9	0	0.6	0	0.3	0	0.3
Eggerella advena	0	3	0	1	1.3	1.4	2.5	4.3	0	0.6	2	1.9	0	0.7	0	0	0	0.3	0	2.6	0	1.3	0	1.7	0	1.9	0	1.6	0	2
Elphidium williamsoni	100	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	45.2	55.2	52.7	83.8	80	75	70.7	100	78.1	93.3	82.7	84.3	86.6	96.2	92.8	100	88.6	23	63.4	71.4	77.7	0	78.9	0	80.9	0	80.1	0	72.8
Organic linings	0	9.1	0	13.7	0	1.4	0	3.4	0	3.9	0	2.6	0	1.2	0	2.5	0	0.3	0	4.7	0	2.7	0	2.6	0	2.5	0	2.8	0	4.6
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	9.1	3.4	10.3	8.8	5	17.5	6.9	0	2.8	2.7	3	15.7	8	1.9	1.1	0	3.8	30.8	9.9	28.6	9.8	0	8.4	0	5.2	0	5.9	0	6.9
Trochammina ochracea	0	30.3	34.5	23.4	6.2	11.1	5	14.7	0	12.4	3.3	6.8	0	2.6	1.9	3.2	0	6	46.2	17.3	0	6.2	0	7.5	0	8.5	0	9	0	11
Reophax scotti	0	0	0	1	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0.9	0	2.1	0	0	0	0	0	0	0	0.3	0	2
Spiroplectammina biformis	0	0	0	0	0	0.4	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	1	0	0.4	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0

Depth in Core (cm)	15-16cm		16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	7	0	7	0	6	0	7	0	6	0	8	0	8	0	8	0	7	0	7	0	7
Number of individuals\10cc's	0	2032	0	1824	0	1616	0	1056	0	1232	0	1568	0	1496	0	1744	0	2104	0	3276	0	3672
Ammobaculites dilatatus	0	0.4	0	0.4	0	0.5	0	0.8	0	0	0	1	0	0.5	0	1.4	0	0.8	0	0.2	0	0.2
Eggerella advena	0	1.2	0	1.8	0	2	0	6.8	0	1.9	0	1	0	1.1	0	1.4	0	2.7	0	1.2	0	1.3
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	78.8	0	78.1	0	75.7	0	53	0	62.3	0	76	0	71.7	0	74.3	0	65.8	0	80.1	0	81.5
Organic linings	0	3.5	0	3.1	0	4	0	8.3	0	8.4	0	10.2	0	12.8	0	10.6	0	6.1	0	3.9	0	3.3
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5	0	1.8	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	0	3.1	0	3.1	0	2.5	0	6.8	0	5.2	0	4.1	0	4.3	0	3.2	0	8.4	0	5	0	4.8
Trochammina ochracea	0	12.6	0	13.1	0	15.3	0	23.5	0	21.4	0	6.6	0	8.6	0	6.9	0	15.6	0	9.3	0	8.5
Reophax scotti	0	0.4	0	0.4	0	0	0	0.8	0	0.6	0	0.5	0	0.5	0	0.5	0	0.8	0	0.2	0	0.2
Spiroplectammina biformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 10- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 2b, September 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm	
% Organic matter	12.18		12.6		10.05		9.78		9.94		10.33		12.1		13.43	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	4	8	2	7	2	5	1	5	3	6	1	5	1	4	1	5
Number of Individuals\10cc's	856	4448	56	4048	80	3142	56	2624	136	3496	64	2888	16	2720	56	2912
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0.5	0	0.2	0	1	0	0.3	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	72	13.8	42.9	0.6	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helenina anderseni	0.9	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	17.8	79	57.1	93.9	80	92.4	100	91.8	76.5	96.1	100	94.5	100	95.6	100	96.7
Organic linings	0	1.3	0	1.4	0	1	0	1.8	0	0.4	0	0.8	0	2.1	0	1.1
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0.2	0	0	0	0	5.9	0.2	0	0	0	0	0	0.3
Trochammina macr. f poly.	9.3	4.1	0	3.6	20	4.3	0	4.6	17.6	2.5	0	3.9	0	2.1	0	1.1
Trochammina ochracea	0	0.9	0	0.2	0	1.3	0	1.5	0	0.4	0	0.6	0	0.3	0	0.8
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropixes aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. pontagulassia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm		15-16cm	
% Organic matter	11.85		10.5		8.75		7.53		9.86		10.57		9.03		8.29	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	5	0	5	1	5	0	7	0	7	0	6	0	5	0	5
Number of Individuals\10cc's	0	3512	0	2592	16	3128	0	1232	0	2024	0	1504	0	601	0	848
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helenina anderseni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	93.2	0	95.1	100	94.6	0	79.9	0	87.4	0	79.3	0	77.2	0	77.4
Organic linings	0	1.4	0	0.6	0	0.5	0	1.9	0	2.8	0	2.7	0	0	0	5.7
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
Trochammina macr. f poly.	0	4.8	0	1.9	0	2.3	0	3.2	0	1.6	0	3.7	0	6.7	0	0.9
Trochammina ochracea	0	0.5	0	2.2	0	1	0	4.5	0	3.6	0	3.7	0	10.6	0	13.2
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0.6	0	0	0	0	0	2.3	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropixes aculeata	0	0.2	0	0.3	0	1.5	0	8.3	0	4.1	0	9.8	0	3.2	0	2.8
G. gordialis	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0
P. pontagulassia	0	0	0	0	0	0	0	0	0	0.2	0	0.8	0	0	0	0

Depth in Core (cm)	16-17cm		17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm	
% Organic matter	6.04		5.6		5.84		6.45		5.37		5.12		5.18	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	8	0	7	0	6	0	6	0	7	0	6	0	8
Number of Individuals\10cc's	0	936	0	1204	0	2560	0	2432	0	2472	0	1784	0	1808
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0.3	0	0	0	0	0	0.3	0	0	0	0.4
Eggerella advena	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0.4
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helenina anderseni	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	72.6	0	78.4	0	94.7	0	95.4	0	92.6	0	92.8	0	95.1
Organic linings	0	6	0	7.3	0	1.3	0	1.3	0	1.6	0	0.5	0	0.4
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f poly.	0	5.1	0	1.3	0	0.6	0	0.3	0	1	0	3.1	0	0.9
Trochammina ochracea	0	4.3	0	7.3	0	2.2	0	2	0	3.2	0	2.4	0	1.3
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropixes aculeata	0	10.6	0	4.7	0	1	0	0.8	0	1.1	0	1.1	0	1.1
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. pontagulassia	0	0.5	0	0.6	0	0.3	0	0.2	0	0.2	0	0.2	0	0.2

Depth in Core (cm)	23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm		29-30cm	
% Organic matter	5.16		4.82		4.58		4.07		4.33		4.27		4.11	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	0	6	0	5	0	6	0	7	0	7	0	5
Number of Individuals\10cc's	0	1848	0	2256	0	2560	0	2288	0	2028	0	2512	0	2496
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helenina anderseni	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	89.2	0	91.1	0	97.8	0	93.4	0	91.1	0	94.9	0	97.4
Organic linings	0	2.6	0	3.5	0	0.3	0	1	0	0.8	0	0.3	0	0
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f poly.	0	1.7	0	0.4	0	0.6	0	2.1	0	2.4	0	0.3	0	0.3
Trochammina ochracea	0	3	0	3.2	0	0.9	0	2.8	0	4.3	0	1.9	0	1.3
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropixes aculeata	0	3.2	0	1.1	0	0.3	0	0.6	0	1.2	0	2.1	0	0.8
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. pontagulassia	0	0.3	0	0.7	0	0	0	0.1	0	0.1	0	0.1	0	0.2

Appendix Table 11- Percent abunance of living (stained, L) and total (T) foraminifera and arcellaceans from Stie 3, October 1996.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm		9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm		15-16cm		16-17cm	
% Organic matter	11.41		11.23		10.87		10.89		10.7		9.95		10.7		10.37		9.87		8.93		10.3		9.8		8.05		9		6.05		11.1		9.9	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	5	9	2	9	4	6	4	6	2	4	2	5	3	5	3	5	2	4	0	4	1	4	1	3	1	3	2	3	1	3	0	3	0	3
Number of Individuals\10cc's	124	724	112	1244	240	1024	384	1844	552	2816	344	2120	232	1904	224	3256	416	3104	0	1888	48	588	144	632	32	880	584	1920	96	1040	0	1000	0	1112
Ammobaculites dilatatus	6.4	6.1	0	3.2	11.7	7	21	3.7	2.9	6.8	2.3	7.9	13.8	8	7.1	2.2	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	6.4	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	51.7	56.3	92.9	49.2	68.3	55.1	91.7	80.3	97.1	81.8	97.7	83.4	82.8	84	89.3	94.6	98.1	94.8	0	94.9	100	91.9	100	88.6	100	92.7	98.6	96.3	100	92.3	0	92	0	91.4
Organic linings	0	15.5	0	21.9	0	18.8	0	10.6	0	9.9	0	7.2	0	6.3	0	2.5	0	2.8	0	3	0	5.4	0	10.1	0	6.4	0	3.3	0	6.9	0	7.2	0	7.9
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0.5	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0.4	0	0	0	0	0	0
Trochammina macr. f polystoma	3.2	2.8	0	2.6	1.7	3.9	3.1	2	0	1.4	0	1.1	0	1.3	3.6	0.2	0	0	0	1.3	0	1.8	0	1.3	0	0.3	0	0	0	0.8	0	0.8	0	0.7
Trochammina ochracea	32.3	16	7.1	19.9	18.3	14.8	3.1	3.3	0	0	0	0.4	3.4	0.4	0	0.5	1.9	1.8	0	0.8	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	1.7	0	1.6	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spiroplectammina biformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0.5	0	0.6	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	17-18cm		18-19cm		19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm		29-30cm	
% Organic matter	9		9.19		9.96		8.8		7.18		7.55		7.02		6.31		3.87		5.69		5.41		5		5.98	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	3	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	5	0	5
Number of Individuals\10cc's	0	1560	0	1424	0	1392	0	1480	0	1368	0	1368	0	720	0	368	0	320	0	368	0	304	0	280	0	344
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.8	0	4.6
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	94.4	0	91.6	0	82.8	0	87	0	87.2	0	85.2	0	43.3	0	41.3	0	40	0	30.4	0	31.6	0	17.1	0	20.9
Organic linings	0	5.1	0	6.7	0	8	0	6.5	0	7.6	0	4.8	0	31.1	0	17.4	0	12.5	0	15.2	0	13.1	0	25.7	0	18.6
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f polystoma	0	0.5	0	0.6	0	5.2	0	2.2	0	2.3	0	4.5	0	14.4	0	8.7	0	5	0	8.7	0	7.9	0	14.3	0	14
Trochammina ochracea	0	0	0	1.1	0	4	0	4.3	0	2.9	0	5.5	0	11.1	0	32.6	0	42.5	0	45.7	0	47.4	0	40	0	41.9
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spiroplectammina biformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 12- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 3, June 1997.

Depth in Core (cm)	0-1cm		1-2cm		2-3cm		3-4cm		4-5cm		5-6cm		6-7cm		7-8cm		8-9cm	
% Organic matter	7.38		7.54		8.54		8.77		9.48		9.18		8.43		9.07		8.85	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	4	8	6	10	1	6	1	8	2	6	0	6	0	7	1	7	1	7
Number of Individuals\10cc's	24	416	30	552	8	600	8	616	12	732	0	892	0	1076	36	860	28	816
Ammobaculites dilatatus	33	9.6	16.7	13.8	0	20.7	0	20.1	33.3	12	0	3.1	0	2.6	0	0.5	0	1
Eggerella advena	0	1.9	16.7	2.9	0	0	0	1.9	0	0	0	1.8	0	0.7	0	0.9	0	1
Elphidium williamsoni	4.2	0.2	16.7	0.9	100	1.3	100	1.3	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	29.8	26.7	16.6	33.6	0	52	0	57.8	66.7	59.6	0	74.4	0	74.7	100	70.7	100	70.6
Organic linings	0	30.8	0	15.9	0	12	0	1.3	0	4.9	0	8.5	0	4.8	0	7.9	0	9.8
Textularia earlandi	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f polystoma	0	5.8	16.6	5.1	0	2	0	0.6	0	1.1	0	0.9	0	0.7	0	4.7	0	3.9
Trochammina ochracea	33	23.1	16.7	26.1	0	12	0	16.2	0	20.8	0	11.2	0	15.6	0	14.9	0	13.2
Reophax nana	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0.7	0	0	0	0	0	1.6	0	0	0	0.7	0	0.5	0	0.5
Spiroplectammina biformis	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	9-10cm		10-11cm		11-12cm		12-13cm		13-14cm		14-15cm		15-16cm		16-17cm		17-18cm		18-19cm	
% Organic matter	9.28		10.44		11.72		10.84		9.21		17.16		11.46		9.13		10.33		7.7	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	1	5	1	5	1	6	1	4	0	6	0	5	0	6	0	4	0	6	0	6
Number of Individuals\10cc's	20	440	24	544	32	1096	24	700	0	1244	0	2216	0	1104	0	2032	0	1072	0	1148
Ammobaculites dilatatus	0	1.8	0	0.7	0	0.7	0	0.6	0	0.3	0	0	0	0.7	0	0	0	1.1	0	0.7
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	100	78.2	100	80.1	100	89.1	100	89.7	0	90.4	0	93.3	0	94.5	0	93.7	0	92.5	0	94.4
Organic linings	0	5.5	0	5.9	0	3.6	0	2.9	0	2.6	0	1.3	0	2.2	0	1.6	0	1.9	0	2.1
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f polystoma	0	2.7	0	4.4	0	1.8	0	0	0	1.3	0	0.7	0	0.4	0	0.4	0	1.5	0	1
Trochammina ochracea	0	11.8	0	8.8	0	4.4	0	6.9	0	5.1	0	4.5	0	1.4	0	4.3	0	2.2	0	1.4
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0.4	0	0	0	0.3	0	0.2	0	0.7	0	0	0	0.7	0	0.3
Spiroplectammina biformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	19-20cm		20-21cm		21-22cm		22-23cm		23-24		24-25cm		25-26cm		26-27cm		27-28cm		28-29cm		29-30cm	
% Organic matter	7.66		6.27		8.18		7.67		5.06		5.39		5.38		4.8		6.47		4.05		3.86	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	0	6	0	6	0	7	0	7	0	7	0	7	0	7	0	6	0	5	0	5
Number of Individuals\10cc's	0	728	0	388	0	296	0	544	0	536	0	504	0	488	0	672	0	456	0	456	0	520
Ammobaculites dilatatus	0	1.6	0	8.2	0	1.4	0	5.9	0	3	0	4.8	0	1.6	0	1.2	0	0	0	0	0	0
Eggerella advena	0	0	0	3.1	0	0	0	2.9	0	6	0	4.8	0	3.3	0	3.6	0	8.8	0	7	0	9.2
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
Miliammina fusca	0	88.5	0	61.8	0	82.4	0	41.2	0	38.8	0	30.2	0	18	0	6	0	14	0	17.5	0	15.3
Organic linings	0	4.4	0	4.1	0	6.8	0	11.8	0	15	0	6.3	0	4.9	0	19	0	7	0	8.8	0	7.7
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f polystoma	0	2.2	0	7.2	0	5.4	0	2.9	0	3	0	3.2	0	23	0	15.5	0	14	0	10.5	0	15.3
Trochammina ochracea	0	1.6	0	15.5	0	2.7	0	33.8	0	32.8	0	49.2	0	45.9	0	51.2	0	54.4	0	56.1	0	52.3
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	1.6	0	0	0	1.4	0	1.5	0	1.5	0	1.6	0	3.3	0	3.6	0	1.8	0	0	0	0
Spiroplectammina biformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thecamoebians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 13- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from Site 3, September 1997.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15		Week 16	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	5	7	5	8	5	7	2	7	4	6	5	7	5	8	2	6	2	7	1	9	4	7	3	6	2	8	0	6	0	6	0	7	0	7
Number of Individuals\10cc's	1744	3044	856	3400	440	2132	248	2672	888	3088	824	3088	672	2680	120	2824	48	3280	80	2316	44	1596	92	1748	96	3628	0	2560	0	2416	0	3088	0	3624
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
Epistominella exiigua	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Islandiella teretis	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	1.8	5.2	4.7	5.9	1.8	6.4	0	0	1.8	3.9	1	4.1	1.2	5.7	0	4	0	3.9	0	3.1	0	4	8.7	8.3	8.3	4	0	3.8	0	5.3	0	6.2	0	10.6
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	3.2	13.1	10.3	18.1	6.4	12	12.9	13.2	2.7	4.1	2.9	7	2.3	6.6	46.7	11.3	16.7	6.1	0	6.9	18.2	5.8	0	5	0	5.1	0	4.4	0	9.6	0	3.1	0	7.1
Tiphotrocha comprimata	0.5	0.7	3.7	3.5	2.7	4.1	0	1.8	1.8	2.6	5.8	3.4	3.6	3.6	0	2.8	0	2.2	0	3.5	54.5	5.8	4.3	4.3	0	2.9	0	4.7	0	5.6	0	4.4	0	2
Trochammina inflata	3.7	2.6	3.7	2.4	0.9	0.6	0	0.3	0	0	1	0.3	1.2	0.6	0	0.3	0	0.2	0	0.2	9.1	1	0	0	0	0.4	0	0.9	0	0.7	0	0.3	0	0.4
Trochammina macr. f macr.	90.8	76.5	77.6	63.1	88.2	75.2	87.1	77.2	93.7	86.8	89.3	84.5	91.7	81.5	53.3	80.7	83.3	85.1	100	82.6	18.2	79.2	87	78.9	91.7	83	0	82.2	0	76.2	0	76.4	0	69.1
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	0	1	0	2.1	0	1.3	0	1.5	0	2.3	0	0.5	0	1.2	0	0.8	0	2.2	0	2.6	0	3.8	0	2.9	0	3.9	0	4.1	0	2.6	0	8.1	0	8.3
Centropyxis constricta	0	0.6	0	0	0	0.4	0	0.3	0	0.3	0	0	0	0	0	0	0	0.2	0	0.3	0	0.5	0	0.6	0	0.6	0	0	0	0	0	1.5	0	2.5

Depth in Core (cm)	Week 17		Week 18		Week 19		Week 20		Week 21		Week 22		Week 23		Week 24		Week 25		Week 26		Week 27		Week 28		Week 29		Week 30		Week 31		Week 32		Week 33	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	0	8	0	8	0	7	0	8	0	0	0	6	0	6	0	7	0	9	0	6	0	8	0	6	0	11	0	7	0	6	0	6
Number of Individuals\10cc's	0	3344	0	3728	0	4512	0	3712	0	3840	0	0	0	3976	0	3080	0	3520	0	3368	0	3272	0	3408	0	3888	0	4816	0	5056	0	3968	0	3344
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma excavatum	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
Epistominella exiigua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Islandiella teretis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	7.2	0	7.1	0	9.2	0	4.1	0	6.5	0	4.5	0	6.2	0	5.5	0	9.1	0	7.6	0	5.4	0	7.3	0	5.8	0	8	0	2.8	0	4.2	0	6
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	1.4	0	3.9	0	1.6	0	3	0	3.5	0	1.3	0	2.6	0	2.1	0	1.8	0	3.3	0	1	0	1.4	0	0.4	0	2.3	0	0.5	0	0.8	0	1.4
Tiphotrocha comprimata	0	1.4	0	2.1	0	2.7	0	2.5	0	2.1	0	3.3	0	3.8	0	2.3	0	1.6	0	1.4	0	1	0	2.8	0	2.9	0	2.8	0	3.3	0	1.2	0	2.6
Trochammina inflata	0	0	0	1.1	0	0.9	0	0.2	0	1.9	0	0.3	0	0	0	0	0	0.2	0	0.2	0	0	0	0.5	0	0	0	0.3	0	0.3	0	0	0	0
Trochammina macr. f macr.	0	83.5	0	75.5	0	75	0	82.5	0	77.3	0	86.9	0	80.1	0	85.5	0	83.4	0	83.4	0	87.3	0	80.8	0	82.3	0	73.6	0	90.8	0	89.3	0	88
Trochammina ochracea	0	0	0	0	0	0.2	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
Centropyxis aculeata	0	5.7	0	9.9	0	8.6	0	5.4	0	7.8	0	3.1	0	5	0	3.2	0	3.4	0	2.4	0	4.6	0	5.9	0	7.7	0	10.4	0	2	0	3	0	1.8
Centropyxis constricta	0	0.8	0	0	0	1.8	0	2.2	0	0.7	0	0.6	0	2.2	0	1.4	0	0.5	0	0.7	0	0.8	0	1.2	0	0.9	0	1.7	0	0.2	0	1.4	0	0.1

Appendix Table 14- Percent abundance of living (L) and total (T) foraminifera and arcellaceans from site 1 surface samples and store in buckets.

Number of weeks	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18
Number of Species\10 cc's	7	5	7	6	7	5	6	5	6	7	6	6	6	6	6	6	6	6	6
Number of Individuals\10cc's	2992	3096	3528	3576	2880	2816	1720	2472	2392	3264	3488	4272	2808	2456	2368	3640	3312	3560	3640
Ammobaculites dilatatus	0.3	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	5.1	2.8	5.9	2.2	8.9	5.4	3.2	1.6	5.4	2.4	2	7.7	4.5	2.9	2	4.4	3.9	4.7	4.8
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0.3	0	0	0	0.3	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	19.3	25.3	16.8	19.7	15.3	15.3	19.1	9.7	17.4	14.2	15.6	7.7	13.1	16.6	19.9	9.2	12.3	10.3	9
Trochammina inflata	5.6	8	0.7	0.4	1.7	1.7	0.9	0	0	1.7	0.7	0.7	0.9	0.7	0.7	1.3	1	0.9	1.5
Trochammina macrescens forma macrescens	43	27.4	63.9	59.7	57.8	75.9	70.7	74.1	52.8	57.8	67.2	62.4	63	64.2	64.2	52.1	55.6	52.6	52.3
Centropyxis aculeata	18.4	24.9	10.2	15.7	11.7	1.7	5.6	10.4	19.7	15.4	10.1	16.3	13.7	11.4	9.8	23.7	16.9	22.7	23.3
Centropyxis constricta	8.1	11.5	2	2.2	4.4	0	0	4.2	4.3	7.8	4.4	5.2	4.8	4.2	3.4	9.2	10.4	8.8	9

Number of weeks	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37
Number of Species\10 cc's	6	6	6	6	6	6	6	6	6	6	7	6	6	6	6	6	6	6	6
Number of Individuals\10cc's	3600	3656	3320	3424	3336	3336	2720	2384	2432	2720	2624	2480	2472	3080	3080	3152	3296	3088	3184
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	4.4	4.2	5.8	6.5	6.5	4.8	2.9	1	2	2.6	4	0.7	1	0.5	0.8	1	0.5	1.3	1.8
Organic linings	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	10.4	10.5	16.6	16.4	16.3	15.1	12.1	12.1	10.9	12.4	9.8	15.8	14.2	14	13.8	14.2	13.8	12.4	12.3
Trochammina inflata	0.7	1.8	1.2	1.9	1.2	2.2	0.9	1.3	1	1.8	0.3	1.9	1.6	1.6	1.3	1.5	2.2	2.1	2.3
Trochammina macrescens forma macrescens	53.1	51.6	54.9	54	54.7	51.8	52.2	58.7	57.9	55	56.7	60.3	60.8	49.9	50.1	50	49	51.3	51.5
Centropyxis aculeata	22	22.5	10.1	11.2	10	17.3	18.8	19.8	19.7	20	18.9	15.5	15.9	28.1	28.3	27.7	26.9	28	26.9
Centropyxis constricta	9.3	9.4	11.3	10	11.4	8.9	9.1	8.1	8.6	8.2	10.1	5.8	6.5	6	5.7	5.6	7.5	4.9	5.3

Number of weeks	Week 38	Week 39	Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51	Week 52
Number of Species\10 cc's	6	6	6	6	6	5	6	6	6	6	5	6	6	6	5
Number of Individuals\10cc's	3032	3792	3336	3448	3704	3744	3792	3976	4136	4192	3720	5024	5520	5608	5072
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	3.4	3.8	2.6	3	3.2	3.6	2.7	1.2	0.1	0.6	0.9	0.5	0.1	0.3	1.4
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	12.9	9.3	10.6	7.9	8.6	9.2	11.4	10.5	12.6	13.5	9.7	14	21.2	16.3	12
Trochammina inflata	1.8	2.7	1.2	1.4	1.5	0	0.4	0.6	0.4	0.2	0	0.3	0.4	0.1	0
Trochammina macrescens forma macrescens	50.9	47.3	48.9	50.8	47.7	48.5	48.7	47.5	48.2	45.4	50.1	47.9	47	48.5	52.2
Centropyxis aculeata	26.1	27.2	26.6	29	28.5	28.6	26.6	30.4	30.4	30.3	29	29.4	23.2	28	26
Centropyxis constricta	4.7	9.7	10.1	7.9	10.4	10	10.1	9.8	8.3	9.9	10.3	7.8	8.1	6.8	8.4

Appendix Table 15- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from subsurface samples collected at Site 1 and stored in buckets.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	9	12	7	10	8	9	5	8	8	12	6	9	6	9	4	10	6	11
Number of Individuals\10cc's	1624	3424	736	2728	872	4448	704	4724	1800	3504	648	3504	432	3104	336	3040	800	3848
Ammobaculites dilatatus	0	0	0	0.3	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
Ammonia beccarii	2	0.9	1.1	0.3	0	0	0	0	0.4	0.2	1.2	0.7	0	0	0	0	0	0.2
Ammotium salsum	0	0.2	0	0	1.8	0.4	1.1	0.5	0	0	1.2	0.2	0	0.3	0	0.3	0	0.4
Eggerella advena	0.5	4	0	0	0.9	1.1	0	0	0	0.7	0	0.7	0	0	0	0.5	1	0.8
Elphdium excavatum forma excavatum	8.8	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1.2
Elphdium excavatum forma clavatum	0	0	2.2	1.8	4.6	0.9	0	0	4	2.1	0	0	7.4	1	0	0	0	0
Elphidum williamsoni	0	0	25	7	12.8	2.5	21.6	5.2	8.9	4.6	46.9	10.3	37	5.7	47.6	6.3	0	0
Fursenkoina fusiformis	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0.5	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	2	1.2	4.3	1.8	0.9	0.4	4.5	1.7	0.9	0.5	4.9	0.9	0	1	9.5	1.1	4	1
Miliammina fusca	82.3	79.4	65.2	79.5	68.8	88.3	67	81.1	77.8	83.3	37	74.7	35.2	81.4	38.1	80	86	85.4
Organic linings	0	0.5	0	3.2	0	0	0	0	0	0	0	0.2	0	0.3	0	1.6	0	0.8
Pseudothuriammina limnetis	1.5	2.3	1.1	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	2.7	0	0.2	0	0	1.9	0.3	0	0	0	0
Trochammina inflata	0	0.2	0	0	0	0	0	0.2	0.9	0.5	0	0	0	0	0	0.3	2	1.2
Trochammina macr. f macr.	2	2.6	1.1	3.2	9.2	4.1	5.7	8.5	6.7	5.3	8.6	9.6	16.7	9.3	4.8	7.9	3	9.4
Trochammina ochracea	0.5	0.7	0	0	0.9	2.2	0	0	0.4	2.1	0	2.5	1.9	0.8	0	1.3	0	0.4
Reophax scotti	0	0	0	0	0	0.2	0	0.2	0	0.2	0	0	0	0	0	0.8	0	0.2
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis constricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15		Week 16		Week 17	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	6	10	3	8	6	9	4	11	2	11	1	7	0	9	0	8	0	10
Number of Individuals\10cc's	448	2928	184	2624	408	3432	448	3184	64	3136	8	2872	0	4352	0	3600	0	4584
Ammobaculites dilatatus	0	0	0	0	0	0.2	0	0.3	0	0.3	0	0	0	0	0	0	0	0
Ammonia beccarii	3.6	0.5	0	0	2	0.2	0	0	0	0.5	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0.2	0	0.2
Eggerella advena	0	0.3	0	0.3	0	0	0	0.3	0	0	0	0	0	0.9	0	0	0	0.3
Elphdium excavatum forma excavatum	0	0	0	0	0	0	3.6	7	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	8.9	1.4	0	0.6	9.8	1.4	0	0	0	0.8	0	0	0	0	0	0.4	0	0
Elphidum williamsoni	25	4.6	73.9	6.7	47.1	7.2	0	0	25	3.3	100	4.7	0	2.6	0	4	0	0.3
Fursenkoina fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0.2	0	1.5	0	0	0	0	0	0	0	0
Haynesina orbiculare	1.8	0.3	8.7	1.2	0	0	0	0.3	0	0.3	0	0	0	0.6	0	0	0	0.3
Miliammina fusca	57.1	83.9	17.4	82.9	29.4	82.8	89.3	78.9	75	84.4	0	83	0	80.3	0	81.6	0	87.6
Organic linings	0	0.3	0	0.6	0	0.5	0	1.3	0	0.3	0	1.1	0	2.4	0	0.2	0	0.3
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
Tiphotrocha comprimata	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	2	0.2	3.6	0.5	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f macr.	3.6	4.9	0	7	5.9	6.3	3.6	7.5	0	6.1	0	5.3	0	9.2	0	7.3	0	5.6
Trochammina ochracea	0	3.3	0	0	0	1.2	0	3.5	0	2.3	0	4.2	0	3.7	0	4.9	0	3.8
Reophax scotti	0	0	0	0.6	0	0	0	0.2	0	0.3	0	0	0	0	0	0	0	0.5
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0.2	0	1.3	0	0.9
Centropyxis constricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	Week 18		Week 19		Week 20		Week 21		Week 22		Week 23		Week 24		Week 25		Week 26	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	13	0	10	0	11	0	11	0	9	0	9	0	8	0	7	0	9
Number of Individuals\10cc's	0	3920	0	4808	0	3496	0	4720	0	4208	0	4000	0	4072	0	4368	0	4040
Ammobaculites dilatatus	0	0	0	0	0	0.2	0	0.2	0	0	0	0	0	0.4	0	0.2	0	0.2
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0.2	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0.2	0	0.5	0	0.5	0	0.3	0	1	0	0.2	0	0.2	0	0.4	0	0.4
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0.2	0	0.3	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0.4	0	1.7	0	0.9	0	0.7	0	0.2	0	1	0	0	0	0	0	0
Fursenkoina fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0.4	0	0	0	0.5	0	0	0	0	0	0	0	0.6	0	0	0	0
Haynesina orbiculare	0	0.6	0	0.3	0	0.5	0	0.3	0	0	0	0.2	0	0	0	0	0	0
Miliammina fusca	0	84.5	0	84.5	0	89.7	0	89	0	82.1	0	89	0	84.5	0	91.4	0	90.7
Organic linings	0	0.2	0	0.5	0	0	0	0.8	0	2.3	0	0.4	0	2	0	0.7	0	1
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Trochammina inflata	0	0.4	0	0.3	0	0	0	0.2	0	0.2	0	0.2	0	0.4	0	0	0	0.4
Trochammina macr. f macr.	0	6.5	0	7.2	0	3	0	6.3	0	10.5	0	5.6	0	10.4	0	6.4	0	4.6
Trochammina ochracea	0	4.3	0	3.8	0	3.9	0	1.5	0	3.2	0	2.6	0	1.6	0	0.7	0	2
Reophax scotti	0	0.6	0	0.2	0	0.5	0	0	0	0.2	0	0	0	0	0	0.2	0	0
Centropyxis aculeata	0	1.4	0	1	0	0.2	0	0	0	0.4	0	0.8	0	0	0	0	0	0.6
Centropyxis constricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	Week 27		Week 28		Week 29		Week 30		Week 31		Week 32		Week 33		Week 34		Week 35	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	6	0	8	0	10	0	9	0	6	0	10	0	5	0	7	0	8
Number of Individuals\10cc's	0	3424	0	4400	0	3960	0	3952	0	3632	0	3392	0	2696	0	3000	0	3856
Ammobaculites dilatatus	0	0.9	0	0	0	0.4	0	0.6	0	0	0	0.5	0	0.6	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0.4	0	0.2	0	0.8	0	0.2	0	0.2	0	0	0	0.3	0	0.6
Elphdium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fursenkoina fusiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0.2	0	0	0	0	0	0.5	0	0	0	0.3	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	85.7	0	86.7	0	90.5	0	90.3	0	83.3	0	88.4	0	92	0	91.7	0	91.7
Organic linings	0	1.6	0	0.9	0	0.6	0	0.2	0	4.6	0	0.5	0	0.6	0	0.3	0	0.2
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0.2	0	0	0	0.2	0	0.4	0	0	0	0.2	0	0	0	0	0	0.2
Trochammina macr. f macr.	0	7.5	0	10.9	0	4.2	0	4.5	0	7.5	0	8	0	6.2	0	4.8	0	4.8
Trochammina ochracea	0	4	0	0.4	0	3.2	0	2.6	0	4	0	0.9	0	0.6	0	2.4	0	1.9
Reophax scotti	0	0	0	0.4	0	0.2	0	0.4	0	0.4	0	0.2	0	0	0	0.3	0	0
Centropyxis aculeata	0	0	0	0.2	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0.4
Centropyxis constricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 16- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from surface samples collected at Site 2a and stored in buckets.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15		Week 16		Week 17	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	8	9	8	10	6	9	7	10	8	11	8	11	6	11	8	9	7	12	6	10	7	10	7	9	6	10	5	10	0	9	0	10	0	10	0	10
Number of Individuals\10cc's	452	1228	284	1324	274	1116	238	836	436	1448	288	862	253	1150	276	860	178	1040	278	970	278	1041	208	860	76	960	236	1296	0	1388	0	1412	0	1296	0	1744
Ammobaculites dilatatus	7.1	14.7	5.6	9.4	4.7	10.2	4.6	11.2	11	11.9	12.2	10.9	8.3	12	5.8	10.5	10.1	8.3	15.1	10.5	2.9	10	0	5.1	5.3	10.4	1.7	13	0	7.5	0	8.5	0	5.6	0	6.4
Ammonia beccarii	5.3	2.2	8.5	2.4	0	3.6	30.3	11.1	14.7	5.8	12.2	4.1	25.3	5.6	17.4	7	3.4	1	11.5	3.5	9.7	3.7	9.6	2.3	5.3	5	47.5	9.3	0	9.8	0	5.7	0	7.4	0	5
Ammotium salsum	12.4	13.4	18.3	13.9	13.5	11.6	8	7.7	4.6	11.6	6.6	9.9	6.3	9.3	2.2	5.8	3.4	7.5	10.8	8	1.8	12	1.9	11.2	0	11.3	0	3.7	0	7.8	0	12.5	0	6.8	0	6.9
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	8	3.6	8.5	3.3	6.9	2.2	5.5	2.9	3.7	1.1	11.1	3.7	15.8	3.5	15.9	5.1	18	6	8.6	2.5	27	8	36.5	8.8	21.1	4.2	16.9	5.5	0	6.9	0	2.3	0	4.3	0	3.2
Elphidium williamsoni	27.4	12.1	14.1	4.2	23.4	9.8	29	12.1	26.6	11	16.7	10.6	17	8.9	32.6	18.8	18	3.1	27.3	10.3	44.2	19.5	38.5	17.7	52.6	13.3	20.3	17.3	0	16.1	0	9.1	0	9.9	0	12.4
Haplophragmoides manilaensis	0	0	0	0	0	0.3	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	2.7	1.3	4.2	1.2	4.7	1.4	4.6	1.9	0.9	1.1	4.5	1.9	0	0	1.4	0.7	0	0.2	0	0.4	0	0.8	2.9	0.7	10.5	1.7	0	2.5	0	0	0	0	0	0	0	0
Miliammina fusca	31.9	42.3	38	52	46.7	52.3	18.1	34.2	36.7	37.8	35.1	45.1	27.3	42.4	22.5	31.9	46.1	39.8	26.6	40.6	13.3	36.3	9.6	44.2	5.3	35.4	13.6	40.9	0	38	0	49.3	0	46.3	0	39.9
Organic linings	0	8.1	0	6	0	8.6	0	16.6	0	15.7	0	11.5	0	13.5	0	17.9	0	31	0	21.4	0	8.5	0	9.1	0	17.1	0	5.6	0	9.8	0	8.5	0	14.2	0	17.9
Pseudothuriammina limnetis	5.3	2.3	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0.6	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f poly.	0	0	2.8	3.6	0	0	0	1.9	1.8	3	1.7	1.5	0	1.4	2.2	2.3	1.1	2.1	0	1.6	0	10.6	1	0.9	0	0.8	0	0	0	1.2	0	2.3	0	2.5	0	2.3
Trochammina ochracea	0	0	0	0	0	0	0	0.4	0	0	0	0.6	0	1.7	0	0	0	0.8	0	1	1.1	0.3	0	0	0	0.8	0	1.9	0	2.9	0	1.7	0	1.9	0	5.5
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0.5

Depth in Core (cm)	Week 18		Week 19		Week 20		Week 21		Week 22		Week 23		Week 24		Week 25		Week 26		Week 27		Week 28		Week 29		Week 30		Week 31		Week 32		Week 33		Week 34		Week 35	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	8	0	10	0	13	0	10	0	10	0	10	0	11	0	11	0	10	0	9	0	10	0	13	0	12	0	11	0	10	0	9	0	10	0	9
Number of Individuals\10cc's	0	1290	0	1568	0	1400	0	1372	0	1408	0	1464	0	1544	0	1508	0	1160	0	1380	0	1708	0	1420	0	1612	0	1284	0	1548	0	1136	0	1368	0	740
Ammobaculites dilatatus	0	7.2	0	10.2	0	9.4	0	11.4	0	5.7	0	10.4	0	11.7	0	11.9	0	20	0	9.9	0	14.1	0	14.1	0	9.9	0	9.3	0	10.8	0	21.1	0	8.8	0	14.6
Ammonia beccarii	0	0	0	3.8	0	6.3	0	5.2	0	7.4	0	5.5	0	7.3	0	0.5	0	3.4	0	0	0	0.5	0	0.6	0	2.5	0	1.2	0	9.3	0	1.4	0	7	0	5.4
Ammotium salsum	0	6.2	0	11.2	0	9.4	0	10.2	0	5.7	0	10.4	0	6.5	0	4.5	0	9.7	0	8.7	0	5.6	0	6.8	0	6.4	0	3.7	0	6.5	0	1.4	0	1.8	0	5.9
Eggerella advena	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma excavatum	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	0	0.6	0	4.1	0	5.7	0	5.2	0	4	0	3.8	0	5.2	0	2.7	0	2.7	0	2.3	0	1.9	0	3.4	0	1.5	0	1.9	0	4.7	0	4.9	0	3.5	0	2.7
Elphidium williamsoni	0	11.8	0	8.4	0	14.3	0	12.2	0	16.5	0	13.7	0	5.2	0	9	0	9.7	0	8.1	0	3.7	0	7.8	0	6.9	0	16.2	0	13.4	0	14.1	0	12.3	0	11.9
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0.6	0	0	0	1.1	0	0.5	0	0	0	0.5	0	0	0	0.6	0	0	0	1.1	0	0	0	0.6	0	0.5	0	2.1	0	0	0	0
Miliammina fusca	0	55.8	0	49	0	32	0	37.3	0	46	0	40.4	0	45.6	0	47.2	0	39.3	0	48.1	0	47.8	0	41.1	0	42.2	0	32.4	0	33.1	0	35.2	0	49.1	0	38.3
Organic linings	0	14.9	0	8.4	0	14.9	0	12.2	0	9.1	0	13.1	0	13.5	0	17	0	12.4	0	19.7	0	20.1	0	21.4	0	21.8	0	31.2	0	17.6	0	16.2	0	12.3	0	11.9
Pseudothuriammina limnetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.2	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0.5	0	0.6	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f poly.	0	1	0	1.5	0	2.3	0	2.9	0	3.4	0	1.6	0	2.1	0	4.8	0	1.4	0	1.4	0	2.6	0	2	0	4.5	0	1.6	0	3.1	0	3.5	0	2.3	0	5.4
Trochammina ochracea	0	2.5	0	2.8	0	3.4	0	2.3	0	1.1	0	0.5	0	2.1	0	1.6	0	0.7	0	1.2	0	1.4	0	0.6	0	2	0	1.2	0	1	0	0	0	2.3	0	3.8
Centropyxis aculeata	0	0	0	0	0	0.6	0	0.9	0	0	0	0	0	0	0	0	0	0.7	0	0	0	2.3	0	0	0	1.5	0	0	0	0	0	0	0	0.6	0	0

Appendix Table 17- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from surface samples collected at Site 3 and stored in buckets.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	3	4	5	5	2	6	1	6	0	7	2	5	2	7	0	6	0	6
Number of Individuals\10cc's	808	4392	1896	6024	40	5528	128	6176	0	6016	504	5200	336	7224	0	4576	0	4568
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	0	0.2	3.4	2.9	20	1	0	0.4	0	1.6	0	0.2	0	0.3	0	0.5	0	0.4
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0	0	0	0	1	0	0.3	0	0.9	0	1.1	0	0.6	0	0.5	0	0.5
Tiphotrocha comprimata	4	7.1	3.8	6.1	0	1.9	0	1.4	0	3.5	7.9	3.5	4.8	2.4	0	1.9	0	2.3
Trochammina inflata	0	0	5.1	6.8	0	0	0	0	0	0.1	0	0	0	0.1	0	0	0	0
Trochammina macrescens formae macrescens	95	84.3	86.1	70.8	80	90.7	100	94.2	0	90.3	92.1	94.6	95.2	93.8	0	90.7	0	90.2
Centropyxis aculeata	1	8.4	1.7	13.4	0	4.3	0	2.8	0	2.6	0	0.6	0	2.2	0	3.5	0	5.2
Centropyxis constricta	0	0	0	0	0	1.1	0	0.9	0	0.9	0	0	0	0.6	0	2.8	0	1.4

Depth in Core (cm)	Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	1	6	1	6	1	6	1	6	0	6	1	6	0	7
Number of Individuals\10cc's	24	7384	16	6744	40	8136	16	7296	0	6128	24	2400	0	11088
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	0	0.4	0	0.3	0	1.4	0	1.4	0	1	0	0.5	0	0.4
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudothuriammina limnetis	0	0.2	0	0.2	0	1.3	0	1	0	1	0	0.9	0	0.9
Tiphotrocha comprimata	0	1.7	0	1.8	0	1.2	0	1.5	0	2.2	0	2.7	0	2.9
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Trochammina macrescens formae macrescens	100	94.3	100	94.1	100	92.6	100	92.3	0	91.5	100	90.7	0	91.8
Centropyxis aculeata	0	1.8	0	2.3	0	3	0	3.1	0	3.3	0	3.6	0	3
Centropyxis constricta	0	1.5	0	1.3	0	0.5	0	0.7	0	1	0	1.6	0	0.4

Appendix Table 18- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from surface samples collected at Site 1 and stored in bags.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	2	2	7	0	8	2	6	0	8	4	8	2	8	0	6	1	6	0	5
Number of Individuals\10cc's	0	448	10	194	0	156	12	268	0	254	25	205	7	96	0	126	6	156	0	100
Ammobaculites dilatatus	0	0	40	3.1	0	0	0	0	0	0	0	0.5	0	1	0	3.2	0	0	0	0
Eggerella advena	0	0	0	1	0	2.6	0	0	0	2.3	4	2.9	0	1	0	1.6	0	7.7	0	0
Milliammina fusca	0	78.6	60	55.7	0	56.4	83.3	73.9	0	65.4	76	57.6	85.7	49	0	79.4	100	51.3	0	64
Organic linings	0	0	0	16.5	0	9	0	11.2	0	13.4	0	7.8	0	20.8	0	0	0	17.9	0	18
Pseudothurianmina limnetis	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	1.3	0	2.2	0	1.6	0	0	0	0	0	1.6	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0.8	4	1	0	0	0	0	0	3.8	0	2
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	1.5	0	2.1	0	0	0	0	0	0
Trochammina inflata	0	0	0	1	0	0	0	0	0	0	16	0	14.3	2.1	0	0	0	0	0	0
Trochammina macrescens forma macrescens	0	0	0	6.2	0	21.8	16.7	6.7	0	5.5	0	16.1	0	17.7	0	7.9	0	7.7	0	14
Trochammina ochracea	0	21.4	0	16.5	0	6.4	0	5.2	0	10.3	0	7.8	0	6.2	0	6.3	0	11.5	0	2
Centropyxis aculeata	0	0	0	0	0	1.3	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0
Glomopyra gordialis	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0

Depth in Core (cm)	Week 10		Week 11		Week 12		Week 13		Week 14		Week 15	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	7	0	5	0	5	0	5	0	5	0	6
Number of Individuals\10cc's	0	170	0	202	0	164	0	126	0	60	0	156
Ammobaculites dilatatus	0	1.2	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	9.4	0	4	0	3.7	0	1.6	0	1.7	0	7.7
Milliammina fusca	0	62.3	0	39.6	0	40.2	0	44.4	0	83.3	0	59
Organic linings	0	5.9	0	6.9	0	6.1	0	4.8	0	3.3	0	9
Pseudothurianmina limnetis	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0	0	0	0	0	0	1.7	0	0
Textularia earlandi	0	4.7	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macrescens forma macrescens	0	4.7	0	41.6	0	43.9	0	46	0	10	0	6.4
Trochammina ochracea	0	11.8	0	7.9	0	6.1	0	3.2	0	0	0	16.7
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	1.3
Glomopyra gordialis	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 19- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from surface samples collected at Site 2a and stored in bags.

Depth in Core (cm)	Week 0		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	2	5	2	11	2	8	2	9	4	9	2	6	1	4	0	9	1	9
Number of Individuals\10cc's	10	192	24	488	20	334	8	346	50	488	64	840	20	260	0	360	8	370
Ammobaculites dilatatus	60	11.4	50	18	80	23.4	75	24.9	24	23.8	12.5	15.2	0	16.9	0	26.5	0	27.3
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	3.8	0	4.6	0	0	0	0
Eggerella advena	0	0	0	0.4	0	0.6	0	0	0	0.4	0	0	0	0	0	1.1	0	0.5
Elphdium excavatum forma clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	3.1	0	1.6	0	0	0	2.3	36	3.7	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	2.1	0	0.4	0	0	0	0.6	4	0.4	0	0	0	0	0	0	0	0
Miliammina fusca	40	68.8	50	66	20	53.9	25	56.1	36	54.9	87.5	52.4	100	69.2	0	58.9	100	56.8
Organic linings	0	14.6	0	7	0	15.6	0	12.8	0	9.4	0	24.8	0	9.2	0	4.4	0	6.5
Textularia earlandi	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0.6	0	1
Tiphotrocha comprimata	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0
Trochammina macr. f poly.	0	0	0	0.8	0	1.2	0	0	0	2	0	2.8	0	0	0	0.6	0	2.2
Trochammina ochracea	0	0	0	3.3	0	4.2	0	0.6	0	4.9	0	1	0	0	0	7.2	0	4.3
Reophax nana	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scotti	0	0	0	0.4	0	0.6	0	2.3	0	0.4	0	0	0	0	0	0.6	0	1
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G. gordialis	0	0	0	1.6	0	0	0	0.1	0	0	0	0	0	0	0	0.2	0	0.2

Depth in Core (cm)	Week 9		Week 10		Week 11		Week 12		Week 13		Week 14		Week 15	
(live\total)	L	T	L	T	L	T	L	T	L	T	L	T	L	T
Number of Species\10 cc's	0	7	0	9	0	7	0	7	0	6	0	7	0	5
Number of Individuals\10cc's	0	170	0	346	0	208	0	184	0	162	0	170	0	204
Ammobaculites dilatatus	0	18.7	0	17	0	13.5	0	14.1	0	17.3	0	15.3	0	9.8
Ammotium salsum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	1.9	0	2.2	0	2.5	0	0	0	0
Elphdium excavatum forma clavatum	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0
Elphidum williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	62.3	0	71	0	69.2	0	67.4	0	65.4	0	69.4	0	67.6
Organic linings	0	8.2	0	3.5	0	5.8	0	6.5	0	7.4	0	7.1	0	12.7
Textularia earlandi	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0
Trochammina macr. f poly.	0	1.2	0	2.3	0	1.9	0	3.3	0	2.5	0	4.7	0	4.9
Trochammina ochracea	0	8.2	0	3.5	0	6.7	0	5.4	0	4.9	0	0	0	4.9
Reophax nana	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Reophax scotti	0	1.2	0	1	0	0	0	1.1	0	0	0	1.2	0	0
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0
G. gordialis	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0

Appendix Table 20- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from surface samples collected at Site 3 and stored in bags.

Number of weeks	Week 0	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 16	Week 18	Week 21	Week 23	Week 25	Week 27	Week 29
Core Interval (cm)	55-56 cm	56-57 cm	56-57 cm	55.5-56.5 cm	55.5-56.5 cm	55-56 cm	54.5-55.5 cm	57-58 cm	57-58 cm	57-58 cm	57-58 cm	59-59.5 cm	59-60 cm	59-61 cm
Number of Species\10 cc's	4	5	4	4	4	4	4	4	4	4	4	2	3	2
Number of Individuals\10cc's	4926	8256	7424	8080	9136	10768	8464	5104	9520	6496	5776	7200	9184	4800
Milliammina fusca	1.2	0.8	0.9	0.6	0.5	0.3	1.1	0.9	0.7	0.5	0.6	0	0.7	0
Tiphotrocha comprimata	1.4	2.9	2.2	2.8	3.7	4.3	3.4	2.2	0.2	1.5	2.5	1.8	1.7	1.7
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macrescens forma macrescens	94.2	94.4	96.3	96.2	95.1	94.9	93.6	96.2	98.3	96.8	94.7	98.2	97.6	98.3
Trochammina ochracea	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	3.2	1.6	0.6	0.4	0.7	0.4	1.9	0.6	0.8	1.2	2.5	0	0	0

Number of weeks	Week 31	Week 33	Week 35	Week 37	Week 39	Week 41	Week 43	Week 45	Week 47	Week 49	Week 51	Week 53	Week 55	Week 57
Core Interval (cm)	59-60 cm	60-61	60-61 cm	58-61 cm	61-62 cm	61-62 cm	62-63 cm	62-63 cm	63-64 cm	54-55 cm	63-64 cm	64-65 cm	65-66 cm	65-66 cm
Number of Species\10 cc's	3	3	3	3	3	3	2	3	3	3	4	2	2	3
Number of Individuals\10cc's	10400	9632	9456	6016	3776	7680	9200	8864	10496	6272	7600	2720	4128	5712
Milliammina fusca	0	0.2	0.6	0.8	1.3	0.9	0	0.7	2	0.3	0.6	2.4	0	1.1
Tiphotrocha comprimata	0.9	1.5	3	0.5	2.1	2.9	2.1	2	1.7	4.3	0.8	0	1.6	1.1
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macrescens forma macrescens	98.9	98.3	96.4	98.7	96.6	96.2	97.9	97.3	96.3	95.4	98.3	97.6	98.4	97.8
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	0.2	0	0	0	0	0	0	0	0	0	0.3	0	0	0

Number of weeks	Week 59	Week 61	Week 63	Week 65	Week 68	Week 70	Week 74	Week 77	Week 79	Week 81	Week 83	Week 85
Core Interval (cm)	66-67 cm	65-66 cm	66-67 cm	67-68 cm	67-68 cm	67-68 cm	67-68 cm	67-68 cm	65-66 cm	67-68 cm	68-69 cm	65-66 cm
Number of Species\10 cc's	3	3	3	3	3	3	3	3	4	3	3	3
Number of Individuals\10cc's	6800	6896	6512	5264	4320	5024	3856	5424	5840	4750	2784	4096
Milliammina fusca	0.5	0.7	1.2	1.8	0.8	0.3	0.8	0.6	1.1	0.8	0.6	1.9
Tiphotrocha comprimata	1.4	0.7	2	1.5	2.2	1	2.5	1.5	1.1	2.4	4.6	1.6
Trochammina inflata	0	0	0	0	0	0	0	0	0.3	0	0	0
Trochammina macrescens forma macrescens	98.1	98.6	96.8	96.7	97	98.7	96.7	97.9	97.5	96.8	94.8	96.5
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 21- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from interval 60-70 cm in an archived core

Number of weeks	Week 0	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 16	Week 18	Week 21	Week 23	Week 25	Week 27
Core Interval (cm)	180-181 cm	180-181 cm	180-181 cm	179-180 cm	179-180 cm	179-180 cm	179-181 cm	182-183 cm	182-183 cm	183-184 cm	182-183 cm	187-187.5 cm	185-186 cm
Number of Species\10 cc's	5	5	5	5	5	5	5	4	5	5	5	5	5
Number of Individuals\10cc's	2352	2224	3632	3312	2944	2912	2224	7248	6144	5826	8704	3136	6416
Milliammina fusca	0.7	0.7	1.8	1	2.2	0.5	2.9	0.9	2.6	1.1	0.9	2.5	0.3
Tiphotrocha comprimata	14.3	11.5	11	15.5	14.7	15.4	15.1	8.8	5.5	7.9	10.7	12.8	16.7
Trochammina inflata	2	5	2.2	1.9	2.7	0.5	5	2.9	0.5	3.6	2	1.5	2
Trochammina macrescens forma macrescen	81.6	81.3	81.9	78.7	76.6	80.8	74.8	87.4	90.1	86.6	86.2	82.7	80.3
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	1.4	1.4	3.1	2.9	3.8	2.7	2.2	0	1.3	0.8	0.2	0.5	0.7

Number of weeks	Week 29	Week 31	Week 33	Week 35	Week 37	Week 39	Week 41	Week 43	Week 45	Week 47	Week 49	Week 51	Week 53
Core Interval (cm)	182-184 cm	186-187 cm	185-186 cm	188-189 cm	181-183 cm	186-187 cm	188-189 cm	190-191 cm	190-191 cm	191-192 cm	177-178 cm	191-192 cm	186-187 cm
Number of Species\10 cc's	4	4	5	4	3	4	4	4	3	4	4	3	3
Number of Individuals\10cc's	7088	3504	6496	3072	1568	3376	2752	1872	2176	1920	2528	2336	1328
Milliammina fusca	0.7	0	0.3	1.6	1	0.5	1.2	0	0	1.7	0.7	0.6	0
Tiphotrocha comprimata	16	11.9	9.6	16.1	9.2	22.7	29.7	10.2	8.8	11.6	5.7	6.2	20.5
Trochammina inflata	2.5	0.9	1.7	0	0	1.9	0.6	1.7	3.7	1.7	2.5	0	6
Trochammina macrescens forma macrescen	80.8	86.3	88.2	81.8	89.8	74.9	68.5	87.2	87.5	85	91.1	93.2	73.5
Trochammina ochracea	0	0	0	0	0	0	0	0.9	0	0	0	0	0
Centropyxis aculeata	0	0.9	0.2	0.5	0	0	0	0	0	0	0	0	0

Number of weeks	Week 55	Week 57	Week 59	Week 61	Week 63	Week 65	Week 68	Week 70	Week 74	Week 77	Week 79	Week 83	Week 85
Core Interval (cm)	186-187 cm	190-191 cm	190-191 cm	187-188 cm	187-188 cm	189-190 cm	188-189 cm	186-187 cm	186-187 cm	190-191 cm	187-188 cm	190-191 cm	195-196 cm
Number of Species\10 cc's	3	3	3	2	3	3	3	3	3	3	3	2	2
Number of Individuals\10cc's	1152	1456	1584	1584	1648	1216	2240	1552	720	944	1680	496	592
Milliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	6.9	5.5	2	7.1	1.9	6.6	5	8.2	20	3.4	3.8	3.2	5.4
Trochammina inflata	2.8	2.2	2	0	1.9	1.3	2.1	2.1	8.9	1.7	1.9	0	0
Trochammina macrescens forma macrescen	90.3	92.3	96	92.9	96.2	92.1	92.9	89.7	71.1	94.9	94.3	96.8	94.6
Trochammina ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 22- Percent abundance of living (stained, L) and total (T) foraminifera and arcellaceans from interval 175-185 cm in an archived core collected near Site 1 in 1992.

Site 1

	Oct. 96			Jan. 97			Apr. 97			Jun-97			Sept. 97		
Species	T. macrescens	M fusca	P. limnetis	T. macrescnes	M. fusca	C. aculeata	T. macrescens	M. fusca	C. aculeata	T. macrescens	M. fusca	C. aculeata	T. macrescens	M. fusca	C. aculeata
0-1 cm	50.9	3	13.9	86.2	4.7	3.4	92.8	1.7	1.9	92.8	0	2.1	89.6	0.2	6.9
1-7 cm Avg.	71.1	4.3	11.2	87.2	4.1	3.7	87.6	5.3	1.9	89.8	1.3	3.1	91.3	1.3	3.8
SD	11.5	2.8	4.6	2.6	1.2	1.2	2.6	2.3	1.1	4.1	0.9	1.8	1.2	0.8	1
2SD	23	5.6	9.2	5.2	2.4	2.4	5.2	4.6	2.2	8.2	1.8	3.6	2.4	1.6	2

Site 2

	Oct. 96			Jan. 97			Jun-97				Sept. 97			
Species	M. fusca	T. macrescens	T. ochracea	M. fusca	T. macrescens	T. ochracea	M. fusca	T. macrescens	T. ochracea	Organic linings	M. fusca	T. macrescens	T. ochracea	Organic linings
0-1 cm	92.1	3	0	54.8	3.5	3.5	31.6	0	30.4	28.3	45.2	9.1	30.3	9.1
1-10 cm	85.9	6.8	1.9	81.7	5.8	5.9	50.8	5.5	25.4	9.1	77.3	5.6	10.8	3.7
SD	6.5	2.6	2.3	5.8	4.6	3.8	18.9	4	12.1	6	12.9	3.3	6.9	4
2SD	13	5.2	4.6	11.6	9.2	7.6	37.8	8	24.2	12	25.8	6.6	13.8	8

Site 3

	Oct. 96			Jun-97			Sept. 97		
Species	M. fusca	Organic linings	T. ochracea	M. fusca	Organic linings	T. ochracea	M. fusca	Organic linings	T. ochracea
0-1 cm	79	1.3	0.9	56.3	15.5	16	26.7	30.8	23.1
1-10 cm	94.4	1.2	0.9	79.8	9.2	4.7	65	7.7	15.1
SD	1.7	0.6	0.7	16.8	7	7.4	14.5	4.2	5.1
2SD	3.4	1.2	1.4	33.6	14	14.8	29	8.4	10.2

Appendix Table 22a-c – Percent abundance of the surface and average percentages from selected intervals of the most common species identified from sites 1, 2, and 3. The standard deviation is also presented. These results are plotted on a 1:1 graph.

Site Location	Distance (in meters)	% OC	Total PAH's (ng/g DW)	Al (ug/g DW)	Fe (ug/g DW)	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Total PCB's
NBH 105	0	8.7	2,480,000	61869	29905	2088	921	398	281233
NBH 111	312.5	8.7	2,080,000	61033	34825	1804	871	613	346972.3
NBH 120	750	8.8	2,080,000	57264	36815	1809	1331	919	214812.9
NBH 131	1312.5	7.2	1,700,000	48174	31127	1036	1496	982	76561.9
NBH 146	1750	5.3	900,000	39161	24285	565	707	204	16762.7
NBH 154	2062.5	4.7	881,000	38425	20710	339	480	250	11265.8
NBH 204	2875	3.4	456,000	40486	20565	363	647	296	7526.1
NBH 216	3500	2.8	204,000	30174	12384	135	271	131	2451.2
NBH 230	4312.5	2.8	304,000	42996	19772	241	260	128	2302.8
NBH 236	4625	4	553,000	45052	29773	349	373	211	5247.5
NBH 247	5437.2	3	283,000	44707	17392	246	374	122	2260.1
NBH 253	5875	4.4	642,000	40809	22087	348	400	237	4783.5

Appendix Table 23- Heavy metal, PCB, and PAH concentrations from surface samples collected in Transect 1- Upper to Lower Harbor, NBH.

Site Location	Distance of transect (m)	% OC	Total PAH's(ng/g DW)	Al (ug/g DW)	Fe (ug/g DW)	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Total PCB's
AB-1	0	0.8	38800	53877	14304	47	20	34	67.3
AB-2	313	2.5	108000	44040	22262	112	49	61	362.6
AB-3	438	2.7	132000	49063	23454	112	52	64	268.7
AB-4	688	1.8	111000	46225	19595	91	39	54	198.9
AB-5	875	2.2	133000	41304	20603	97	38	57	289.8
NBH 331	2500	1.6	216000	24248	30476	124	38	50	364.5

Appendix Table 24- Heavy metal, PCB, and PAH concentrations from surface samples collected near Apponagasnett Bay, NBH.

Sediment Sample ID	distance	% OC	PAHs (ng/g DW)	total PCBs	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Pb (ug/g DW)	Ni (ug/g DW)
CP-A	1435	2.6	487,000	2,238	292	115	157	74	163
CP-B	1176	1.8	400,000	741	205	55	92	60	25
CP-C	783	0.8	130,000	469	86	23	39	27	8
CP-D	2057	1	79,600	191	176	28	1020	27	391
CP-E	1696	2.3	156,000	519	318	75	197	71	41
CP-F	1957	1.1	472,000	1,380	134	40	64	37	16
CP-G	2478	0.4	39,150	69	80	7	23	19	6
NBH-333	2739		14,700	10	15	7	9	14	62
NBH-335	6391		22,000	13	19	3	8	16	7
NBH-346	5607	0.4	21,500	31	37	4	23	19	7
NBH-324	1043	2.1	406,000	1,379	153	161	122	65	29
NBH-325	2609	1.6	238,000	603	109	51	85	51	19
NBH-304	3522	0.2	46,000	184	32	20	0	22	4
NBH-317	1304	2.5	495,000	1,943	183	83	112	75	21

Sediment Sample ID	Cd (ug/g DW)	Ag (ug/g DW)	As (ug/g DW)	Al (ug/g DW)	Fe (ug/g DW)	Mn (ug/g DW)
CP-A	0.8	115.8	10.2	51,913	30,949	424
CP-B	0.4	2	7.9	35,550	24,608	313
CP-C	0.2	0.7	4.5	17,732	11,433	202
CP-D	0.1	0.6	3.9	17,214	27,772	494
CP-E	0.2	4.6	10.2	23,628	52,724	668
CP-F	0.3	18.6	3.9	12,452	19,933	303
CP-G	0.1	0.2	2	12,121	8,921	194
NBH-333	0.1	0.1	2.2	10,726	5,694	187
NBH-335	0.1	0.8	2.3	10,538	5,402	125
NBH-346	0.1	0.1	3.9	11,230	10,071	222
NBH-324	0.8	2.9	14.5	26,109	30,360	377
NBH-325	0.2	1.4	8	19,688	24,099	340
NBH-304	0.2	0.3	2.4	19,281	6,897	296
NBH-317	0.8	4.4	10.2	26,709	33,253	420

Appendix Table 25- Heavy metal, PCB, and PAH concentrations from surface samples collected near Clark's Point, NBH.

Depth of Core	Pb-210 Date	% OC	% H	PAHs	Sum of PCB's	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Pb (ug/g DW)	Ni (ug/g DW)	Cd (ug/g DW)	Ag (ug/g DW)	Al (ug/g DW)	Fe (ug/g DW)
1	1994	5.67	1	116,000	30443	479	788	473	217	59.9	11.6	3.8	38,988	23,482
2	1990	5.2				467	780	470	218	59.8	10	4.1	28,727	22,895
3	1985	4.84	0.95	3,270,000	54623	558	898	548	244	67.7	13.2	4.2	41,048	25,961
4	1981	5.2				507	787	505	200	59	13.7	4.4	35,910	22,001
5	1977	6.41	0.86	3,300,000	57432	600	812	565	218	69.6	16.5	4.8	35,840	22,343
6	1973	5.2				719	921	643	251	82.3	20.6	4.9	36,786	21,996
7	1969	5.2				818	996	711	267	93.1	27.8	6.6	23,136	20,360
8	1964	5.2		5,040,000	110200	1394	1511	1211	390	138	53	8.4	37,094	27,484
9	1960	6.67				2011	2086	1522	537	191	78	9.7	42,860	32,428
10	1956	5.2		6,250,000	176941	2127	2239	1660	554	187	93	8.6	47,824	32,833
11	1952	5.2		3,930,000	170927	2504	2362	1738	604	190	106	7	46,509	31,321
12	1947	5.2		5,085,000	186051	2099	2010	1536	519	170	82	5.9	39,373	28,402
13	1943	5.2	1.09	2,560,000	133674	1756	1774	1277	450	129	61	3.6	24,048	26,460
14	1939	5.2				985	1085	706	276	72	29	2.3	22,450	17,593
15	1935	4.61	0.5	942,000	58000	802	853	466	232	45	16	5	26,394	15,084
16	1931	5.2				1251	1001	370	321	44	9.1	0.4	15,108	19,642
17	1926	5.2				1011	722	230	240	29	5.4	1.5	18,226	16,448
18	1922	5.2		2,520,000	32061	981	884	273	266	34	8.5	2.5	33,363	18,999
19	1918	5.4	0.52	2,210,000	20262	719	596	160	208	21	3.7	1.4	18,941	16,649
20	1914	5.2				630	419	95	193	13	1.5	6	36,251	16,752
21	1910	5.2	0.57			460	349	70	176	16	1.4	1.4	21,664	19,258
22	1905	5.2		682,000	1485	357	277	62	151	15	1.5	1.1	21,584	19,497
23	1901	5.2				324	208	26	110	12	1.1	1	25,613	13,853
24	1897	2.17				164	94	18	58	7	1	1	15,413	11,398
25	1893	2.01	0.39			109	45	39	30	13	0.8	0.4	24,408	22,284
26	1888	2.17		51,800	41	55	7	43	7	15	1	0.5	31,990	26,044
27	1884	2.17				54.6	7	47	8	15	1.1	0.5	26,258	26,728
28	1880	2.17				61.9	6	58	8	16	1.1	6	38,280	27,622
29	1876	3.05	0.74			50	7	51	8	15	1	7	48,756	25,086
30	1872	2.17				34	6	37	6	6	1	6	43,320	23,035
31	1867	2.17				34	7	41	7	9	1	7	36,781	18,487
32	1863	2.17				44	7	48	6	14	1	7	40,615	21,305
33	1859	2.33	0.5			39	6	41	6	9	1	6	38,562	19,992
34	1855	2.17				39	6	48	7	12	1	6	43,160	20,840
35	1850	2.17		28,600	9	39	6	44	6	10	1	6	36,984	20,586
36	1846	2.17				41	16	54	7	10	2	6	40,489	23,830
37	1842	2.73	0.65			43	16	56	7	11	1	7	46,931	24,232
38	1838	2.17				31	15	47	7	8	1	7	55,816	19,730
39	1834	2.17				33	13	46	7	7	1	6	41,907	20,087
40	1829	2.17				37	14	51	7	9	1	6	44,690	22,831
41	1825	2.17	0.53			35	14	48	6	9	1	6	40,356	21,653
42	1821	2.17		63,600	269	34	14	44	5	8	1	5	40,030	18,937
43	1817	2.17		191,000	6076	140	124	114	32	16	4	5	42,556	21,095

Appendix Table 26- Heavy metal, PCB, and PAH concentrations as well as dates from core 1c052396 collected in the Upper Harbor

Depth of Core	Pb-210 Date	% OC	PAH	Sum of PCB's	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Pb (ug/g DW)	Ni (ug/g DW)	Cd (ug/g DW)	Ag (ug/g DW)	As (ug/g DW)	Al (ug/g DW)	Fe (ug/g DW)
1	1994	6.9	2,110,000	45457.1	772	1132	670	318	79	3.8	4.7	10.7	47,648	30,702
2	1990				710	1111	645	305	72	2.7	4.4	10.7	47,059	29,640
3	1985	7.2	2,000,000	41209.3										
4	1981													
5	1977	7.1			700	1057	628	294	63	6.7	4.7	9.6	37,596	26,118
6	1973		2,260,000	48838.6	762	1095	623	290	65	8.6	5.9	10.6	40,115	26,323
7	1969	6.8			779	1170	675	305	69	8.2	4.9	10.6	38,196	26,673
8	1961													
9	1960	6.5			959	1329	794	330	84	10.8	5	10.5	37,747	26,046
10	1956													
11	1952													
12	1947													
13	1943	7.6												
14	1939													
15	1935													
16	1931	8.6	3,420,000	141511.3	1568	1842	637	534	64	7.7	3.2	15.8	37,201	24,448
17	1926													
18	1922													
19	1918													
20	1914													
21	1910	9			1643	1337	265	426	29	3	2.5	14.6	31,862	20,871
22	1905													
23	1901													
24	1897													
25	1893	8.2	1,180,000	2342.5	975	775	109	341	17	0.7	1	11.9	25,207	25,941
26	1888				887	769	83	337	15	0.9	1	12	28,463	26,573
27	1884													
28	1880													
29	1876													
30	1872	6.5			354	338	69	227	4	0.8	1	10.3	33,248	26,264
31	1867		775,000	688.919										
32	1863													
33	1859				139	113	43	78	4	0.3	0.4	7.9	30,614	21,673
34	1855	3.1	120,000	33.374	100	71	47	60	4	0.3	0.3	7.6	32,312	22,799
35	1850													
36	1846				84	57	45	44	4	0.3	0.2	7.2	25,726	22,909
37	1842	2.5	82,400	34.6905	71	43	38	25	4	0.2	0.3	5.8	28,877	19,723
38	1838													
39	1834													
40	1829													
41	1825													
42	1821	2.4			53	18	44	7	12	0.2	0	6.1	27,886	23,516
43	1817													
44	1812													
45	1808													
46	1804	2.7			57	19	44	7	4	0.2	0.1	7.1	31,738	25,505
47	1800													
48	1796													
49	1791				54	17	45	6	12	0.3	0.1	6.3	31,237	24,516
50	1787	2.4	15,600	144.4707	54	18	48	7	8	0.2	0.1	7.6	30,025	26,050

Appendix Table 27- Heavy metal, PCB, and PAH concentrations as well as dates from core 1c102596 collected in the Upper Harbor.

Depth of Core	Pb-210 Date	% OC	PAH	Sum of PCB's	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Pb (ug/g DW)	Ni (ug/g DW)	Cd (ug/g DW)	Al (ug/g DW)	Fe (ug/g DW)	Mn (ug/g DW)
1	1996	6.7	287,000	25.639	606	1023	486	281	64	0.7	52,070	33,368	327
2	1996				688	1167	553	308	73	3.1	53,800	38,191	355
3	1995												
4	1995												
5	1995	6.2			628	1071	494	285	63	1.8	53,474	34,480	345
6	1994												
7	1994	6	1,990,000	596.311	627	963	480	283	64	1.7	53,524	32,364	346
8	1993												
9	1993												
10	1992												
11	1992	5.9			691	1078	515	315	64	2	53,963	38,114	390
12	1991												
13	1990												
14	1989	6	4,370,000	665.038	688	1047	497	299	65	1.9	52,938	35,519	366
15	1988												
16	1988	6.1			769	1079	533	305	73	1.7	51,484	36,098	372
17	1987												
18	1986												
19	1985												
20	1984	6.5	2,170,000	636.148	937	1304	593	373	82	2.6	57,150	37,370	395
21	1983												
22	1982				913	1270	582	370	86	0.1	52,414	35,843	371
23	1981	6.4			917	1288	598	356	89	3.4	55,696	36,203	380
24	1980												
25	1979												
26	1978												
27	1977												
28	1975												
29	1974	6.3	1,660,000	682.929	969	1403	645	365	103	2.7	51,076	34,546	360
30	1973												
31	1972												
32	1971	6.5											
33	1970												
34	1968												
35	1967												
36	1966	6.6	3,390,000	988.263	1142	1441	804	429	150	3.5	53,022	36,000	369
37	1965												
38	1963												
39	1962												
40	1960	3.8			776	1232	699	341	101	2.9	46,997	28,884	308
41	1959	3.8	2,450,000	33120.805									
42	1957												
43	1956												
44	1955												
45	1953												
46	1952	4	59,900,000	16206.48	528	1448	925	256	76	1.6	53,013	31,026	373
47	1951				438	1217	789	193	57	0.9	51,647	30,060	370
48	1949												
49	1948	2	119,000	1036.89	164	101	129	57	38	0	60,364	36,892	482
50	1946												
51	1945												
52	1944												
53	1942												
54	1941												
55	1940	1.4			2	6	3	6	4	0	533	169	2
56	1938												
57	1937												
58	1935	1.7	254,000	45.285	83	72	41	34	15	0.1	36,248	19,617	286

Appendix Table 28- Heavy metal, PCB, and PAH concentrations as well as dates from core 2c101896 collected in the Lower Harbor.

Depth of Core	Pb-210	%OC	PAHs	PCBs	Zn	Cu	Cr	Pb	Ni	Cd	Ag	Al	Fe	Mn
0	#REF!	8.89	2980000	17600.1	631	2053	196	183	86.4	4.23	5.4	36618	39010	351
1	#REF!	8.3	534000	17144.5	620	1605	545	363	51.5	2.8	2.4	35530	36901	360
3	#REF!				576	1471	400	327	45.6	3.18	1.86	52751	36170	343
5	#REF!	7.92	1690000	2496.35	440	1015	115	170	35.1	0.94	1.57	26674	32583	328
6	#REF!	7.8	493000	2105.42	418	938	130	367	31.7	1.08	1.68	46318	35515	354
8	#REF!	6.9	438000	633.5										
10	#REF!	5.74	1310000	100.367	285	490	65	345	49	0.78	1.75	49723	35438	370
11	#REF!	5.3	264000	31.482										
13	#REF!	3.09			233	288	77	282	25.7	0.63	1.69	37813	33464	373
15	#REF!		392000	14.446	200	145	95	140	25.3	0.71	1.36	30303	31329	342
16	#REF!	3.2	54200	176.468	210	83	68	181	23.5	1.61	1.29	57694	35116	365
18	#REF!													
20	#REF!	2.41	133000	8.837	161	73	79	104	26.1	0.52	0.76	51298	32172	332
21	#REF!	3.5			163	46	62	119	22.8	1.28	0.79	49910	34879	367
23	#REF!													
25	#REF!	2.41	74100	139.185	159	48	74	97	23.6	0.7	0.59	42345	34032	369
26	#REF!				152	38	55	84	21.9	0.6	0.59	57019	33201	353
28	#REF!	2.9												
30	#REF!	2.08	38700	2.1109	94	69	65	69	23	0.35	0.21	45801	26338	260
31	#REF!													
33	#REF!													
35	#REF!	2.14	28700	5.6185	67	63	67	53	25.1	0.22	0.14	30840	30176	325
36	#REF!													
38	#REF!													
40	#REF!	2.06	25300	3.8973	62	43	62	38	22.4	0.31	0.12	35061	28837	302
41	#REF!													
43	#REF!													
45	#REF!													
47	#REF!													
49	#REF!													
50	#REF!	1.96	22500	3.209	65	35	64	36	22.5	0.28	0.12	28246	30731	331
51	#REF!													
53	#REF!				63	25	61	28	24	0.36	0.1	28695	29538	338
55	#REF!													
57	#REF!				68	17	61	25	24.6	0.37	0.12	26468	29586	315
59	#REF!													
60	#REF!	1.7												
61	#REF!				59	14	58	21	26.1	0.43	0.08	18728	28506	318
63	#REF!													
65	#REF!				67	17	67	23	25	0.48	0.1	35145	32196	332
67	#REF!													
69	#REF!													
70	#REF!	1.81												
71	#REF!				64	20	66	21	24.5	0.49	0.1	36320	31513	328
73	#REF!													
75	#REF!				61	27	63	21	24.9	0.39	0.09	39286	31767	326
77	#REF!													
79	#REF!													
80	#REF!	1.62												
81	#REF!				61	21	63	20	24	0.38	0.11	31395	31019	317
83	#REF!													
85	#REF!				64	16	69	22	23	0.78	0.1	34945	32436	339
87	#REF!													
89	#REF!													
90	#REF!	1.68												
91	#REF!				55	29	59	19	21.7	0.37	0.07	39992	29672	302
93	#REF!													
95	#REF!				53	12	54	19	21.4	0.32	0.07	20750	27073	298
97	#REF!													
99	#REF!													
100	#REF!	1.87												
101	#REF!				65	49	58	27	19.5	0.42	0.14	16031	27405	306
103	#REF!													
107	#REF!													
109	#REF!													
110	#REF!													
111	#REF!													
113	#REF!													
115	#REF!													
117	#REF!													
119	#REF!													
120	#REF!	1.59			62	0	61	20	14.3	0.29	0.07	32367	30031	331
121	#REF!													
123	#REF!													
125	#REF!													
127	#REF!													
129	#REF!													
130	#REF!													

Appendix Table 29- Heavy metal, PCB, and PAH concentrations as well as dates from core 5c061098 collected in the Lower Harbor.

Depth of Core	Pb-210	%OC	PAHs	PCBs	Zn	Cu	Cr	Pb	Ni	Cd	Ag	Al	Fe	Mn
131	#REF!													
133	#REF!													
135	#REF!													
137	#REF!													
139	#REF!													
140	#REF!	1.72			66	0	59	20	19.6	0.27	0.09	32966	32298	342
141	#REF!													
143	#REF!													
145	#REF!													
147	#REF!													
149	#REF!													
150	#REF!													
151	#REF!													
153	#REF!													
155	#REF!													
157	#REF!													
159	#REF!													
160	#REF!	1.59			54	0	52	17	13.4	0.53	0.06	10723	23057	246
161	#REF!													
163	#REF!													
165	#REF!													
167	#REF!													
169	#REF!													
170	#REF!													
171	#REF!													
173	#REF!													
175	#REF!													
177	#REF!													
179	#REF!													
180	#REF!	1.45			64	0	55	19	11.8	0.63	0.09	26928	29242	343
181	#REF!													
183	#REF!													
185	#REF!													
187	#REF!													
189	#REF!													
190	#REF!													
191	#REF!													
193	#REF!													
195	#REF!													
197	#REF!													
199	#REF!													
200	#REF!	1.58												
201	#REF!													
203	#REF!													
205	#REF!													
207	#REF!													
209	#REF!													
210	#REF!				43	0	42	15	10.3	0.44	0.05	2396	16532	196
211	#REF!													
213	#REF!													
215	#REF!													

Appendix 29- continued

Depth of Core	Pb-210 dates	% OC	PAHs	PCB's	Zn	Cu	Cr	Pb	Ni	Cd	Ag	Al	Fe	Mn
0	#REF!	7.6	752000	6387	424	425	207	155	56.8	3.74	3.26	34430	30415	305
4	#REF!		604000	6544.46	438	447	204	181	39.9	3.43	3.4	38301	30514	303
8	#REF!	5.9	855500	6102.01	421	421	210	155	35.2	2.64	3.28	26115	28965	306
18	#REF!	6.5	357000000	6328.18	422	501	255	184	43.9	3.67	4.35	32332	30595	301
20	#REF!				426	503	245	195	40.9	2.9	4.49	31832	31279	313
22	#REF!	6	406000000	5236.92	445	569	280	206	42.9	2.88	4.85	29786	33150	330
26	#REF!	5.2	238000000	8527.64	459	571	278	206	49.1	3.46	4.92	33806	32442	310
30	#REF!	6.1	328000000	10628.75	500	663	326	239	62.6	4.82	5.65	30708	34764	331
34	#REF!		168000000	11456.45	490	752	468	252	60.6	5.52	7.07	33727	31627	327
38	#REF!	4.2	1040000	12125.23	429	806	463	254	54	5.86	7.19	31666	31485	319
56	#REF!	4.4			509	1019	599	176	52	6.46	1.37	32907	30789	329
74	#REF!	7.5	602000	24087.45	633	1238	555	259	47.3	4.55	1.49	21371	32343	357
88	#REF!				501	503	195	178	28.3	2.14	1.26	33018	20618	248
106	#REF!				339	498	155	155	26.1	1.39	1.36	25630	25840	294
128	#REF!	3.3	75200000	3965.98	135	193	39	64	13.8	0.26	0.51	19048	16737	226

Appendix Table 30- Heavy metal, PCB, and PAH concentrations as well as dates from core 1c061098 collected near the hurricane barrier, NBH.

Depth of Core	Pb-210 Date	% OC	PAHs	Sum of PCB's	Zn (ug/g DW)	Cu (ug/g DW)	Cr (ug/g DW)	Pb (ug/g DW)	Ni (ug/g DW)	Cd (ug/g DW)	Ag (ug/g DW)
1	1996	2.5	367,000	1716.03	169	139	133	65	14	2.8	7
2	1995										
3	1995										
4	1995										
5	1994	2.3	449,000	2206.6	238	167	158	69	17	3.4	6
6	1994										
7	1994										
8	1993										
9	1993	2	371,000	2389.34	161	165	133	52	19	3.4	5
10	1993										
11	1992										
12	1992										
13	1991	2.2	332,000	2418.81	194	179	147	66	19	3.6	6
14	1991										
15	1991										
16	1990										
17	1990	1.9	239,000	1869.01	148	136	121	50	18	2.4	5
18	1990										
19	1989										
20	1989										
21	1988	2	150,000	734.97	80	47	88	31	13	1.1	5
22	1988										
24	1987										
25	1987										
26	1987	2.1	124,000	758.66	99	54	105	38	22	0.8	7
27	1986										
28	1986										
29	1986										
30	1985	2.9	387,000	3431.95	180	173	141	92	24	1	5
31	1985										
32	1984										
33	1984										
34.5	1984	2.9	206,000	2246.7	158	121	139	76	24	1	7
36	1983										
37	1983										
38	1982										
39	1982	3.5	237,000	2032.87	123	85	133	63	24	1.1	7
40.5	1981										
42	1981										
43	1980										
44	1980	3.2	123,000	234.7	84	11	97	11	24	0	6
45	1980										
46	1979										
47	1979										
48	1979	3.3	79,900	46.13	69	8	118	9	24	1.3	8
49	1978										
50	1978										
51	1977										
52	1977	3.3	107,000	139.68	82	6	98	8	25	0.9	6
53	1977										
54	1976										
55	1976										
56	1976	3.2	69,400	66.57	77	7	108	7	25	1	7
57	1975										
58	1975										
59	1975										
60	1974	2.9	72,900	115.01	85	7	117	7	26	1.1	7
61	1974										
62	1973	4.9	245,000	10555.45	251	383	171	102	11	0.8	0.6
65	1972	4.9	434,000	15835.16	274	470	212	136	12	0.8	0.8
68	1971	5.1	998,000	12882.1	268	430	212	123	25	2.9	6
71	1970	5.9	265,000	13263.76	284	422	181	119	13	0.7	0.7
74	1969	4.6	224,000	6264.52	231	289	108	116	10	0.4	0.6
75	1969										
76	1968	3.3	829,000	642.22	210	221	99	125	20	0.8	5
77	1968										
78	1968										
79	1967										
80	1967	3.7	830,000	522.4	261	277	120	136	25	0.9	6
81	1966										
82	1966										
83	1966										
84	1965	3.4	711,000	464.55	255	273	121	137	23	0.9	6
85	1965										
86	1965										
87	1964										
88	1964	3.7	777,000	405.96	299	321	130	171	31	1.3	6
89	1964										
90	1963										
91	1963										
92	1962	4.2	878,000	438.04	301	333	129	184	29	0.9	6
93	1962										
95	1961										
97	1961										
99	1960	4.2	1,080,000	1281.87	341	372	148	175	28	1.1	7
101	1959										
103	1958										
105	1958										

Appendix Table 31- Heavy metal, PCB, and PAH concentrations as well as dates from core 1c101896 collected near the hurricane barrier, NBH.

Depth of Core	As (ug/g DW)	Al (ug/g DW)	Fe (ug/g DW)	Mn (ug/g DW)
1	35	40,741	17,504	298
2				
3				
4				
5	31	41,111	17,444	304
6				
7				
8				
9	23	45,363	19,152	315
10				
11				
12				
13	28	47,965	23,506	354
14				
15				
16				
17	23	47,842	24,670	376
18				
19				
20				
21	27	50,367	25,601	377
22				
24				
25				
26	27	65,143	38,535	529
27				
28				
29				
30	33	52,219	36,114	455
31				
32				
33				
34.5	34	49,265	38,896	461
36				
37				
38				
39	37	55,720	39,127	471
40.5				
42				
43				
44	28	61,966	39,258	458
45				
46				
47				
48	42	55,090	39,784	448
49				
50				
51				
52	30	69,388	40,553	459
53				
54				
55				
56	33	57,571	43,851	479
57				
58				
59				
60	35	60,205	46,113	512
61				
62	8.6	50,930	22,609	291
65	9.5	44,591	22,364	285
68	29	48,190	21,366	284
71	9.5	45,470	21,957	293
74	9.7	44,796	24,196	306
75				
76	26	52,446	29,462	360
77				
78				
79				
80	30	59,819	33,286	394
81				
82				
83				
84	31	53,016	33,594	400
85				
86				
87				
88	28	55,857	38,506	475
89				
90				
91				
92	30	41,523	34,971	425
93				
95				
97				
99	37	63,303	39,904	445
101				
103				
105				

Appendix Table 31- continued

Depth of core	Pb-210 Date	% OC	PAH	Sum of PCB's	Zn (ug/g)	Cu (ug/g)	Cr (ug/g)	Pb (ug/g)	Ni (ug/g)	Al (ug/g)	Fe (ug/g)	Mn (ug/g)
1	1993	2.5	169,000	20.2345	112	55	62	26	8	37,080	21,915	297
2	1990											
3	1988											
4	1985											
5	1981	2.5	156,000	29.337	112	49	54	32	8	34,099	20,527	292
6	1976											
7	1970	2.6			.109	49	55	27	8	28,479	20,817	291
8	1966		260,000	45.5006	151	65	73	48	17	43,229	26,551	359
9	1964											
10	1963	2.8			168	53	61	46	16	43,556	28,929	362
11	1960				147	48	57	40	8	44,714	27,747	359
12	1956	2.8	150,000	15.548	136	59	57	35	5	49,794	23,592	334
13	1951											
14	1946	2.4			139	50	59	40	26	55,694	23,039	346
15	1941											
16	1937		129,000	0	168	49	62	61	10	52,487	29,745	335
17	1933											
18	1928	3.1	109,000	0	153	44	66	37	16	49,404	30,594	345
19	1924											
20	1920	3.3	146,000	0	156	47	67	51	12	46,677	31,407	339
21	1915											
22	1911											
23	1907	2.2	89,100	0	132	34	54	42	15	40,387	26,670	346
24	1902											
25	1898				127	33	53	39	5	40,241	26,067	361
26	1894											
27	1889	2.1			133	21	24	53	18	32,360	25,843	377
28	1885											
29	1880											
30	1876				149	14	50	53	20	31438	37813	479
31	1872	2.1	88300	5.3098								
32	1867				120	13	38	52	15	36296	31793	418
33	1863				118	10	39	46	13	34803	30793	425
34	1859				126	10	52	40	13	32186	36752	501
35	1854	1.7										
36	1850											
37	1846											
38	1841				84	7	39	29	14	34577	31437	409
39	1837	1.6										
40	1833											
41	1828											
42	1824											
43	1820	1.7	38400	1.744	84	6	23	30	13	35518	23699	367
44	1815											
45	1811											
46	1807				78	5	43	22	15	31771	33854	463
47	1802	1.5										
48	1798											
49	1794											
50	1789											
51	1785	1.7										
52	1780											
53	1776				67	7	39	20	15	37726	30155	377
54	1772				82	4	43	21	15	32172	34349	459
55	1767	1.9	40600	3.0579								
56	1763				81	6	54	21	16	17037	36252	459
57	1759											
58	1754											
59	1750	1.9			85	4	66	18	13	26789	40267	530
60	1746											
61	1741											
62	1737											
63	1733	1.9										
64	1728											
65	1724											
66	1720				66	3	33	15	15	20413	29783	384
67	1715	2.1			61	8	40	15	16	27902	29343	379
68	1711				71	1	52	18	81	22272	31798	435
69	1707											
70	1702				62	7	29	16	32	26027	27491	454
71	1698	2.1										
72	1694											
73	1689											
74	1685				72	7	44	21	21	31826	33148	445
75	1680	2.2	25500	0.9136								
76	1676											
77	1672				93	6	67	22	18	33374	43525	555

Appendix Table 32- Heavy metal, PCB, and PAH concentrations as well as dates from core 1c101396 collected near Apponoganstett Bay, NBH.

Site Location	NBH 105	NBH 111	NBH 120	NBH 131	NBH 146	NBH 154	NBH 204	NBH 216	NBH 230	NBH 236	NBH 247	NBH 253
Water Depth (in meters)	1.2	1.5	1.8	2.1	4.6	7.3	4	2.4	3.4	9.8	3	5
Distance (in meters)	0	312.5	750	1312.5	1750	2062.5	2875	3500	4312.5	4625	5437.2	5875
Number of Species\10cc's	5	7	4	7	5	6	7	9	8	8	9	9
Number of Individuals\10cc's	320	90	560	946	104	240	232	2968	1003	391	3088	1176
Ammobaculites dilatatus	84	27.3	12.9	3.4	7.7	6.7	10.3	0.3	3.2	0	0.3	1.4
Ammonia beccarii	0	0	7.1	23.6	15.4	23.4	41.4	29.1	19.4	20.5	12.7	9.2
Brizalina lowmani	0	0	0	0	0	0	0	0.3	0	0	0	0
Bucella fridgida	0	0	0	0	7.7	0	6.9	0	0	0	7.8	0
Buliminella elegantissima	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0.8	0	0
Elphidium excavatum f. clavatum	0	0	0	0	23	0	3.5	7	28.7	8.2	1.8	0
Elphidium exc. f. excavatum	0	0	0	0	0	0	0	5.4	11.2	0.5	4.9	0
Elphdium exc. f. selseyensis	0	0	0	0	0	0	0	1.3	6.4	0	7.8	1.7
Elphdium poeyanum	0	0	0	0	0	3.3	0	2.7	0	0	2	3.4
Haynesina depressulum	0	0	0	0	0	0	0	0	0	0	0	0
H. orbiculare	0	9.1	75.7	60.6	46.2	60	24.1	53.4	29.5	59.3	62.4	79.3
Miliammina fusca	0	0	0	1.7	0	0	6.9	0	0	2	0	0.3
Organic linings	0	0	0	0	0	0	0	0	0	8.2	0	1
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0
Saccammina atlantica	0.5	0	0	0	0	0	0	0	0	0	0	0
Spiroplectammina biformis	0.5	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	27.3	0	1.7	0	3.3	6.9	0.5	0	0	0.3	2.7
Tiphotrocha comprimata	2.5	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	8	0	0.5	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	12.5	27.3	4.3	8.5	0	3.3	0	0	1.1	0.5	0	1
T. ochracea	0	0	0	0	0	0	0	0	0.5	0	0	0
Difflugia oblonga	0	0.5	0	0	0	0	0	0	0	0	0	0
Difflugia proteiformis	0	0.5	0	0	0	0	0	0	0	0	0	0

Appendix Table 33- Foraminiferal distributions of Transect 1 from Upper to Lower Harbor, NBH.

Site Location	AB-1	AB-2	AB-3	AB-4	AB-5	331
Distance of transect (m)	0	313	438	688	875	2500
Number of Species\10cc's	5	11	12	11	8	7
Number of Individuals\10cc's	80	2328	816	1688	312	648
Ammobaculites dilatatus	20	32	19.6	5.7	0	3.7
Ammonia beccarii	0	2.1	2.9	10	10.3	0
Brizalina lowmani	0	0	0	0	0	0
Buccella frigida	0	0.7	5.9	8.5	0	0
Buliminella elegantissima	0	0	0	0.5	0	0
Eggerella advena	0	0	0	0.5	5.1	0.6
Elphidium excavatum f. clavatum	0	47.8	21.6	12.8	0	0
Elphidium excavatum f. excavatum	0	5.2	3.9	2.8	0	0
Elphidium excavatum f. selseyensis	0	0	0	0	0	0
Elphidium williamsoni	0	0	2.9	0	0	0
Elphidum spp. (total)	0	53	28.4	15.6	0	0
Haynesina depressulum	0	0.3	0	0	0	0
H. orbiculare	10	5.8	27.5	40.8	15.4	0
Miliammina fusca	20	0	6.9	0	0	0
Organic linings	40	4.1	2.9	1.9	28.2	92.6
Reophax nana	0	0	0	0	2.6	0.6
Saccammina atlantica	0	0	0	0	0	0
Spiroplectammina biformis	0	0	0	0	0	0
Textularia earlandi	0	0.3	2.9	11.3	25.6	0
Tiphotrocha comprimata	0	0	0	0	0	0.6
Trochammina inflata	10	0	0	0	0	0
T. macrescens f. polystoma	0	0.3	2	0	5.1	1.2
T. ochracea	0	1.4	1	5.2	7.7	0.6

Appendix Table 34- Foraminiferal distributions from surface samples collected near Apponagansett Bay, New Bedford Harbor.

Station	CPA	CPB	CPC	CPD	CPE	CPF	CPG	NBH325	NBH333	NBH304	NBH317	NBH346	NBH324
# of Species	13	13	7	8	7	4	10	4	3	8	13	8	2
# of Individuals	944	480	236	612	320	52	1048	212	48	160	1488	440	256
Ammobaculites dilatatus	0.8	0	1.7	0	7.5	15.4	0	3.8	0	15	1.3	0	3.1
Ammonia beccarii	1.7	13.3	15.3	23.5	0	0	38.2	0	50	22.5	1.3	25.5	0
Buccella frigida	3.4	4.2	0	2.6	0	0	1.5	0	0	7.5	1.3	7.3	0
Eggerella advena	0.8	0	0	0	0	0	1.5	1.9	0	0	0	10.9	0
Elphidium exclavatum forma clavatum	22	30.8	1.7	26.1	8.8	0	22.1	0	33.3	30	48.4	23.6	0
E. exclav. f. exclavatum	15.3	15	0	13.1	0	0	3	0	0	5	18	3.6	0
E. exclav. f. selseyensis	11	1.7	3.4	0	0	0	0	0	0	0	0	0	0
E. poeyanum	22	1.7	1.7	17	0	0	12.2	0	16.7	2.5	11.8	23.6	0
E. williamsoni	4.2	15.8	0	0.7	0	0	3.8	0	0	0	1.3	0	0
Haynesina orbiculare	8.5	8.3	0	16.3	0	0	8.4	0	0	7.5	7.3	3.6	0
Milliammina fusca	0	0.8	0	0	2.5	0	0	0	0	0	0	0	0
Organic linings	4.2	0	74.6	0.7	70	69.2	8.4	92.5	0	10	6.7	1.8	96.9
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	1.7	0	3.8	0	0.8	0	0	0	0.5	0	0
Textularia earlandi	4.2	1.7	0	0	0	7.7	0	0	0	0	1.1	0	0
Trochammina comprimata	0.8	1.7	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina macrescens	0	2.5	0	0	6.3	0	0	1.9	0	0	1.1	0	0
Trochammina ochracea	0	2.5	0	0	1.2	7.7	0	0	0	0	1.1	0	0

Appendix Table 35- Foraminiferal distributions from surface samples collected near Clark's Point, NBH.

Depth of Core (cm)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
Number of Species	8	6	4	6	6	7	4	4	6	6	6	9	6	8	9	7	6	5	8	6	8	7
Number of Individuals	233	252	136	132	190	132	115	136	181	135	178	278	234	289	325	258	252	295	205	276	185	132
Ammobaculites dilatatus	23	23.1	29.4	21.2	12.3	7.7	11.4	14.7	4	11.1	10.1	15.8	37.1	34.6	32.6	29.4	37.3	34.6	24.4	15.6	8.6	9.1
Ammonia beccarii	3.4	12.3	0	6.2	0	3	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0
Ammotium salsum	12.8	15.8	11	9.1	7.9	4.5	10.4	5.3	1.7	4.4	16.8	13.6	25.6	23.8	29.8	26.3	28.9	28.1	28.8	23.9	24.3	30.3
Fursenkoina fusiformis	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides manilaensis	0	0	0	0	0	0	0	0	4.4	15.5	0	2.1	0	0.6	0.4	1.1	1.2	0	1.5	0	2.3	0
Haynesina orbiculare	2.6	2	0	0	0	0	0	0	0	0	0	15.1	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0.8	2.3	1	1.2	0.6	0	0	0	0	3.8	4.5
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0.5	0	0	0	0.4	0	2.2	1.7
Textularia earlandi	2.1	0	0	1.5	0	0	0	0	0	0	1.6	0	2.2	0	1.2	5	1.2	2.4	1.5	1.1	0	0
Tiphotrocha comprimata	2.1	0	0	0	4.2	1.5	0	0	2.7	0.9	1.4	3.6	0	2.4	1.2	0	0	0	1.5	0.4	1.6	3
Trochammina inflata	46.3	37.7	46.3	54.5	47.3	66.7	56.5	67.6	72.9	60	64.6	40.3	24.3	29	28.6	24.4	25	29.8	30.7	43.1	40	34.8
T. macrescens	7.7	9.1	13.3	7.5	26.8	15.1	21.7	12.4	14.3	8.1	5.5	7.9	8.5	7.2	4.5	13.2	6.4	5.1	11.2	16.9	17.2	16.6

Appendix Table 36- Foraminiferal distributions from Core 1c052396 collected in the Upper Harbor.

Depth of Core (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Number of Species\10cc's	6	7	6	5	4	8	6	7	4	6	5	4	6	5	2	3	3	3	2	4	3	3	3	4	3
Number of Individuals\10cc's	367	555	490	73	68	470	188	364	56	223	100	107	28	66	35	68	36	113	45	32	24	45	23	140	23
Ammobaculites dilataus	12.8	10.8	9.1	45.2	47.1	8.5	14.9	6.6	42.9	17.9	40	49.5	28.5	54.5	0	8.8	22.2	41.6	55.6	25	33.3	33.4	47.8	80	43.5
Ammonia beccarii	29.2	33.6	28.6	15.1	0	57.4	70.1	46.2	0	35.9	12	18.7	14.3	0	0	0	0	0	0	0	0	0	0	0	0
Bucella frigida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. F. excavatum	3.5	3.6	5.1	0	0	5.3	4.3	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium poeyanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	47.1	48.1	53.1	9.6	0	21.3	4.3	39.5	0	13	0	6.5	0	6.1	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	0	1.3	0	0	5.9	3.2	0	0	0	7.6	0	0	14.3	0	0	0	0	0	0	12.5	0	0	43.1	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	5.5	0	0	9.6	23.5	1.1	4.3	2.2	28.5	7.6	16	25.3	14.3	13.6	0	0	0	0	0	0	0	0	0	2.9	13
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	1.3	1	0	0	2.1	0	0	14.3	0	12	0	14.3	6.1	42.9	16.2	11.1	29.2	0	50	16.7	22.2	0	5.7	0
T. macrescens f. polystoma	1.9	1.3	3.1	20.5	0	1.1	2.1	3.3	14.3	17.9	20	0	14.3	19.7	57.1	75	66.7	29.2	44.4	12.5	50	44.4	39.1	11.4	43.5

Depth of Core (cm)	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Number of Species\10cc's	6	4	4	4	6	4	5	9	12	6	3	2	3	4	4	3	4	3	4	4	2	2	2	2	1
Number of Individuals\10cc's	58	33	94	128	360	120	82	208	201	88	53	55	50	36	91	40	52	44	84	80	31	24	36	20	17
Ammobaculites dilataus	50	54.5	24.5	18.8	11.1	13.3	73.2	33.7	28.8	73.9	62.3	72.7	60	55.6	62.6	72.5	61.5	70.5	71.4	56.3	71	83.3	91.7	80	100
Ammonia beccarii	0	0	0	0	0	0	0	7.2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella frigida	0	0	0	0	0	0	0	8.6	6	0	0	0	0	0	6.6	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	0	0	0	0	0	8.6	21.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. F. excavatum	0	0	0	0	0	0	0	25.7	21.4	0	0	0	0	0	12.1	0	0	0	0	0	0	0	0	0	0
Elphidium poeyanum	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	5.2	0	0	0	0	0	0	10.6	8.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	0	18	34.4	34.7	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	0	0	0	0	0	0	0	1.4	0	4.5	0	0	30	11.1	0	0	0	0	4.8	12.5	0	0	8.3	0	0
Reophax nana	0	0	0	0	0	0	3.7	0	1.5	4.5	5.6	0	0	0	0	0	7.7	0	0	0	0	0	0	0	0
Textularia earlandi	5.2	12.1	0	0	2.8	6.7	15.8	1.4	3	8	32.1	27.3	0	11.1	18.7	17.5	7.7	9	9.5	6.2	29	16.7	0	20	0
Tiphotrocha comprimata	5.2	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	19	12.1	33	9.3	26.4	0	3.7	2.8	1.5	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	15.5	21.3	24.5	37.5	23.6	40	3.7	0	1.5	4.5	0	0	10	22.2	0	10	23.1	20.5	14.3	25	0	0	0	0	0

Appendix Table 37- Foraminiferal distributions from Core 1c102596 collected in the Upper Harbor

Depth of Core (cm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Number of Species\10cc's	2	2	4	3	3	3	3	3	3	3	2	3	3	1	1	2	2	2	2
Number of Individuals\10cc's	15	40	45	40	30	32	28	42	43	9	4	36	24	5	6	13	8	16	8
Ammobaculites dilataus	33.3	0	22.2	0	16.7	50	71.4	40.5	39.6	33.3	50	30.6	29.2	100	100	30.8	50	50	50
Organic linings	0	0	0	12.5	0	0	0	0	0	33.4	0	0	0	0	0	0	0	0	0
Textularia earlandi	66.7	82.5	33.3	50	33.3	25	14.3	33.3	30.2	33.3	50	30.6	16.6	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	11.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	0	17.5	33.3	37.5	50	25	14.3	26.2	30.2	0	0	38.8	54.2	0	0	69.2	50	50	50

Depth of Core (cm)	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Number of Species\10cc's	1	2	2	2	2	1	1	2	1	1	1	1	2	2	2	1	1	1	3	2
Number of Individuals\10cc's	5	10	20	15	10	4	13	14	6	4	7	4	10	4	8	7	4	5	16	8
Ammobaculites dilataus	0	50	25	33.3	50	100	100	50	100	100	100	0	50	50	50	100	100	100	50	50
Organic linings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	50	0	0	0	100	50	50	0	0	0	0	25	50
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	100	50	75	66.7	50	0	0	0	0	0	0	0	0	0	50	0	0	0	25	0

Depth of Core (cm)	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Number of Species\10cc's	3	2	3	2	3	2	1	2	2	1	2	1	0	0	1	1	2	2	1
Number of Individuals\10cc's	18	8	8	6	8	6	2	6	8	2	10	3	0	0	3	3	6	6	3
Ammobaculites dilataus	0	0	50	50	50	50	0	66.7	62.5	0	70	100	0	0	100	0	50	50	0
Organic linings	16.7	0	25	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	50	50	0	0	25	50	100	33.3	37.5	100	30	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	33.3	50	25	0	25	0	0	0	0	0	0	0	0	0	0	100	50	50	100

Appendix Table 38- Foraminiferal distributions from core 2c101896 collected in the Lower Harbor, NBH.

Depth of Core	0	1	3	5	6	8	10	11	13	15	16	18	20	21	23	25	26	28	30	31	33	35	36	38	40	41	43	45	47	49	50
Number of Species	4	6	5	8	8	4	9	7	7	11	8	10	9	11	9	11	7	9	10	11	10	8	8	11	10	7	10	8	8	5	11
Number of Individuals	31	98	152	272	228	124	169	79	128	465	506	496	398	662	420	750	226	616	719	700	690	512	664	684	558	332	536	428	316	232	372
Ammobaculites cf. crassus	35.5	12.2	68.4	32.3	56.1	67.8	1.8	17.7	8.6	15.5	19.8	12.9	9.8	14.8	17.6	11.5	26.5	17.2	3.1	16.9	15.1	10.9	8.4	15.2	8.2	31.3	19.4	12.1	13.9	44.8	15.6
A. dilatatus	0	30.7	5.3	1.5	1.7	0	4.7	1.3	0	0	0	4.4	0	3	0	2.1	0	0	0.1	0	0	0	0	0	1.4	0	0	0	0	0	2.4
Ammonia beccarii	0	0	0	7.4	0	0	4.1	0	0.8	5.8	1.6	2	6	5.4	8.1	19.7	3.5	26.6	21.8	4.6	1.4	0	0	0	0	0	0	1.9	0	0	0.5
Bucella fridgida	0	0	0	0	1.8	0	0	0	0	0.6	2.8	10.1	8.3	4.8	1.4	1.9	0	3.2	1.8	1.4	1.2	1.6	3.6	1.2	0.3	0	4.5	2.8	6.3	0	1.9
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	0	0	0	1.5	0	0	4.1	3.8	8.6	31.4	40.3	37.9	39.4	36.9	23.8	29.1	14.2	25.3	40.9	42.3	53.9	65.6	53.6	55	51.6	33.7	38.8	46.7	50.6	13.8	53.2
E. exc. f. excavatum	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	6.3	5.5	0	0	0	0	0	0	0	0	0	0
E. poeyanum	0	0	0	0	0	0	0.6	0	0	0	1.6	0.4	0.8	1.8	0.5	0.8	0	1	0.8	1.4	0	0.8	4.8	0.6	3.6	0	0.7	0	2.5	0	0.3
E. williamsoni	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0.6	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	7.9	32.3	7	3.2	10.7	1.3	1.6	17.4	24.9	26.6	17.8	19.6	19.5	18.7	2.7	0	21.6	20.6	13.6	14.8	22.9	18.1	19	7.2	17.9	15.9	12.7	0	4
Organic linings	3.2	24.5	0	10.3	1.7	3.2	46.7	46.8	57	18.9	5.1	2.8	16.6	10	22.4	12.5	46.9	10.4	9.2	3.1	4.6	1.6	1.8	5.8	8.2	18.1	9	13.1	6.3	34.5	20.4
Reophax nana	0	4.1	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.3	0.6	0	0	0.6	0	1.2	0.7	0	0	0	0.3
R. scorpirus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	54.8	16.3	15.8	13.2	26.3	25.8	23.7	27.8	22.7	8.4	4	1.6	0	0.9	3.3	1.3	1.8	4.5	0.1	2	3.1	3.9	3.6	1.8	0.2	4.8	6.7	3.7	5.1	3.4	0.8
Tiphotrocha comprimata	0	0	2.6	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
T. macrescens	6.5	12.2	0	1.5	3.5	0	3.6	1.3	0.8	0.4	0	1.2	1	2.4	3.3	1.9	4.4	0.6	0.6	1.1	0	0.8	1.2	0.6	0.2	3.6	1.5	3.7	2.5	3.4	0.5
T. ochracea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0.7	0	0	0	0
Deformities	0	4.1	2	0	3.1	0	0	3.2	0	0.4	1.2	5.2	1	0.6	0	0	0	0	0	1.1	0	0.8	1.6	1.2	0	0	0	0.9	0	0	0

Depth of Core	51	53	55	57	59	60	61	63	65	67	69	70	71	73	75	77	79	80	81	83	85	87	89	90	91	93	95	97	99	100	101
Number of Species	7	9	8	9	11	11	5	12	9	11	9	10	9	10	8	9	5	9	12	7	9	8	7	9	7	9	7	10	6	12	8
Number of Individuals	168	516	240	756	528	746	136	758	1040	600	312	411	252	364	156	248	128	232	407	300	224	130	214	460	164	262	222	326	90	365	194
Ammobaculites cf. crassus	20.2	14	15	3.7	17.4	4.3	29.4	7.8	8.8	5.3	23.1	20.9	31.7	16.5	38.5	37.9	53.1	8.6	25.6	27.3	35.7	32.3	32.3	15.2	24.4	37.4	47.7	22.7	17.8	6	29.9
A. dilatatus	0	0	0	0	0	3.2	0	0	0	0	0	6.8	0	0	0	0	0	2.6	0	0	0	0	0	13.5	0	0	0	0	0	21.4	0
Ammonia beccarii	0	0	0	0	0	0.7	0	0.1	0	0	0	0	0	0.5	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0.3	0
Bucella fridgida	1.2	3.1	1.7	3.7	3.8	2.5	0	1.8	9.6	7.3	2.6	2.2	0.8	5.5	0	2.4	0	1.3	3.2	3.3	1.8	3.1	0	2.6	1.2	2.3	0	2.5	0	1.6	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	28.5	49.6	58.3	60	57.6	52.3	26.4	45	51.2	42.6	39.7	22.4	20.6	45.6	16.7	29.8	0	31.9	34.9	40.7	25	16.9	0	37.6	19.5	36.6	3.6	38	11.1	21.9	3.1
E. exc. f. excavatum	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	6.7	0	0	0
E. poeyanum	0	0.8	0	4.2	0.8	5.5	0	8.4	4.6	6.7	1.3	2.9	0	0.5	0	0	0	5.2	0.2	0	0	0	0	13.7	0	0	0	0	0	1.4	0
E. williamsoni	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	3.6	20.2	11.7	22.8	9.8	23.5	0	27	21.2	16.7	12.8	1.9	7.1	17	2.6	3.2	0	7.3	7.1	14.7	1.8	3.1	0	2.2	0	5.3	0	6.1	0	4.4	0
Organic linings	32.1	10.1	5	2.1	3.8	6.2	32.4	5.3	2.7	4	11.5	36.7	19.1	4.4	19.2	16.1	31.3	40	19.2	8	16.1	32.3	42.1	14.1	29.3	10.7	37.8	17.8	44.4	40.5	54.6
Reophax nana	0	0	1.7	0	0.8	0	0	0.1	0	0	0	0	1.6	1.1	2.6	0	4.7	0	0.5	0	2.7	1.5	2.8	0	0	0	0	0	4.4	0.5	2.1
R. scorpirus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	5.9	0.8	5	1.6	2.3	1.1	8.8	2.8	0.8	7.3	2.6	5.1	13.5	7.7	14.4	5.6	9.4	1.7	4.2	3.3	7.1	7.7	7.5	0.2	8.5	3.1	2.7	0.6	6.7	1.1	3.1
Tiphotrocha comprimata	0	0	0	0	0.8	0	0	0.3	0.8	0.7	0	0.5	0	0	0	1.6	0	0	0	0	0	0	3.7	0	1.2	0.8	2.7	1.8	0	0.3	0
Trochammina inflata	0	0	0	0	0.8	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	1
T. macrescens	8.3	0.8	1.7	1.6	2.3	0.7	2.9	1.1	0.4	2	3.8	0.5	4.8	1.1	5.1	2.4	1.6	1.3	0.7	2.7	6.3	3.1	10.3	0.9	15.9	2.3	4.5	2.5	15.6	0.5	5.2
T. ochracea	0	0.8	0	0.5	0	0	0	0.3	0	1.3	2.6	0	0	0	1.3	0.8	0	0	0.5	0	3.6	0	0.9	0	0	1.5	0	1.2	0	0	1
Deformities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 39- Foraminiferal distributions from core 5c101898 collected in the Lower Harbor.

Depth of Core	103	107	109	110	113	115	120	123	125	130	133	135	140	143	145	150	153	155	160	163	165	170	173	175	180
Number of Species	5	6	6	7	5	6	10	5	11	8	8	9	8	6	5	7	7	9	8	10	10	5	6	8	7
Number of Individuals	76	68	93	396	362	148	347	154	145	291	98	83	237	91	101	311	90	255	414	122	128	175	46	140	329
Ammobaculites cf/crassus	39.5	61.8	35.5	46.2	82.9	52.7	41.8	36.3	37.9	35.4	11.2	16.9	48.1	18.7	31.7	52.7	24.4	25.5	34.1	14	22.6	71.4	10.9	17.9	55.6
A. dilatatus	0	2.9	0	11.8	0	0	13	0	0.7	6.2	0	0	0.4	0	0	15.4	0	0	16.2	1.6	0.8	11.4	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	0	0	0	0	0.6	0	0.7	0	1	6	0	0	0	0	0	0.8	1	3.3	3.1	0	2.2	1.4	2.4
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	5.3	0	0	0.3	6.1	25.7	13.8	2.6	22.1	34	17.3	45.8	28.3	2.2	17.8	9.6	35.6	43.5	24.9	54.9	37.5	4.6	34.8	43.6	34.3
E. exc. f. excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.1	0
E. poeyanum	0	0	0	0	0	0	2	0	0	1.7	0	0	3	0	0	0	0	0.8	4.8	0	0	0	0	0	0
E. williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Haynesina orbiculare	0	0	0	0	0	2.7	0.6	0	1.4	3.1	1	2.4	0	0	0	0.3	2.2	1.6	1.4	1.6	1.6	0	0	0	2.4
Organic linings	39.5	20.6	51.6	40.9	8.8	13.5	26.5	49.4	33.8	17.9	58.2	18.1	16.5	74.7	45.5	20.9	31.1	26.3	15.7	21.3	24.2	9.7	43.5	15	4
Reophax nana	0	1.5	1.1	0.3	0	0	0	0	0.7	0	0	2.4	0.4	0	0	0	0	0	0	0.8	0.8	0	0	0	0
R. scorpirus	0	0	1.1	0	0	0	0	0	0	0	0	1.2	0	0	0	0	1.1	0	0	0	0	0	0	0	0
Textularia earlandi	7.9	0	4.3	0.3	1.1	4	0.9	10.4	0.7	1	5.1	4.8	2.5	1.1	2	0.6	1.1	0.8	1.9	0.8	4.7	2.9	2.2	3.6	0.9
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0.8	0	0	0	0
Trochammina inflata	0	1.5	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0
T. macrescens	7.9	11.8	6.5	0.3	1.1	1.4	0.6	1.3	0.7	0.7	2	2.4	0.8	2.2	3	0.3	4.4	0	0	0.8	3.9	0	6.5	0.7	0
T. ochracea	0	0	0	0	0	0	0	0	0.7	0	0	0	0	1.1	0	0	0	0.4	0	0	0	0	0	0.7	0
Deformities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Depth of Core	183	185	190	193	195	200	203	205	210	211	213	215
Number of Species	13	11	11	11	14	5	3	9	5	4	5	4
Number of Individuals	196	83	404	187	115	157	23	70	79	20	21	39
Ammobaculites cf. crassus	16.3	20.5	33.9	28.9	30.4	59.8	47.8	24.3	70.9	80	28.5	35.9
A. dilatatus	0	0	0	0	2.6	1.3	0	0	1.3	0	0	0
Ammonia beccarii	0.5	1.2	0.2	0.5	0.9	0	0	0	0	0	0	0
Bucella fridgida	4.6	3.6	1.2	1.1	2.6	0	0	27.1	0	0	0	0
Eggerella advena	0	0	0	0	0.9	0	0	0	0	0	0	0
Elphidium excavatum forma clavatum	31.1	24.1	41.8	36.9	39.1	33.2	0	20	13.9	0	4.8	20.5
E. exc. f. excavatum	5.6	1.2	1.7	8	1.7	0	0	4.2	0	0	0	0
E. poeyanum	4.6	1.2	0	3.2	0.9	0	0	0	0	0	0	0
E. williamsoni	4.1	2.4	3.4	0	0.9	0	0	0	0	0	0	0
Haynesina orbiculare	13.8	7.2	13.4	10.7	6.1	0	0	10	0	0	0	0
Organic linings	16.3	34.9	3.2	8.6	11.3	4.4	47.8	5.7	6.3	10	57.1	35.9
Reophax nana	0	0	0.2	0	0	0	4.4	0	0	0	0	0
R. scorpirus	0.5	0	0	0	0.9	0	0	0	0	0	0	0
Textularia earlandi	1.5	1.2	0.7	0	0	0	0	1.4	7.6	0	0	0
Tiphotrocha comprimata	0	0	0	1.1	0.9	0	0	1.4	0	0	0	0
Trochammina inflata	0.5	0	0	0	0	0	0	0	0	5	4.8	0
T. macrescens	0.5	2.4	0.2	0.5	0.9	1.3	0	5.7	0	5	4.8	7.7
T. ochracea	0	0	0	0.5	0	0	0	0	0	0	0	0
Deformities	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 39- continued

Depth of Core (cm)	0-1cm	1-2cm	2-3cm	3-4cm	4-5cm	5-6cm	6-7cm	7-8cm	8-9cm	9-10cm	10-11cm	11-12cm	12-13cm	13-14cm	14-15cm	15-16cm	16-17cm	17-18cm
Number of Species\10cc's	9	5	3	4	2	2	3	3	4	2	2	3	4	2	1	2	4	1
Number of Individuals\10cc's	225	68	80	100	79	54	60	27	48	13	34	20	35	12	16	53	63	8
Ammobaculites dilatatus	8.5	29.4	33.8	20	43.1	13	0	33.3	25	0	20.6	0	28.6	0	0	17	14.3	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	23.5	23.5	16.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. excavatum	12.5	11.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. selseyensis	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	8.5	23.5	0	0	0	0	16.6	0	0	0	0	15	14.2	0	0	0	0	0
Miliammina fusca	14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	14.5	0	0	10	0	0	16.6	0	25	30.8	0	35	28.6	0	0	0	14.3	0
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	6	0	50	60	56.9	87	66.7	33.4	37.5	69.2	79.4	50	28.6	0	100	83	57.1	100
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	12.5	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	6	12	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0
T. ochracea	0	0	0	0	0	0	0	33.3	0	0	0	0	0	50	0	0	14.3	0

Depth of Core (cm)	18-19cm	19-20cm	20-21cm	21-22cm	22-24cm	24-25cm	25-26cm	26-27cm	27-28cm	28-29cm	29-30cm	30-31cm	31-32cm	32-33cm	33-34.5cm	34.5-36cm	36-37cm	37-38cm
Number of Species\10cc's	2	2	1	2	2	3	2	2	2	3	3	2	2	3	2	2	3	3
Number of Individuals\10cc's	14	8	5	8	8	12	10	15	52	35	66	28	44	53	8	44	17	32
Ammobaculites dilatatus	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. selseyensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	0	0	0	50	50	33.3	50	33.3	88.5	57.1	66.7	71.4	81.8	58.5	62.5	50	64.8	50
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
Textularia earlandi	50	37.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	0	0	0	0	0	33.3	50	0	0	14.3	0	0	0	17	0	0	17.6	12.5
T. ochracea	0	62.5	100	50	50	33.4	0	66.7	11.5	28.6	27.3	28.6	18.2	24.5	37.5	50	17.6	37.5

Appendix Table 41- Foraminiferal distributions from core 1c101896 collected near the hurricane barrier, NBH.

Appendix Table 41- continued

Depth of Core (cm)	38-39cm	39-40.5cm	40.5-42cm	42-43cm	43-44cm	44-45cm	45-46cm	46-47cm	47-48cm	48-49cm	49-50cm	50-51cm	51-52cm	52-53cm	53-54cm	54-55cm	55-56cm	56-57cm	57-58cm
Number of Species\10cc's	3	2	3	3	3	2	4	2	2	3	3	3	3	3	2	2	3	2	2
Number of Individuals\10cc's	17	10	18	24	40	22	39	31	28	37	44	40	18	13	20	24	20	28	8
Ammobaculites dilatatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia beccarii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. excavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium exc. f. selseyensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Milliammina fusca	0	0	0	0	0	0	10.3	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	52.8	50	44.4	33.3	50	59	10.3	42	28.6	59.5	9.1	32.5	38.9	38.4	80	66.7	15	57.1	50
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	23.6	0	27.8	16.7	40	0	60.2	0	71.4	10.8	81.8	45	22.2	38.4	0	0	50	0	0
T. ochracea	23.6	50	27.8	50	10	41	10.3	58	0	29.7	9.1	22.5	38.9	23.2	20	33.3	35	22.9	50

Depth of Core (cm)	58-59cm	59-60cm	60-61cm	61-62cm	62-65cm	65-68cm	68-71cm	71-74 cm	74-75cm	75-76cm	76-77cm	77-78cm	78-79cm	79-80cm	80-81cm	81-82cm	82-83cm	83-84cm	84-85cm
Number of Species\10cc's	3	1	3	8	9	10	10	3	7	4	10	5	2	3	4	3	4	3	3
Number of Individuals\10cc's	30	5	190	1359	1128	1338	1568	64	380	40	124	53	12	21	48	19	23	22	36
Ammobaculites dilatatus	0	0	0	0.8	0	0.6	0	0	0	0	0	11.3	0	0	0	0	0	0	0
Ammonia beccarii	0	0	25.3	12.5	16.3	12.1	17.8	0	2.2	0	21.8	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	0	5.9	1.4	1.2	12.9	0	23.2	0	1.6	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	33.7	11.8	11.3	11.1	1	0	22.1	0	29	0	0	0	0	0	0	0	0
Elphidium exc. f. excavatum	0	0	0	5.9	7.1	14.9	7.1	0	34.7	0	21.8	0	0	0	37.5	0	0	0	0
Elphidium exc. f. selseyensis	0	0	0	1.6	11.3	13.2	24	0	1	0	1.6	0	0	0	0	0	0	0	0
Elphidium williamsoni	0	0	0	5.9	0.9	0.6	2.6	0	0	0	0	0	0	0	0	0	0	0	0
Haynesina orbiculare	0	0	42	55.5	40.6	41.8	32.1	0	15.8	0	8.9	0	0	0	0	0	0	0	0
Milliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	43.3	0	0	0	1.4	2.4	1.5	50	0	40	7.3	11.3	0	14.3	22.9	21.1	47.8	50	44.4
Quinqueloculina seminulum	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	17.4	0	0
Textularia earlandi	0	0	0	0	2.1	1.8	0.5	25	1	20	3.2	54.7	66.6	42.9	31.3	57.8	17.4	18.2	33.4
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	13.4	100	0	0	0	0	0	25	0	20	1.6	11.3	0	0	0	0	0	0	22.2
T. ochracea	43.3	0	0	0	0	0	0	0	0	0	3.2	11.3	33.4	42.8	8.3	21.1	17.4	31.8	0

Depth of Core (cm)	85-86cm	86-87cm	87-88cm	88-89cm	89-90cm	90-91cm	91-92cm	92-93cm	93-95cm	95-97cm	97-99cm	99-101cm	101-103cm	103-105cm
Number of Species\10cc's	3	4	4	3	4	3	7	4	4	3	3	4	4	11
Number of Individuals\10cc's	32	38	30	34	36	54	59	80	38	36	38	24	32	876
Ammobaculites dilatatus	0	0	0	0	0	0	0	5	0	0	0	0	0	1.3
Ammonia beccarii	0	0	0	0	0	0	13.6	0	0	0	0	0	0	25.6
Bucella fridgida	0	0	0	0	0	0	5.1	0	0	0	0	0	0	1.3
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	0	0	0	0	0	0	0	0	0	0	0	0	0	21.9
Elphidium exc. f. excavatum	0	0	0	0	0	0	22	0	0	0	0	0	0	9.7
Elphidium exc. f. selseyensis	0	0	0	0	0	0	0	0	0	0	0	0	0	10.9
Elphidium williamsoni	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Haynesina orbiculare	0	0	0	0	0	0	0	0	0	0	0	0	12.5	21.9
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	28.1	10	30	21.2	23.4	20.4	27.1	65	53.7	88.8	52.6	50	62.5	1.3
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	8	0	0	0	0	5.1	0	0	0	0	8.4	12.5	0
Textularia earlandi	53.1	61	20	42.4	27.2	48.1	22	10	15.7	5.6	15.8	16.6	12.5	1.3
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	0	0	30	36.4	27.2	0	0	0	15.3	0	0	0	0	0
T. ochracea	18.8	21	20	0	22.2	31.5	5.1	20	15.3	5.6	31.6	25	0	3.6

Appendix Table 41- continued

Depth of Core (cm)	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm	10-11 cm	11-12 cm	12-13 cm	13-14 cm	14-15 cm	15-16 cm	16-17 cm	17-18 cm	18-19 cm	19-20 cm
Number of Species\10cc's	7	6	11	13	13	14	10	13	16	9	14	9	15	12	5	3	5	6	4	4
Number of Individuals\10cc's	164	199	497	1457	2636	1405	1519	1933	1953	611	2259	1213	3399	4140	733	350	574	240	300	587
Ammobaculites dilatatus	71.3	86.9	35.6	15.3	7.4	25.9	28.1	13.8	12.3	21.8	7.7	12.1	3.7	5.3	0	8.6	0	0	0	0
Ammonia beccarii	0	0	7.4	14.9	13.2	3.8	0.8	4.8	8.2	0	6.5	0	5.9	3.9	0	0	0	0	0	0
Bucella fridgida	0	0	2.6	6.2	7.1	2.6	0	4.1	11.1	0	13	0	6.9	5.8	1.8	0	0	0	0	0
Eggerella advena	1.8	0	0	0	0.1	0.6	0.8	0.7	1.7	0	0	1.1	0.2	0	0	0	2.3	0	0	0
Elphidium excavatum f. clavatum	0	0	29.6	24	34.1	22.1	0	18	5.8	0	20.8	4.4	9.8	3.9	0	0	0	0	0	0
Elphidium exc. f. excavatum	0	0	9.5	10.3	8.3	4.4	0	4.1	1.2	0	3	0	29	46.4	3.7	0	0	0	0	0
Elphidium exc. f. selseyensis	0	0	4.6	12.4	9.8	5.7	0	10.3	5.8	0	8.1	0	10.4	12.1	0	0	0	0	0	0
Elphidium williamsoni	0	0	2.6	3.6	3.1	1.3	0	8.9	1.2	0	1.5	0	3.3	1.4	0	0	0	0	0	0
Elphidium poeyanum	0	0	0	0	0	0	0	0	0	0	0	0	1.5	2.4	0	0	0	0	0	0
Elphidium spp.	0	0	46.3	50.3	55.3	33.5	0	41.3	14	0	33.4	4.4	54	66.2	3.7	0	0	0	0	0
Haynesina orbiculare	0	0	4.6	8.7	11.6	0.6	0	0	1.7	2.1	23.8	1.1	16.9	12.1	0	0	0	0	0	0
Miliammina fusca	0	0	0	0	0	2.6	1.8	0	4.1	2.1	0	0	0	0.5	0	0	0	0	0	0
Organic linings	6.1	5	1.4	1.4	3	17.1	50	17.2	23.4	41.4	6.6	63.7	6.5	5.3	89.1	88.5	81.4	40.8	80	88.6
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
Reophax nana	0	1.5	0	1.2	0	0	0.8	1.4	0.6	2.1	0	0	0	0	0	0	0	3.8	0	0
Textularia earlandi	4.3	3.5	1.4	1.2	0.8	7	5.3	8.3	15.2	17.5	3.5	5.5	3.3	0	1.8	2.9	4.7	22.1	10.3	4.6
Tiphotrocha comprimata	0	0	0	0.2	0.1	0	0	0	0	2.1	1.5	1.1	0	0	0	0	0	3.8	0	0
Trochammina inflata	4.3	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. macrescens f. polystoma	6.1	0	0	0	1.2	4.4	7.9	4.8	3.5	2.1	2.5	5.5	1.2	0	0	0	7	7.6	6.7	4.6
T. ochracea	6.1	1.5	0.6	0.7	0	1.9	2.6	2.1	3.5	8.7	1	5.5	0	1	3.7	0	4.7	22.1	3	2.2

Depth of Core (cm)	20-21 cm	21-22 cm	22-23 cm	23-24 cm	24-25 cm	25-26 cm	26-27 cm	27-28 cm	28-29 cm	29-30 cm	30-31 cm	31-32 cm	32-33 cm	33-34 cm	34-35 cm	35-36 cm	36-37 cm	37-38 cm	38-39 cm	39-40 cm
Number of Species\10cc's	7	9	12	10	5	9	12	4	6	3	10	8	4	9	10	9	10	6	8	10
Number of Individuals\10cc's	274	296	688	708	360	888	1720	300	580	92	418	664	538	1057	1122	931	918	457	6.54	688
Ammobaculites dilatatus	0	2.7	2.3	1.8	6.6	1.8	2.3	16.7	0	10.9	1.2	2.4	1.9	1.7	1.8	0.4	2	2.4	5.4	0.8
Ammonia beccarii	0	0	2.3	0	0	0	1.2	0	0	0	1.9	0.9	0.5	0.7	0.9	0.2	0.8	0	6.6	0.6
Bucella fridgida	0	0	3.5	1	0	0	1.7	0	0	0	0.7	3	0	0.5	1.8	1.7	0.4	0	0	1.1
Eggerella advena	0	0	1.2	0	2.2	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	2.9	27	25.6	23.6	0	12.6	34.9	0	24.1	0	22.2	73.8	1.9	71	76.6	65.6	53.3	19.9	48.9	50.6
Elphidium exc. f. excavatum	1	2.7	8.1	6.6	0	6.3	26.7	0	6.9	0	7.2	0.6	0	9	1.2	18.9	22.8	0	19.9	25.6
Elphidium exc. f. selseyensis	4.4	13.5	22.1	21.6	0	19.8	18	0	12.1	0	28.7	1.2	0	2.1	2.9	0.4	1.2	0.4	4.6	1.7
Elphidium williamsoni	0	0	3.5	4.7	0	0	3.5	0	0	0	0	0	0	0.2	0.3	0.8	1.7	0	0	0.3
Elphidium poeyanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium spp.	8.3	43.2	59.3	56.5	0	38.7	83.1	0	43.1	0	58.1	75.6	1.9	82.3	81	85.7	79	20.3	73.4	78.2
Haynesina orbiculare	0	0	5.8	0	0	4.5	4	0	0	0	4.3	5.7	0	5.7	6.2	4.5	6.8	2.4	12.7	14.2
Miliammina fusca	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	76.6	35.1	19.8	37.7	82.2	45.9	4	70	44.8	86.9	31.8	12.3	95.7	9	8	7.4	10.7	74	1.5	4.4
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	7.3	0	1.2	1	4.4	1.8	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiphotrocha comprimata	0	5.4	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0.6	0	0	2.2	0	0	0	0	0	0	0	0	0.5	0.6
T. macrescens f. polystoma	5.5	2.7	0	1	0	4.5	0	0	3.4	0	0	0	0	0	0	0	0.4	0.9	0	0
T. ochracea	2.2	8.1	4.7	1	4.4	2.7	1.2	6.7	8.6	0	0	0	0	0	0.3	0	0	0	0	0

Appendix Table 42- Foraminiferal distributions from core 1c103096 collected in Apponogansett Bay

Depth of Core (cm)	40-41 cm	41-42 cm	42-43 cm	43-44 cm	44-45 cm	45-46 cm	46-47 cm	47-48 cm	48-49 cm	49-50 cm	50-51 cm	51-52 cm	52-53 cm	53-54 cm	54-55 cm	55-56 cm	56-57 cm	57-58 cm	58-59 cm	59-60 cm
Number of Species\10cc's	12	12	3	8	11	10	9	8	7	5	5	7	9	5	7	7	3	8	4	8
Number of Individuals\10cc's	847	1168	188	362	350	736	650	287	237	156	341	440	365	173	258	325	163	623	386	352
Ammobaculites dilatatus	0.9	0.7	4	2.8	7.1	2.4	2.6	10.5	4.6	14.7	0.9	4.5	7.1	13.3	10.1	22.8	21.5	2.7	6	4.8
Ammonia beccarii	0.5	5.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	2.8	2	0	2.2	1.4	2.2	1.1	0	0	0	0	0	0.8	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium excavatum f. clavatum	64.6	46.2	0	62.4	1.4	47.6	43.1	30.3	4.6	0	0	15.9	19.5	0	2.3	8.9	0	24.7	0	9.7
Elphidium exc. f. excavatum	5.3	12.4	0	0.6	1.4	9.8	5.7	0	0	0	0	0	2.5	1.7	0	0	0	3.7	0	0.9
Elphidium exc. f. selseyensis	5.9	2.6	0	1.7	1.4	3.5	9.7	4.5	5.5	0	0	9.1	11	1.7	5.4	12.3	0	4.7	0	7.4
Elphidium williamsoni	0.9	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium poeyanum	0.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium spp.	77.6	63.3	0	64.7	4.2	60.9	58.5	34.8	10.1	0	0	26	33	3.4	7.7	21.2	0	33.1	0	18
Haynesina orbiculare	7.1	14.8	0	13.3	7.1	19	22	2.4	0	0	0	0	4.7	0	0	0	0	0.5	0	0
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic linings	10.3	12.7	96.8	16.6	70	13.9	14.3	38.3	75.9	72.3	87.1	61.4	41.4	79.2	70.9	51.1	76.7	60	91.7	73
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia earlandi	0	0	0	0	1.4	0.3	0	3.5	0.8	6.4	0.9	2.3	3	4	3.5	1.8	0	0	0	0.9
Tiphotrocha comprimata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina inflata	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0	0.8	0.9
T. macrescens f. polystoma	0.5	0.4	0	0.6	4.3	0.3	0.5	3.5	0.8	0	0.9	3.9	0	0	2.3	0.9	0	2.7	1.6	0
T. ochracea	0.2	0.3	0	0	1.4	1.1	1.1	7	7.6	4.5	6.7	3	10.1	0	5.4	2.2	1.8	1.4	0	2.6

Depth of Core (cm)	60-61 cm	61-62 cm	62-63 cm	63-64 cm	64-65 cm	65-66 cm	66-67 cm	67-68 cm	68-69 cm	69-70 cm	70-71 cm	71-72 cm	72-73 cm	73-74 cm	74-75 cm	75-76 cm	76-77 cm	77-79 cm
Number of Species\10cc's	4	8	9	11	8	12	7	13	11	8	6	5	12	13	12	7	6	2
Number of Individuals\10cc's	304	169	962	558	561	839	679	1322	629	550	362	426	650	395	206	64	45	12
Ammobaculites dilatatus	8.2	10	2.5	7.7	3.6	3.1	0.7	4.8	2.4	7.8	7.5	6.3	6.6	8.6	5.8	31.3	17.8	33.3
Ammonia beccarii	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0
Bucella fridgida	0	0	1.4	0	0	0	0	1.4	1.1	0	0	0	1.1	0.8	0	0	0	0
Eggerella advena	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	1.9	6.2	0	0
Elphidium excavatum f. clavatum	0	1.8	45.9	29.2	69.5	57.2	0.4	57.7	28.9	0.5	8.6	0	29.2	49.1	21.3	0	0	0
Elphidium exc. f. excavatum	0	0	21.2	7.2	3	8.5	0	11.6	3.2	0	0	0	13.4	10.9	17.5	0	0	0
Elphidium exc. f. selseyensis	2.6	1.8	3.4	5.4	11.2	5.8	0	9.1	4.9	0	0.6	0	14.3	8.6	11.6	0	0	0
Elphidium williamsoni	0	0	2.1	0	0	0	0	0.4	0	0	0	0	1.5	0.8	9.7	0	0	0
Elphidium poeyanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidium spp.	2.6	3.6	72.6	41.8	83.7	71.5	0.4	78.8	37	0.5	9.2	0	58.4	69.4	60.1	0	0	0
Haynesina orbiculare	0	1.8	21	0	3	4.4	0	5.9	0.6	0	0	0	10.8	1.5	9.7	0	0	0
Miliammina fusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	6.3	4.4	0
Organic linings	88.2	79.2	2.3	45.7	7.1	17.8	96.5	7.9	55.8	84.9	81.8	91.5	16.5	14.4	9.7	31.3	46.7	0
Quinqueloculina seminulum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax nana	0	0	0	0.5	0	0.4	0	0	0	0.5	0	0	0.5	0	0	0	0	0
Textularia earlandi	0	0	0	0.9	1.2	0.4	0.4	0.2	0	1.3	0	0	1.5	1.5	0	6.2	8.9	0
Tiphotrocha comprimata	0	0	0	0.5	0	0.4	0	0	0.6	1.3	0	0.7	0	1.5	1.9	6.2	0	0
Trochammina inflata	0	1.8	0	0.5	0	0.4	0.4	0.4	0.6	0	0	0.7	0	0.8	0	0	0	0
T. macrescens f. polystoma	0	0	0	0.5	1.2	0.7	0.7	0.2	0.6	1.3	1.1	0	3.1	0.8	11.7	12.5	11.1	0
T. ochracea	1	1.8	0.2	1.8	0	1.1	0.7	0.2	1.1	2.4	0.6	0.7	1.5	0.8	1.9	0	11.1	66.7

Appendix Table 42- continued

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