Late Glacial to Holocene benthic foraminifera in the Marmara Sea: implications for Black Sea–Mediterranean Sea connections following the last deglaciation

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Abstract

Benthic foraminifera were studied from four gravity cores that penetrated Holocene marine sediments in the Marmara Sea. Morphogroup and assemblage analyses reveal that the Holocene sea-level rise did not result in a catastrophic flooding event as proposed by W.B.F. Ryan and others, whereby well-oxygenated, saline Mediterranean waters rapidly inundated a low-lying low salinity 'Black Sea Lake' at ∼7.15 ka (popularly known as the 'Noah's Flood Hypothesis'). Rather, the benthic foraminiferal data confirm the hypothesis that the Dardanelles sill was breached by the Mediterranean at ∼12 ka, allowing saline waters to penetrate the Marmara Sea. These saline waters reached the level of the Bosphorus sill at ∼9.5 ka, but were unable to penetrate into the Black Sea until after ∼9.1 ka because of the persistent strong outflow of brackish to fresh water from the Black Sea. The initial colonisation of the Marmara Sea by benthic foraminifera is essentially synchronous with the re-establishment of marine connections through the Dardanelles Strait at ∼12 ka. By ∼10 ka, *Ammonia*-dominated faunas developed on the strait-exit delta (Δ1) at the southern end of the Bosphorus, and at ∼9.1 ka the appearance of fully marine species documents the establishment of a more stratified water column over Δ1. Finally, the increase in abundance of planktonic foraminifera at the southern exit of the Bosphorus after ∼6.1 ka reflects a decreased volume of outflow water from the Black Sea. Quantitative analysis of benthic foraminiferal morphogroups reveals that the oxygen content of sub-halocline water was low (below ∼1.5 ml/l) throughout the Holocene, and the occurrence of sapropel sediment in the deeper part of the basin suggests bottom waters may have been anoxic at times. After ∼4.5 ka, an increase in benthic foraminiferal oxic morphotypes suggests a reduction in Black Sea outflow and weakening of the halocline. The strong and persistent stratification of the water column in the Marmara Sea throughout the Holocene is entirely incompatible with the 'Noah's Flood Hypothesis'.
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Keywords: Marmara Sea Gateway; Black Sea; Holocene; benthic foraminifera

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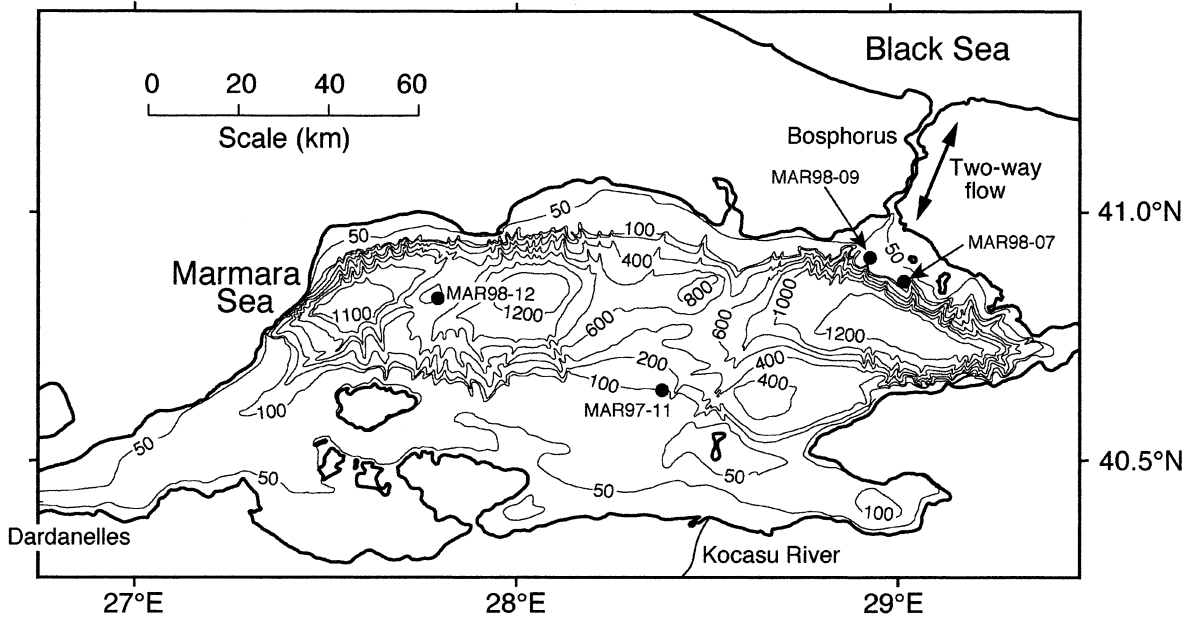   *E-mail address:* m.kaminski@ucl.ac.uk (M.A. Kaminski).

Fig. 1. Core locations (black circles) in the Marmara Sea. Bathymetry is from Aksu et al. (2000)

1. Introduction

The Marmara Sea occupies a transtensional basin situated along a set of en echelon dextral strike-slip faults that form part of the North Anatolian Transform Fault system (Aksu et al., 2000). It is a critical oceanographic gateway connecting the Aegean Sea, to the west, and the Black Sea, to the northeast, and serves as the only link between the Black Sea and the Mediterranean. Two relatively shallow and slender straits, the Dardanelles and the Bosphorus, connect the Marmara Sea to the Aegean and Black seas, respectively (Fig. 1). Even though the Dardanelles strait reaches depths of 100–110 m, several sills are present to contemporary depths of 60–70 m. These sills prevent the exchange of deep water between the Aegean Sea and the Black Sea (Ergin et al., 1997). Today, brackish surface water exits the Black Sea through the Bosphorus strait, while saline deeper water from the Marmara Sea flows northward as a countercurrent. An identical two-way flow exists in the Dardanelles Strait, thereby establishing an overall estuarine circulation within the Marmara Sea. Because of the existence of brackish Black Sea outflow water, a strong halocline is present

throughout the Marmara Sea, leading to low-oxygen conditions below a thin well-mixed surface layer.

During the last glacial maximum, global sea level was ∼120 m below its present level (Fairbanks, 1989), and the Marmara Sea (as well as the Black Sea) was isolated from the Mediterranean. During the last deglaciation as sea level rose to ca. −70 m, a marine connection was first established with the Mediterranean through the Dardanelles. As sea level rose to the depth of the Bosphorus sill (−40 m), an effective marine connection was eventually established with the Black Sea once two-way flow developed (Lane-Serff et al., 1997). This two-way flow required a sufficient depth of water in the strait and a reduction of the earlier strong outflow of Black Sea surface water to the point where Mediterranean saline water could penetrate along the full length of this waterway.

The development of a marine connection between the Black Sea and Mediterranean during the early Holocene would have had a profound influence on the biotic record of the intervening Marmara Sea. In recent years, a much-publicised controversy has emerged concerning the timing and development of marine connections to the

Black Sea following the last deglaciation. On the one hand, geochemical studies of the youngest sapropel horizon (S1, ∼9.5–6.4 ka) in the Aegean Sea (Aksu et al., 1995, 1999) and a partly contemporaneous sapropel in the deep Marmara Sea (∼10.6–6.4 ka; Çağatay et al., 2000; Aksu et al., 2002a) suggest a strong outflow of low-salinity water from the Black Sea beginning at ∼10.5 ka. The presence of a strait-exit delta with an age of ∼10–9 ka at the southern end of the Bosphorus Strait supports the timing of this outflow (Hiscott et al., 2002). On the other hand, Ryan et al. (1997) cited sedimentological and faunal evidence from the northern Black Sea that in their opinion points to the catastrophic inundation of the Black Sea by water of Mediterranean origin at ∼7.15 ka, spawning the 'Noah's Flood Hypothesis' (Ryan and Pitman, 1998). More recent studies suggest a more gradual transgression of the Black Sea shelves, beginning no later than ∼11 ka (Görür et al., 2001; Aksu et al., 2002b).

Micropalaeontological studies of the Holocene sediment in the Marmara Sea may be instrumental in resolving this debate. If, as the studies of sapropels suggest, a two-way flow and a strongly stratified water column had been established by ∼10.5 ka, benthic foraminiferal assemblages from the Marmara Sea should reflect low-oxygen conditions. However, if the scenario discussed by Ryan et al. (1997) is correct and a rapid unidirectional flow of marine surface waters into the Black Sea through the Bosphorus Strait had taken place at ∼7.15 ka, marine organisms of Mediterranean origin would have been swept into the Marmara Sea at that time by the strong flooding currents. Moreover, the stable density stratification of the Marmara Sea would have been disrupted, resulting in a well-oxygenated water column. Initial studies of Holocene sediments and fauna from the Marmara Sea (Algan et al., 2001) strongly support the existence of persistent dysoxic conditions below a stable halocline, contrary to the expected conditions during a rapid inundation.

The objectives of this study are to (1) provide a taxonomic census of the benthic foraminifera in gravity cores collected from a range of water depths in the Marmara Sea, (2) more fully investigate the history of the marine connections between the Black Sea and Mediterranean, (3) trace the development of oxygen depletion beneath the pycnocline, and (4) distinguish between the conflicting hypotheses regarding the timing of marine connections using quantitative analysis of benthic foraminiferal assemblages.

2. Previous studies

Benthic foraminifera from the Eastern Mediterranean have been studied by Cimerman and Langer (1991), who produced a workable taxonomic framework for the region. This framework has been expanded by faunal studies of the Gulf of Naples, Italy by Sgarrella and Moncharmont Zei (1993). Black Sea foraminifera have been documented by Yanko and Troitskaja (1987), and their ecology summarised by Yanko (1990). The only published studies of foraminifera from the Marmara Sea are (1) the work of Alavi (1988), who examined two sediment cores collected from a depth of 1200 m in the deep basin south of Istanbul, and (2) descriptions of upper Pliocene to Holocene foraminifera from geotechnical boreholes in the Gulf of Izmit (Meriç et al., 1995). Alavi (1988) found the foraminifera in the upper metre of the marine sediment column to consist mostly of infaunal forms that are known from oxygen-deficient environments rich in organic matter, and noted faunal similarities to older sapropel layers exposed on land in other areas of the Mediterranean. Alavi (1988) concluded that these sediments were deposited subsequent to the establishment of an estuarine circulation in the Marmara Sea, but owing to the lack of absolute age determinations, he was unable to provide a chronology for his cores. In addition to the work of Meriç et al. (1995), shallow-water benthic foraminifera have been recently studied from Iskundrun Bay on the Mediterranean coast of Turkey (Basso and Spezzaferri, 2000). This study provides calibration of the depth ranges of neritic benthic foraminifera in this sector of the Mediterranean, and many of the same species are found in our sediment cores (see below). Unfortunately, little is known about the depth distribution of modern

benthic foraminifera within the Marmara Sea it-self.

3. Methods

In this paper, we document the benthic forami-nifera from four cores collected during the MAR97 and MAR98 cruises of the R/V *Koca Piri Reis* of the Institute of Marine Sciences and Technology, Dokuz Eylül University, Izmir, Tur-key (Fig. 1). The sediments were collected using a 4-m-long corer with 10 cm internal diameter and 400 kg weight. Two of the cores (MAR98-7 and MAR98-9) were collected from the Holocene del-ta on the northern Marmara Sea shelf near the southern exit of the Bosphorus (Hiscott et al., 2002). A third core (MAR97-11) was studied form the southern Marmara Sea shelf, and a fourth (MAR98-12) penetrated a sapropel in the deeper part of the Marmara Sea. The sedimentol-ogy and depositional history at these core loca-tions are described in detail by Hiscott et al. (2002) and Hiscott and Aksu (2002), while geo-chemistry and water mass history are discussed by Aksu et al. (2002a,c). Details of the cores are given in Table 1; they are currently curated at the Department of Earth Sciences, Memorial Uni-versity of Newfoundland. Standard 10-cm^3 sam-ples were collected at 10-cm intervals from the working half of the four cores. Samples were dis-aggregated by boiling in a 1% Calgon solution, and wet-sieved over a 63-μm sieve. Foraminifera were picked out of the >125-μm fraction, and mounted on cardboard microscope slides, housed in the Kaminski Collection at the Department of Geological Sciences, University College London. Selected specimens were photographed using a Zeiss-940 digital scanning electron microscope at UCL.

In this study, we utilise the Benthic Foraminif-eral Oxygen Index (BFOI) originally developed by Kaiho (1991). The BFOI was originally based on benthic foraminiferal data from DSDP cores from the Pacific, South Atlantic and Indian oceans. Us-ing oxic and dysoxic morphotypes originally de-termined by Bernhard (1986), Kaiho (1991) divid-ed benthic foraminifera into three main groups according to test morphology: (1) the 'anaerobic' forms were defined as those with small- to me-dium-sized tests with a high surface area to vol-ume ratio, and elongate-flattened, tapered, and cylindrical morphotypes, and with thin, unorna-mented, porous test walls; (2) the 'aerobic' forms are those with low surface area to volume ratio, and spherical, planoconvex, and lenticular mor-phologies with thick test walls (3) the 'intermedi-ate' or 'suboxic' forms were those similar to 'anaerobic' forms but possessing thick or orna-mented test walls, such as costate *Uvigerina* and *Bulimina*, *Nodosaria*, and *Stilostomella*. Also in-cluded were this lenticular and planispiral forms characterised by medium surface area to volume ratios and thin walls. Kaiho (1994) further divid-ed suboxic indicators into three groups, A, B, and C. Group A comprises small specimens (< 350 μm) of oxic species able to live in less oxygenated con-ditions because of their size. Group B consists of species that are considered to be between the mor-phological extremes of the oxic and dysoxic indi-cators. These include *Lenticulina*, large *Nodosaria*, *Dentalina*, and large ornamented species of *Buli-mina*; rounded planispiral, flat ovoid and spheri-cal forms; small and/or thin-walled, planoconvex and biconvex trochospiral forms; and *Uvigerina*, *Gyroidina*, *Gyroidinoides*, and *Hoeglundina*. Spe-cies of group B contain both epifaunal dwellers and infaunal dwellers under high-oxygen condi-tions that are epifaunal faunal dwellers in low-oxygen conditions. Group C indicators are those species that have thin walls but are considered to have a microhabitat between those of group B and dysoxic indicators, these taxa include *Bulimina aculeata*, *Nonionella* spp., and *Elphidium excava-tum*. In this study, we used the oxic, suboxic, and dysoxic morphogroups defined by Kaiho (1994).

Table 1
Core locations and water depths

Core number	Latitude (N)	Longitude (E)	Water depth (m)
MAR97-11	40°39.20′	28°22.67′	111
MAR98-7	40°50.98′	29°00.98′	95
MAR98-9	40°55.36′	28°56.80′	64
MAR98-12	40°50.54′	27°47.68′	549

Kaiho's (1991, 1994) BFOI is an empirical ratio of dysoxic and oxic forms which was defined as:

$$[a/(a+n) \times 100]$$

where a is the number of oxic species and n the number of dysoxic species. When $a = 0$ and $n+s > 0$ (s is the number of suboxic indicators) then the BFOI value is given by $[(s/(s+n)-1] \times 50$. In the latter study, Kaiho (1994) calibrated the modern values of the BFOI to levels of dissolved oxygen in bottom waters in the modern ocean. Three main BFOI value divisions are defined by Kaiho (1994): oxic BFOI values, which range from 100 to 0, represent dissolved oxygen conditions of > 1.2 ml/l; suboxic BFOI values, ranging from 0 to -40, represent dissolved oxygen values of between 1.3 and 0.3 ml/l; and dysoxic BFOI values, which range from -40 to -55, represent dissolved oxygen levels of between 0.3 and 0.1 ml/l. Black laminated mud and shale barren of calcareous benthic foraminifera but containing planktonic foraminifera are assigned a BFOI value of < -55.

Kaiho (1999) re-evaluated his BFOI with respect to organic carbon flux, temperature, and salinity. He analysed calcareous benthic foraminifera from core tops at 73 oceanic sites and calculated the BFOI values for each site. Kaiho found that correlation coefficients between productivity, organic carbon flux, and dissolved oxygen level ($R^2 = 0.36$–0.51) were much lower than those between dissolved oxygen levels and BFOI values ($R^2 = 0.78$ and 0.81). This study demonstrated the usefulness of the BFOI as a proxy for bottom-water dissolved oxygen content, especially over the range of values observed in the Marmara Sea.

4. Results

4.1. Taxonomy

A total of 117 species of benthic foraminifera were found in the studied Marmara Sea cores. Foraminifera are abundant in the Holocene mud drape. The recovered assemblages display strong affinities to those described from the modern Mediterranean Sea but are lower in diversity, being poor in groups such as larger foraminifera and organically cemented agglutinated foraminifera. The taxonomic classification of benthic foraminifera recovered from our studied cores is outlined in Appendix 1. Representative specimens are illustrated in Plates I–V.

4.2. The Bosphorus Strait-exit delta

Core MAR98-9 was collected from a water depth of 64 m on the outer shelf, just south of the exit of the Bosphorus Strait. Major lithological boundaries are observed at 55 cm and 110 cm in the core. The uppermost unit is interpreted to represent a transgressive to highstand marine drape (Hiscott et al., 2002), and radiocarbon dates constrain its age to ∼9.0–0 ka. The sediment below 55 cm contains increasing amounts of sand with depth, and is interpreted as the distal equivalent of a prograding lobate delta located south of the exit of the strait (Δ1 of Hiscott et al., 2002). Radiocarbon dates give an age of 10–9 ka for this interval. Δ1 is unusual in that it was not sourced from a river, but from a strait linking two small seas when one sea (the Black Sea) was flowing vigorously into the other (see below).

Benthic foraminiferal assemblages in the core (Fig. 2; Appendix 2) reflect a history of increasing water depth through time, as Holocene sea level rose and the site became increasingly more marine. Foraminifera at the base of the core (120 cm) are abundant, display low diversity, and are highly dominated by *Ammonia* spp. *Textularia* spp. and *Elphidium* spp. are also present. This impoverished assemblage (radiometrically dated at 10 220 yr BP at 113 cm) is interpreted as reflecting shallow-water conditions and low salinity.

Between 110 and 55 cm, the diversity of benthic foraminifera increases upcore, and the first occurrences of *Aubignyna perlucida*, *Porosononion martkobi*, *Nonionella opima*, *Bulimina* spp., *Brizalina* spp., *Fursenkoina acuta*, and *Lobatula lobatula* are observed. Planktonic foraminifera are absent in this interval. This change from an *Ammonia*-dominated assemblage to a more diverse one coincides with an upwards increase in the amount of
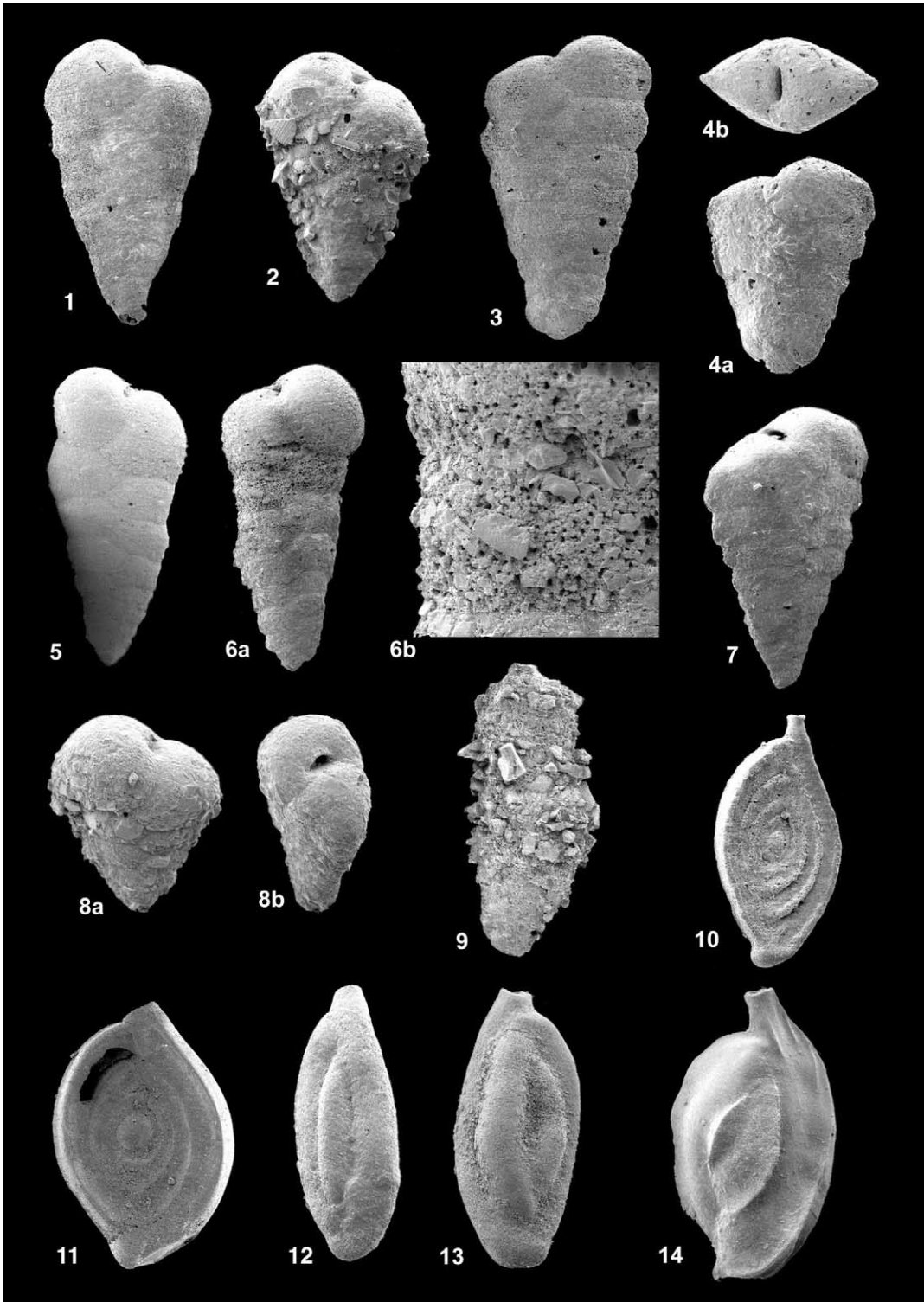
Plate I.

silt and clay, and reflects increasing water depths and drowning of Δ1. This faunal change is constrained by radiometric dates of 9840 yr BP at 94 cm and 9070 yr BP at 60 cm.

At 40 cm, planktonic foraminifera become common, and *Ammonia* disappears from the record entirely. Instead, an assemblage dominated by infaunal forms such as *Brizalina* and *Bulimina* suggests deposition beneath a stratified water column (radiometrically dated at 6120 yr BP at 42 cm).

Core MAR98-7 was collected near the shelf edge at a depth of 95 m. During the last Glacial lowstand, the water level in the Marmara Sea was 90–100 m lower than it is today, so this site would have been near the shoreline of the 'Marmara Lake' (Aksu et al., 1999). Below 70 cm in the core, the fresh- to brackish-water mollusc *Dreissena rostiformis distincta* is observed (Hiscott et al., 2002). Benthic foraminifera are very sparse, but are consistently present to the base of the core (Fig. 3; Appendix 2). The occurrence of *Haynesina depressa*, *Aubignyna perlucida*, and *Ammonia compacta*, species that are rare in the overlying marine unit, suggests either reworking from older strata, or that a relict fauna may have been present in the Marmara Sea during glacial times. Radiocarbon dates from this interval give an age in excess of 40 ka.

At 70 cm in the core, an abrupt change in the numbers and diversity of benthic foraminifera is observed. The assemblage recovered from 70–60 cm is dominated by *Bulimina* spp., *Brizalina* spp., *Cassidulina carinata*, and *Nonionella opima*, indicating that marine conditions were rapidly established. No shallow-water *Ammonia*-dominated assemblage was observed at the base of this marine interval, which supports the idea of rapid flooding when the Dardanelles was breached. Higher in the core, the proportions of *C. carinata* and *N. opima* decrease, and *Bulimina*, *Polymorphina*, *Biloculinella*, and *Hyalinea* increase, reflecting deeper marine conditions in a permanently stratified water column.

4.3. Southern Marmara Sea shelf

Core MAR97-11 was collected from a water depth of 111 m on the southern Marmara Sea shelf, in the toeset of the most seaward lowstand delta of oxygen isotopic stage 2. The core locality was in a permanently subaqueous part of the basin, and therefore records the history of palaeoenvironmental conditions during the last lowstand as well as the marine invasion of the Marmara Sea after the breaching of the Dardanelles Strait.

Below a core depth of 100 cm, only the mollusc

Plate I.

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1.	*Textularia bocki* Höglund, 1947	Core MAR97-11 – 10 cm	Side view ×90
2.	*Textularia bocki* Höglund, 1947	Core MAR97-11 – 10 cm	Side view ×95
3.	*Spirorutilus* sp	Core MAR97-11 – 50 cm	Side view ×95
4a.	*Spirorutilus* sp	Core MAR97-11 – 50 cm	Side view ×150
4b.	*Spirorutilus* sp	Core MAR97-11 – 50 cm	Apertural view ×170
5.	*Textularia cushmani* Said, 1949	Core MAR97-11 – 50 cm	Side view ×90
6a.	*Textularia cushmani* Said, 1949	Core MAR97-11 – 50 cm	Side view ×90
6b.	*Textularia cushmani* Said, 1949	Core MAR97-11 – 50 cm	Pseudopores ×1200
7.	*Textularia* sp	Core MAR97-11 – 50 cm	Side view ×145
8a.	*Textularia* sp	Core MAR97-11 – 50 cm	Side view ×300
8b.	*Textularia* sp	Core MAR97-11 – 50 cm	Side view ×300
9.	*Bigenerina nodosaria* d'Orbigny, 1826	Core MAR97-11 – 0 cm	Side view ×130
10.	*Spiroloculina tenuiseptata* Brady, 1884	Core MAR97-11 – 10 cm	Side view ×150
11.	*Spiroloculina excavata* d'Orbigny, 1846	Core MAR97-11 – 40 cm	Side view ×150
12.	*Adelosina cliarensis* (Heron-Allen and Earland, 1930)	Core MAR97-11 – 80 cm	Side view ×120
13.	*Adelosina cliarensis* (Heron-Allen and Earland, 1930)	Core MAR97-11 – 80 cm	Side view ×180
14.	*Adelosina* sp	Core MAR97-11 – 80 cm	Side view ×100
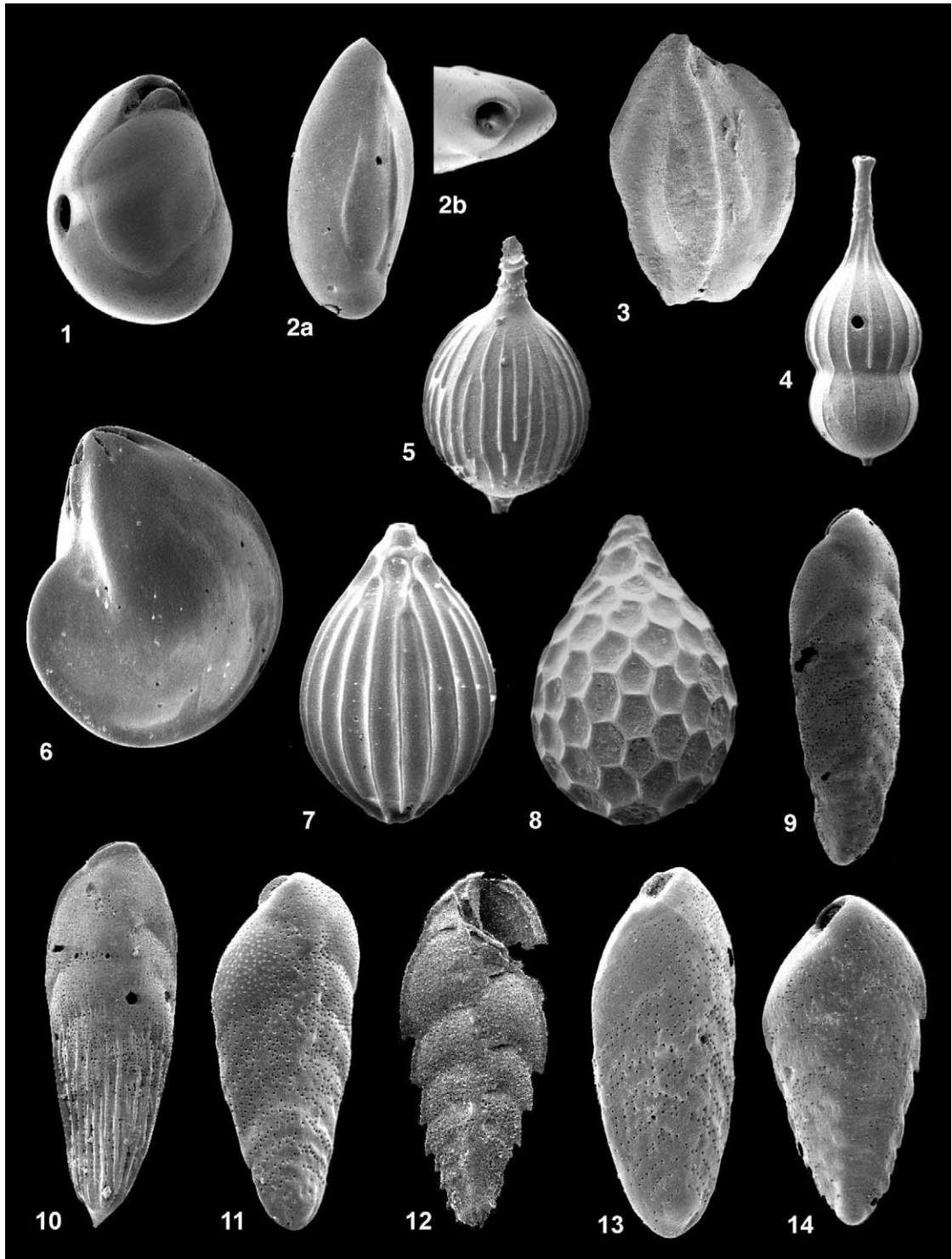
Plate II.

Dreissena rostriformis distincta is present. Benthic foraminifera (Fig. 4; Appendix 2) are either absent or are represented by very rare specimens that could have been reworked from older strata and/or downmixed by burrowers or by the coring process. Radiometric dates of 14 970 yr BP at 174 cm and 12 970 yr BP at 92 cm pre-date the breaching of the Dardanelles Strait, and therefore correspond to a time when lowstand deltas were still active along the southern shelf of the Marmara Sea (Aksu et al., 1999).

At ∼80 cm, benthic foraminifera suddenly become abundant (Fig. 4). The assemblage at this depth is comprised mostly of *Textularia* spp., *Cassidulina carinata*, *Haynesina depressa*, *Aubignyna perlucida*, and *Fursenkoina acuta*. Both *F. acuta* and *C. carinata* display the behaviour of 'pioneering' species which can initially colonise a barren substrate in large numbers. Their relative abundance then decreases upcore as the diversity of the fauna increases. A maximum of *Nonionella opima* is observed from 60 to 40 cm. At 40 cm, an increase in the relative abundance of *Brizalina* spp. and *Bulimina* spp. is observed. At 30 cm, there is an increase in the abundance of *Discorbinella bertheloti*, while *Hyalinea balthica* and *Textularia* spp. increase at 20 cm. A radiometric age of 10 790 yr BP at 79 cm clearly documents that the drowning of the delta and the rapid transition to a fully marine fauna occurred when global sea level stood ∼65–70 m lower than today. This

elevation coincides with the modern depth of the bedrock sills in the Dardanelles Strait. Following the initial rapid transition, additional marine species from the Mediterranean then gradually colonised the deeper shelf as sea level continued to rise.

4.4. Deep Marmara Sea

The deepest locality studied is Core MAR98-12, recovered from a present-day water depth of 549 m. Samples from the basal section of the core are barren of foraminifera. At 130 cm at the base of sapropel M1 (radiocarbon date of 10 660 yr BP), a bloom of *Fursenkoina* accompanied by a few specimens of *Brizalina* and *Bulimina* is observed. The entry of these marine species documents the establishment of marine connections between the Marmara Sea and the Aegean Sea. Samples collected from the sapropel layer itself are barren of foraminifera, or contain just a few specimens of *Chilostomella*, *Bolivina*, and *Brizalina* which may have been downmixed. Conditions during the deposition of the sapropel at this locality must have been anoxic at times. Near the top of the sapropel layer at 90 cm, a maximum in *Globobulimina* is observed, indicating a slight improvement in the bottom water oxygenation. At 80 cm, miliolids and *Hyalinea* appear, while *Uvigerina* makes its first appearance at 20 cm, suggesting further increase in oxygenation.

Plate II.

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1.	*Biloculinella globula* (Bornemann, 1855)	Core MAR97-11 – 40 cm	Oblique side view ×500
2a.	*Quinqueloculina patagonica* d'Orbigny, 1839	Core MAR97-11 – 40 cm	Side view ×90
2b.	*Quinqueloculina patagonica* d'Orbigny, 1839	Core MAR97-11 – 40 cm	Apertural view ×500
3.	*Quinqueloculina stelligera* Schlumberger, 1893	Core MAR97-11 – 10 cm	Side view ×90
4.	*Lagena striata* (d'Orbigny, 1839)	Core MAR97-11 – 10 cm	Side view ×130
5.	*Amphicoryna proxima* (Silvestri, 1872)	Core MAR97-11 – 20 cm	Side view ×150
6.	*Lenticulina gibba* (d'Orbigny, 1826)	Core MAR97-11 – 50 cm	Side view ×240
7.	*Homalohedra* sp	Core MAR97-11 – 10 cm	Side view ×300
8.	*Favulina hexagona* (Williamson, 1848)	Core MAR97-11 – 80 cm	Side view ×310
9.	*Brizalina spathulata* (Williamson, 1858)	Core MAR97-11 – 30 cm	Side view ×115
10.	*Brizalina striatula* (Cushman, 1922)	Core MAR97-11 – 0 cm	Side view ×150
11.	*Brizalina catanensis* (Seguenza, 1862)	Core MAR97-11 – 0 cm	Side view ×175
12.	*Brizalina alata* (Seguenza, 1862)	Core MAR97-11 – 20 cm	Side view ×90
13.	*Brizalina dilatata* (Reuss, 1850)	Core MAR97-11 – 30 cm	Side view ×140
14.	*Brizalina* sp	Core MAR97-11 – 30 cm	Side view ×150
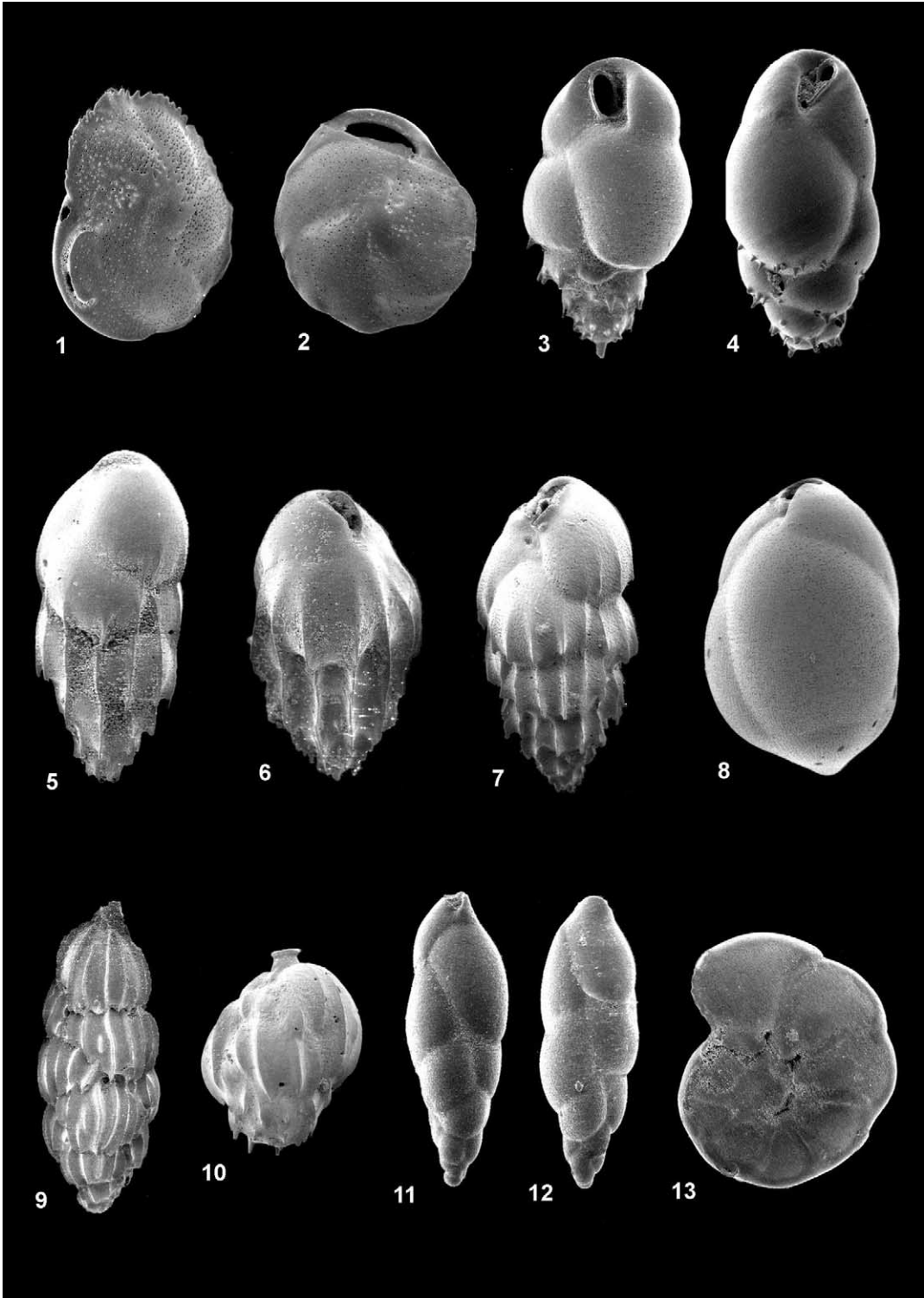
Plate III.

5. Discussion

5.1. Initial recolonisation of the Marmara Sea after the last deglaciation

Three of the studied cores recovered the base of the upper marine layer that drapes the lowstand deltas on the Marmara Sea shelf. Radiocarbon dates at the two deeper sites (MAR98-12 and MAR97-11) are consistent with the ∼12-ka estimate for the breaching of the Dardanelles sill (Aksu et al., 2002a). At that time, Mediterranean Sea water began to flow into the 'Marmara Lake' from the Aegean Sea. Among the first species to establish themselves at the deeper localities in the Marmara Sea were *Aubignyna perlucida*, *Cassidulina carinata*, *Haynesina depressula*, and *Fursenkoina acuta*. In Iskundrun Bay, *H. depressula* occurs at water depths as shallow as 9 m (Basso and Spezzaferri, 2000), while *Fu. acuta* is known from the littoral zone in the northern Adriatic (Iaccarino, 1967, reported in Sgarrella and Moncharmont Zei, 1993). This initial recolonisation event documents the first significant influx of Mediterranean surface waters through the Dardanelles after the last deglaciation (benthic foraminifera recovered from Pliocene and older Pleistocene sediments in the Gulf of Izmet by Meriç et al., 1995 point to previous periods of faunal connections with the Mediterranean). The Dardanelles, however, apparently acted as a selective faunal filter, as we do not observe any of the larger rotaliids and miliolids that are common at shallow depths in the eastern Mediterranean. Rare (and stunted) specimens of *Planorbulina mediterranensis* constitute the only 'larger' foraminifera in our samples. It is quite possible that the larger foraminifera have been excluded because of the low salinity of the upper 20 m of the water column.

This initial recolonisation event was followed by an increase in *Brizalina* and *Bulimina*, which is observed at all studied localities. These forms have a wide bathymetric range, but on average occur at deeper stations in Iskundrun Bay (Basso and Spezzaferri, 2000). At a later stage in the recolonisation, species such as *Hyalinea balthica* appear in our cores. This species lives below 70 m depth in the Gulf of Naples (Sgarrella and Moncharmont Zei, 1993), and its appearance in the Marmara Sea reflects the deepening of water over the Dardanelles sill as sea level rose further during the later Holocene.

The selective filter effect of the Dardanelles sill is still in evidence today, since deep stations in the Marmara Sea are poor in organically cemented deep-water agglutinated foraminifera and cosmopolitan bathyal benthics such as *Pullenia* and *Melonis*. These forms are present in the Aegean Sea, but because they possess upper depth limits that are deeper than the Dardanelles sill, they have not been able to enter the Marmara Sea.

5.2. Drowning of the Bosphorus Strait-exit delta

The location of Core MAR98-9 was chosen to decipher the history of the Holocene delta (Δ1) at

Plate III.

|			
1.	*Cassidulina carinata* Silvestri, 1896	Core MAR97-11 – 70 cm	Side view ×155
2.	*Cassidulina carinata* Silvestri, 1896	Core MAR97-11 – 70 cm	Apertural view ×250
3.	*Bulimina aculeata* d'Orbigny, 1826	Core MAR97-11 – 30 cm	Side view ×100
4.	*Bulimina elongata* d'Orbigny 1846	Core MAR97-11 – 10 cm	Side view ×160
5.	*Bulimina costata* d'Orbigny, 1852	Core MAR97-11 – 30 cm	Side view ×120
6.	*Bulimina costata* d'Orbigny, 1852	Core MAR97-11 – 30 cm	Side view ×150
7.	*Bulimina* sp	Core MAR97-11 – 30 cm	Side view ×135
8.	*Globobulimina affinis* (d'Orbigny, 1839)	Core MAR97-11 – 20 cm	Side view ×80
9.	*Rectiuvigerina phlegeri* Le Calvez, 1959	Core MAR97-11 – 70 cm	Side view ×90
10.	*Uvigerina mediterranea* Hofker, 1932	Core MAR97-11 – 10 cm	Side view ×55
11.	*Fursenkoina acuta* (d'Orbigny, 1846)	Core MAR97-11 – 70 cm	Apertural view ×160
12.	*Fursenkoina acuta* (d'Orbigny, 1846)	Core MAR97-11 – 70 cm	Side view ×160
13.	*Hyalinea balthica* (Schroeter, 1783)	Core MAR97-11 – 30 cm	Umbilical view ×95
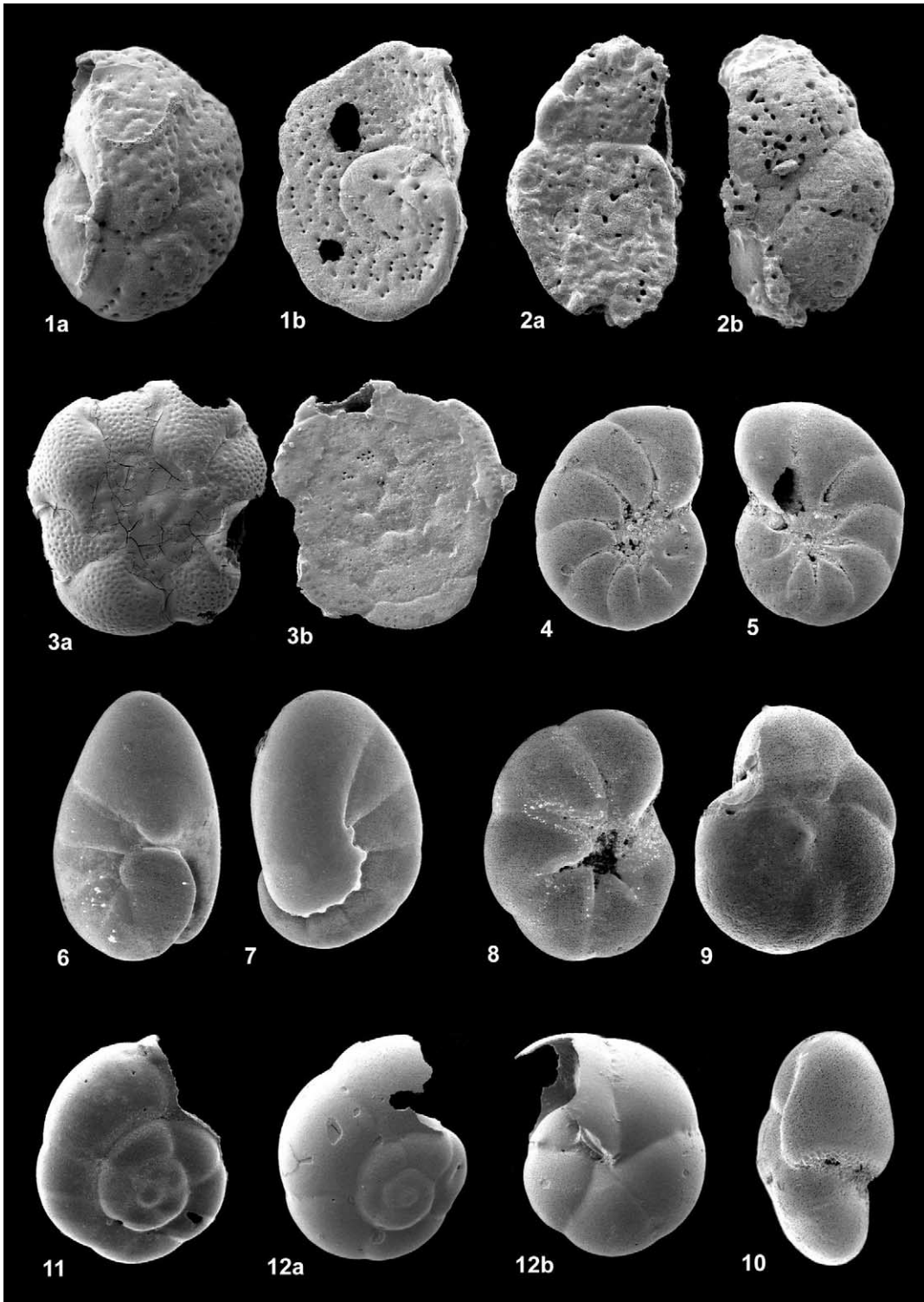
Plate IV.

the southern entrance of the Bosphorus, and by inference the history of outflow from the Black Sea. Here, the presence in seismic profiles of a southward-prograding delta is interpreted as evidence for a strong unidirectional outflow current from the Black Sea (Hiscott et al., 2002). The presence of brackish *Ammonia*-dominated faunas within deltaic sediments at the base of Core MAR98-9, dated radiometrically at ∼10.2 ka, is here interpreted as evidence of this freshwater outflow from the Black Sea. On the modern Black Sea shelf, foraminiferal faunas with >80% *Ammonia* characterise very shallow deltaic or lagoonal environments with salinities below 5‰ (Yanko, 1990). Using the known sill depth of the Bosphorus and the sea-level curve of Fairbanks (1989), Aksu et al. (1999) estimated that rising water levels in the Marmara Sea would have reached the sill at about 9.5 ka. The first occurrences of *Aubignyna*, *Porosononion*, *Nonionella*, *Bulimina*, *Brizalina*, *Fursenkoina*, and *Lobatula* between 100 and 50 cm in the core (dated radiometrically at 9070 yr BP at a depth of 60 cm) are entirely consistent with this estimate. Modern assemblages with common *Aubignyna* and *Porosononion* are found in water depths of 10–25 m on the Black Sea shelf, where salinities vary from 11 to 16‰ (Yanko, 1990). The genera *Bulimina* and *Brizalina* are currently extremely rare within the modern Black Sea (Yanko and Troitskaja, 1987).

Their appearance toward the top of the distal Δ1 succession at 60 cm is here interpreted as reflecting the appearance of more saline waters of Mediterranean origin and the initial establishment of a salt wedge at this site. Between ∼9.1 and 6.1 ka, Black Sea outflow had decreased to the point that planktonic foraminifera were no longer excluded from the delta, and the appearance of a dysoxic benthic foraminiferal assemblage reflects deposition of the marine drape beneath a stably stratified water column.

Our data suggest a reduction of fresh-water outflow from the Black Sea at ∼9.1 ka, when planktonic foraminifera were first able to live in surface waters over the distal fringe of the drowned Holocene delta south of the Bosphorus exit. This reduction in outflow would be a prerequisite for establishment of a two-way flow through the Bosphorus. Even occasional incursions of Mediterranean water through the strait, potentially long before a permanent and stable two-way flow was established, could have allowed pioneering bottom dwellers like benthic foraminifera to colonise the Black Sea shelf, particularly those species that tolerate hyposaline conditions. Infrequent and irregular marine incursions into marginal seas with restricted entrances are common even today; for example, there are some years when marine incursions into the modern Baltic Sea do not occur.

Plate IV.

|			
1a.	*Lobatula lobatula* (Walker and Jacob, 1798)	Core MAR97-11 – 70 cm	Umbilical view ×135
1b.	*Lobatula lobatula* (Walker and Jacob, 1798)	Core MAR97-11 – 70 cm	Spiral view ×135
2a.	*Lobatula lobatula* (Walker and Jacob, 1798)	Core MAR97-11 – 70 cm	Spiral view ×220
2b.	*Lobatula lobatula* (Walker and Jacob, 1798)	Core MAR97-11 – 70 cm	Umbilical view ×220
3a.	*Planorbulina mediterranensis* d'Orbigny, 1826	Core MAR97-11 – 60 cm	Unattached side ×90
3b.	*Planorbulina mediterranensis* d'Orbigny, 1826	Core MAR97-11 – 60 cm	Attached side ×90
4.	*Haynesina depressula* (Walker and Jacob, 1798)	Core MAR97-11 – 80 cm	Side view ×90
5.	*Haynesina depressula* (Walker and Jacob, 1798)	Core MAR97-11 – 80 cm	Side view ×70
6.	*Nonionella opima* Cushman, 1947	Core MAR97-11 – 40 cm	Side view ×150
7.	*Nonionella opima* Cushman, 1947	Core MAR97-11 – 40 cm	Side view ×200
8.	*Aubignyna perlucida* (Heron-Allen and Earland, 1913)	Core MAR97-11 – 80 cm	Umbilical view ×150
9.	*Aubignyna perlucida* (Heron-Allen and Earland, 1913)	Core MAR97-11 – 80 cm	Edge view ×150
10.	*Aubignyna perlucida* (Heron-Allen and Earland, 1913)	Core MAR97-11 – 80 cm	Edge view ×95
11.	*Gyroidinoides lamarckiana* (d'Orbigny, 1839)	Core MAR97-11 – 10 cm	Spiral side ×100
12a.	*Gyroidinoides lamarckiana* (d'Orbigny, 1839)	Core MAR97-11 – 10 cm	Spiral side ×100
12b.	*Gyroidinoides lamarckiana* (d'Orbigny, 1839)	Core MAR97-11 – 10 cm	Umbilical view ×100
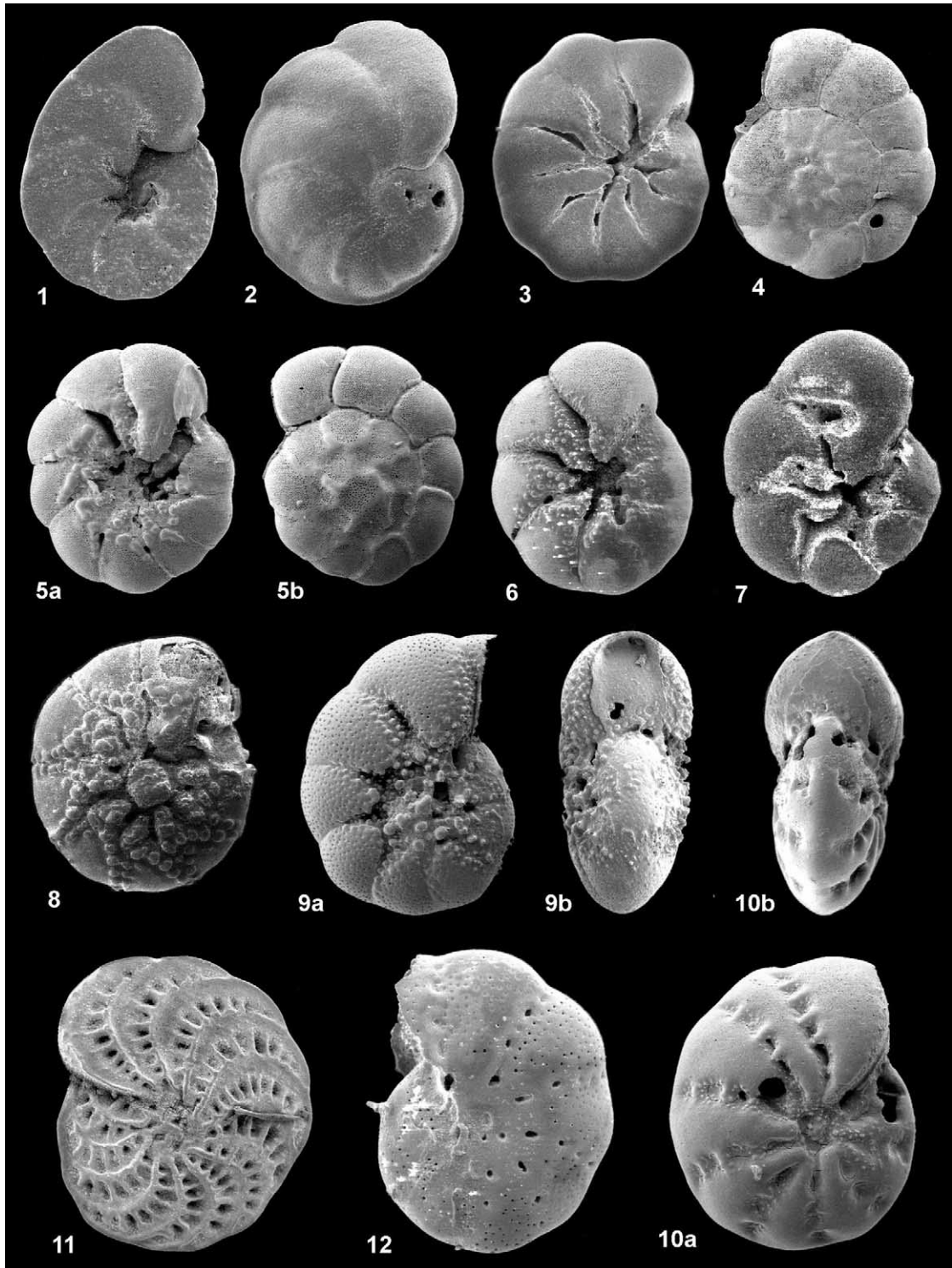
Plate V.

Evidence for the first post-glacial colonisation of the Black by benthic foraminifera was reported by Yanko and Troitskaja (1987, p. 88) who documented the first appearance of Holocene foraminifera in a sediment core from the Russian (eastern) Black Sea shelf. These authors reported an assemblage consisting of *Mayerella*, *Ammonia* and *Elphidium* in a transgressive interval near the base of the core, which was dated radiometrically at 9.58 ka. Yanko (1990) indicated that other cores in the area have yielded similar radiometric dates. Based on studies of modern foraminiferal distributions in the Black Sea, this assemblage indicates water depths of 2–3 m and salinities of ∼4–5‰ (Yanko and Troitskaja, 1987; Yanko, 1990). Yanko (1990) emphasised that the foraminifera found in this core are of Mediterranean origin. Clearly, the suggestion by Ryan et al. (1997) that there was no connection between the Mediterranean and Black Seas until 7.15 ka cannot be sustained. This is in line with independent evidence from a number of studies that the Black Sea was persistently exporting brackish water to the Marmara and Aegean seas from ∼10.6 ka to the present (Aksu et al., 1995, 1999, 2002a; Hiscott and Aksu, 2002; Çağatay et al., 2000; Algan et al., 2001). As argued by Aksu et al. (1999), the delay, until 7.15 ka, of the arrival of Mediterranean molluscs on the northern shelves of the Black Sea (Ryan et al., 1997) may be explained by a protracted replacement of the bottom water of the Black Sea by saline Mediterranean water so

that surface waters remained relatively fresh long after the establishment of two-way flow.

5.3. The establishment of the stable density stratification of the Marmara Sea

Benthic foraminiferal data from Cores 97-11, 98-7, and 98-9 were analysed to calculate the BFOI of Kaiho (1991, 1994) (Fig. 5). Dissolved oxygen data collected from the Sea of Marmara show that modern values beneath the halocline range from between ∼2 in the western basin and 0.5 ml/l in the east (Alavi, 1988), which is well within the useful range of Kaiho's BFOI.

At each locality except at the shallowest station (MAR98-9), the onset of suboxic to dysoxic conditions below the surface mixed later in the Marmara Sea was very rapid. The initial recolonising assemblages, consisting of *Fursenkoina* and *Cassidulina*, are regarded as 'dysoxic' forms in the morphogroup classification of Kaiho (1994). The initial influx of Mediterranean waters into the 'Marmara Lake' at ∼12 ka must have quickly created a stable halocline as the dense marine water mass displaced the pre-existing, likely brackish deep water. Although the surface waters of the Mediterranean were well-oxygenated at the time, the deeper marine waters of the Marmara Sea must have been rapidly depleted of oxygen owing to the oxidation of organic matter and lack of ventilation of the deep water across the halocline. Our analysis of the foraminiferal mor-

Plate V.

1.	*Discorbinella bertheloti* (d'Orbigny, 1839)	Core MAR97-11 – 70 cm	Spiral view ×125
2.	*Discorbinella bertheloti* (d'Orbigny, 1839)	Core MAR97-11 – 70 cm	Umbilical view ×125
3.	*Ammonia parasovica* Stshedrina and Mayer	Core MAR98-9 – ?? cm	Umbilical view ×75
4.	*Ammonia parasovica* (Stschedrina and Mayer, 1975)	Core MAR97-11 – 150 cm	Spiral view ×100
5a.	*Ammonia* sp. 1 (Cimerman and Langer, 1991)	Core MAR98-9 – 80 cm	Umbilical view ×75
5b.	*Ammonia* sp. 1 (Cimerman and Langer, 1991)	Core MAR98-9 – 80 cm	Spiral view ×75
6.	*Ammonia* sp. 1 (Cimerman and Langer, 1991)	Core MAR97-11 – 150 cm	Umbilical view ×70
7.	*Ammonia tepida* (Cushman, 1926)	Core MAR98-9 – ?? cm	Umbilical view ×105
8.	*Ammonia compacta* (Hofker, 1969)	Core MAR98-9 – ?? cm	Spiral view ×100
9a.	*Porosononion martkobi* (Bogdanowicz)	Core MAR97-11 – 110 cm	Side view ×160
9b.	*Porosononion martkobi* (Bogdanowicz)	Core MAR97-11 – 110 cm	Apertural view ×160
10a.	*Elphidium articulatum* (d'Orbigny, 1839)	Core MAR97-11 – 80 cm	Side view ×90
10b.	*Elphidium articulatum* (d'Orbigny, 1839)	Core MAR97-11 – 80 cm	Apertural view ×90
11.	*Elphidium macellum* (Fitchel and Moll, 1798)	Core MAR97-11 – 80 cm	Side view ×70
12.	*Elphidium translucens* Natland, 1938	Core MAR98-7 – 120 cm	Side view ×150
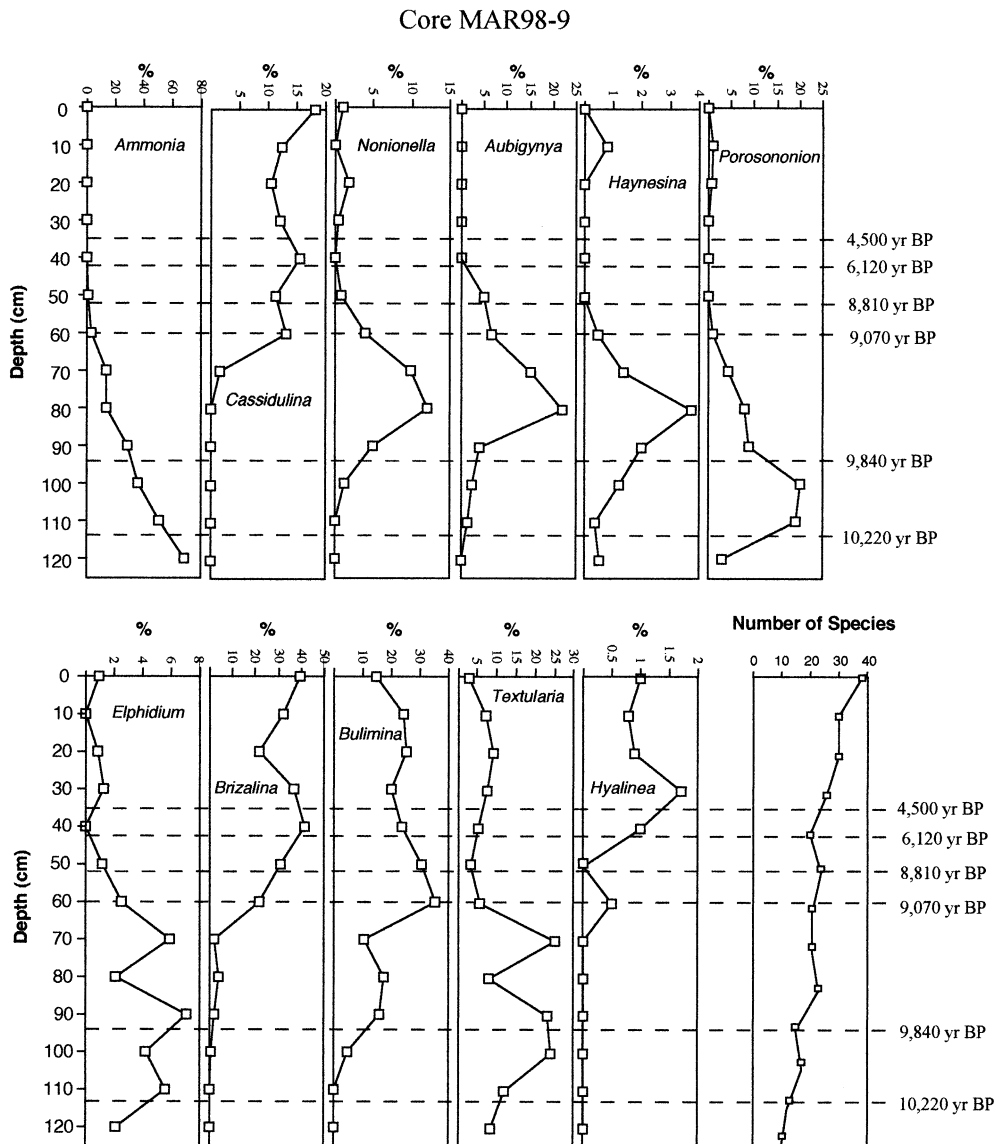
Core MAR98-9

Fig. 2. Downcore plots of percentage abundances of benthic foraminifera for Core MAR98-9. Radiocarbon dates are fully explained and tabulated in Aksu et al. (2002a).

phogroups and the BFOI (Fig. 5, also summarised in Aksu et al., 2002a) indicates that dissolved oxygen values were even lower during the initial recolonisation stage than today's values.

The initiation of a strong outflow of fresh water from the Black Sea at ∼10.5–10.0 ka intensified the stratification of the Marmara Sea (Fig. 6, 10.0 ka). This outflow is linked to the deposition of sapropel sediments in both the Marmara Sea

(M1) and the Aegean Sea (S1) (Aksu et al., 1995, 2002a; Çağatay et al., 2000). The sparse *Chilostomella* assemblages and intervals barren of benthic foraminifera at our deep site (MAR98-12) suggest the bottom waters of the deep basins may have been anoxic at times. However, at shelf depths the oxygen content, although low, was sufficient to sustain communities of predominantly 'dysoxic' and 'suboxic' benthic foraminifera. Çağatay et
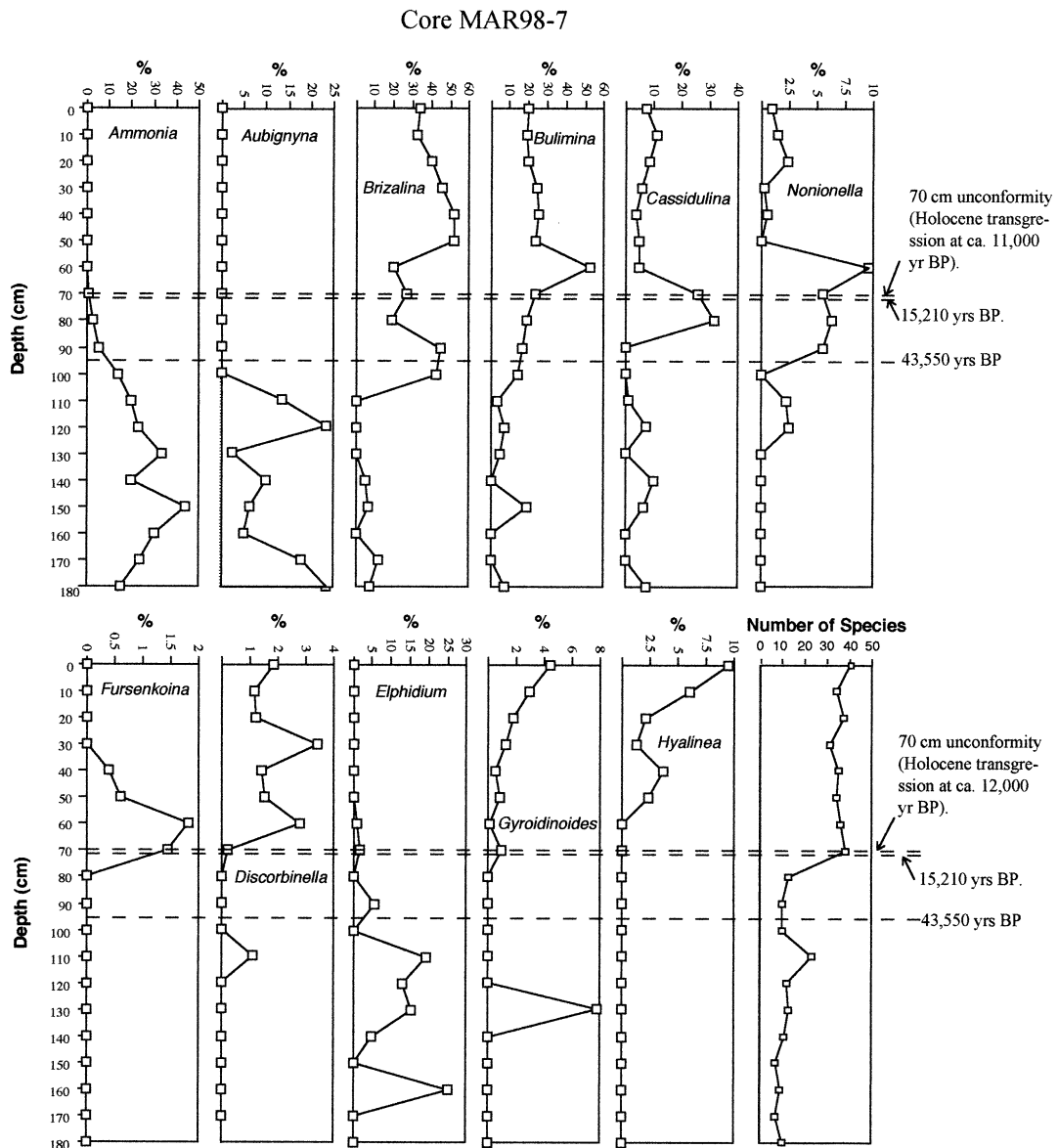
Core MAR98-7

Fig. 3. Downcore plots of percentage abundances of benthic foraminifera for Core MAR98-7. Radiocarbon dates are fully explained and tabulated in Aksu et al. (2002a).

al. (2000) also report moderate to high benthic foraminiferal abundances in Holocene sapropel deposits on the shelves of the Marmara Sea, consistent with higher oxygen contents outside the deep basinal areas.

After the observed reduction in Black Sea outflow occurred at ∼6.5 ka, oxygenation of the deep waters in the Marmara Sea improved some-

what. The upper 30–40 cm of the marine drape in studied cores contain greater proportions of the 'oxic' foraminiferal morphogroup, which includes forms such as *Discorbinella*, *Cibicides*, *Planorbulina*, and miliolids. Nevertheless, our data and those of Yanko et al. (1999) indicate persistent stratification and predominantly dysoxic taxa. Significantly, we did not observe any return to
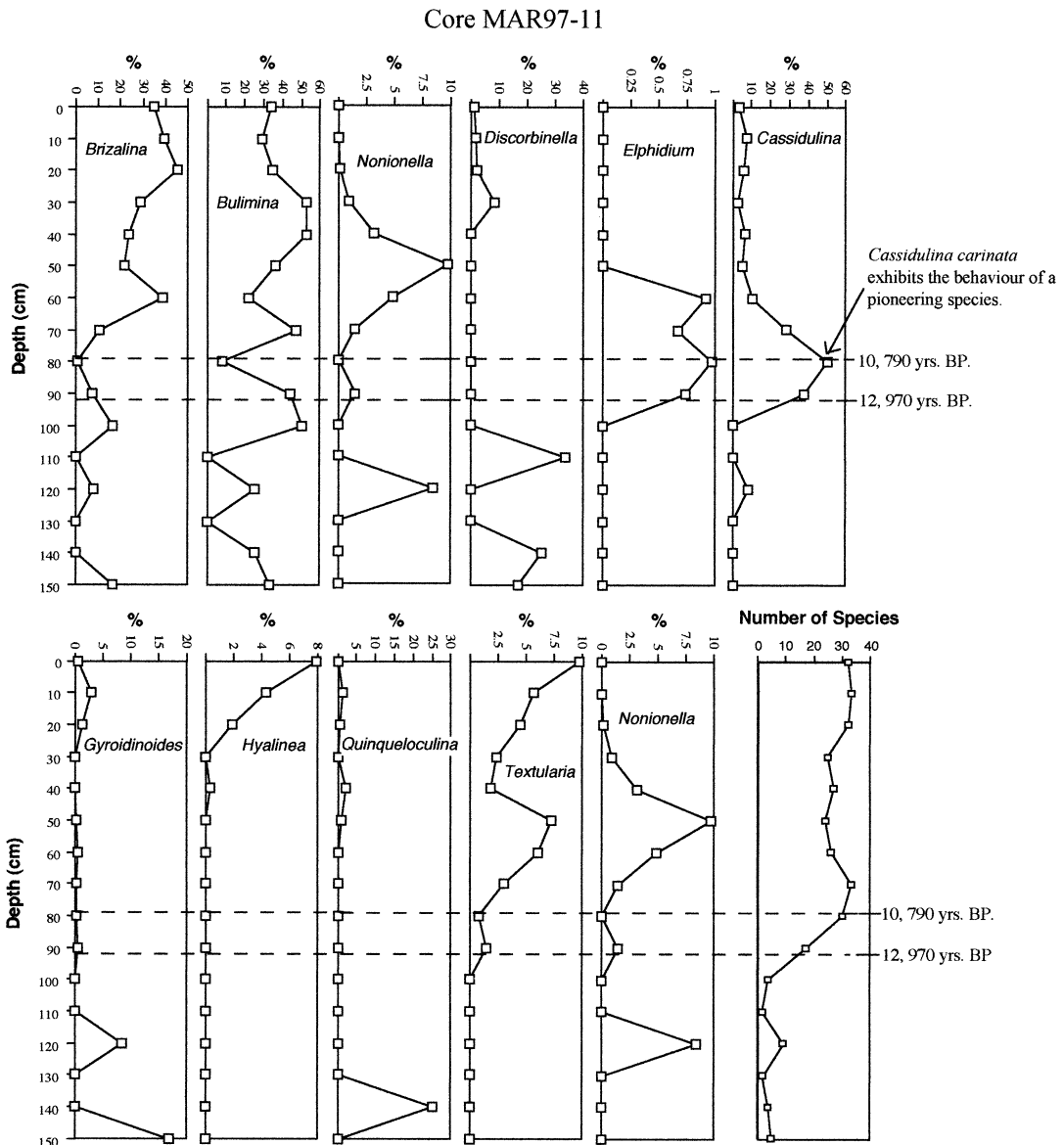
Fig. 4. Downcore plots of percentage abundances of benthic foraminifera for Core MAR97-11. Radiocarbon dates are fully explained and tabulated in Aksu et al. (2002a).

fully oxygenated conditions at any time since the the onset of marine deposition after the last deglaciation.

If the hypothesis of Ryan et al. (1997) is correct, and surface water of Mediterranean origin had catastrophically infilled the Black Sea at ∼7.15 ka, the Marmara Sea would have been effectively flushed with well-oxygenated Mediterranean waters. The outflow from the small rivers that empty into the southern Marmara Sea shelf would have been inadequate to create a low-salinity lid over the Marmara Sea. In effect, the Marmara Sea would have become simply an arm of the Aegean Sea. Had this occurred, typical Med-
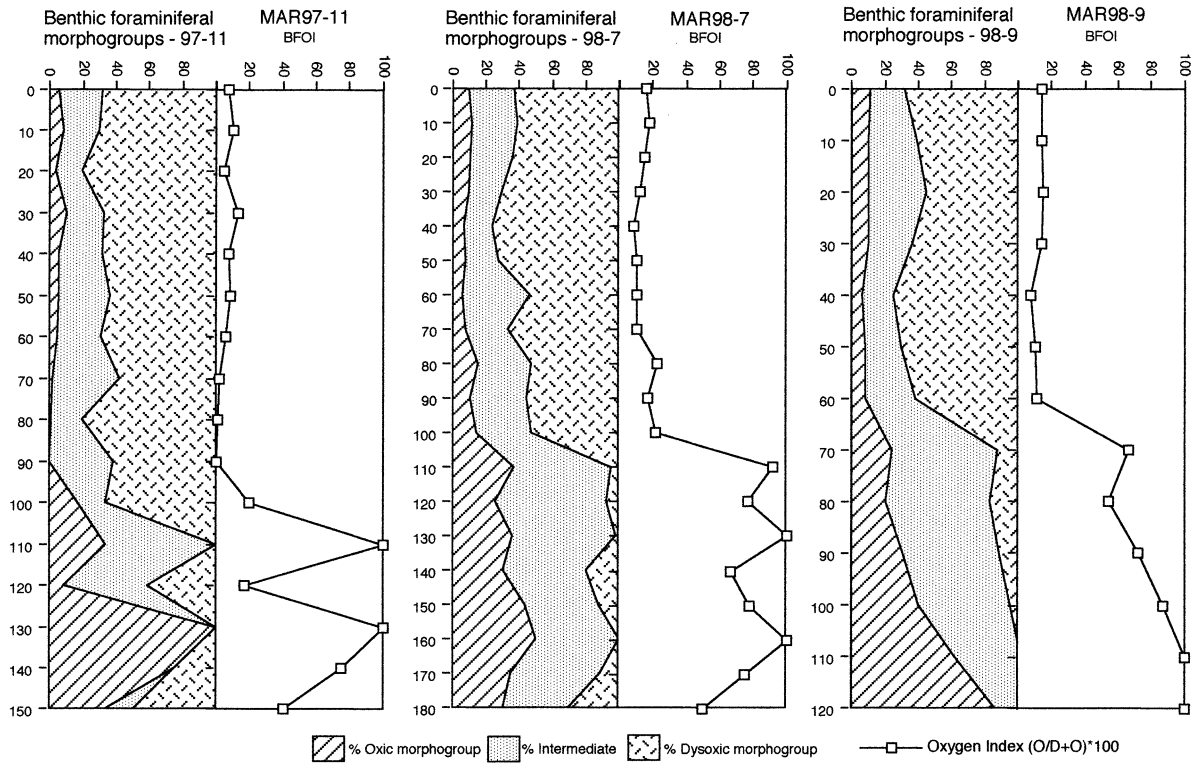
Fig. 5. Calculated BFOI values in the studied cores.

iterranean planktonic and benthic foraminifera would have been swept into the Marmara Sea together with the inrushing current, and benthic foraminiferal faunas would be dominated by the 'oxic' morphogroup. Our findings do not support such a scenario. Çağatay et al. (2000) have made very similar observations that refute the notion of catastrophic flooding across the Marmara Sea. Instead, the exclusive occurrence of dysoxic assemblages throughout the period ~10.8–6 ka supports the scenario of Aksu et al. (1995, 1999, 2002a) that attributes the deposition of sapropels to stable stratification caused by outflow of brackish water from the Black Sea. This brackish outflow makes its way into the Aegean Sea via the Marmara Sea and the intervening straits. Fig. 6 summarises our reconstruction of the history of water exchange through the Marmara Sea and connecting straits since 18 ka, and differs only in detail from the model published by Aksu et al. (1999, their fig. 19).

6. Conclusions

The benthic foraminiferal data from Marmara Sea cores MAR97-11, MAR98-7, MAR98-9, and MAR98-12 presented in this study yield the following interpretations:

(1) The Marmara Sea was a brackish, well-oxygenated, inland lake during the last glacial maximum until the Aegean Sea rose to the height of the Dardanelles sill at ~12 ka (Fig. 6). At this time, molluscs adapted to brackish environments and only very sparse foraminifera inhabited the Marmara Sea.

(2) At ~12 ka, marine surface waters from the Aegean Sea were introduced into the deeper parts of the Marmara Sea basin but left the shelf margins brackish, and initiated a two-way water exchange between the Marmara Sea and the Aegean Sea through the Dardanelles Strait. The deeper parts of the Marmara Sea basin show an initial colonisation of the substrate by abundant 'pio-

18 ka
Aegean Sea   *Marmara Sea*   Black Sea

Dardanelles   Bosphorus
-120 m   -100 m below modern sea level
                                                                        ?-150 m

12 ka
Aegean Sea   *Marmara Sea*   Black Sea

                     Dardanelles   Bosphorus
-70 m
                                                                        ?

10 ka
Aegean Sea   *Marmara Sea*   Black Sea

              Dardanelles   Bosphorus
                                        halocline
                                                        Outflow delta

9.1 ka - Present
Aegean Sea   *Marmara Sea*   Black Sea

              Dardanelles   Bosphorus
                                      halocline
                                                                        ?
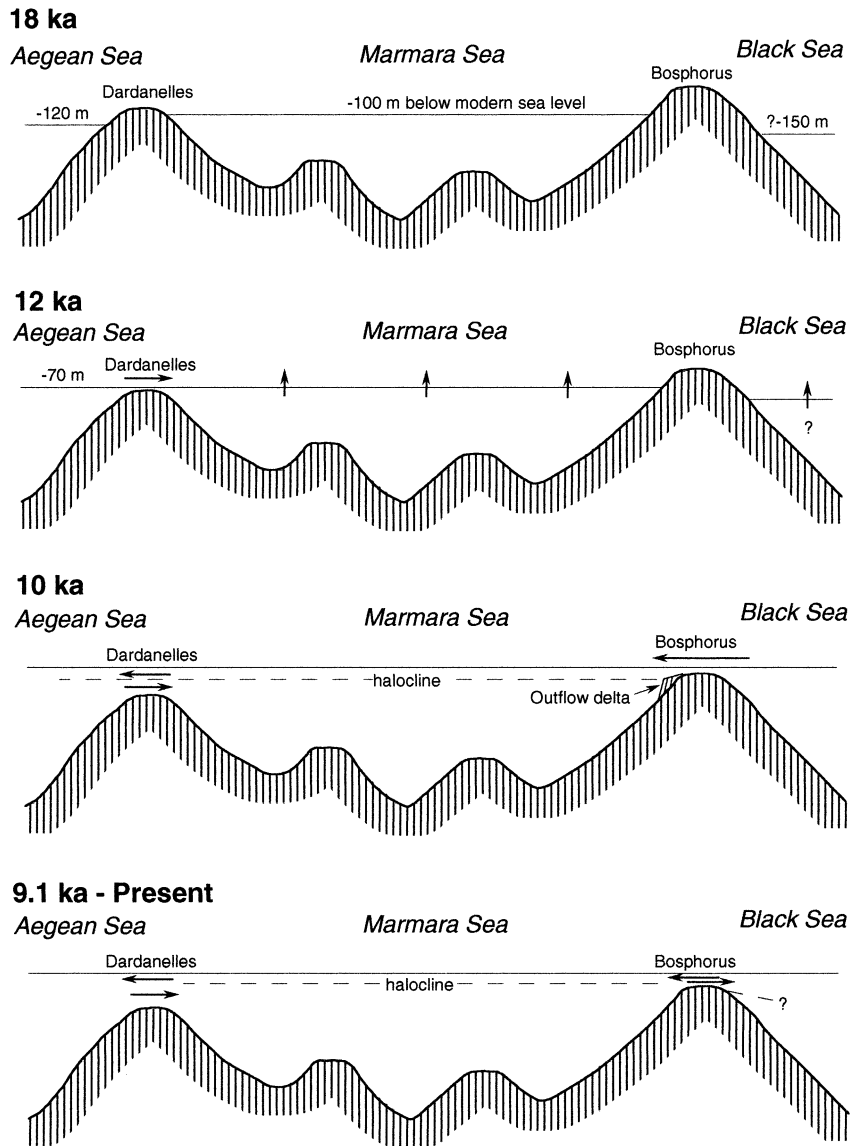
Fig. 6. Palaeoceanographic reconstruction of water exchange across the Marmara Sea since the last glacial maximum. Horizontal arrows indicate directions of predominant water flow. Vertical arrows indicate changing water levels.

neering' foraminifera, such as *Cassidulina*, *Nonionella*, and *Fursenkoina*; whereas the Marmara shelf south of the Bosphorus Strait is dominated by a low-diversity *Ammonia* assemblage at this time, indicating brackish conditions. The Dardanelles acted as a faunal filter between the Marmara Sea and the Mediterranean, so that only shallow-dwelling species have crossed the strait.

(3) After ∼10.5 ka, there was a decline of the

'pioneering' foraminifera on the southern Marmara Sea shelf and a subsequent increase in 'dysoxic' forms such as *Bulimina* and *Brizalina*. Very sparse foraminiferal assemblages dominated by *Fursenkoina* indicated that anoxia/dysoxia prevailed from ∼10.6 ka in the deeper parts of the the basin during the deposition of sapropel M1 (Core MAR98-12). The stable stratification of the water column prevented mixing, so that dis-

solved oxygen contents remained low (below $\sim$1.5 ml/l) beneath the halocline (Fig. 5).

(4) The drowning of the Bosphorus Strait-exit delta (Δ1) and the establishment of a salt wedge over the drowned delta occurred at $\sim$9.1 ka. The benthic foraminifera assemblages reflect a continued rise in sea level throughout this period, and the oxygen content of bottom waters reached a minimum at this time. Continued sea-level rise and the reduction in Black Sea outflow led to the establishment of a permanent two-way flow between the Marmara Sea and the Black Sea (across the Bosphorus) after $\sim$9.1 ka.

(5) The first appearance and subsequent proliferation of planktonic foraminifera in the shallow waters near the Bosphorus strait-exit delta at $\sim$6.1 ka indicate the encroachment of more saline surface waters as outflow from the Black Sea diminished. In the upper part of the Holocene mud drape at all studied localities (after $\sim$4.5 ka in Core MAR98-9), there was an increase in benthic foraminiferal oxic morphotypes. This suggests a continued reduction in Black Sea outflow and weakening of the halocline.

(6) The benthic foraminiferal data support the hypothesis of Aksu et al. (1999, 2002a) that Mediterranean Sea water began to flow into the Marmara Sea at $\sim$12 ka. At $\sim$9.5 ka, rising sea level reached the Bosphorus sill depth but was unable to penetrate the Black Sea to a major extent owing to the strong outflow of Black Sea surface water. Foraminiferal assemblages on the Russian Black Sea shelf (Yanko and Troitskaja, 1987) indicate that some faunal exchange took place as early as 9.58 ka. By $\sim$9.1 ka, brackish water discharge through the Black Sea–Marmara Sea gateway decreased sufficiently to allow the initiation of a stable and persistent two-way flow in the Bosphorus Strait. Importantly, the hypothesis of Ryan et al. (1997) that a catastrophic inflow of Mediterranean water penetrated the Black Sea at $\sim$7.15 ka, flooding the arable shelves of the Black Sea, is incompatible with our observations.

Acknowledgements

Appendix 1. Taxonomy

The taxonomy of benthic foraminifera reported here is based primarily on studies of Mediterranean foraminifera of Parker (1958), Jorissen (1988), Cimerman and Langer (1991), and Sgarrella and Moncharmont Zei (1993); the monograph of Black Sea foraminifera by Yanko and Troitskaja (1987); and the study of Marmara Sea foraminifera by Meriç et al. (1995). We also consulted J.A. Cushman's (1918–1931) eight-part treatise 'Foraminifera of the Atlantic Ocean', Saidova's (1975) three-part 'benthic foraminifera of the Pacific Ocean', the taxonomical monograph of Red Sea foraminifera by Hottinger et al. (1993), Indo-Pacific foraminifera by Loeblich and Tappan (1994), the revision of the HMS Challenger Foraminifera by Jones (1994), and the monograph of New Zealand foraminifera by Hayward et al. (1999). Generic classification follows Loeblich and Tappan (1987). Direct comparisons were made using the M. Al Salameen collection

of Mediterranean Sea foraminifera housed in the micropalaeontological collections at UCL.

Adelosina cliarensis **(Heron-Allen and Earland, 1930)** Plate I, 12, 13

1930 *Quinqueloculina cliarensis* Heron Allen and Earland, p. 58, pl. 3, figs. 26, 31.

1991 *Adelosina cliarensis* (Heron-Allen and Earland) – Cimerman and Langer, p. 26, pl. 18, figs. 1–4.

Adelosina dubia **(d'Orbigny, 1826)**

1826 *Triloculina dubia* d'Orbigny, p. 300, no. 24.

1923 *Adelosina dubia* (d'Orbigny) – Wiesner, p. 77, pl. 14, fig. 193.

1991 *Adelosina dubia* (d'Orbigny) – Cimerman and Langer, p. 27, pl. 18, figs. 5–7.

Adelosina **sp.** Plate I, 14

Agglutinella arenata **(Said, 1949)**

1949 *Quinqueloculina anguina* Said, p. 9, pl. 1, fig. 25.

1988 *Quinquelloculina arenata* (Said) – Haig, p. 233, pl. 4, figs. 15–17.

1994 *Agglutinella arenata* (Said) – Loeblich and Tappan, p. 306, 307, and 311, pl. 69, figs. 9–11, pl. 70, figs. 10–15, and pl. 74, figs. 10–13.

Ammonia ammoniformis **(d'Orbigny, 1826)**

1826 *Rotalia ammoniformis* d'Orbigny, p. 174, pl. 12, fig. 149.

1974 *Ammonia ammoniformis* (d'Orbigny) – Colom, p. 140, fig. 23.

1987 *Ammonia ammoniformis* (d'Orbigny) – Yanko and Troitskaja, p. 42, pl. 10, figs. 1–10.

Occurrence: Reported from the Mediterranean and the Atlantic coast of Spain (Colom, 1974) and from 5 to 220 m depth on the Black Sea Shelf where it is often very abundant (Yanko and Troitskaja, 1987).

Ammonia beccarii **(Linné, 1758)**

1758 *Nautilus beccarii* Linné, p. 710 (fide Ellis and Messina, 1940).

1987 *Ammonia beccarii* (Linné) – Loeblich and Tappan, p. 664, pl. 767, figs. 1–7.

Ammonia compacta **(Hofker, 1964)** Plate V, 8

1964 *Streblus compactus* Hofker, p. 99, figs. 242, 243.

1987 *Ammonia compacta* (Hofker) – Yanko and Troitskaja, p. 44, pl. 11, figs. 1–10.

Ammonia inflata **(Seguenza, 1862)**

1862 *Rosalina inflata* Seguenza, p. 106, pl. 1, fig. 6.

1988 *Ammonia beccarii* forma *inflata* – Jorissen, p. 52, pl. 6, figs. 1–4.

1991 *Ammonia parkinsoniana* (Sequenze) – Cimerman and Langer, p. 76, pl. 87, figs. 5, 6.

Ammonia novoeuxinica **Yanko, 1979**

1979 *Ammonia novoeuxinica* Yanko, 1979, pl. 24b, fig. 1

1987 *Ammonia novoeuxinica* Yanko – Yanko and Troitskaja, p. 46, pl. 12, figs. 1–3.

Occurrence: Originally described from the Black Sea Shelf where it was found at depths of 7–56 m (Yanko and Troitskaja, 1987).

Ammonia parasovica **Stschedrina and Mayer, 1975** Plate V, 3, 4

1975 *Ammonia parasovica* Stschedrina and Mayer, p. 255, pl. 2, figs. 4–6.

1987 *Ammonia parasovica* Stschedrina and Mayer – Yanko and Troitskaja, p. 47, pl. 12, figs. 4–6.

1995 *Ammonia parasovica* – Meriç et al., pl. 12, figs. 4a–c.

Occurrence: Originally described from the Black Sea Shelf where it was found at depths of 5–40 m (Yanko and Troitskaja, 1987); Meriç et al. (1995) first reported it from the Marmara Sea.

Ammonia parkinsoniana **(d'Orbigny, 1839)**

1839 *Rosalina parkinsoniana* d'Orbigny, p. 99, pl. 4, figs. 25–27.

1991 *Ammonia parkinsoniana* (d'Orbigny) – Cimerman and Langer, p. 76, pl. 87, figs. 7–9.

1993 *Ammonia parkinsoniana* (d'Orbigny) – Sgarrella and Moncharmont Zei, p. 228, pl. 20, figs. 3–4.

Ammonia tepida **(Cushman, 1926)** Plate V, 7

1926 *Rotalia beccarii* (Linné) var. *tepida* Cushman, p. 79, pl. 1 (fide Ellis and Messina, 1940).

1931 *Rotalia beccarii* (Linné) var. *tepida* Cushman – Cushman, p. 61, pl. 13, fig. 3a–c.

1965 *Streblus beccarii* (Cushman) – Todd, p. 29, pl. 6, fig. 1, pl. 7, fig. 2.

1988 *Ammonia parkinsoniana* (d'Orbigny) forma *tepida* Cushman – Jorissen, p. 56, pl. 10, figs. 1–3.

1991 *Ammonia tepida* (Cushman) – Cimerman and Langer, p. 76, pl. 87, figs. 10–12.

Ammonia sp. 1 (Cimerman and Langer, 1991)
Plate V, 5a,b, 6

1991 *Ammonia* sp. 1 – Cimerman and Langer, p. 77, pl. 88, figs. 1–4.

Remarks: Valentina Yanko (personal communication to M.A.K., 2001) regards this to be a form of *Ammonia tepida*.

Amphicoryna proxima (Silvestri, 1872) Plate II, 5

1872 *Nodosaria proxima* Silvestri, p. 63, pl. IV, fig. 138–147.

1994 *Amphicoryna proxima* (Silvestri) – Jones, pl. 64, fig. 5.

Angulogerina angulosa (Williamson, 1858)
1858 *Uvigerina angulosa* Williamson, p. 67, pl. 5, figs. 3–4.

1987 *Angulogerina angulosa* (Williamson) – Loeblich and Tappan, p. 525, pl. 574, figs. 5–9.

Anomalinoides globulosus (Chapman and Parr, 1937)
1937 *Anomalina globulosa* Chapman and Parr, p. 117, pl. 9, fig. 27.

1989 *Anomalinoides globulosus* (Chapman and Parr) – Inoue, pl. 27, fig. 8.

Asterigerinata mamilla (Williamson, 1858)
1858 *Rotalina mamilla* Williamson, p. 54, pl. 4, figs. 109–111.

1931 *Rotalina mamilla* (Williamson) – Cushman, p. 23, pl. 5, fig. 11.

1958 *Discorbis mamilla* (Williamson) – Le Cavez, Y., p. 182.

1991 *Asterigerinata mamilla* (Williamson) – Cimerman and Langer, p. 73, pl. 82, figs. 1–4.

1995 *Asterigerinata mamilla* (Williamson) – Meriç et al., pl. 10, figs. 4a–d.

Astrononion stelligerum (d'Orbigny, 1839)
1839 *Nonionina stelligerum* d'Orbigny, p. 128, pl. 3, fig. 12.

1930 *Nonionina stelligerum* (d'Orbigny) – Cushman, p. 7, pl. 8, fig. 8–12, pl. 3, fig. 1–3.

1991 *Astrononion stelligerum* (d'Orbigny) – Cimerman and Langer, p. 74, pl. 84, figs. 13–15.

Aubignyna perlucida (Heron-Allen and Earland, 1913) Plate IC, 8–10
1913 *Rotalia perlucida* Heron-Allen and Earland, p. 139, pl. 13, figs. 7–9.

1987 *Aubignyna perlucida* (Heron-Allen and Earland) – Yanko and Troitskaja, p. 36, pl. 7, figs. 6–9; pl. 8, fig. 1.

1988 *Ammonia perlucida* (Heron-Allen and Earland) – Jorissen, p. 62, pl. 2, figs. 11–12.

1999 *Aubignyna perlucida* (Heron-Allen and Earland) – Hayward et al., p. 162, pl. 16, figs. 1–3.

Aubignyna planidorso (Atkinson, 1969)
1969 *Buccella planidorso* Atkinson, p. 535, pl. 6, fig. 3a–c.

1991 *Aubignyna planidorso* (Atkinson, 1969) – Cimerman and Langer, p. 75, pl. 86, figs. 5–6.

Bigenerina nodosaria d'Orbigny, 1826 Plate I, 9
1826 *Bigenerina nodosaria*, d'Orbigny, p. 261, pl. 2, figs. 9–10.

1974 *Bigenerina nodosaria* d'Orbigny – Colom, p. 87, fig. 6a–k.

1987 *Bigenerina nodosaria* d'Orbigny – Loeblich and Tappan, p. 172, pl. 191, figs. 1, 2.

1991 *Bigenerina nodosaria* d'Orbigny – Cimerman and Langer, p. 21, pl. 9, figs. 1–6.

Biloculinella globula (Bornemann, 1855) Plate II, 1
1855 *Biloculina globulus* Bornemann, p. 349, pl. 19, fig. 3a,b.

1891 *Biloculina globulus* Bornemann – Schlumberger, p. 575, pl. 12, fig. 97–100.

1991 *Biloculina globulus* Bornemann – Cimerman and Langer, p. 40, pl. 36, fig. 1–2.

Bolivina variabilis (Williamson, 1858)

1858 *Textularia variabilis* Williamson, p. 76, pl. 6, figs. 7–8.

1988 *Bolivina variabilis* (Williamson) – Alavi, pl. 2, fig. 4.

1991 *Bolivina variabilis* (Williamson) – Cimerman and Langer, p. 59, pl. 61, figs. 7–8.

Brizalina alata (Seguenza, 1862) Plate II, 12

1862 *Vulvulina alata* Seguenza, p. 115, pl. 2, fig. 5.

1937 *Bolivina alata* (Seguenza) – Cushman, p. 106, pl. 13, figs. 3–11.

1991 *Brizalina alata* (Seguenza) – Cimerman and Langer, p. 59, pl. 61, figs. 12–14.

1995 *Brizalina alata* (Seguenza) – Meriç et al., pl. 6, figs. 8a–c.

Brizalina catanensis (Seguenza, 1862) Plate II, 11

1862 *Bolivina catanensis* Seguenza, pp. 113, 125, pl. 2, fig. 3.

1993 *Bolivina catanensis* Seguenza – Sgarrella and Moncharmont Zei, p. 208, pl. 14, figs. 4–5.

Brizalina dilatata (Reuss, 1850) Plate II, 13

1850 *Bolivina dilatata* Reuss, p. 381, pl. 48, figs. 15a–c.

1988 *Bolivina dilatata* Reuss – Alavi, pl. 2, fig. 5.

1991 *Brizalina dilatata* (Reuss) – Cimerman and Langer, p. 59, pl. 62, fig. 2.

Brizalina spathulata (Williamson, 1858) Plate II, 9

1858 *Textularia variabilis* var. *spathulata* Williamson, p. 76, pl. 6, figs. 164, 165.

1988 *Brizalina spathulata* (Williamson) – Alavi, pl. 1, fig. 7; pl. 2, fig. 10.

1991 *Brizalina spathulata* (Williamson) – Cimerman and Langer, p. 60, pl. 62, figs. 3–5.

Brizalina striatula (Cushman, 1922) Plate II, 10

1922 *Bolivina striatula* Cushman, p. 27, pl. 3, fig. 10.

1991 *Brizalina striatula* (Cushman) – Cimerman and Langer, p. 60, pl. 62, figs. 6–9.

Brizalina sp. 2 (Cimerman and Langer)

1991 *Brizalina* sp. 2. Cimerman and Langer, p. 60, pl. 62, fig. 1

Brizalina sp. Plate 2, fig. 14

Remarks: A flairing form with an inflated proloculum and a slightly dentate periphery.

Bulimina aculeata d'Orbigny, 1826 Plate III, 3

1826 *Bulimina aculeata* d'Orbigny, p. 269, fig. 7.

1988 *Bulimina aculeata* d'Orbigny – Alavi, pl. 1, fig. 12.

1991 *Bulimina aculeata* d'Orbigny – Cimerman and Langer, p. 61, pl. 63, fig. 10–11.

Bulimina costata d'Orbigny, 1852 Plate III, 5, 6

1859 *Bulimina costata* d'Orbigny, p. 194.

1888 *Bulimina alazanensis* d'Orbigny – Alavi, pl. 1, figs. 6, 8.

1991 *Bulimina alazanensis* d'Orbigny – Sgarrella and Moncharmont Zei, p. 211, pl. 15, fig. 3.

Bulimina elongata d'Orbigny, 1846 Plate III, 4

1846 *Bulimina elongata* d'Orbigny, p. 187, pl. 11, figs. 19–20.

1991 *Bulimina elongata* d'Orbigny – Cimerman and Langer, p. 62, pl. 64, figs. 3–8.

Bulimina inflata Seguenza, 1862

1862 *Bulimina inflata* Seguenza, p. 109, pl. 1, fig. 10.

1988 *Bulimina inflata* Seguenza – Alavi, pl. 1, fig. 5.

Bulimina marginata d'Orbigny, 1875

1875 *Bulimina marginata* d'Orbigny, p. 269, pl. 12, figs. 10–12.

1991 *Bulimina marginata* d'Orbigny – Cimerman and Langer, p. 62, pl. 64, figs. 9–11.

1994 *Bulimina marginata* d'Orbigny – Jones, p. 55, pl. 51, figs. 3–5.

Bulimina sp. Plate III, 7

Remarks: A species with fine, discontinuous costae.

Canalifera parkerae (Yanko, 1974)

1958 *Nonion* sp. B – Parker, p. 259, pl. 1, figs. 40, 41.

1974 *Cribroelphidium parkeri* Yanko, p. 24, pl. 1, fig. 1

1987 *Canalifera parkerae* (Yanko) – Yanko and Troitskaja, p. 51, pl. 14, figs. 1–6.

Occurrence: Reported from the Mediterranean and Black Sea, where it is found at depths from 7 to 200 m.

Cassidulina crassa d'Orbigny, 1839

1839 *Cassidulina crassa* d'Orbigny, p. 56, pl. 7, figs. 18–20.

1993 *Cassidulina crassa* d'Orbigny – Sgarrella and Moncharmont Zei, p. 236, pl. 23, figs. 10–11.

Cassidulina carinata Silvestri, 1896 Plate III, 1, 2

1896 *Cassidulina laevigata* d'Orbigny var. *carinata* Silvestri, p. 104, pl. 2, fig. 10a-c.

1993 *Cassidulina carinata* Silvestri – Sgarrella and Moncharmont Zei, p. 236, pl. 23, figs. 8–9.

Cassidulina laevigata d'Orbigny, 1826

1826 *Cassidulina laevigata* d'Orbigny, p. 282.

1987 *Cassidulina laevigata* d'Orbigny – Loeblich and Tappan, p. 504, pl. 555, figs. 1–8.

Cibicides advenum (d'Orbigny, 1839)

1839 *Truncatulina advena* d'Orbigny, p. 87, pl. 6. figs. 3–5.

1977 *Cibicides advenum* (d'Orbigny) – Le Calvez, Y., p. 122, figs. 1–5.

1991 *Cibicides advenum* (d'Orbigny) – Cimerman and Langer, p. 70, pl. 74, figs. 8–10.

1995 *Cibicides advenum* (d'Orbigny) – Meriç et al., pl. 9, figs. 4a–c.

Cibicides refulgens deMontfort, 1808

1808 *Cibicides refulgens* deMontfort, p. 123, fig. 122 (fide Ellis and Messina).

1974 *Cibicides refulgens* deMontfort – Colom, p. 150, fig. 31o–t.

1987 *Cibicides refulgens* deMontfort – Loeblich and Tappan, p. 582, pl. 634, fig. 1–3.

1991 *Cibicides refulgens* deMontfort – Cimerman and Langer, p. 70, pl. 75, figs. 5–9.

Cornuspira planorbis Schultze, 1854

1854 *Cornuspira planorbis* Schultze, p. 40, pl. 2, fig. 21.

1993 *Cornuspira planorbis* Schultze – Hottinger et al., p. 43, pl. 23, figs. 1–3.

Cycloforina rugosa (d'Orbigny, 1826)

1826 *Quinqueloculina rugosa* d'Orbigny, p. 302, fig. 24.

1991 *Cycloforina rugosa* (d'Orbigny, 1826) – Cimerman and Langer, p. 33, pl. 28, figs. 3–4.

Discorbia candeiana (d'Orbigny, 1839)

1839 *Rosalina candeiana* d'Orbigny, p. 97, pl. 4, figs. 2–4.

1922 *Truncatulina candeiana* (d'Orbigny) – Cushman, p. 47, pl. 6, figs. 7–9.

1959 *Discorbis candeiana* (d'Orbigny) – Graham and Militante, p. 93, pl. 13, fig. 22.

1977 *Discorbia candeiana* (d'Orbigny) – Sellier de Civrieux, p. 18, pl. 4, figs. 1–8, pl. 5, figs. 1–8, pl. 6, figs. 1–8, pl. 14, figs. 6–8.

Discorbinella bertheloti (d'Orbigny, 1839)

1839 *Rosalina bertheloti* d'Orbigny, p. 135, pl. 1, figs. 28–30.

1884 *Discorbinella bertheloti* (d'Orbigny) – Brady, p. 650, pl. 89, fig. 10.

1993 *Discorbinella bertheloti* (d'Orbigny) – Hottinger et al., p.1114, pl. 150, figs. 1–4.

1999 *Discorbinella bertheloti* (d'Orbigny) – Hayward et al., p. 152, pl. 14, figs. 1–3.

Elphidium aculeatum (d'Orbigny, 1846)

1846 *Polystomella aculeata* d'Orbigny, p. 131, pl. 6, figs. 1–4.

1991 *Elphidium aculeatum* (d'Orbigny) – Cimerman and Langer, p. 77, pl. 89, figs. 1–4.

Elphidium cf. E. advenum (Cushman, 1922)

cf. 1922 *Polystomella advena* Cushman, p. 56, pl. 9, figs. 11, 12.

1991 *Elphidium* cf. *E. advenum* (Cushman) –

Cimerman and Langer, p. 77, pl. 89, figs. 5–7.

Elphidium articulatum (d'Orbigny, 1839) Plate V, 10a,b

1839 *Polystomella articulata* d'Orbigny p. 30, pl. 3, figs. 9–10.

1980 *Elphidium articulatum* (Boltovskoy et al.) – Boltovskoy et al., p. 85, pl. 13, figs. 1–4.

Elphidium depressulum (Cushman, 1933)

1933 *Elphidium advenum* Cushman var *depressulum* – Cushman p. 51, pl. 12, figs, 4a, b.

1991 *Elphidium depressulum* Cushman – Cimerman and Langer, p. 78, pl. 90, figs. 7–8.

Elphidium jenseni Cushman, 1924

1924 *Elphidium jenseni* Cushman, p. 49, pl. 16, figs. 4, 6.

1933 *Elphidium jenseni* Cushman – Cushman, p. 48, pl. 11, figs. 6, 7.

1939 *Elphidium jenseni* Cushman – Cushman, p. 62, pl. 17, figs. 14, 15.

1991 *Elphidium jenseni* (Cushman) – Cimerman and Langer, p. 78, pl. 92, figs. 1–3.

Elphidium granosum (d'Orbigny, 1846)

1846 *Nonionina granosa* d'Orbigny, p. 110, pl. 5, figs. 19–20.

1991 *Elphidium granosum* (d'Orbigny) – Sgarrella and Moncharmont Zei, p. 229, pl. 21, figs. 1–2.

Elphidium macellum (Fichtel and Moll, 1798) Plate V, 11

1798 *Nautilus macellum* var. *beta* Fichtel and Moll, p. 66, pl. 19, fig. h–k.

1991 *Elphidium macellum* (Fichtel and Moll) – Cimerman and Langer, p. 78, pl. 89, fig. 9.

Elphidium ponticum Dolgopolskaya and Pauli, 1931

1931 *Elphidium advenum* var. *pontica* Dolgopolskaya and Pauli, p. 36, pl. 3, fig. 14.

1987 *Elphidium ponticum* Dolgopolskaya and Pauli – Yanko and Troitskaja, p.56, pl. 16, fig. 3; pl. 17, figs. 1–3.

Occurrence: Yanko and Troitskaja reported this species from the Black Sea Shelf and from the Mediterranean Sea.

Elphidium translucens Natland, 1938 Plate V, 12

1938 *Elphidium translucens* Natland, p. 144, pl. 5, figs. 3, 4.

1970 *Cribrononion translucens* (Natland) – v. Daniels, p. 88, pl. 7, figs. 13a,b.

1976 *Elphidium translucens* Natland – Hansen and Lykke – Andersen, p. 11, pl. 7, figs. 1–11.

1991 *Elphidium translucens* Natland – Cimerman and Langer, p. 79, pl. 92, figs. 7–11.

Elphidium sp. 2 (Cimerman and Langer)

1991 *Elphidium* sp. 2 – Cimerman and Langer, p. 80, pl. 90, fig. 9.

Elphidium vitreum Collins, 1974

1974 *Elphidium vitreum* Collins, p. 43, pl. 3, fig. 35.

Evolutononion shansiense N.W. Wang, 1964

1964 *Evolutononion shansiense* N.W. Wang, p. 58.

1975 *Nonion shansiense* (N.W. Wang) – P.X. Wang, p. 27, pl. 2, figs. 1–2.

1981 *Evolutononion shansiense* (N.W. Wang) – N.W. Wang, p.15, pl. 1, figs. 1–15.

Favulina hexagona (Williamson, 1848) Plate II, 8

1848 *Entosolenia squamosa* (Montague) var. *hexagona* Williamson, p. 20, pl. 2, fig. 23.

1987 *Favulina hexagona* (Williamson) – Hottinger et al., p. 80, pl. 92, figs. 9–13.

1995 *Favulina hexagona* (Williamson) – Meriç et al., pl. 6, fig. 7.

Favulina scalariformis (Williamson, 1848)

1848 *Entosolenia squamosa* (Montague) var. *scalariformis* Williamson, p. 13, pl. 2, figs. 21, 22.

1991 *Favulina scalariformis* (Williamson, 1848) – Cimerman and Langer, p. 55, pl. 58, figs. 5–7.

Fursenkoina acuta (d'Orbigny, 1846) Plate III, 11, 12

1846 *Polymorphina acuta* d'Orbigny, p. 234, pl. 13, fig. 4–5.

1848 *Virgulina schreibersiana* Czjzek, p. 147, pl. 13, fig. 18–21.

1972 *Virgulina schreibersiana* Czjzek – Rosset Moulinier, p. 184.

1985 *Fursenkoina acuta (*d'Orbigny) – Papp and Schmid, p. 82, pl. 75, figs. 1–6.

1991 *Fursenkoina acuta* (d'Orbigny) – Cimerman and Langer, p. 64, pl. 67, figs. 1–2.

Globobulimina affinis (d'Orbigny, 1839) Plate III, 8

1839 *Bulimina affinis* d'Orbigny, p. 105, pl. 2, figs. 25–26.

1958 *Globobulimina affinis* (d'Orbigny), p. 262, pl. 2, figs. 24–25.

Globocassidulina subglobosa (Brady, 1881)

1881 *Cassidulina subglobosa* Brady, p. 60.

1884 *Cassidulina subglobosa* Brady – Brady p. 430, pl. 54, fig. 17a–c.

1991 *Globocassidulina subglobosa* (Brady) – Cimerman and Langer, p. 61, pl. 63, figs. 4–6.

Gavelinopsis praegeri (Heron-Allen and Earland, 1913)

1913 *Discorbina praegeri* Heron-Allen and Earland, p. 122, pl. 10, figs. 8–10 (fide Ellis and Messina, 1940).

1987 *Gavelinopsis praegeri* (Heron-Allen and Earland) – Loeblich and Tappan, p. 560, pl. 608, fig. 6–12.

1991 *Gavelinopsis praegeri* (Heron-Allen and Earland) – Cimerman and Langer, p. 66, pl. 70, figs. 3–4.

Gyroidinoides lamarckiana (d'Orbigny, 1839) Plate IV, 11, 12a,b

1939 *Rotalia larmarckiana* d'Orbigny, p. 131, pl. 1, figs. 13–15.

1991 *Gyroidinoides lamarckiana* (d'Orbigny) – Cimerman and Langer, p. 75, pl. 85, figs. 7–9.

1995 *Gyroidina umbonata* (Silvestri) – Meriç et al., pl. 12, figs. 1a–b.

Gyroidinoides soldanii (d'Orbigny, 1826)

1826 *Gyroidina soldanii* d'Orbigny, p. 278, fig. 5.

1991 *Gyroidinoides soldanii* (d'Orbigny, 1826) –

Cimerman and Langer, p. 75, pl. 85, figs. 5–6.

Haynesina anglica (Murray, 1965)

1965 *Protelphidium anglicum* Murray, 1965, p. 149, pl. 25, figs. 1–5.

1987 *Haynesina anglica* (Murray) – Yanko and Troitskaja, p. 54, pl. 20, figs. 1–5.

Haynesina depressula (Walker and Jacob, 1798) Plate IV, 4, 5

1798 *Nautilus depressula* (Walker and Jacob), p. 641, pl. 14, fig, 33.

1976 *Nonion depressulu*s (Walker and Jacob) – Hansen and Lykke – Andersen, p. 21, pl. 19, figs. 3, 6.

1978 *Haynesina depressula* (Walker and Jacob) – Banner and Culver, p. 200, pl. 10, fig. 1–8.

1991 *Haynesina depressula* (Walker and Jacob) – Cimerman and Langer, p. 81, pl. 83, figs. 1–4.

Homalohedra sp. Plate II, 7

Hyalinea balthica (Schroeter, 1783) Plate III, 13

1783 *Nautilus balticus* Schroeter, p. 20, pl. 1, fig. 2.

1958 *Hyalinea balthica* (Schroeter) – Parker, p. 275, pl. 4, fig. 39.

1993 *Hyalinea balthica* (Schroeter) – Sgarrella and Moncharmont Zei, p. 234, pl. 22, fig. 12.

1995 *Hyalinea balthica* (Schroeter) – Meriç et al., pl. 9, figs. 2a–b.

Occurrence: Generally found at outer neritic to middle bathyal depths in the eastern Mediterranean (Parker, 1958), it is occasionally found at shallow stations (25–39 m) in the Gulf of Naples (Sgarrella and Moncharmont Zei, 1993).

Laevidentalina leguminiformis (Batsch, 1791)

1791 *Nautilus (Orthoceras) leguminiformis* Batsch, pp. 2, 5, pl. 3, fig. 8a–b.

1993 *Dentalina leguminiformis* (Batsch) – Sgarrella and Moncharmont Zei, p. 194, pl. 11, fig. 10.

Laevidentalina sidebottomi (Cushman, 1933)

1933 *Dentalina sidebottomi* Cushman, p. 12, pl. 3, fig. 4.

1994 *Laevidentalina sidebottomi* (Cushman) – Loeblich and Tappan, p. 350, pl. 113, figs. 13–19.

Lagena doveyensis Haynes, 1973
1973 *Lagena doveyensis* Haynes, p. 85, pl. 12, figs. 7–8.

Lagena striata (d'Orbigny, 1839) Plate II, 4
1839 *Oolina striata* d'Orbigny, pl. 5, fig. 12.
1991 *Lagena striata* (d'Orbigny) – Cimerman and Langer, p. 53, pl. 55, figs. 6–7.

Lagena strumosa Reuss, 1858

1858 *Lagena strumosa* Ruess, p. 434.
1993 *Lagena strumosa* Ruess – Hottinger et al., pl. 90, figs. 18–25.

Lenticulina gibba (d'Orbigny, 1826) Plate II, 6
1826 *Cristellaria gibba* d'Orbigny, p. 292, no. 17.
1839 *Cristellaria gibba* d'Orbigny, p. 40, pl. 7, figs. 20, 21.
1913 *Cristellaria gibba* d'Orbigny – Cushman, p. 105, pl. 25, fig. 4.
1974 *Robulus gibba* (d'Orbigny) – Colom, p. 96, fig. 11 g.
1977 *Lenticulina gibba* (d'Orbigny) – Le Calvez, Y., p. 25, fig. 1.
1991 *Lenticulina gibba* (d'Orbigny) – Cimerman and Langer, p. 51, pl. 53, figs. 7–11.

Linaresia bikiniensis (McCulloch, 1977)
1977 *Valvulineria* (?) *bikiniensis* McCulloch, p. 349, pl. 134, figs. 9–11.
1990 *Linaresia semicribrata* (McCulloch) – Ujiie, p. 50, pl. 29, figs. 5–6.
1994 *Linaresia bikiniensis* (McCulloch) – Loeblich and Tappan, p. 605, pl. 363, figs. 1–6.

Lobatula lobatula (Walker and Jacob, 1798) Plate IV, 1a,b, 2a,b
1798 *Nautilus lobatulus* Walker and Jacob (in Kanmacher), p. 642, pl. 14, fig. 36 (fide Ellis and Messina, 1940).
1958 *Cibicides lobatulus* (Walker and Jacob) – Le Calvez, Y., p. 188.
1987 *Lobatula lobatula* (Walker and Jacob) – Loeblich and Tappan, p. 583, pl. 637, figs. 10–13.

1991 *Lobatula lobatula* (Walker and Jacob) – Cimerman and Langer, p. 71, pl. 75, figs. 1–4.
1995 *Lobatula lobatula* (Walker and Jacob) – Meriç et al., pl. 9, figs. 3a–b.

Massilina gualtieriana (d'Orbigny, 1839)
1839 *Quinqueloculina gualtieriana* d'Orbigny, p. 186, pl. 11, figs. 1–3.
1991 *Massilina gualtieriana* (d'Orbigny) – Cimerman and Langer, p. 35, pl. 29, figs. 6–9.

Mayerella brotzkajae (Mayer) emend Yanko, 1987
1968 *Elphidiella*(?) *brotzkajae* Mayer, p. 33, fig. 52.
1987 *Mayerella brotzkajae* (Mayer) emend Yanko – Yanko and Troitskaja, p. 60, pl. 22, figs. 1–3; pl. 23, figs. 1–4; pl. 24, figs. 1, 2.
Occurrence: Yanko and Troitskaja (1987) reported this species from low-salinity waters on the Black Sea shelf (Danube Delta), the Caspian Sea, and the Aral Sea.

Melonis barleanum (Williamson, 1858)
1858 *Nonionina barleana* Williamson, p. 32, pl. 3, figs. 68–69.
1993 *Melonis barleanum* (Williamson, 1858) – Sgarrella and Moncharmont Zei, p. 242, pl. 26, figs. 1–2.

Melonis pompilioides (Fichtel and Moll, 1798)
1798 *Nautilus pompilioides* Fichtel and Moll, p. 31, pl. 2, figs. a–c.
1988 *Melonis pompilioides* (Fichtel and Moll, 1798) – Alavi, pl. 2, figs. 6–9.
1991 *Melonis pompilioides* (Fichtel and Moll, 1798) – Cimerman and Langer, p. 74, pl. 85, figs. 1–4.

Miliolinella labiosa (d'Orbigny, 1839)
1839 *Triloculina labiosa* d'Orbigny, p. 178, pl. 10, figs. 12–14.
1923 *Miliolina labiosa* (d'Orbigny) –Wiesner, p. 71, pl. 134, fig. 172.
1929 *Triloculina lobiosa* d'Orbigny – Cushman, p. 60, pl. 15, fig. 3.
1991 *Miliolinella labiosa* (d'Orbigny) – Cimerman and Langer, p. 41, pl. 3 8, figs. 1–3

Miliolinella subrotunda (Montagu, 1803)
1803 *Vermiculum subrotunda* Montagu, p. 521 (fide Ellis and Messina, 1940).
1923 *Miliolinella subrotunda* (Walker and Boys) – Wiesner, p. 69, pl. 13, figs. 165–169.
1991 *Miliolinella subrotunda* (Montagu) – Cimerman and Langer p. 42, pl. 38, figs. 4–9.

Nonionoides auris (d'Orbigny, 1839)
1839 *Valvulina auris* d'Orbigny, p. 47, pl. 2, figs. 15–17.
1933 *Nonionella auris* (d'Orbigny) – Cushman, p. 45, pl. 10, fig. 10, pl. 11, fig. 10, pl. 11, fig. 1.
1975 *Nonionoides auris* (d'Orbigny) – Saidova, p. 248.
Remarks: Saidova (1975) transferred this species to her new genus *Nonionoides.*

Nonionella opima Cushman, 1947 Plate IV, 6, 7
1947 *Nonionella opima* Cushman, p. 90, pl. 20, figs. 1–3.

Nonionella turgida (Williamson, 1858)
1858 *Rotalina turgida* Williamson, p. 50, pl. 4, figs. 95–97.
1991 *Nonionella turgida* (Williamson) – Cimerman and Langer, p. 74, pl. 84, figs. 6–8.

Parafissurina staphyllearia (Schwager, 1866)
1866 *Fissurina staphyllearia* Schwager, p. 209, pl. 5, fig. 24
1991 *Parafissurina staphyllearia* (Schwager) – Sgarrella and Moncharmont Zei, p. 205, pl. 13, fig. 12.

Planorbulina mediterranensis d'Orbigny, 1826
Plate IV, 3a,b
1826 *Planorbulina mediterranensis* d'Orbigny, p. 280, no. 2.
1931 *Planorbulina mediterranensis* d'Orbigny – Cushman, p. 129, pl. 24, figs. 5–8.
1960 *Planorbulina mediterranensis* d'Orbigny – Barker, pl. 92, figs. 1–3.
1991 *Planorbulina mediterranensis* d'Orbigny – Cimerman and Langer, p. 71, pl. 78, figs. 1–8.
1995 *Planorbulina mediterranensis* d'Orbigny – Meriç et al., pl. 10, figs. 5a–b

Polymorphina sp. A

Porosononion martkobi (Bogdanowicz, 1947)
Plate V, 9a,b
1947 *Nonion martkobi* Bogdanowicz, p. 30, pl. 4. figs. 4a–c.
1987 *Porosononion martcobi* (Bogdanowicz) (sic) – Yanko and Troitskaya, p. 52, pl. 18, figs. 1–4.
cf. 1991 *Porosononion* sp. 1 – Cimerman and Langer, p. 81, pl. 84, figs. 9–12.
Remarks: Found in high numbers within the deltaic sediments recovered in Core MAR98-9. On the Black Sea shelf, this species tolerates salinities as low as 11‰ (Yanko and Trotskaya, 1987). Our identification of this species was verified by Valentina Yanko.

Procerolagena chathamensis (McCulloch, 1977)
1977 *Lagena multilatera* subsp. *chathamensis* McCulloch, p. 41, pl. 50, fig. 6.
1994 *Procerolagena chathamensis* (McCulloch) – Loeblich and Tappan, p. 380, pl. 143, figs. 7–11.

Procerolagena implicata (Cushman and McCulloch, 1950)
1950 *Lagena implicata* Cushman and McCulloch, p. 340, pl. 45, figs. 5–7.
1951 *Cushmanina*? sp. *A.* (Cushman and McCulloch) – Hatta and Ujiie, p. 168, pl. 23, figs. 2–3.
1994 *Procerolagena implicata* (Cushman and McCulloch) – Loeblich and Tappan, p. 380, pl. 143, figs. 12–13.

Protoglobobulimina pupoides (d'Orbigny, 1846)
1846 *Bulimina pupoides* d'Orbigny, p. 185, pl. 11, figs. 11, 12.
1991 *Protoglobobulimina pupoides* (d'Orbigny, 1846) – Cimerman and Langer, p. 62, pl. 65, figs. 1–3.

Pseudononion granuloumbilicatum (Zheng, 1979)
1979 *Pseudononion granuloumbilicatum* Zheng, p. 189, 229, pl. 25, fig. 6.

Pygmaeoseistrom islandicum (W.R. Jones, 1984)
1984 *Pygmaeoseistrom islandicum* W.R. Jones, p. 134, pl. 7, fig. 18.

Pyramidulina catesby (d'Orbigny, 1839)
1839 *Nodosaria catesbyi* d'Orbigny, p. 16, pl. 1, figs. 8–10.
1977 *Lagenonodosaria catesbyi* (d'Orbigny) – Le Calvez, p. 47, figs. 1–5, 8–10.
1994 *Pyramidulina catesbyi* (d'Orbigny) – Loeblich and Tappan, p. 353, pl. 116, figs. 10–12.

Quinqueloculina patagonica d'Orbigny, 1839
Plate II, 2a,b
1839 *Quinqueloculina patagonica* d'Orbigny, v. 5, pt. 5, p. 84, pl. 4, figs. 14–16.

Quinqueloculina seminula (Linné, 1758)
1758 *Serpula seminulum* Linné, p. 786, pl. 2, fig. 1a–c.
1991 *Quinqueloculina seminula* (Linné) – Cimerman and Langer, p. 38, pl. 34, figs. 9–12.

Quinqueloculina stalkeri Loeblich and Tappan, 1953
1953 *Quinqueloculina stalkeri* Loeblich and Tappan, p. 40, pl. 5, figs. 5–9
1993 *Quinqueloculina stalkeri* Loeblich and Tappan – Sgarrella and Moncharmont Zei, p. 174, pl. 5, figs. 13–14.

Quinqueloculina stelligera Schlumberger, 1893
Plate II, 3
1893 *Quinqueloculina stelligera* Schlumberger, p. 210, textfig. 17, pl. 2, figs. 58, 59.
1991 *Quinqueloculina stelligera* Schlumberger – Cimerman and Langer, p. 38, pl. 34, figs. 13–15.

Rectuvigerina phlegeri Le Calvez, 1959 Plate III, 9
1959 *Rectuvigerina phlegeri* Le Calvez – Berthois and LeCalvez, p. 363, pl. 1, fig. 11.
1960 *Rectuvigerina raricosta* Moncharmont Zei, pp. 149–150, pl. 4, figs. 18–20.
1988 *Rectuvigerina phlegeri* Le Calvez – Alavi, pl. 1, fig. 4.
1993 *Rectuvigerina phlegeri* Le Calvez –

Sgarrella and Moncharmont Zei, p. 215, pl. 16, figs. 3, 4.
1995 *Rectuvigerina* cf. *elongastriata* (Colom) – Meriç et al., pl. 7, fig. 3.

Rosalina bradyi (Cushman, 1915)
1884 *Discorbina globularis* – Brady (not d'Orbigny), p. 178, pl. 86, figs. 8a–c.
1915 *Discorbina globularis* (d'Orbigny) var. *bradyi* Cushman, p. 12.
1951 *Discopulvinulina bradyi* (Cushman) – Hofker, p. 452, fig. 310a,b.
1991 *Rosalina bradyi* (Cushman) – Cimerman and Langer, p. 66, pl. 71, figs. 1–5.

Rosalina catesbyana d'Orbigny, 1839
1839 *Rosalina catesbyana* d'Orbigny, p. 99, pl. 4, figs. 22, 24.
1987 *Rosalina catesbyana* d'Orbigny – Yanko and Troitskaja, p. 37, pl. 8, figs. 2–6.
Occurrence: Yanko and Troitskaja (1987) reported this species in water depths less than 25 m on the Black Sea shelf off the Ukraine. Also known from the Caspian Sea (Yanko and Troitskaja (1987)).

Rotorbinella lepida McCulloch, 1977
1977 *Rotorbinella lepida* McCulloch, p. 360, pl. 116, fig. 4.

Sigmoilinita sp. 1 (Cimerman and Langer)
1991 *Sigmoilinita* sp. 1 – Cimerman and Langer, p. 48, pl. 46, figs. 1–5.

Sigmoilina sp. 2 (Cimerman and Langer)
1991 *Sigmoilinita* sp. 2 – Cimerman and Langer, p. 48, pl. 46, figs. 6–8.

Sigmoilinita tenuis (Czjzek, 1848)
1848 *Quinqueloculina tenuis* Czjzek, p. 149, pl. 13, figs. 31–34.
1987 *Sigmoilinita tenuis* (Czjzek) – Loeblich and Tappan, p. 348, pl. 356, figs. 17, 18.
1988 *Sigmoilina tenuis* (Czjzek) – Alavi, pl. 1, fig. 1.

Sigmoilopsis schlumbergeri (Silvestri, 1904)
1904 *Sigmoilina schlumbergeri* Silvestri, p. 267,

textfigs. 12–14; p. 481, textfig. 6; p. 482, text-fig. 7.

1986 *Sigmoilopsis schlumbergeri* (Silvestri, 1904) – Van Morkhoven et al. p. 57, pl. 18, fig. 1a–c.

Spiroloculina cymbium d'Orbigny, 1839
1839 *Spiroloculina cymbium* d'Orbigny, p. 140, pl. 3, figs. 5, 6.
1991 *Spiroloculina cymbium* d'Orbigny – Cimerman and Langer, p. 29, pl. 22, figs. 1–4.

Spiroloculina dilatata d'Orbigny, 1846
1846 *Spiroloculina dilatata* d'Orbigny, p. 271, pl. 16, figs. 16–18.
1991 *Spiroloculina dilatata* d'Orbigny – Cimerman and Langer, p. 30, pl. 22, figs. 5–8.

Spiroloculina excavata d'Orbigny, 1846 Plate I, 11
1846 *Spiroloculina excavata* d'Orbigny, 1846 p. 271, pl. 16, figs. 19–21.
1991 *Spiroloculina excavata* d'Orbigny – Cimerman and Langer, p. 30, pl. 23, figs. 1–3.
1995 *Spiroloculina excavata* d'Orbigny – Meriç et al., pl. 2, fig. 4.

Spiroloculina tenuiseptata Brady, 1884 Plate I, 10
1884 *Spiroloculina tenuisepta* Brady, p. 153, pl. 10, fig. 5.
1991 *Spiroloculina tenuisepta* Brady – Cimerman and Langer, p. 31, pl. 24, figs. 6–9.
1995 *Spiroloculina tenuisepta* Brady – Meriç et al., pl. 2, figs. 5a–b.

Spirorutilus spp. Plate I, 3, 4a,b
1991 *Spiroplectinella sagittula* (d'Orbigny) – Cimerman and Langer, p. 20, pl. 6, figs. 5–6.
Remarks: The specimen illustrated by Cimerman and Langer (1991) as *Spiroplectinella sagittula* is misidentified and rightly belongs in the genus *Spirorutilus*. *Textularia sagittula* is the type species of *Textularia*, and cannot be transferred to a different genus.

Textularia bocki Höglund, 1947 Plate I, 1, 2
1947 *Textularia bocki* Höglund, p. 171, pl. 12, figs. 5, 6.

1991 *Textularia bocki* Höglund – Cimerman and Langer, p. 21, pl. 10, fig. 3–6.

Textularia conica d'Orbigny, 1839
1839 *Textularia conica* d'Orbigny, p. 143, pl. 1, figs. 19, 20.
1899 *Textularia conica* d'Orbigny – Flint, p. 285, pl. 29, fig. 6.
1923 *Textularia conica* d'Orbigny – Cushman, p. 11, pl. 2, figs. 8–10.
1991 *Textularia conica* d'Orbigny – Cimerman and Langer, p. 22, pl. 10, figs. 7–9.

Textularia cushmani Said, 1949 Plate I, 5, 6a,b
1949 *Textularia cushmani* Said, p. 7, pl. 1, fig. 13.
1995 *Spiroplectinella saggitula* (d'Orbigny) – Meriç et al., pl. 1, figs. 2a–b.

Textularia stricta Cushman, 1911
1911 *Textularia stricta* Cushman, p. 11, text fig. 13.
1951 *Valvotextularia stricta* (Cushman) – Hofker, p. 33, fig. 11.
1966 *Textulina srticta* (Cushman) – Norvang, p. 6, pl. 1, fig. 1, pl. 2, figs. 1–2.
1994 *Textularia stricta* (Cushman) – Loeblich and Tappan, p. 275, pl. 38, figs. 1–9.

Textularia truncata Höglund, 1947
1947 *Textularia truncata* Höglund, p. 175, pl. 12, figs. 8, 9, textfigs. 147–149.
1991 *Textularia truncata* Höglund – Cimerman and Langer, p. 22, pl. 12, figs. 1–3.
1995 *Textularia truncata* Höglund – Meriç et al., pl. 1, figs. 5a-c.

Textularia sp. Plate I, 7, 8a,b

Triloculina tricarinata d'Orbigny, 1826
1826 *Triloculina tricarinata* d'Orbigny, p. 299.
1991 *Triloculina tricarinata* d'Orbigny – Cimerman and Langer p. 46, pl. 44, figs. 3–4.

Uvigerina bradyana Fornasini, 1900
1900 *Uvigerina bradyana* Fornasini, p. 390, text-fig. 40.

1994 *Uvigerina bradyana* Fornasini – Loeblich and Tappan, p. 128, pl. 250, figs. 1–6.

1999 *Uvigerina bradyana* Fornasini – Hayward et al., p. 135, pl. 9, fig. 27.

Uvigerina mediterranea Hofker, 1932 Plate III, 10

1932 *Uvigerina mediterranea* Hofker, p. 118, textfigs. 32a–g.

1958 *Uvigerina mediterranea* Hofker – Parker, p. 263, pl. 2, figs. 39, 40.

1988 *Uvigerina mediterranea* Hofker – Alavi, pl. 2, fig. 1.

1991 *Uvigerina mediterranea* Hofker – Cimerman and Langer p. 63, pl. 65, figs. 7–9.

Vaginulina lequilensis Fornasini, 1901

1901 *Vaginulina lequilensis*, Fornasini, p. 60, p. 61, text fig. 13.

Appendix 2. Benthic foraminiferal data (number of specimens per sample)

Core MAR98–9 Depth in centimetres	0	10	20	30	40	50	60	70	80	90	100	110	120
?*Eponides* sp.	3	2											
?*Haynesina* sp. Cimerman							1	1					
?*Mayerella* spp.									1	2	2	5	
Adelosina spp.												1	
Ammonia beccarii												2	8
Ammonia sp. 1	1			1	1	3	8	32	26	51	49	108	113
Ammonia tepida									1	3	11	17	5
Amphicoryna spp.	1	2	7	3	3								
Angulogerina spp.				3	2								
Anomalinoides spp.				2					2				
Astacolus spp.		1											
Astigerinata mammila								1	1				
Aubignyna perlucida						12	13	34	42	8	4	4	
Bulimina costata	2	4	4	2		1	1						
Bulimina marginata	6	7	5	6	5	4	4	3	5				
Bulimina aculeata	14	19	11	14	13	15	17	5	14	12	1		
Bigenerina nodosaria			5	1									
Biloculinella spp.	1	2	3			1							
Bolivina spp.	2	2			1				1				
Brizalina spp.	97	81	48	89	85	76	43	5	8	4	2		
Bulimina elongata	16	28	34	26	31	60	48	13	14	19	7		
Cassidulina crassa	21	1	3		1	1							
Cassidulina carinata	26	30	20	29	30	27	26	4					
Chilostomella spp.	2	4	9	3	1	3	1						
Cibicides refugens						1							
Cibicides sp.	1												
Discorbinella bertheloti	2	3	3	3	1	5	3	1	1				
Elphidium cuvielleri													6
Elphidium spp.	2		2	3		3	5	13	4	13	7	14	4
Favulina hexigona	1	1	1										
Fissurina neptuna	1				1								
Fursenkoina acuta							1	2	5		1		
Gavelinopsis praegeri			1										
Globobulimina spp.		1											
Globocassidulina subglobosa	3	1	2			1	2						
Gyroidinoides lamarckiana	6	3	5	1	3	1		1					
Haynesina depressula	1	2					1	3	7	4	2	1	1
Hyalinea balthica	2	2	2	4	2		1						
Laevidentalina spp.			1										
Lagena semistriata									2				

Appendix 2 (*Continued*).

Core MAR98–9

Depth in centimetres	0	10	20	30	40	50	60	70	80	90	100	110	120
Lagena sp. (smooth)		1											
Lagena striata	1		1						1	1			
Lenticulina gibba			1C >										
Lobatula lobatula	1	2			4								
Nonion sp.	1												
Nonionella opima	2		4			2	8	22	22	10	2		
Nonionella turgida	1			1									
Planorbulina mediterranensis			2	1			1		1		1		
Porosononion martkobi	1	3	2				2	10	15	18	33	47	0
Quinqueloculina seminula	1	2	2			1		6					
Quinqueloculina spp.	2			2		6		2	2	1	1	1	1
Rectuvigerina phlegeri	2	19	14	12	5	6							
Rosalina spp.	1							1			1		
Sigmoilinita tenuis	2	4	2	3	5		1	10	1	1			
Siphotextularia spp.	2												
Spiroloculina excavata		1	1	4	2	1							
Spiroloculina tenuisepta				1									
Spirorutilus spp.		5	3	3		2							
Textularia spp.	8	18	20	18	11	8	11	53	15	45	41	30	16
Unident. Trochospiral w arched limbate sutures						3	22	31					
Uvigerina sp.	1												
Valvulina spp.	6	5	2		2	2							
Total benthic foraminifera	248	254	217	239	205	242	198	222	191	192	168	252	185

Core MAR98-7

Depth in centimetres:	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Agglutinella arenata	2																		
Ammonia ammoniformis							1				2	2	2	4					
Ammonia beccarii						1		1	1										
Ammonia compacta							1				1	8	2	8	4	7			2
Ammonia inflata	1					1					3								
Ammonia novoeuxinica										1	9				1		3	4	
Ammonia pakinsoniana								1											
Ammonia sp. 1 (Cimerman)			1	2							6								
Ammonia tepida	2						3				1	5	1				3		
Amphicoryna scalaris	7	1	5		6	6		1											1
Angulogerina angulosa																			
Anomalinoides globulosus																	1		
Asterigerinata cf. *mamilla*							3												
Astrononion stelligerum											1						1	2	
Aubignyna perlucida							1				12	9	1	2	1	1	1	3	3
Bigenerina nodosaria	3	1														1			
Biloculinella globula	19	14	7	1	2				1										1
Bolivina variabilis			7																
Brizalina alata	12		3	5	8	12	4	3	1										
Brizalina catanensis	46	19	29	12	13	24	5	12											
Brizalina dilatata	19	25	37	40	138	52	40	43	3	3	5								1
Brizalina sp. 2 (Cimerman)					25	6													
Brizalina spathulata	107	68	134	79	70	77	51	54	2	5	4				1	1		2	1
Bulimina aculeata	33	26	39	21	40	38	128	45	5		1	1	3	2		3			
Bulimina costata	7	5	6	2	5	1			1										
Bulimina elongata	21	15	26	9	16	14	31	10											1

Appendix 2 (*Continued*).

Core MAR98-7

Depth in centimetres:	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Bulimina inflata	9	3	9	3	1	3													
Bulimina marginata	38	18	21	38	62	23	104	43	1	2	2	2							
Canalifera parkerae																2			
Cassidulina crassa	27	30	30	12	9	6	8	38						1	1				
Cassidulina carinata	13	9	14	6	11	10	16	59	10			1	3	1					1
Cassidulina laevigata								9											
Cibicides advenum						3	2	2						1					
Cibicides refugens							3	1											
Cornuspira planorbis				1															
Cycloforina rugosa			2																
Discorbia candeiana				8															
Discorbinella bertheloti	10	4	6	10	7	5	14	1				1							
Elphidium aculeatum												2							
Elphidium advenum												3							
Elphidium jenseni							3						1						
Elphidium macellum							4												
Elphidium ponticum												7							
Elphidium sp. 2 (Cimerman)							1					1							
Elphidium translucens							1	1				4	4	5			5		
Elphidium depressulum								2		1				1	1				
Evolutononion shansiense														2	1		1		
Favulina hexagona	1			1	2	2													
Favulina scalariformis			2																
Fursenkoina acuta				2	2		9	6											
Globobulimina affinis	2		2	1	2														
Globobulimina globula						2	1												
Globocassidulina subglobosa			3			6		3											
Gravelinopsis praegeri			2																
Gyroidinoides lamarckiana	24	9	9	4	3	3	1	4						3					
Gyroidinoides soldanii		1																	
Haynesina anglica												2							
Haynesina depressula	1						3	12	3			16	5	8	6		2	1	1
Hyalinea balthica	52	21	11	4	18	8													
Laevidentalina sidebottomi	1																		
Lagena doveyensis		1	1					1											
Lagena striata		1	1				2	1											
Lenticulina gibba	1					2													
Lobatula lobatula	3	2		2			2	5		1			1						
Mayerella brotzkajae											1								
Melonis barleanum								1		1	3			3					
Melonis pompilioides														2				3	
Miliolinella labiosa								1											
Miliolinella subrotunda	1					3		1											
Nonionella opima					2		32	11											
Nonionella turgida	5	5	12	1	1		16	12	2	1		2	1						
Planorbulina mediterranensis	1	1	5	2															
Polymorphina sp. A	30	24	18	9	7	2	1	1			1								
Porosononion martkobi												2		1	1				
Procerolagena chathamensis							1												
Protobulimina pupoides		3																	
Pygmaeoseistrom islandicum	1																		
Quinqueloculina patagonica	3	4	13	1	2	2		2											
Quinqueloculina stalkeri							4												
Rectuvigerina phlegeri						1													

Appendix 2 (*Continued*).

Core MAR98-7

Depth in centimetres:	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Rosalina bradyi												1							
Rosalina catesbyana												2			1		3	2	1
Sigmoilina sp. 1				3	3		2												
Sigmoilina sp. 2 (Cimerman)				4	3		5												
Sigmoilina tenuis	8	4	8	1		2	1												
Spiroloculina cymbium		2	1			1													
Spiroloculina dilatata			1			1													
Spiroloculina excavata	2				1														
Spiroloculina tenuiseptata	2	1			1	1													
Spirorutilus spp.	11	5	8	1		1	3	4											
Textularia bocki	11	6	8	4	9	5	2	5											
Textularia conica	8	7	10	12	7	6	8			2	1								
Textularia striata							1												
Textularia truncata			2																
Triloculina tricarinata							1												
Uvigerina bradyana	3	2	6	4	2	2	1												
Uvigerina mediterranea	1																		
Valvulineria bradyana		6	4		2														
Valvulineria minuta	2		2																
Planktonic Foraminifera	136	69	222	38	47	66	68	15		3	2	10	3	5			1	6	
Total benthic foraminifera	549	344	501	296	491	332	501	414	32	18	21	89	39	39	20	16	20	17	13

Core MAR97-11

Depth in centimetres:	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adelosina cliarensis	1								2							
Adelosina dubia						1										
Ammonia compacta																1
Ammonia inflata								1	1		1					
Ammonia parasovica														1		
Ammonia tepida														2		
Amphicoryna scalaris	3	7	3													
Angulogerina angulosa					2	1										
Aubignyna perlucida									52	1	1		3			
Aubignyna planidorso								3	2							
Bigenerina nodosaria	4	2														
Biloculinella globula				1		11	5									
Brizalina alata	19	24	43	7	17	8	19	15		2						
Brizalina catanensis	43	40	26					14	3	4						
Brizalina dilatata	33	38	105	11	43	26	39	19	1							1
Brizalina spathulata	100	234	382	128	141	43	70	17	3	4	1		1			
Brizalina striatula	1		1													
Bulimina aculeata	24	50	82	83	148	33	38	197	28	39						
Bulimina costata		3	4	4	1											
Bulimina elongata	10	33	47	19	17		3	6	11	4					1	
Bulimina inflata	13	12	22	5	2								1			
Bulimina marginata	143	151	276	159	276	93	33	78	27	17	3		2			2
Cassidulina crassa	7	16	8	5	18											
Cassidulina carinata	11	45	60	7	40	18	34	170	410	52			1			
Cibicides advenum				1				2								
Discorbinella bertheloti	6	16	29	44	1								1		1	1
Eilohedra levicula								1	2	1						
Elphidium advenum								2								
Elphidium articulatum							1		4							
Elphidium granosum							2		2							

Appendix 2 (*Continued*).

Core MAR97-11 Depth in centimetres:	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Elphidium macellum								1	1							
Elphidium sp.								1	1							
Elphidium vitreum										1						
Favulina hexagona	1	2							1							
Fursenkoina acuta	1	1	7		20	33	32	30	206	2						
Globocassidulina subglobosa	2	6					1									
Gyroidinoides lamarckiana	3	20	14	1		1	2		2	1			1			1
Gyroidinoides soldanii		6	3				2		1							
Hanzawaia sp.													1		1	
Haynesina depressula			1				2	1	34	2						
Homalohedra sp.		1														
Hyalinea balthica	44	37	24		3											
Laevidentalina leguminiformis	1															
Lagena striata					1			1	2							
Lagena strumosa							2									
Lenticula gibba						1										
Linaresia bikiniensis										2			1			
Lobatula lobatula				2			1	2								
Massilina gualtieriana	3	4														
Melonis barleanum									8							
Melonis pompilioides								1	5							
Miliolinella subrotunda	7	22	2	1	21	1										
Nonionella auris								2								
Nonionella opima			2	5	10	28	16	4								
Nonionella turgida					17	6		3		2			1			
Parafissurina staphyllearia			1													
Planorbulina mediterranensis							1									
Polymorphina sp. A		10	11	1	3	1										
Porosononion martkobi								1								
Procerolagena implicata									1							
Pseudononion granuloumbilicatum								3								
Pulleniatina obliquiloculata												2				
Pyramidulina catesby								1								
Quinqueloculina patagonica		11	4		17	4										
Quinqueloculina seminula			1												1	
Quinqueloculina stelligera			1				1	1	1							
Rotorbinella lepida							2									
Sigmoilina tenuis	8	10	6	1												
Sigmoilopsis schlumbergeri		1					2									
Spiroloculina cymbium	1															
Spiroloculina dilatata	1				6	2	1									
Spiroloculina excavata		2		1	1											
Spiroloculina tenuiseptata	4	1	1													
Spirorutilus sp.	9	6	7	10	24	13	4									
Textularia bocki	28	22	14	8	8	8	3	6	1							
Textularia conica	23	24	36	2	4	8	10	12	4	2						
Textularia cushmani				2	4	1	1									
Textularia cf. *truncata*	3	3	6			8	6		2							
Uvigerina bradyana	3	6			1			1		1						
Uvigerina mediterranea		1						1								
Vaginulina lequilensis									1							
Planktonic foraminifera	134	428	430	34	59	1				4			1			
Total benthic foraminifera	560	860	1234	509	846	350	330	600	819	137	6	3	12	3	4	6

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