BENTHIC FORAMINIFERA DYNAMICS IN RESPONSE TO NATURAL AND MAN-MADE EUTROPHICATION IN THE OLIGOTROPHIC SOUTHEAST MEDITERRANEAN SHELF

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Abstract

Total standing stocks (TSS), simple diversity and in-sediment distribution depth of living benthic foraminifera vary remarkably along the eastern Mediterranean inner shelf, tracking the trajectory of eutrophication, from naturally oligotrophic to man-made hyper-eutrophic ecosystem. While the oligotrophic environments show high seasonality, TSS and biodiversity, the anthropogenically eutrophic environments show small seasonal variations and low to moderate TSS and simple diversity values.

Key words: Southeastern Mediterranean, benthic foraminifera, eutrophication

Introduction

The continental shelf of the southeastern Mediterranean is dominated by recycled Nile delta sediment input from the south, falling off northwards. This reduced sediment flux is coupled to low natural nutrient input, making the Levant shelf a most oligotrophic shallow water environment (1, 2). During the last decades, however, it is subjected to natural as well as man-made eutrophication influences tracking the full range of trophic levels. This makes it a unique area to study the impact of eutrophication processes on living benthic foraminifera. This group is most abundant and diverse in the Israeli shallow shelf (3), and is known to respond to environmental factors, e.g. food supply and oxygen levels.

The present study aims to record the response of benthic foraminifera to changes in seasonality and trophic levels in the inner shelf of the southeastern Mediterranean. This will be done using benthic foraminifera as sensitive tracers of the natural and man-made interference. For this, a comparison is performed between 4 sites along the Israeli coast varying between oligotrophic and hyper-eutrophic conditions. The southernmost station is probably within the permanently nutrient enriched Nile cell (post the high Aswan dam, 1965) while the stations to the north represent both natural and local point source pollution.

Material and Methods

Three permanent stations were sampled during winter and spring 2003 in the southern part of the Israeli coast: AS1, off Ashqelon at 33m; PL3 and PL29, off Palmahim, at 38 and 36m, respectively. A fourth station S1 at 40m, off Bet-Yannai, was studied during 1996-1998, and was used for comparison. These sites are situated from south to north along the known gradient of sediment and nutrient supply reflecting increasing distance from the Nile sources with the exception of the Palmahim PL3 site located amid this transect. PL3 is situated 200m north to a sewage sludge outlet ("Shafdan" domestic sewage treatment plant) being the most hyper-eutrophic station, with the highest supply of organic matter. PL29 is located 4.5km north to the sludge outlet and is a relatively clean station. AS1, located ~27km southern to Palmahim stations, represents the site most proximal to the recycled nilotic nutrients' source while S1 located 50km northern to Palmahim represents the natural highly oligotrophic environment (4).

Water column properties as temperature, salinity, turbidity, pH and dissolved oxygen were determined *in-situ* using YSI 6000. Water for nutrients and chlorophyll-a (Chl-a) was sampled from the sea surface and above the sea floor using Niskin bottles. At each sampling site sub-cores were taken from a box corer for foraminiferal reconnaissance and chemical analyses. The sub-cores were sliced immediately on board into 0.5 or 1cm thick layers and stored in Rose Bengal-ethanol solution. The oxygen content in the sediment was measured immediately on board with oxygen-needle-electrodes (micromanipulator). The Chl-a content, of the top sediment 0.5cm, was determined using spectrophotometer after lyophilization and acetone extraction. In the lab, Rose-Bengal stained benthic foraminifera from the 63-2000μm size-fraction were picked and counted. The data on the benthic foraminifera refers to the top 5cm of the sediment.

Results and Discussion

Density, diversity and in-sediment distribution varies considerably between the three studied sites. In general the TSS varies between 100 and 1300 specimens/10cc and simple diversity varies between 22 and 76 species/site. The in-sediment living depth varies between top 2 to top 10cm while the average living depth (ALD, cf. 5) is changing between 0.4 and 2cm.

The benthic foraminiferal census data shows two ecologically distinct groups. The first group includes sites PL29 and S1 which reflect the healthy natural oligotrophic southeastern Mediterranean inner shelf conditions. The other group includes sites AS1 and PL3 that primarily reflect mesotrophic and hyper-eutrophic conditions attributed to man-made interventions.

Oligotrophic southeastern Mediterranean - The first group is characterized by large seasonal variation in TSS, high diversity, ventilated sediments down to 2.0 cm and relatively low content of Chl-a. The average TSS in PL29 is 890±260 (Std. Error of the Mean) with high TSS of 800-1000 specimens/10cc during spring in both sites. Species richness is high, with up to 76 species/site in PL29 (on average 67±9). Living foraminifera are found down to 10cm in PL29 with ALD of 2.7cm. Chl-a of 0.1μg/g occurred during winter, increasing to 1.7μg/g during early spring.

Anthropogenically eutrophic southeastern Mediterranean - Sites PL3 and AS1 are characterized by small seasonal variations and low to moderate TSS and simple diversity values. The TSS in the hyper-eutrophic PL3 is low with 134±21 specimens/10cc. The simple diversity is 25±1 species/site, and the in-sediment habitat depth is restricted to the top 2cm, as also reflected by the 0.4cm ALD. In AS1 the TSS and simple diversity is somewhat higher with 257±42 specimens/10cc, and 53±3 species/site. The in-sediment depth range is 2-5cm as is also reflected by the shallow ALD of 0.5cm.

Periodic anoxia alternating with periods of oxygen penetration down to 0.9cm occurred in PL3. Chl-a in the top sediment varies seasonally between 0.2μg/g dry wt. during winter overturn and 10.6μg/g during early spring with the initiation of water column stratification. In site AS1 the sediments are ventilated down to 0.5-2cm and Chl-a varies between 0.7μg/g during winter and 3.2μg/g during early spring.

The increasing nutrient load due to man-made intervention, of sewage disposal (PL3) or of the permanently nutrient enriched Nile water (AS1), shows a dramatic impact on the ecologically sensitive benthic foraminiferal group in the otherwise oligotrophic southeastern Mediterranean shelf. It considerably reduces the seasonal variability, causing moderate to sharp decline in species richness whereas in natural undisturbed regions it is much higher. It also causes a marked decrease in TSS as compared with healthy regions. It reduces sharply the living zone of the benthic foraminifera, often to the topmost sediment layer, occasionally causing the temporary disappearance of the group.

References

1 - Yacobi Y.Z., Zohary T., Kress N., Hecht A., Robarts R.D., Waiser M., Wood A.M., and Li W.K.W., 1995. Chlorophyll distribution throughout the southeastern Mediterranean in relation to the physical structure of the water mass. *J. Mar. Systems*, 6: 179-190.

2 - Herut B., Almogi-Labin A., Jannink N.T., and Gertman I., 2000. The seasonal dynamics of nutrient and chlorophyll a concentrations on the SE Mediterranean shelf-slope. *Oceanol. Acta*, 23: 771-782.

3 - Hyams O., 2000. Benthic foraminifera from the Mediterranean inner shelf, Israel. M.Sc. thesis (In Hebrew, English abstract), Ben-Gurion University of the Negev, 228 p.

4 - Jannink N.T., 2001. Seasonality, biodiversity and microhabitats in benthic foraminiferal communities. *Geologica Ultraiectina*, 203, 192 pp.

5 - Jorissen F.J., de Stigter H.C., and Widmark J.G.V., 1995. A conceptual model explaining benthic foraminiferal microhabitats. *Mar. Micropaleont.*, 26: 3-15.