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The impact of thermal pollution on benthic foraminiferal assemblages in the SE Mediterranean shore (Israel) as an analog to global warming

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Scientific and public awareness to global warming increased significantly lately. In the Mediterranean Sea the current rate of warming stands at 0.028 °C/year in accordance with the forecast of global warming of 0.2 °C per decade. The aim of this study is to examine the effects of locally elevated vs. natural SST on benthic foraminifera, which are known to be sensitive bioindicators of environmental change. The thermal patch originating from the "Orot Rabin" power plant off the coast of Israel was chosen as a sampling area for this research since it presents a unique small-scale analog for expected future rise in SST. Ten monthly sampling campaigns were performed during a period of one year in 4 stations located along a temperature gradient of approximately 10 °C, from the discharge site of the heated seawater to a few kilometers south. Benthic foraminifera were collected from a shoreface complex of macroalgae and sediments trapped within. The SST varied between winter, 25/18 °C and summer, 36/31 °C along the transect. During the summer, the addition of the temperature anomaly to the already extreme summer temperatures becomes a biologically threat.

The natural seasonal variability, depicted best by station 4 located beyond the thermal patch, shows that foraminifera reach maximal abundance in winter and spring. A significant negative correlation was found between SST in all stations and benthic foraminiferal assemblage characteristics. The abundance, species richness and species diversity show negative correlation with the SST anomaly throughout most of the sampling period, though the species diversity was not as significant as the abundance. The total foraminiferal abundance was significantly lower at the thermally polluted stations, especially during the summer, but also throughout the entire year, indicating that the thermal pollution has a detrimental effect on benthic foraminifera, irrelevant to the natural cyclic changes in SST. The foraminiferal abundances decrease drastically as the SST rises, reaching minimal abundances when the SST rises above 30 °C, indicating that this temperature may be a critical threshold above which foraminiferal growth and reproduction are severely retarded.

Species richness reached extremely low values at the thermally polluted stations during the summer, with a minimum of 3 species compared to a maximum of 24 in the natural, unaffected station 4. This indicates that some species have adapted to the elevated temperatures better than others. The foraminiferal assemblage, composed mostly of epiphytic species, contains a total of 42 species with six species dominating the assemblage. Out of the six dominant species *Rosalina globularis*, *Tretomphalus bulloides* and *Textularia agglutinans* show a clear preference to the winter months, while species belonging *Lachlanella* reach maximum abundances in spring and *Pararotalia spinigera* in summer. The miliolids, *Lachlanella* sp. 1 and sp. 2 seem to have high tolerance to the elevated SST and even survived the most extreme summer temperatures at the thermally polluted stations. In this research we show that even a rise, as small as 2 °C, in SST can have serious ramifications on the benthic community characteristics living in the near shore environment. If foraminifera are affected to such an extent it is not unlikely that other more developed marine creatures will be negatively affected as well, either directly by the rise in SST or via the decrease in organisms lower down the marine food chain, such as foraminifera.