

Interactive comment on “Low planktic foraminiferal diversity and abundance observed in a 2013 West-East Mediterranean Sea transect” by Miguel Mallo et al.

Miguel Mallo et al.

patrizia.ziveri@uab.es

Received and published: 14 October 2016

We appreciate the overall positive referee remarks and acknowledge the detailed and constructive comments that greatly helped to clarify a number of points and to improve the manuscript.

Below are our detailed responses to the referee's comments, including expected modifications of the manuscript.

REFeree #3: The authors provided new information on planktonic foraminiferal abundance from the upper part of the water column (200 m) in the Mediterranean Sea during May (spring) 2013 collected with BONGO nets (mesh size 150 micron and 40 cm of

Printer-friendly version

Discussion paper



diameter). The authors documented a strong difference between western and eastern Mediterranean basins, and between different Mediterranean sub-basins, in terms of abundance and diversity in planktonic foraminiferal assemblage. They document 10 species and they proposed a study on the size-normalised weight (SNW) of two species (*Globigerinoides ruber* s.s. and *Globigerina bulloides*) and their relation with change with food availability. The manuscript is properly constructed and it is evident that the data support the interpretation proposed in the manuscript. I think that the authors need to stress some issues:

REFeree #3 COMMENT: i) the statistical analysis (in my opinion the Principal Component Analysis is the appropriate approach) carried out of the planktonic foraminiferal data [maybe including data of other authors (ie., Pujol & Vergnaud-Grazzini 1995; De Castro Coppa et al 1980) to produce a complete framework of the Mediterranean]; REPLY: We agree that proper statistical analysis should be conducted on our data set. This is why in the revised version we will include a principal component analysis performed on the environmental parameters. Note that new environmental parameters will be added: the nutrients (NO₃ and PO₄), the oxygen concentrations and the pCO₂. The results of the PCA show that 2 factors explain about 77% of the total variance in the environmental parameters. The 1st factor exhibited positive loadings on the nutrients and the fluorescence and negative loadings on temperature and salinity (and to a lesser degree on carbonate ion concentrations). This factor explains 56.99% of the total variance and represents the strong west-east gradient characterizing the Mediterranean Sea as the water becomes warmer, saltier and more oligotrophic eastward. The second factor explains about 20.02% of the total variance and is characterized by positive loadings on pH and oxygen concentrations (and to a lesser degree on carbonate ion concentrations) and a negative loading on the pCO₂. It is interpreted as the variations of the carbonate system properties in the Mediterranean Sea with more acidic conditions in the western basin compared to the eastern basin. The sample scores on the 2 first factors with overlay of absolute abundances of foraminifera species (*G. ruber* (white), *G. bulloides*, *G. inflata*, *O. universa* and *T. sacculifer* (without sac)) and density

area (*G. ruber* (white), *G. bulloides* and *O. universa*) are presented and discussed in the revised manuscript (REV Fig. 1).

REFeree #3 COMMENT: ii) the correlation with sediment trap data (Barcena et al. 2004, Alboran Sea; Rigual-Hernández et al 2012, Gulf of Lion); REPLY: The references are added to the manuscript and compared with our data. Also, we added Hernández-Almeida et al. (2011). See minor comment about Line 87 for more details.

REFeree #3 COMMENT: iii) the comparison with data from Gulf of Naples (De Castro Coppa et al 1980), REPLY: The data presented by de Castro Coppa et al. (1980) are compared to our results. See minor comment about Line 87 and line 180-181 for more details.

REFeree #3 COMMENT: iv) the Oceanographic setting chapter (in my opinion some planktonic foraminiferal difference between different Mediterranean sub-basins could be linked to different oceanographic settings) also adding more references; REPLY: The oceanographic settings section has been changed in the revised manuscript as follows: “The Mediterranean Sea, with a strong thermohaline and wind-driven circulation, and a surface of approximately 2,500,000 km², is divided into two main basins near the Strait of Sicily: the western and eastern basins (Rohling et al., 2015; Rohling et al., 2009). These basins are composed of different sub-basins due to partial isolation caused by sills that influence the water circulation, and by different water properties (Rohling et al., 2015; Rohling et al., 2009). Natural connection with the ocean is through the narrow Strait of Gibraltar, where the nutrient-rich Atlantic surface waters enter the Mediterranean and experience an eastward increase of temperature and salinity (Fig. 1) driven by insolation and evaporation, having a negative hydrological balance (evaporation exceeding precipitation; Rohling et al., 2015; Rohling et al., 2009). The Mediterranean also becomes increasingly oligotrophic towards the east (Fig. 1; Fig. 2). In addition, the incoming Atlantic waters enter the Algero–Provençal Basin and reach as far as the Tyrrhenian Sea, and contribute to deep water formation in the Gulf of Lions in cold winters (Rohling et al., 2015; Rohling et al., 2009). In the eastern

BGD

Interactive
comment

Printer-friendly version

Discussion paper



basin, two main sources of deep water formation are active mainly during winter in the Adriatic and the Aegean Seas. Cold dry winds cause evaporation and cooling forming denser and more saline water masses that sink to depth (Rohling et al., 2015; Rohling et al., 2009; Hassoun et al., 2015b). The same process is active in the Levantine basin, forming an intermediate water mass, which becomes progressively cooler and fresher toward the western basin. Some waters reach the Tyrrhenian Sea (Rohling et al., 2015; Rohling et al., 2009). Waters returning to the Atlantic through the Strait of Gibraltar at depth are cooler and saltier than the inbound waters, and compensate for the inflow from the Atlantic (Rohling et al., 2015; Rohling et al., 2009). The Mediterranean Sea has a large physicochemical gradient for such a small marginal sea (Rohling et al., 2015; Rohling et al., 2009; Fig. 1).”

REFeree #3 COMMENT: v) detailed comparison between data related to the spring season (this work) with past spring seasons documented by planktonic foraminifera in the Mediterranean (living and sediment traps data); REPLY: New references were added to the revised manuscript and compared to our data, such as the work by Hernández-Almeida et al. (2011). In the discussion of the revised manuscript we compare as well our data with samples from late spring (Cifelli (1974), Pujol and Vergraud-Grazzini (1995)). We consider this enough detailed description for purposes of the manuscript.

REFeree #3 COMMENT: vi) the authors need to improve the figures and maybe add new ones; REPLY: See comments in the “minor comments: figures” section.

REFeree #3 COMMENT: vii) it could be interesting to propose contouring map of the planktonic foraminiferal species REPLY: Unfortunately, for each station and for a given species we only have one data point. Then a contour map would create excessive interpretation.

REFeree #3 COMMENT: viii) add a small chapter (maybe in the material and methods) concerning the criteria used to classify the planktonic foraminifera REPLY: The fol-

[Printer-friendly version](#)[Discussion paper](#)

lowing paragraph will be added in the Methodology section of the revised manuscript: “We classified the different foraminifera species with visual identification with the optical microscopy with the option of picking and turning the specimens to see their different sides. We followed the morphometric guidelines and genetic nomenclature proposed by Aurahs et al. (2011) for *Globigerinoides ruber* (white), *Globigerinoides ruber* (pink) and *Globigerinoides elongatus*. For *Trilobatus sacculifer* (with sac) and *T. sacculifer* (without sac) we used Spezzaferri et al. (2015). Hemleben et al. (1989) was used as a guide to classify *Globigerinoides bulloides*, *Orbulina universa*, *Globorotalia inflata*, *Globorotalia menardii*, and *Hastigerina pelágica*. *Globigerinoides quadrilobatus* was inferred from Papp and Schmid (1985). *G. bulloides* could not be differentiated from *Globigerina falconensis* in our samples and are treated together; the *G. bulloides*/*G. falconensis* plexus is referred as *G. bulloides* in our study. *Globigerinella siphonifera*/*G. calida*/*G. radians* plexus (see Weiner et al., 2015) is treated as *G. siphonifera* in our study.”

REFeree #3 COMMENT: ix) I would like to suggest to add in the title of the manuscript the word SPRING. REPLY: We agree with the comment of the referee. The title will be changed as follow: “Low planktic foraminiferal diversity and abundance observed in a spring 2013 West-East Mediterranean Sea transect”

REFeree #3 COMMENT: I think that it is very important to publish these data, because of the interpretation of marine fossil archives of the Mediterranean are basically based on data (interpretation) provided by Hemleben et al., (1989) and by Pujol & Vergraud-Grazzini (1995), and it results important to improve the information on living planktonic foraminifera to better reconstruct the past climate oscillation recorded in the fossil archives. Anyway, in my opinion, the present version of the manuscript needs still important modifications concerning the presentation of data (including comparison with literature data) and discussion. REPLY: We appreciate the comment and agree on the importance of publishing these kinds of observations, still relatively rare in the world of planktic foraminifera and their interpretive use for examining past environments. Some

BGD

Interactive
comment

Printer-friendly version

Discussion paper



of those landmark studies mentioned do lay the ground work for detailed ecologic descriptions of key species and their preferred environments, however they are dated by decades now and more modern observations are critical to publish in order to illustrate perhaps rapidly changing marine plankton responses to ocean climate conditions.

Minor comments: REFEREE #3 COMMENT: Line 34: Hemleben et al. 1989 REPLY: Changed in the revised manuscript.

REFEREE #3 COMMENT: Line 36-38: please add Reference REPLY: Schiebel et al. (2005) and Hembelen et al. (1989) added to the revised manuscript.

REFEREE #3 COMMENT: Line 47-49: please add the write reference for the Swedish Deep-Sea expedition 1947-1948 REPLY: Pettersson (1953) added to the revised manuscript.

REFEREE #3 COMMENT: Line 61: the reference is Pujol & Vergraud-Grazzini (1995). Please modify in the entire manuscript REPLY: Changed in the revised version.

REFEREE #3 COMMENT: Line 79: please modify the reference in De Castro Coppa et al., (1980) REPLY: Changed in the revised version.

REFEREE #3 COMMENT: Line 87: it is necessary to compare the acquire data also with sediment trap data of Barcena et al. (2004) from Alboran Sea and of Rigual-Hernandez et al. (2012) from Gulf of Lion REPLY: The suggested references were added and discussed in the revised version as well as Castro Coppa et al. (1980) and Hernández-Almeida et al. (2011). For example we changed some parts of the discussion as follows: “Despite no new plankton tow study was published covering the Mediterranean, three regional studies based on sediment traps were realized in the Alboran Sea (Bárcena et al., 2004; Hernández-Almeida et al., 2011) and the Gulf of Lions (Rigual-Hernández et al., 2012). The one year time series of the Alboran Sea sediment traps (July 1997 – May 1998) showed big differences in the main species relative abundances and daily fluxes through the different seasons, driven by food avail-

ability (related with water mixing/stratification periods) and temperature (Bárcena et al., 2004; Hernández-Almeida et al., 2011). The 12-year sediment trap records at Gulf of Lions (October 1993 – January 2006) showed a big seasonal pattern of the species, being more than 80% of the data from winter and spring in correlation with the nutrient supply and mixed water column (Rigual-Hernández et al., 2012).” “Comparisons are made with older similar studies from Pujol and Vergraud-Grazzini (1995), Cifelli (1974), de Castro Coppa et al. (1980); Bárcena et al. (2004), Hernández-Almeida et al. (2011), Rigual-Hernández et al. (2012), and Thunell (1978).” “The presence of *G. inflata* is related with cool waters and high food availability (Pujol and Vergraud-Grazzini, 1995; Rigual-Hernández et al., 2012), following high phosphate concentrations (Ottersen, 1992).” “In winter, with cooler temperatures, the opposite process happens, and *G. inflata* becomes the dominant species in the Alboran Sea (Bárcena et al., 2004) and the southwestern basin, with high frequencies in the Strait of Sicily and just east of it.”

REFeree #3 COMMENT: Line 98: SNW; please modified in Size-Normalized Weight (SNW) REPLY: We decided to change “Size-Normalized Weight” to “Density Area” in the revised manuscript. The latter denomination is less confusing and in agreement with previous study (Marshall et al., 2013).

REFeree #3 COMMENT: Line: please add Fig. 3 in the text REPLY: Referee did not indicate which line.

REFeree #3 COMMENT: Line 170: *Globigerinoides ruber sensu strictu* (ss) is correctly referable to *G. ruber* white variety. Please change the name in the manuscript. Anyway, I think that the authors due to the target of the manuscript have to add a small chapter where they report exactly the criteria followed to discriminate the different planktonic foraminiferal species as well as the species included in other. REPLY: As mentioned above, a new paragraph was added to methodology section. Moreover, we changed the names in the revised manuscript in agreement with Aurahs et al. (2011) as follows: *Globigerinoides ruber sensu stricto* changed to *Globigerinoides ruber* (white) *Globigerinoides ruber sensu lato* changed to *Globigerinoides elongatus*

REFeree #3 COMMENT: Line 175-176: the data clearly document higher percentages of individuals >500 micron between Sicily channel and Ionian Sea. It is important to be more precise about the geographic position of these abundances because of changes in abundance and size could be associated to change in oceanographic setting between the different parts of the Mediterranean. REPLY: We agree and the text in the revised version was changed as follows: “Overall, higher percentages of individuals >500 μm are found in the western part of the Mediterranean compared to the eastern part (Fig. 4). The highest percentages are found at the Strait of Sicily and the Northern Ionian Sea (St. 7a, 16-18; Fig. 4; Fig. S1; Appendix A).”

REFeree #3 COMMENT: Line 180-181: the authors report that the *G. ruber* s.s abundance is low in the southern Mediterranean (station 16-18, 15 and 9). These data are strongly in contrast with the quantitative distribution of Thunell (1978) that reports for this area values >60%. Conversely in the Tyrrhenian Sea Thunell (1978) documents a decrease in abundance values of *G. ruber* respect to the Ionian Sea. This contradiction need to take in account in the discussion if you want to consider, for general comparison, the data proposed by Thunell (1978). REPLY: We agree and the text was modified according to referee’s suggestion as follows: “*G. ruber* (white) remains scarce or absent in May in the Ionian Sea stations, increasing its abundance towards the Tyrrhenian Sea, on the other hand, in the Ionian Sea it shows values of >60% of relative abundance in Thunell (1978) surface sediments, and decreases towards the Tyrrhenian Sea. That situation could be due to more food availability in the Tyrrhenian Sea relative to the Ionian Sea during May 2013 (Fig. 1c) plus a small difference in temperature between both seas (Fig. 1a). This fact could not be the typical spring situation, as due to surface sediment evidence, the Ionian Sea is more abundant in *G. ruber* tests (Thunell, 1978) and May is the most productive season in foraminiferal tests (Rigual-Hernández, 2012; Bárcena et al., 2004; Hernández-Almeida et al., 2011). Also, we note that in May 1979, scarce presence of *G. ruber* was reported in the Bay of Naples (de Castro Coppa et al., 1980), meanwhile our study shows a 46.8 % presence in the Tyrrhenian Sea, being the main species, something only previously achieved in

[Printer-friendly version](#)[Discussion paper](#)

August, September and December (de Castro Coppa et al., 1980), accentuating more the atypical situation of May 2013.”

REFeree #3 COMMENT: Line 182: Fig. 3 is not necessary. Should maintain only Fig. 4. REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 186: see comment proposed in Line 182. REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 190: see comment proposed in Line 182 REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 191: if the authors want to use the classification proposed by Spezzaferri et al (2015), Globigerinoides sacculifer should be Trilobatus sacculifer. Once more, it is important to have short chapter concerning the criteria adopted for classification. REPLY: We agree and use the classification proposed by Spezzaferri et al. (2015). We changed the names in the revised manuscript as follows: Globigerinoides sacculifer sacculifer type changed to Trilobatus sacculifer (with sac) Globigerinoides sacculifer trilobus type changed to Trilobatus sacculifer (without sac) Globigerinoides sacculifer quadricameratus type changed to Globigerinoides quadrilobatus

REFeree #3 COMMENT: Line 194: fraction are ≥ 350 micron, please add Fig. 4 at the end of the sentence. REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 195: but is usually less abundant, please add Fig. 3 at the end of the sentence. REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 196: Fig. 3 is not necessary REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 197: Globigerinoides sacculifer of the quadricameratus-type, should change in Globigerinoides quadrilobatus in the manuscript REPLY: We agree and changed it in the revised manuscript.

BGD

Interactive
comment

Printer-friendly version

Discussion paper



REFeree #3 COMMENT: Line 201: The authors report that they grouped some stations to achieve a minimum number of planktonic foraminifera. In my opinion is not correct and I think that also the low number of planktonic foraminifera need to take in account in the interpretation. The low number is related some specific environmental setting those characterised a specific part of the Mediterranean, and you cannot lose (or overlook) this datum in this manuscript. In addition, it is not necessary to plot the % abundance of the species, because of it is not useful for comparison with data from Pujol & Vergraud-Grazzini (1995) or from De Castro Coppa et al. (1980). If you want to use the % abundance you have to covert in % also data from literature. Probably it make sense for comparison. REPLY: We set the minimum number of tests to 95 because our samples come from a single picking in each station (a snap shot in time), the remaining sample from the BONGO collectors come from aliquots of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{6}$, and $\frac{1}{8}$ (information not added before, now actualized in the Methodology section). That makes a difference of one individual much more significant, meaning that a different picking could change substantially the small sample results, especially the relative abundances, and having the risk of showing no realistic data. We decided to not discuss the groupings with <95 tests but include the data in Appendix A for giving further information to the readers and to help promote future studies. Moreover, relative abundance (%) data is useful for comparison with Cifelli (1974), Thunell, (1978), the regional studies of Bárcena et al. (2004), Hernández-Almeida et al. (2011) and some text information of Pujol and Vergraud-Grazzini (1995) presented in percentages. We consider useful the relative abundance data for comparison with the mentioned studies and for future researcher utility; we consider important to have the absolute values as well.

REFeree #3 COMMENT: Line 217-224: In my opinion, I consider the PCA the correct statistical approach for these data, anyway, it is important to show the complete correlation matrix where the reader can see all the obtained values for each variables. In addition, please specify the software used of statistical analysis. REPLY: We agree and as mentioned above a PCA analysis was performed and added to the revised

[Printer-friendly version](#)[Discussion paper](#)

manuscript.

REFeree #3 COMMENT: Line 227-235: it is very hard to follow this discussion using the diagrams proposed in Fig. S2. If you want to compare the size of planktonic foraminifera between different parts of the Mediterranean, maybe the authors can chose other graphical representation. REPLY: We consider Fig. S2 appropriate. We decided to investigate the relation between area and long axis in the three selected main species to see their growth pattern. We clarify it in the text of the revised manuscript: "...The high two-dimensional (silhouette) area-to-long axis correlation is best fitted by a power regression (Fig. S2). The same growth pattern can be seen in *G. ruber* s.s., *G. bulloides*, and *O. universa* with that correlation, represented graphically in the shape of a power function (Fig. S2). They grow slightly faster when they are smaller (steepest in the lower left part of the regression line) and slightly slower when they are bigger (less steep in the upper right part of the regression line; Fig. S2). Comparing the average values from different locations sampled within the Mediterranean, *G. ruber* s.s. individuals from the Atlantic have the largest size followed by individuals from the Tyrrhenian Sea, and tests from east of the Strait of Sicily. ..."

REFeree #3 COMMENT: Line 261-275: I think that a table could be useful for a visual comparison between absolute abundance in the different areas REPLY: We already tabulated the data by station, such that future readers and researchers can group similarly to our area grouping, or they can do it differently. If it is already grouped by area, then we short-circuit the opportunity for other grouping schemes in the future.

REFeree #3 COMMENT: Line 276-285: I think that a graphical representation is very useful to show this comparison. In addition, the authors need to take in account also the data reported in De Castro Coppa et al (1980) from Gulf of Naples that you could tentatively correlate with the station 19 in the Tyrrhenian Sea. REPLY: We consider that a graphical representation is not indispensable for that purpose. Now we use de Castro Coppa et al. (1980) for our discussion comparison (see answers to your questions at line 87, line 180-181). In that paragraph (276-285), we compare absolute

BGD

Interactive
comment

Printer-friendly version

Discussion paper



abundance values from past studies with respect to our study. The study of de Castro Coppa et al. (1980) gives their absolute values in individuals obtained (they just give a general and approximate value of how many m³ they filter in each towing), making the results incomparable (i.e. individuals-m³). We obtained the valuable information of the relative distribution of the foraminifera assemblage through the seasons, used in the discussion section 5.2.

REFeree #3 COMMENT: Line 286-288: It is not correct to group these species. They are different
REPLY: We agree and the text was changed as follows in the revised manuscript: “Comparing with previous studies that covered the Mediterranean, we notice that Thunell (1978) and Pujol and Vergraud-Grazzini (1995) did not find *G. menardii*, despite it being found in this study and Cifelli (1974), both in very low quantities. The lack of data from surface sediments and their tropical water preference suggest that is a new species in the Mediterranean (Cifelli, 1974), possibly caused by warmer conditions than in past times. The rest of the species found in our study are found in the past studies covering the Mediterranean Sea (Cifelli, 1974; Thunell, 1978; Pujol and Vergraud-Grazzini, 1995), but it remains in doubt if whether Pujol and Vergraud-Grazzini found *G. falconensis* and classified it as *G. bulloides*; or if Thunell (1978) found *G. elongatus* and *T. sacculifer* (without sac) and classified them as *G. ruber* and *G. sacculifer*. The former problem is also found in Pujol and Vergraud-Grazzini (1995). Also, it is not certain if Cifelli (1974) found *G. calida* and classified it as *G. aequilateralis* (old equivalent of *G. siphonifera*). For the figures in Cifelli (1974) we deduce that *G. elongatus* was classified as *G. ruber* in the study. In the same way, we do not find any evidence of finding *T. sacculifer* (with sac) from the Cifelli (1974) figures, but we cannot discard the possibility of it being classified as *G. trilobus* (*T. sacculifer* without sac). Finally, we do not have the evidence if Cifelli (1974) found *G. ruber* (pink) and classified it together with the white variety into *G. ruber*.

G. quadrilobatus was not found in previous studies working with plankton tows in the Mediterranean, despite its abundance in sedimentary cores (i.e. Cramp et al., 1988;

Rio et al., 1990); there exists the possibility to classify it as *G. sacculifer* or *G. trilobus* in previous studies as was suggested by Hemleben et al. (1989). Some of the species not found reached high frequencies in the aforementioned studies: e.g., the winter species *Turborotalita quinqueloba*, *Neogloboquadrina pachyderma*, and *Globorotalia truncatulinoides*. The fact that these species were not sampled in the present study may be caused by their absence or presence at extremely low abundances of adult specimens at the sampled stations in May, as they use to have low abundances at that time according to a 12-year sediment trap record in the Gulf of Lions (Rigual-Hernández et al., 2012). Another possibility is their presence in a size smaller than 150 μm , escaping from our BONGO nets mesh size. That possibility could be supported by the fact that previous Mediterranean studies with thinner mesh sizes found that species (see Pujol and Vergraud-Grazzini, 1998: 120 μm mesh size; Rigual-Hernández et al., 2012: 63-150 μm mesh size).

To be able do a quantitative comparison of the number of species found with previous Mediterranean studies, first, we make the following simplification: *G. bulloides* and *G. falconensis* count as one species for that comparison; the same is applied for *G. siphonifera* and *G. calida*, and *G. ruber* (white) and *G. ruber* (pink). Secondly, we made the assumption that all the doubtful species found in previous studies (see two paragraphs above) were found (e.g.: we assume that Thunell (1978) found *G. elongatus* and he classified it as *G. ruber*). After applying these conditions we arrive at a smaller number of species able to be compared. Our number of apparent species becomes 11, clearly inferior to Cifelli (1974) with 19 apparent species, and Thunell (1978) and Pujol and Vergraud-Grazzini (1995) with 17 apparent species. In station 3 of this study (Alboran Sea), we found 8 species; meanwhile the number ascends to 12 in Rigual-Hernández et al. (2012) species flux in the same month.”

REFeree #3 COMMENT: Line 288-292: the authors compare *G. sacculifer* morphotype *trilobus* and *quadricameratus* (please modify in *quadrilobatus*) with literature data (Cifelli 1974; Pujol & Grazzini 1995 and Thunell 1978). Please be sure that in these

papers are reported these species (i.e., in Thunell 1978, *G. quadrilobatus* is not reported). In addition, the authors have to consider also De Castro Coppa (1980). Once more, a graphic representation is useful. **REPLY:** See the answer the previous comment (Line 286-288). We consider de Castro Coppa et al. (1980) for the discussion section 5.2., here the purpose of the paragraph was to compare our species number with the studies that covered the Mediterranean. Regional studies are not included in that comparison as they miss the rest of the areas of the Mediterranean. Comparison of regional studies with individual stations in our study was discarded, as results can be more biased (as it only depends on 1 station of our study instead of several ones that can reduce the bias of no collected specimens in a single plankton tow). But a comparison of our station 19 with de Castro de Coppa et al. (1980) at 200 m depth can be mentioned here: Our study yields 7 different apparent species (read the answer to your question about line 286-288) in the Tyrrhenian Sea station, meanwhile de Castro Coppa (1980) found 12 apparent species at the Bay of Naples. We consider that a graphical representation is not indispensable for that purpose.

REFEREE #3 COMMENT: Line 292-294: A possible reason could be the mesh size used in this work, even if in De Castro Coppa et al. (1980) where they used in the Gulf of Naples a mesh size of 145 micron, in May 1979, they found *N.pachyderma*, *T. quinqueloba* and *G. truncatulinoides* (no high number of individuals). However, I think that with this mesh size you lose small size planktonic foraminifera. **REPLY:** We agree. Pujol and Vergraud-Grazzini (1995) used a mesh size of 120 μm and found the three species. Rigual-Hernández et al. (2012) used a 63-150 μm size fraction and collected the three species too. We note, as well, that Cifelli (1974) with 158 μm mesh size collected specimens of *G. truncatulinoides* and *T. quinqueloba*. We modify the manuscript as follows: “Some of the species not found reached high frequencies in the aforementioned studies: e.g., the winter species *Turborotalita quinqueloba*, *Neoglobobulimina pachyderma*, and *Globobulimina truncatulinoides*. The fact that these species were not sampled in the present study may be caused by their absence or presence at extremely low abundances of adult specimens at the sampled stations in May, as

they use to have low abundances at that time according to a 12-year sediment trap record in the Gulf of Lions (Rigual-Hernández et al., 2012). Another possibility is their presence in sizes smaller than 150 μm , escaping from our BONGO nets mesh size, a possibility that could be supported by previous Mediterranean studies with thinner mesh sizes finding that species (see Pujol and Vergraud-Grazzini, 1998, 120 μm mesh size; Rigual-Hernández et al., 2012, 63-150 μm mesh size)."

REFEREE #3 COMMENT: Line 296-298: probably Globigerinoides sacculifer type quadrocameratus (quadrilobatus) is not reported in the previous literature because of it was included in G. trilobus or G. sacculifer. I would suggest a graphical comparison between literature data concerning G. sacculifer and G. trilobus (Cifelli 1974, Thunell 1978, De Castro Coppa et al 1980 and Pujol & Grazzini 1995) and a group G. quadrilobatus of your data (where you can include sacculifer, sacculifer trilobus-type and quadrocameratus-type). Maybe it make sense. You can try. REPLY: See the answer to the comment about Line 286-288. We consider that a graphical comparison is not indispensable for that purpose.

REFEREE #3 COMMENT: Line 298: I think that the authors can refer to a paper spanning a more recent time interval than the Eocene. In particular, it is necessary to select a paper where G. sacculifer type quadrocameratus (quadrilobatus) is present. REPLY: We agree and references: Cramp et al. (1988) and Rio et al. (1990) were added to the revised manuscript.

REFEREE #3 COMMENT: Line 302: the reference is Cossarini et al. (2015). Please modify REPLY: Changed in the revised manuscript.

REFEREE #3 COMMENT: Line 323-324: they are two different species and not varieties and they have different environmental preferences. Reply: We agree. This paragraph will be deleted.

REFEREE #3 COMMENT: Line 344-346: please add a reference REPLY: Pujol and Vergraud-Grazzini (1995) added to the revised manuscript.

BGD

Interactive
comment

Printer-friendly version

Discussion paper



REFeree #3 COMMENT: Line 350: the authors can report as reference also Rigual-Hernandez et al (2011) where in February from sediment trap G. ruber pink is not present. REPLY: We agree the reference was added to the revised manuscript.

REFeree #3 COMMENT: Line 365-367: I think that is necessary to report also the data from De Catro Coppa et al. (1980) where G. inflata is documented in May 1979. REPLY: We agree. See our answer to your question about line 87.

REFeree #3 COMMENT: Line 370-371: these data are opposite to data reported in Barcena et al. (2004) for sediment trap in the Alboran Sea, where in spring season G. bulloides is more abundant than G. inflata. Can the authors try to explain this discrepancy? REPLY: We modify the text in the manuscript as follows: “Alboran Sea spring distribution of G. inflata, with G. bulloides as a clear secondary species, matches with other studies (Pujol and Vergraud-Grazzini, 1995; van Raden et al., 2011). Although, in May 1998, G. bulloides clearly exceeds G. inflata in abundance, but seems an exceptional year in which G. inflata productivity is unfavored by high temperature anomalies that might be influenced by the El Niño-Southern Oscillation event (Bárcena et al., 2004; Hernández-Almeida et al., 2011).”

REFeree #3 COMMENT: Line 371: is van Raden et al. (2011) REPLY: Changed in the revised manuscript.

REFeree #3 COMMENT: Line 385-386: see comment reported in Line 370-371 REPLY: Changed in the revised manuscript: “In April (Pujol and Vergraud-Grazzini, 1995; van Raden et al., 2011) and May, it is found to be the second most abundant species, surpassed by G. inflata, in the westernmost Alboran Sea. High temperature anomalies provoke an inverse situation, thanks to G. bulloides faster reproduction plus G. inflata being further for its optimum temperature (Bárcena et al., 2004).”

REFeree #3 COMMENT: Line 391-392: data from sediment trap (Gulf of Lion) of Rigual-Hernandez et al (2011) reports a decrease in abundance of G. inflata respect to G. bulloides during May, while in April these species strongly reduce the difference

BGD

Interactive
comment

Printer-friendly version

Discussion paper



in abundance.

REPLY: The text here was stating that *G. bulloides* abundances were higher in winter than in late summer overall. The Rigual-Hernández et al. (2012) reference is now added, as it demonstrated what was stated by Pujol and Vergraud-Grazzini (1995) as well.

REFEREE #3 COMMENT: Line 394-395: add Fig. 3 at the end of the sentence. REPLY: We consider no need for placing Fig. 3 here as the last sentence speaks about Pujol & Vergraud-Grazzini (1995) and does not mention or compare with our results in May.

REFEREE #3 COMMENT: Line 416-417: the quantitative data of *O. universa* seem to suggest a strong decrease in abundance towards eastern Mediterranean and two possible decreasing trends, one versus the Gulf of Lion and the second one from Balearic versus Alboran Sea. Can suggest these trends a possible explanation? REPLY: We do not observe any strong decrease in absolute abundance towards the eastern Mediterranean (see Appendix A: absolute abundance, total numbers, *O. universa*). We think that those differences are not large enough to be certainly caused by environmental factors or ecological competition for food. Those differences can merely be coincidental since we did one plankton tow in each station, meaning a “snapshot” in time. Thus, small differences can be misinterpreted.

REFEREE #3 COMMENT: Line 493: Kohler-Rink and Kuhl 2005 is missing in the references REPLY: Changed in the revised manuscript.

Reference comments: REFEREE #3 COMMENT: Please add: Bárcena, M.A., Flores, J.A., Sierro, F.J., Pérez-Folgado, M., Fabres, J., Calafat, A., Canals, M., 2004. Planktonic response to main oceanographic changes in the Alboran Sea (Western Mediterranean) as documented in sediment traps and surface sediments. *Marine Micropaleontology* 53, 423-445. REPLY: Added to the revised manuscript. REFEREE #3 COMMENT: Rigual-Hernández, A.S., Sierro, F.J., Bárcena, M.A., Flores, J.A., Heussner, S.,

BGD

Interactive
comment

Printer-friendly version

Discussion paper



2012. Seasonal and interannual changes of planktic foraminiferal $\delta^{18}O$ in the Gulf of Lions (NW Mediterranean) and their implications for paleoceanographic studies: Two 12-year sediment trap records. Deep Sea Research Part I: Oceanographic Research Papers 66, 26-40. REPLY: Added to the revised manuscript.

REFeree #3 COMMENT: Modify Coppa et al. (1980) in De Castro Coppa et al. (1980). REPLY: Changed to de Castro Coppa et al., (1980) in the revised manuscript.

REFeree #3 COMMENT: Line 578-579: the reference is Bijma et al 1990. REPLY: Changed to the revised manuscript.

REFeree #3 COMMENT: Please modify Line 615-616: this reference (Ivanov et al. 2003) is missing in the manuscript REPLY: Changed to the revised manuscript.

Figure comments:

REFeree #3 COMMENT: Fig.1: the numbers are too small it is very hard to read. Please increase the size. If the station 8 was not sampled for planktonic foraminifera, please remove it from the Mediterranean location map. REPLY: Numbers size changed in the revised version. The station 8 is mentioned here as the values were used for the interpolation of the environmental parameters.

REFeree #3 COMMENT: Fig. 2: In my opinion it is necessary to add close to the number of the station also the geographic location (i.e, 1-Atlantic or Gulf of Cadiz; 2 - Gibraltar; 3- Alboran Sea etc. : :). REPLY: We consider this unnecessary as the geographic location of the station codes is presented in Table 1, and the naming of all stations in the figure can be a problem for good visibility of the transect and the names themselves. We explain where to check the names of the station codes in the new legend for Figure 2:

“Fig. 2. Sampled stations with BONGO nets (dots). The numbers in the picture represent the station codes: First leg: 1 to 13, second leg: 14 to 22. For station code names see Table 1. Colour scale at right represents the values of surface chlorophyll con-

centration (in $\mu\text{g/l}$), retrieved from MODIS Aqua (L2), from the closest day as possible, specified in the upper part, of the first leg transect.”

REFeree #3 COMMENT: In addition, it is necessary to follow the same direction for the position of the columns (i.e., W versus E), so that for Fig. 3b the correct sequence is: 22, 20, 21, 19. The same modification you have to make for the other transect 17, 16, 16-18, 15, 14. Fig.4: see comments reported for Fig. 3 REPLY: Changed in the revised figures 3 and 4 (REV Fig.3 and REV Fig. 4).

Appendix A: REFeree #3 COMMENT: modify *quadrocameratus*-type in *quadrilobatus*, and *G. ruber* s.s. with *G. ruber* white or *G. ruber* alba REPLY: Changed in the revised manuscript.

References

Aurahs, R., Treis, Y., Darling, K., Kucera, M.: A revised taxonomic and phylogenetic concept for the planktonic foraminifer species *Globigerinoides ruber* based on molecular and morphometric evidence, *Mar. Micropaleontol.*, 79, 1-14, 2011. Bárcena, M.A., Flores, J.A., Sierro, F.J., Pérez-Folgado, M., Fabres, J., Calafat, A., and Canals, M.: Planktonic response to main oceanographic changes in the Alboran Sea (Western Mediterranean) as documented in sediment traps and surface sediments, *Mar. Micropaleontol.*, 53, 423-445, 2004. Bé, A. W. H. and Tolderlund, D. S.: Distribution and ecology of living planktonic foraminifera in surface waters of the Atlantic and Indian Oceans, in: *The micropaleontology of oceans*, edited by: Funnel, B. M. and Riedel, W. R., Cambridge University Press, London, U.K., 105-149, 1971. Cifelli, R.: Planktonic foraminifera from the Mediterranean and adjacent Atlantic waters (Cruise 49 of the Atlantis II, 1969), *J. Foramin. Res.*, 4, 171-183, 1974. Cramp, A., Collins, M., and West, R.: Late Pleistocene-Holocene sedimentation in the NW Aegean Sea: A palaeoclimatic palaeoceanographic reconstruction, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 68, 61-77, 1988. de Castro Coppa, M. G., Zei, M. M., Placella, B., Sgarella, F., and Ruggerio, E. T.: Distribuzione stagionale e verticale dei foraminiferi planctonici del Golfo di

Napoli, Boll. Soc. Natur. Napoli, 89, 1-25, 1980. Glaçon, G., Grazzini, C. V., and Sigal, J.: Premiers resultants d'une série d'observations saisonnières des foraminifères du plankton méditerranéen, in: Proceedings of the 2nd Plankton Conference, Rome, 1970, 555-581, 1971. Hassoun, A. E. R., Guglielmi, V., Gemayel, E., Goyet, C., Saab, M. A., Giani, M., Ziveri, P., Ingrosso, G., and Touratier, M.: Is the Mediterranean Sea circulation in a steady state, J. Water Res. Ocean Sci., 4 (1), 6-17, 2015b. Hembelen, Ch., Spindler, M., and Anderson, O.R.: Modern Planktonic Foraminifera, Springer-Verlag, New York, Berlin, Heidelberg, 363 pp., 1989. Hernández-Almeida, I., Bárcena, M. A., Flores, J. A., Sierro, F. J., Sanchez-Vidal, A., and Calafat, A.: Microplankton response to environmental conditions in the Alboran Sea (Western Mediterranean): One year sediment trap record, Mar. Micropaleontol., 78, 14-24, 2011. Mortyn, P. G. and Charles, C. D.: Planktonic foraminiferal depth habitat and $\delta^{18}\text{O}$ calibrations: plankton tow results from the Atlantic sector of the Southern Ocean, Paleoceanography, 18 (2), 1037, doi: 10.1029/2001PA000637, 2003. Ottens, J. J.: April and August Northeast Atlantic surface water masses reflected in planktic foraminifera, Neth. J. Sea Res., 28 (4), 261-283, 1992. Papp A., Schmid M. E.: Die fossilen Foraminiferen des tertiären Beckens von Wien, Revision der Monographie von Alcide d'Orbigny (1846). Wien: Abhandlungen der Geologischen Bundesanstalt, 1985. Pettersson, H.: The Swedish Deep-Sea Expedition, 1947-48, Deep-Sea Res., 1, 17-24, 1953. Pujol, C. and Vergnaud-Grazzini, C.: Distribution patterns of live planktic foraminifers as related to regional hydrography and productive systems of the Mediterranean Sea, Mar. Micropaleontol., 25, 187-217, 1995. Rigual-Hernández, A., Sierro, F. J., Bárcena, M. A., Flores, J. A., and Heussner, S.: Seasonal and interannual changes of planktic foraminiferal fluxes in the Gulf of Lions (NW Mediterranean) and their implications for paleoceanographic studies: Two 12-year sediment trap records, Deep-Sea Res I, 66, 26-40, 2012. Rio, D., Sprovieri, R., Thunell, R., Vergnaud-Grazzini, C., and Glaçon, G.: Pliocene-Pleistocene paleoenvironmental history of the western Mediterranean: A synthesis of ODP site 653 results, Proc. Ocean Drill Prog. Sci. Results, 107, 695-704, 1990. Rohling E. J., Marino, G., and Grant, K. M.: Mediterranean climate and

oceanography, and the periodic development of anoxic events (sapropels), Earth Sci., 143, 62-97, 2015. Rohling, E., Ramadan, A., Casford, J., Hayes, A., and Hoogakker, B.: The marine environment: present and past, in: The physical geography of the Mediterranean, edited by: Woodward, J., Oxford University Press, New York, United States, 33-67, 2009. Schiebel, R. and Hemleben, C.: Modern planktic foraminifera, Palaeont. Z., 79 (1), 135-148, 2005. Spezzaferri, S., Kucera, M., Pearson, P. N., Wade, B. S., Rappo, S., Poole, C. R., Morard, R., and Stalder, C.: Fossil and genetic evidence for the polyphyletic nature of the planktonic foraminifera “Globigerinoides”, and description of the new genus Trilobatus, PLOS One 10 (5), doi: 10.1371/journal.pone.0128108, 2015. Thunell, R. C.: Distribution of recent planktonic foraminifera in surface sediments of the Mediterranean Sea, Mar. Micropaleontol., 3, 147-173, 1978. van Raden, U. J., Groeneveld, J., Raitzsch, M., and Kučera, M.: Mg/Ca in the planktonic foraminifera Globorotalia inflata and Globigerinoides bulloides from Western Mediterranean plankton tow and core top samples, Mar. Micropaleontol., 78, 101-112, 2011. Weiner A. K. M., Weinkauf, M. F. G., Kurasawa, A., Darling, K. F., and Kucera, M.: Genetic and morphometric evidence for parallel evolution of the Globigerinella calida morphotype, Mar. Micropaleontol., 114, 19-35, 2015.

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-266, 2016.

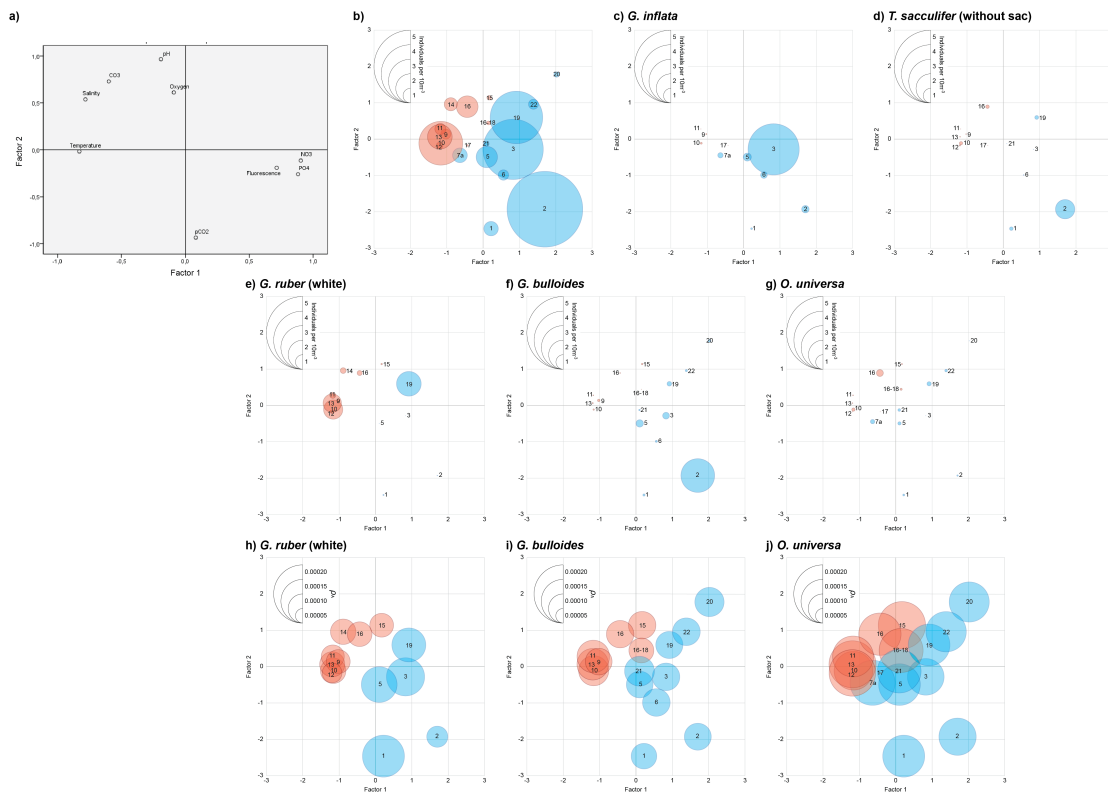
BGD

Interactive
comment

Printer-friendly version

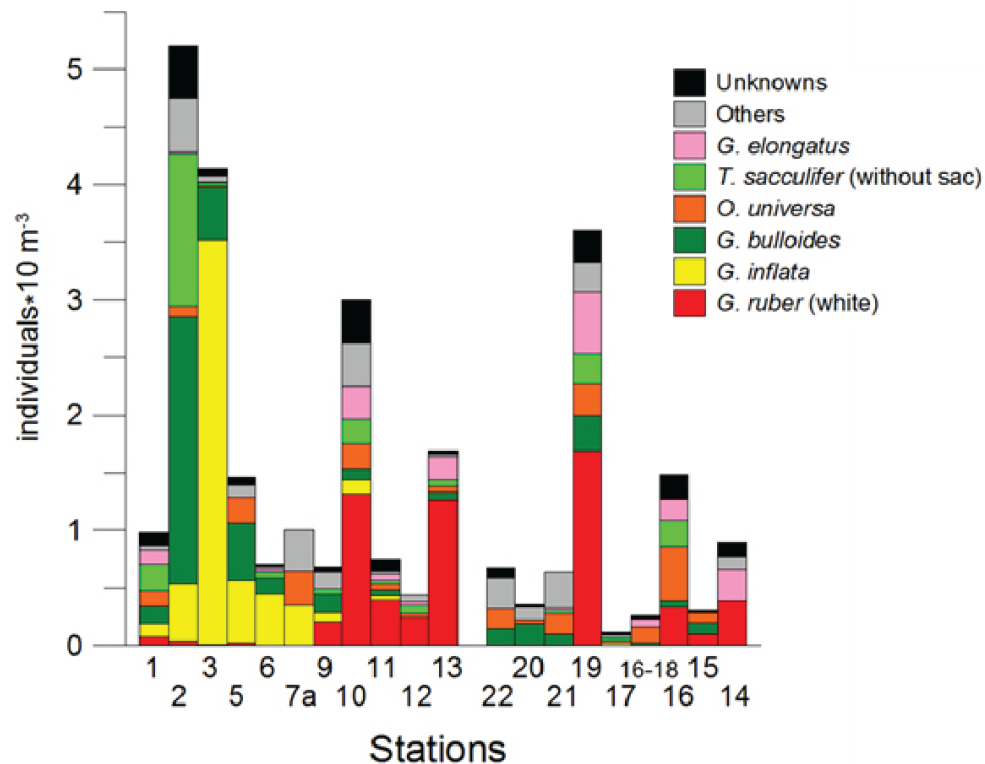
Discussion paper





REV Figure 7: Sample scores on the two PCA factors with (a) the loadings of the environmental parameters on each factor, (b) with overlay of the absolute abundance values (individuals*10 m⁻³) of every station of all the foraminifera sample, (c) *G. inflata*, (d) *T. sacculifer* (without sac), (e) *G. ruber* (white), (f) *G. bulloides*, and (g) *O. universa*. With overlay of the pA values (µg*µm⁻²) of (h) *G. ruber* (white), (i) *G. bulloides*, and (j) *O. universa*. In blue color western Mediterranean stations (incl. Atlantic and Strait of Gibraltar), in red colour the eastern Mediterranean stations.

Fig. 1.



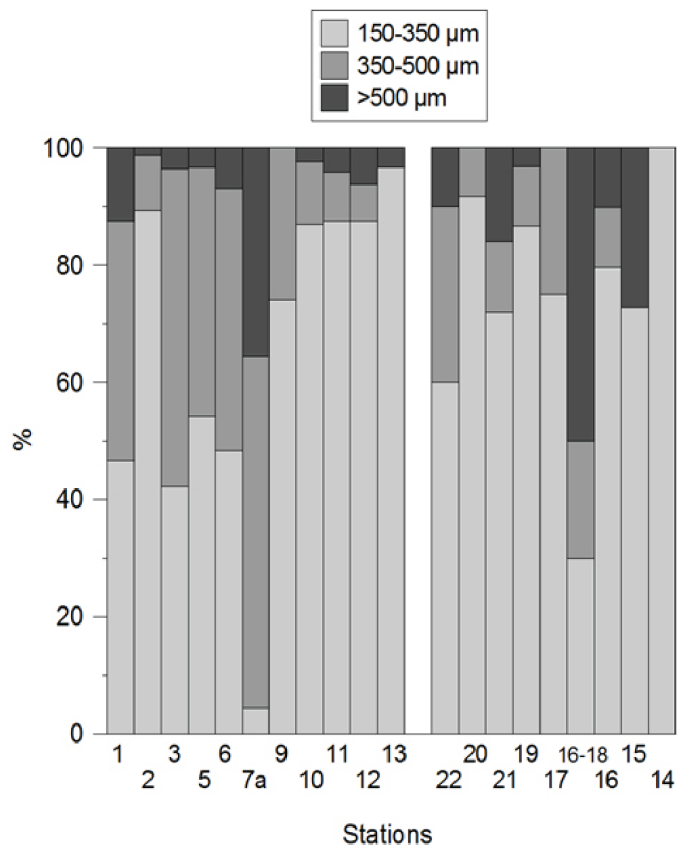
REV Figure 3: Absolute abundance of planktic foraminifera from BONGO nets during leg 1 (stations 1 to 13) and leg 2 (stations 22 to 14). Category 'Others' is comprised by *G. siphonifera*/*G. calida* *G. radians*, *G. quadrilobatus*, *H. pelagica*, *G. ruber* (pink), *G. menardii* and *T. sacculifer* (with sac).

Fig. 2.

Printer-friendly version

Discussion paper





REV Figure 4: Percentage of each planktic foraminifera size fraction in leg 1 (stations 1 to 13) and leg 2 (stations 22 to 14).

Fig. 3.