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Late Holocene planktic foraminiferal assemblages from Orca Basin: Effects of dissolution on faunal assemblages

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Late Holocene Planktic Foraminiferal Assemblages From Orca Basin; Effects of Dissolution on Faunal Assemblages

by

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ABSTRACT

Studies of planktic foraminifers have been, and continue to be, very important to paleoceanographic reconstructions and are dependent on the integrity of the carbonate tests. This study investigates the methods and procedures that can be used to obtain an accurate planktic foraminifer assemblage. Samples from Orca Basin boxcore OB-BC4D were processed and examined to obtain census data on planktic foraminifers. Experimentation of the splitting technique demonstrates the method is acceptable for estimating a planktic foraminifer assemblage. The effects of a sonication step in the processing of the faunal assemblage were also examined and revealed that sonication is not recommended for processing planktic foraminifers for faunal-assemblage analyses. Census data revealed downcore variation in the foraminifer species and intervals of increased dissolution over the last 1000 years.

INTRODUCTION

Faunal and chemical analyses of planktic foraminifers preserved in deep-sea sediments are commonly used to estimate sea surface temperatures (SST) (Imbrie and Kipp 1971, Kipp, 1976), primary production with higher abundances of planktic foraminfers (Mix, 1989), annual tempertature as a function of mixed-layer depth in the tropical Atlantic (Ravelo et al., 1990), and thermocline depth in the tropical Pacific (Andreason and Ravelo, 1997).

Planktic foraminifera are single-celled protozoans which live in the high latitude polar oceans to the warm tropical seas. They secrete a calcareous test made of calcium carbonate which records information about the water characteristics where they formed. These observations provide information on present-day environmental conditions, which form the basis for analyses of fossil planktic foraminiferal assemblages (Be, 1967). Early studies comparing foraminifer assemblages from plankton tows to water-column characteristics (temperature, salinity, thermocline) suggested that species distributions are most highly correlated to SST, salinity and nutrients (Berger, 1969). Alteration of the composition of the original assemblages by selective removal of species due to seafloor dissolution could mask these primary relationships (Parker and Berger, 1971; Coulbourn et al., 1980) and may influence paleoenvironmental interpretations based on relative species abundances (Berger, 1970).

Planktic foaminifers fall into two general categories. Spinose forms, such as the species *Globigerinoides ruber*, have spines from 1-3 mm long that radiate out from the

surface of their shell. In contrast, species such as *Globorotalia menardii* lack spines and are referred to as nonspinose forms (Parker, 1962). Although most if not all species of planktic foraminifers are omnivorous, individual species are most likely herbivores or carnivores. In general, the spinose species appear to be predominately carnivorous and the nonspinose species predominately herbivorous (Bé, 1967). This may explain why the carnivorous spinose species *Globigerinoides ruber, Globigerinoides sacculifer,* and *Globigerinoides conglobatus* among others usually constitute the bulk of the foraminifer population in the mixed zone of the Sargasso Sea and other nutrient-poor oceanic regions (Bé and Tolderland, 1971). Moreover, the spinose species posses symbiotic or comensal algae which manufacture additional nutrients to sustain their hosts in an oligotrophic environment. This may also explain in part why there is a greater incidence of nonspinose species in eutrophic waters and upwelling regions where high phytoplankton productivity occurs (Bé and Tolderland, 1971).

The depth habitat of planktic foraminifers is predominately in the euphotic zone, where their phytoplankton and zooplankton food occur in highest concentrations. Symbiont-bearing species such as *Globigerinoides ruber* (pink and white varieties) and *Globigerinoides sacculifer* are limited to the upper photic zone in near surface waters (0-65m) whereas species that are symbiont-free such as *Pulleniatina obliquiloculata* and *Globigerina calida* are not limited by light and can reside in deeper waters (105-200m) (Bé, 1967).

Major studies have dealt with the transition from living organism to carbonate test, rates of sinking and extent of dissolution in the water column and on the sea bottom

(Thunell and Honjo, 1981). An extensive investigation of planktic foraminifers in sediment trap samples was conducted from the central Atlantic and the tropical Pacific oceans. Thunell and Honjo (1981) found a decrease in carbonate flux with depth at both sites. The individual species of planktic foraminifers varied with an increase in depth as well. Formally, diagenesis should probably not be considered to start until the planktic foraminifer test reaches the seafloor, but pelagic carbonates can be altered considerably between death in the upper water column and deposition on the seafloor (Milliman et al., 1999).

Calcium carbonate is more abundant in Atlantic Ocean sediments and generally occurs in significant amounts to deeper depths than in Pacific Ocean sediments. This is due to the Pacific Ocean being less saturated with respect to calcium carbonate than Atlantic Ocean waters. Another factor leading to better preservation of calcium carbonate in Atlantic sediments is due to the higher influx of terrigenous materials in the Atlantic, which allows the carbonate to be buried and therefore preserved (Archer 1996b). Productivity in the overlying waters due to upwelling can cause higher concentrations to be deposited. A final major factor influencing calcium carbonate preservation is the relative $CaCO_3$ to organic carbon rain ratio because oxidation of sedimentary organic matter can decrease the saturation of pore waters with respect to $CaCO_3$ by increasing pCO_2 (Mekik et al., 2002).

The carbonate compensation depth (CCD) (Bramlette, 1961) is the boundary in the water column where the dissolution is equal to the flux, and preservation of $CaCO_3$ below this depth is unlikey. The lysocline (Berger, 1968) is the region in the water column

where the rate of dissolution rapidly increases and is characterized by lack of thin-shelled foraminifers, or planktic foraminifers that show signs of dissolution and was defined by Berger (1968) as the depth where the dominant type of foraminifera shifts from soluble to resistant species in bottom sediments.

As the water depth increases, aragonitic pteropods are the first to disappear, followed by the small and delicate types of planktic foraminifers until only fragments of the robust, thick-shelled foraminifers remain in the surface sediments. Resistance to solution in planktic foraminifers varies according to species (Berger, 1968). At shallow to intermediate seafloor depths (<3000m), foraminiferal tests tend to be well preserved in bottom sediments. The preservation of various types of carbonate shells and skeletons differs and the wall textures dictate the planktic foraminifers susceptibility to dissolution. For example, the smooth-walled *Globorotalia* are highly resistant to dissolution whereas the cratered wall of *Globigerinoides* are most susceptible to dissolution. The *Globigerina* forms show elongated spines in well preserved samples and tend to show a medium resistance to dissolution.

Studies of planktic foraminifers have been and continue to be a very important to paleoceanographic reconstructions and are dependant on the integrity of the tests. This study investigates the methods and procedures that can be used to obtain an accurate planktic foraminifer faunal assemblage. The objectives of this study are to complete a census of planktic foraminifer assemblages in a box core from the Orca Basin and determine the environmental significance of any assemblage changes that were observed

with depth in the core and to determine whether any dissolution found was due to methodology or environmental influences.

STUDY LOCATION

The Orca Basin is centered near 26' 57' N latitude and 91' 19' W longitude on the continental slope southwest of Louisiana (Figure 1). It is a small interdomal basin that is elbow-shaped that is 25km long and 5 km to 6 km wide. The long axis of the basin trends northeast to southwest and the basin rim lies between 1700 m and 1900 m water depth and the basin floor is located at a depth of about 2400 m sub-basin on the southwest side, separated by a saddle (2158m) in the center. The sub-basins have a 200 m thick hypersaline (250ppm) anoxic brine layer over the floor due to the erosion of salt diapers, with oxic conditions existing elsewhere in the basin (Shokes et al., 1977; McKee et al., 1978; Trabant and Presley, 1978). Box core OB-BC4D was collected on the gentle northwestern slope of the Orca Basin to reduce possibility of obtaining sediments that may have been subject to slumping.

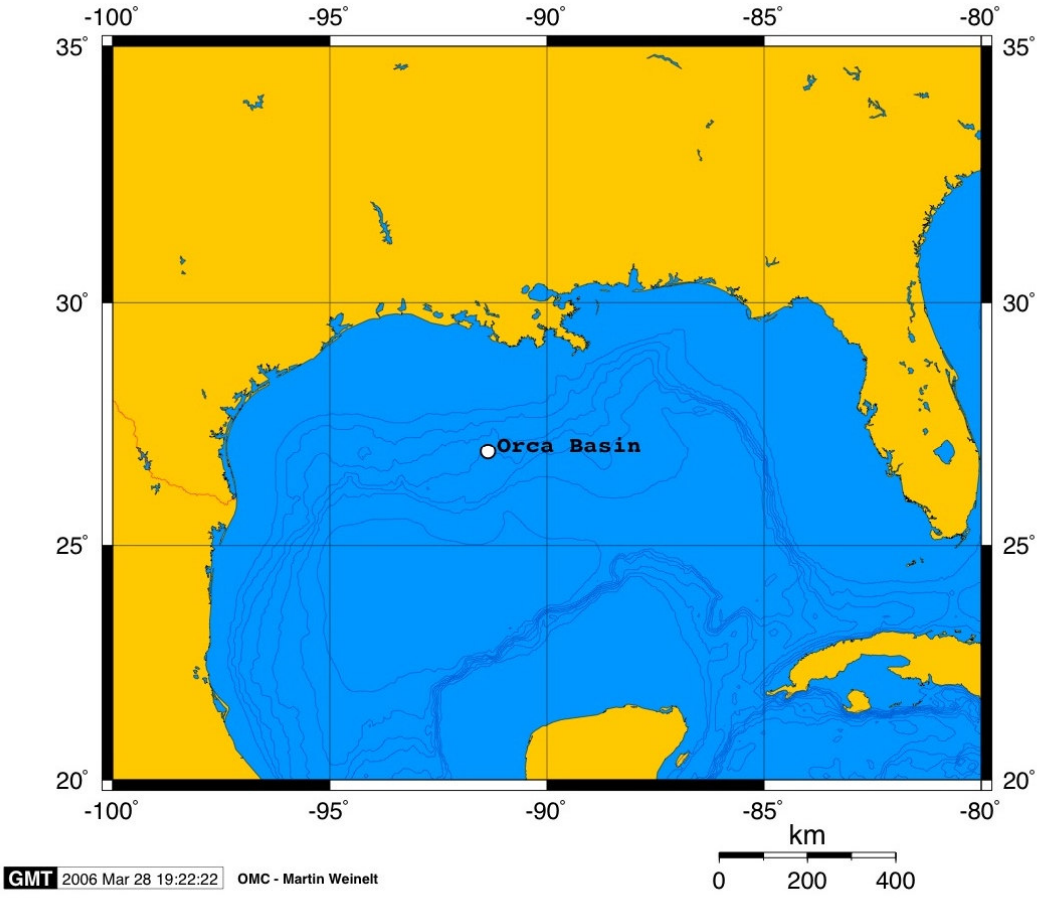

Figure 1. Map of Gulf of Mexico. Orca Basin is located SW of Louisiana on the continental slope. Basin rim lies between 1700-1900 m and basin depth is 2400m.

METHODS

Box core OB-BC4D was obtained from the gentle western slope of the oxic Orca Basin from the research vessel, R.V. Longhorn in June 2003 (Figure 1). The 55cm box core was sub-cored on board and samples were extruded at ½ cm intervals from the core and p placed in 2oz jars and frozen. The OB-BC4D sub-samples were stored in a deep freezer at College of Marine Science, St. Petersburg, Florida, until analyses began in June 2005. Faunal assemblages were obtained from the sub-sample sets in the upper 27cm of the cor core.

Nonsonicated Procedure

Samples from OB-BC4D were processed with and without a sonication step. Sample sets from equivalent depths were processed separately. For nonsonicated sample set, the mud and sediment sample was removed from the freezer and placed in a small tray with cold water to defrost for approximately five minutes. A clean Nalgene bottle was labeled and filled half way with deionized (DI) water. Approximately 2ml of sodium metaphoshate ($NaPO_4$) was added to the DI water. Mud was gently removed from the jar and placed in the DI-$NaPO_4$ solution. The sample was then agitated on a New Brunswick Scientific innOva 2100 platform shaker at 172 rpm for 2 hours until well separated. The sample was transferred to a wet sieve (63μm) and gently washed with DI water. Filter paper was labeled and inserted into a funnel and the sample was carefully washed into the

funnel to allow excess water to drip for 24 hours. The samples were placed on the top rack in a clean oven at 50°F to dry for 12-24 hours. The samples were dry sieved (150μm) and placed in a sample vial labeled >150μm for the coarse sample and 63-150μm for the fine sample. The 63-150μm sample vials were stored.

Sonicated Procedure

For the second subset, the process was the same except after the 63um wet sieving step, the > 63μm part of the sample was resuspended in a 600ml beaker in ~200ml of DI water and sonicated in a Fisher Scientific FS20 sonicator for 8 seconds. This sample set is referred to as the sonicated sub-sample set.

Faunal Split

The faunal splitting procedure is as follows. A spreadsheet with core, sample interval, split fraction, number of planktics and comments column was constructed. Starting with a sample vial of >150μm size fraction, the sample was dry sieved (150μm) to be sure all material was in the>150μm size fraction. The >150μm fraction sample was split until the split contained approximately 300 planktic foraminifers, however there are samples that contain more or less planktic foraminifers.

To obtain the faunal split, we started with a clean work surface, brushes, trays, three holding trays, microsplitter (2.25″X 2.29″X 3.00″), an air can, and two denominators. The microsplitter was set up with two holding trays underneath and the denominator placed to the right of the microsplitter. A 28 ply, 60- square cardboard slide was labeled

with name of core, sample interval, and size fraction and then assembled with the glass microslide and metal slide holder. The slide was then placed on a black metal grid tray and put aside.

The >150μm sample was transferred into an aluminum weighing tray and then carefully poured into the top of the microsplitter, moving evenly across the chutes. The weighing tray was tapped gently with a brush to remove all material, the microsplitter was gently tapped, and the surfaces of the microsplitter were brushed to ensure all remaining sample went down the chutes and into the holding trays. The denominator was hit to read '1'. The holding tray on the right side of the microsplitter was removed, poured into the weighing tray, and replaced. This process was repeated, and each split was recorded on the denominator until approximately 300-350 planktic foraminifers remained in the holding tray on the right side. "Eyeballing" the correct amount came with experience and varies with each core. A third holding tray was used to catch half of the last split in case the estimate was low and more material was needed to be added to reach 300-350 planktic foraminifers.

When the sample looked to be about the right size, it was poured onto a black grid tray and counted with a second denominator. Fragments or benthic foraminifers were not counted. It was important to decide ahead of time if the foraminifers on the lines would be counted with the square to the top or bottom, right or left of the line, and to remain consistent. If the slide contained 300-350 planktic foraminifers, the splitting was done. If the slide contained >350 planktic foraminifers, splitting was continued until the correct amount was reached. If the slide contained <300 planktic foraminifers, material was

added from the 3rd holding tray that contained the second half of the last split until the correct amount was reached. There are a few slides that have more or less of the ideal 300 planktic foraminifers, however they are minimal and would not affect the outcome of the faunal-assemblage census. When the splitting was finished, the sample was placed on the 28-ply slide, covered with the glass slide and the fraction of the sample was calculated (by taking the number of splits from the first denominator and converting to fraction according to the Split-fraction table) (Table 1). The split and number of planktic foraminifers were entered on spreadsheet and the remaining sample returned to the >150μm vial.

1	2	3	4	5	6	7	8	9	10	11
1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	1/512	1/1024	1/2048

Table 1. Split-fraction reference chart. Top row represents number of splits. Bottom row represents fraction of specimens for the sub-sample set.

The planktic foraminifer specimens were identified using a Nikon SMZ-2T stereomicroscope and counted to obtain the relative abundance of the species and species groups (Tables 2 and 3). An Excel spreadsheet was constructed with core, interval, plotting depth, all species observed, benthic foraminifers, fragments, total planktic foraminifers and comment section. A map was constructed with 60 squares to match the 28-ply slide and labeled with the core, interval, size fraction, and comment lines.

An adhesive was prepared by adding a couple of drops of Elmer's glue to a small vial of DI water and applied to the 28-ply slide with a small brush. The specimens were adhered to the slide using a size 0 script paint brush while carefully labeling the map with the proper location of the species, including benthic foraminifers and fragments. The results were recorded in the Excel spreadsheet for further analyses.

Taxon
Globigerinoides tenellus
Globigerina digitata
Globigerina rubescens
Globigerina bulloides
Globigerina falconensis
Globigerinita iota
Globigerina pachyderma (dupac)*
Globigerina pachyderma (right coiling)
Globorotalia crassiformis
Globorotalia inflata
Globorotalia tosaensis
Globorotalia scitula
Candeina nitida
Sphaeroidinella dehiscens
Hastigerina pelagica
Non-identified

Table 2. Rarely occurring species (>150μm) in core OB-BC4D. The species listed are placed in 'other' (OT) category in census data.

* Dupac refers to *Globigerina pachyderma* if species is right coiling and has more than four chambers.

Headings	Code
Globigerinoides ruber (white)	rubW
Globigerinoides ruber (pink)	rubP
Globigerinoides sacculifer	sac
Globigerinoides conglobatus	con
Globigerina calida	cal
Globigerinella aequilateralis	aeq
Globigerinita glutinata	glu
Pulleniatina obliquiloculata and *P. finalis*	obl
Orbulina universa	orb
Globoquadrina dutertrei	dut
Globorotalia truncatulinoides	tru
Globorotalia menardii	men
Globorotalia tumida	tum
Globorotalia ungulata	ung
Other	OT
Benthic foraminifers	ben
Fragments	frag
Total *Globigerinoides ruber* (pink and white)	Trub
Globorotalia menardii group (*G. menardii, G. tumida, G. ungulata*	Tmen
Total planktic foraminifers	Tplk
Total Planktic foraminifers + Benthic foraminifers	TP+B
Interval Depth (mm)	depthmm

Table 3. Census data abbreviations for core OB-BC4D.

REPLICATE EXPERIMENT

The relative abundance of species and species groups of planktic foraminifers in samples from core OB-BC4D were estimated by identifying and counting specimens in a 300 specimen sub-sample, or counting split, from the total processed sample in the >150 um size fraction. To test the reproducibility of the counting splits, three separate counting splits were obtained and tabulated from two samples, OB-BC4D 20-25mm and OB-BC4D 25-30mm (Table 4). Relative abundance was calculated as number of a particular species divided by the number of total planktic foraminifers in the sub-sample. The relative abundance of species and species groups in the three counting splits from each sampling level were then compared (Figures 3 and 4). The results are shown in Figures 2 and 3. Inspection of the figures indicates that species abundances are very similar in the replicate counting splits from each sample. For example, sample interval 20-25 mm, *G. ruber* (pink variety) has relative abundance values of 13 to 14% with an average of 13.5%. Likewise, in sample 25-30, *G. ruber* (pink variety) has values of 12% relative abundance for all three sample splits. *Globorotalia truncatulinoides* illustrates similar values in replicate splits with values between 9 to 12% relative abundance in sample interval 20-25mm, with an average of 10%, and values from 10 to11% with an average of 10.5% in sample interval 25-30mm. The replicate counting splits illustrate consistency in each sample and it is concluded that the splitting technique used produced

a consistent estimate of the planktic foraminiferal assemblage in the samples from OB-BC4D.

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	Tplk	ben	frag	TP+B	Trub	Tmen
20-25A	64	47	16	10	29	15	14	52	6	23	34	26	4		10	350	4	85	354	111	30
20-25B	77	49	23	4	25	19	17	48	11	22	31	19			9	354	11	82	365	126	19
20-25C	68	46	16	9	23	8	13	56	19	17	41	24	1	3	7	351	7	70	358	114	28
AVG	70	47	18	8	26	14	15	52	12	21	35	23	2	1	8	352	7	79	359	117	26
25-30A	63	37	15	3	29	16	12	40	13	22	31	16	2	5	10	314	4	91	318	100	23
25-30B	68	36	14	6	14	10	17	40	9	15	32	13	1	3	11	289	8	64	297	104	17
25-30C	60	37	21	4	31	15	12	37	16	17	33	15	4	4	11	317	7	77	324	97	23
AVG	64	37	17	4	25	14	14	39	13	18	32	15	2	4	10	307	6	77	313	100	21

(A)

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	ben	frag	Trub	Tmen
20-25A	18	13	5	3	8	4	4	15	2	7	10	7	1	0	3	1	24	32	9
20-25B	22	14	6	1	7	5	5	14	3	6	9	5	0	0	3	3	23	36	5
20-25C	19	13	5	3	7	2	4	16	5	5	12	7	0	1	2	2	20	32	8
AVG	20	13	5	2	7	4	4	15	3	6	10	7	0	0	2	2	22	33	7
25-30A	20	12	5	1	9	5	4	13	4	7	10	5	1	2	4	1	29	32	7
25-30B	24	12	5	2	5	3	6	14	3	5	11	4	0	1	4	3	22	36	6
25-30C	19	12	7	1	10	5	4	12	5	5	10	5	1	1	4	2	24	31	7
AVG	21	12	5	1	8	4	4	13	4	6	10	5	1	1	3	2	25	33	7

(B)

Table 4. (A) Raw data for OB-BC4D replicate experiment. (B) replicate split relative abundance. Averages (AVG) of the three counting splits are displayed.

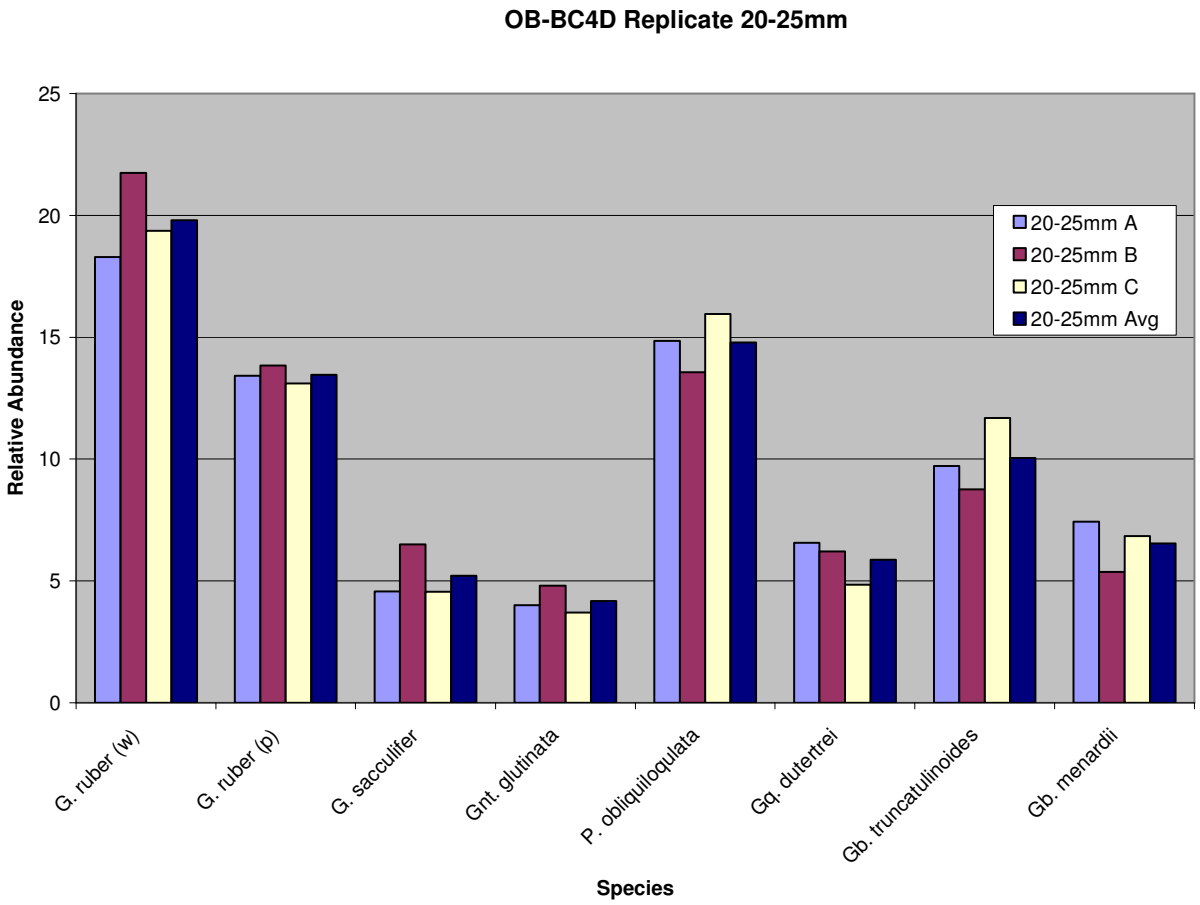

Figure 2. Plot of relative abundance from replicate counting splits from interval 20-25 mm. Dark blue bar represents the average of a, b, and c.

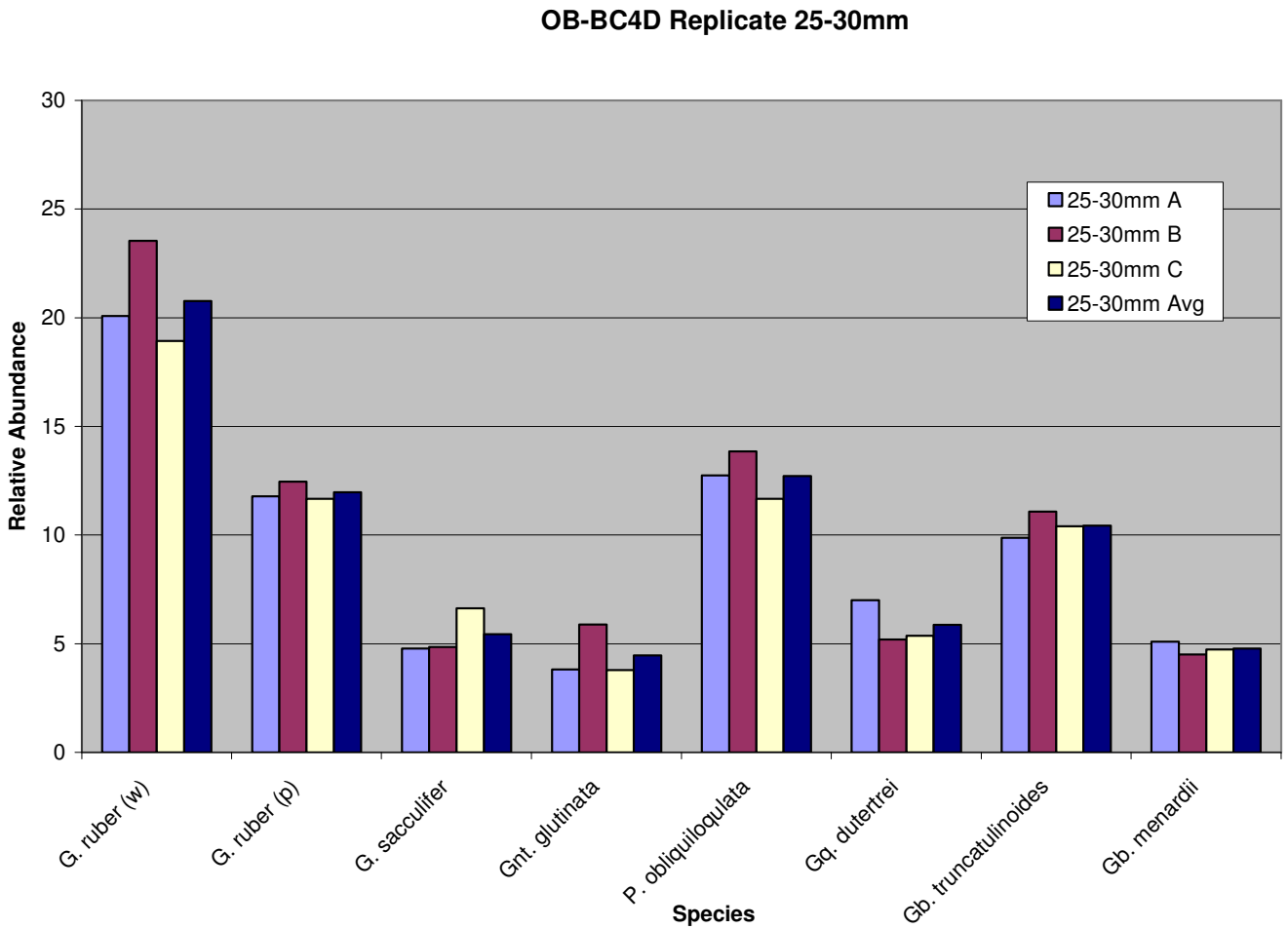

Figure 3. Plot of relative abundance from replicate counting splits from interval 25-30 mm. Dark blue bar represents the average of a,b, and c.

EFFECTS OF PROCESSING AND DISSOLUTION

One objective of this study was to determine the effect of using a brief sonication step on the assemblages during the processing of the planktic foraminifers. Comparison of the census results from samples processed with and without the sonication step revealed significant differences between the two data sets (Appendices II, IV). In general the number of robust, heavily calcified species and the relative abundance of fragments of foraminifers were elevated in the sample set that underwent the sonication step. The difference is very pronounced in the fragmentation index (Figure 4a). Note that values for the fragmentation index (calculated as number of fragments / number of planktic foraminifers) are almost always much higher in samples from the data set using the sonication step than in the equivalent samples that did not undergo the sonication step. The difference varies with depth in the core and reached a maximum in two intervals centered at about 125mm and 225mm depth. At the intervals of greatest difference, the fragmentation index in the sonicated sample set reaches values near 200, whereas maximum values in the nonsonicated sample set do not exceed 80.

A similar pattern is present in the relative abundance values for the *Globorotalia menardii* group below approximately 75mm depth (Figure 4b). The *Gb. menardii* group includes *Gb. menardii*, *Gb. tumida*, and *Gb. ungulata*. These taxa are heavily calcified compact forms with solid calcite keels. Below 75mm, values of the *Gb. menardii* group in the sonicated sample set are usually higher than the values in the sample set that was not sonicated.

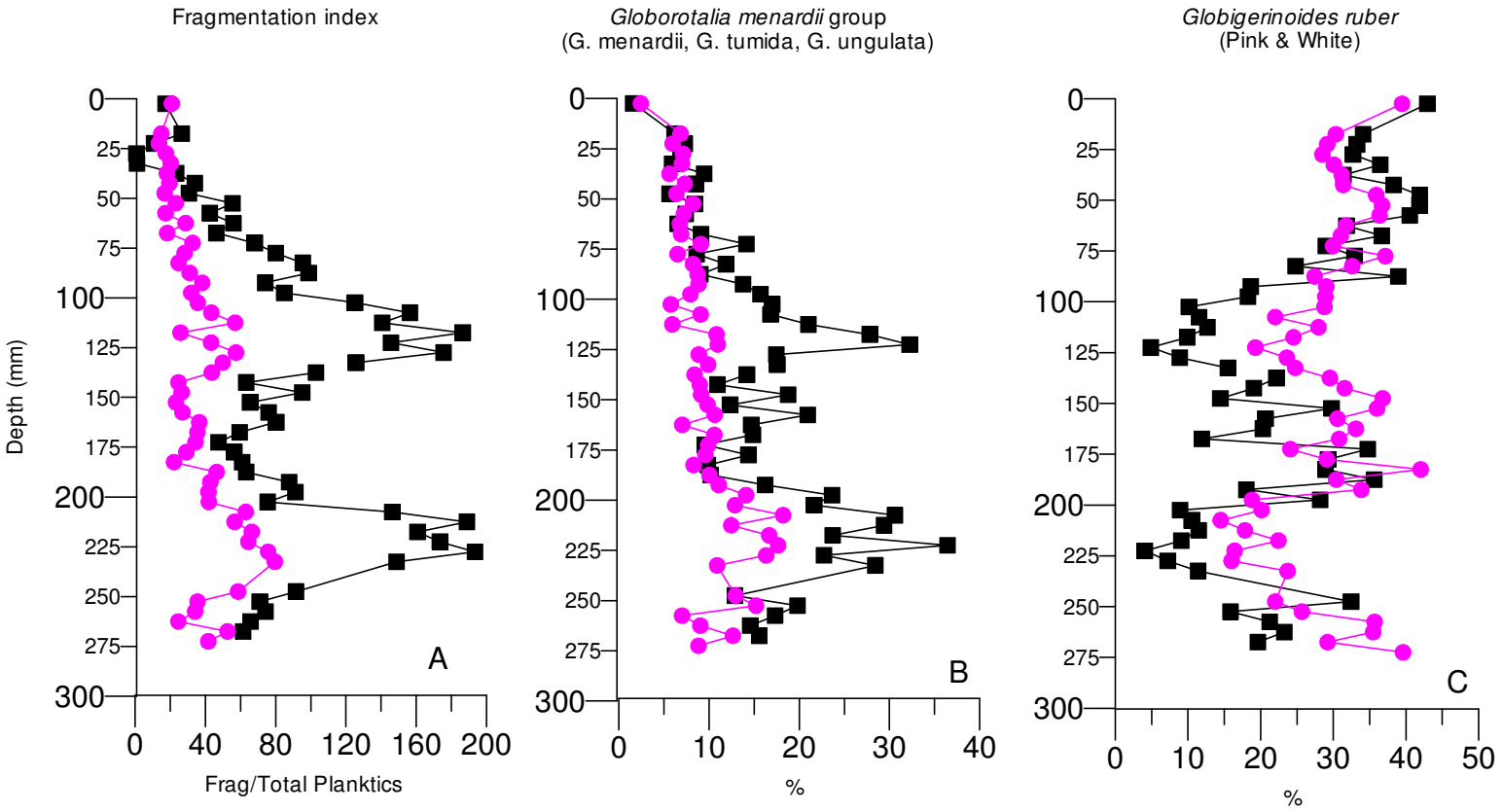

Figure 4. Plot of fragmentation index and relative abundance for selected species from sonicated (black) and nonsonicated (red) samples. (A) represents the fragmentation index which is calculated as number of fragments / total number of planktic foraminifers. Relative abundance shown in (B) for robust species *Globorotalia menardii* group and (C) delicate species *Globigerinoides ruber* (pink and white varieties).

In the intervals associated with maxima in the fragmentation index, the values of the *Gb. menardii* group are much higher in the sonicated samples compared to the nonsonicated samples.

The downcore variations in the relative abundance of *Globigerinoides ruber* (pink and white varieties) are plotted on Figure 4c. In contrast to the *Gb. menardii* group, *Globigerinoides ruber* are a more delicate, lightly calcified form with a more porous test wall. The variations in relative abundance of *G. ruber* are opposite the variations observed in the *Gb. menardii* group and the fragmentation index. Maxima in the fragmentation index and *Gb. menardii* group abundance corresponds with minima in the abundance of *G. ruber* (total). In general, the abundance of *G. ruber* in the sonicated sample set are lower than values in the nonsonicated sample set and the difference in values is largest when the fragmentation index values are the highest.

These observations are consistant with the conclusion that mechanical agitation caused by the sonication step altered the planktic foraminifer assemblages. Fragmentation was greater in more delicate, less heavily calcified forms than it was in more robust, heavily calcified forms.

The downcore variation in the amount of fragmentation observed in the sonicated sample set and the differences observed in the *Gb. menardii* group and total *G. ruber* can not be explained solely by the sonication process since the step was applied uniformly to all samples yet the differences between the two are much more prominent at the two peaks. Variations in selected components from the nonsonicated sample set are compared (figure 5). The more robust species *Gq. dutertrei, Gb. truncatulinoides,*

Gb. menardii group and the fragmentation index have similar downcore pattern in relative abundances. The relative abundance of the more robust species and fragmentation index show a maximum centered around 100-125mm and another around 200-250mm. In contrast, the total *G. ruber,* which is a more delicate species, shows minimum relative abundance at those same intervals. The most likely explanation for the pattern is that two intervals of increased dissolution are recorded in the sample and are accentuated by the sonication process, which appears to yield more fragments, and higher abundances of the robust species, and lower relative abundances of the delicate *G. ruber*.

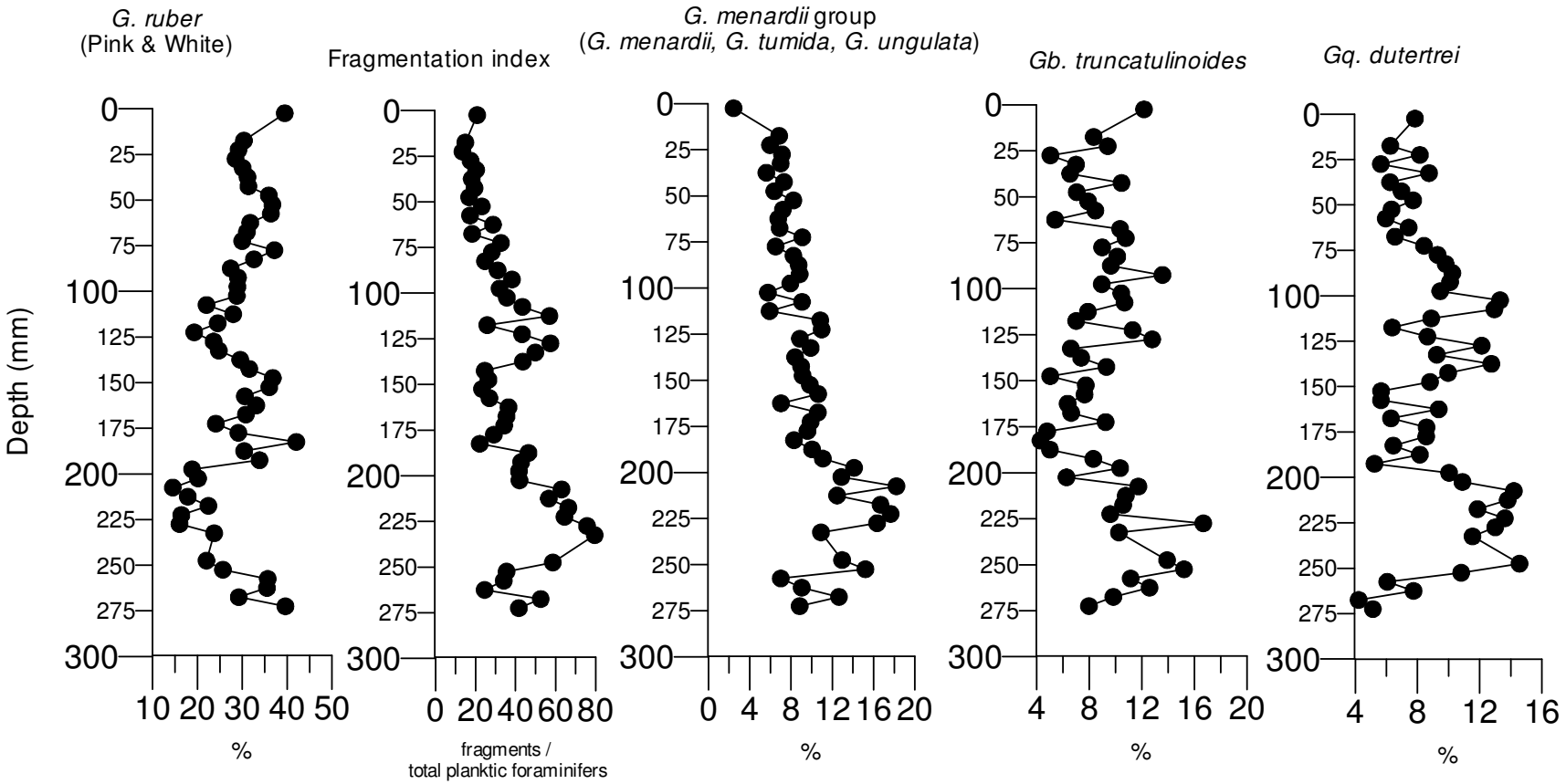

Figure 5. Variation of relative abundance and fragmentation index of selective nonsonicated species downcore to 27.5 mm of OB-BC4D.

DISCUSSION

The variation in relative abundance of robust and delicate species provides evidence for two pulses of dissolution in the upper 275 mm of core OB-BC4D. Dissolution down core was not expected due to depth since the depth of the OB-BC4D (2400m) is well above the lysocline (3800m) and CCD (4800m) which is based on the Atlantic Ocean.

The box core was obtained from a site from the oxic area of Orca Basin, which is known for the two sub-basins that contain a hypersaline brine layer ~ 150 m above the anoxic basin floor. Perhaps the hypersaline boundary is dynamic and was present over the study site during those intervals. Dissolution due to sulfate- reducing microbes that are associated with high saline environments could also be a factor. OB-BC4D was obtained from an organic-rich, oxic region of Orca Basin and dissolution due to biological processes at the water-sediment interface such as respiration and oxidation could be a cause.

There must be other influences on the planktic foraminifers, perhaps an environmental signal being recorded in the faunal assemblage. Comparison of OB-BC4D planktic foraminifer faunal assemblage with other faunal assemblages within the Gulf of Mexico, i.e.: Pigmy Basin which is located ~ 17km NW may shed light on whether or not dissolution is a local or regional feature.

SUMMARY AND CONCLUSIONS

Samples from Orca Basin core OB-BC4D were processed and examined to obtain census data on planktic foraminifer assemblages. An experiment was conducted to test

the reliability of “counting splits” to estimate assemblages. The results were very similar and consistent in both intervals and it is concluded that the splitting technique used was an acceptable method to estimate the planktic foraminifer assemblage. The effects of a brief sonication step in the process on the faunal assemblages were also examined. The faunal assemblage compositions were altered and the foraminiferal tests fragmented or destroyed as a result of the sonication step. Sonication is not recommended for processing planktic foraminifers for faunal-assemblage analyses.

Downcore variation in the foraminifer species revealed two intervals of increased fragmentation and increased relative abundance of the robust foraminifer species, and a decrease in the delicate foraminifer species. These observations suggest two intervals of increased dissolution are present in the upper 27cm of the OB-BC4D record.

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APPENDICES

Appendix I. Raw data for sonicated OB-BC4D sample set.

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	Tplk	ben	frag	TP+B	Trub	Tmen
0-5	54	80	20	8	14	6	3	24	13	20	47	5			7	312	5	54	317	134	5
15-20	67	49	20	2	25	15	13	46	11	21	37	19	2		8	340	11	90	351	116	21
20-25*	70	47	18	8	26	14	15	52	12	21	35	23	2	1	5	352	7	79	359	117	26
25-30*	64	37	17	4	25	14	14	39	13	18	32	15	2	4	6	307	6	77	313	100	21
30-35	94	54	10	5	41	17	23	34	7	35	30	14	5	5	26	406	8	94	414	148	24
35-40	62	31	12	3	30	8	20	30	6	19	31	12	9	7	14	296	11	69	307	93	28
40-45	81	40	8	1	16	13	15	36	6	27	29	15	4	8	13	316	10	107	326	121	27
45-50	80	39	9	5	19	7	17	36	2	11	22	12	1	3	14	284	9	87	293	119	16
50-55	100	39	9	1	18	13	15	23	6	36	34	14	6	8	6	332	11	184	343	139	28
55-60	96	30	7	4	23	13	13	36	9	22	27	11	5	7	3	311	10	132	321	126	23
60-65	58	25	9	3	13	13	10	34	8	23	42	8	8	1	3	261	9	146	270	83	17
65-70	126	35	19	6	19	20	17	63	10	33	37	25	7	8	4	439	8	203	447	161	40
70-75	73	15	10	6	19	8	8	40	8	34	34	37	5	1	1	304	13	207	317	88	43
75-80	82	25	15	9	20	10	7	42	12	36	32	16	9	3	3	325	15	260	340	107	28
80-85	57	14	13	7	9	11	7	45	16	32	33	23	8	3	4	286	13	273	299	71	34
85-90	85	10	5	6	6	5	5	25	7	26	34	15	6	1	4	244	11	241	255	95	22
90-95	48	13	14	15	5	10	5	53	10	52	56	30	12	3	1	327	18	242	345	61	45
95-100	47	10	11	14	11	9	6	46	16	41	42	32	17		4	312	10	265	322	57	49
100-105	28	3	11	13	9	4	1	63	16	31	63	38	14		4	306	10	383	316	31	52
105-110	33	4	7	17	9	9	2	59	13	39	60	36	17	1	8	321	15	502	336	37	54
110-115	43	4	13	24	7	5	4	64	15	52	49	50	27	1	7	371	24	522	395	47	78
115-120	23	4	7	16	5	4	2	50	7	36	38	46	30		2	273	26	509	299	27	76
120-125	14	1	6	28	3	6	2	70	12	35	22	56	43		1	307	27	447	334	15	99
125-130	22	6	11	17	11	8	3	75	26	46	31	31	24		2	315	17	553	332	28	55
130-135	42	11	9	16	5	8	10	71	18	46	42	44	16		0	342	21	430	363	53	60

* Interval used in replicate split experiment.

Appendix I. Raw data for sonicated OB-BC4D sample set (continued)

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	Tplk	ben	frag	TP+B	Trub	Tmen
135-140	65	13	13	6	9	8	11	54	16	40	61	32	17	1	3	352	11	362	363	78	50
140-145	44	17	20	7	14	11	7	67	18	32	43	14	19	2	1	320	10	202	330	61	35
145-150	45	2	17	14	4	10	5	61	9	37	53	44	17		1	325	8	309	333	47	61
150-155	90	21	19	8	4	14	11	64	10	32	46	35	10	1	1	373	18	244	391	111	46
155-160	58	16	25	15	9	19	3	50	17	32	36	36	36	3	1	358	11	272	369	74	75
160-165	56	9	10	20	7	3	6	65	21	44	29	27	20		1	320	23	257	343	65	47
165-170	28	12	21	25	5	8	6	57	23	42	51	31	19		3	336	13	200	349	40	50
170-175	93	31	37	10	17	22	15	20	22	25	22	20	12	2	6	357	13	169	370	124	34
175-180	87	19	37	17	7	9	14	39	10	34	27	31	19	2	3	362	18	204	380	106	52
180-185	74	11	24	11	10	5	13	25	15	27	41	17	10	2	5	294	13	179	307	85	29
185-190	93	26	28	19	10	4	13	29	14	31	27	22	9	3	4	334	17	211	351	119	34
190-195	51	9	29	11	20	4	9	41	16	38	42	28	25	1	7	333	23	292	356	60	54
195-200	79	14	16	13	8	4	10	23	6	26	43	47	31		5	330	29	301	359	93	78
200-205	28	0	14	18	4	6	4	55	25	45	43	39	29		3	314	16	237	330	28	68
205-210	29	3	14	16		1	2	38	13	50	41	44	49		3	304	30	445	334	32	93
210-215	28	8	11	8	8	8	1	50	12	33	49	55	37		3	313	24	591	337	36	92
215-220	24	4	8	8	8	5	2	44	16	54	57	45	28		4	308	29	495	337	28	73
220-225	13	0	7	5	3	5	3	36	11	42	74	63	54		5	321	29	557	350	13	117
225-230	15	5	16	4	2	4	6	37		56	66	38	24	1	2	277	21	536	298	20	63
230-235	18	6	3	4	2	2	1	25	8	30	50	34	26		2	211	22	314	233	24	60
245-250	82	29	24	4	21	11	8	24	7	22	51	33	11		8	342	14	313	356	111	44
250-255	28	20	25	2	7	8	1	42	9	30	69	51	7	2	1	303	9	215	312	48	60
255-260	46	19	18	3	7	12	6	44	14	34	42	38	15		7	306	9	227	315	65	53
260-265	39	28	25	3	13	12	3	33	11	27	45	34	8		5	288	4	189	292	67	42
265-270	47	16	28	7	16	15	5	36	7	31	60	36	11	3	1	321	13	197	334	63	50

Appendix II. Relative abundance for sonicated OB-BC4D sample set

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	ben	frg	Trub	Tmen
0-5	17	26	6	3	4	2	1	8	4	6	15	2	0	0	2	2	17	43	2
15-20	20	14	6	1	7	4	4	14	3	6	11	6	1	0	2	3	26	34	6
20-25*	20	13	11	3	6	4	1	9	3	6	12	6	1	1	1	2	11	33	7
25-30*	21	12	23	7	7	4	4	15	3	6	10	7	0	0	2	0	1	33	7
30-35	23	13	22	4	8	4	4	13	4	6	10	5	1	1	6	0	1	36	6
35-40	21	10	4	1	10	3	7	10	2	6	10	4	3	2	5	4	23	31	9
40-45	26	13	3	0	5	4	5	11	2	9	9	5	1	3	4	3	34	38	9
45-50	28	14	3	2	7	2	6	13	1	4	8	4	0	1	5	3	31	42	6
50-55	30	12	3	0	5	4	5	7	2	11	10	4	2	2	2	3	55	42	8
55-60	31	10	2	1	7	4	4	12	3	7	9	4	2	2	1	3	42	41	7
60-65	22	10	3	1	5	5	4	13	3	9	16	3	3	0	1	3	56	32	7
65-70	29	8	4	1	4	5	4	14	2	8	8	6	2	2	1	2	46	37	9
70-75	24	5	3	2	6	3	3	13	3	11	11	12	2	0	0	4	68	29	14
75-80	25	8	5	3	6	3	2	13	4	11	10	5	3	1	1	4	80	33	9
80-85	20	5	5	2	3	4	2	16	6	11	12	8	3	1	1	4	95	25	12
85-90	35	4	2	2	2	2	2	10	3	11	14	6	2	0	2	4	99	39	9
90-95	15	4	4	5	2	3	2	16	3	16	17	9	4	1	0	5	74	19	14
95-100	15	3	4	4	4	3	2	15	5	13	13	10	5	0	1	3	85	18	16
100-105	9	1	4	4	3	1	0	21	5	10	21	12	5	0	1	3	125	10	17
105-110	10	1	2	5	3	3	1	18	4	12	19	11	5	0	2	4	156	12	17
110-115	12	1	4	6	2	1	1	17	4	14	13	13	7	0	2	6	141	13	21
115-120	8	1	3	6	2	1	1	18	3	13	14	17	11	0	1	9	186	10	28
120-125	5	0	2	9	1	2	1	23	4	11	7	18	14	0	0	8	146	5	32
125-130	7	2	3	5	3	3	1	24	8	15	10	10	8	0	1	5	176	9	17
130-135	12	3	3	5	1	2	3	21	5	13	12	13	5	0	0	6	126	15	18

* Intervals used in replicate experiment.

Appendix II. Relative abundance for sonicated OB-BC4D sample set (continued)

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	ben	frg	Trub	Tmen
135-140	18	4	4	2	3	2	3	15	5	11	17	9	5	0	1	3	103	22	14
140-145	14	5	6	2	4	3	2	21	6	10	13	4	6	1	0	3	63	19	11
145-150	14	1	5	4	1	3	2	19	3	11	16	14	5	0	0	2	95	14	19
150-155	24	6	5	2	1	4	3	17	3	9	12	9	3	0	0	5	65	30	12
155-160	16	4	7	4	3	5	1	14	5	9	10	10	10	1	0	3	76	21	21
160-165	18	3	3	6	2	1	2	20	7	14	9	8	6	0	0	7	80	20	15
165-170	8	4	6	7	1	2	2	17	7	13	15	9	6	0	1	4	60	12	15
170-175	26	9	10	3	5	6	4	6	6	7	6	6	3	1	2	4	47	35	10
175-180	24	5	10	5	2	2	4	11	3	9	7	9	5	1	1	5	56	29	14
180-185	25	4	8	4	3	2	4	9	5	9	14	6	3	1	2	4	61	29	10
185-190	28	8	8	6	3	1	4	9	4	9	8	7	3	1	1	5	63	36	10
190-195	15	3	9	3	6	1	3	12	5	11	13	8	8	0	2	6	88	18	16
195-200	24	4	5	4	2	1	3	7	2	8	13	14	9	0	2	8	91	28	24
200-205	9	0	4	6	1	2	1	18	8	14	14	12	9	0	1	5	75	9	22
205-210	10	1	5	5	0	0	1	13	4	16	13	14	16	0	1	9	146	11	31
210-215	9	3	4	3	3	3	0	16	4	11	16	18	12	0	1	7	189	12	29
215-220	8	1	3	3	3	2	1	14	5	18	19	15	9	0	1	9	161	9	24
220-225	4	0	2	2	1	2	1	11	3	13	23	20	17	0	2	8	174	4	36
225-230	5	2	6	1	1	1	2	13	0	20	24	14	9	0	1	7	194	7	23
230-235	9	3	1	2	1	1	0	12	4	14	24	16	12	0	1	9	149	11	28
245-250	24	8	7	1	6	3	2	7	2	6	15	10	3	0	2	4	92	32	13
250-255	9	7	8	1	2	3	0	14	3	10	23	17	2	1	0	3	71	16	20
255-260	15	6	6	1	2	4	2	14	5	11	14	12	5	0	2	3	74	21	17
260-265	14	10	9	1	5	4	1	11	4	9	16	12	3	0	2	1	66	23	15
265-270	15	5	9	2	5	5	2	11	2	10	19	11	3	1	0	4	61	20	16

Appendix III. Raw data for nonsonicated OB-BC4D sample set.

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	Tplk	ben	frag	TP+B	Trub	Tmen
0-5	70	76	11	6	17	20	19	32	12	29	45	8	1		24	370	21	77	391	146	9
15-20	69	33	20	5	30	20	17	41	9	21	28	23			20	336	16	50	352	102	23
20-25	55	38	14	6	22	17	12	37	17	26	30	16	1	2	26	319	21	43	340	93	19
25-30	72	24	17	4	16	30	18	43	28	19	17	18	3	3	25	337	22	59	359	96	24
30-35	62	24	18	5	19	19	10	32	14	25	20	13	4	3	18	286	15	58	301	86	20
35-40	55	45	13	3	14	42	14	42	21	20	21	13	4	1	13	321	18	58	339	100	18
40-45	46	44	9	3	21	21	15	19	9	20	30	19	2		29	287	7	56	294	90	21
45-50	87	20	9	6	13	22	12	29	17	23	21	14	5		20	298	14	50	312	107	19
50-55	80	36	8	1	18	22	16	32	12	20	25	14	9	3	20	316	4	73	320	116	26
55-60	76	40	7	5	16	27	12	46	10	19	27	15	4	4	11	319	4	55	323	116	23
60-65	52	42	14	6	24	19	15	34	18	22	16	15	4	1	14	296	11	85	307	94	20
65-70	45	45	21	4	20	16	6	41	16	19	30	10	7	3	7	290	7	53	297	90	20
70-75	74	15	11	3	23	17	16	38	8	25	32	19	4	4	8	297	11	97	308	89	27
75-80	87	33	10	6	14	21	10	43	10	30	29	15	1	5	9	323	19	91	342	120	21
80-85	80	23	16	5	13	21	5	36	18	31	32	19	5	2	10	316	13	78	329	103	26
85-90	75	16	14	6	18	23	7	46	18	34	32	18	5	6	14	332	17	103	349	91	29
90-95	73	19	16	5	24	8	10	37	7	32	43	16	8	4	15	317	13	121	330	92	28
95-100	94	19	16	8	13	27	9	58	27	37	35	23	5	3	17	391	17	125	408	113	31
100-105	73	7	18	6	10	11	4	40	12	37	29	8	4	4	15	278	9	99	287	80	16
105-110	56	12	23	3	19	15	4	49	18	40	33	18	8	2	9	309	22	134	331	68	28
110-115	73	12	27	7	22	18	13	28	26	27	24	15	2	1	9	304	19	173	323	85	18
115-120	53	24	18	13	12	19	5	46	27	20	22	26	6	2	21	314	10	81	324	77	34
120-125	44	14	16	11	11	16	4	62	21	26	34	23	9	1	9	301	24	130	325	58	33
125-130	57	15	16	10	12	13	14	38	16	37	39	20	6	1	11	305	22	175	327	72	27
130-135	66	9	23	11	18	23	9	37	14	28	20	18	8	4	15	303	10	151	313	75	30

Appendix III. Raw data for nonsonicated OB-BC4D sample set (continued)

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	Tplk	ben	frag	TP+B	Trub	Tmen
135-140	67	21	30	7	13	9	5	35	17	38	22	22	2	1	9	298	19	130	317	88	25
140-145	76	19	20	6	6	21	8	30	25	30	28	16	11		5	301	13	74	314	95	27
145-150	94	23	24	6	9	16	14	34	15	28	16	19	3	7	10	318	8	84	326	117	29
150-155	98	23	18	12	9	16	12	40	21	19	26	23	6	4	9	336	13	78	349	121	33
155-160	69	23	23	7	11	26	5	31	25	17	23	19	7	6	9	301	20	81	321	92	32
160-165	67	32	16	11	12	16	13	34	22	28	19	11	6	4	8	299	26	109	325	99	21
165-170	74	19	21	10	18	14	10	34	21	19	20	21	6	5	10	302	20	107	322	93	32
170-175	59	14	34	14	21	11	4	34	15	26	28	17	7	6	13	303	10	104	313	73	30
175-180	64	21	34	14	11	13	8	31	22	25	14	12	8	8	7	292	12	85	304	85	28
180-185	104	33	25	8	20	14	9	29	12	21	14	17	7	3	10	326	10	72	336	137	27
185-190	79	18	34	11	18	12	9	38	18	26	16	19	9	4	8	319	33	148	352	97	32
190-195	86	24	28	10	12	12	18	28	14	17	27	17	11	8	13	325	21	139	346	110	36
195-200	40	20	30	13	13	17	10	37	23	32	33	23	19	3	6	319	17	133	336	60	45
200-205	49	12	33	13	7	10	13	45	23	33	19	23	15	1	7	303	34	127	337	61	39
205-210	39	8	35	5	14	8	10	44	13	46	38	42	15	2	5	324	25	204	349	47	59
210-215	47	6	26	6	12	19	5	35	23	41	32	18	15	4	8	297	29	168	326	53	37
215-220	60	10	37	4	4	14	10	30	11	37	33	32	16	4	10	312	29	207	341	70	52
220-225	49	4	27	2	9	20	14	37	21	44	31	38	19		8	323	29	208	352	53	57
225-230	42	6	26	4	11	8	1	42	11	39	50	24	23	2	11	300	28	227	328	48	49
230-235	60	14	23	5	10	10	9	42	19	36	32	18	12	4	18	312	32	248	344	74	34
245-250	50	18	18	4	14	11	8	32	14	45	43	33	6	1	12	309	20	181	329	68	40
250-255	45	31	22	1	21	9	8	25	9	32	45	35	8	2	3	296	19	105	315	76	45
255-260	86	26	30	1	16	17	10	29	12	19	35	13	5	4	11	314	16	107	330	112	22
260-265	72	38	24		17	18	5	22	11	24	39	23	5		12	310	8	76	318	110	28
265-270	77	27	36	1	26	31	8	30	17	15	35	38	6	1	8	356	11	187	367	104	45
270-275	107	32	21	2	21	25	14	30	13	18	28	27		4	9	351	13	146	364	139	31

Appendix IV. Relative abundance for nonsonicated OB-BC4D sample set

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	ben	frag	Trub	Tmen
0-5	19	21	3	2	5	5	5	9	3	8	12	2	0	0	6	5	21	39	2
15-20	21	10	6	1	9	6	5	12	3	6	8	7	0	0	6	5	15	30	7
20-25	17	12	4	2	7	5	4	12	5	8	9	5	0	1	8	6	13	29	6
25-30	21	7	5	1	5	9	5	13	8	6	5	5	1	1	7	6	18	28	7
30-35	22	8	6	2	7	7	3	11	5	9	7	5	1	1	6	5	20	30	7
35-40	17	14	4	1	4	13	4	13	7	6	7	4	1	0	4	5	18	31	6
40-45	16	15	3	1	7	7	5	7	3	7	10	7	1	0	10	2	20	31	7
45-50	29	7	3	2	4	7	4	10	6	8	7	5	2	0	7	4	17	36	6
50-55	25	11	3	0	6	7	5	10	4	6	8	4	3	1	6	1	23	37	8
55-60	24	13	2	2	5	8	4	14	3	6	8	5	1	1	3	1	17	36	7
60-65	18	14	5	2	8	6	5	11	6	7	5	5	1	0	5	4	29	32	7
65-70	16	16	7	1	7	6	2	14	6	7	10	3	2	1	2	2	18	31	7
70-75	25	5	4	1	8	6	5	13	3	8	11	6	1	1	3	4	33	30	9
75-80	27	10	3	2	4	7	3	13	3	9	9	5	0	2	3	6	28	37	7
80-85	25	7	5	2	4	7	2	11	6	10	10	6	2	1	3	4	25	33	8
85-90	23	5	4	2	5	7	2	14	5	10	10	5	2	2	4	5	31	27	9
90-95	23	6	5	2	8	3	3	12	2	10	14	5	3	1	5	4	38	29	9
95-100	24	5	4	2	3	7	2	15	7	9	9	6	1	1	4	4	32	29	8
100-105	26	3	6	2	4	4	1	14	4	13	10	3	1	1	5	3	36	29	6
105-110	18	4	7	1	6	5	1	16	6	13	11	6	3	1	3	7	43	22	9
110-115	24	4	9	2	7	6	4	9	9	9	8	5	1	0	3	6	57	28	6
115-120	17	8	6	4	4	6	2	15	9	6	7	8	2	1	7	3	26	25	11
120-125	15	5	5	4	4	5	1	21	7	9	11	8	3	0	3	7	43	19	11
125-130	19	5	5	3	4	4	5	12	5	12	13	7	2	0	4	7	57	24	9
130-135	22	3	8	4	6	8	3	12	5	9	7	6	3	1	5	3	50	25	10

Appendix IV. Relative abundance for nonsonicated OB-BC4D sample set (continued)

depthmm	rubW	rubP	sac	con	cal	aeq	glu	obl	orb	dut	tru	men	tum	ung	OT	ben	frag	Trub	Tmen
135-140	22	7	10	2	4	3	2	12	6	13	7	7	1	0	3	6	44	30	8
140-145	25	6	7	2	2	7	3	10	8	10	9	5	4	0	2	4	25	32	9
145-150	30	7	8	2	3	5	4	11	5	9	5	6	1	2	3	2	26	37	9
150-155	29	7	5	4	3	5	4	12	6	6	8	7	2	1	3	4	23	36	10
155-160	23	8	8	2	4	9	2	10	8	6	8	6	2	2	3	6	27	31	11
160-165	22	11	5	4	4	5	4	11	7	9	6	4	2	1	3	8	36	33	7
165-170	25	6	7	3	6	5	3	11	7	6	7	7	2	2	3	6	35	31	11
170-175	19	5	11	5	7	4	1	11	5	9	9	6	2	2	4	3	34	24	10
175-180	22	7	12	5	4	4	3	11	8	9	5	4	3	3	2	4	29	29	10
180-185	32	10	8	2	6	4	3	9	4	6	4	5	2	1	3	3	22	42	8
185-190	25	6	11	3	6	4	3	12	6	8	5	6	3	1	3	9	46	30	10
190-195	26	7	9	3	4	4	6	9	4	5	8	5	3	2	4	6	43	34	11
195-200	13	6	9	4	4	5	3	12	7	10	10	7	6	1	2	5	42	19	14
200-205	16	4	11	4	2	3	4	15	8	11	6	8	5	0	2	10	42	20	13
205-210	12	2	11	2	4	2	3	14	4	14	12	13	5	1	2	7	63	15	18
210-215	16	2	9	2	4	6	2	12	8	14	11	6	5	1	3	9	57	18	12
215-220	19	3	12	1	1	4	3	10	4	12	11	10	5	1	3	9	66	22	17
220-225	15	1	8	1	3	6	4	11	7	14	10	12	6	0	2	8	64	16	18
225-230	14	2	9	1	4	3	0	14	4	13	17	8	8	1	4	9	76	16	16
230-235	19	4	7	2	3	3	3	13	6	12	10	6	4	1	6	9	79	24	11
245-250	16	6	6	1	5	4	3	10	5	15	14	11	2	0	4	6	59	22	13
250-255	15	10	7	0	7	3	3	8	3	11	15	12	3	1	1	6	35	26	15
255-260	27	8	10	0	5	5	3	9	4	6	11	4	2	1	4	5	34	36	7
260-265	23	12	8	0	5	6	2	7	4	8	13	7	2	0	4	3	25	35	9
265-270	22	8	10	0	7	9	2	8	5	4	10	11	2	0	2	3	53	29	13
270-275	30	9	6	1	6	7	4	9	4	5	8	8	0	1	3	4	42	40	9

Appendix V: Taxonomic notes

Taxon
Candeina nitida d'Orbigny
Globigerina bulloides d'Orbigny
Globigerina calida Parker
Globigerina falconensis Blow
Globigerina digitata Brady
Globigerina rubescens Hofker
Globigerina aequilateralis (Brady)
Globigerinita glutinata (Egger)
Globigerinita iota Parker
Globigerinoides conglobatus (Brady)
Globigerinoides sacculifer (Brady)
Globigerinoides ruber (white variety)(d'Orbigny)
Globigerinoides ruber (pink variety)(d'Orbigny)
Globigerinoides tenellus Parker
Globorotalia crassiformis (Galloway and Wissler)
Globorotalia inflata (d'Orbigny)
Globorotalia menardii (Parker, Jones and Brady)
Globorotalia scitula (Brady)
Globorotalia truncatulinoides (d'Orbigny)
Globorotalia tumida (Brady)
Globorotalia tosaensis Takayanagi and Saito
Globorotalia ungulata Bermudez
Hastigerina pelagica (d'Orbigny)
Globoquadrina dutertrei (d'Orbigny)
Globigerina pachyderma (Ehrenberg)
Orbulina universa d'Orbigny
Pulleniatina obliquiloculata (Parker and Jones)
Sphaeroidinella dehiscens (Parker and Jones)

List of species. Species (>150um) identified in top 27.5 mm of box core OB-BC4D (Parker, 1962, 1967). *Globigerinoides ruber* specimens were split into two categories, the white variety is entirely white and the pink variety is considered pink if one or more chambers are pink. If both white and pink listed, the species were combined. Likewise, the *Globigerinoides sacculifer* category contains specimens of *Globigerinoides quadrilobatus* and *Globigerinoides trilobus*. Single or bi-chambered *Orbulina universa* were placed in one category. The *Pulleniatina finalis* was placed in the *Pulleniatina obliquiloculata* category. Workers occasionally separate Holocene *Sphaeroidinella dehiscens* into two species *S. dehiscens* and *S. excavatum*, however, for the purposes of this study, both specimens were placed in *S. dehiscens*. Workers separate *Globigerina pachyderma* into three categories. Right coiling specimens with four chambers are *Gg. pachyderma* (right), and *Gg. pachyderma* (dupac) if right coiling and more than four chambers. The left coiling specimens with any number of chambers are *Gg. pachyderma* (left). Many taxon occurred occasionally and had inconsequential abundances and were placed in the 'other' category (Table 2).