Benthic Foraminifera of the Peruvian & Ecuadorian Continental Margin

DISSERTATION

zur Erlangung des Doktorgrades

Dr. rer. nat.

an der Mathematisch-Naturwissenschaftlichen Fakultät
der Christian-Albrechts-Universität zu Kiel

vorgelegt von

Dipl.-Geol.

JÜRGEN MALLON

Kiel, 2011

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Tag der mündlichen Prüfung:	**18.01.2012**
Zum Druck genehmigt:	**30.01.2012**

Erklärung gem. § 10 Absatz 2 der PO der Mathematisch-Naturwissenschaftlichen Fakultät

Ich versichere hiermit an Eides statt, dass ich erstmalig an einem Promotionsverfahren teilnehme.

Der Inhalt und die Form der vorliegenden Dissertation wurde, außer den von mir angegeben Quellen und Hilfsmitteln und der Beratung durch meine akademischen Berater, von mir verfasst.

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Außerdem erkläre ich hiermit, dass diese Dissertation unter Einhaltung der Regeln guter wissenschaftlicher Praxis entstanden ist.

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Kurzfassung

Der tropische und subtropische Ostpazifik vor der Nordwestküste Südamerikas ist geprägt vom windgetriebenen Auftrieb kalter und nährstoffreicher Wassermassen. Das große Nährstoffangebot führt zur massenhaften Produktion von Phyto- und Zooplankton. Die mikrobielle Zersetzung von toten Lebewesen führt zur Verarmung an Sauerstoff in flachen bis mittleren Wassertiefen (~50-500 m) und in den angrenzenden Sedimenten. Die Ausbildung einer Sauerstoffminimumzone (OMZ) ist die Folge. Die resultierenden Sauerstoffgradienten in den Oberflächensedimenten beeinflussen direkt die Verteilung und Artzusammensetzung der in ihnen lebenden benthischen Foraminiferen.

Die vorliegende Arbeit hat zum einen das Ziel, die Verbreitung lebender benthischer Foraminiferen im Bereich des nordwestlichen Kontinentalrands Südamerikas, mit besonderem Schwerpunkt auf die in der OMZ vorkommenden Arten, zu untersuchen. Da spezielle Literatur über die Taxonomie und Verbreitung lebender Benthosforaminiferen für dieses Gebiet fehlt, soll diese Arbeit einen entsprechenden Beitrag leisten. Zum anderen soll ein auf benthischen Foraminiferen basierender Proxy für Sauerstoffkonzentrationen im Bodenwasser mit Hilfe einiger ausgewählter Arten entwickelt werden. An einem Sedimentkern (SO147-106KL) aus der peruanischen OMZ soll dieser Proxy angewendet und Schwankungen in der Sauerstoffkonzentration im Bodenwasser vom letzten Glazial bis ins späte Holozän rekonstruiert werden.

In dieser Arbeit wurden insgesamt 170 lebende Benthosforaminiferen-Arten identifiziert. Den größten Anteil bilden die 101 Kalkschaler, gefolgt von 63 agglutinierten und 6 miliolinen Arten. Nur 7 Arten wurden ausschließlich im langen Sedimentkern gefunden.

Die Untersuchung der Lebendfauna in den Oberflächensedimenten zeigt einen deutlichen Trend mit geringer Diversität und gleichzeitig hoher Populationsdichte in Sedimenten mit geringen Sauerstoffkonzentrationen und zunehmender Diversität in Verbindung mit abnehmender Populationsdichte bei höheren Sauerstoff-konzentrationen. Im Kern der OMZ erreicht die Populationsdichte der Lebendfauna bis zu 1045 Individuen/ccm. Innerhalb der OMZ besteht eine deutliche Dominanz an

flach-endobenthischen Arten der Gattung *Bolivina*. Diese erreichen dort einen Anteil von 76-95%. Epibenthische Arten, z.B. aus den Gattungen *Planulina* oder *Cibicidoides*, sind vergleichsweise selten. Vertreter der tief-infaunalen Gattung *Globobulimina*, welche typisch für sehr niedrige Sauerstoffkonzentrationen ist, wurden nur in wenigen Proben innerhalb der OMZ angetroffen und dort nur in geringer Häufigkeit.

Zwölf kalkschalige Spezies zeigten einen deutlichen Trend in ihrer Häufigkeitsverteilung in Abhängigkeit zur Sauerstoffkonzentration im Bodenwasser und wurden als Grundlage der Entwicklung eines Proxies für Sauerstoffkonzentrationen im Bodenwasser ausgewählt. Über die Änderungen der prozentualen Häufigkeiten zwischen den ausgewählten Spezies und in den Proben aus verschiedenen Wassertiefen, wurden fünf Zonen von Sauerstoffkonzentrationen definiert, welche einen Bereich von ≤2.5-27 µmol/kg abdecken.

Die Rekonstruktion der spätpleistozänen und holozänen Sauerstoffvariabilität am Kern SO 147-106KL aus 184 m Tiefe mit Hilfe des oben beschriebenen Proxies zeigte unerwartet geringe Schwankungen innerhalb von ≤2,5 bis 6,7 µmol/kg während der letzten 20.000 Jahre. Aufgrund des kompletten Fehlens an Gehäusen benthischer Foraminiferen in größeren Abschnitten des Kerns konnten keine Schwankungen während der späten Termination I und des frühen Holozäns zwischen 5 und 14 ky BP nachgewiesen werden. Allerdings zeigte sich eine Intensivierung der Schwankungen in den letzten 5000 Jahren, welche sich mit Schwankungen im Opalgehalt decken und wahrscheinlich mit Variationen im Auftriebsgeschehen und einer langfristigen Intensivierung der El Niño-Aktivität zusammenhängen.

Abstract

The tropical and subtropical East Pacific off South America is characterized by wind driven upwelling of cold and nutrient rich water masses. The very high nutrient supply leads to enhanced productivity of phyto- and zooplankton. The decay of dead organisms and organic matter is responsible for an extensive depletion of oxygen in shallow and midwater depths (~50-500 m) and in the underlying sediments.

Consequently, an oxygen minimum zone (OMZ) develops. Steep gradients of oxygen concentrations in the surface sediments directly influence the distribution and composition of the inhabiting benthic foraminifera.

This study investigated the distribution of living (Rose Bengal stained) benthic foraminifera of the northwestern continental margin of South America with focus on the OMZ inhabiting species. This study should give an extensive contribution to the taxonomy of benthic foraminifera. Further, a new proxy for bottom water oxygen concentrations based on benthic foraminifera has been developed. On sediment core SO147-106KL from the Peruvian OMZ which comprises the last 20 kys the new proxy was applied to reconstruct the variability of bottom water oxygen concentrations during the past 19.6 kys.

A total of 170 living benthic foraminiferal species were identified. The majority of 101 species are rotaliids, followed by 63 agglutinated and 6 miliolid species. Additionally, 7 species from fossil assemblages of the sediment core were identified. These species were also described.

The investigation of the living fauna in surface sediments shows a conspicuous trend of low diversities coupled with high population densities within the OMZ and increased diversity with decreased population density at increased bottom water oxygen concentrations. A maximum of 1045 living individuals/cm^3 was found in the OMZ core. Within the OMZ an explicit dominance of species belonging to the genus *Bolivina* was found. Members of this genus account for 76-95% at stations within the OMZ. The proportion of epibenthic genera, e.g. *Planulina* and *Cibicidoides*, is low in general. Species of the deep-infaunal genus *Globobulimina*, which are typical for very low oxygen concentrations, were rarely found in just few samples within the OMZ.

Twelve calcareous species which showed a conspicuous trend in their commonness in respect to the ambient bottom water oxygen concentration were chose for the benthic foraminiferal proxy for bottom water oxygen concentration. By determining the changes in percentaged values of commonness among each species and in samples from different water depths, we defined five zones of oxygen concentrations which comprise a range of ≤2.5-27 µmol/kg.

Concentrations of ≤2.5 µmol/kg are characterized by the dominance of Bolivina seminude, followed by *B. plicata* and *B. costata*. At concentrations between 3.3 and 4.8 µmol/kg B. interjuncta , followed by B. seminude and *B. alata* are the dominiating species. *Uvigerina peregrina* followed by *B. interjuncta* and *Bolovinita minuta* characterize a concentration of 8.6 µmol/kg. The dominance of *B. minuta* and *U. peregrina* characterize a concentration of 15.7 µmol/kg, whereas *B. interjuncta* and *Fursenkoina fusiformis* disappear. At 27.7 µmol/kg *U. peregrina*, with *B. minuta* and *Angulogerina angulosa* are dominating.

The reconstruction of oxygen variability on core SO147-106KL showed unexpected low fluctuations within a low range of concentrations between ≤2.5 to 6.7 µmol/kg during the past 19.6 kys. Due to lacking tests of benthic foraminifera no fluctuations could be observed for the time interval between 5 and 14 ky. However, for the past 5 ky BP we could find an increased oxygen variability which could be correlated with opal concentrations and probably are linked with variations in upwelling intensity and a general intensification of El Niño activity during this time interval.

Danksagung

Bei Herrn Dr. J. Schönfeld möchte ich mich für die Vergabe und intensive fachliche Betreuung der Arbeit und nicht zuletzt für die wertvollen Diskussionen ausdrücklich bedanken.
Herrn Prof. Dr. Frank sei an dieser Stelle herzlich für die gutachterliche Tätigkeit gedankt, aber auch dafür, mir bei Fragen und Problemen jeglicher Art stets zur Seite zu stehen.
Frau PD Dr. P. Heinz vom Institut für Geowissenschaften an der EKU Tübingen als Zweitgutachterin möchte ich ebenfalls meinen ganz besonderen Dank für den Zugang und die Bereitstellung von Vergleichsproben, sowie die wertvollen Diskussionen aussprechen.

Frau Dr. E. Perez vom Natural History Museum in London und Herrn Dr. M. Kaminski vom University College in London danke ich ganz besonders für den Zugang und die Bereitstellung von Vergleichsproben, sowie die zahlreichen, wertvollen Diskussionen vor Ort.
Für den wissenschaftlichen Austausch während und nach den Expeditionsabschnitten M77-1 und -2 sei an dieser Stelle Frau Dr. M. Graco, Herrn Dr. E. Enriquez und nicht zuletzt Herrn Dr. D. Gutierrez vom IMARPE (Lima, Peru) herzlich gedankt.

Frau U. Schuldt möchte ich für die Arbeit am REM der CAU Kiel, dem Team der Zentralen Mikroskopie an der CAU Kiel, sowie Herrn M. Thöner vom IFM-GEOMAR für den Zugang zur Mikrosonde vielmals danken, mit deren Hilfe diese Arbeit in bildhafter Weise ergänzt wurde.

Meinem Mitstreiter Dipl.-Chem. N. Glock möchte ich für die gelungene Zusammenarbeit, den umfangreichen Ideenaustausch und die gegenseitige Motivation sehr danken.
Ganz herzliche bedanke ich mich für die Zusammenarbeit und Diskussionen aller Art bei Herrn Dr. S. Sommer, Dipl.-Umweltwiss. L. Bohlen, M. Sc. T. Böschen, Dipl.-

Geol. C. Ehlert, Dipl.-Biol. P. Grasse, Dipl.-Geol. T. Mosch, Dipl.-Umweltwiss. A. Noffke und Dipl.-Biol. L. Rovelli.

Für die wissenschaftliche Unterstützung bei der Begutachtung von Sedimentproben bedanke ich mich vielmals bei Herrn Prof. Dr. Chr. Betzler von der Universität Hamburg als auch bei Agatha Szczygielski für die Unterstützende Mitarbeit beim Aufbereiten der Sedimentproben.

Mein außerordentlicher Dank gilt meinen Freunden, meiner Familie und besonders meinen Eltern für den Rückhalt und für alle Art an Unterstützung, welche sie für mich uneingeschränkt geleistet haben und somit ebenfalls zum Gelingen dieser Arbeit im besonderen Maße beigetragen haben.

Diese Studie wurde von der Deutschen Forschungsgemeinschaft durch den Sonderforschungsbereich 754 „Klima – Biogeochemische Wechselwirkungen im tropischen Ozean“ finanziell unterstützt.

Contents

1.

Introduction

1. Introduction

1.1. General introduction

Benthic foraminifera occur in all marine habitats and respond quickly to environmental changes. The tests of the hard shelled species are readily preserved in fossil record and calcareous species provide archives of environmental changes in chemical or stable isotopic compositions. Biotic data such as assemblage composition, population density, diversity and biometry of their tests also allow reconstructions of various environmental parameters. Benthic foraminifera play therefore an important role in paleoceanographic and paleoclimatic research.

The Peruvian oxygen minimum zone (OMZ) is one of the most intense and widespread OMZ and provides a worthwhile area to study the impact of steep, vertical oxygen gradients to the inhabiting fauna. Thus, it offers to investigate to what extend changes in the intensity and spread of the OMZ affect the spatial distribution patterns of benthic foraminifera. Mutually, benthic foraminifera would be used as proxies for past bottom water oxygenation in OMZs. They may contribute profoundly to the understanding of the dynamics in intensity and variability of OMZs. Due to their high population densities within OMZs, benthic foraminifera may have a significant effect on the marine carbon cycle. Some species are able to completely denitrify nitrate, and also play an important role in the marine nitrogen cycle (e.g. Piña-Ochoa et al., 2010).

The base of all paleontological or biological investigations is the knowledge of the taxonomy of involved species. The South American coasts account as well studied in respect to the distribution of benthic foraminifera. In particular, the Peruvian and Chilean fauna were extensively studied (Bandy and Rodolfo, 1964; Ingle et al., 1980; Resig, 1981, 1990,; Morales et al., 2006). But most work has been performed on dead assemblages. However, for quantitative ecological studies and for describing in how far these organisms actually respond to environmental changes it is necessary to investigate the living fauna. Until now, only a few studies considering living assemblages off Peru were published (e.g. Bandy and Rodolfo, 1964; Ingle et al., 1980; Resig, 1981, 1990). The Ecuadorian coastal area has not been explored to date for living benthic foraminifera. The Ecuadorian fauna links two major provinces: The Panamanian faunal province to the north and the Chilean-Peruvian province to the south. The studies of Boltovskoy and Gualancañay provide insights on the inhabiting benthic foraminiferal fauna off Ecuador (e.g. Boltovskoy, 1976; Boltovskoy and Gualancañay, 1975).

1.2. Study area

Our study area comprises the continental shelf and slope off Peru and the southern part off Ecuador (17°38'-1°45'S). A major part of this area is influenced by the Peruvian OMZ which affects the water masses between ~100 and 500 m water depth. As part of an active continental margin, this area is characterized by a narrow continental shelf (up to 100 km, Strub et al., 1998) and a steep trench which divides the South American plate from the Nazca plate.

The major part of the surface water masses of this study area is influenced by permanent coastal upwelling. Southeasterly trade winds generate a longshore water transport to the north. In combination with the Coriolis effect, the water masses are displaced orthogonally to the left and therefore are deflected to the west (Fig. 1.1.). Cold and nutrient rich intermediate water

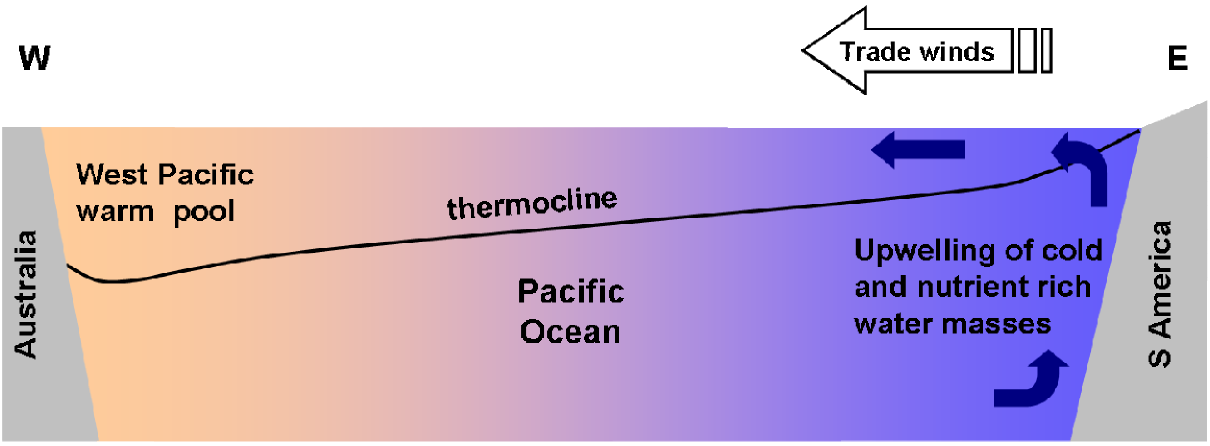


Figure 1.1. Simplified model for the upwelling process in the tropical East Pacific, free after Garrison (2003).

masses rise up and lead to a high productivity in the euphotic zone. Subsequently, high amounts of organic matter are produced and sink through the water column. Microbial degradation of this organic matter consumes oxygen and leads to oxygen depleted and even anoxic conditions at water depths between ~100 and 500 m (Fig. 1.2).

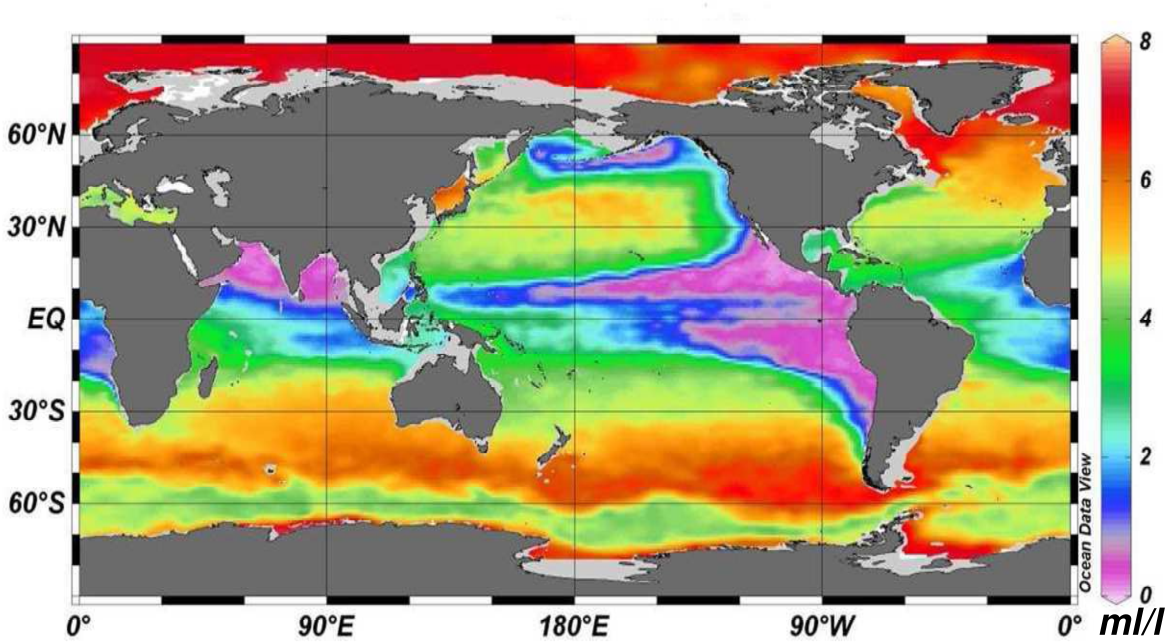


Figure 1.2. Global distribution of dissolved oxygen concentrations in 300 m water depth (Boyer et al., World Ocean Database, 2009).

The eastern South American continental margin is influenced by following ocean currents (see fig. 1.3):

The uppermost water masses, between ca. 4 and 42°S are part of the northward directed Peru-Chile Current (PCC). The PCC is an extension of the Humboldt Current, which originates as the northward diverted branch at ~42°S from the eastward flowing Antarctic Circumpolar Current (ACC). Flowing along the South American coast to the north, the PCC diverts at ~5°S to the west where it joins the South Equatorial Current (SEC; Strub et al., 1998).

Closer to the coast the Peru Coastal Current (PCoC) flows equatorwards where it also the Southern Equatorial Current. At the Galapagos Islands, the eastward flowing Equatorial Undercurrent (EUC) splits into two branches. They both are deflected southwards by the coast. One branch is named Peru-Chile Countercurrent (PCCC), whereas the second, named as Gunther Undercurrent (GUC), or Poleward Undercurrent, is more pronounced. It is centred between the PCCC and the PCoC and flows to the south. The GUC is a subsurface current and carries cold, oxygen-depleted and nutrient rich water. The equatorial water masses of the GUC are the main source of the upwelling of the Peruvian OMZ (Strub et al., 1998).

Between 800 and 1200 m depth, the northward directed Antarctic Intermediate Water (AIW) prevails, which is low in salinity but has a relatively high density due to its low temperature (Sverdrup et al, 1942).

Below the AIW slowly flows the Pacific Deep Water (PDW, Leth et al, 2004). The deepest water mass is the Antarctic Bottom Water (AABW). It mainly originates from the Weddel Sea (Sverdrup et al, 1942) and partly flows northward within the trench axis (Ingle et al., 1980).

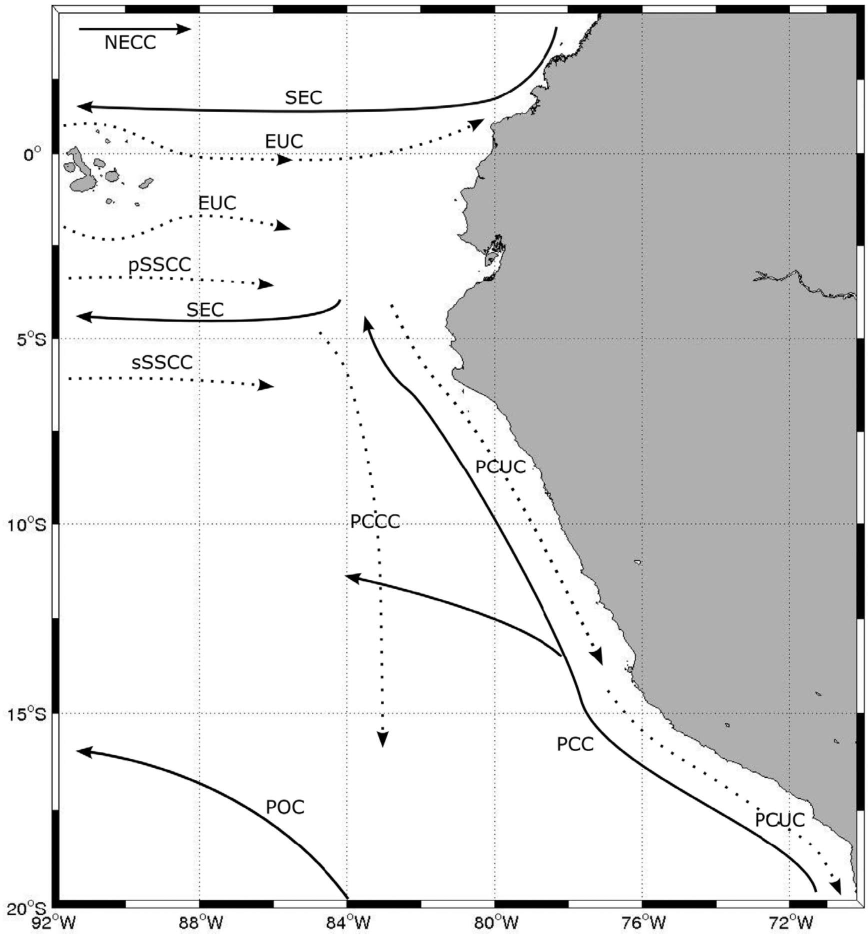


Figure 1.3. Generalized map of surface and subsurface currents in the study area (taken over from Montes et al., 2010; based on Gunther (1936), Wyrtki (1963), Tsuchiya (1975, 1985), Lukas (1986), Huyer et al. (1991), Strub et al. (1998), Johnson and McPhaden (1999), Rowe et al. (2000), McCreary et al. (2002), and Kessler (2006)). Solid lines indicate surface currents, dotted lines show subsurface currents. NECC: North Equatorial Countercurrent; SEC: South Equatorial Current; EUC: Equatorial Undercurrent; pSSCC: primary Southern Subsurface Countercurrent; sSSCC: secondary Southern Subsurface Countercurrent; PCC: Peru Coastal Current; POC: Peru Oceanic Current; PCUC: Peru-Chile Undercurrent; and PCCC: Peru-Chile Countercurrent.

1.3. Sediments

Sediments in the centre of the OMZ are olive-green, organic-rich muds. They show very high porosities due to high concentrations of diatom frustules (93-96%, Neira et al., 2001). Common inhabitants of these sediments are filamentous sulfide-oxidizing, nitrate-reducing bacteria (*Thioploca* spp., Gallardo, 1977; Levin et al., 2002) which form dense, patchy distributed mats in some areas. Nematodes, annelids and small oligochaetes are also common. *Thioploca* spp. has been reported from stations not deeper than 506 m water depth (Henrichs and Farrington, 1984; Levin et al., 2002). Bioturbation by macroinvertebrates is nearly absent. Consequently, these sediments are commonly laminated like it has been seen in profiles of gravity and piston corer sediments recovered from the same localities during M77 legs 1 and 2. The first bioturbating macroinvertebrates, e.g. small gastropods, occur at the upper and lower OMZ boundaries (Levin et al., 1991; Neira et al., 2001). They were observed at stations deeper than ca. 460 m water depth (at 11°S) by the author and in personal communication with T. Mosch (IFM-GEOMAR). Further characteristic features of the lower OMZ boundary are phosphorites which have been described in many studies (Levin et al., 2002 and references therein). They occur as irregular nodules from few millimeters to several centimeter in size. They were found between 465 and 516 m depth in our samples.

Sedimentation rates of the upper slope and shelf area off Peru were calculated by several authors but show a high variabilitiy, probably due heterogenous morphologies of the seabed and erosional processes as described by Kim and Burnett (1988) and Froelich et al. (1988). Values range between 28 to 180 cm per 1000 yrs for this region (Kim and Burnett, 1988).

Sediments from stations above the OMZ are silty sands with a higher degree of bioturbation. Porosity decreases to ~66% at 1210 m water depth (Neira et al., 2001) and carbonate content decreases (Krissek and Scheidegger, 1983). The upper 123 cm of the long sediment core (SO147-106KL) contain irregular shaped calcitic ooids (pers. comm. Prof. Betzler, University Hamburg) which were not found in any of the multicorer samples.

In general, the northern stations off Ecuador are subjected to a higher input of riverine suspended material than stations off Peru (Krissek and Scheidegger, 1983).

1.4. Methodology

During R/V Meteor cruise M77 leg 1 and 2 from October until December 2008, a comprehensive program was carried out in order to investigate the interaction among benthic biogeochemical processes which take place in oxygen-depleted environments and to observe how they affect the marine life on the continental margin. Further, new geochemical and micropaleontological proxies were developed for reconstructing variabilities in past bottom water oxygen concentration. Those findings should lead to a better understanding how oxygen minimum zones evolve.

One of the most intense and wide-spread oxygen minimum zone is situated off Peru and the southern continental margin off Ecuador. Here, steep gradients of geochemical parameters (e.g. oxygen, nitrate, redox-sensitive elements) allow to investigate the effects of extreme conditions on marine life and biogeochemical cycles.

On both legs the main focus lay on benthic investigation methods. Gravity- piston- and multicorer but also benthic chambers were used for sediment recovery. Water was sampled with a conductivity-temperature-depth profiler (CTD). Before sediment sampling each investigation area was mapped with a multibeam echosounder. Lander technology was applied for in-situ geochemical analyses of the sediment-water interface and subsurface sediments.

1.4.1. Foraminiferal sampling

Thirty-five sediment cores were recovered during non El Niño conditions between October and December 2008 by using a TV-guided multicorer with 10 cm outer tube diameter. Immediately after recovery, one tube of the array with the most even sediment surface was selected and brought to a laboratory container with ambient temperature of 4°C where the sediment core was sliced with a shuffle spatula in 2 mm, 3 mm, 5 mm 10 mm intervals from 0 to 10 mm, in 5 mm intervals from 10 to 40 mm and in 10 mm intervals from 40 to 50 mm sediment depth. Subsamples were filled in 200 ml Kautex™ bottles and stained with a solution of ethanol (96%) and Rose Bengal (2 g/l) for distinguishing living from dead individuals. Under 4°C and dark conditions, the samples were transported and stored until processing. The core SO147-106KL was sampled about every 20 cm by using 10 ml cut-off syringes.

1.4.2. Sample processing and faunal analysis

Stained subsamples were gently wet sieved with tap water through 2000 and 63 µm screens. To beware of contamination, the sieves were thoroughly cleaned and treated with Metyhlene Blue before every use. The >2000 µm fraction (pebbles, gastropode shells etc.) were dried and stored in polyethylene bags. The 63-2000 µm fractions were dried at 40°C and weighed before they were picked. At least 100 stained specimens were picked per subsample in order to attain statistically reliable census data but some subsamples contained less than 100 stained specimens. In other cases it was necessary to split the subsamples into manageable aliquots by using an ASC^{TM} sample microsplitter. Only individuals which contained more than 50 % of all chambers stained were considered as individuals that were living at the time of sampling. Non-transparent agglutinated or miliolid species they were wetted, and cracked with a needle to control if they contained protoplasm. After they were picked, the specimens were sorted by species, fixed in Plummer cells and counted.

Species were photographed with a CamScan CS44 SEM or Zeiss DSM940 SEM, both at the Christian-Albrecht-University of Kiel with coatings of gold and a voltage of 13 or 15 kV.

Identification of benthic species based mainly on online database of Ellis and Messina Catalogues (1942-2006) and determinations by Brady (1884), Ingle et al. (1980), Resig (1981, 1990), Smith (1963), Uchio (1960) and Whittaker (1988).

2.

Outline

2. Outline

This study was performed in the Collaborative Research Centre SFB 745: *Climate-Biogeochemistry Interactions in the Tropical Ocean*. The benthic foraminiferal study of subproject B7 which had its aim to develop micropaleontological and geochemical proxies for reconstructing the past levels of oxygen and its controlling processes in the Peruvian upwelling system over the last 20,000 years.

The study gives an overview about the distribution and diversity of living Peruvian and Ecuadorian benthic foraminifera, the development of a benthic foraminiferal proxy for reconstruction of past bottom water oxygen concentrations, first results of a downcore application of this newly developed proxy and a description of all frequent or new species that were found.

Chapter 3 gives a taxonomical description of all species found in this study, including 5 species which were found only in the fossil record of core SO147-106KL (s. chapter 6) but not in living assemblages of surface samples recovered during *Meteor* cruise M77 leg 1 & 2.

In **chapter 4** the distribution and diversity of living benthic foraminifera off Peru and Ecuador will be described. Possible linkages to other biogeographic provinces and similarities in spatial diversity and species distribution in comparison with the Arabian OMZ will be presented.

Chapter 5 gives an overview about depth distribution of the most common living species in the Peruvian OMZ and focuses on a transect along 11°S off Callao. Therefore surface samples of 13 stations from the upper part, within and below the OMZ were investigated. We found overlapping species distributions and developed a new wide range proxy for bottom water oxygen concentrations based on benthic foraminiferal assemblage zones. This chapter is published in Altenbach, A.V., Bernhard, J.M. and Seckbach, J. (eds.), ANOXIA: Evidence for eukaryote survival and paleontological strategies, Springer, as ***The response of benthic foraminifera to low-oxygen conditions of the Peruvian oxygen minimum zone*** by Jürgen Mallon, Nicolaas Glock and Joachim Schönfeld.

In **chapter 6** the new proxy introduced in chapter 5 is applied to the fossil record. For this purpose we sampled a sediment core off Peru covering the past 20,000 years. A record of 52 syringe samples comprises the past ca. 19.6 ky BP. The results show that enhanced variability in bottom water oxygen concentrations could be linked to productivity variations and increased El Niño activity as previously demonstrated by other studies in this area.

The **Outlook** gives an overview about ongoing work which is not yet published and implications for future studies in this area.

2. Outline

3.

Taxonomy of species

3 Taxonomy of species

Order ASTRORHIZIDA

(Lankester, 1885)

***Bathysiphon* sp.**

Diagnosis. A slender, tubular species. The tube-formed chamber is almost even in thickness and diameter, many slight latitudinal thickenings and thinnings occur. Surface is very smooth, white or brown in colour.

Remarks. All found specimens were very finely agglutinated and soft-shelled. This species resembles *Bathysiphon rufus* (de Folin, 1886).

Rarely found in this study. Only at three stations off Peru (11 and 12°S) at 465, 823 and 1004 m water depth.

Length: 498-1718 µm.

***Hyperammina echinata* Saidova 1970**

* 1970 *Hyperammina echinata* – Saidova: pl. 3, fig. 4.

Diagnosis. A large, tubular specimen. The proloculus is rather indistinct, like a slub at the basal end of the tube. The tubular portion straight, no branches are visible. Outer surface is very rough, consisting of coarse grains with the sharp edges projecting outwards. The inner surface is rather smooth. Terminal aperture. Yellow or light brown in colour, slightly transparent.

Remarks. A rare species. Only found at one station off Peru (10°53'S/78°46'W) in 1923 m water depth. *Hyperammina echinata* resembles *H. ramosa* (Brady) but differs from it by the surface texture and morphology of the proloculus. *H. echinata* has a very rough surface with the sharp parts of grains projecting outwards and the proloculus is more elliptical but not sphaerical.

None of the fragments found in this study have an intact proloculus. But the angle of the upper accretion of the proloculus in relation to the longitudinal axis of the tubular portion is very low. This fact, together with the typical rough surface makes it justifiable to name this species as *H. echinata*.

Distribution. Recent, off Kurile Islands, "Occurs in the boreal and tropical regions of the Pacific" (Saidova, 1970).

Length: 2912-3120 µm.

***Hyperammina friabilis* Brady 1884**

(Pl. 1, fig. 1)

* 1884 *Hyperammina friabilis* – Brady: pl. 23, figs. 1, 2, 3, 5, 6.

. 1899 *Hyperammina friabilis* – Flint: pl. 10, fig. 1.

Diagnosis. A very slender, tubular species. Proloculus also slender, sack-like and bluntly rounded at its base. Tubular portion straight. Surface is finely agglutinated, smooth. Yellow, brown or white in colour.

Remarks. A rare species in this study. Two stained specimens were found off Ecuador (3°60'S/81°19'W) at 995 m water depth.

Distribution. Recent, SE of Pernambuco, W-Atlantic; Faroe Channel, N-Atlantic and Banda Sea, Pacific (Jones, 1994 [cop. Brady, 1884]).

Length: 1813-3088 µm.

Marsipella granulosa **Brady 1879**

* 1879 *Marsipella granulosa* – Brady: p. 36, pl. 3, figs. 8-9.

. 1960 *Amphitremoidea granulosa* – Barker: p. 41, pl. 20, figs. 14-23 [cop. Brady, 1884].

. 1994 *Astrorhiza granulosa* – Jones: pl. 20, figs. 10-23 [cop. Brady, 1884].

Diagnosis. A single-chambered, very finely agglutinated species. Both ends tapered and open. Thickest part at the middle of the test. Two simple apertures at both ends (Brady, 1879). Test surface dark brownish in colour.

Remarks. The cracked specimen showed the typical straight channel with uniform diameter which extended all the way through the central part of the specimen as described and figured out by Brady (1879). The test is not well solidified because the wet specimen broke down when touched carefully with the brush.

This species was found at one station at 465 m water depth and 11°S off Peru.

Distribution. Recent, off Azores Islands, Atlantic (Brady, 1879; Barker, 1960 [cop. Brady, 1884]).

Size: 208-291 µm.

Saccammina sphaerica **Brady 1871**

* 1868 *Saccammina sphaerica* – Sars, M.: [nomen nudum]

. 1871 *Saccammina sphaerica* – Brady: p. 183.

. 1899 *Saccammina sphaerica* – Flint: pl. 9, fig. 3.

. 1994 *Saccammina sphaerica* – Jones: pl. 18, figs. 11-15, (?)17 [cop. Brady, 1884].

Diagnosis. Test single-chambered, very small and sphaerical. Apertural end tapered. Aperture simple, terminal. Surface coarsely agglutinated.

Remarks. Very rare in this study. Only found at one station off Peru (17°28'S/71°52'W) in a water depth of 492 m.

Distribution. Recent, off Norway (Sars, 1872); recent, North Atlantic; off Norway and, Ki Island, South Pacific (Jones, 1994 [cop. Brady, 1884]); recent, Arctic Ocean (Wollenburg, 1995).

Size: 208-315 µm.

3 Taxonomy of species

Saccorhiza ramosa Brady 1879

* 1879 *Hyperammina ramosa* – Brady: pl. 3, figs. 14-15.

. 1994 *Saccorhiza ramosa* – Loeblich & Tappan: p. 238, pl. 1, figs. 4, 5.

. 1995 *Saccorhiza rumosa* – Jones: pl. 23, figs. 15-19 [cop. Brady, 1884].

Diagnosis. A large, tubular and branched species. Test consists of a rounded or even globular initial part and a long subsequent and branched, tubular portion. Tubular portion even in diameter. The initial portion is usually spiculose by incorporated sponge spicules. Surface rough.

Remarks. A rare species. It occurred in 2092 m water depth off Ecuador (1°45S/82°37'W).

Distribution. Recent, NW off Ireland and North Pacific (Barker, 1960 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 978-2912 µm.

Technitella sp.

(Pl. 1, fig. 2)

Holotype. A living specimen from a 0-5 mm sediment interval from station M77/2-776/MUC-67 off Ecuador (Datum: 16th December 2008; Coordinates: 1°45'S, 82°37'W 12°32.75'S, 77°34.75'W; 2092 m water depth).

Paratypes. There have been no paratypes found in any other samples.

Material examined. One living (Rose Bengal stained) specimen of *Technitella* sp. from a multicorer sample off Ecuador.

Diagnosis. A singe-chambered, coarsely agglutinated species. Test consists of large elongated chamber with an almost cyclic cross-section. Both sides tapered, whereas the basal end merging to a long, robust spine. The apertural and is tapered with a simple, terminal opening. The wall is soft and rough, composed of coarse, densely agglutinated grains, predominantly quarz.

Discrimination from other species. This species resembles *Technitella arenacea* (Zheng, 1988) by the elongated shape of the chambers which are agglutinated with quarz grains but differs in having a prominent basal spine and is more slender than *T. arenacea*. The only *Technitella* which possess a basal spine is *T. nanshaensis* (Zheng & Zhaoxian, 2001) but the test of this species is composed of longitudinal arranged sponge spicules instead of being grain supported. The closest species out of Zheng's (2001) figures of *T. nanshaensis* is figure 4 from plate 7 because of its slender shape and the strongly tapered basal end.

Length: 1204 µm.

Thurammina albicans **Brady 1879**

* 1879 *Thurammina albicans* – Brady: pl. 37, figs. 2-6.

. 1995 *Thurammina albicans* – Jones: pl. 37, figs. 2-7 [cop. Brady, 1884].

Diagnosis. A small, rounded, single-chambered species. Test consists of a sphaerical or slightly compressed chamber with four to six evenly distributed orifices (Brady, 1879). Surface rather smooth, typically white or light greyish.

Remarks. A rare species in this study. This species was found at one station off Ecuador in 2092 m water depth (1°45'S/82°37'W).

Distribution. Recent, off the E-coast of South America, S-Atlantic (Jones, 1995 [cop. Brady, 1884]); recent, off Costa Rica and Nicaragua (Heinz et al., 2008).

Size: 199-332 µm.

Order LITUOLIDA

(Lankester, 1885)

Adercotryma glomerata Brady 1878

* 1878 *Lituola glomerata* – Brady: p. 433, pl. 20, figs. 1a-c.

. 1964 *Adercotryma glomeratus* – Phleger: pl.1, fig. 3.

. 1981 *Adercotryma glomeratum* – Resig: p. 665, pl. 10, fig. 11.

. 1994 *Adercotryma glomeratum* – Jones: pl. 34, figs. 15-18 [cop. Brady, 1884].

. 1995 *Adercotryma glomerata* – Schmiedl: p. 135, pl. 1, fig. 12.

. 1995 *Adercotryma glomerata* – Wollenburg: p. 49, pl. 2, fig. 12.

. 2001 *Adercotryma glomerata* – Schumacher: p. 139, pl. 3, fig. 1.

. 2007 *Adercotryma glomerata* – Schroeder: p. 642, pl. 3, fig. 9.

Diagnosis. A small irregularly shaped agglutinated species with three to five elongated chambers, visible in the last coil. Sutures distinct and depressed. Aperture is simple at the inner margin of the final chamber. Test often very coarsely agglutinated, transparent or opaque; colourless, often with brownish or yellowish hue.

Remarks. This species occurs in variable shapes, depending from grain size of the agglutinated material. Most specimens found in this study are coarsely agglutinated. In this case the outline is almost globular and the sutures are less distinctively developed.

This species was found at three stations between 521 and 1923.5 m water depth off Peru (10-12°S).

Distribution. Recent, off S-Brazil (Boltovskoy, 1976); living (Rose Bengal stained), western Weddell Sea (Cornelius & Gooday, 2004), recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); Holocene, Pleistocene, Gulf of Mexico (Schroeder, 2007); living, off California (Phleger, 1964); recent, off Peru (Resig, 1981); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); recent, South Atlantic (Schumacher, 2001); recent, Arctic Ocean (Wollenburg, 1995); recent, Kerguelen Island, Pacific (Jones, 1994 [cop. Brady, 1884]).

Diameter: 125-374 µm.

Alveolophragmium scitulum Brady 1881

* 1881 *Lituola (Haplophragmium) scitulum* – Brady: pl. 34, figs. 11-13.

. 1899 *Haplophragmium scitulum* – Flint: pl. 20, fig. 2.

. 1960 *Alveolophragmium scitulum* – Barker: p. 71, pl. 34, figs. 11-13 [cop. Brady, 1884].

. 1995 *Veleroninoides scitulus* – Jones: Pl. 34, figs. 11-13 [cop. Brady, 1884].

Diagnosis. A partially evolute, stout, medium sized species. Test bilateral-symmetric, thick and robust, consisting of eight to eleven inflated but rather flat chambers in the last whorl. Chambers broader than high, increasing slowly in size as added. Periphery rounded or very slightly lobulated. Sutures distinct and slightly depressed. Umbilicus deep. Aperture is a basal opening of the last chamber, following the curvature of the last convolution. Surface rather smooth, light brown hue.

Remarks. A rare species in this study. It was found at two stations at 525 and 823 m water depth off Ecuador (1°53'S/71°11') and Peru (12°33'S/77°35'W), respectively.

Distribution. Recent, Faroe Channel, N-Atlantic (Barker, 1960 [cop. Brady, 1884]).

Diameter: 183-415 µm.

Alveolophragmium subglobosum **Cushman 1910**

1868 (1869) *Lituola subglobosa* – M. Sars [no type figure and type description].

* 1910 *Haplophragmoides subglobosum* – Cushman: Pl. 34, figs. 11-13.

. 1960 *Alveolophragmium subglobosum* – Barker: p. 71, pl. 34, figs. 7, 8, 10, 14 (?) [cop. Brady, 1884].

. 1995 *Cribrostomoides subglobosus* – Jones: pl. 34, figs. 8-10 [cop. Brady, 1884].

Diagnosis. Test involute, plani-spiral, medium to large in size. Test stout with lobulate periphery. Consists usually of two but sometimes more whorls. Chambers strongly inflated, nearly globular in the last whorl. Chambers increasing siginficantly in size as added; broader than high. Sutures distinct and incised. Test slightly twisted from side view. Aperture is a wide and distinct basal opening of the last chamber, following the curvature of the last convolution. Surface rather smooth.

This species was found at five stations between 9 and 17°S and 302 and 1923 m water depth off Peru.

Distribution. Recent, North Pacific (Cushman, 1910); recent, West Indies and North Pacific (Jones, 1995 [cop. Brady, 1884]).

Diameter: 125-913 µm.

Ammobaculites agglutinans **d'Orbigny 1846**

(Pl. 1, fig. 3)

* 1846 *Spirolina agglutinans* - d'Orbigny: pl. 7, figs. 10-12.

. 1981 *Ammobaculites agglutinans* – Resig: p. 663, pl. 9, fig. 16.

. 1995 *Ammobaculites agglutinans* – Schmiedl: p. 132, pl. 1, figs. 8-9.

. 2001 *Ammobaculites agglutinans* – Schumacher: p. 141, pl. 4, fig. 1.

. 2007 *Ammobaculites agglutinans* – Schröder: p. 642, pl. 3, fig. 15.

Diagnosis. A small to medium sized, uniserial species. First chambers curled up. Younger chambers are grown upright. Chambers are broader than high, cylindrical in shape and increase slowly in size. Aperture is a round opening on a short neck, centred on the apical side of the last, subrounded chamber. Sutures distinct and depressed.

Remarks. This species occurs in two different varieties which were combined to one species. The one variety is very small, finely agglutinated and has a smooth, shiny and dark-brown surface. The other is coarsely agglutinated, shows a rough surface and is usually bigger than the other.

This species was found between 697 and 2092 m water depth off Peru and Ecuador (11°S to 1°45'S).

Distribution. Recent, N-Atlantic (Barker, 1960 [cop. Brady, 1884]); recent, S-Atlantic (Schumacher, 2001); recent, E-Pacific (Resig, 1981); Tertiary, Austria (d'Orbigny, 1846), recent, Gulf of Mexico, off Louisiana (Schröder, 2007); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); living, western Weddell Sea (Cornelius & Gooday, 2004); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010).

Length: 199-664 µm.

Ammobaculites americanus **Cushman 1898**

* 1910 *Ammobaculites americanus* – Cushman: p. 118, text figs. 184, 185.

. 1960 *Ammobaculites americanus* – Barker: p. 71, pl. 34, figs. 1-4 [cop. Brady, 1884].

. 1995 *Glaphyrammina americana* – Jones: Pl. 34, figs. 1-4 [cop. Brady, 1884].

Diagnosis. A plano-spiral, medium sized species. Test rounded and compressed. One side very slightly convex. Usually nine chambers in the last whorl. Chambers increasing slowly in size as added, whereas the last chamber is broader than the anterior ones. Sutures straight, distinct and depressed. Aperture is a terminal opening comprising almost the whole face of the last chamber. Surface coarsely agglutinated, rough.

Found at three deep stations between 1004 and 2092 m water depth off Peru and Ecuador (between 10°53' and 1°45'S)

Distribution. Recent, off west coast of Mexico (Cushman, 1910); recent, South Atlantic (Barker, 1960 [cop. Brady, 1884]).

Diameter: 291-872 µm.

Ammodiscus incertus d'Orbigny 1839

* 1839 *Operculina incerta* – d'Orbigny: p. 49, pl. 6, figs. 16-17.

. 1960 *Involutina anguillae* – Barker: p. 79, pl. 38, figs. 1, 3 [cop. Brady, 1884].

. 1899 *Ammodiscus incertus* – Flint: pl. 23, fig. 2.

. 1964 *Ammodiscus incertus* – Kristan-Tollmann: pl. 3, figs. 1-2.

. 2007 *Ammodiscus incertus* – Schröder: p. 641, pl. 2, fig. 11.

Diagnosis. A single chambered, plani-spiral and bilateral symmetric coiled species of varying size. Diameter of tube-like chamber increases very slowly, so, the test is a biconcave spiral. Test finely agglutinated, yellow to light-brown in colour. Shape is strictly rounded. Aperture is the simple opening at the end of the tube.

This species was found between 207 and 2092 m water depth off Peru and Ecuador (11°S-1°45'S).

Distribution. Austria, fossil (Kristan-Tollmann, 1964); recent, W-Indies (Barker, 1960 [cop. Brady, 1884]), recent, Gulf of Mexico, off Louisiana (Schröder, 2007).

Diameter: 58-747 µm.

Ammodiscus tenuis **Brady 1881**

* 1881 *Trochammina (Ammodiscus) tenuis* – Brady: p. 51, pl. 38, figs. 4-6.

. 1899 *Ammodiscus tenuis* – Flint: pl. 23, fig. 1.

. 1960 *Involutina tenuis* – Barker: p. 79, pl. 38, figs. 5, 6 [cop. Brady, 1884].

. 1981 *Ammodiscus tenuis* – Resig: p. 662, pl. 9, fig. 7.

. 1994 *Ammodiscus tenuis* – Jones: pl. 38, figs. 4-6 [cop. Brady, 1884].

. 2008 *Ammodiscus incertus* – Lobegeier & Sen Gupta: p. 110, pl. 4, fig. 2.

Diagnosis. A medium sized circular species. Proloculus visible in the central part of the spiral. Convolutions slightly overlapping. Apertural end often protrude out of spiral plane. Test finely agglutinated, yellow to light brown in colour.

Remarks. This species resembles *Ammodiscus incertus* but differs in being sometimes more irregularly rounded, the diameter of the chamber doesn't increase significantly. Specimens are usually bigger in size than *A. incertus* and have fewer convolutions.

A rare species. It was found at two stations between 214 and 697 m water depth off Peru (11-12°5'S).

Distribution. Recent, North Atlantic and off New Zealand, Pacific (Jones, 1994 [cop. Brady, 1884]); recent, Peru-Chile Trench area (Bandy & Rodolfo, 1964); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, off Peru (Resig, 1981); recent, Gulf of Mexico (Loebegeier & Sen Gupta, 2008).

Diameter: 191-266 µm.

Ammolagena clavata **Jones & Parker 1860**

* 1860 *Trochammina irregularis* d'Orbigny var. *clavata* – Jones & Parker: p. 304.

. 1994 *Ammolagena clavata* – Loeblich & Tappan: p. 241, pl. 4, figs. 1-4.

Diagnosis. A small, peculiar shaped species, consisting of a single, strongly inflated, and elongated sack-like chamber, bluntly rounded at the basal end, whereas the apertural end is an elongated, tubular neck. This sack-like chamber merges rapidly to the flat basal portion which is fixed on any kind of shell fragment, like other foraminiferal tests. Aperture is a broad, terminal opening. Surface smooth, slightly transparent, light-brown to yellow.

Length: 241, width: 183 µm.

Ammomarginulina foliacea **Brady 1881**

(Pl. 1, fig. 4)

* 1881 *Lituola (Haplophragmium) foliaceum* – Brady: pl. 33, figs. 20-25 [as Haplophragmium foliaceum: figs.

20-23].

. 1960 *Ammomarginulina foliaceus* – Barker: p. 69, pl. 33, figs. 20-25 [cop. Brady, 1884].

. 1994 *Eratidus foliaceus* – Jones: Pl. 33, figs. 20-25 [cop. Brady, 1884].

Diagnosis. Test bilateral-symmetrically plani-spiral, very compressed and small. The chambers are low and evolutely coiled up. Barely increasing in size as added. The last few chambers are often grown in a straight direction and are not continuing the curvature of the cyclic portion of the test. The final chamber is bluntly rounded and often has a small tapered projection at the upper apical side. Sutures straight, moderately distinct, slightly depressed. The periphery is slightly edged at the bases and tops of the peripheral part of the chambers. Aperture is a small, simple, terminal opening.

Remarks. This species was only found at one station off Peru (11°S/78°W) in 697 m water depth. All 37 specimens are minute.

Distribution. Recent, S-Atlantic (Barker, 1960 [cop. Brady, 1884]).

Diameter: 125-249 µm.

***Ammosphaeroidina grandis* Cushman 1910**

* 1910 *Ammosphaeroidina grandis* – Cushman: p. 442, text figs. 17-19.

. 1994 *Ammosphaeroidina grandis* – Loeblich & Tappan: p. 248, pl. 11, figs. 1, 2.

Diagnosis. A large globular species. Three inflated, sub-sphaerical chambers visible. Chambers increasing rapidly in size as added. Sutures distinct and depressed. Aperture is a comma-shaped opening at the base of the last chamber. Surface rather smooth, light brown in colour.

Remarks. Rare in this study. Only two stained specimens were found off Peru (11°S/78°S) at 319 m water depth.

Distribution. Recent, off eastern coast of Mindanao, Philippine Islands (Cushman, 1910); recent, Timor Sea (Loeblich & Tappan, 1994).

Buzasina sp.

Diagnosis. The only specimen found in this study shows a nearly rounded biconvex shape from side view and no sutures are recognisable, even the chambers were not distinctive. Periphery slightly acute. The test is very finely agglutinated, resulting in a smooth surface, dark yellow in colour. Aperture: a slit-like opening centred on the face of the last chamber; bordered by a distinct rim.

Remarks. Because of the indistinctiveness of the sutures and the uniform increase in width it was not possible to define a number of chambers. This specimen is not referable to any of the species shown in Ellis & Messina online catalogues (19XX-19XX), Barker (1960), Boltovskoy & Theyer (1970) or Loeblich & Tappan (1994).

A single specimen was found at 2092 m water depth off Ecuador (1°45'S/82°37'W).

Diameter: 747 µm.

Cyclammina cancellata Brady 1879

(Pl. 1, fig. 5)

* 1879 *Cyclammina cancellata* – Brady: [1884, Rept. Voy. Challenger, Zool., v. 9, pl. 37, figs. 8-16].

. 1899 *Cyclammina cancellata* – Flint: pl. 27, fig. 3, pl. 28, fig. 1.

. 1992 *Cyclammina cancellata* – Kato: p. 389, pl. 1, fig. 3a-b.

. 2001 *Cyclammina cancellata* – Zheng & Zhaoxian: pl. 52, figs. 3-6.

Diagnosis. Usually big plano-spiral coiled specimens. Finely agglutinated, resulting in a smooth surface. The very robust tests are intensively brown-coloured. Sutures are thin but distinct and slightly curved forward. The aperture is a slit-like opening on the base of the last chamber. Often, the face of the last chamber shows many irregularly distributed pores as described by Brady (1879).

Remarks. This species resembles *Cyclammina trullissata* but *C. cancellata* has more chambers and is usually bigger in size.

This species was found between 697 and 1923 m water depth off Peru between 11 and 3°56'S.

Distribution. Recent, N-Atlantic, off New Zealand, West Indies (Barker, 1960 [cop. Brady, 1884]); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); recent, China Sea (Zheng & Zhaoxian, 2001); Miocene to Pliocene, Japan Sea (Kato, 1992).

Diameter: 550-2241 µm.

Cyclammina trullissata **Brady 1879**

* 1879 *Trochammina trullissata* - Brady: p. 56, pl. 5, fig. 10.

. 1960 *Cyclammina trullissata* – Barker: p. 83, pl. 40, fig. 13 [cop. Brady, 1884].

. 1994 *Cyclammina trullissata* – Loeblich & Tappan: p. 251, pl. 14, figs. 7, 8.

Diagnosis. Usually big plano-spiral coiled specimens. Finely agglutinated, resulting in a smooth surface. The very robust tests are intensively brown-coloured. Sutures are thin but distinct and slightly curved forward. Umbilicus depressed on both sides. The aperture is a slit-like opening on the base of the last chamber. Often, the face of the last chamber shows many irregularly distributed pores (Brady, 1879).

Remarks. This species resembles *Cyclammina trullissata* but *C. cancellata* have more chambers and is usually bigger in size.

Very rare. This species was only found at 1004 water depth off Peru (10°59'S/78°31'W).

Distribution. Recent, W-Indies (Barker, 1960 [cop. Brady, 1884]), eastern Timor Trough (Loeblich & Tappan, 1994).

Gaudryina baccata Schwager 1866

* 1866 *Gaudryina baccata* – Schwager: p. 200, pl. 4, 12a-b.

. 1899 *Gaudryina baccata* – Flint: pl. 32, fig. 5.

. 1960 *Karreriella novangliae* – Barker: p. 95, pl. 46, figs. 8-10 [cop. Brady, 1884].

. 1990 *Karreriella novangliae* – Sprovieri & Hasegawa, 1990: p. 455, pl. 1, figs. 11, 12.

. 2005 *Karreriella baccata* – Narayan et al: p. 141, pl. 1, figs. 26-27.

Diagnosis. A medium sized, finely or coarsely agglutinated species. Test biserial, irregularly coiled up, twisted. More or less tapered to the initial end. Chambers inflated. Sutures distinct and depressed. Aperture a latitudinal or obliquely oriented, broad slit at the base of the last chamber. Surface smooth or rough.

Remarks. A very rare species in this study. Only two stained specimens were found at two stations at 207 and 700 m water depth off Ecuador.

Distribution. Recent, off Car Nicobar, Andaman Sea (Schwager, 1866); recent, off NW-Ireland, Atlantic (Barker, 1960 [cop. Brady. 1884]; recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); recent and sub recent, Tyrrhenian Sea (Sprovieri & Hasegawa, 1990); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005).

Size: 747-1785 µm.

Gaudryina bradyi **Cushman 1911**

* 1911 *Gaudryina bradyi* – Cushman: p. 67, pl. 107.

. 1981 *Karreriella bradyi* – Barker: p. 95, pl. 46, figs. 1-4 [cop. Brady, 1884].

Diagnosis. A small biserial, finely agglutinated species. Early chambers triserial arranged, later biserial. The biserial part making up about three quarter of the test length. Early triserial arranged chambers minute, not significantly increasing in size. Biserial arranged chambers are bigger and increase slowly in size except for the two last chambers which making up one third to about one half of the test size. Chambers in the triserial and biserial part moderately inflated and broader than high, the last two chambers are more rounded and much more inflated. Sutures distinct and depressed. Aperture is an oval opening on the base of the last chamber and surrounded by a lip. Test surface smooth with a grey hue. The basal end is slightly bended and tapered, whereas the youngest chambers form a stump end.

Remarks. Very rare in this study. Only a single specimen was found at 579 m water depth at 11°S off Peru.

Distribution. Recent, SW of Ireland, Atlantic; North Pacific; north of Juan Fernandez, Chile (Barker, 1960 [cop. Brady, 1884]; recent, Peru-Chile Trench Area (Ingle et al., 1980); living, NW Indian Ocean (Hermelin & Shimmield, 1990); Neogene and Quaternary of the southern South China Sea (Hess & Kuhnt, 2005); Late Quaternary, South China Sea (Jian & Wang, 1997); recent, Carribean Sea (Culver & Buzas, 1982); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); living, off Cape Blanc, NW Africa (Jorissen et al., 1998); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, eastern Indian Ocean (Murgese & De Deckker, 2005); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); recent, SW Indian Ocean (Juyaraju et al., 2010).

Length: 2158 µm.

Glomospira gordialis Jones & Parker 1860

* 1860 *Trochammina squamata* Jones & Parker var. *gordialis* – Jones & Parker: p. 304.

. 1960 *Glomospira gordialis* – Barker: p. 79, pl. 38, figs. 7-9 [cop. Brady, 1884].

p 1964 *Glomospira gordialis* – Kristan-Tollmann: pl. 3, figs. 12a-b, 13a [non 13b, 14, 15].

. 1981 *Glomospira gordialis* – Resig: p. 663, pl. 9, fig. 12.

. 2001 *Glomospira gordialis* – Schumacher: p. 135, pl. 1, fig 11.

. 2001 *Glomospira gordialis* – Zheng & Zhaoxian: pl. 12, figs. 3, 4.

. 2005 *Glomospira gordialis* – Narayan et al.: p. 141, pl. 1, figs. 2-3.

Diagnosis. An irregularly coiled, tubular, small to medium sized species. Test finely agglutinated, yellow to light brown in colour. Aperture is a simple opening at the end of the chamber.

Remarks. This species is easily recognized by its irregular coiled shape. The build-up is comparable with the genus *Ammodiscus*.

This species occurred between 214 and 1923 m water depth 12°5' and 3°56'S off Peru and Ecuador.

Distribution. Recent, Canaries, Atlantic; Fiji, Pacific (Barker, 1960 [cop. Brady, 1884]); China Sea (Zheng & Zhaoxian, 2001); recent, off San Diego, California, U.S.A. (Uchio, 1960); recent, Atlantic and Pacific coast of South America (Boltovskoy, 1976); recent, off Peru (Resig, 1981); living, NW Indian Ocean (Hermelin & Shimmield, 1990); living, Sagami Bay, Japan (Kitazato, 2000); Austria, fossil (Kristan-Tollmann, 1964); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); living, off NW Africa (Lutze & Coulbourn, 1983/84); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005); recent, South Atlantic (Schumacher, 2001).

Size: 125-249 µm.

***Haplophragmoides canariensis* var. *mexicana* Kornfeld 1931**

* 1931 *Haplophragmoides canariensis* d'Orbigny var. *mexicana* – Kornfeld: p. 83, pl. 13, fig. 4a-c.

Diagnosis. A small to medium sized plani-spiral species. Test shape is round. Test biumbilical, compressed, involute with 5 to six chambers visible in the last whorl. Umbilicus depressed, sutures very slightly curved, usually distinct in the younger part, at some specimens rather indistinct in the early part. Test material composed of fine and coarse material agglutinated together but surface relatively smooth. Chambers slightly increase as added. Aperture is an opening at the base of the last chamber.

Remarks. Rare in this study. This species was found at four stations between 214 and 1923 m water depth off Peru (10-12°S).

Distribution. Recent, off Calcasieu Pass, Lousiana, U.S.A (Kornfeld, 1931).

Diameter: 291-332 µm.

Haplophragmoides columbiense var. *evolutum* Cushman & McCulloch 1939

* 1939 *Haplophragmoides columbiense* Cushman var. *evolutum* – Cushman & McCulloch: pl. 5, figs. 11-12; pl. 6, figs. 1-2.

Diagnosis. Test medium to large in size. Plani-spiral and evolute. Chambers very inflated, nearly globular, especially in the adult portion. Sutures distinct and depressed. Chambers increasing gradually in size as added. Last whorl composed of 7 visible chambers. Test material finely agglutinated, sometimes contents coarser grains. Surface smooth, yellow to light brown in colour. The aperture, located at the base of the last chamber, is a slit, bordered by rim.

Remarks. This species was found at five stations between 465 and 995 m water depth off Peru (12° to 3°57'S).

Distribution. Recent, off S-California, Mexico, Pacific (Cushman & McCulloch, 1939).

Diameter: 133-672 µm.

Haplophragmoides pusillus Collins 1974

* 1974 *Haplophragmoides pusillus* – Collins: p. 9, pl. 1, fig. 2.

. 1994 *Haplophragmoides pusillus* – Loeblich & Tappan: p. 244, pl. 7, figs. 1-7.

Diagnosis. A small to medium sized, evolute, plani-spiral species. Test consists of six to seven inflated chambers in the last whorl. Chambers gradually increasing in size as added. Periphery rounded and lobulate. Sutures distinct, slightly curved and depressed. Umbilicus depressed. Aperture is a loop-shaped opening at the base of the last chamber. Surface rather smooth, shiny.

Remarks. A rare species in this study. Only three stained specimens were found at two stations off Peru in 302 and 522 m water depth (12-15°S).

Distribution. Holocene, northern and southern sector of Port Phillip Bay, Victoria, Australia (Collins, 1974); recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 789 µm.

Haplophragmoides rotulatum Brady 1881

* 1881 *Lituola (Haplophragmium) rotulatum* – Brady: pl. 34, figs. 5-6.

. 1960 *Haplophragmoides rotulatum* – Barker: pl. 34, figs. 5, 6 [cop. Brady, 1884].

. 1994 *Evolutinella rotulata* – Jones: pl. 34, figs. 5-6 [cop. Brady, 1884].

Diagnosis. A robust, medium to large species consisting of numerous very compressed chambers. Test bilateral symmetric, evolutely convoluted, biconcave, consisting of about three whorls, visible from both sides. Both umbilici deeply depressed. Periphery sub-rounded to squarish. Sutures more or less distinct, very slightly incised. Aperture indistinct on the base of the last chamber. Surface rough, coarsely agglutinated. Brown to yellow coloured.

Remarks. Rare in this study. Found at three stations off Peru between 3°45'S and 12°32'S in water depths between 350 and 1004 m.

Distribution. North Atlantic (Jones, 1994 [cop. Brady, 1884].

Diameter: 415-996 µm.

***Haplophragmoides sphaeriloculum* Cushman 1910**

* 1910 *Haplophragmoides sphaeriloculum* – Cushman: p. 107, pl. 165.

Diagnosis. Test small, plani-spiral. Five chambers in the last whorl. Chambers strongly inflated, sphaerical. Increasing significantly in size as added. Periphery rounded and lobulate. Sutures distinct and depressed. Aperture simple, located at the base of the last chamber. Surface finely agglutinated and very smooth, yellowish or light-brown in colour. The wall is very thin and fragile.

Remarks. Very rare in this study. Only one stained specimen was found at 627 off Peru (7°S/80°W).

Distribution. Recent, off Japan (Cushman, 1910).

Diameter: 183-216 µm.

Hormosina globulifera **Brady 1879**

* 1879 *Hormosina globulifera* – Brady: pl. 4, figs. 4-5.

Diagnosis. Test medium to large in size, consists of one or more globular chambers with a thin, tubular neck. Younger chambers increasing significantly in size as added and arranged in a straight or curved series (Brady, 1884). Surface very finely agglutinated, smooth, yellowish or light brown in colour.

Remarks. Only four stained specimens were found off Ecuador (1°45'S/82°37'W) at 2092 m water depth. These specimens consist of one or two chambers.

Distribution. Recent, North and South Atlantic, North and South Pacific (Brady, 1879).

Size: 623-1245 µm.

Hormosinella distans **Brady 1881**

(Pl. 1, fig. 6)

* 1881 *Lituola* (*Reophax*) *distans* – Brady: p. 50.

. 1884 *Reophax distans* – Brady: p. 296, pl. 31, figs. 18-22.

. 1994 *Hormosinella distans* – Jones: pl. 31, figs. 18-22 [cop. Brady, 1884].

. 1994 *Hormosinella distans* – Loeblich & Tappan: pl. 5, figs. 15-17.

Diagnosis. Test medium to large in size, consisting of a single sub-sphaerical chamber with both ends terminating in elongated necks. The basal neck is usually shorter than the apertural neck. Test surface coarsely agglutinated and rough.

Remarks. Rare in this study. Only four stained specimens were found at one station off Ecuador (1°45'S/82°37'W) at 2092 m water depth.

Distribution. Recent, north of Juan Fernandez Island, East Pacific (Jones, 1994 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1995).

Size: 481-1204 µm.

***Recurvoides contortus* Earland 1934**

* 1934 *Recurvoides contortus* – Earland: p. 91, pl.10, figs. 7-19.

. 1981 *Recurvoides contortus* – Resig: p. 665, pl. 10, fig. 12.

. 1990 *Recurvoides contortus* – Hermelin & Shimmield: p. 12, pl.1, figs. 6-7.

. 1994 *Recurvoides contortus* – Loeblich & Tappan: p. 249, pl. 12, figs. 1-14.

. 2001 *Recurvoides contortus* – Schumacher: p. 139, pl. 3, figs. 5, 6.

Diagnosis. A medium to large sized plani-spiral species. Test slightly ovate from side view. Chambers slightly inflated, increasing slightly in size as added. Umbilicus on one side depressed, at the other side flat or even slightly convex. Sutures distinct and slightly incised.

Aperture is a loop-shaped opening at the base of the last chamber. Surface smooth or a bit rough. Wall is thick and robust, it shows a brownish hue.

Remarks. This species resembles *Alveolophragmium scitulum* but differs from it by the more acute periphery of the convolution. The apical end of the last chamber seems to be more tapered. As described by Earland (1934) the early part of the test often shows another orientation of the coiling plane than the adult convolutions.

This species was found between 291 and 2092 m water depth off Peru and Ecuador (12° to 1°45'S).

Distribution. Recent, off Peru (Resig, 1981); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, off Argentina (Boltovskoy, 1976); recent, Sahul Shelf, Timor Sea (Loeblich & Tappan, 1994); recent, Falkland sector of the Antarctic Ocean (Earland, 1934); recent, Cascadia convergent margin, NE Pacific (Heinz et al., 2005); recent, South Atlantic (Schumacher, 2001).

Diameter: 166-664 µm.

***Reophax apiculatus* Zheng 1988**

(Pl. 1, fig. 7)

* 1988 *Reophax apiculatus* – Zheng: pl. 9, figs. 9, 10.

. 2001 *Reophax apiculatus* – Zheng & Zhaoxian: pl. 13, figs. 10, 11.

Diagnosis. A very large, stout and robust species. Test consists of three to five subglobular chambers, whereas the initial chamber is often slightly elongated and always has a thin but robust basal ledge. Following chambers slightly overlapping, appearing broader than high.

Sutures distinct and depressed. Aperture simple at the apical end of the last chamber. Surface rough. Wall consists of coarse quarz grains and a fine interfacing matrix.

Remarks. Only found at 697 m water depth of Peru (11°S/78°25'W). This species may consist of more than four chambers. Zheng (2001) described specimens consisting of up to four chambers, whereas one specimen in our study consists of even five chambers.

Distribution. Recent, China Sea (Zheng, 1988, Zheng & Zhaoxian, 2001).

Length: 872-2656 µm.

***Reophax dentaliniformis* Brady 1881**

* 1881 *Lituola* (*Reophax*) *dentaliniformis* – Brady: pl. 30, figs. 21-22.

. 1899 *Reophax dentaliniformis* – Flint: pl. 18, fig. 2.

. 1960 *Reophax dentaliniformis* – Barker: p. 63, pl. 30, figs. 21-22 [cop. Brady, 1884].

. 1960 *Reophax dentaliniformis* – Uchio: pl. 1, fig. 4.

. 1964 *Reophax dentaliniformis* – Phleger: p. 379, pl. 1, fig. 1.

. 1981 *Reophax dentaliniformis* – Resig: p. 663, pl. 9, fig. 11.

. 1990 *Reophax dentaliniformis* – Hermelin & Shimmield: p. 12, pl. 1, figs. 1-2.

. 2004 *Reophax dentaliniformis* – Cornelius & Gooday: p. 1588, text fig. 5(A, B).

Diagnosis. This species occurs as a big sized *Reophax* with typical uniserial chamber arrangement. The top and base of each internal chamber terminates abruptly; resulting in a cylindrical shape of the chambers. The oldest and youngest chambers are rounded at their base and top, respectively. Sutures very distinct. Chambers increasing slightly in size as added. Test material mostly consists of quarz grains giving the test a gray to whitish hue and a glassy transparency. The aperture is a terminal opening on a neck at the periphery of the last chamber and is bordered by a surrounding lip.

Remarks. The majority of our specimens show a straight growth but a few are slightly bended. This species occurred between 465 and 2092 m water depth off Peru and Ecuador (12 to 1°45'S).

Distribution. Recent, off San Diego, California, U.S.A. (Uchio, 1960); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, Gulf of Lions, NW Mediterranean Sea (Fontanier et al., 2008); recent, Pacific coast of Costa Rica and Nicaragua (Heinz et al., 2008); recent, off Peru (Resig, 1981); recent, Gulf of California (Phleger, 1964); recent, Peru-Chile Trench area (Ingle et al., 1980); living, off Cape Blanc, NW Africa (Jorissen et al., 1998); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, South Atlantic (Schumacher, 2001); living, eastern Weddell Sea, (Cornelius & Gooday, 2004).

Length: 208-1494 µm.

***Reophax difflugiformis* Brady 1879**

* 1879 *Reophax difflugiformis* – Brady: pl. 4, fig. 3.

. 1899 *Reophax difflugiformis* – Flint: pl. 16, fig. 2.

. 1960 *Reophax difflugiformis* – Barker: p. 63, pl. 30, figs. 1-4 [cop. Brady, 1884].

. 1995 *Lagenammina difflugiformis* – Jones: pl. 30, figs. 1-3 [cop. Brady, 1884].

. 2001 *Lagenammina difflugiformis* – Schumacher: p. 137, pl. 2, fig. 6.

. 2008 *Lagenammina difflugiformis* – Lobegeier & Sen Gupta: p. 110, pl. 4, fig. 11.

Diagnosis. A small sized, single chambered *Reophax*. The chamber is rounded and somewhat elongated. The aperture is a simple round opening at the end of a neck.

Remarks. Most specimens found in this study are coarsely agglutinated and not as rounded as it is shown by the principal author.

This species occurred between 207 and 2092 m water depth off Peru and Ecuador (10 to 1°45'S).

Distribution. Recent, South Atlantic and Tahiti (Barker, 1960 [cop. Brady, 1884]); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, South Atlantic (Schumacher, 2001).

Size: 249-374 µm.

Reophax duplex **Grzybowski 1896**

* 1896 *Reophax duplex* – Grzybowski: pl. 8, figs. 23-25.

Diagnosis. A medium to large sized *Reophax*. Test consists of two globular chambers which are usually different in size. Sutures distinct and depressed. Coarsely agglutinated. Surface rough and robust. Aperture simple, terminal.

Remarks. Rare in this study. This species was found at two stations between 1105 and 1923 m water depth off Peru (10°53' and 9°17'S).

Distribution. Lower Oligocene, near Krakow, Poland (Grzybowski, 1896).

Length: 813-875 µm.

Reophax fusiformis Williamson 1858

* 1858 *Proteonina fusiformis* – Williamson: pl. 1, fig. 1.

. 1995 *Reophax fusiformis* – Jones: pl. 30, figs. 7-10, ?11.

Diagnosis. A small, single chambered, very coarsely agglutinated species. Chamber rounded or nearly straight, inflated, fusiform, with both ends tapered. Aperture is a terminal opening at the end of a neck. Surface very rough, agglutinated with coarse grains. Slightly transparent.

Remarks. Found at 492 m water depth off southern Peru (17°28'S/71°52'W).

Distribution. Recent, Isle of Skye, off the west coast of Scotland (Williamson, 1858); South Atlantic and Tahiti, South Pacific (Barker, 1960 [cop. Brady, 1884]).

Reophax guttifer Brady 1881

* 1881 *Reophax guttifera* – Brady: p. 49 [nomen nudum].

. 1960 *Reophax guttifer* – Barker: p. 65, pl. 31, figs. 10-15 [cop. Brady, 1884].

. 1995 *Hormosinella guttifera* – Jones: pl. 31, figs. 10-15 [cop. Brady, 1884].

Diagnosis. Test uniserial, small to medium in size. Test consists of three or more inflated, pyriform chambers which are flattened at their base and tapered to their upper end but the proloculus is nearly globular. Chambers are connected by tubular segments. The chambers and tube segments are round in cross section and increasing just slightly in size as added. Apertural and has a tapered neck with a terminal opening. Surface rather coarsely agglutinated and transparent.

Remarks. A rare species in this study. Found at one station off Peru in 1004 m water depth (10°59'S/78°31'W).

Distribution. Recent, South Atlantic (Barker, 1960 [cop. Brady, 1884]); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

***Reophax insectus* Goës 1896**

* 1896 *Reophax insectus* – Goës: pl. 3, figs. 6-7.

. 2001 *Reophax insectus* – Zheng & Zhaoxian: pl. 18, figs. 1-5.

Diagnosis. Test uniserial, very large, consisting of numerous chambers. Chambers much overlapping, sub-spherical. Initial and final chamber almost globular, the intermediate ones appear more depressed on both top and bottom. Increasing slowly in size as added. Periphery rounded and strongly lobulate because of the distinct and incised sutures. Aperture is a terminal, round opening on the apical side of the last chamber. Surface coarsely agglutinated, rough, light brown.

Remarks. The specimens of this study are straight and not bended and resemble these shown in Zheng & Zhaoxian (2001, pl. 18, figs. 1-5) more than the type figure from Goës (1896) because of their rounded base, whereas that of Goës is strongly tapered to its basal end.

A very rare species in this study. It was found at only one station off Peru (10°59'S/78°31W) in a water depth of 1004 m.

Distribution. Recent, East China Sea (Zheng & Zhaoxian, 2001).

Length: 3536 µm.

Reophax pilulifer Brady 1884

(Pl. 1, fig. 8)

* 1884 *Reophax pilulifera* – Brady: pl. 30, figs. 18-20.

. 1899 *Reophax pilulifera* – Flint: pl. 18, fig. 1.

. 1960 *Reophax pilulifer* – Barker: p. 63, pl. 30, figs. 18-20 [cop. Brady, 1884].

. 1994 *Hormosina pilulifera* – Jones: pl. 30, figs. 18-20 [cop. Brady, 1884].

Diagnosis. A small to large, uniserial, coarsely agglutinated species. Test straight or bended, consists of three to five globular chambers, which increase significantly in size as added. Chambers just marginally overlapping. Sutures distinct and depressed. Aperture terminal on a coniform neck at the apical part of the last chamber. Surface rough and agglutinated with coarse grains; sometimes with attached tests of other foraminifera and diatoms etc. Wall transparent or opaque.

Remarks. A rare species in this study. This species was found at two stations off Peru and Ecuador in 1004 and 2092 m water depth, respectively (10°59'S/78°31'W and 1°45'S/82°37'W).

Distribution. Recent, North Atlantic (?) (Barker, 1960 [cop. Brady, 1884]); late Quaternary, eastern S-Atlantic (Schmiedl, 1995).

Length: 600-1350 µm.

Reophax pisiformis **Zheng 1988**

(Pl. 1, fig. 9)

* 1988 *Reophax pisiformis* – Zheng: pl. 13, figs. 2, 3.

. 2001 *Reophax pisiformis* – Zheng & Zhaoxian: pl. 20, figs. 8a-c, 9.

Diagnosis. A large compressed, coarsely agglutinated species. The distinctively carinated test consists of three or more very compressed chambers which are separated by distinct and depressed sutures. Both ends bluntly rounded or stump. Marginal periphery slightly or distinctively serrate. Large specimens are usually slightly bended upwards to their terminal ends. Aperture is a broad slit at the apical keel of the last chamber. It makes up almost the whole breadth of the keel. Surface rough and slightly transparent.

Remarks. Only found at 2092 m water depth off Ecuador (1°45'S/82°37'W).

Distribution. Recent, East China Sea at 495 m water depth (Zheng, 1988, Zheng & Zhaoxian 2001).

Length: 1826 µm.

Reophax scorpiurus de Montfort 1808

* 1808 *Reophax scorpiurus* – de Montfort: p. 330 text fig.

. 1899 *Reophax scorpiurus* – Flint: pl. 17, fig. 1.

. 1960 *Reophax scorpiurus* – Uchio: pl. 1, fig.9.

. 1970 *Reophax scorpiurus* – Boltovskoy & Theyer: pl. 3, figs. 24-26.

. 1981 *Reophax scorpiurus* – Resig: p. 663, pl. 9, fig. 14.

. 1990 *Reophax scorpiurus* – Hermelin & Shimmield: p. 12, pl. 1, fig. 3.

1995 *Reophax scorpiurus* – Wollenburg: p. 48, pl. 1, fig. 10.

2001 *Reophax scorpiurus* – Schumacher: p. 137, pl. 2, figs. 10-11.

. 2001 *Reophax scorpiurus* – Zheng & Zhaoxian: pl. 22, figs. 8-14.

. 2008 *Reophax scorpiurus* – Lobegeier & Sen Gupta: p. 110, pl. 4, fig. 20.

Diagnosis. A multi chambered, small to large sized species. The rounded to subrounded uniserial arranged chambers increasing significantly in size as added. The final chamber is elongated and posses a simple terminal aperture with very short neck. Sutures distinct, more or less depressed. Test transparent and composed of rather coarse agglutinated quarz grains. The test is usually slightly or distinctively bended but also straight specimens occur.

Remarks. It is a common species in study. It occurred between 207 and 2092 m water depth off Peru and Ecuador (12 to 1°45'S).

Distribution. Recent, Gulf of California, U.S.A. (Phleger, 1964); recent, off Panama (Boltovskoy, 1976); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off Costa Rica and Nicaragua (Heinz et al., 2008); recent, Peru-Chile trench area (Ingle et al., 1980); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, South Atlantic (Schumacher, 2001); recent, Arctic Ocean (Wollenburg, 1995); recent, China Sea (Zheng &

Zhaoxian, 2001); recent, Adriatic Sea (De Montfort, 1808); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010).

Length: 232-2075 µm.

Spiroplectammina biformis **Parker & Jones 1865**

* 1865 *Textularia agglutinans* d'Orbigny var. *biformis* – Parker & Jones: pl. 15, figs. 23a-b, 24.

. 1995 *Spiroplectammina biformis* – Jones: pl. 45, figs. 25-27 [cop. Brady, 1884].

Diagnosis. Test very small and biserial with a spiral initial part. Initial end rounded, apertural end subrounded, often slightly tapered by the apical end of the last chamber. Chambers slightly inflated, alternately arranged. Sutures distinct and slightly depressed. Aperture is a simple basal opening at the inner margin of the last chamber.

Remarks. A very rare species in this study. It was found at one station off Peru in 1004 m water depth (10°59'S/78°31'W).

Distribution. Recent, South Atlantic and South Pacific (Barker, 1960 [cop. Brady, 1884]).

Verneuilina advena **Cushman 1922**

* 1922 *Verneuilina advena* – Cushman: p. 57, pl. 9, figs. 7-9.

. 1981 *Verneuilinulla advena* – Loeblich & Tappan: p. 256, pl. 19, figs. 8, 9.

. 1998 *Eggerella advena* – Patterson, Burbidge and Luternauer p. 5, pl. 28, fig. 6.

Diagnosis. A very small, triserial species. Test elongated, straight or slightly bended, tapered to the basal end, apertural end rounded or slightly tapered. Chambers inflated, numerous, usually twenty five. Sutures distinct and depressed. Aperture simple, in a depression, located at the junction of the last of the three series of chambers (Cushman, 1922). Surface rather smooth, light brown in colour, last chamber sometimes often white (Cushman, 1922).

Remarks. This species resembles *Eggerella scabra* but differs from it, from my point of view, by its non-twisted chamber arrangement.

A rare species in this study. It was found at one station off Ecuador in 207 m water depth.

Distribution. Recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 166-498 µm.

Verneuilina bradyi **Cushman 1911**

* 1911 *Verneuilina bradyi* – Cushman: p. 54, text fig. 87, pl. 6, fig. 4.

. 1960 *Eggerella bradyi* – Barker: p. 97, pl. 47, figs. 4-7 [cop. Brady, 1884]

1994 *Eggerella bradyi* – Loeblich & Tappan: p. 265, pl. 28, figs. 9-14.

. 2001 *Eggerella bradyi* – Schumacher: p. 141, pl. 4, fig. 10.

2005 *Eggerella bradyi* – Hess & Kuhnt: p. 70, text fig. 5a.

. 2007 *Eggerella bradyi* – Schröder: p. 641, pl. 2, fig. 14.

Diagnosis. A medium to large sized species with numerous strongly inflated, almost globular chambers. Chambers slightly increasing as added. Sutures distinct. Basal and of the test rounded. Aperture is a slit like opening centred on the base of the last chamber but has no contact with the two younger chambers. The aperture is surrounded by an indistinct lip. Test very finely agglutinated; surface smooth.

Remarks. This species resembles *Verneuilina propinqua* (Brady) but differs from that species by possessing a lip surrounding the aperture and usually the test surface is finer agglutinated.

A common species. It was found in water depths of 298 to 2092 m off Peru and Ecuador, from 17°S to 1°45'S.

Distribution. Recent, eastern Timor Trough (Loeblich & Tappan, 1994); recent, South Pacific and West Indies (Barker, 1960 [cop. Brady, 1884]); recent, South Atlantic (Schumacher, 2001); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, eastern Indian Ocean (Murgese & Deckker, 2005); recent, southern China Sea (Jian & Wang, 1997, Jian et al., 1999); Neogene and Quaternary, southern South China Sea (Hess & Kuhnt, 2005); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, Peru-Chile trench area (Ingle et al., 1980); living, off Cape Blanc, NW Africa (Jorissen et al., 1998); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, Mississippi Fan, off Louisiana, U.S.A. (Schroeder, 2007); Holocene, central Adriatic Sea (Morigi et al., 2005); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010).

Length: 563-875 µm.

Verneuilina propinqua Brady 1884

p*1884 *Verneuilina propinqua* – Brady: pl. 47, figs. 8-12 [non fig. 13,14].

. 1899 *Verneuilina propinqua* – Flint: pl. 31, fig. 2.

. 1960 *Eggerella propinqua* – Barker: p. 97, pl. 47, figs. 8-12 [cop. Brady, 1884].

. 2007 *Eggerella propinqua* – Schröder: p. 641, pl. 2, fig. 14.

Diagnosis. A triserial, medium to large sized species. Test composed of grains from different sizes, resulting in a slightly rough surface. Chambers strongly inflated, bordered by distinct and depressed sutures. Size of chambers slightly increases as added. Basal end of test is rounded. Aperture is a small undefined opening without a lip, located at the base of the last chamber and stays in direct contact with the two older chambers. Colour is light brown.

Remarks. Specimens were found at two stations off Peru on 11°S and water depths of 302 and 823 m.

Distribution. Recent, North and South Atlantic, North and South Pacific (Brady, 1884); recent, off Africa, Atlantic and North Pacific (Barker, 1960 [cop. Brady, 1884]); recent, Mississippi Fan, off Louisiana, U.S.A. (Schroeder, 2007).

Length: 913-1079 µm.

3 Taxonomy of species

Order TROCHAMMINIDA

(Saidova, 1981)

Ammoglobigerina globigeriniformis Brönnimann & Whittaker 1988

p*1884 *Haplophragmium globigeriniforme* Parker & Jones - Brady: p. 312, pl. 35, fig. 10 [not fig. 11].

. 1899 *Haplophragmium globigeriniforme* – Flint: pl. 21, fig. 1.

p 1960 *Ammoglobigerina globigeriniformis* – Barker: p. 73, pl. 35, fig. 10 [not fig. 11; cop. Brady, 1884].

. 1988 *Paratrochammina challengeri* – Brönnimann & Whittaker: pl. 10, figs. 10a-c.

. 1995 *Paratrochammina challengeri* – Jones: Pl. 35, fig. 10 [cop. Brady, 1884].

. 1995 *Paratrochammina challengeri* – Loeblich & Tappan: p. 259, pl. 22, figs. 7-12.

Diagnosis. A medium to large sized, stout, trochospiral species. Test consists of three convolutions, visible from the spiral side. Chambers strongly inflated, almost globular. Four chambers visible from the umbilical side. Chambers increasing rapidly in size as added. Sutures distinct and deeply incised. Umbilicus wide and deeply depressed. Periphery lobulate.

"Single low-crescentic interiomarginal aperture, asymmetric with respect to coiling axis and in direct communication with the deep umbilical depression into which all the preceding apertures open" (Brönnimann & Whittaker, 1988). The aperture is surrounded by a lip. Surface rough.

Remarks. Many of the specimens found in this study occurred as smaller individuals as described by the principal authors. In this study it commonly occurred between 17 and 1°45'S off Peru and Ecuador in water depths between 207 and 2092 m.

Distribution. Recent, S-Atlantic (Brönnimann & Whittaker, 1988); recent, S-Atlantic and east of Azores Islands, E-Atlantic (Barker, 1960 [cop. Brady, 1884]).

Diameter: 116-498 µm.

Ammoglobigerina globulosa **Cushman 1920**

* 1920 *Trochammina globulosa* – Cushman: p. 77, pl. 16, figs. 3, 4.

. 1988 *Globotrochamminopsis globulosus* – Brönnimann & Whittaker: p. 32, figs. 12a-c.

. 1994 *Ammoglobigerina globulosa* – Loeblich & Tappan: P. 258, Pl. 22, figs. 1-6.

Diagnosis. Test small, depressed trochospiral, sub-globular. Usually consisting of three whorls. Chambers inflated, sub-sphaerical. Three or more chambers visible from umbilical side. Chambers increasing rapidly in size as added. Sutures deep and depressed. Umbilicus deep. “Aperture large, umbilicate, formed by the umbilicate region of the last volution and the arch of the last-formed chamber” (Cushman, 1920). Wall very finely agglutinated, smooth, brown or yellow in colour.

Remarks. This species resembles *A. globigeriniformis* (Brönnimann & Whittaker, 1988) but differs from this by the relatively big aperture and a very smooth surface.

Very rare. Found at one station at 17°38’S/71°58’W off S-Peru in 918 m water depth.

Distribution. Recent, off northeastern coast of U.S.A. (Cushman, 1920); recent, Timor Sea (Loeblich & Tappan, 1994).

Diameter: 116-349 µm.

Trochammina globorotaliformis **Zheng 1988**

* 1988 *Trochammina globorotaliformis* - Zheng: pl. 39, fig. 3.

. 1994 *Paratrochammina globorotaliformis* – Loeblich & Tappan: p. 260, pl. 23, figs. 1-12.

. 2001 *Trochammina globorotaliformis* – Zheng & Zhaoxian: pl. 62, figs. 11, 12.

Diagnosis. A medium sized, stout *Trochammina*. Test is trochospiral coiled, consisting of numerous chambers which strongly increase is size as added. Test material predominantly agglutinated with fine grains but contains coarse grains which are irregularly distributed in the test. Chambers rather inflated, especially those of the last whorl appear almost globular. Last whorl shows four chambers, whereas last chamber making up about a half of the test. Sutures distinct and slightly depressed. Aperture on the umbilical side is an oval or loop shaped opening at the central base of the last chamber, right above the oldest chamber of the last whorl. Aperture is bordered by a lip. Test shows a yellow to light brown colour.

Remarks. Very rare in this study. Only found at one station off Peru in 823 m water depth (12°S). This species resembles *Trochammina globigeriniformis* (Parker & Jones) but differs in possessing a lip surrounding the aperture and the higher trochospiral chamber arrangement.

Distribution. Recent, East China Sea (Zheng, 1988, Zheng & Zhaoxian 2001); recent, Timor Sea (Loeblich & Tappan, 1994).

Trochammina inflata **Montagu 1808**

* 1808 *Nautilus inflatus* – Montagu: pl. 18, fig. 3.

1994 *Trochammina inflata* – Jones: pl. 41, fig. 4 [cop. Brady, 1884].

. 2001 *Trochammina inflata* – Zheng & Zhaoxian: pl. 66, fig. 13a-c.

Diagnosis. A small, stout, trochospiral species. Test consists of numerous rather inflated chambers, coiled up to a low trochoid, almost planispiral spire with usually three whorls. Periphery rounded, often slightly lobulate. Spiral side evolute, umbilical side involute with five chambers visible on this side, slightly concave. Chambers increasing gradually in size as added. Sutures straight, distinct and incised. Aperture is a basal slit at the last chamber. Surface rather smooth, yellow or light brown in colour.

Remarks. This species differs from *Trochammina nitida* by its lower number of chambers visible in the last whorl. Furthermore it's more trochospiral and the spiral side is slightly depressed. A very rare species in this study. It was found at one station at 1923 m water depth off Peru (10°53'S/78°46'W).

Distribution. Recent, coast of Devon, England (Montagu, 1808); recent, East China Sea (Zheng & Zhaoxian, 2001); recent, Peru-Chile Trench area (Ingle et al., 1980).

Diameter: 149-249 µm.

Trochammina nana Brady 1881

* 1881 *Haplophragmium nanum* – Brady: ?

. 1988 *Portatrochammina bipolaris* (Brönnimann & Whittaker) – Brönnimann & Whittaker: p. 69, pl. 27, figs. J-L.

. 1994 *Trochammina nana* – Jones: pl. 35, figs. 7-8 [cop. Brady, 1884].

Diagnosis. A small, trochospiral species. Test coiled up to a low spire consisting of two whorls which are visible from the spiral side. Umbilical side involute with seven chambers visible from this side. Chambers strongly inflated, increasing slowly in size as added, but last chamber significantly bigger than the penultimate. Sutures distinct and incised. Aperture is allow slit at the base of the last chamber. Surface smooth or slightly rough. Yellow or light brown in colour.

Remarks. A rare species in this study. Found at one station off Peru (11°6'S/78°3'W) in 248 m water depth.

Distribution. Recent, South Atlantic (Jones, 1994 [cop. Brady, 1884]).

Diameter: 166 µm.

Trochammina nitida Brady 1881

* 1881 *Trochammina nitida* – Brady: pl. 41, figs. 5-6.

. 1995 *Polystomammina nitida* – Jones: pl. 41, figs. 5-6 [cop. Brady, 1884].

Diagnosis. Test small, compressed, almost plani-spiral. Spiral side shows up to three whorls, umbilical side depressed. Chambers just slightly inflated, increasing slowly in size as added. Nine chambers visible in the last whorl. Upper apical part of the face of last chamber slightly tilted forwards. Sutures more or less distinct and very slightly depressed, depending from grain size of the incorporated material. Periphery rounded, cyclic outline. Aperture is a curved slit at the base of the last chamber. Surface rather smooth, yellow or light brown coloured. Last chamber often white.

Remarks. This species was found at just one station off southern Peru (17°28'S/71°52'W) in a water depth of 492 m. All specimens are very small and relatively coarse agglutinated, thus the sutures are just indistinctively developed. It differs from *Trochammina inflata* by it's nearly plani-spiral coiling and the large number of chambers in the last whorl.

Distribution. Recent, Nightingale Island, Atlantic and off Prince Edward Island, South Pacific (Jones, 1995 [cop. Brady, 1884]).

Diameter: 158 µm.

***Trochammina squamata* Jones & Parker 1860**

* 1860 *Trochammina squamata* – Jones & Parker: [type figure not given].

. 1960 *Trochammina squamata* – Barker: p. 85, pl. 41, fig. 3 [cop. Brady, 1884].

. 1970 *Trochammina squamata* – Boltovskoy & Theyer: pl. 5, fig. 20a,b.

. 2001 *Trochammina squamata* – Zheng & Zhaoxian: pl. 44, fig. 1.

Diagnosis. A small to medium sized *Trochammina*. Spiral side trochoid, somewhat tapered. Umbilical side slightly concave. Chambers are strongly depressed but very broad and increase significantly in size as added. All chambers usually visible from spiral side. Four chambers are visible at the umbilical side. Sutures distinct but only depressed on the umbilical side. Aperture is located at the base of the last chambers on the umbilical side. The shape from side view is coniform. The highest, tapered point is the centred.

Remarks. Rare in this study. This species was found at three stations off Peru and Ecuador (17 to 1°45'S) in water depths between 521 and 2092 m.

Distribution. Recent, near Crete, Mediterranean Sea (Jones & Parker, 1860); recent, West Indies (Barker, 1960 [cop. Brady, 1884]); recent, off Costa Rica and Nicaragua (Heinz et al., 2008); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, East China Sea (Zheng & Zhaoxian, 2001); recent, at the mouth of Quequén Grande River, off Argentina (Boltovskoy, 1976); recent, South Atlantic (Schumacher, 2001); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 291-457 µm.

***Trochammina triloba* Zheng 2001**

* 2001 *Trochammina triloba* – Zheng & Zhaoxian: pl. 67, figs. 1-6.

Diagnosis. A small, low trochospiral species. Test consists of three whorls, visible from the slightly convex spiral side. Three or three and one half chambers visible at the depressed umbilical side. Chambers strongly inflated, almost globular, increasing rapidly in size as added. Last chamber very large, making up about one half of the test. Periphery round and lobulate. Sutures of dorsal side indistinct in the early whorl, distinct in final whorl, slightly curved to radial. Those of the ventral side distinct, straight, radial and depressed. Wall consists of coarse and fine sand grains. Surface coarsely finished, inner wall smooth. Aperture short, arched, located near the umbilical end of the chamber with thickened apertural lip. Color reddish-brown, final chamber of lighter hue (Zheng & Zhaoxian 2001).

Remarks. This species differs from *Ammoglobigerina globigeriniformis* by the lower number of visible chambers at its umbilical side, by its smaller size and the barely visible aperture. This species resembles *Trochammina globorotaliformis* but differs from it by the much lower trochospiral chamber arrangement.

A very rare species in this study. It was found at two stations off N-Peru and Ecuador in water depths of 995 and 2092 m.

Distribution. Recent, East China Sea (Zheng & Zhaoxian, 2001).

Diameter: 166-540 µm.

Order TEXTULARIIDA

(Lankester, 1885)

Cribrogoesella pacifica Cushman & McCulloch 1939

* 1939 *Cribrogoesella pacifica* – Cushman & McCulloch: p. 99, pl. 10, figs. 10-12.

Diagnosis. A large cylindrical species with early triserial and younger uniserial stage, whereas the triserial stage makes up just a minor part of the individual but is thicker than the beginning of the uniserial stage. The prominent uniserial part of the test composes of numerous chambers which are broader than high, increasing slowly in size as added. Sutures are distinct in the later uniserial part but less in the early part of the test. The test is agglutinated with coarse material but shows a smooth surface. Aperture consists of a variable number of circular openings on the face of the last chamber.

Remarks. Very rare in this study, only four specimens were found in one sample at 823 m water depth in 0-5 mm sediment depth (M77-1-622/MUC85, 12°S/77°W). White colour of test material. The specimens are slightly bended at the lower part of the test, right above the transition from the triserial to the uniserial part.

Distribution. Recent, off Guadalupe Island, off Mexico, Pacific (Cushman & McCulloch, 1939).

Dorothia pseudoturris **Cushman 1922**

* 1922 *Textularia pseudoturris* – Cushman: pl. 3, fig. 1.

. 1960 *Dorothia pseudoturris* – Barker: p. 91, pl. 44, figs. 4, 5 [cop. Brady, 1884].

Diagnosis. A large, robust species. Test rounded or quadrangular in cross section. Tapered to the basal end, the final end concave. Consists of numerous biserially arranged, just very slightly inflated, low chambers. Sutures distinct and slightly depressed. Aperture is a small, arched opening centred at the base of the inner margin of the last chamber (Cushman, 1922).

Surface variable in texture, but predominantly rough.

Remarks. Only three stained individuals were found at 995 m water depth off Ecuador (3°56'S/81°19'W).

Distribution. Recent, off the coast of Georgia, U.S.A. (Cushman, 1922); West Indies (Barker, 1960 [cop. 1884]).

Eggerella humboldti Todd & Brönnimann 1957

(Pl. 1, fig. 10)

* 1957 *Eggerella humboldti* – Todd & Brönnimann: pl. 2, fig. 26a-b.

Diagnosis. A small to medium sized, coarsely agglutinated species. Test distinctively tapered to the basal end because the chambers increasing rapidly in size as added. Apertural end rounded. Test consists only of a small, indistinct number of strongly inflated chambers. The youngest chamber makes up about 90% of the whole test. Sutures indistinct because of the coarse, often overlapping grains of adjacent chambers. Aperture a narrow fissure-like

opening at the bottom of the suture between the final chamber and the second from the last chamber (Todd & Brönnimann, 1957).

Remarks. Specimens found in this study are very coarsely agglutinated. The last whorl of the smallest specimens appears to consist of only a few coarse grains.

This species was found off Ecuador at two stations (1°57'S/81°7'W and 1°53'S/81°11'W) in water depths of 206 and 525 m.

Distribution. Recent, eastern Gulf of Paria, Trinidad, Caribbean Sea (Todd and Brönnimann, 1957).

Size: 191-872 µm.

Eggerella scabra Williamson 1858

* 1858 *Bulimina scabra* – Williamson: pl. 5, figs. 136-137.

. 1960 *Eggerella scabra* – Barker: p. 97, pl. 47, figs. 15-17 [cop. Brady, 1884].

. 1994 *Eggerelloides scaber* – Jones: pl. 47, figs. 15-17 [cop. Brady, 1884].

. 2003 *Eggerelloides scaber* – Murray: p. 12, text fig. 2: 11.

. 2005 *Eggerelloides scabrus* – Frenzel et al.: p. 74, pl. 3, fig. 5.

. 2009 *Eggerelloides scabrus* – Frezza & Carboni: p. 54, pl. 1, fig. 8, p. 56, pl. 2, fig. 10.

Diagnosis. A small to medium sized, triserial arenaceuos species. Test consisting of numerous inflated, nearly globular chambers which are coiled up to an irregular spiral, slightly tapered to the basal end. Chambers increasing rapidly in size as added, especially these of the last whorl. Last whorl making up about the half of the test. Apical end of last chamber may be somewhat tapered. Sutures distinct and depressed. Aperture simple, interiomarginal in a depression. Surface relatively smooth or rough, depending on grain size of agglutinated material. Brownish or yellowish hue.

Remarks. This species was found between 207 and 995 m water depth off Peru and Ecuador (12 to 1°57'S).

Distribution. Recent, In the Clyde, Scotland and off Spain (Barker, 1960 [cop. Brady, 1884]); recent, German Baltic Sea coast (Frenzel et al., 2005); recent, Peru- Chile Trench area (Ingle et al., 1980); recent, off Pacific coast of Costa Rica and Nicaragua (Heinz et al., 2008); recent, Hebridean Shelf, off W-Scotland (Murray, 2003); recent, eastern South Atlantic (Schmiedl, 1995); recent, northern North Sea (Klitgaard & Sejrup, 1996), recent, Northern Tyrrhenian Sea, Italy (Frezza & Carboni, 2009); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); recent, off New Zealand (Hayward et al., 1999).

Size: 208-747 µm.

Martinottiella nodulosa Cushman 1927

* 1927 *Clavulina communis* var. *nodulosa* – Cushman: pl. 18, figs. 1-3.

. 1992 *Martinottiella nodulosa* – Kato: p. 389, pl. 1, fig. 6.

. 1995 *Multifidella nodulosa* – Jones: pl. 48, figs. 9-13 [cop. Brady, 1884].

Diagnosis. A large, tubular, uniserial species. Test straight, just the initial portion is slightly bended. The test consists of numerous low, pyriform chambers which are round in cross section. Chambers increasing just very slightly in size but more in diameter as in height. The basal end is rounded, whereas the top is almost flat. The base of each new chamber is broader than its top. Sutures distinct. Aperture simple, in a small depression, centred on the middle of the face of the last chamber. Wall coarsely agglutinated, but smooth. Whitish or greyish hue.

Remarks. This species was found at only one station off Ecuador (1°45'S/82°37'W) in a water depth of 2092 m.

Distribution. Recent, eastern coast of the United States (Cushman, 1927); recent, north of St. Thomas, West Indies (Jones, 1994 [cop. Brady, 1884]); Miocene to Pliocene, Japan Sea (Kato, 1992).

Size: 688-3475 µm.

Textularia conica d'Orbignby 1839

* 1839 *Textularia conica* – d'Orbigny: pl. 1, figs. 19-20.

. 1899 *Textularia conica* – Flint: pl. 29, fig. 6.

. 1995 *Sahulia conica* – Jones: pl. 43, figs. 13-14.

Diagnosis. A minute, conical *Textularia*. Test tapered sharply to the basal end, apertural end rather flat. Ovate, almost round in cross section. Chambers low, increasing rapidly in size as added but more in breadth as in height. Sutures distinct but very fine, nearly undepressed. Aperture is a horizontal slit at the base of the last chamber.

Remarks. This species was found between 207 and 995 m water depth off Peru and Ecuador (12°-1°57’S).

Distribution. Recent, off Tongatabu, Friendly Islands, Pacific and off Raine Island, Torres Strait, Pacific (Jones, 1995 [cop. Brady, 1884]); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010).

Size: 83-481 µm.

Textularia porrecta **Brady 1884**

* 1884 *Textularia agglutinans* d’Orbigny var. *porrecta* – Brady: pl. 43, fig. 4.

. 1995 *Textularia porrecta* – Jones: pl. 43, fig. 4 [cop. Brady, 1884].

Diagnosis. Test small to medium in size, biserial, slender. Straight growth but slightly tapered to the basal end, bluntly rounded at apertural end. Chambers inflated, the final pair nearly globular. Sutures distinct and slightly depressed. Aperture simple, at the base of inner margin of the last chamber.

Remarks. Very rare in this study. Found at one station off Ecuador in 2092 m water depth (1°45°S/82°37'W).

Distribution. Recent, off Raine Island, Torres Strait, Pacific (Jones, 1995 [cop. Brady, 1884]).

Size: 291-498 µm.

Textularia tenuissima Earland 1933

p 1931 *Textularia elegans* – Lacroix: p. 8, figs. 4, 6 [not fig. 5].

* 1933 *Textularia tenuissima* – Earland: pl. 3, figs. 21-30.

2010 *Textularia tenuissima* – Majewski: p. 65, text fig. 2, 2.

Diagnosis. A very small, elongated but slender species. Test slightly tapered to the basal end. Apertural end rounded, slightly tapered. Basal end irregularly shaped, often coiled to a small spire. Chambers moderately inflated, barely increasing in size. Sutures distinct and depressed. Aperture is a loop-shaped opening at the inner edge of the last chamber. Surface rather smooth, dark brown to yellow coloured.

Remarks. A rare species in this study. Only found at 1923 m water depth off Peru (10°53'S/78°46'W).

Distribution. Recent, off Monaco (Lacroix, 1931); recent, West Antarctic fiord environments (Majewski, 2010); living, off South England (Alve & Murray, 2001).

Size: 191-457 µm.

Order *Miolida* (Lankester, 1885)

Ammomassilina alveoliniformis Millett 1898

* 1898 *Massilina alveoliniformis* – Millett: pl. 13, figs. 5a-b, 6a-b, 7.

. 1994 *Ammomassilina alveoliniformis* – Jones: Pl. 8, fig. 13 [cop. Brady, 1884].

. 1994 *Ammomassilina alveoliniformis* – Loeblich & Tappan: p. 242, pl. 5, figs, 1-5, p. 306, pl. 69, figs. 1, 2.

Diagnosis. A medium sized, plani-spiral species. "Test elliptical, chambers tubular, the earlier ones arranged irregularly around the long axis, the later ones in a Spiroloculine series, periphery rounded, aperture terminal, radiate or cribrate, obscured by sand-grains" (Millett, 1898). Test surface finely agglutinated, smooth, slightly transparent, shiny. Light brown hue.

Remarks. Very rare. Only one stained individual found at 918 m water depth off northern Chile (17°S/71°58'W).

Distribution. Recent, off Papua, Pacific (Jones, 1994 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1995).

Size: 415 µm.

***Nubeculina* sp.**

(Pl. 1, fig. 11)

Holotype. A living specimen from a 5-10 mm sediment interval from station M77/1-621/MUC-85 off Peru (Datum: 20th November 2008; Coordinates: 12°32.75'S, 77°34.75'W; 823 m water depth).

Paratypes. One living specimen from 0-5 mm sediment depth of station M77/1-421/MUC-13 (Coordinates: 15°11.39'S, 75°34.81'W, 522 m water depth), 1 specimen from 10-15 mm sediment depth of station M77/1-616/MUC-81 (Coordinates: 12°22.69'S, 77°29.06'W, 302 m water depth), eight specimens from 5-10 mm, seven specimens from 10-15 mm and one specimen from 15-20 mm sediment depth of station M77/1-621/MUC-85 (12°32.75'S, 77°34.75'W; 823 m water depth).

Material examined. Nineteen living specimens of *Nubeculina* sp. from multicorer samples off Peru.

Diagnosis. A small , single-chambered species. Chamber consisting of a pyriform chamber with a peaked basal end and a broad, stout, tubular neck with a down curved flange. The broadest part of the test is the upper portion of the pyriform chamber. The surface of the tapered and of the test and the tubular neck is sleek, whereas tiny, acuminate projections extending from the upper, marginal periphery of the pyriform chamber. The wall is not fragile but flexible when wetted.

Discrimination from other species. *Nubeculina* sp. resembles *N. chapmani* Cushman (1932) but differs from it by the centred tubular neck and centred basal end. *N. chapmani* is much more asymmetrical build with the tubular neck protruding from the upper marginal part of the chamber. All other species of *Nubeculina* found in previous literature are at least partially agglutinated with coarse fragments possessing more chambers and are usually much bigger in size. It is arguable if this species always consists of one chamber or if all species found in size study are juveniles. Furthermore *Nubeculina* sp. shows no tooth-like projections at the inner part of the tubular neck.

Remarks. All specimens found in this study are minute and have a smooth surface. Some of them posses downward directed protrusions of shell material at the marginal part of the chamber. It is a rare species in this study and was found at three stations off Peru in 302, 522 and 823 m water depth (12°22'S/77°29'W, 15°11'S/75°34'W and 12°32'S/77°34'W).

Total length (with basal spine): 166-274 µm.

Nummoloculina irregularis **d'Orbigny 1839**

* 1839 *Biloculina irregularis* – d'Orbigny: pl. 8, figs. 20-21.

. 1899 *Biloculina irregularis* – Flint: pl. 41, fig. 3.

. 1960 *Nummoloculina irregularis* – Brady: p. 3, pl. 1, figs. 17, 18.

1977 *Nummoloculina irregularis* – Decrouez & Radoicic: pl. 1, figs. 1-18.

. 1991 *Nummoloculina irregularis* – van Marle: p. 279, pl. 4, fig. 3.

. 1994 *Pyrgoella irregularis* – Jones: pl. 1, figs. 17-18 [cop. Brady, 1884]

. 1995 *Nummoluculina irregularis* – Wollenburg: p. 50, pl. 3, fig. 8.

. 2005 *Nummoloculina irregularis* – Murgese & De Deckker: p. 34, text fig. 4: (3), (4).

Diagnosis. A big, stout miliolid species. Test robust, globular, consisting of about four chambers. Sutures distinct, slightly incised. The apertural end is somewhat elongated. Aperture is a terminal loop-shaped opening. Surface very smooth, white and opaque.

Remarks. *N. irregularis* is very rare in this study. Only three living specimens were found off Peru at 823 and 1004 m water depth.

Distribution. Cretaceous of Serbia (Decrouez & Radoicic, 1977); recent, West Indies and off Canary Islands (Barker, 1960 [cop. Brady, 1884]); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, eastern Indian Ocean (Murgese & De Deckker, 2005); recent, Arctic Ocean (Wollenburg, 1995); recent, Caribbean Sea and Gulf of Mexico (in: Flint, 1899); recent, off NW-Africa (Eberwein & Mackensen, 2006); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

Planispirinoides bucculentus **Brady 1884**

(Pl., 1, fig. 12)

* 1884 *Miliolina bucculenta* – Brady: pl. 114, pl. 3a-b.

. 1899 *Miliolina bucculenta* – Flint: pl. 45, fig. 1.

. 1941 *Planispirina bucculenta* – Chapman: p. 186.

. 1994 *Planispirinoides bucculentus* – Jones: pl. 114, fig. 3 [cop. Brady, 1884].

Diagnosis. A large, stout, species. “Test subglobular, more or less compressed, the two sides nearly symmetrical, margin lobulated; segments inflated, broad and embracing, the last three forming a single convolution, which completely encloses the preceding ones. Aperture a long, irregularly arched, transverse slit, on the face of the terminal segment, near the line of union with the previous convolution” (Brady, 1884). The aperture is partially hidden behind a flap-like protrusion emerging from the lower boarder of the opening. Surface very smooth, white.

Remarks. Only found at one station off Peru (1°45'/82°37'W) in a water depth of 2092 m.

Distribution. Recent, Faröe Channel, NE-Atlantic (Brady, 1884); Late Cenozoic of Eastern Indonesia (van Marle, 1991); recent, continental shelf of SE-Australia (Chapman, 1941).

Diameter: 963 µm.

Pyrgo murrhyna **Schwager 1866**

(Pl. 1, fig. 13)

* 1866 *Biloculina murrhina* - Schwager: p. 203, pl. 4, figs. 15a-c.

1884 *Biloculina depressa* d'Orbigny var. *murrhyna* – Brady: p. 146, pl. 2, figs. 10, 11.

. 1932 *Pyrgo murrhina* – Cushman: part 1, pl. 15, fig. 1-3.

. 1960 *Pyrgo murrhyna* – Barker: p. 5, pl. 2, figs. 10, 11, 15 [cop. Brady, 1884].

. 1981 *Pyrgo murrhyna* – Resig: p. 655, pl. 5, fig. 9.

. 1991 *Pyrgo murrhina* – van Marle: p. 277, pl. 3, fig. 3.

. 1992 *Pyrgo myrrhina* – Kato: p. 389, pl. 1, fig. 7a-b.

. 1994 *Pyrgo murrhina* – Loeblich & Tappan: p. 328, pl. 91, figs. 11-15.

. 2005 *Pyrgo murrhina* – Murgese & De Deckker: p. 39, fig. 4, fr. 9, 10.

Diagnosis. Test globular to ovoid and rimmed by distinct carinate periphery. The chamber is thickest at the central part of both symmetrical sides. The aperture, located at the end of a short protruding neck, is a circular or oval opening with a distinct tooth plate. Surface very smooth and bright white in colour. The basal peripheral keel is depressed. Test robust.

Remarks. Only found in deep stations in water depths between 918 and 2092 m off Peru and Ecuador.

Distribution. Recent, off west coast from Central America (Bandy & Arnal, 1957); recent, N-Pacific, S-Atlantic (Barker, 1960 [cop. Brady, 1884]); recent, Sahul Sea (Loeblich & Tappan, 1994; Rathburn & Corliss, 1994); recent, NW Indian Ocean (Hermelin & Shimmield, 1990), Neogene and Quaternary, southern South China Sea (Hess & Kuhnt, 2005); recent, off Concepciòn, central-southern Chile (Tapia et al, 2008); recent, off Peru (Resig, 1981, 1990); recent, off Peru and Chile (Ingle et al., 1980); recent, Mid-Atlantic Ridge (Hooper et al., 1977); recent, off NW-Africa (Lutze & Coulbourn, 1983/84); recent, eastern Indian Ocean (Murgese & De Deckker, 2008); sub-recent, Okhotsk Sea (Bubenshchikova et al, 2010); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); Late Cenozoic of Eastern Indonesia (van Marle, 1991); Miocene to Pliocene, Japan Sea (Kato, 1992).

Size: 291-747 mm.

Quinqueloculina seminula Linné 1758

(Pl. 1, fig. 14)

* 1758 *Serpula seminulum* – Linné: pl. 2, fig. 1a-c.

. 1884 *Miliolina seminulum* – Brady: p. 157, pl. 5, fig. 6a-c.

. 1899 *Miliolina seminulum* – Flint: pl. 43, fig. 2.

. 1921 *Quinqueloculina seminulum* – Cushman: p. 416, pl. 88, figs. 4a-c.

. 1935 *Quinqueloculina seminulum* – Keijzer: p. 116, fig. 16a-f.

1970 *Quinqueloculina seminulum* – Boltovskoy & Theyer: pl. 4, fig. 18.

. 1991 *Quinqueloculina seminulum* – van Marle: p. 277, pl. 3, figs. 11-13.

. 1994 *Quinqueloculina seminulum* – Jones: pl. 5, fig. 6 [cop. Brady, 1884].

. 2009 *Quinqueloculina seminulum* – Frezza & Carboni: p. 55, Pl. 1, figs. 10, 11

Diagnosis. Test stout, robust, medium to large and oval in shape. Chambers inflated and of constant diameter, increasing gradually in size as added. From one side are four chambers visible, whereas three from the other. Sutures distinct and depressed. Aperture terminal with a tooth plate and surrounded by a lip. Surface smooth, opaque, bright white.

Remarks. The shape of the specimens found in this study varies from slender to broadly rounded.

It was found in water depths between 697 and 2092 m off Peru and Ecuador.

Distribution. Late Cenozoic of Eastern Indonesia (van Marle, 1991); Recent, Philippine and adjacent seas (Cushman, 1921); recent, off Skye, N-Atlantic and off NW-Ireland, Atlantic (Jones, 1994 [cop. Brady, 1884]); recent, Northern Tyrrhenian Sea, Italy (Frezza & Carboni, 2009).

Size: 374-664 µm.

Triloculina trigonula **Lamarck 1804**

* 1804 *Miliolites trigonula* – Lamarck: pl. 17 (15), fig. 4.

. 1899 *Miliolina trigonula* – Flint: pl. 44, fig. 3.

. 1994 *Triloculina trigonula* – Jones: pl. 3, figs. 15-16 [cop. Brady, 1884].

Diagnosis. A medium to large, stout species. Test consisting of three moderately inflated chambers. Both ends slightly tapered. Periphery sub-rounded. Aperture is a large terminal, arched opening at the apical part of the last chamber. Surface smooth.

Remarks. Rare, only two dead specimens were found in the 968 cm sediment depth interval of station SO-147-106KL off Peru.

Distribution. Recent, NW of Ireland and off Sky, North Atlantic (Jones, 1994 [cop. Brady, 1884]).

Size: 440 µm.

Order LAGENIDA

(Lankester, 1885)

Dentalina filiformis d'Orbigny 1826

* 1826 *Nodosaria filiformis alveoliniformis* – d'Orbigny: [type figure not given].

. 1899 *Nodosaria filiformis* – Flint: pl. 55, fig. 6.

. 1991 *Dentalina filiformis* – van Marle: p. 273, pl. 1, fig. 14.

. 1994 *Dentalina filiformis* – Jones: Pl. 63, figs. 3-5 [cop. Brady, 1884].

Diagnosis. A very long, curved, uniserial species. The test consists of numerous elliptical chambers which growing gradually in size as added. Both ends tapered. Sutures are distinct and depressed. Aperture is terminal. The tapered apertural neck-like end is gashed. Surface very smooth, shiny, translucent with greyish or whitish hue.

Remarks. The specimens found in this study correspond most with these displayed in Jones (1994 [cop. Brady, 1884]).

A very rare species. It was found at one station off Ecuador in 207 m water depth (1°57'S/81°7'W).

Distribution. Recent, off Bermuda and Prince Edward Island, S-Pacific (Jones, 1994 [cop. Brady, 1884]); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

Length: 1121-1577 µm.

Fissurina annectens **Burrows & Holland 1895**

* 1895 *Lagena annectens* – Burrows & Holland: pl. 7, fig. 11a-b [in T. R. Jones, 1895].

. 1994 *Fissurina annectens* – Jones: Pl. 59, figs. 7, 15 [cop. Brady, 1884].

Diagnosis. A small to medium sized *Fissurina*. Test single-chambered, ovate, slightly compressed, often with a distinct carinate periphery, entirely surrounding the test. The apertural side elongated to a flattened neck with a small terminal opening as the aperture. The basal end rounded and slightly notched, rarely with a basal spine. Surface very smooth and transparent.

Remarks. This species resembles *Fissurina submarginata* (Boomgaart) but differs from it by the ovate shape, whereas *F. submarginata* has a cyclic shape. Furthermore this species is not always carinate.

A rare species in the study area. It was found between 697 and 1105 m water depth off Peru.

Distribution. Pliocene, Suffolk, England (Burrows & Holand, 1895); recent, S-Atlantic and Kerguelen Island, S-Pacific (Jones, 1994 [cop. Brady, 1884]).

Diameter: 291-830 µm.

***Fissurina orbignyana* var. *baccata* Heron-Allen & Earland 1922**

* 1922 *Fissurina orbignyana* Seguenza var. *baccata* – Heron-Allen & Earland: pl. 6, figs. 15-16.

. 1994 *Fissurina baccata* – Jones: Pl. 59, fig. 20 [cop. Brady, 1884].

Diagnosis. Test very small, cyclic in shape, globular but slightly compressed. Periphery slightly carinated, but often broken. Aperture prominent, fissurine.

Remarks. A rare species in this study. Only found at one station off northern Peru (9°17'S/79°53'W) in a water depth of 1105 m. This species shows a variable outline regarding the carinate structure of its test. The carina is very thin and thus fragile, resulting in variable shapes of broken carinae.

Distribution. Recent , type locality not given (Heron-Allen & Earland, 1922).

Diameter: 191-208 µm.

***Fissurina* sp.**

(Pl. 1, fig. 15)

Holotype. One living specimen from 0-3 mm sediment depth at station M77/2-767/MUC-64 off Ecuador (Datum: 14th December 2008; Coordinates: 1°53.49'S, 81°11.75'W; 525 m water depth).

Paratypes. No paratypes have been found in this study.

Diagnosis. Test is small, consisting of a single sphaerical chamber without a keel and no surficial ornamentations. The aperture is a short and narrow elliptical opening and tapered at both ends. Two tooth plates protruding from the deeper inner margin of the aperture. Surface is smooth, glassy and translucent.

Discrimination from other species. *Fissurina* sp. resembles *Fissurina paula* (McCulloch, 1977) but differs from it in being more inflated and by the absence of the alternating opaque-non-opaque areas of the test, described by the principal author. It differs from all other species of *Fissurina* reported in Ellis and Messina online catalogues (1942-2006) by its strongly inflated, nearly sphaerical chamber, the low aperture and the absence of any ornamentation. The apertural end of *F. agassizi* (Todd & Brönnimann, 1957) in comparison with that of *Fissurina* sp. is more tapered, the apertural opening is much more elongated and the chamber is ellipsoid. The test of *F. balteata* (McCulloch, 1977), which firstly has been described from a recent assemblages collected from near the Galapagos Islands and off California, also consists of a sphaerical chamber but possesses a distinct marginal keel and an elongated apertural end. *F. britannica* (Jones, 1984) shows also a circular outline and a short but narrow aperture but the test is distinctively compressed.

Length: 116-199 µm.

Fissurina submarginata **Boomgart 1949**

. 1784 *Serpula (Lagena) marginata* – Walker & Boys: p. 2, pl. 1, fig. 7 [non-Linnean, invalid].

1803 *Vermiculum marginatum* – Montagu: not given [i.e. Walker & Boys, 1784]

* 1949 *Entosolenia submarginata* – Boomgaart: [i.e. Walker & Boys, 1784]

. 1994 *Fissurina submarginata* – Jones: Pl. 59, figs. 21-22 [cop. Brady, 1884].

Diagnosis. A small to medium sized, globular but slightly compressed *Fissurina*. Chamber has a cyclic shape and a carinate periphery which is not distinctly developed at all species. The basal part of the keel is very slightly notched. Aperture a short fissurine one. Surface very smooth and translucent.

Remarks. This species differs from *F. annectens* (Burrows & Holland) in its cyclic shape, whereas *F. annectens* has an ovate chamber. Very rare in this study. It was found at two stations off Peru in 526 and 1105 m water depth.

Distribution. Recent, north of Juan Fernandez, E-Pacific (Jones, 1994 [cop. Brady, 1884]).

Diameter: 274-498 µm.

Lagena gracillima **Seguenza 1862**

* 1862 *Amphorina gracillima* – Seguenza: p. 51, pl. 1, fig. 37.

. 1899 *Lagena gracillima* - Flint: pl. 53, fig. 3.

. 1960 *Lagena gracillima* – Barker: p. 115, pl. 56, figs. 19-26 [cop. Brady, 1884].

. 1970 *Lagena gracillima* – Boltovskoy & Theyer: pl. 3, fig. 21.

1992 *Lagena sulcata* – Hodgkinson: p. 51. pl. 1, fig. 22.

. 1994 *Hyalinonetrion distomapolitum* Parker & Jones – Loeblich & Tappan: p. 374, pl. 137, figs. 10-12.

Diagnosis. A very slender species with both ends developed to elongated necks. Round in cross section. Broadest at the middle of the test, tapering symmetrically to both ends. Surface very smooth and translucent, no ornamentations.

Remarks. This species is variable in morphology. The ratio of length to width ranges between different specimens. A rare species with low abundances. It was found at stations between 525 and 2092 m water depth.

Distribution. Recent, S Pacific (Barker, 1960 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994); recent, off Central Chile (Boltovskoy & Theyer, 1970); Pliocene to recent, Chile Triple Junction, southeastern Pacific (Schönfeld & Spiegler, 1995); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008).

Length:440-623 µm.

Lagena hispidula **Cushman 1913**

* 1913 *Lagena hispidula* – Cushman: pl. 5, figs. 2, 3.

Diagnosis. A small to medium sized, stout *Lagena*. Test consists of an ovate chamber, sometimes a bit elongated, basal end rounded. The apertural end is a tubular neck, with a terminal opening. The whole surface, including the neck is apiculated by short, densely distributed knops.

Remarks. A very rare species in this study. It was found at three stations off Peru in water depths between 995 and 1004 m.

Distribution. Recent, NW-Pacific (Cushman, 1913).

Diameter (chamber only): 249-540, total length with neck: 349-913 µm.

Lagena laevis Montagu 1803

.*1803 *Vermiculum laeve* – Montagu: p. 52.4 [cit. apud Brady, 1884]

. 1933 *Lagena laevis* – Cushman: pl. 4, fig. 5a-b.

. 1960 *Lagena laevis* – Barker: p. 115 pl. 56, figs. 7-9 [cop. Brady, 1884].

. 1970 *Lagena laevis* – Boltovskoy & Theyer: pl. 3, fig. 22.

. 1971 *Lagena laevis* – Murray: p. 82, pl. 32, figs. 6, 7.

. 1992 *Lagena laevis* – Kato: p. 389, pl. 1, fig. 10.

1994 *Reussoolina laevis* – Loeblich & Tappan: p. 381, pl. 144, figs. 13, 14.

Diagnosis. A small rounded *Lagena* with a long neck. The chamber is sphaerical or slightly elongated without any ornamentations. Surface is somewhat rough. Greyish hue and transparent but not translucent.

Remarks. This species was found at stations between 492 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, Falkland Islands, S-Atlantic; Torres Strait, Pacific (Barker, 1960 [cop. Brady 1884]); recent, tropical Central Pacific (Cushman, 1933); recent, North Sea (Murray, 1971); recent, off W-Coast of Central America (Bandy & Arnal, 1957); recent, off Central Chile (Boltovskoy & Theyer, 1970); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, eastern Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic of Eastern Indonesia (van Marle, 1991); Miocene to Pliocene, Japan Sea (Kato, 1992).

Diameter (chamber only): 158-208, total length with neck: 208-291 µm.

Lagena substriata **Williamson 1848**

* 1848 *Lagena substriata* – Williamson: p. 15, pl. 2, fig. 12.

. 1994 *Lagena substriata* – Loeblich & Tappan: p. 375, pl. 138, figs. 1-5.

. 2003 *Lagena substriata* – Murray: p. 18, fig. 5.7.

Diagnosis. Test small, consisting an ovate chamber with a rounded base. The upper part merging into a tubular neck. The surface is completely covered by closely parallel running, longitudinal costae which running even upwards to the terminal end of the neck. The number of costae deceases at the transition from the chamber to the neck, where some costae are braking up.

Remarks. A rare species in this study. Only one specimen from one station off Peru at 1923 m water depth.

Distribution. Recent, off Great Britain (Williamson, 1848); recent, west of Scotland (Murray, 2003); recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 332 µm.

Lagena sulcata Walker & Jacob 1789

* 1789 *Serpula (Lagena) sulcata* – Walker & Jacob:

. 1913 *Lagena sulcata* – Cushman: p. 22, pl. 9, fig. 2.

. 1991 *Lagena sulcata* – van Marle: p. 275, pl. 2, fig. 10.

. 1994 *Lagena sulcata* – Jones: pl. 57, figs. 23, 25-27, 33-34 [cop. Brady, 1884].

Diagnosis. A small, globular, single-chambered species. Test consists of a sphaerical chamber with strong longitudinal costae, running from a crest, near the base, to the transition between chamber and neck. The neck is variable in morphology and can be short or long but is always ornamented. Surface smooth, transparent and finely perforated.

Remarks. A rare species in this study. Only found at one station off Peru (10°53'S/78°46'W) in a water depth of 1923 m. The globular chamber with its strong longitudinal costae is readily to distinguish from other species. The species here has a short neck and corresponds with Brady's figure 34 (pl. 57, in Jones 1994 [cop. Brady, 1884]).

Distribution. Recent, Kerguelen Island, off Ki Islands and north of Papua (Jones, 1994 [cop. Brady, 1884]); Late Cenozoic of Eastern Indonesia (van Marle, 1991); recent, N-Pacific Ocean (Cushman, 1913).

Diameter: 191 µm.

Lagenosolenia inflatiperforata McCulloch 1977

* 1977 *Lagenosolenia inflatiperforata* – McCulloch: pl. 64, fig. 28a-b.

. 1994 *Lagenosolenia inflatiperforata* – Loeblich & Tappan: p. 396, Pl. 159, figs. 1-11.

Diagnosis. A minute fissuriniform species. Test inflated, just slightly compressed, ovate in shape and slightly carinate, especially the basal part of the test. Aperture fissurine. Surface smooth but perforated by evenly distributed pores.

Remarks. This species was found at one station off Peru (3°51'S/81°15'W) in 700 m water depth.

Distribution. Recent, off California, Mexico, Pacific Ocean (McCulloch, 1977); recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 191 µm.

Lenticulina convergens Bornemann 1855

p*1855 *Cristellaria convergens* – Bornemann: pl. 13, fig. 16 [not fig. 17].

. 1960 *Lenticulina convergens* – Barker: p. 145, pl. 69, figs. 6, 7 [cop. Brady, 1884].

Diagnosis. A small to medium sized *Lenticulina*. Biconvex. Aperture is very small opening at the end of a short neck with radial incisions; located at the apical upper end of the last chamber. An additional vertical slit on the face of the last chamber. Periphery of the first few chambers possesses a distinct keel. This keel becomes indistinct at the younger chambers. Test surface very smooth and translucent. Very finely perforated.

Remarks. A rare species in this study. Found at three stations off Peru and Ecuador between 207 and 823 m water depth.

Distribution. Oligocene, near Berlin, Germany (Bornemann, 1855); recent, North Pacific, north of Juan Fernandez (Barker, 1960 [cop. Brady, 1884]); recent, Peru-Chile trench area (Ingle et al. 1980).

Diameter: 332-357 µm.

Lenticulina gibba **d'Oorbigny 1839**

* 1839a *Cristellaria gibba* – d'Orbigny: pl. 7, figs. 20-21.

. 1884 *Cristellaria gibba* – Brady: p. 546, pl. 69, figs. 8-9.

. 1899 *Cristellaria gibba* – Flint: pl. 64, fig. 1.

. 1933 *Robulus gibbus* – Cushman: p. 6, pl. 2, figs. 2, 6-7.

. 1960 *Lenticulina gibba* – Barker: p. 144, pl. 69, figs. 8-9 [cop. Brady, 1884].

. 1991 *Lenticulina gibba* – van Marle: p. 273, pl. 1, fig. 1.

. 1994 *Lenticulina gibba* – Jones: pl. 69, figs. 8-9 [cop. Brady, 1884].

Diagnosis. Small to medium in size. Test involute, biconvex, bilateral-symmetric, periphery acute, maybe slightly carinated. Chambers high, just slightly inflated, increasing rapidly in size. Sutures distinct but not appreciably depressed, slightly curved backwards. Test rounded, tapered to the upper, apical end of the last chamber. Aperture terminal on a notched, tapered protrusion on the upper apical side of the last chamber. Surface very smooth slightly transparent with a whitish hue and very finely perforated.

Remarks. Very rare in this study. One single specimen was found at one station off Peru from 526 m water depth.

Distribution. Recent, West Indies (Jones, 1994 and Barker, 1960 [both cop. Brady, 1884]); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

Diameter: 332 µm.

Lenticulina pliocaena **Silvestri 1898**

(Pl. 2, fig. 1)

* 1898 *Polymorphina pliocaena* – Silvestri: pl. 4, fig. 3a-c.

. 1960 *Robulus pliocaenicus* – Barker: pl. 69, fig. 5 [cop. Brady, 1884].

. 1994 *Lenticulina pliocaena* – Jones: pl. 69, fig. 5 [cop. Brady, 1884].

Diagnosis. Test minute, consisting and stout, consisting of few indistinct chambers, from which the one is globular and making up more than 75% of the test. The globular chamber has a basal spine. Sutures indistinct. Periphery carinate. A keel running down the whole dorsal side and two strong costae running down on the ventral side of the test, like it is shown by the type figures from the principal author. The apertural end is elongated and tapered and bears the terminal aperture. Surface smooth, transparent, white.

Remarks. Very rare in this study. Only found at one station off Ecuador (1°45'S/81°7'W) in 207 m water depth.

Distribution. Pliocene, Province of Siena, Italy (Silvestri, 1898); recent, southwest of Ireland, Atlantic (Barker, 1960 [cop. Brady, 1884]).

Diameter (with basal spine): 212 µm.

Oolina apiculata Reuss 1851

* 1851 *Oolina apiculata* – Reuss: pl. 2, fig. 1.

Diagnosis. A small, stout, single-chambered species. Test consists of one ovate chamber with its broadest part near the base. It possesses a strong basal spine. The apertural part is tapered and merged in a neck with the terminal aperture. Surface very smooth, shiny and transparent.

Remarks. Very rare in this study. Only found at one station off Peru in 1004 water depth.

Distribution. Upper Cretaceous, Poland (Reuss, 1851).

Length (with spine): 490 µm.

Parafissurina lateralis Cushman 1913

* 1913 *Lagena lateralis* – Cushman: p. 9, pl. 1, fig. 1.

. 1994 *Parafissurina lateralis* – Loeblich & Tappan: p. 401, pl. 164, figs. 1-10.

Diagnosis. A small species, consisting of a somewhat elongated, ovate, inflated chamber. Broadest at the basal part. Slightly tapered to the apertural end. “Aperture lateral, at one side below the apex, elongate, elliptical with lip-like margins, with a long entosolenian neck more than half the length of the test, flaring at its inner end” (Cushman, 1913).

Remarks. Very rare in this study. This species was found at one station in 1004 m water depth off Peru (10°59’S/78°31’W).

Distribution. Recent, off Yokohama, Japan (Cushman, 1913); recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 191 µm.

Robulus thalmanni **Hessland 1943**

. 1804 *Lenticulites rotulata* – Lamarck: pl. 62 (14), fig. 11.

. 1884 *Cristellaria rotulata* – Brady: pl. 69, fig. 13.

* 1943 *Robulus thalmanni* – Hessland: pl. 2, fig. 16a-b.

. 1960 *Robulus thalmanni* – Barker: p. 145, pl. 69, fig. 13 [cop. Brady, 1884].

. 1994 *Lenticulina thalmanni* – Jones: pl. 69, fig. 13 [cop. Brady, 1884].

Diagnosis. A medium to large, robust, cyclic species. Test bilateral-symmetric, consisting of numerous high but narrow chambers, broadest at the umbilical part, resulting in biconvex shape from edge view. Chambers barely increasing in size as added. Periphery rounded and carinate. Sutures distinct but even and very slightly curved backwards. Aperture typical lenticuline; terminal at the upper apical point of the last chamber on a small tapered, coniform and notched projection. Surface very smooth, shiny and slightly transparent.

Remarks. Very rare in this study. A single specimen was found at 1004 m water depth off Peru (10°59'S/78°31'W).

Distribution. Late Cretaceous, near Paris (Lamarck, 1804); recent, West Indies (Jones, 1994 [cop. Brady, 1884]); Pleistocene to recent, near Göteborg, Sweden (Hessland, 1943).

Diameter: 1664 µm.

Saracenaria stolidota Loeblich & Tappan 1994

* 1994 *Saracenaria stolidota* – Loeblich & Tappan: p.361, pl. 124, figs. 12, 13.

Diagnosis. A large, robust species. Test shape is elongated, bended and tricarinate with both ends tapered, whereas the basal end is spinose. Cross section is a concave triangle. Test consists of numerous compressed, very low but broad chambers which just slowly increasing in size as added. Sutures distinct and depressed, curving downwards to the periphery. Aperture notched, terminal, typical for *Lenticulinae*. Surface very smooth. Wall thick but slightly transparent

Remarks. Very rare in this study. Only found at one station off Peru (11°S/78°25'W) in a water depth of 697 m.

Distribution. Recent, Timor Sea (Loeblich & Tappan, 1994).

Length: 2739 µm.

Vaginulina americana Cushman 1923

* 1923 *Vaginulina americana* – Cushman: pl. 38, figs. 3-4.

. 1967 *Vaginulina americana* – Seiglie: p. 125, fig. 42.

Diagnosis. A large, elongated, uniserial species. Test consisting of numerous distinct chambers. The initial chamber is large and globular, usually broader than the few following chambers, which are low and compressed and increase slowly in size as added. This compressed portion merges in a chain of almost globular, inflated chambers, whereas the globular character increases to the apertural end. The apical end of final chamber is merging in a broad, tapered neck with its terminal opening. The whole test is covered by few distinct, longitudinal costae. Sutures distinct and depressed, especially at the globular-chambered portion of the test. The test is bended and stout at its initial end and tapered at its apertural end. Surface very smooth, shiny and transparent, white. Wall is thick and robust.

Remarks. A very rare species in this study. It was found at one station in 207 m water depth off Ecuador (1°57'S/81°07'W).

Distribution. Recent, off the coast of Florida, (Cushman, 1923); recent, off Venezuela (Seiglie, 1967).

Length: 789-2864 µm.

Order ROBERTINIDA

(Mikhalevich, 1980)

Epistominella exigua Brady 1884

* 1884 *Pulvinulina exigua* – Brady: p. 696, pl. 103, figs. 13, 14.

. 1960 *Epistominella exigua* – Barker: p. 213, pl. 103, figs. 13, 14 [cop. Brady, 1884].

. 1965 *Epistominella exigua* – Todd: pl. 10, fig. 1a-c.

. 1980 *Epistominella exigua* – Ingle et al.: p. 135, pl. 2, fig. 4.

. 1981 *Epistominella exigua* – Resig: p. 657, pl. 6, figs. 6, 7.

. 1988 *Pseudoparella exigua* – Whittaker: p. 126, pl. 17, figs. 4-9.

. 1990 *Pseudoparella exigua* – Resig: p. 294, pl. 3, fig. 2.

. 1991 *Epistominella exigua* – van Marle: p. 301, pl. 15, figs. 4-6.

. 1994 *Pseudoparella exigua* – Loeblich & Tappan: p. 544, pl. 307, figs. 1-7.

. 2001 *Epistominella exigua* – Schumacher: p. 147, pl. 7, figs. 11-13.

. 2005 *Epistominella exigua* – Heinz et al.: p. 83, text fig. 6g-h.

. 2008 *Epistominella exigua* – Lobegeier & Sen Gupta: p. 104, pl. 1, fig. 18a-b.

Diagnosis. A small rounded, trochospiral species. Five rather inflated, nearly globular chambers visible on the involute umbilical side. Numerous chambers visible from the evolute spiral side. Usually three whorls are visible on the spiral side. The chambers of the first two whorls appear not inflated. Sutures straight and distinct; on the umbilical side even depressed. Aperture is an almost vertical slit in a depression on the face of the last chamber. Test transparent and densely perforated by very fine pores.

Remarks. From edge view this species is variable in thickness. Specimens were found off Peru and Ecuador in water depths between 79 and 995 m.

Distribution. Recent, South Atlantic and Southern Ocean (Barker, 1960 [cop. Brady, 1884]); recent, tropical Pacific (Todd, 1965); Cenozoic of Ecuador (Whittaker, 1988); recent, off Peru (Resig, 1981; 1990); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, Peru-Chile Trench area (Ingle et al., 1980); recent,Timor Sea (Loeblich & Tappan, 1994); recent, Rio de la Plata area, Brazil (Boltovskoy, 1976); recent, Cascadia convergent margin, NE Pacific (Heinz et al. 2005); recent, eastern Indian Ocean (Murgese & Deckker, 2005); Late Quaternary, South China Sea (Jian & Wang, 1997; Jian et al., 1999); Neogene and Quaternary, southern South China Sea (Hess & Kuhnt, 2005); recent, Sagami Bay, Japan (Kitazato et al., 2000); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, off Louisiana, U.S.A. (Schroeder, 2007); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); living, off Cape Blanc, NW-Africa (Jorissen et al., 1998); recent, off NW Africa (Lutze & Coulbourn, 1983/84); recent, South Atlantic (Schumacher, 2001); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 208-291 µm.

Epistominella obesa **Bandy & Arnal 1957**

* 1957 *Epistominella obesa* – Bandy & Arnal: pl. 7, fig. 8.a-c.

. 1964 *Epistominella obesa* – Phleger: pl. 2, figs. 26, 27.

. 1981 *Epistominella obesa* – Resig: p. 651, pl. 3, figs. 1, 2.

Diagnosis. A small, obese *Epistominella* with eight to nine chambers visible on the umbilical side. Umbilical side involute and strongly convex, spiral side evolute and less convex. Spiral side shows two or three volutions. Chambers just moderately inflated and narrow. Sutures straight or slightly curved, distinct and somewhat depressed on both sides. Aperture is a vertical, slightly curved slit on the face of the last chamber. Test smooth, finely perforated and translucent.

Remarks. This species was commonly found between 248 and 823 m off Peru.

Distribution. Recent, off west coast of Central America (Bandy & Arnal, 1957); recent, Gulf of California (Phleger, 1964); recent, off Peru (Resig, 1981; 1990).

Diameter: 166-249 µm.

Epistominella pacifica **Cushman 1927**

(Pl. 2, figs. 2-3)

* 1927 *Pulvinulinella pacifica* – Cushman: p. 165, pl. 5, figs. 14-15.

. 1988 *Epistominella pacifica* – Whittaker: p. 126, pl.17, figs. 1-3.

. 1995 *Epistominella pacifica* – Schönfeld & Spiegler: p. 221, pl. 2, figs. 8, 9.

. 2005 *Epistominella pacifica* – Narayan et al.: p. 149, pl. 5, figs. 2-4.

Diagnosis. A small to medium sized, plano-convex species. Round to ovate in lateral view. Periphery slightly carinate. Evolute spiral side shows five to six chambers in the last whorl. Sutures distinct on both sides. The sutures on the spiral side curved backwards and slightly raised, but are straight or just slightly curved and depressed on the umbilical side. Umbilicus depressed. The aperture is a slit-like opening, nearly parallel to the periphery, located on the face of the last chamber.

Remarks. This species was found at stations between 207 and 1105 m water depth off Peru and Ecuador.

Distribution. Recent, off W coast of U.S.A. (Cushman, 1927); Cenozoic of Ecuador (Whittaker, 1988); recent, off Concepción, Chile (Tapia et al., 2008); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, Chile Triple Junction, southeastern Pacific (Schönfeld & Spiegler); living, Okhotsk Sea (Bubenshchikova et al., 2010); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005); recent, off California (Bandy et al., 1965).

Diameter: 149-291 µm.

Hoeglundina elegans **d'Orbigny 1826**

* 1826 *Rotalia (Turbinuline) elegans* – d'Orbigny: [type figure not given]

. 1931 *Epistomina elegans* – Cushman: p. 65, pl. 13, fig. 6a-c.

. 1965 *Hoeglundina elegans* – Todd: pl. 23, fig. 2a-c.

. 1979 *Hoeglundina elegans* – Corliss: p. 12, pl. 5, figs. 11-13.

. 1980 *Hoeglundina elegans* – Ingle et al.: p. 135, pl.2, fig. 11.

. 1988 *Hoeglundina elegans* – Whittaker: p. 108, pl. 14, figs. 17-19.

. 1990 *Hoeglundina elegans* – Hermelin & Shimmield: p. 13, pl. 2, figs. 3-4.

. 1991 *Hoeglundina elegans* – van Marle: p. 279, pl. 4, figs. 14-16.

. 1994 *Hoeglundina elegans* – Loeblich & Tappan: p. 411, pl. 174, figs. 1-6.

. 2008 *Hoeglundina elegans* – Lobegeier & Sen Gupta: p.106, pl. 2, figs. 6a-b.

Diagnosis. Medium to large sized biconvex species. Surface very smooth and shiny, sutures slightly curved and indistinct on the dorsal side, but straight on the umbilical side. The latero-marginal aperture is formed by a slit on the peripheral part of the last chamber, parallel to the curvature of the test.

Remarks. The carinate periphery described by Whittaker (1988) is not well pronounced at our specimens. This species was found at stations between 465 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, Peru-Chile Trench area (Ingle et al., 1980); Cenozoic of Ecuador (Whittaker, 1988); recent, tropical Pacific (Todd, 1965); living, NW Africa (Jorissen et al., 1998); SW-Pacific, off New Zealand (Martin et al., 2010); recent, off NW-Africa (Lutze & Coulbourn, 1983/84); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic of Eastern Indonesia (van Marle, 1991); recent, Atlantic Ocean (Cushman, 1931); recent SE Indian Ocean (Corliss, 1979).

Diameter: 291-1328 µm.

***Robertina oceanica* Cushman & Parker 1947**

(Pl. 2, fig. 4)

* 1947 *Robertina oceanica* – Cushman & Parker: p. 75, pl. 18, fig. 18.

. 1960 *Robertina Oceanica* – Barker: p. 103, pl. 50, fig. 19 [cop. Brady, 1884].

. 1994 *Robertinoides oceanicus* – Loeblich & Tappan: p. 413, Pl. 176, figs. 4-8.

Diagnosis. A small to medium sized, stout, biarpertural species. Test almost as broad as high, tapered to the initial end but not pointed, final end rounded. Numerous strongly inflated chambers, increasing rapidly in size as added. Four chambers visible at the apertural end. Sutures distinct and incised. Primary aperture a curved, vertical slit at the central base of the last chamber. Secondary aperture much shorter than the primary one and situated at the marginal base of the last chamber. Surface very smooth, shiny, translucent, very finely perforated.

Remarks. Found at only one station off southern Ecuador (3°57'S/81°19'W) in 995 m water depth.

Distribution. Recent, off North Cape, New Zealand (Cushman & Parker, 1947); recent, Timor Sea (Loeblich & Tappan, 1994); recent, Ki Islands, Central Pacific (Barker, 1960 [cop. Brady, 1884]).

Size: 266-349 µm.

Order BULIMINIDA

(Fursenko, 1958)

Angulogerina angulosa **Williamson 1858**

(Pl. 2, fig. 5)

* 1858 *Uvigerina angulosa* – Williamson: pl. 5, fig. 140.

. 1884 *Uvigerina angulosa* – Brady: p. 576, pl. 74, figs. 15-16.

. 1960 *Angulogerina angulosa* – Barker: p. 155, pl. 74, figs. 15, 16 [cop. Brady, 1884].

. 1960 *Angulogerina angulosa* – Uchio: pl. 7, fig. 18.

. 1970 *Angulogerian angulosa* – Boltovskoy & Theyer: pl. 1, fig. 3.

. 1971 *Trifarina angulosa* – Murray: p. 122, pl. 51, figs. 1-6.

. 1980 *Trifarina angulosa* – Ingle et al.: p. 137, pl. 3, figs. 1, 4.

. 1991 *Angulogerina angulosa* – van Marle: p. 285, pl. 7, figs. 6-7.

. 1994 *Angulogerina angulosa* – Loeblich & Tappan: p. 487, pl. 250, figs. 13-20.

. 2001 *Trifarina angulosa* – Schumacher: p. 145, pl. 6, figs. 9-10.

. 2005 *Trifarina angulosa* – Rasmussen: p. 89, Pl. 12, fig. 1.

Diagnosis. A robust, medium sized, triserial species. Chambers rather inflated or even globular, sutures distinct and depressed. The peripheral parts of the chambers are keeled by very distinct costae which run longitudinal from the aperture to the base. Smaller and narrower costae are running more or less longitudinally over the chambers but often break up. The terminal aperture with a toothplate is a round opening at the end of a neck on the apical part of the last chamber. The neck is rimmed by a lip. Surface smooth, whitish and very finely perforated, slightly translucent. The short basal end is more or less tapered. Overall shape is stout. Cross section tends to be tripartite because of the three prominent peripheral costae.

Remarks. This species occurs in different shapes. Some are elongated but thin, whereas others are short but broader. At most specimens the apertural neck is often destroyed. This species is usually smaller than *Angulogerina carinata* and differs from it in having several longitudinal costae.

This species was found between 302 and 823 m water depth off Peru (17-12°S).

Distribution. Recent, Sahul Shelf, Timor Sea (Loeblich & Tappan, 1994); Sulu Sea (Rathburn & Corliss, 1994); recent, off San Diego, California, U.S.A. (Uchio, 1960); recent, off Great Britain, North Sea (Murray, 1971); recent, Prince Edward Island, S-Pacific (Barker, 1960 [cop. Barker, 1884]); recent, off Peru and Chile (Ingle et al., 1980); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off NW-Africa (Lutze & Coulbourn, 1983/84); recent, S-Atlantic (Schumacher, 2001); sub-recent, Okhotsk Sea (Bubenshchikova et al., 2010); Plio-Pleistocene of the Kallithea Bay section, Rhodes, Greece (Rasmussen, 2005); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

Length: 249-564 µm.

Angulogerina carinata Cushman 1927

* 1927 *Angulogerina carinata* – Cushman: p. 159, pl. 4, fig. 3.

. 1960 *Angulogerina angulosa* – Barker: p. 155, pl. 74, fig. 18 [cop. Brady, 1884].

. 1960 *Angulogerina carinata* – Uchio: pl. 7, fig. 19.

. 1970 *Angulogerina carinata* – Boltovskoy & Theyer: pl. 1, fig. 4.

. 1980 *Trifarina carinata* – Ingle et al.: p. 137, pl. 3, figs. 2-3.

. 1981 *Angulogerina carinata* – Resig: p. 649, pl. 2, fig. 1.

. 1988 *Trifarina carinata* – Whittaker: p. 74, pl. 9, figs. 1, 2.

Diagnosis. A medium to large sized species. Chambers rather inflated. Sutures distinct. Periphery of the test longitudinal bordered by three distinct keels running from the aperture down to the base. In contrast to *Angulogerina angulosa* the fine costae on the face of the chambers are absent. Aperture terminal at the end of a neck. The neck is rimmed by lip. Surface smooth and translucent with a whitish hue. Test is tripartite in cross section.

Remarks. This species differs from *Angulogerina angulosa* by the absence of fine costae on the chambers. The tripartite shape in cross section is more emphasized than at *A. angulosa*.

This species was found between 298 and 2092 m water depth off Peru and Ecuador (17-1°45'S).

Distribution. Recent, north of Juan Fernandez Island, E-Pacific (Barker, 1960 [cop. Brady, 1884]); Cenozoic, Ecuador (Whittaker, 1988); recent, off San Diego, California, U.S.A.

(Uchio, 1960); recent, off Peru and Chile (Ingle et al., 1980); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off Peru (Resig, 1981); Late Holocene, west coast of India (Nigam et al, 2009).

Length: 232-830 µm.

Bolivina alata **Seguenza 1862**

(Pl. 2, fig. 6)

* 1862 *Valvulina alata* – Seguenza: p. 115, pl. 2, fig. 5.

. 1884 *Bolivina beyrichi* Reuss var. *alata* – Brady: p. 442, pl. 53, figs. 2-4.

. 1966 *Brizalina alata* – Belford: p. 24, pl. 1, figs. 1-2.

. 1980 *Bolivina alata* – Ingle et al.: p. 131, pl. 3, fig. 12.

. 1991 *Brizalina alata* – van Marle: p. 305, pl. 17, figs. 1-2.

Diagnosis. A medium sized biserial species. Size of chambers strongly increases with age, resulting in a somewhat conical shape with a tapered basal end. Periphery carinate. Sutures distinct. Chambers moderately inflated. Aperture is a broad slit-like opening on the apical side of the last chamber. Test smooth and transparent.

Remarks. In this study most specimens of *B. alata* are relatively small and have a serrate periphery. It was found in water depths between 207 and 679 m off Peru and Ecuador.

Distribution. Recent, Pacific (Arrou Island, N-Pacific; Philippines: Barker, 1960 [cop. Brady, 1884]); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, off Costa Rica and Nicaragua (Heinz et al., 2008); Late Cenozoic of Eastern Indonesia (van Marle, 1991);

recent, Peru-Chile Trench area (Ingle et al. 1980); Miocene and Pliocene, Papua and New Guinea (Belford, 1966).

Length: 332-772 µm.

***Bolivina alata* var. A**

Diagnosis. A flat, medium sized biserial species. Size of chambers strongly increases with age, resulting in a somewhat conical shape. Periphery carinate. Sutures distinct. Chambers moderately inflated. Aperture is a broad slit-like opening on the apical side of the last chamber. Test smooth and transparent.

Remarks. *Bolivina alata* var. A has the same chamber arrangement and morphology as the typical form but has no serrate periphery. It was found between 248 and 465 m water depths off Peru only at 11 and 12°S, where oxygen concentrations do not exceed 3.8 µmol/kg.

Length: 208-747 µm.

***Bolivina* cf. *boltovskoyi* Smith 1963**

* 1963 *Bolivina* (*Loxostomum*) *boltovskoyi* – Smith: pl. 31, figs. 9, 10.

Diagnosis. Test biserial, stout, small to medium in size, inflated, slightly tapered to initial end but not pointed. Chambers moderately inflated, increasing rapidly in size as added.

Chambers of the younger portion are low and broad but becoming higher with younger age and even higher than broad at the youngest part of the test. Sutures distinct and just very slightly incised. Periphery rounded. Aperture is a large and broad terminal slit with a surrounding lip. Surface smooth, transparent and densely but very finely perforated.

Remarks. The specimens of this study are twisted around their longitudinal axis and no basal spines protruding from the youngest chambers as described by the principal author but the overall shape with apertural structure and characteristic chamber arrangement corresponds with *B. boltovskoyi*.

In this study we found only three specimens at one station (11°S/78°19'S) off Peru in 465 m water depth.

Distribution. For *Bolivina boltovskoyi*: recent, Pacific Ocean, off Nicaragua (Smith, 1963).

Length: 457-581 µm.

Bolivina costata d'Orbigny 1839

(Pl. 2, fig. 7)

* 1839 *Bolivina costata* – d' Orbigny: pl. 8, figs. 8-9.

. 1981 *Bolivina costata* – Resig: p. 647, pl. 1, fig. 1.

Diagnosis. A small to medium sized, but stout species. Test consists of numerous, biserially arranged chambers. Periphery rounded, sometimes slightly tapered to the rounded initial end. Last formed chamber bluntly rounded. Chambers increasing slowly in size as added. Sutures distinct and more or less depressed. Surface covered by many, very strongly developed longitudinal costae, running from top to base, often slightly bended. Typically two very prominent longitudinal costae running parallel across the median part on both sides of the test. Aperture is a vertical opening on the face of the last chamber, bordered by a lip. Wall is robust and transparent and densely covered by rather large pores.

Remarks. A very common species in this study. It occurred between 79 and 1923 m water depth off Peru and Ecuador (17-1°57'S).

Distribution. Recent, off northern Chile (d'Orbigny, 1839); recent, off Peru (Resig, 1981).

Length: 125-747 µm.

Bolivina hantkeniana **Brady 1881**

* 1881 *Bolivina hantkeniana* – Brady: [type figure not given].

Diagnosis. A small, compressed and biserial species. Test consists of numerous low chambers, obliquely downward directed to the periphery, slightly convex from both sides. Chambers slightly inflated, increasing strongly in size as added, resulting in a triangular shape from side view with a tapered initial part and a broadly rounded apertural end. Periphery conspicuously keeled by thin, clear shell material. The fragile keel is not equally in width but notched. Sutures distinct and depressed. Aperture is a narrow slit at the top of the last chamber reaching almost down to the inner sutural end, running parallel to the narrow side of the test. Wall is smooth, translucent and very finely perforated.

Remarks. This species resembles *Bolivina alata* but differs from it in being smaller in size and the strongly increasing chambers, whereas B. alata has a more slender more elongated outline.

The species found in this study do not posses any longitudinal costae, like it has been described by the principal author for some of his specimen.

Distribution. Very rare in this study. It was found at one station off northern Peru (3°56'S/81°19'W) in 995 m water depth.

Length: 349-490 µm.

***Bolivina interjuncta* Cushman 1926**

(Pl. 2, fig. 8)

* 1926 *Bolivina costata* d'Orbigny var. *interjuncta* - Cushman: p. 41, pl. 6, fig. 3.

. 1970 *Bolivina interjuncta* – Boltovskoy & Theyer: p. 304, pl. 1, figs. 8, 9.

. 2005 *Bolivina interjuncta* – Figueroa et al.: text. fig. 6a-b.

Diagnosis. A medium to large sized robust *Bolivinid*. Test more elongated but more compressed than the typical species. Chambers biserially arranged, broader than high. Increasing in size as added and oriented obliquely downward. Surface smooth and translucent. Two very pronounced costae running vertical over the whole broad side of the test. Sutures distinct. Periphery distinctively keeled. Aperture is a simple slit at the apical side of the last chamber. Megalospheric individuals have a rounded base whereas the microspheric form shows a distinctively tapered base.

Remarks. A common species off Peru and Ecuador. It was found in water depths ranging from 207 to 2092 m.

Distribution. Pliocene of California (Cushman, 1926); recent, off southern Chile (Figueroa et al., 2005); recent, off central Chile (Boltovskoy & Theyer, 1970).

Length: 623-1129 µm.

Bolivina plicata **d'Orbigny 1839**

(Pl. 2, fig. 9)

p*1839 *Bolivina plicata* – d'Orbigny: p. 62, pl. 8, figs. 5-7 [non fig. 4].

. 1970 *Bolivina plicata* – Boltovskoy & Theyer: pl. 1, fig. 12.

. 1981 *Bolivina plicata* – Resig: p. 647, pl. 1, figs. 3, 4.

. 1988 *Bolivina plicata* – Whittaker: p. 84, pl. 10, figs. 1-3.

. 2006 *Bolivina plicata* – del Carmen Morales et al.: p. 12, text fig. 6 right.

Diagnosis. A medium to large sized *Bolivina*. Test rather inflated, oval or round in cross section. The two youngest chambers are more inflated and much bigger than the older ones. Older chambers are much broader than high and are covered by many very distinct longitudinal costae which run irregularly down the test. The two youngest chambers have no costae. The complete test is densely covered by big pores. Microspheric forms are tapered to the basal end whereas macrospheric forms have a blunted base. The aperture, located on the base of the last chamber, is a rather broad slit-like opening surrounded by a distinct lip which is bent outward. Test is translucent or sometimes transparent, depending from the pore density and the arrangement of costae.

Remarks. The initial part of the microspheric forms is usually twisted like it has been described by Whittaker (1988).

A common species in this study .It was found in water depths between 214 and 579 m off Peru (17-3°45'S).

Distribution. Recent, off Valparaiso, Chile (d'Orbigny, 1839); recent, off Peru (Resig, 1981, 1990; del Carmen Morales et al., 2006); Cenozoic of Ecuador (Whittaker, 1988); recent, off west coast of central America (Bandy & Arnal, 1957); recent, off west coast of South America (Boltovskoy, 1976); recent, off Concepción, southern-central Chile (Tapia et al., 2008).

Length: 498-855 µm.

***Bolivina* cf. *salvadorensis* Smith 1963**

* 1963 *Bolivina* (*Loxostomum*) *salvadorensis* – Smith: pl. 31, figs. 11, 12.

Diagnosis. Test biserial, small to medium in size, compressed and slender, tapered to initial end but bluntly rounded at the tip. Chambers increasing rapidly in size as added. Early chambers low and broad but becoming higher with age and finally higher than broad at the final part of the test. Sutures distinct and slightly incised. Aperture is a long slit running from the apical end to the inner marginal base of the last chamber. Aperture surrounded by a lip and with an internal tooth plate.

Remarks. The sutures of the specimen found in this study are not as broad as described by the principal author but more incised and the specimen is twisted around its longitudinal axis, but the overall shape and characteristic chamber arrangement corresponds with *B. salvadorensis*.

Very rare in this study. Only a single specimen from 465 m water depth off Peru (11°S/78°19'W) was identified.

Distribution. For *Bolivina salvadorensis*: recent, Pacific Ocean, off Nicaragua (Smith, 1963).

Length: 789 µm.

Bolivina seminuda Cushman 1911

(Pl. 2, fig. 10)

* 1911 *Bolivina seminuda* – Cushman: p. 34, pl. 55.

. 1963 *Bolivina seminuda* – Smith: pl. 29, figs. 1-7.

. 1980 *Bolivina seminuda* – Ingle et al.: p. 133, pl. 1, fig. 5.

. 1981 *Bolivina seminuda* – Resig: p. 655, pl. 5, fig. 14.

. 1990 *Bolivina seminuda* – Hermelin & Shimmield: p. 13, pl. 2, fig. 8.

. 2006 *Bolivina seminuda* – del Carmen Morales et al.: p. 12, text fig. 6 left.

Diagnosis. A small stout, non-costate *Bolivinida*. Test cylindrical and ovate in cross section. Both ends rounded, the basal end can be tapered. Chambers broader than high, biserially arranged and gradually increasing in size as added. Periphery smooth and distinctively perforated. Sutures distinct and just slightly depressed. Aperture is a loop shaped opening ranging from the apical part to the base of the last chamber; aperture surrounded by a lip. Surface smooth and transparent.

Remarks. The specimen shown in Uchio (1960, pl. 5, fig. 3) named as *Bolivina lowmani* (Phleger & Parker) appears to me as to be synonymous with *B. seminuda*.

This is the most common species in this study. It occurs in nearly all stations at water depths between 79 and 2092 m and at all determined latitudes (17-1°45'S).

Distribution. Recent, west coast of central America (Bandy & Arnal, 1957); recent, off Peru (Resig, 1981; del Carmen Morales et al., 2006); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, eastern Indian Ocean (Murgese & De Deckker, 2005).

Length: 125-623 µm.

***Bolivina serrata* Natland 1938**

* 1938 *Bolivina subadvena* Cushman var. *serrata* – Natland: pl. 5, figs. 8, 9.

. 1988 *Bolivina serrata* – Whittaker: p. 100, pl. 13, figs. 1-3.

Diagnosis. Test small, periphery acute and serrate. A more or less distinct and longitudinal keel is running down at the middle of the test. The marginal part of the chambers is strongly curved downwards. The proloculus is thicker than the next few chambers. Basal end at megalospheric individuals rounded, tapered at microspheric ones. Apertural end stump. Aperture is loop shaped on the apical part of the last chamber. Surface is perforated, smooth and transparent.

Remarks. The serrate character of some specimens in this study is just rudimentary developed as also the longitudinal keel. This may be due to mechanical disruption when samples were sieved. Another explanation is the synonymy *Bolivina subadvena* var. *serrata* (Natland) with *Bolivina subadvena* var. *acuminata* (Natland) as described by Natland (1946). The type photographs of variety *acuminata* show no serrate character and also the longitudinal keel is not developed as it is shown by the type figure of this variety. This species was found at water depths between 207 and 823 m off Peru.

Distribution. Recent, off California, U.S.A. (Natland, 1938); Cenozoic of Ecuador (Whittaker, 1988).

Length: 166-415 µm.

***Bolivina* cf. *spathulata* Williamson 1858**

* 1858 *Textularia variabilis* Williamson var. *spathulata* – Williamson: pl. 6, figs. 164-165.

. 1960 *Bolivina spathulata* – Barker: p. 107, pl. 52, figs. 20, 21 [cop. Brady, 1884].

. 1991 *Bolivina spathulata* – van Marle: p. 303, pl. 16, figs. 15-16.

. 1994 *Brizalina spathulata* – Jones: pl. 52, figs. 20-21 [cop. Brady, 1884].

Diagnosis. Test minute and depressed. Chambers biserially arranged, directed obliquely downwards (ca. 35-40°) in relation to longitudinal axis. Increasing gradually in size as added. Sutures distinct and slightly depressed. Periphery somewhat lobulate, slightly tapered. Aperture simple at the base of the marginal face of the last chamber. Surface smooth but densely perforated.

Remarks. A very rare species. Only found in the 483 cm sediment depth interval of the 184 m station So147-106KL, 12°S off Peru. This species resembles mostly *B. spathulata* by the chamber arrangement, the compressed outline and the apertural end of the test. But it differs from the type specimen in the straight growth of the chambers, whereas the chambers of Williamson's type figure are slightly down curved to the periphery and also his specimen appears to be more compressed and has a more acute marginal periphery.

Distribution (for *Bolivina spathulata* Williamson). Recent, Porcupine, west of Ireland (Jones, 1994 [cop. Barker, 1884]); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Length: 125 µm.

Bolivina spinescens **Cushman 1911**

* 1911 *Bolivina spinescens* – Cushman: pl. 47, fig. 76.

Diagnosis. Test medium in size, inflated, stout, and slightly tapered to its basal end. Cross section oval to rounded. Chambers inflated, younger chambers tending to become spinose at basal peripheries. Sutures distinct and depressed. Periphery lobate. Surface smooth, transparent and densely perforated

Remarks. Only found at one station off northern Peru (9°17'S/79°17'W). The spinose periphery of the chambers was just developed at one specimen.

Distribution. Not designated by the principal author, North Pacific? (Cushman, 1911).

Length: 432-623 µm.

Bolivina spissa **Cushman 1926**

(Pl. 2, fig. 11)

.*1926 *Bolivina subadvena* Cushman var. *spissa* – Cushman: pl. 6, figs. 6a-b.

. 1960 *Bolivina spissa* – Uchio: pl. 7, figs. 7, 8.

. 1964 *Bolivina spissa* – Phleger: p. 2, fig. 5.

. 1980 *Bolivina spissa* – Ingle et al.: p. 137, pl. 3, figs. 13-14.

. 1981 *Bolivina spissa* – Resig: p. 647, pl. 1, fig. 7.

. 1988 *Brizalina spissa* – Whittaker: p. 90, pl. 11, figs. 17-20.

. 1992 *Bolivina spissa* – Kato: p. 389, pl. 1, fig. 16a-b.

. 2005 *Bolivina spissa* – Heinz et al.: p. 82, text figs. 5f-g.

Diagnosis. A small to medium sized bolivinid with acute periphery. Test not inflated. Chambers distinctively curved downward at the periphery. Surface smooth, transparent and finely perforated. Aperture is a loop shaped opening at the subterminal end of the last chamber. Some very fine longitudinal costae running across the initial end of the test, encompassing the proloculus and the first two to four pairs of chambers.

Remarks. The majority of the specimens of this study are megalospheric. At many specimens the basal spine is not developed or broken. This species was found between 114 and 1004 m water depth off Peru.

Distribution. Pliocene of Timms Point, Santa Barbara, California, U.S.A. (Cushman, 1926); recent, off west coast of central America (Bandy & Arnal, 1957); Cenozoic of Ecuador (Whittaker, 1988); recent, Peru-Chile trench area (Ingle et al., 1980); recent, off Peru (Resig, 1981); recent, off Concepción, central-southern Chile (Tapia et al., 2008); recent, off San Diego (Uchio, 1960); Hyperion outfall, Santa Monica Shelf, California, U.S.A. (Bandy et al., 1965); recent, Gulf of California (Phleger, 1964); living, southern California margin (Shepherd et al., 2007); recent, living, Okhotsk Sea (Bubenshchikova et al., 2008, 2010); recent, Cascadia convergent margin, NE Pacific (Heinz et al., 2005); recent, Sagami Bay, Japan (Kitazato et al., 2000); Miocene to Pliocene, Japan Sea (Kato, 1992).

Length: 208-664 µm.

***Bolivina subadvena* Cushman 1926**

* 1926 *Bolivina subadvena* – Cushman: pl. 6, fig. 6.

Diagnosis. Test biserial, stout, elongated and small to medium in size. Chambers inflated, much broader than high and curve downwards to the periphery. The few early pairs of chambers growing very slowly in size, whereas the two or three last pairs increasing strongly in size as added. Basal end bluntly rounded, apertural end rounded but slightly tapered. Sutures distinct but only depressed at the younger part of the test. Aperture is a vertical, loop-shaped opening reaching from the apical part to the base of the last chamber, surrounded by an indistinct lip. Surface transparent, smooth but covered by rather big, densely distributed pores.

Remarks. Very rare in this study. Found only at one station off Ecuador (1°S/81°W) in 525 m water depth.

Distribution. Pliocene, Santa Barbara, California, U.S.A. (Cushman, 1927).

Length: 697 µm.

Bolivina subaenariensis **Cushman 1922**

* 1922 *Bolivina subaenariensis* – Cushman: p. 46, pl. 7, fig. 6.

. 1988 *Brizalina subaenariensis* – Whittaker: p. 90, pl. 11, figs. 7-9.

Diagnosis. A medium to large sized, very compressed and costate *Bolivina*. Periphery carinate, tapered to the initial end, more rounded at the apertural end. Numerous broad but low chambers biserially arranged, increasing slowly in size as added and strongly curved downwards to the periphery. Sutures distinct and slightly depressed. Four longitudinal costae running down both sides of the test, whereas the two inner costae are more prominent and running down almost the whole test. The marginal costae are finer and do not always reach the last chambers. Some species possess a distinct basal spine. Aperture is a vertical loop-shaped opening at the sutural side of the last chamber. Surface very smooth, finely perforated and translucent.

Remarks. A very rare species in this study. Only found at one station off Ecuador (3°S/81°W) at 350 m water depth. Not all species found in this study posses spines. This species differs from the very similar *B. argentea* (Cushman) by having somewhat lower chambers and four distinct longitudinal costae whereas *B. argentea* has just two distinct longitudinal costae at the median part of the test which do not reach the last chambers. These species appear to be the same species as commented by Whittaker (1988). Some of the specimens found in this study posses a basal spine. Both varieties were found in at one station off northern Peru (3°45'S/81°7'W) in a water depth of 350 m, whereas 7 spinose and 32 non-spinose stained specimens were found. In this study both varieties are put together to one species.

Distribution. Recent, southeast of Nantucket (Cushman, 1922); Cenozoic of Ecuador (Whittaker, 1988).

Length: 149-872 µm.

Bolivinita minuta **Natland 1938**

(Pl. 2, fig. 12)

* 1938 *Bolivinita minuta* – Natland: pl. 5, fig. 10.

. 1980 *Bolivinita minuta* – Ingle et al.: p. 139, pl. 4, fig. 1.

. 1981 *Bolivinita minuta* – Resig: p. 647, pl. 1, fig. 9.

1994 *Abditodentrix pseudothalmanni* Boltovskoy & Guissani de Kahn – Loeblich & Tappan: pl. 268, figs. 1, 2.

Diagnosis. A minute, very compressed biserial species. Chambers compressed and increase strongly in size as added. They are obliquely arranged, directed strongly downward to the periphery. Basal end tapered, apertural end stump. The shape of this species is almost tripartite. Sutures distinct and raised. Aperture is a loop shaped opening on the apical side of the last chamber.

Remarks. Specimens were found between 492 1004 m water depths off Peru.

Distribution. Off California, U.S.A. (Natland, 1839); recent, off west coast of Central America (Bandy & Arnal, 1957); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, off Peru (Resig, 1981, 1990); recent, Gulf of California (Phleger, 1964); living, off southern California (Shepherd, et al., 2007).

Length: 166-315µm.

Bulimina marginata **d'Orbigny 1826**

* 1826 *Bulimina marginata* – d'Orbigny: p. 269, pl. 12, figs. 10-12.

. 1884 *Bulimina marginata* – Brady: p. 405, pl. 1, figs. 3-5.

. 1951 *Bulimina marginata* – Phleger & Parker: p. 47, pl. 7, figs. 27,28.

. 1960 *Bulimina marginata* – Barker: p. 105, pl. 51, figs. 3-5 [cop. Brady, 1884].

. 1971 *Bulimina marginata* – Murray: p. 118, pl. 49, figs. 1-7.

. 1988 *Bulimina marginata* – Whittaker: p. 56, pl. 7, fig. 7.

. 1991 *Bulimina marginata* – van Marle: p. 281, pl. 5, figs. 9-10.

. 1994 *Bulimina marginata* – Loeblich & Tappan: p. 479, pl. 242, figs. 1-4.

. 1995 *Bulimina marginata* – Schmiedl: p. 137, pl. 2, fig. 10.

. 2008 *Bulimina marginata* – Lobegeier & Sen Gupta: p. 104, pl. 1, fig. 11.

. 2009 *Bulimina marginata* – Frezza & Carboni: p. 56, pl. 2, fig. 11.

Diagnosis. A small to medium species. Chambers increasing gradually in size as added, inflated and spinose at their marginal base. Test tapered to the initial end. Sutures distinct and depressed. Aperture is located in a depression on the inner face of the last chamber. It is an oval opening, surrounded by a lip.

Remarks. It differs from *Bulimina aculeata* (d'Orbigny) by the absence of a prominent basal spine. This species was found in two deep intervals of station SO-147-106KL off Peru (12°S): 1068.5 and 1132.5 cm sediment depth.

Distribution. Recent, Adriatic Sea (d'Orbigny, 1826); recent, west of Ireland, N-Atlantic (Barker, 1960 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994); recent, North Sea (Murray, 1971); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); Cenozoic of Ecuador (Whittaker, 1988); recent, Gulf of Mexico (Phleger & Parker, 1951; Lobegeier & Sen Gupta, 2008); recent, Atlantic shelf of E-Coast of S-America and off the Pacific coast of S-America (Boltovskoy, 1976); recent, Northern Tyrrhenian Sea, Italy (Frezza & Carboni, 2009); Late Cenozoic of Eastern Indonesia (van Marle, 1991).

Length: 125-332 µm.

***Bulimina ovata* var. *primitiva* Todd 1952**

* 1952 *Bulimina ovata* d'Orbigny var. *primitiva* – Todd: pl. 4, figs. 9-11.

Diagnosis. A medium to large, stout species. Test often somewhat lobulate, consisting of an indistinct number of more or less inflated chambers, but more than three are visible. Sutures distinct. Aperture is a terminal narrow, loop-shaped opening with a tooth-plate, surrounded by a slight lip. Apertural end rounded, the initial end bluntly rounded or tapered.

Remarks. This species differs from *Globobulimina pacifica* (Cushman) by the greater number of chambers and the more stout habitus but also by its rounded apertural part. This species is closest to *Bulimina otovata* d'Orbigny var. *primitiva* (Todd) displayed by the type figures. A rare species in this study. It was found at 5-20 cm sediment depth of one station in 823 m water depth off Peru (12°32'S/77°34'W).

Distribution. Middle Oligocene, near Vicksburg, Warren County, Mississippi, U.S.A. (Todd, 1911).

Length: 664-1204 µm.

Bulimina pagoda **Cushman 1927**

(Pl. 2, fig. 13)

* 1927 *Bulimina pagoda* – Cushman: p. 152, pl. 2, fig. 16.

. 1960 *Bulimina pagoda* – Uchio: pl. 6, fig. 5.

. 1988 *Bulimina pagoda* – Whittaker: p. 56, pl. 7, fig. 10.

. 1994 *Bulimina pagoda* – Loeblich & Tappan: p. 479, pl. 242, figs. 5-7.

Diagnosis. Test small and tapered to the basal end. Broadest at the base of the last whorl forming chambers. Chambers moderately inflated, sharply undercut at their lower border. Chambers belonging to one whorl slightly increasing in size as added, whereas chambers from neighbouring whorls are significantly different in size. Large, sharply pointed spines projecting downwards from the periphery of each chamber. Older chambers usually possess two spines whereas the youngest chambers possess four or five spines. Sutures distinct and depressed. Aperture is a vertical loop shaped opening at the base of the last chamber. Test surface smooth, transparent and covered by densely distributed pores.

Remarks. This species differs from *Bulimina striata* (d'Orbigny) by the spines projecting from the periphery of each chamber, whereas *B. striata* has costae running over the lower part of each chamber and usually possess a basal spine which is missing at *B. pagoda*. Furthermore, the aperture of *B. pagoda* is not surrounded by a lip and the test size is usually significant bigger than *B. pagoda*. A rare species in this study. Specimens were found at two stations off Peru in 526 and700 m water depth (1°53'S and 3°51'S).

Distribution. Recent, off Panama, E Pacific (Cushman, 1927); dead, Cenozoic of Ecuador (Whittaker, 1988); recent, off W coast of central America (Bandy & Arnal, 1957); dead, Timor Trough (Loeblich & Tappan, 1994); living, off San Diego, California, U.S.A. (Uchio, 1960).

Length: 224-390 µm.

Bulimina pupoides d'Orbigny 1846

* 1846 *Bulimina pupoides* – d'Orbigny: pl. 11, figs. 11, 12.

. 1858 *Bulimina pupoides* – Williamson: pl. 5, figs. 124, 125.

. 1960 *Bulimina pupoides* – Barker: p. 103, pl. 50, fig. 14 [cop. Brady, 1884].

. 1966 *Protoglobobulimina pupoides* – Belford: p. 67, pl. 6, figs. 4-5.

. 1980 *Globobulimina pupoides* – Ingle et al.: p. 145, pl. 7, fig. 4.

. 1991 *Praeglobobulimina pupoides* – van Marle: p. 281, pl. 5, figs. 13-14.

. 1994 *Protoglobobulimina pupoides* – Loeblich & Tappan: p. 481, pl. 244, figs. 8-10.

Diagnosis. A stout, small to medium sized *Bulimina*. Test tapered to the basal end, but not pointed. Chambers moderately inflated, increasing gradually in size as added. Sutures distinct and depressed. Aperture is round or oval opening at the base of the last chamber. Test smooth, whitish in colour, sometimes transparent.

Remarks. It's a common species in this study. This species differs from *Virgulina rotundata* (Parr) by its round aperture, the more inflated and globular chambers and the stout character. Furthermore it has a round cross section, whereas *V. rotundata* is more compressed or ovoid in cross section. From the variety *fusiformis*, *B. pupoides* differs in having a straight growth, whereas *B. pupoides fusiformis* has a bended test. A common species in this study. It was found in water depths between 79 and 521 m off Peru.

Distribution. Middle Miocene of the Vienna Basin (d'Orbigny, 1846); recent, west of Patagonia, E-Pacific (Barker, 1960 [cop. Brady, 1884]); Neogene and Quaternary of southern South China Sea (Hess & Kuhnt, 2005); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, NE Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic of Eastern Indonesia (van Marle, 1991); Miocene and Pliocene of Papua and New Guinea (Belford, 1966); recent, off Peru (Resig, 1990).

Length: 158-166 µm.

***Buliminella curta* Cushman 1925**

* 1925 *Buliminella curta* - Cushman: pl. 5, fig. 13.

Diagnosis. A small to medium sized, stout species. Numerous inflated chambers are obliquely coiled up. Five to six chambers per whorl. Test slightly tapered to the basal end but not pointed. Sutures distinct and depressed. Aperture is a loop-shaped opening in a depression at the margin of the last chamber. Surface very smooth and shiny, translucent.

Remarks. This species differs from *Bulimina pupoides* (d'Orbigny) by its more elongated chambers which are coiled up more obliquely. The test is broader at the younger part of the test than in relation with *B. pupoides*. Furthermore, *B. curta* is usually much bigger in size and *B. pupoides* has a more slender outline. This species was found between 317 and 360 m water depth off Peru.

Distribution. Miocene, San Luis Obispo County, California, U.S.A. (Cushman, 1925).

Length: 149-332 µm.

***Buliminella curta* var. *basispinata* R. E. & K. C. Stewart 1930**

(Pl. 2, fig. 14)

* 1930 *Buliminella curta* Cushman var. *basispinata* – R. E. & K. C. Stewart: pl. 8, fig. 6.

Diagnosis. Nearly the same build-up as the typical form. Test a bit more elongated. The few initial chambers posses many short, downward directed spines.

Remarks. This species resembles *Bulimina aculeata* d'Orbigny var. *basispinosa* (Tedeschi & Zanmatti, 1957) but differs from its more slender form, by the more rounded and higher apertural end and the aperture which is located in a depression on the marginal part of the last chamber. Furthermore, the chambers are more elongated and not globular.

It was found between 350 and 579 m water depths off Peru.

Distribution. Lower Pliocene, near Ventura, California, U.S.A. (R. E. & K. C. Stewart, 1930).

Length: 249-457 µm.

***Buliminella elegantsissima* var. *limbosa* Cushman & McCulloch 1948**

(PL. 2, fig. 15)

* 1948 *Buliminella elegantissima* d'Orbigny var. *limbosa* – Cushman & McCulloch: pl. 29, fig. 5.

. 1990 *Buliminella elegantissima limbosa* – Resig: p. 292, pl. 1, fig. 2.

. 1990 *Buliminella limbosa* – Revets: p. 343, pl. 4, figs. 1-6.

Diagnosis. A minute but relatively stout variety of *B. elegantissima*. Numerous chambers obliquely arranged to form a spiral. Sutures are distinct. Aperture is a small round subterminal opening on the last chamber. Surface is very smooth and translucent.

Remarks. This species differs from the variety hensoni (Lagoe) by the absence of basal spines. This species was found off Peru between 79 and 319 m water depth.

Distribution. Recent, off Peru (Cushman & McCulloch, 1948); recent & sub-recent, off Peru (Resig, 1990).

Length: 50-208 µm.

***Buliminella elegantsissima* var. *tenuis* Cushman & McCulloch 1948**

* 1948 *Buliminella elegantissima* d'Orbigny var. *tenuis* – Cushman & McCulloch: pl. 29, fig. 6.

. 1994 *Buliminella* cf. *tenuis* – Loeblich & Tappan: p. 483, pl. 246, fig. 1-4.

Diagnosis. A slender variety of *B. elegantissima*. Test minute, consists of numerous narrow chambers which are obliquely screwed up to form a high spiral. Aperture is a round subterminal opening on the last chamber. Test very smooth and translucent.

Remarks. This variety is characteristic and differs from the varieties *hensoni* and *limbosa* by its slender shape and the aperture located at the apical end of the last chamber.

It was found between 79 and 375 m off Peru.

Distribution. Gulf of California and coast of Mexico (Cushman & McCulloch, 1948); Timor Sea (Loeblich & Tappan, 1994).

Length: 183-232 µm.

Cassidulina auka Boltovskoy & Theyer 1970

* 1970 *Cassidulina auka* – Boltovskoy & Theyer: pl. 1, fig. 27.

. 1981 *Cassidulina auka* – Resig: p. 653, pl. 4, figs. 11, 15.

Diagnosis. A medium sized, involutely coiled species with rounded and acute periphery. Sutures distinct, slightly depressed and bifurcating at their periphery. Aperture is a narrow, tripartite opening at the base of the last chamber. Surface smooth and translucent, very finely perforated.

Remarks. It is a common species in the study area. It was found between 114 and 579 m water depth off Peru.

Distribution. Recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off Peru (Resig, 1981).

Diameter: 191-564 µm.

Cassidulina auka var. A Boltovskoy & Theyer 1970

(Pl. 2, fig. 16)

* 1970 *Cassidulina auka* – Boltovskoy & Theyer: pl. 1, fig. 26a-b.

. 1975 *Cassidulina auka* – Manheim et al.: p. 248, text fig. 6.

Diagnosis. A medium sized biconvex and bilateral-symmetrical species, nearly round in side view. Periphery acute and keeled. Chambers numerous, not inflated. Sutures distinct, raised and bifurcating at the periphery. Surface very smooth, transparent and very finely perforate. The width of the chambers is slightly increasing. Face of the last chamber triangular with broadest part at the base and acuminating to the keeled periphery. Last chamber reaches down to the umbilicus and embraces the older part of the test. Aperture is a tripartite opening at the base of the last chamber. The vertical leg of the tripartite aperture is located directly above the older parts of the whorl, whereas the other leg is oriented perpendicular to the right periphery of the specimen.

Remarks. This species was only found in deep intervals of station SO147-106KL in 967.5 and 1068.5 cm sediment depth.

Distribution. Recent, off central Chile (Boltovskoy & Theyer, 1970); recent, sub-recent, off Peru (Manheim et al., 1975).

Diameter: 183-581 µm.

Cassidulina crassa **d'Orbigny 1839**

(Pl. 2, fig. 17)

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

. 1970 *Cassidulina crassa* – Boltovskoy & Theyer: pl. 1, fig.24.

. 1981 *Cassidulina crassa* – Resig: p. 653, pl. 4, fig. 12-13.

. 1983 *Globocassidulina crassa* – Nomura: pl. 3, figs. 9a-c, 10a, b; pl. 6, fig. 17; pl. 18, 3-6.

1991 *Cassidulina crassa* – van Marle: p. 289, pl. 9, figs. 13-15.

Diagnosis. Test medium in size, somewhat globose in side view but chambers are not inflated. From dorsal view showing typical chamber arrangement with zigzag path of very slightly depressed sutures. Last chamber protruded. Test surface very smooth a bit transparent and white in colour. Tiny pores densely and evenly distributed over the whole test. Aperture is a tripartite opening at the base of the last chamber.

Remarks. This species was found between 298 and 823 m water depth off Peru.

Distribution. Off Falkland (d'Orbigny, 1839); recent, off Peru (Resig, 1981, 1990); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off southern Argentina and off Chile, Peru (Boltovskoy, 1976); late Cenozoic of Japan (Nomura, 1983); fossil, southern Scandinavia (Knudsen & Feyling-Hanssen, 1976); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, eastern Indian Ocean (Murgese & de Deckker, 2005); recent, South Atlantic (Schumacher, 2001); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Size: 208-374 µm.

Cassidulina delicata Cushman 1927

(Pl. 2, figs. 18-19)

* 1927 *Cassidulina delicata* - Cushman: p. 168, pl. 6, fig. 5.

. 1960 *Cassidulina delicata* – Uchio: pl. 9, fig. 17.

. 1981 *Cassidulina cushmani* – Resig: p. 653, pl. 10, fig. 10.

. 1991 *Cassidulina delicata* – van Marle: p. 289, pl. 9, fig. 8.

. 1994 *Takayanagia delicata* – Loeblich & Tappan: p. 462, pl. 225, figs. 11-12.

Diagnosis. A small, biconvex species. Periphery slightly carinate. Test is smooth and transparent. Dorsal side shows no distinct sutures. On ventral side the chambers look moderately inflated and are bordered by distinct sutures. The aperture is a long slit but narrow which follows the peripheral curve like it has been described by Whittaker (1988).

Remarks. We agree with Whittaker (1988) that *Cassidulina delicata* is synonymous with Cassidulina cushmani. The figure 19 on plate 4 shown in Resig (1981) illustrates the same architecture of chamber arrangement and the aperture like the individuals of my study. The specimens presented by Loeblich & Tappan (1994) shows also the typical aperture and chamber arrangement but is just a bit more obese than the specimens of my study.

This is a common species in the study area. It was found between 207 and 1004 m water depth off Peru and Ecuador.

Distribution. Recent, off Peru (Resig, 1981); recent, Peru-Chile Trench area (Bandy & Rodolfo, 1964); Cenozoic of Ecuador (Whittaker, 1988); recent, off Panama: (Cushman, 1927); recent, off San Diego, California (Uchio, 1960); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 125-249 µm.

***Cassidulina laevigata* var.*carinata* Silvestri 1898**

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

. 1994 *Cassidulina laevigata* var. *carinata* – Jones: pl. 54, figs. 2-3 [cop. Brady, 1884].

Diagnosis. A very small, compressed species. Test low biconvex, consisting of numerous, moderately inflated chambers. Chambers are more inflated on the ventral side. Periphery rounded, distinctively carinate, lobulate, whereas the keel is very thin and translucent. Sutures distinct and not depressed on the dorsal side, but on the ventral side. Aperture is a low, loop-shaped opening at the ventral base of the last chamber. Surface very smooth, glassy and translucent.

Remarks. A very rare species. It was found at one station off Peru in 995 m water depth (3°57'S/81°19'W).

Distribution. Recent, off New Zealand and west of Ireland (Jones, 1994 [cop. Brady, 1884]).

Diameter: 166-291 µm.

Cassidulina subglobosa **Brady 1881**

* 1881 *Cassidulina subglobosa* – Brady: pl. 54, fig. 17.

. 1991 *Globocassidulina subglobosa* – van Marle: p. 291, pl. 10, figs. 10-11.

. 1994 *Globocassidulina subglobosa* – Jones: Pl. 54, fig. 17 [cop. Brady, 1884].

Diagnosis. Test nearly globular. Consisting of numerous inflated chambers, Sutures distinct and incised. Aperture is broad, vertical slit at the base of the last chamber. Surface smooth, glassy and translucent.

Remarks. Only one very small, probably juvenile specimen was found off Peru (9°17'S/79°53'W) at 1105 m water depth. This specimen resembles *Cassidulina crassa* (d'Orbigny, 1839) but differs by the final chamber which is more protruded. Furthermore the aperture is a vertical, straight, broad slit but not a curved, elongated opening.

Distribution. Recent, off Pernambuco, Brazil, SE-Atlantic (Brady, 1881); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Size: 208 µm.

Ehrenbergina compressa Cushman 1927

(Pl. 3, fig. 1)

* 1927 *Ehrenbergina compressa* – Cushman: pl. 6, fig. 7.

. 1960 *Ehrenbergina compressa* – Uchio: pl. 9, figs. 28-31.

Diagnosis. A small to medium sized, biserial, compressed species. Test broad, consists of numerous very low but broad, slightly inflated and biserially arranged chambers which are deeply embracing each other. The test is distinctly bended along its longitudinal axis. The dorsal side is the convex and the ventral side is concave. The basal end bluntly rounded, the apertural end stump. Chambers increasing gradually in size as added, basal periphery of the few youngest chambers are tapered and overhang the preceding chamber. Sutures distinct and on the ventral side more depressed as on the dorsal side. Aperture is long curved slit on the face of the last chamber. Surface smooth, finely porous and slightly transparent.

Remarks. This species differs from the similar *Ehrenbergina pupa* (d'Orbigny) by its less inflated chambers and the distinct pointed basal ends of the few younger pairs of chambers.

This species was found at four stations off Peru in 298-511 m water depth.

Distribution. Recent, off Panama Pacific (Cushman, 1927); recent, off San Diego, California, U.S.A. (Uchio, 1960).

Length: 332-689 µm.

Ehrenbergina trigona Goës 1896

(Pl. 3, fig. 2)

* 1896 *Ehrenbergina serrata* Reuss var. *trigona* – Goës: pl. 6, figs. 183-184.

. 1960 *Ehrenbergina trigona* – Barker: p. 113, pl. 55, figs. 2, 3, ?5 [cop. Brady, 1884].

. 1965 *Ehrenbergina trigona* – Todd: pl. 20, fig. 2a-c.

. 1990 *Ehrenbergina trigona* – Hermelin & Shimmield: p. 14, pl. 3, figs. 3-4.

Diagnosis. A medium sized *Ehrenbergina* with serrate periphery. Tripartite in cross section. Numerous broad but low chambers. The three acute edges consist of two vertical rows of serrate keels with downward curved, sharply pointed projections. Sutures distinct and depressed. Aperture is a very narrow but elongated curved slit running across apical part of the last chamber. Surface smooth, greyish to whitish hue. Densely covered by fine, evenly distributed pores.

Remarks. A very rare species, only a single specimen found at one station off Ecuador (1°45’S/82°37’W) in a depth of 2092m and 0-5mm sediment depth.

Distribution. Recent, SW of Juan Fernandez and South Pacific (Barker, 1960 [cop. Brady, 1884]); recent, tropical Pacific (Todd, 1965); recent, Peru-Chile Trench area (Ingle et al. 1980); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); recent, eastern Indian Ocean (Murgese & Deckker, 2005); Late Quaternary, South China Sea (Jian & Wang, 1997); recent, Mid-Atlantic ridge (Hooper & Jones, 1977).

Length: 664 µm.

Fursenkoina fusiformis **Williamson 1858**

(Pl. 3, fig. 3)

* 1858 *Bulimina pupoides* var. *fusiformis* – Williamson: p. 63, pl. 5, figs. 129-130.

. 1947 *Bulimina fusiformis* – Höglund: p. 232, pl. 20/3, figs. 219-233.

. 1971 *Fursenkoina fusiformis* – Murray: p.184, pl. 77, figs. 1-5.

. 2006 *Stainforthia* sp. – Risgaard-Petersen et al.: p.94, pl. 2, fig. C.

2006 *Buliminella curta* – del Carmen Morales et al.: p. 16, pl. 1, fig. 5.

Diagnosis. Test is small and sometimes medium in size, fusiform and biserially arranged. Chambers consists of numerous inflated and slightly elongated chambers. Wall is thin and translucent. Usually the overall shape is bended because of the twisted chamber arrangement. The round aperture is formed by an immersion on the apical side of the last chamber. Sutures are distinct and depressed. Surface smooth, transparent.

Remarks. This species was found very common in all samples from oxygen depleted locations off Peru and between 79 and 995 m water depth. Specimens with the same morphology but which do not show a bended but straight shape were named as *Bulimina pupoides*.

Distribution. Recent, Gullmar Fjord, Sweden (Höglund, 1947; Risgaard-Petersen et al., 2006); recent, NE Atlantic (Murray, 1971); recent, SE Pacific, off Peru (del Carmen Morales et al., 2006).

Length: 125-489 µm.

Globobulimina hoeglundi **Uchio 1960**

* 1960 *Globobulimina hoeglundi* – Uchio: pl. 6, figs. 7-8.

Diagnosis. A medium or large sized species. Test consists of numerous chambers. Chambers increasing very slowly in size at the initial part but rapidly in size at the younger part of the test. Sutures distinct and slightly depressed, horizontally in the younger part. Periphery rounded. Test tapered at the initial end at microspheric form but rounded at the megalospheric form, whereas the test of latter is distinctly bigger in size. Aperture is a narrow curved opening at the apical part of the last chambers with a n indistinctly formed tooth-plate. Wall very thin and fragile, transparent.

Remarks. Very rare in this study. Found at one station off Ecuador (3°51'S/81°15'W) in 700 m water depth. This species is characterised by the great number of visible chambers, especially in the younger part of the test.

Distribution. Recent, off San Diego, California, U.S.A. (Uchio, 1960).

Length: 332-540 µm.

Globobulimina pacifica **Cushman 1927**

* 1927 *Globobulimina pacifica* - Cushman: pl. 14, fig. 12.

. 1951 *Globobulimina pacifica* – Hofker: p. 260, text. Fig. 173.

. 1960 *Globobulimina pacifica* – Barker: p.103, pl. 50, figs. 7-10 [cop. Brady, 1884].

. 1970 *Globobulimina pacifica* – Boltovskoy & Theyer: pl. 2, fig. 19.

p 1980 *Globobulimina pacifica* – Ingle et al.: p. 135, pl. 2 fig. 8 (not fig. 7).

. 1991 *Globobulimina pacifica* – van Marle: p. 281, pl. 5, figs. 11-12.

. 1992 *Globobulimina pacifica* – Kato: p. 390, pl. 2, fig. 10.

. 1994 *Globobulimina pacifica* – Loeblich & Tappan: p. 480, pl. 243, figs. 13-16.

. 1999 *Globobulimina pacifica* – Bernhard & Sen Gupta: p. 213, pl. 12.6, fig. G.

Diagnosis. Large ovoid specimens with a thin, smooth and translucent wall. Test slender. Sutures are not very distinct. Base is frustum without a basal spine. Aperture on the apical side of the last chamber is a loop-like opening with a tooth-plate (Cushman, 1927).

Remarks. Very rare in this study. In very few samples we have found wall fragments which maybe belong to *G. pacifica*. Probably because of the fragile wall, few specimens were not readily preserved in the samples or were destroyed while sieving.

Intact specimens were found in subsurface samples from three stations in 697, 823 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, subtropical E-Pacific (Cushman, 1927); recent, OMZ off California, U.S.A. (Bernhard & Sen Gupta, 1999); recent, SE-Pacific, off central Chile (Boltovskoy & Theyer, 1970); recent, SE-Pacific, off Chile and Peru (Ingle et al., 1980); recent, off New Zealand, Azores, central Pacific (Barker, 1960 [cop. Brady, 1884]); recent, Sahul Shelf, Timor Sea (Loeblich & Tappan, 1994); NE-Pacific, off S-Australia (Basak et al., 2009); living, off S-California (Shepherd et al. 2007); Late Cenozoic of Eastern Indonesia (van Marle, 1991); Miocene to Holocene, Japan Sea (Kato, 1992).

Length: 689-1494 µm.

Loxostomum limbatum **Brady 1881**

* 1881 *Bulimina (Bolivina) limbata* - Brady: pl. 52, figs. 26-28 [in Brady, 1884].

. 1884 *Bolivina limbata* – Brady: p. 419, pl. 52, figs. 26-28.

. 1949 *Loxostoma limbata* – Boomgaart: p. 114, pl. 3, fig. 19.

. 1960 *Loxostomum limbatum* – Barker: p. 107, pl. 52, figs. 26-28 [cop. Brady, 1884].

. 1991 *Rectobolivina limbata* – van Marle: p. 283, pl. 6, figs. 17-18.

. 1994 *Loxostomina limbata* – Jones: pl. 52, figs. 26-28 [cop. Brady, 1884].

? 1995 *Loxostomina limbata* – Loeblich & Tappan: p. 470, pl. 233, figs. 1-8.

Diagnosis. Test minute and somewhat compressed. Periphery lobate. We found a slender and a stouter from in this study. Initial part of test slightly twisted. Both ends bluntly rounded. Chambers biserially arranged and moderately inflated. Chambers increase gradually as added. Sutures distinct and depressed. Sutures of the later chambers irregularly curved like shown by Brady's type figure 26 (1884, pl. 52). Aperture is an apical rather wide slit. Surface smooth, translucent and evenly covered by very fine pores.

Remarks. A rare species in this study. Only three specimens were found off Peru at 79 m water depth.

Distribution. Recent, Admiralty Islands and Honolulu reefs, Pacific (Jones, 1994 [cop. Brady, 1884]); recent, off North Brazil (Boltovskoy, 1976); recent, Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic of Eastern Indonesia (van Marle, 1991); Bodjonegoro, Java (Boomgaart, 1949).

Length: 183-249 µm.

Pleurostomella brevis **Schwager 1866**

* 1866 *Pleurostomella brevis* - Schwager: pl. 6, fig. 81.

. 2007 *Pleurostomella brevis* – Lutze: p. 431, pl. 3, figs. 4a-b.

Diagnosis. A very small, biserial species with moderately inflated chambers. Test surface smooth and transparent. The 3-4 youngest chambers are readily identifiable, whereas the earliest chambers are very small and not good to characterize. Sutures are distinct. Aperture is vertical slit in a depression on the base of the last chamber. The apertural slit is boarded by two very thin flaps. The basal part of the test is rounded. The last chamber is highly arched. This character is good recognizable from side view. Overall shape is ovate.

Remarks. This is a rare species in this study. Although this species counts as extinct since about 600.000 years (Hayward & Kawagata, 2005 and other authors citied therein), the identification of this species matches clearly to *P. brevis*.

A rare species in this study. Only a single living specimen was found at 511 m water depth off Peru (11°S/78°20'W). Dead specimens were found in 123 cm sediment depth of station SO147-106KL (12°S).

Distribution. Central equatorial and N-Pacific, N-Atlantic (Hayward et al., 2010); recent, Central Pacific, Ki Islands (Barker, 1960 [cop. Brady, 1884]); Neogene and Quaternary of southern South China Sea (Hess & Kuhnt, 2005); NW-African margin (Lutze, 2007).

Length: 58-191 µm.

Pseudobrizalina lobata **Brady 1881**

(Pl. 3, fig. 4)

* 1881 *Bulimina* (*Bolivina*) *lobata* – Brady: pl. 53, pl. 22-23.

. 1960 *Loxostomum lobatum* – Barker: p. 109, pl. 53, figs. 22-23 [cop. Brady, 1884].

. 1994 *Pseudobrizalina lobata* – Jones: pl. 53, figs. 22-23 [cop. Brady, 1884].

Diagnosis. A small to medium sized, slightly compressed species. Chambers inflated. Periphery lobate. Test consists of a biserial initial part, making up more than ¾ of the test length and is followed by the younger uniserial part. The initial portion of the biserial part is tapered to the basal end. The uniserial part is more cylindrical. Coarse spines are protruding from the marginal periphery. Sutures distinct and depressed. The aperture is a wide terminal opening with a surrounding lip at the apical end of the last chamber. Surface rough and transparent.

Remarks. The uniserial part of some species from this study comprises just one chamber. Some very small or young individuals have no distinct spines but already show the typical morphology with the rough surface. A rare species in this study. Specimens were found at 115, 207, 1923 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, Admiralty Islands, Pacific (Barker, 1960 [Brady, 1884]).

Length: 208-473 µm.

Stainforthia complanata Egger 1893

* 1893 *Virgulina schreibersiana* Cziczek var. *complanata* – Egger: pl. 8, figs. 91, 92.

1992 *Stainforthia complanata* – Kato: p. 390, pl. 2, fig. 5.

. 1994 *Fursenkoina complanata* – Jones: pl. 52, figs. 1-3 [cop. Brady, 1884].

. 1994 *Cassidella complanata* – Loeblich & Tappan: p. 467, pl. 230, figs. 1-10.

Diagnosis. A very small, biserial and slightly compressed species. Test nearly straight, or slightly bended (from edge view), consisting of usually four or five moderately inflated chambers per row. The few last chambers increasing rapidly in size as added. Last chamber making up about a third of the whole test. Test tapered to the basal end, rounded at its final end. Sutures distinct and depressed. Aperture is a big, oval, marginal opening at the last chamber. Surface thin, smooth, shiny and transparent.

Remarks. Specimens found in this study don't possess basal spines. This species was only found in deeper sediment intervals of station SO147-106KL between 52 and 967.5 cm sediment depth.

Distribution. Recent, north of Mermaid, Australia (Egger, 1893); recent, S-Pacific and S-Atlantic (Jones, 1994 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic, Eastern Indonesia (van Marle, 1991); Miocene to Holocene, Japan Sea (Kato, 1992).

Length: 58-208 µm.

Suggrunda californica Kleinpell 1938

* 1938 *Suggrunda californica* – Kleinpell: pl. 18, figs. 8-10.

Diagnosis. A small biserial species with low but broad and moderately inflated chambers. The lower edges of the last few pairs of chambers are extending downwards to form short but pointed spines. Test is nearly rectangular in cross section and tapered at the initial part. The chambers increasing gradually in size as added. Last two chambers relatively big and their tops are rounded. Sutures distinct and depressed. Aperture is a broad but low opening at the base of the last chamber. Wall is smooth but finely perforated and transparent.

Remarks. A very rare species. Only five5 individuals were found at station SO147-106KL (12°03'S/77°39'W) at sediment depths of 58, 123 and 163 cm.

Distribution. Miocene of Contra Costa County, California, U.S.A. (Kleinpell, 1938).

Suggrunda kleinpelli Bramlette 1951

* 1951 *Suggrunda kleinpelli* – Bramlette: pl. 23, figs. 4-5.

. 2005 *Suggrunda kleinpelli* – Narayan et al.: p. 145, pl. 3, fig. 36.

Diagnosis. A very small, tapered and serrate *Suggrunda* with a distinct ovate cross section. Chambers increasing gradually in size as added. Sutures straight (not curved downwards) and distinct but not very depressed at the older part of the test; more depressed between the last pair or the second last pairs of chambers. Periphery distinctively serrate at the younger part of the test. Aperture is an arched slit at the base of the last chamber. Surface is smooth, transparent and densely perforated by fine pores.

Remarks. The serrate character of the test is often constraint to the last pair of chambers. This species resembles *S. eckisi* but differs from it by having shorter projections at the periphery, the sutures are not that much depressed and are more straight and not angled (in relation to the vertical axis).

This species was found at one station in 319 m water depth off Peru (11°S/78°09'W) and in 303, 1113 and 1153.5 cm sediment depth of station SO-147-106KL.

Distribution. Late upper Miocene of Monterey County, California, U.S.A. (Bramlette, 1951); Cenozoic, off Vancouver Island, British Columbia, Canada (Narayan et al., 2005).

Length: 149-208 µm.

Suggrunda porosa Hoffmeister & Berry 1937

(Pl. 3, fig. 5)

* 1937 *Suggrunda porosa* – Hoffmeister & Berry: pl. 5, figs. 9-11.

Diagnosis. A very small and slender *Suggrunda*. Test very acute to the basal end, consisting usually of more than ten pairs of moderately inflated chambers. The younger chambers appear to be more inflated than the older ones. The last or two last pairs of chambers are nearly globular. Marginal peripheries of the chambers are often slightly acute. Chambers forming an angle of about 60° with the vertical axis (Hoffmeister & Berry, 1937). Sutures distinct and depressed. Aperture is loop at the base of the last chamber. The test surface is smooth, transparent and finely but densely perforated.

Remarks. This species was found living at two stations in 375 and 437 m water depth off Peru and commonly in 52 to 1153.5 cm sediment depth of station SO147-106KL.

Distribution. Middle Miocene of eastern Venezuela (Hoffmeister & Berry, 1937).

Length: 58-299 µm.

***Uvigerina auberiana* d'Orbigny 1839**

(Pl. 3, fig. 6)

* 1839 *Uvigerina auberiana* – d'Orbigny: p. 106, pl. 2, figs. 23, 24.

. 1980 *Uvigerina auberiana* – Ingle et al.: p. 143, pl. 6, fig. 1.

. 1981 *Uvigerina auberiana* – Resig: p. 649, pl. 2, fig. 2.

. 1988 *Uvigerina auberiana* – Whittaker: p. 66, pl. 8, fig. 14.

. 1995 *Uvigerina auberiana* – Schmiedl: p. 139, pl. 3, fig. 4.

Diagnosis. A stout, medium sized, spinose *Uvigerina*. Basal end of test is tapered, whereas the apertural end is rounded. Chambers strongly overlapping each other. Inflated, densely covered by short spines. Sutures distinct and depressed. Aperture is a terminal opening at the end of a neck. The aperture doesn't possess a surrounding lip.

Remarks. Some of the specimens in this study have a basal spine. This species resembles *Uvigerina prabascidea* (Schwager) but differs from it by the stouter shape, the final end is the broadest part of the test and the apertural neck has no surrounding lip.

A rare species in this study. It was found in four stations in water depths between 697 and 2092 m off Peru and Ecuador.

Distribution. Cenozoic of Ecuador (Whittaker, 1988); living, Gulf of Lions, NW Mediterranean Sea (Fontanier et al., 2008); recent, off Costa Rica and Nicaragua (Heinz et al., 2008); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); Late Quaternary, South China Sea (Jian et al., 1999); Neogene and Quaternary of southern South China Sea (Hess & Kuhnt, 2005); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, off Peru (Resig, 1981, 1990); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); recent, Chile Triple Junction, southeastern Pacific (Schönfeld & Spiegler, 1995); recent, South Atlantic (Schumacher, 2001); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010).

Length: 374-664 µm.

Uvigerina canariensis **d'Orbigny 1839**

* 1839 *Uvigerina canariensis* – d'Orbigny: pl. 1, figs. 25-27.

p 1960 *Uvigerina canariensis* – Barker: p. 155, pl. 74, figs. 1-2, ?3 [cop. Brady, 1884].

. 1991 *Uvigerina canariensis* – van Marle: p. 287, pl. 8, figs. 9-11.

Diagnosis. A small to medium sized, stout *Uvigerina* with a smooth surface and a variable morphology. Test stout, consists of numerous strongly inflated chambers. The size of the chambers increase gradually in size as added. Basal end is stump or slightly tapered. The test is broadest at the final whorl. Sutures distinct and depressed. A relative short neck protrudes out from the apical part of the last chamber. Aperture terminal. Surface rather smooth.

Remarks. *U. canariensis* is a rare species in this study. It was found at stations from 526 to 1004 m water depth off Peru and Ecuador.

Distribution. Recent, off Tenerife, Canary Islands (d'Orbigny, 1839); recent, South Atlantic, W-Coast of Patagonia and off Bermuda (Barker, 1960 [cop. 1884]); recent, Peru-Chile Trench area (Ingle et al., 1980); living, Cascadia convergent margin, NE Pacific (Heinz et al., 2005); Pliocene and Pleistocene, western N-Atlantic (Blanc-Vernet, 2007); Late Holocene west coast of India (Nigam et al., 2009); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Length: 208-374 µm.

Uvigerina peregrina **Cushman 1923**

(Pl. 3, fig. 7)

* 1923 *Uvigerina peregrina* – Cushman: p. 166, pl. 42, figs. 7-10.

. 1970 *Uvigerina peregrina* – Boltovskoy & Theyer: pl. 4, fig. 23.

. 1981 *Uvigerina peregrina* – Resig: p. 649, pl. 2, fig. 6.

. 1980 *Uvigerina peregrina* – Ingle et al.: p. 137, pl. 3, fig. 6.

. 1988 *Uvigerina peregrina* – Whittaker: p. 66, pl. 8, figs. 1-6.

. 1991 *Uvigerina peregrina* – van Marle: p. 285, pl. 7, figs. 14-15.

. 1995 *Uvigerina peregrina* – Schmiedl: p. 139, pl. 3, figs. 1, 2.

. 2006 *Uvigerina peregrina* – Schönfeld: p. 358, pl. 1, figs. 14-16.

. 2009 *Uvigerina peregrina* – Frezza & Carboni: p. 56, pl. 2, fig. 15.

. 2010 *Uvigerina peregrina* – Li et al.: p. 674, pl. 2, figs. G-L.

? 2010 *Uvigerina peregrina* – Frezza et al.: p.310, pl. 2, fig. 27.

Diagnosis. A medium sized cone-shaped species with numerous round inflated chambers. Chambers coated with branched distinct longitudinal costae. Typically on the younger chambers the costae taper off into spines but they are not always developed. The aperture on the peripheral side of the last chamber is formed by a high cylindrical neck with a collar-like end.

Remarks. This species were identified by its typical arrangement of the branched costae which in most cases taper off to form spines on the youngest chambers. In many cases the aperture is broken.

Uvigerina peregrina was discriminated from *U. striata* by its high, branched costae and, if developed, the short spines of the youngest chambers.

It is a very common species. It was found between 207 and 1923 m water depth off Peru and Ecuador. But in oxygen minimum stations it didn't occur in shallower stations than 521.

Distribution. Recent, off central Chile (Boltovskoy & Theyer, 1970); recent, Peru-Chile Trench area (Ingle et al., 1980); recent, off Peru (Resig, 1981); Cenozoic of Ecuador (Whittaker, 1988); NE Pacific (Li et al., 2010); NW Pacific (Ohga & Kitazato, 1997); Sulu Sea (Rathburn & Corliss, 1994); recent, central E Pacific (Heinz et al., 2008); recent, NE Atlantic (Schönfeld, 2006); low latitude Atlantic (Fariduddin & Loubere, 1997); Arabian Sea (Erbacher & Nelskamp, 2006); Tyrrhenian Sea (Frezza et al., 2010); recent, Northern Tyrrhenian Sea, Italy (Frezza & Carboni, 2009); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Length: 174-979 µm.

Uvigerina semiornata d'Orbigny 1846

(Pl. 3, fig. 8)

* 1846 *Uvigerina semiornata* – d'Orbigny: pl. 11, figs. 23, 24.

. 1981 *Uvigerina bifurcata* – Resig, 1981: p. 649, pl. 2, fig. 3.

. 2005 *Uvigerina semiornata* – Brânzilâ & Chira: p. 23, pl. 1, figs. 5, 6.

Diagnosis. A medium sized, stout species. Test more or less tapered to the basal end, final chamber broadly rounded. Consisting of few inflated chambers with a few thin, longitudinal costae which are just slightly raised. Chambers rapidly increasing in size as added. Last chamber making up almost half the length of the specimen and posses a prominent neck with a downwards bended rim. Sutures distinct and strongly depressed. Aperture terminal. Surface smooth, slightly transparent.

Remarks. This species resembles *U. striata* but differs from it by having fewer and less developed costae.

It was found at two stations in 823 and 1004 m water depth off Peru.

Distribution. Upper Badenian to Sarmatian, Romania (Brânzilâ & Chira, 2005), recent, off Peru (Resig, 1981).

Length: 440-664 µm.

Uvigerina striata d'Orbigny 1839

(Pl. 3, fig. 9)

* 1839 *Uvigerina striata* – d'Orbigny: pl. 7, fig. 16.

. 1981 *Uvigerina striata* – Resig: p. 649, pl. 2, fig. 7.

Diagnosis. A stout, medium sized *Uvigerina*. Chambers inflated and strongly overlapping. Basal and youngest end bluntly rounded. Many fine and narrow costae running longitudinal down from the youngest to the oldest part of the test. The costae do not branch out but running continuously from one chamber to the next. Sutures distinct, rather sharply incised. Aperture is a terminal opening at the end of a neck.

Remarks. This species was found at stations between 350 and 1105 m water depth off Peru.

Distribution. Recent, off Falkland Islands (d'Orbigny, 1839); recent, off W-Coast of Chile and Peru (Boltovskoy, 1976); recent, off Peru (Resig, 1981).

Length: 249-1079 µm.

Virgulina bradyi Cushman 1922

(Pl. 3, fig. 10)

* 1922 *Virgulina bradyi* – Cushman: pl. 24, fig. 1.

. 1960 *Virgulina bradyi* – Barker: p. 107, pl. 52, fig. 9 [cop. Brady, 1884].

Diagnosis. A small to medium sized *Virgulina*. Test biserial, cylindrical and oval to nearly round in cross section; initial portion somewhat twisted. Both ends bluntly rounded. Chambers moderately inflated, increasing gradually in size as added. Sutures distinct and depressed. Aperture is a loop shaped opening reaching from the apical part to the base of the last chamber. Surface smooth and transparent.

Remarks. It is a rare species in this study. It was found at two stations off Peru (11 and 12°S) in water depths of 465 and 823 m.

Distribution. Recent, off NE coast of U.S.A. (Cushman, 1922); recent, off Tahiti (Barker, 1960 [cop. Brady, 1884]).

Length: 166-872 µm.

Virgulina rotundata Parr 1950

. 1899 *Virgulina subsquamosa* Egger – Flint: pl. 37, fig. 7.

* 1950 *Virgulina rotundata* – Parr: pl. 12, fig. 14.

. 1960 *Virgulina rotundata* – Barker: p. 107, pl. 52, figs. 10, 11 [cop. Brady, 1884].

. 1994 *Fursenkoina rotundata* – Loeblich & Tappan: pl. 256, figs. 7-13.

. 1995 *Fursenkoina mexicana* – Schmiedl: p. 137, pl. 2, figs. 14, 15.

Diagnosis. Test small in size, somewhat compressed with both ends slightly tapered. Ovate in cross section. Chambers slightly inflated, biserially arranged. The chambers are about two and one-half-times broader than high (Parr, 1950). Sutures distinct and depressed. Aperture is an elongate slit running from the apical point to the basal end of the last chamber. Surface smooth and transparent.

Remarks. A rare species in this study. It was found in 163 and 483 cm sediment depth of station SO147-106KL. Some specimens are slightly bended like it is shown by the figures of Barker (1960) but not as much depressed as shown in Loeblich & Tappan (1994, pl. 256, figs. 7-13). Thus it makes it difficult to distinguish between *V. rotundata* and the less depressed *V. earlandi* shown in Loeblich & Tappan (1994, pl. 256, figs. 14, 15).

Distribution. Recent, off New South Wales and off Tasmania, Australia (Parr, 1950); recent, off Tahiti (Barker, 1960 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994); late Quaternary, eastern S-Atlantic (Schmiedl, 1995).

Length: 199-257 µm.

Virgulina schreibersiana **Czjzek 1848**

* 1848 *Virgulina schreibersiana* – Czjzek: pl. 13, figs. 18-21.

. 1899 *Virgulina schreibersiana* – Flint: pl. 37, fig. 6.

. 1994 *Fursenkoina schreibersiana* – Loeblich & Tappan: p. 493, pl. 256, figs. 1-12.

. 2005 *Fursenkoina schreibersiana* – Narayan et al.: p. 145, pl. 3, figs. 33-34.

Diagnosis. Test small, slender, biserial, compressed and twisted, especially the initial part. Basal end tapered, apertural and bluntly rounded. Chambers moderately inflated, increasing gradually in size as added. Sutures distinct, depressed. Apical part of last chamber highly arched. Aperture is a loop shaped opening on the last chamber. The tests have no basal spine. Surface smooth and transparent.

Remarks. This species resembles Murray's *Fursenkoina fusiformis* Williamson (shown in Murray, 1971, p. 184, pl. 77, figs. 1-5.). His species need to be referred to *Virgulina schreibersiana* because of the more compressed shape, the typical twisted initial part of the test and the few chambers. Also the aperture is not typical for *F. fusiformis* but more for *V. schreibersiana*.

A very rare species in this study. It was found at one station off Peru in 697 m water depth (11°S/78°25'W).

Distribution. Tertiary of the Vienna Basin (Czjzek, 1848); recent, North Sea (Murray, 1971); recent, Timor Sea (Loeblich & Tappan, 1994); recent, west coast of Central America (Bandy & Arnal, 1957); recent, Peru-Chile Trench area (Ingle et al., 1980); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005).

Length: 623-805 µm.

Virgulina texturata **Brady 1884**

* 1884 *Virgulina texturata* – Brady: pl. 52, fig. 6a-b.

. 1960 *Virgulina texturata* – Barker: p. 107, pl. 52, fig. 6a-b [cop. Brady, 1884].

Diagnosis. A slender, biserial species. Test small to medium sized. Tapered to the initial end, periphery lobulated. Chambers inflated, increasing gradually in size as added. The initial chambers which making up almost the half of the test are slightly overlapping, whereas the younger chambers are strongly overlapping. The base of the last chamber extends over the whole width of the test. The entire specimen appears somewhat compressed. Sutures distinct and depressed. Aperture is an elongated slit parallel to the compressed of the test, reaching from the apical part to the base of the last chamber. Surface smooth, transparent and very finely perforated.

Remarks. This species differs from the similar *Virgulina earlandi* (Cushman) by its straight growth and the simple oblique sutures, also the chambers are more globular.

It is a rare species in this study. It was found living at two stations off Peru in water depths of 79 and 214 m. Dead specimens were found in 58, 103 and 1153.5 cm sediment depth of station SO147-106KL.

Distribution. Recent, South Pacific (Brady, 1884; Barker, 1960 [cop. Brady, 1884]).

Length: 183-307 µm.

Order ROTALIIDA

(Lankester, 1885)

Melonis barleeanum Williamson 1858

(Pl. 3, figs. 11-12)

* 1858 *Nonionida barleeana* – Williamson: p. 32, pl. 3, figs. 68, 69

. 1930 Nonion barleeanum – Cushman: p. 11, pl. 11, fig. 5

. 1979 Melonis barleeanum – Corliss: p. 10, pl. 5, figs. 7, 8.

Diagnosis. The species found in this study is plani-spiral, small to medium in size, nearly bilateral-symmetric. Test involute, cyclic in outline, consists of about twelve chambers in the last whorl. Older convolutions not visible. Chambers very slowly increasing in size as added, relatively high but narrow. Only the base of the chambers becoming distinctively broader, so that especially the basal parts of the last few chambers slightly overhang the umbilical parts of the penultimate whorl. Periphery rounded, becoming very slightly lobulate at the younger part of the last whorl. Sutures distinct, slightly curved forwards at the innermost umbilical sides, then slightly backwards to the periphery. The sutures are broader at the innermost umbilical portion and then thinning rapidly out to even breadth. One umbilical side is usually more depressed then the other, whereas the one not depressed side is often more or less covered by knob of glassy test material. Aperture is a curved slit at the base of the last chamber. Surface very smooth, glassy, transparent but densely covered by evenly distributed, rather big pores.

Remarks. Rare in this study. It was found at two stations off Ecuador in water depths of 995 and 2092 m. This species resembles *Anomalina bilateralis* (Cushman, 1922) and *Nonionina umbilicatula* Walker & Jacob var. *pacifica* (Cushman, 1924). It differs clearly from *A. bilateralis* by the morphology of its aperture. It is much broader from edge view, also the periphery is more bluntly rounded and consisting of about twelve chambers. From *N. umbilicatula* var. *pacifica* it differs in having twelve instead of ten chambers, a less lobulate periphery and curved sutures. It is denominated as *M. barleeanum* because of its size, the rounded periphery and the apertural and umbilical structure.

Distribution. Recent, Sahul Shelf and Timor Sea (Loeblich & Tappan, 1994).

Length: 208-332 µm.

Cancris carmenensis Natland 1950

(Pl. 3, figs. 13-14)

* 1950 *Cancris carmenensis* – Natland: pl. 9, fig. 1.

. 1981 *Cancris carmenensis* – Resig: p. 649, pl. 2, fig. 9-11.

. 1990 *Cancris carmenensis* – Resig: p. 293, pl. 3, figs. 11-13.

Diagnosis. A medium to large sized evolute and biconvex species. Chambers slightly inflated and increase strongly in size as added. Last chamber makes up more than half the diameter of the specimen. Eight chambers form the last whorl. Sutures distinct and depressed, especially at the initial part of the umbilical side. The sutures are almost straight or slightly curved backwards. The deep umbilicus is covered by a thin, indistinct and transparent flap which protrudes from the base of the last chamber. The periphery of the last few chambers, especially at the last chamber is somewhat acute but not keeled. Surface smooth, shiny, transparent and densely perforated by small pores. The aperture, only visible from the umbilical side, is a low arc at the base of the last chamber.

Remarks. This is a common species in this study. It was found between 214 and 627 m water depth off Peru.

Distribution. Pliocene, Gulf of lower California, Mexico (Natland, 1950); recent, off Peru (Resig, 1981, 1990);

Diameter: 208-1038 µm.

Chilostomella oolina **Schwager 1878**

(Pl. 3, fig. 15)

* 1878 *Chilostomella oolina* – Schwager: p. 527, pl. 1, fig. 16.

. 1991 *Chilostomella oolina* – van Marle: p. 291, pl. 10, figs. 12-13.

. 1994 *Chilostomella oolina* – Loeblich & Tappan: p. 586, pl. 349, figs. 12, 13.

. 1995 *Chilostomella oolina* – Jones: pl. 55, figs. 12-14, 17-18 [cop. Brady, 1884].

Diagnosis. A small to medium sized, ovoid species. Test consisting of few chambers, two per whorl. The last two chambers making up more than 75% of the test, embracing strongly the previous chambers. Sutures distinct. Aperture is small, interiomarginal slit with a slight lip. Surface thin, smooth, punctate and transparent.

Remarks. The majority of the specimens found in this study are stout and broader than these displayed on the principal author's plate.

A rare species in this study. It was found at two stations off Peru in 437 and 465 m water depth (9°17'S/79°17'W and 11°S/78°19'W).

Distribution. Miocene, Sicily, Italy (Schwager, 1878); recent, Ki Islands, Central Pacific, south of Japan, N-Pacific, Philippines, N-Pacific (Jones, 1994 [cop. Brady, 1884]); recent, Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Length: 291-390 µm.

Cibicidoides mckannai **Galloway & Wissler 1927**

* 1927 *Cibicides mckannai* – Galloway & Wissler: p. 65, pl. 10, figs. 5a-c, (?)6a-c.

. 1988 *Cibicidoides mckannai* – Whittaker: p. 144, Pl. 20, figs. 10-12.

Diagnosis. A medium sized, biconvex species. Test consists of numerous chambers, 10 to 12.5 chambers visible in the last whorl. Periphery rounded, sub-acute; keel just visible from umbilical side, like described by Whittaker (1988). Sutures of the umbilical side and the last whorl of the spiral side distinct and just very slightly depressed, slightly curved on the umbilical side, more curved on the spiral side. The early whorls of the spiral side are indeterminable and condensed to a glassy rising. Aperture is an arched opening at the marginal base of the last chamber, staying in contact with the periphery of the last formed whorl. Surface glassy, transparent and distinctively punctuated by rather large pores.

Remarks. This species was only found at one station off northern Peru (3°57'S/81°19'W) in 995 m water depth.

Distribution. Pleistocene, south of Los Angeles, California, U.S.A. (Galloway & Wissler, 1927); Cenozoic of Ecuador (Whittaker, 1988).

Diameter: 291-664 µm.

Cibicidoides wuellerstorfi **Schwager 1866**

* 1866 *Anomalina wuellerstorfi* - Schwager: p.258, pl. 7, figs. 105, 107.

. 1884 *Truncatulina wuellerstorfi* – Brady: p. 622, pl. 93, figs. 8-9.

. 1988 *Cibicidoides wuellerstorfi* – Whittaker: p. 152, pl. 22, figs. 10-12, 16-21.

Diagnosis. Test medium to large in size, compressed and plano-convex or slightly biconvex. Consisting of nine to twelve chambers in the last whorl. Involute umbilical side and partially evolute spiral-side. Periphery rounded, lobulate and keeled. Sutures distinct and slightly raised. Aperture a small loop-shaped opening centred at the base of the last chamber with a small surrounding lip. Surface densely covered by large pores.

Remarks. A common species in the study area but always occurred in small quantities. It was found between 207 and 2092 m water depth off Peru and Ecuador.

Distribution. Upper Tertiary, Kar Nikobar (Schwager, 1866); Cenozoic of Ecuador (Whittaker, 1988).

Diameter: 415-1328 µm.

***Eponides* sp.**

(Pl. 4, fig. 1)

Holotype. A living specimen from the upper 0.5 cm sediment interval of station M77/2-776/MUC-67 off Ecuador (Datum: 16th December 2008; Coordinates: 1°45'S, 82°37'W 12°32.75'S, 77°34.75'W; 2092 m water depth).

Paratypes. One smaller species from the same station like the holotype.

Diagnosis. Test is very small and rounded with a lobulated periphery but not acute. It is low trochospiral. Evolute from spiral side, involute from umbilical side. Chambers are strongly inflated, nearly globular from umbilical side but less inflated from spiral side and increasing gradually in size as added. The last whorl consists of seven to eight chambers. Three to four whorls are visible on the spiral side. The umbilicus is strongly depressed. A curved opening at the base of the last chamber forms the aperture. The surface is very smooth, glassy and transparent.

Discrimination from other species. *Eponides* sp. is closest to *E. ecuadorana* Cushman & Stevenson (1948) because of the overall outline and number of chambers but also the small size and the deep umbilicus. But *Eponides* sp. differs from *E. ecuadorana* by the non-acute periphery and the more globular chambers and the narrower umbilical depression. All other species of *Eponides* reported in Ellis & Messina online catalogues (1942-2006) are more compressed or differing in number of chambers.

Diameter: 158-208 µm.

Gyroidina neosoldanii Brotzen 1936

* 1936 *Gyroidina neosoldanii* - Brotzen: p. 706, pl. 107, fig. 6 (not fig. 7) [cop. Brady, 1884].

. 1971 *Gyroidina neosoldanii* – Murray: p. 196, pl.83, figs. 1-5.

. 1991 *Gyroidina neosoldanii* – van Marle: p. 293, pl. 11, figs. 11-12.

. 1994 *Gyroidina neosoldanii* – Loeblich & Tappan: p. 598, pl. 361, figs. 13-15; p. 599, pl. 362, figs. 1-7.

Diagnosis. A small to medium sized trochospiral *Gyroidina* with 3 to 4 whorls visible on the slightly convex spiral side. Sutures distinct, straight but swept back on the spiral side (Whittaker, 1988), straight or very slightly curved on the umbilical side. Deep umbilicus. Very smooth surface, no pores visible under binocular. Aperture is an interiomarginal slit.

Remarks. This species resembles *G. soldanii* but differs from it by the backward swept sutures on the spiral side.

This species was found between 114 and 700 m water depth off Peru and Ecuador.

Distribution. Recent, North and South Pacific (Brotzen, 1936); recent, Sahul Shelf and Timor Sea (Loeblich & Tappan, 1994); recent, NE Atlantic (Murray, 1971); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 208-415 µm.

Gyroidina soldanii d'Orbigny 1826

* 1826 *Gyroidina soldanii* – d'Orbigny: [type figure not given].

. 1988 *Gyroidina soldanii* – Whittaker: p. 132, pl. 18, figs. 13-15.

. 1994 *Gyroidinoides soldanii* – Jones: pl. 107, figs. 6-7 [cop. Brady, 1884].

Diagnosis. A medium sized Gyroidina with four whorls visible on the spiral side. Sutures distinct and straight radial on the spiral side (Whittaker, 1988) and straight or slightly curved on the umbilical side. Deep open umbilicus. Smooth surface, no pores visible with binocular. Aperture is an interiomarginal slit.

Remarks. This species differs from *G. neosoldanii* by its radial sutures on the spiral side.

This species was found at water depths between 114 and 700 m off Peru.

Distribution. Cenozoic of Ecuador (Whittaker, 1988); recent, South Pacific and North pacific (Jones, 1994 [cop. Brady, 1884]).

Diameter: 166-415 µm.

Gyroidina soldanii var. *multilocula* Coryewll & Mossman 1942

(Pl. 4, figs. 2-3)

* 1942 *Gyroidina soldanii* d'Orbigny var. *multilocula* – Coryell & Mossman: pl. 36, fig. 20.

Diagnosis. A medium sized Gyroidina. Sutures distinct and straight radial on the spiral side (Whittaker, 1988) and straight or slightly curved on the umbilical side. Deep open umbilicus. Smooth surface, no pores visible with binocular. Aperture is an interiomarginal slit.

Remarks. This variety is discriminable from typical *G. soldanii* by having 12 to 14 chambers. The typical species has maximum of 10 chambers (Coryell & Mossman, 1942). Usually the specimens found in our study are bigger on average than the typical specimens of *G. soldanii*.

It differs from *Hansenisca soldanii* (Loebllich & Tappan, 1988) in having no umbilical flaps.

This species was found off Peru and Ecuador between 298-995 m water depth.

Distribution. Pliocene, tropical East Pacific, off Panama (Coryell & Mossman, 1942)

Diameter: 291-664 µm.

Hanzawaia boueana d'Orbigny 1846

* 1846 *Truncatulina boueana* – d'Orbigny: p. 169, pl. 9, figs 24-26.

. 1994 *Hanzawaia boueana* – Loeblich & Tappan: p. 601, pl. 364, figs. 1-8.

. 2006 *Hanzawaia boueana* – Mojtahid et al.: p. 68, pl. 2, fig. 17.

Diagnosis. A medium to large, rounded, plano-convex species. Test consists of nine chambers per whorl, visible from both sides, flattened on the ventral side but strongly convex on the dorsal side. Chambers gradually increase in size as added, possessing flap-like protrusions projecting from their inner marginal base and covering partially the umbilical depression. Sutures distinct, very slightly curved backwards and slightly depressed, limbate on the ventral side. Periphery rounded, slightly lobulate, carinate on the ventral side. Dorsal umbilicus round and strongly depressed. Aperture is an elongated slit on the base of the last chamber. Periphery smooth but densely perforated, transparent.

Remarks. An extremely rare species in this study. It was found at one station off Peru in 350 m water depth (3°45'S/81°7'W).

Distribution. Middle Miocene, Vienna Basin, Austria (d'Orbigny, 1846); recent, Timor Sea (Loeblich & Tappan, 1994); recent, Gulf of Guinea (Mojtahid et al., 2006).

Diameter: 581-672 µm.

***Hanzawaia mexicana* Lankford 1973**

(Pl. 4, figs. 4-5)

* 1973 *Hanzawaia mexicana* – Lankford: pl. 6, figs. 20 a-c.

. 1987 *Hanzawaia mexicana* – Crouch & Poag: p. 168, pl. 2, fig. 7.

Diagnosis. A rare medium sized plano-convex foraminifera. The planar ventral side is carinate and slightly evolute with flap-like protrusions on the inner marginal base of the chambers whereas the convex dorsal side is involute. Test consists of six to eight chambers in the last whorl. Chambers increasing gradually in size as added, last chamber elongated, somewhat tapered to the upper apical end. Sutures are distinct, slightly depressed and curved. Smooth surface perforated by numerous pores. The aperture is located on the ventral base of the last chamber and is surrounded by a slight lip.

Remarks. Very rare in our study. It was found at three stations off Peru and Ecuador in 207 to 579 m water depth. This species seems to be the only recent *Hanzawaia* species which shows not only the distinct plano-convex shape but also the slight trochospiral part formed by the last chambers and by possessing additional umbilical flaps.

Distribution. Central Indian Ocean (Scott & Leger, 1990), recent, off Baja California, E-Pacific (Lankford & Phleger, 1973); recent, off southern Baja California, Mexico (Crouch & Poag, 1987).

Diameter: 208-664 µm.

Hanzawaia prona **Poag 1966**

* 1966 *Hanzawaia prona* – Poag: pl. 9, figs. 29-31.

Diagnosis. Test small to medium in size, plano-convex, consisting of eleven chambers in the last whorl, visible from both sides. Chambers limbate, high but narrow, increasing slowly in size as added. Periphery rounded, tapered to the planar side. A very slight keel is visible only when specimen is wetted. The umbilical part of the flat side is completely covered by thin, glassy lamellae protruding from the basal parts from the chambers. Sutures distinct, relatively broad and not depressed, curved slightly backwards. Aperture is a short arched slit with a lip on the upper part of the opening. Surface smooth and transparent , covered by densely distributed pores.

Remarks. Very rare in this study. It was found at one station off Peru in 114 m water depth (9°3'S/79°26'W).

Distribution. Lower Miocene (?), west bank of the Chickasawhay River, Wayne County, Mississippi, U.S.A. (Poag, 1966).

Diameter: 166-614 µm.

***Nonion commune* d'Orbigny 1846**

* 1846 *Nonionina communis* – d'Orbigny: pl. 5, figs. 7, 8.

. 1994 *Nonion commune* – Jones: pl. 109, figs. 14-15 [cop. Brady, 1884].

Diagnosis. Test small, plani-spiral, sub-rounded with acute periphery, very slightly limbate. Two whorls with nine slightly inflated chambers in the last whorl, visible from both sides. Chambers high but narrow, increasing gradually in size, getting broader at their base and higher. Test broadest at the umbilical parts of the last formed chamber. Sutures distinct and depressed, radial. Aperture is a small arched opening at the central part of base of the last chamber. Surface smooth, translucent, shiny.

Remarks. This species was found between 114 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, west coast of Patagonia, East Pacific (Jones, 1994 [cop. Brady, 1884]).

Diameter: 208-291 µm.

Nonionella auris d'Orbigny 1839

(Pl. 4, fig. 6)

* 1839 *Valvulina auris* – d'Orbigny: p. 47, pl. 2, figs. 15-17.

. 1994 *Nonionella auris* – Loeblich & Tappan: p. 582, pl. 345, figs. 5-16.

Diagnosis. A small, stout, rounded, plani-spiral species. Spiral side evolute, umbilical side involute with a deep umbilicus, which is covered by a strong elongated protrusion, projecting from the base of the last chamber. Test consists of a variable number of moderately inflated, high but narrow chambers, which are increasing gradually in size as added. The number of chambers appears to be dependent from the age of the specimens. Small individuals have about eight chambers in the last whorl, whereas large individuals show ten or more chambers in the last whorl. Sutures distinct and depressed. Aperture is an arched slit at the base of the last chamber. Surface smooth, transparent

Remarks. Very rare in this study. Found at one station in 145 m water depth on 11°S off Peru.

Distribution. Recent, Timor Sea (Loeblich & Tappan, 1994).

Diameter: 125-274 µm.

***Nonionella japonica* var. *mexicana* Cushman & McCulloch 1940**

* 1940 *Nonionella japonica* Asano var. *mexicana* – Cushman & McCulloch: p. 160, pl. 17, fig. 10a-c.

Diagnosis. A small, plani-spiral species with ten to eleven chambers visible on both nearly symmetrical sides. Rounded periphery. Chambers narrow, inflated but compressed. Test very compressed from edge view. Sutures distinct and sharply incised. Aperture is a small opening at the base of the last chamber.

Remarks. A very rare species. Only one living specimen was found off Peru in 291 m water depth.

Distribution. Recent, off Clarion Island, E-Pacific, Mexico; off California and Galapagos Islands (Cushman & McCulloch, 1940).

Diameter: 415 µm.

***Nonionella stella* Cushman & Moyer 1930**

(Pl. 4, fig. 7)

* 1930 *Nonionella miocenica* Cushman var. *stella*: Cushman & Moyer: p. 56, pl. 7, fig. 17.

1964 *Nonionella stella* – Phleger: p. 379, pl. 1, figs. 33, 34.

. 1980 *Nonionella miocenica* – Ingle et al.: p. 135, pl. 2, figs. 15-18.

. 1990 *Nonionella miocenica* – Resig: p. 292, pl. 1, figs. 6-8.

. 1992 *Nonionella stella* – Kato: p. 391, pl. 3, fig. 8a-c.

. 1999 *Nonionella stella* – Bernhard & Bowser: p. 152, text fig. 1(A).

. 2005 *Nonionella stella* – Narayan et al.: p. 147, pl. 4, fig. 23.

Diagnosis. A very small, rounded, plani-spiral species. Chambers inflated, broader than high. Nine to ten inflated chambers visible on the umbilical side. The evolute, slightly trochoid spiral side shows two whorls with numerous chambers and the proloculus. Sutures are distinct and sharply incised. Chambers increasing gradually in size as added. The umbilicus is covered by a typical and distinct protrusion, which extends from the base of the last chamber. The Protrusion has small finger-like excrescences which cover the umbilical portions of the sutures. The aperture is a small basal opening of the last chamber and is bordered by a lip.

Remarks. This species is highly abundant at the stations with extremely low oxygen concentrations. That confirms former studies which showed that this species is an indicator for low-oxygen conditions.

This species was found at stations between 79 and 375 m water depth off Peru.

Distribution. Recent, off W-Coast of Central America (Bandy & Arnal, 1957); recent, Peru-Chile Trench area (Ingle et al., 1980); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005); recent, off California (Bandy et al., 1965); recent, Gulf of California (Phleger, 1964); recent, off Peru (Resig, 1990); living, Santa Barbara Basin, off California, U.S.A. (Bernhard & Bowser, 1999); Miocene to Holocene, Japan Sea (Kato, 1992).

Diameter: 91-398 µm.

Nonionina grateloupii **d'Orbigny 1839**

(Pl. 4, fig. 8)

* 1839 *Nonionina grateloupii* – d'Orbigny: p. 46, pl. 6, figs. 6-7.

. 1994 *Nonionina grateloupi* – Loeblich & Tappan: p. 379, pl. 342, figs. 1-5.

Diagnosis. A small to medium sized, compressed, plani-spiral species. Test consists of slightly inflated but marginally compressed chambers, ten visible in the last whorl. Chambers high but narrow. One side evolutely and the other involutely coiled, whereas the involute side shows a deeply depressed umbilicus. Periphery rounded and slightly lobate. Sutures distinct and incised. Aperture is a low arched opening at the base of the last chamber. Surface smooth, shiny and transparent.

Remarks. This species is closest to the figures displayed in Loeblich and Tappan (1994) because they show clearly the umbilical flap-like protrusions extending from the basal part of the chambers. The specimens of this study are broader from edge view but are consistent with the number of nine to ten chambers visible on the umbilical side, which is described by the principal author and shown by the figures of Loeblich and Tappan (1994).

Remarks. A very rare species in this study. Found at one station off Peru (11°S/78°09'W) in 319 m water depth.

Distribution. Recent, Timor Sea (Loeblich & Tappan, 1994).

Diameter: 58-415 µm.

***Oridorsalis* cf. *pauciapertura* Belford 1966**

* 1966 *Oridorsalis pauciapertura* – Belford: pl. 30, figs. 7-13.

Diagnosis. Test minute, stout, obese and trochospiral. Umbilical side involute, no umbilical depression. Spiral side evolute with a strongly convex centre. Last whorl consists of five chambers visible from both sides. Sutures distinct and depressed, nearly straight. Periphery rounded. Aperture is an arched opening at the lower central portion of the last chamber. Surface very smooth, glassy and transparent.

Remarks. Very rare. Only found at one station off Peru (10°53'S/78°46'W) in a water depth of 1923 m.

Distribution. For *O. pauciapertura*: Upper Miocene, New Guinea (Belford, 1966).

Diameter: 141 µm.

***Oridorsalis tenerus* subsp. *profundus* Saidova 1975**

* 1975 *Oridorsalis tenerus* Brady subsp. *profundus* – Saidova: pt. 3, pl. 75, fig. 9, pl. 76, fig. 1.

Diagnosis. Test medium to large, high trochospiral. Umbilical side involute, no umbilical depression. Spiral side evolute with a strongly convex centre. Last whorl consists of five chambers visible from both sides. Sutures distinct, depressed and straight. Periphery sub-rounded and keeled. Aperture is an arched opening at the lower central portion of the last chamber. Surface very smooth, glassy and transparent.

Remarks. Very rare in this study. Only found at one station off Peru (7°52'S/80°31'W) in a water depth of 627 m.

Distribution. Recent, northwest Pacific Basin, southeast of Honshu (Saidova, 1975).

Diameter: 340 µm.

Oridorsalis umbonatus **Reuss 1851**

* 1851 *Rotalina umbonata* – Reuss: p. 75, pl. 5, fig. 35a-c.

. 1951 *Eponides umbonatus* – Phleger & Parker: pl. 11, figs. 10a-b, 13a-b, 14a-b.

. 1981 *Oridorsalis umbonatus* – Resig: p. 661, pl. 8, fig. 8.

. 1988 *Oridorsalis umbonatus* – Whittaker: p. 136, pl. 19, figs. 1-3.

1990 *Oridorsalis umbonatus* – Resig: p. 294, pl. 3, fig. 3.

. 1991 *Oridorsalis umbonatus* – van Marle: p. 293, pl. 11, figs. 13-15.

. 1992 *Oridorsalis umbonatus* – Kato: p. 392, pl. 4, fig. 10a-c.

. 1995 *Oridorsalis umbonatus* – Schmiedl: p. 143, pl. 5, figs. 13-18.

. 1995 *Oridorsalis umbonatus* – Schönfeld & Spiegler: p. 220, pl. 1, fig. 9.

. 2001 *Oridorsalis umbonatus* – Schumacher: p. 147, pl. 7, figs. 8-10.

. 2005 *Oridorsalis umbonatus* – Hess & Kuhnt: p. 70, text. fig. 5a.

. 2005 *Oridorsalis umbonatus* – Narayan et al.: p. 147, pl. 4, figs. 33-34.

. 2007 *Oridorsalis umbonatus* – Lutze: p. 429, pl. 2, fig. 7.

. 2008 *Oridorsalis umbonatus* – Lobegeier & Sen Gupta: p. 106, pl. 2, fig. 14a-b.

Diagnosis. A medium sized, circular, biconvex. Test somewhat depressed, carinate periphery. Five to six chambers visible in the last whorl. Sutures distinct, slightly curved on the umbilical side but straight and backwards oriented on the spiral side. Umbilicus is a small depression. Aperture is vertical slit on the face of the last chamber. Surface smooth.

Remarks. A rare species in this study. Found at two stations in 492 and 579 m water depth off Peru (17°28'S/71°52'W and 11°S/78°23'W).

Distribution. Eocene, near of Berlin, Germany (Reuss, 1951); Cenozoic of Ecuador (Whittaker, 1988); living, Okhotsk Sea (Bubenshchikova et al., 2010); Late Quaternary, South China Sea (Jian & Wang, 1997; Jian et al., 1999); Neogene and Quaternary, southern South China Sea (Hess & Kuhnt, 2005); recent, Mid-Atlantic Ridge (Hooper & Jones, 1977); recent, S-Atlantic (Schumacher, 2001); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); recent, Gulf of Mexico (Phleger & Parker, 1951; Lobegeier & Sen Gupta, 2008); off Cape Bojador, northwestern Africa (Lutze, 2007); recent, continental margin of NW-Africa (Lutze & Coulbourn, 1983/84); Cenozoic, off Vancouver Island, Canada (Narayan et al., 2005); off Peru (Resig, 1981, 1990); recent, Chile Triple Junction, southeastern Pacific (Schönfeld & Spiegler, 1995); recent, off Louisiana, U.S.A. (Schroeder, 2007); Late Cenozoic, Eastern Indonesia (van Marle, 1991); Miocene to Holocene, Japan Sea (Kato, 1992).

Diameter: 208-498 µm.

Planulina ecuadorana **Cushman & Stevenson 1948**

(Pl. 3, figs. 16-18)

* 1948 *Planulina ecuadorana* – Cushman & Stevenson: pl. 10, fig. 29a-b.

. 1988 *Planulina ecuadorana* – Whittaker: p. 148, pl. 21, figs. 22-24.

Diagnosis. A medium to large, flat, virtually plani-spiral coiled species. Dorsal side flattened or even concave. Test consists of numerous chambers evolutely coiled up in two whorls, visible from both sides. About nine to eleven chambers in the last whorl. Chambers slightly inflated, increasing gradually in size as added. The chambers of the last whorl slightly increasing in their basal breadth, so that the chambers of the preceding whorl appear to lie in a depression. Periphery sub-rounded and lobate. Sutures distinct, strongly curved forwards, limbate, in the youngest part becoming depressed. “Aperture is a low opening at the base of the peripheral margin of the last-formed chamber” (Cushman & Stevenson, 1948). Surface smooth but densely covered by rather big pores, transparent.

Remarks. Very rare in this study. Found at one station off Peru (10°26’S/78°54’W) in a water depth of 521 m. This species differs from *P. limbata* (Natland) by the absence of a thickened keel, by the more curved sutures and the test is even more compressed.

Distribution. Lower Miocene, Pacific coast of Ecuador (Cushman & Stevenson, 1948); Cenozoic, Ecuador (Whittaker, 1988).

Diameter: 415-1079 µm.

Pullenia bulloides **d’Orbigny 1846**

* 1846 *Nonionina bulloides* – d’Orbigny: p. 107, pl. 5, figs. 9, 10.

. 1951 *Pullenia bulloides* – Phleger & Parker: p. 55, pl. 15, fig. 11.

. 1960 *Pullenia bulloides* – Barker: p. 175, pl. 84, figs. 12, 13 [cop. Brady, 1884].

. 1965 *Pullenia bulloides* – Todd: pl. 18, fig. 6a-b.

. 1981 *Pullenia bulloides* – Resig: p. 659, pl. 7, fig. 13.

. 1988 *Pullenia bulloides* – Whittaker: p. 166, pl. 24, figs. 30-32.

. 1990 *Pullenia bulloides* – Hermelin & Shimmield: p. 14, pl. 3, fig. 8.

. 1991 *Pullenia bulloides* – van Marle: p. 301, pl. 20, figs. 13-15.

. 1994 *Pullenia bikiniensis* – Loeblich & Tappan: p. 585, pl. 348, figs. 7-14.

. 1995 *Pullenia bulloides* – Schmiedl: p. 145, pl. 6, figs. 3, 4.

1995 *Pullenia bulloides* – Wollenburg: p. 52, pl. 5, figs. 9, 10.

Diagnosis. A small and stout species of *Pullenia*. Test robust, nearly globular, consists of four visible, inflated chambers. Chambers increasing just slightly in size as added. Sutures distinct and slightly depressed. Aperture is the opening at the base of the last chamber, following the outline of the last whorl. Surface very smooth, shiny, white.

Remarks. This is a rare species in this study. It was found at two stations off Peru in 995 and 1923 m water depth.

Distribution. Recent, off Peru (Resig, 1981); recent, tropical Pacific (Todd, 1965); recent, Timor Sea, Sahul Shelf (Loeblich & Tappan, 1994); Cenozoic of Ecuador (Whittaker, 1988); Austria, Tertiary of Vienna Basin (d'Orbigny, 1846); recent, off NW-Africa (Lutze & Coulbourn, 1983/84); recent, Arctic Ocean (Wollenburg, 1995); recent, NW Indian Ocean (Hermelin & Shimmield, 1990); late Quaternary, eastern S-Atlantic (Schmiedl, 1995); recent, N-Pacific and S-Atlantic (Barker, 1960 [cop. Brady, 1884]); recent, Gulf of Mexico (Phleger & Parker, 1951); recent, Porcupine Sea bight, NE-Atlantic (Schönfeld et al., 2010); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 141-457 µm.

Pullenia elegans **Cushman & Todd 1943**

(Pl. 4, fig. 10)

* 1943 *Pullenia elegans* – Cushman & Todd: p. 23, pl. 4, fig. 11.

Diagnosis. A medium sized compressed *Pullenia* which composed of 7 involutely coiled chambers. The surface is very smooth and white in colour. Sutures distinct and slightly curved backwards. The aperture is low, following the outline of the last whorl (Cushman & Todd, 1943). The face of the last chamber his rather high. The umbilical parts of the chambers overlap irregularly, resulting in an uneven joining of the sutures at the umbilicus (Cushman & Todd, 1943).

Remarks. This species differs from *Pullenia subcarinata* in being more compressed. The last chamber is not broader than the early chambers and the umbilicus is not a depressed hole.

It’s a common species in this study. It was found between 375 and 2092 m water depth off Peru and Ecuador.

Distribution. Recent, off California (Cushman & Todd, 1943).

Diameter: 581-747 µm.

Pullenia subcarinata **d’Orbigny 1839**

(Pl. 4, fig. 9)

* 1839 *Nonionina subcarinata* – d’Orbigny: p. 28, pl. 5, figs. 23-24.

. 1960 *Pullenia subcarinata* – Barker: p. 175, pl. 84, figs.14-15 [cop. Brady, 1884].

. 1970 *Pullenia subcarinata* – Boltovskoy & Theyer: pl. 5, fig. 18a-b.

. 1981 *Pullenia subcarinata* – Resig: p.653, pl. 4, fig. 5.

. 1988 *Pullenia subcarinata* – Whittaker: p. 166, pl. 24, figs. 33-38.

. 1995 *Pullenia Subcarinata* – Schmiedl: p. 145, pl. 6, figs. 5,6.

. 2001 *Pullenia subcarinata* – Schumacher: p. 151, pl. 9, figs. 13-16.

Diagnosis. A medium sized *Pullenia*. A plani-spiral coiled species with 6-8 chambers in the last whorl. Test robust, rather obese, and slightly ovate to round in outline. Chambers increasing gradually in size as added. The last chamber becomes wider at the umbilical parts and covers partially the umbilical part of the penultimate chamber. Sutures distinct and sharply notched. Aperture is a narrow opening, following the basal extension of the last chamber. Surface very smooth, whitish.

Remarks. This species was found in stations between 302 and 823 m water depth off Peru.

Distribution. Recent, off Falkland Islands (d'Orbigny, 1839); recent, off central Chile (Boltovskoy & Theyer, 1970); recent, off Peru (Resig, 1981, 1990); recent, S-Pacific, Kerguelen Islands (Barker, 1960 [cop. Brady, 1884]); Cenozoic of Ecuador (Whittaker, 1988); recent, S-Atlantic (Schumacher, 2001); late Quaternary, eastern S-Atlantic (Schmiedl, 1995).

Diameter: 398-863 µm.

Pulvinulinella subperuviana **Cushman 1926**

(Pl. 4, figs. 11-12)

* 1926 *Pulvinulinella subperuviana* – Cushman: pl. 9, fig. 9.

1981 *Epistominella subperuviana* – Resig: p. 651, pl. 3, fig. 12.

. 1990 *Pseudoparella subperuviana* – Finger: p. 210, plate figs. 1-3, 4-9.

Diagnosis. A small trochospiral species. Test consists of ten to twelve chambers in the last whorl. Sutures distinct, even, slightly curved backwards on the spiral side, straight or very slightly curved on the umbilical side. Spiral side evolute, slightly convex on its central portion, usually two whorls visible. Periphery slightly lobate, subacute. Aperture is a narrow slit at the central base of the last chamber. Surface smooth, shiny, transparent.

Remarks. A common species. It was found at stations between 79 and 1004 m water depth off Peru.

Distribution. Upper Miocene, San Luis Obispo, California, U.S.A. (Cushman, 1926); recent, off Peru, (Resig, 1981, 1990); Neogene, California, U.S.A. (Finger, 1990).

Diameter: 58-266 µm.

Rosalina vilardeboana **d'Orbigny 1839**

* 1839 *Rosalina vilardeboana* – d'Orbigny: pl. 6, figs. 13-15.

. 1991 *Rosalina vilardeboana* – van Marle: p. 299, pl. 14, figs. 13-14.

. 1995 *Rosalina vilardeboana* – Jones: pl. 86, fig. 9 [cop. Brady, 1884].

Diagnosis. A small, trochospiral species with a slightly convex and evolute dorsal side and a slightly concave, involute ventral side. Periphery sub-rounded. Test consists of usually three whorls of chambers which are inflated at their umbilical side but flat at their spiral side. Increasing rapidly in size as added and possess curved, plate-like extensions at the base of the umbilical side. Five to six chambers visible from at the umbilical side. Umbilicus deep. Sutures distinct, slightly curved backwards and more depressed at the umbilical side than at spiral side. Surface smooth and transparent.

Remarks. Very rare species in this study. Three specimens were found at 1004 m water depth off Peru (10°59'S/78°31'W).

Distribution. Recent, off Falkland Islands, S-Pacific (d'Orbigny, 1839); recent, off Hongkong, Pacific (Jones, 1995 [cop. Brady, 1884]); Late Cenozoic, Eastern Indonesia (van Marle, 1991).

Diameter: 125-249 µm.

***Valvulina oblonga* d'Orbigny 1839**

.*1839 *Valvulina oblonga* – d'Orbigny: p. 136, pl. 1, figs. 40-42

. 1960 *Cancris oblongus* – Barker: p. 219, pl. 106, figs. 4-5 [cop. Brady, 1884].

. 1988 *Cancris oblonga* – Whittaker: p. 116, pl. 15, figs. 16-19.

. 1991 *Cancris oblongus* – van Marle: p. 297, pl. 13, figs. 15-16, p. 299, pl. 14, fig. 1.

. 1994 *Cancris oblongus* – Loeblich & Tappan: p. 502, pl. 265, figs. 11-13.

Diagnosis. Adult individuals are medium to large in size. Test plani-spiral furled. Chambers gradually increasing as added. Last chamber elongated and slightly acuminated. Distinct sutures which are depressed on evolute umbilical side. Flaps protruding from base of the youngest chambers are covering umbilicus. Spiral side involute. Test surface smooth, very finely perforated and transparent.

Remarks. This species was found at four stations between 492 and 823 m water depth off Peru (17-11°S).

Distribution. Recent, off Tenerife (d'Orbigny, 1839); Cenozoic of Ecuador (Whittaker, 1988); recent, Timor Sea (Loeblich & Tappan, 1994); Late Cenozoic, Eastern Indonesia (van Marle, 1991); recent, off S-Africa and West Indies (Brady, 1884); Holocene, Adriatic Sea (Morigi et al., 2005).

Diameter: 141-1328 µm.

Valvulineria vilardeboana var. *glabra* Cushman 1927

(Pl. 4, fig. 13)

* 1926 *Valvulineria vilardeboana* (d'Orbigny) var. *glabra* - Cushman: p. 161, pl. 9, figs. 5-6.

1960 *Valvulineria glabra* – Uchio: p. 48, pl. 8, figs. 6-7.

. 1994 *Valvulineria glabra* – Loeblich & Tappan: p. 505, pl. 268, figs. 1-3.

Diagnosis. A medium to large sized, round shaped, plano-spiral species. Test transparent, and smooth with evenly distributed pores. Sutures slightly curved and distinct on both, umbilical and spiral sides. Chambers increasing slowly in size as added, slightly inflated. Deep umbilicus concealed by umbilical flaps protruding from the last few chambers. Spiral side evolute; showing all chambers including proloculus. Nine to ten chambers visible in the last whorl. Aperture is a narrow slit on the base of the last chamber.

Remarks. Specimens found in this study are densely perforated. This is a common species in this study. It was found at many stations between 114 and 995 m water depth off Peru and Ecuador.

Distribution. Recent, Sahul Shelf, Timor Sea (Loeblich & Tappan, 1994); recent, E-Pacific (Cushman, 1927); recent, off San Diego, California, U.S.A. (Uchio, 1960); Neogene and Quaternary, southern South China Sea (Hess & Kuhnt, 2005); recent, Gulf of Mexico (Lobegeier & Sen Gupta, 2008); recent, Okhotsk Sea (Bubenshchikova et al, 2008).

Diameter: 166-523 µm.

Plates

1 – 4

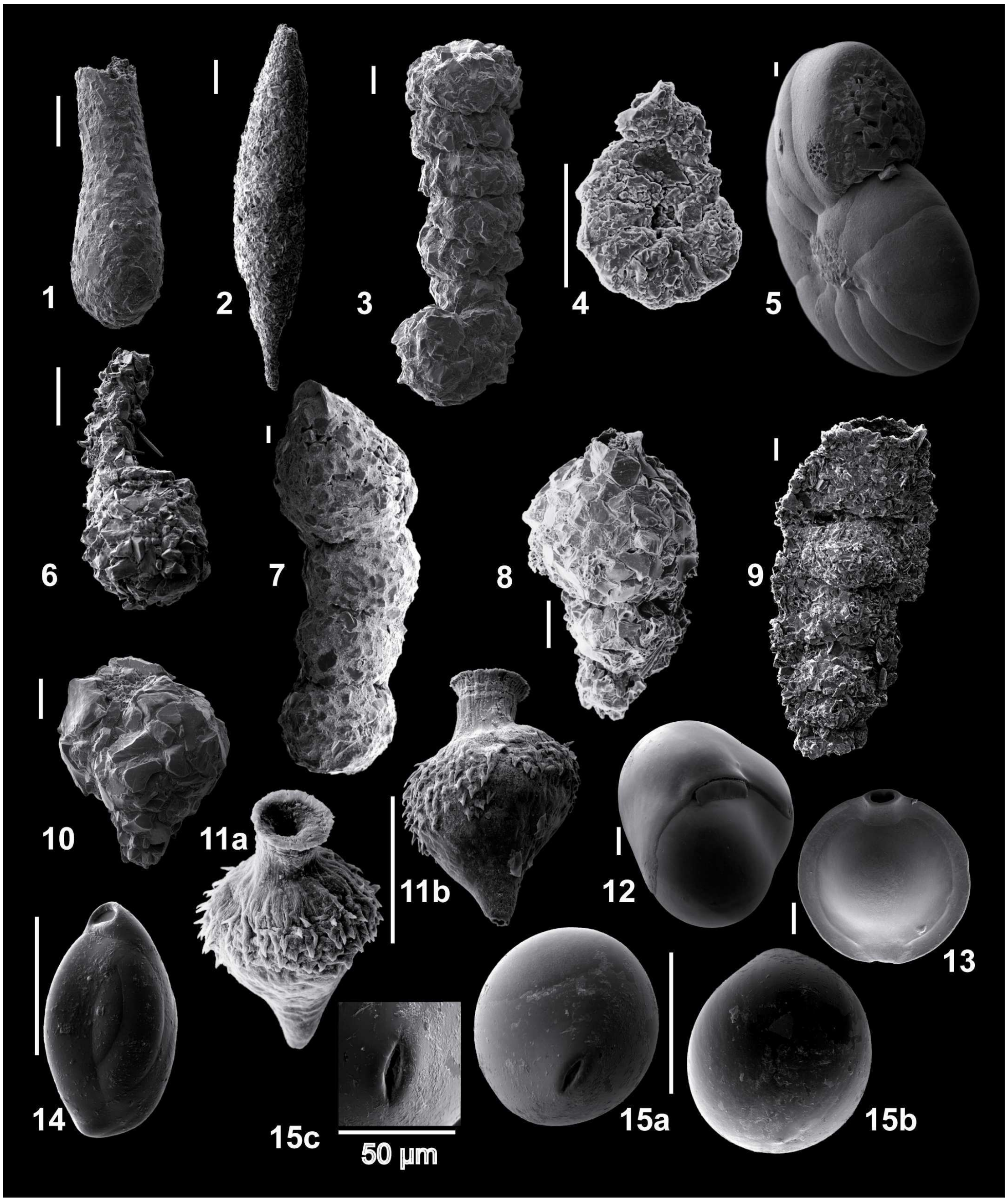


Plate 1. fig. 1. *Hyperammina friabilis*, 130X (p. 15). **fig.2.** *Technitella* sp., 72X (p. 18). **fig. 3.** *Ammobaculites agglutinans*, 70X (p. 23). **fig. 4.** *Ammomarginulina folicea*, 500X (p. 27). **fig. 5.** *Cyclammina cancellata*, 42X (p. 29). **fig. 6.** *Hormosinella distans*, 165X (p. 38). **fig. 7.** *Reophax apiculatus*, 43X (p. 40). **fig. 8.** *Reophax pilulifer*, 140X (p. 45)**. fig. 9.** *Reophax pisiformis*, 47X (p. 47)**. fig. 10.** *Eggerella humboldti***,** 140X (p. 62). **fig11a-b.** *Nubeculina* sp., 500X, a: oblique side view, b: side view (p. 68). **fig. 12.** *Planispirinoides bucculentus*, 110X (p. 70). **fig. 13.** *Pyrgo murrhyna*, 120X (p. 71). **fig. 14.** *Quinqueloculina seminula*, 430X (p. 72). **fig. 15a-c.** *Fissurina* sp., **a:** apertural view, 525X, **b:** side view, 500X, **c:** detail of **a**, aperture (p. 77). **Scale bars: 100 µm**

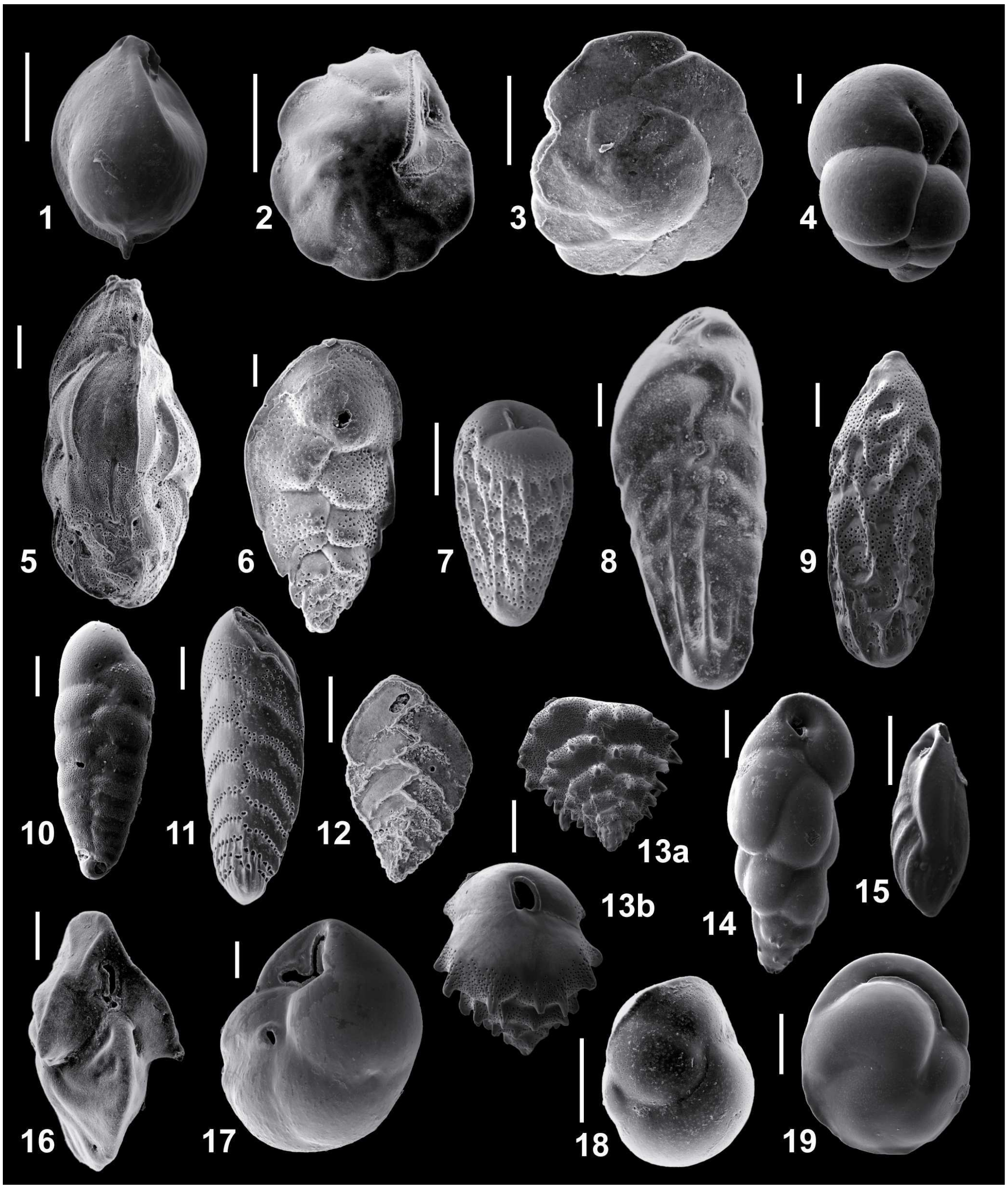


Plate 2. fig. 1. *Lenticulina pliocaena*, 400X (p. 85). **figs. 2-3.** *Epistominella pacifica*, **2:** umbilical side, 370X, **3:** spiral side, 370X (p. 92). **fig. 4.** *Robertina oceanica*, 220X (p. 94). **fig. 5.** *Angulogerina angulosa*, 180X (p. 95). **fig. 6.** *Bolivina alata*, 160X (p. 98). **fig. 7.** *Bolivina costata*, 350X (p. 100). **fig. 8.** *Bolivina interjuncta*, 120X (p.102). **fig. 9.** *Bolivina plicata*, 190X (p. 103). **fig. 10.** *Bolivina seminuda*, 200X (p. 105). **fig. 11.** *Bolivina spissa*, 200X (p. 108). **fig. 12.** *Bolivinita minuta*, 450X (p. 111). **fig. 13a-b.** *Bulimina pagoda*, **a:** oblique apical side, 340X, **b:** apertural side, 360X (p. 114). **fig. 14.** *Buliminella curta* var. *basispinata*, 190X (p. 117). **fig. 15.** *Buliminella elegantissima* var. *limbosa*, 400X (p. 118). **fig. 16.** *Cassidulina auka* var. A, 185X (p. 120). **fig. 17.** *Cassidulina crassa*, 175X (p. 121). **figs. 18-19.** *Cassidulina delicata*, **18:** dorsal view, 170X, **19:** apertural view, 350X (p. 122). **Scale bars: 100 µm**

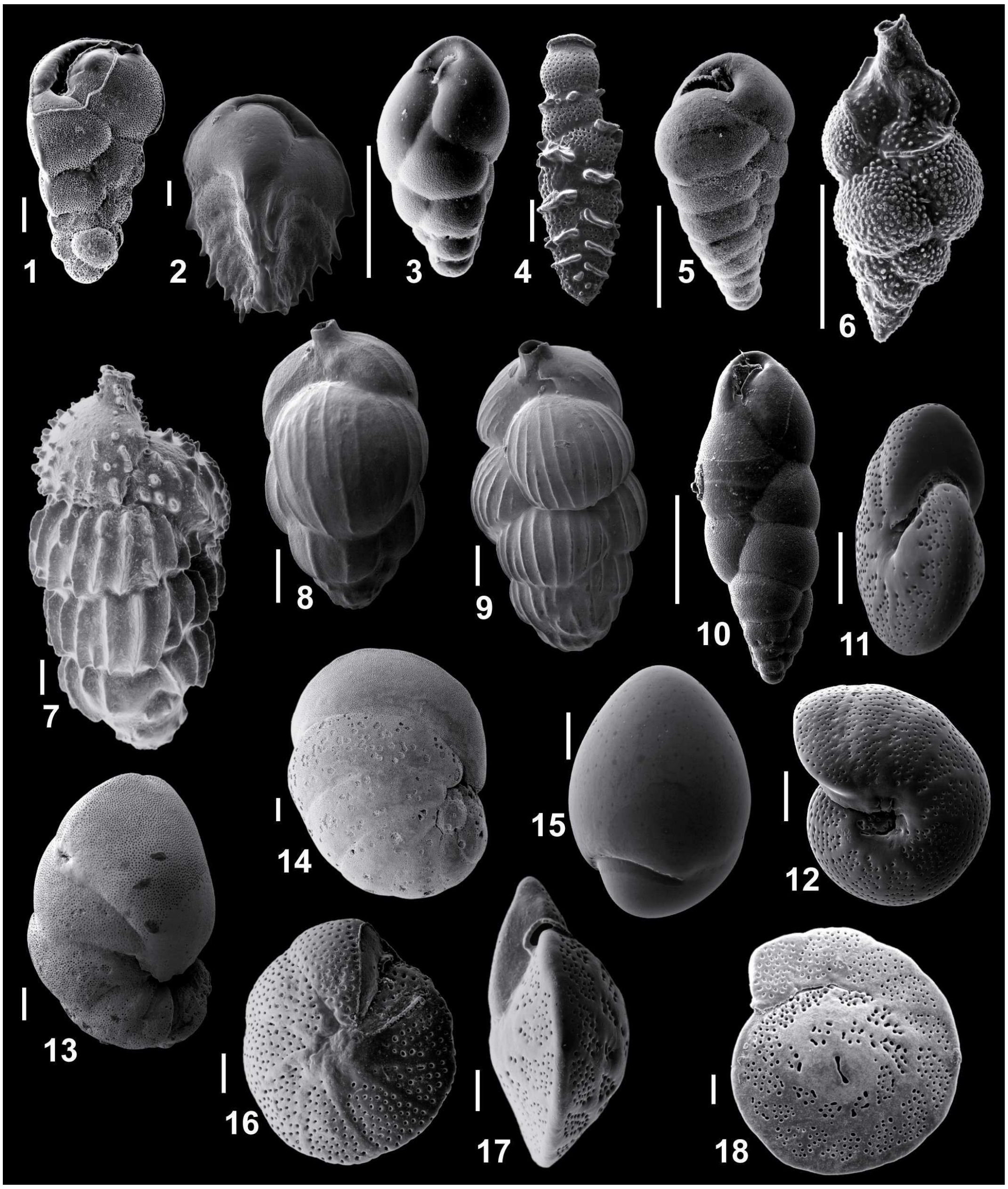
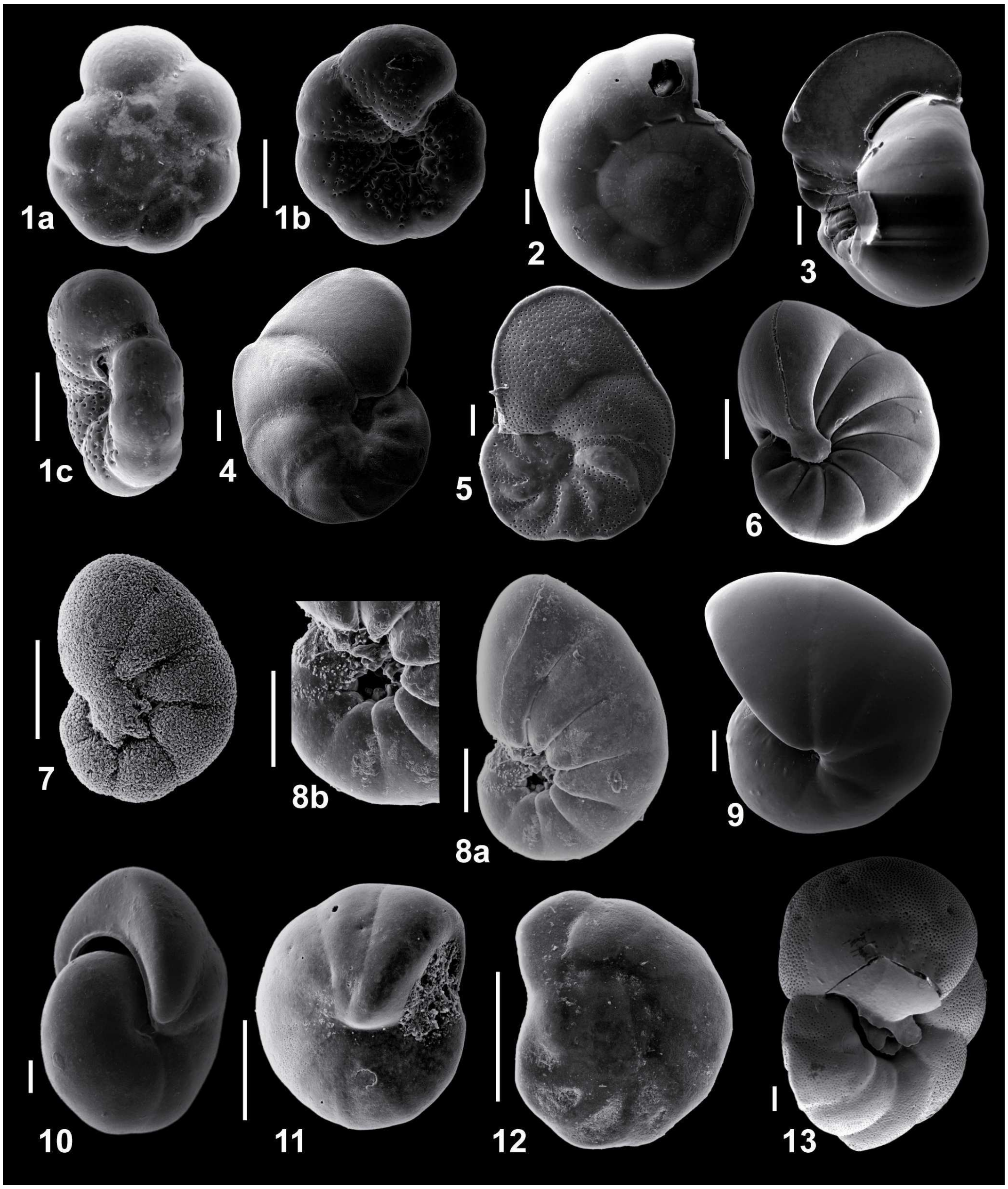


Plate 3. fig. 1. *Ehrenbergina compressa*, 180X (p. 125). **fig. 2.** *Ehrenbergina trigona*, 120X (p. 126). **fig. 3.** *Fursenkoina fusiformis*, 750X (p. 127). **fig. 4.** *Pseudobrizalina lobata*, 175X (p. 132). **fig. 5.** *Suggrunda porosa*, 500X (p. 135). **fig. 6.** *Uvigerina auberiana*, 400X (p. 136). **fig. 7.** *Uvigerina peregrina*, 130X (p. 138). **fig. 8.** *Uvigerina semiornata*, 200X (p. 140). **fig. 9.** *Uvigerina striata*, 150X (p. 141). **fig. 10.** *Virgulina bradyi*, 350X (p. 141). **figs. 11-12.** *Melonis barleeanum*, edge view, 330X (p. 145). **figs. 13-14.** *Cancris carmenensis***, 13:** umbilical side, 130X, **14:** spiral side, 100X (p. 145). **fig. 15.** *Chilostomella oolina*, 210X (p. 147). **figs. 16-18.** *Planulina ecuadoran*a. **16:** umbilical side, 180X, **17:** edge view, 200X, **18:** spiral side, 120X (p. 163). **Scale bars: 100 µm**



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Scale bars: 100 µm

3 Taxonomy of species

4.

Living benthic foraminifera of the Peruvian and Ecuadorian continental margin

4.1. Abstract

Living (Rose Bengal stained) benthic foraminifera from surface sediment samples and from deeper sediment levels down to 5 cm were examined from >63 µm fractions from off coast Peru and Ecuador. Samples were taken with a multicorer at 35 stations from depth range from 79 to 2092 m and between 17 and 1°S off Peru and Ecuador. A total of 170 living benthic species belonging to nine benthic foraminiferal orders were identified.

The eastern tropical and subtropical South Pacific represents an especial area to study a highly diverse assemblage of benthic foraminifera because of steep gradients in bottom water oxygen concentrations and food supply.

4.2. Introduction

The southwestern coast of South America was intensively studied for the distribution of benthic foraminifera (Bandy & Rodolfo, 1964; Boltovskoy & Theyer, 1970; Ingle et al., 1980; Resig, 1981, 1990; Morales et al., 2006). However, the Peruvian and the Ecuadorian upper continental margins were rather unattended with regard to living benthic foraminiferal composition and distribution.

Apart from the problem of scarce data, different sampling methods as well as dealing only with dead assemblages and the use of different grain sizes the synonymy of species is still problematic.

Living benthic foraminifera of the Peruvian continental margin were investigated by Bandy and Rodolfo (1964) who considered only stations deeper than 2558 m in this area. The investigations by Boltovskoy and Gualancañay (1975) refer to living benthic foraminifera of the bay of Guayaquil.

This study provides an outline of the living benthic foraminiferal species found between 1 and 17°S off Peru and Ecuador (Fig. 4.1, Tab. 4.1) collected from surface and subsurface sediments down to 5 cm sediment depth during R/V *Meteor* cruise M77 Leg 1 and 2 from October to December 2008.

The distribution of benthic foraminiferal communities can be grouped into large-scaled areas of so called biogeographical provinces. These provinces at shallow waters are characterised by faunas which are “associated in space and time” (Valentine, 1968). Bio-provinces are mainly bordered by currents and or steep temperature gradients. For instance, Boltovskoy and Wright (1976) subdivided the world's shelf areas into seventeen provinces. Two cold water, seven warm water and eight temperate water provinces were discovered.

The Pacific coast of South American Pacific is inhabited by a temperate water fauna up to 4°S. North of 4°S a warm-water fauna is recognized. Our study area comprises these two biogeographical provinces. The northernmost part from Bay of Guayaquil (~3°S) up to the North is denominated "Panamanian province" and the coastal area south of Guayaquil Bay is named "Chilean-Peruvian province". The northward transition from the temperate Chilean-Peruvian to the Panamanian warm water province at about 4°S is related to the westward bending of the cold Peru Chile Current and the increasing influence of the warm South Equatorial Current.

4.3. Study area

The west coast of South America is characterised by steep bathymetrical gradients between a narrow shelf and the abyssal plain which are separated by a deep trench. At medium to shallow water depths, at between ca. 80 and 550 m water depth, the Peruvian and, to a somewhat less extant, the Ecuadorian continental margin are affected by cold but nutrient rich, severely oxygen depleted water masses. This wind-driven upwelling-system accounts for the most extant oxygen minimum zones and large amounts of organic matter accumulate at the sea floor under these conditions due to good preservation. The study area comprises stations beyond within and at the upper boundary of the OMZ as well as stations under the northern extension of the OMZ.

Large numbers of sulphide-oxidizing bacterial mats (*Thioploca* spp.) and nematodes are present in the upper sediment layers as described by previous authors (e.g. Levin et al., 2002; Gutierrez et al., 2008).

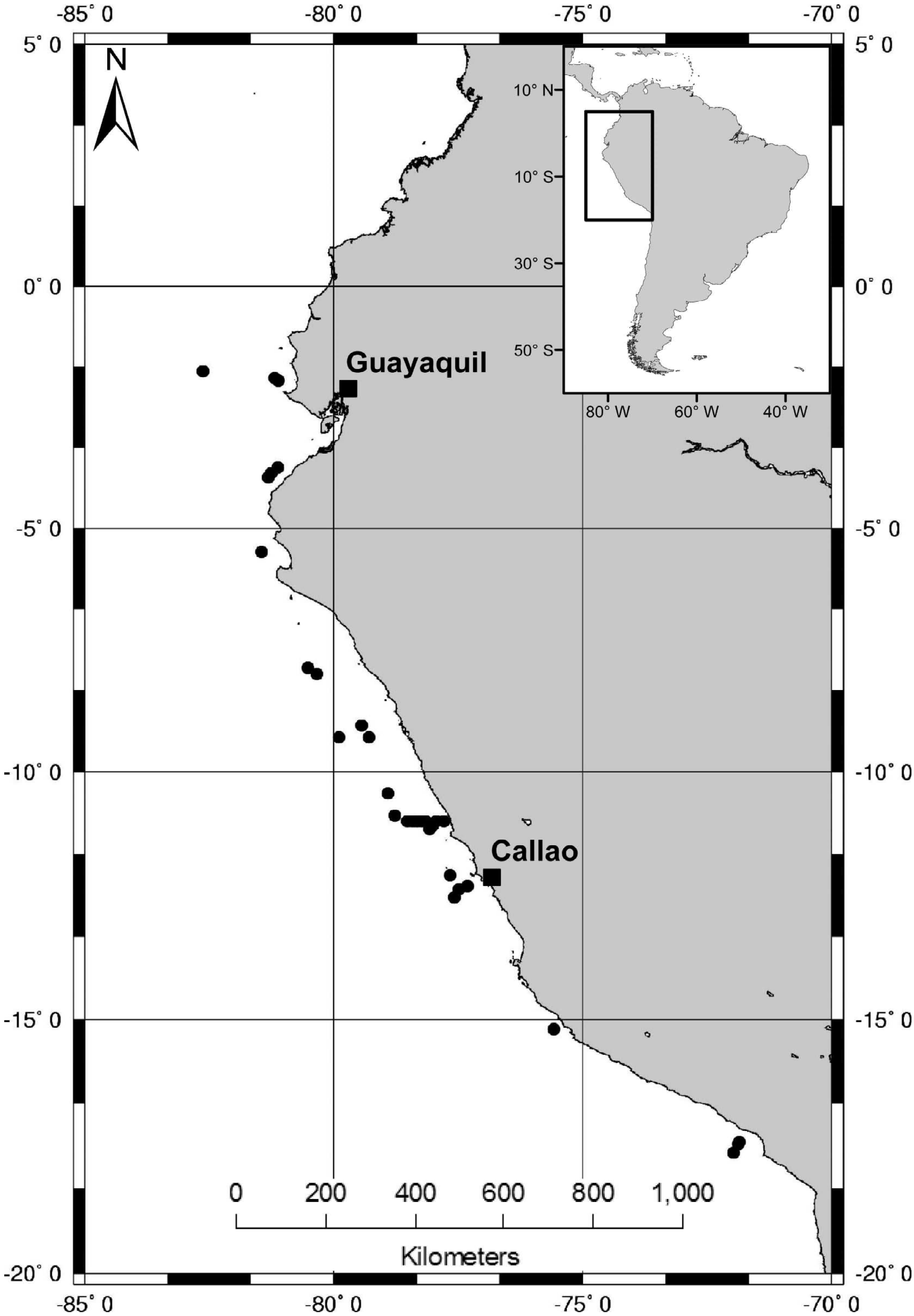

Figure. 4.1. Geographical setting and locations of sampling.

Site	Longitude (W)	Latitude (S)	water depth [m]
M77/1-403/MUC-4	71°51.41'	17°26.01'	298
M77/1-406/MUC-6	71°52.40'	17°28.00'	492
M77/1-410/MUC-10	71°58.23'	17°38.38'	918
M77/1-421/MUC-13	75°34.82'	15°11.38'	522
M77/1-449/MUC-19	78°09.97'	11°00.01'	319
M77/1-456/MUC-22	78°19.23'	11°00.13'	465
M77/1-459/MUC-25	78°25.60'	11°00.03'	697
M77/1-470/MUC-29	77°56.60'	11°00.02'	145
M77/1-473/MUC-32	78°09.94'	11°00.01'	317
M77/1-482/MUC-34	78°14.17'	11°00.01'	375
M77/1-487/MUC-38	78°23.17'	11°00.00'	579
M77/1-516/MUC-40	78°20.00'	11°00.00'	511
M77/1-540/MUC-49	77°47.40'	11°00.01'	79
M77/1-549/MUC-53	78°31.26'	10°59.80'	1004
M77/1-553/MUC-54	78°54.07'	10°26.38'	521
M77/1-582/MUC-64	78°04.88'	11°09.69'	291
M77/1-583/MUC-65	78°03.06'	11°06.86'	248
M77/1-616/MUC-81	77°29.05'	12°22.69'	302
M77/1-619/MUC-83	77°19.01'	12°18.06'	152
M77/1-622/MUC-86	77°34.75'	12°32.75'	823
M77/2-635/MUC-5-4	77°40.07'	12°05.66'	214
M77/2-669/MUC-22-3	78°46.38'	10°53.22'	1923
M77/2-676/MUC-24-5	78°00.91'	11°05.01'	211
M77/2-684/MUC-28-2	79°53.86'	9°17.69'	1105
M77/2-692/MUC-29-6	79°17.07'	9°17.07'	437
M77/2-694/MUC-31-2	79°26.88'	9°02.97'	115
M77/2-716/MUC-45-3	80°20.51'	7°59.99'	359
M77/2-723/MUC-47-4	80°31.36'	7°52.01'	627
M77/2-734/MUC-52-4	81°27.00'	5°29.01'	1251
M77/2-744/MUC-56-2	81°07.27'	3°45.01'	350
M77/2-753/MUC-59-3	81°19.16'	3°56.95'	995
M77/2-757/MUC-60-3	81°15.49'	3°50.99'	700
M77/2-767/MUC-64-3	81°11.75'	1°53.49'	526
M77/2-772/MUC-65-3	81°07.23'	1°57.01'	207
M77/2-776/MUC-67-3	82°37.47'	1°45.14'	2092

Table 4.1. Coordinates and water depths of sample locations.

The sediments of the oxygen depleted stations of the OMZ are predominantly composed of dark olive-green muds containing high amounts of organic material. The lower part of the OMZ is characterized by the occurrence of phosphorites in form of nodules or pellets of various sizes. Deeper stations well below the OMZ are coarser and contain more tests of planctonic and agglutinated foraminifera. Sediments of the shelf and upper most slope contain variable amounts of mica and quarz grains.

4.4. Material and methods

Surface sediments were collected during October and December 2008 with a TV-guided multicorer (tube-Ø = 10 mm) at 35 stations off Ecuador and Peru between 1 ° and 17°S. The Sediment-cores were sliced in 2, 3, 5 or 10 mm intervals to a maximum sediment depth of 5 cm. Immediately afterwards the sediment slices were preserved a solution of 2 g Rose Bengal per liter 96%-Ethanol and stored at 4°C ambient temperature until processing. Sieves were treated with Methylene Blue before every use to beware of contamination. A 2000 and 63 µm screen was used for washing. Most sample residues were dried at 50°C for dry picking. A few samples were filled in Nunc™ beakers and stored under Ethanol until wet picking. The choice of dried or wet picking was made depending on grain-size. The coarse fractions (>2000 µm) were dried at 50 °C and stored in polyethylene bags. If sieved samples contained more than 300 individuals, they were splitted into manageable aliquots by using an ASC™ microsplitter. Individuals were considered as living if at least 50% of the chambers were stained. In case of non-transparent agglutinated or miliolid species they were wetted and cracked with a needle to control if they contained protoplasm. The specimens were sorted at species level and counted.

4.4. Species distribution and diversity

The majority of species of Peru, showed similar distribution patterns as described in earlier studies from this area (e.g. Boltovskoy, 1976; Crouch & Poag, 1987; Resig, 1981, 1990). Living species from Ecuador were not described to date.

The majority of 170 living benthic species found in this study are calcareous and comprise 107 species (62.9%) versus 63 agglutinated species (37.1%). We found a dominance of the order Buliminida which makes up 35% of the total, followed by Lituolida (27%), Lagenida (13%), Textulariida (6.3%), Astrorhizida and Trochamminida (each 5.6%), Miliolida (4.2%)

and Robertinida (3.5%, figure 4.4). On a transect through the OMZ at 11°S we found 53 species at stations with <5 µmol/kg from which 10 species were agglutinated.

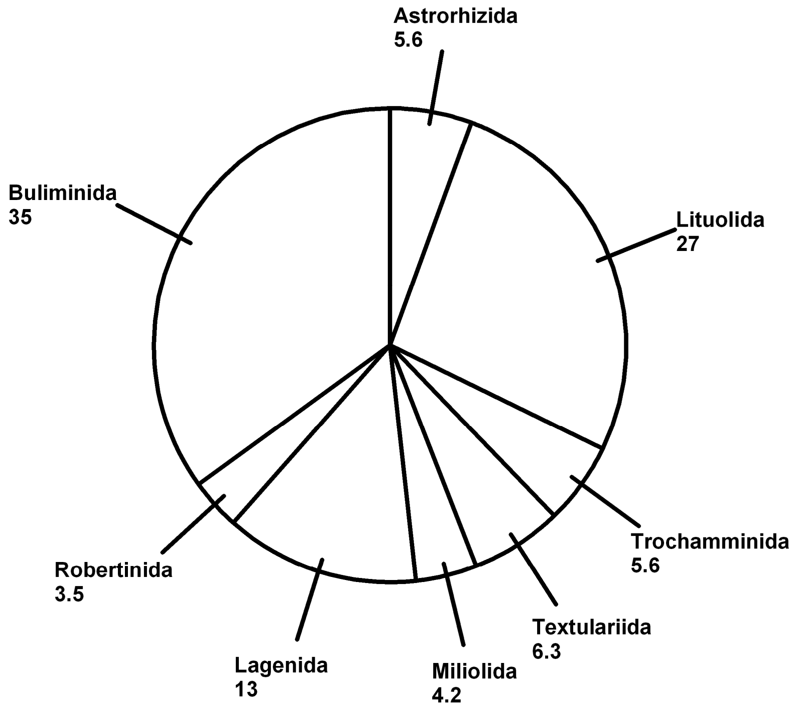

Figure 4.4. Compilation of benthic foraminiferal orders found in this study. Values represent percentages of total fauna.

The most common species in this study are *Bolivina costata*, *B. interjuncta*, *B. plicata*, *B. seminuda*, *Buliminella elegantissima* var. *limbosa*, *Cancris carmenensis*, *Cassidulina crassa*, *Fursenkoina fusiformis*, *Uvigerina peregrina* and *Valvulineria glabra*. All these species were also described in dead assemblages from Peru by Resig (1981 and 1990).

A differentiation between the Panamanian and Chilean-Peruvian province was proposed by Crouch and Poag (1987) who identified *Hanzawaia mexicana* as endemic for the Panamanian province. But Scott and Leger (1990) found this species also in subrecent sediments of the distal Bengal Fan. Actually we found this species in shallow water (207 m) and in high abundance at the northernmost stations and one specimen at a single station at 11°S and 579 m water depth. Thus, we showed that *H. mexicana* is not restricted to the coasts of Central and North America but even occurs south of Costa Rica. In respect to the study of Crouch and Poag (1987) this species has not been found south of Costa Rica.

A decreasing abundance of *B. costata* to the north, including the stations which belong to the Panamanian province was found. *B. costata* was found in most stations, infaunal under oxic and anoxic conditions. *B. interjuncta* was found between 17 and 1°45'S whereas *B. plicata* did not occur north of 3°45'S. Like *B. costata* these species occurred as well under oxic as under anoxic conditions but *B. interjuncta* covered a greater depth range (207-2092 m water depth) than *B. plicata* (145-579 m water depth). Thus, both species are common members of the Chilean-Peruvian and Panamanian province. These observations are in agreement with the data of Boltovskoy (1976). He additionally designated *Reophax scorpiurus* and *Globobulimina pacifica* as typical temperate species. However, we found different distribution patterns. Specimens of *R. scorpiurus* were found just in few stations between 10°26' and 1°57'S in low abundance. Highest abundances were observed in deep stations (1004 to 2092 m water depth). Thus, *R. scorpiurus* appears to be more a typical deep water species than a temperate water species. *G. pacifica* as a deep infaunal species was poorly represented in this study, even in subsurface and surface samples from the OMZ core, we found just low numbers of this species. This is in contrast to the TROX model (Jorissen et al., 1995) which suggests a migration of deep infaunal species to the surface when oxygen concentrations are low and eutrophic conditions prevail. It appears that the depth distribution of *G. pacifica* is seemingly restricted by distinct redox fronts in the sediment as it has been suggested for this species in the Arabian Sea OMZ (Jannink et al., 1998).

Bolivina seminuda is the most widely distributed species in the study area. It inhabits the complete depth range (79-2092 m water depth) and latitudinal range (17-1°45'S). Despite its wide occurrence, this species showed highest population densities in the OMZ core as it has observed by previously studies from the Peruvian OMZ (e.g. Oberhänsli et al., 1990; Resig, 1981; Smith, 1963) and the Arabian Sea OMZ (Gooday et al., 2000). *B. seminuda* was found within deepest sample intervals of stations at 79 (50 mm), 152 (30 mm) and 302 m water depth (20 mm) where anoxic conditions prevail already within the upper ca. 2 mm. Piña-Ochoa et al. (2010) showed that *B. seminuda*, amongst others, is able to store and denitrify nitrate, a fact, which makes this species well adapted for living under severely oxygen-depleted environments. Nitrate storage and denitrification were further evidenced by their study for few other species from the Peruvian OMZ, e.g. *Bolivina plicata*, *Cyclammina cancellata*, *Gyroidina neosaldanii*.

Buliminella elegantissima var. *limbosa* is restricted to shallow water depths (79-319 m) and was only found between 9 and 12°S. It protruded down to 50 and 20 mm sediment depth (79 and 302 m water depth).

Cancris carmenensis is more, but it occurred only between 17 and 7°S and covered a depth range of 214-627 m. Resig (1981) observed *C. carmenensis* restricted to the upper slope (between 151-500 m). The vertical distribution in sediments revealed that *C. carmenensis* is able to live not only under aerated but preferentially under anoxic conditions. At the OMZ stations, between 291 and 465 m water depth, it was found down to 15 mm sediment depth.

Cassidulina crassa occurred at stations below the OMZ core (465 to 823 m water depth) and at 298 m water depth at 17°S. Resig (1981, 1990) reported a similar depth range from 501-1000 m for *C. crassa* from the Nazca Plate area. This species favors cool water temperatures with oxic to suboxic conditions.

Fursenkoina fusiformis is a widely distributed species in this study. Specimens were found from 17 to 1°45'S in water depths from 79 to 1004 m and were observed in maximum sediment depths to 35 mm within the OMZ and down to 20 mm outside the OMZ. The distribution *F. fusiformis* was also found in other oxygen depleted locations (Gullmar Fjord, Sweden, Risgaard-Petersen et al., 2006).

Uvigerina peregrina is also widely distributed but preferentially occurred below the OMZ where oxygen concentrations exceed 4.8 µmol/kg (see also chapter 5). A latitudinal trend in respect to the extension of the OMZ is pronounced. Between 10 and 15°S, where the OMZ is most intense, no individuals were found in stations shallower than 520 m. The distribution of *U. peregrina* from different water depths leads to the conclusion that the occurrence of this species is limited by very low oxygen values but also takes advantage by high organic matter supply like it has been suggested by previous studies (e.g. Altenbach and Sarnthein, 1989; Rathburn and Corliss, 1994; Shepherd et al., 2007).

Valvulineria glabra occurred between 114 and 995 m water depth and between 17 and 1°S. This species is, like *C. carmenensis*, not restricted to oxic conditions but inhabits infaunal habitats (down to 20 mm sediment depth) even under anoxic conditions within the OMZ.

A large group of species found in this study are cosmopolitans. In particular *Buliminella elegantissima* var. *limbosa* and var. *tenuis*, *Uvigerina peregrina*, *Uvigerina semiornata* (= *U. bifurcata* sensu Boltovskoy, 1976 and Resig, 1990), *Ammobaculites agglutinans*, *Glomospira gordialis*, *Hoeglundina elegans*, *Oridorsalis umbonatus*, *Pullenia bulloides* and *Reophax scorpiurus* occur not only in the Pacific but also in the Atlantic and in the Indian Ocean. They occurred usually in low abundance. We found cosmopolitan species at the lower edge and beyond the OMZ. This has also been described in the studies of Schumacher et al. (2007) and Mullins et al. (1985) for the Arabian and Californian OMZ areas. They found *Bolivina* dominated assemblages within the OMZ and faunas dominated by *U. peregrina* below the OMZ. This is also typical for the Peruvian OMZ assemblages. Schumacher et al. (2007) observed very high percentages of *Bolivina dilatata* (up to 88%) within the OMZ core whereas the Peruvian OMZ core is dominated by *B. seminuda*. Therefore *Bolivina dilatata* was not recorded in the Peruvian OMZ.

Species which are restricted to samples off Ecuador (Panamanian province) are *Alveolophragmium scitulum*, *Dentalina filiformis*, *Eggerella humboldti* (=*Rhumblerella humboldti* sensu Hayward et al., 2006), *Lenticulina plioceana*, *Vaginulina americana* and *Verneuilina advena*. These species were very rare and occurred in low abundances. However, all these species are not endemic but have been reported from other areas. We found that assemblages characterized by high diversity are rich in rare species.

Values of Fisher's α diversity for core surface samples range between 0.7 for the oxygen depleted stations and deeper sediment intervals and 21.4 for the deepest, oxygen supplied bathyal core top at 2092 m water depth.

The diversity patterns show remarkable trends from very low diversity within the OMZ affected stations to high values outside the OMZ. This trend is not only vertically pronounced but also latitudinal in respect to the extension of the OMZ (Fig. 4.3.). The increasing trend in diversity from about 3°S to the north is in agreement with the changes in current regime and matches the northern boundary of the OMZ. It also probably delineates the transition from the Chilean-Peruvian to the Panamanian province.

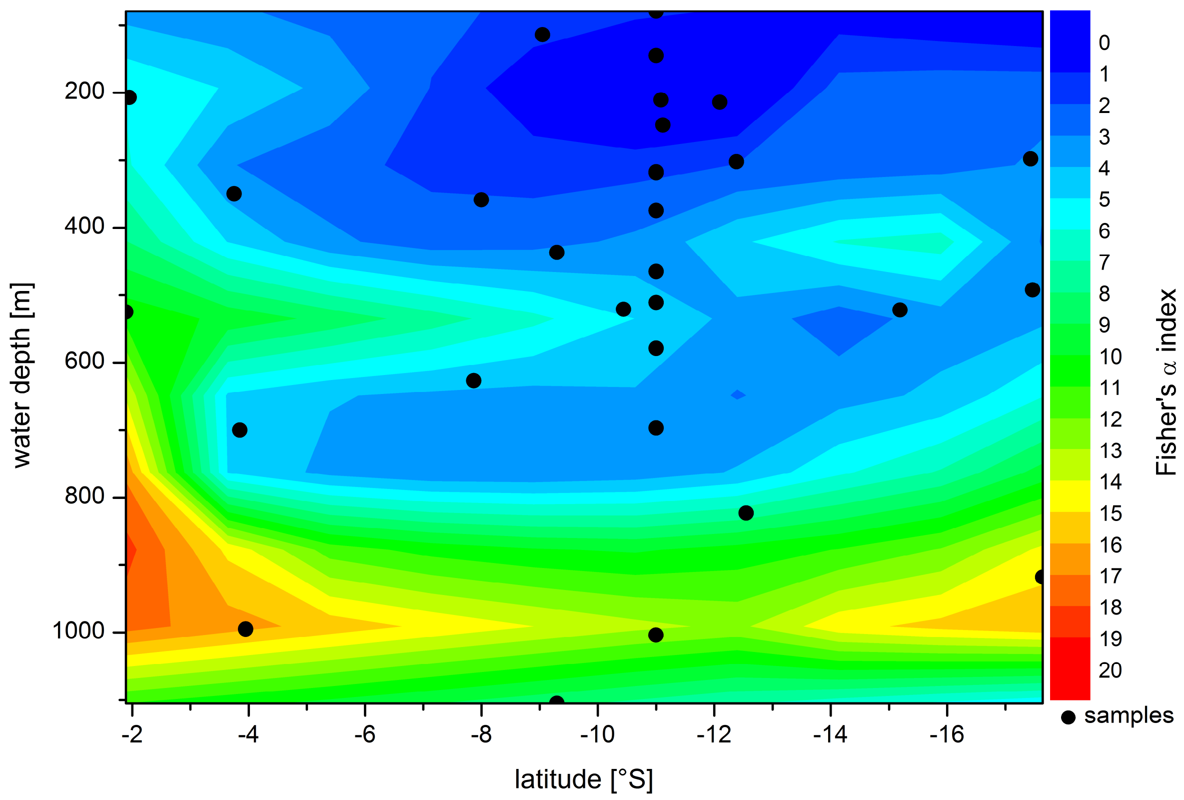

Figure 4.3. Fisher's alpha diversity plotted against latitude (1°57'-17°6'S, off Peru/Ecuador, parallel to the coast) and water depth (down to 1105 m) with black dots representing sampling locations. Despite of the interpolating uncertainty caused by absence of available samples, especially at low latitudes, a general trend of low diversity in the OMZ and increasing diversity outside the OMZ is clearly visible. Two stations at 1923 and 2092 m water depth (Fisher's alpha: 12.7 and 21.4, respectively) are not included.

In general, the trends of vertical distribution patterns in the Peruvian OMZ show a striking similarity to that of the Arabian Sea. High population densities in combination with low diversity occur within the OMZ were also observed in the Arabian OMZ (Jannink et al., 1998; Schumacher et al., 2007; Maas, 2000) and the California coastal upwelling system (Mullins et al., 1985). The vertical trend of population density in sediments is highest in surface sediments and then rapidly decreases with increasing depth.

In comparison with the study of Schumacher et al. (2007) and Maas (2000) for the Arabian OMZ, Fisher's alpha diversities from our study reached lower values within the OMZ but higher values outside the OMZ. Actually we found 53 living species in the stations within the OMZ core (<5 µmol/kg bottom water oxygen) whereas Schumacher et al. (2007) found a maximum of 37 living species within the OMZ core. Further, the Fisher's alpha diversity showed an increasing trend with increasing oxygen and depth whereas there is no clear trend in the Arabian Sea OMZ.

4.6. Concepts for diversity and endemism of benthic foraminifera in the southern tropical and subtropical East Pacific

The tropical and subtropical East Pacific counts as one of the most diverse marine habitats in the world. Prominent diversity hotspots are the areas between the Galapagos Islands and the NW coast of South America (Miloslavich et al., 2011) off Peru and Ecuador, the Indo-Australian Archipelago (Langer and Lipps, 2003; Renema et al., 2008; Makled and Langer, 2011 and references therein) whereas diversity decreases from the West to the East Pacific (Makled and Langer, 2011).

There are several approaches which may contribute to the understanding of the development of diversity and endemism for the tropical and subtropical South East Pacific. The approaches can be divided into two groups: those which base on tectonic processes, or biological substantiations. The latter is closely linked with oceanographic changes whereas certainly both kinds of approaches act together.

Tectonic approaches involve shifts in plate tectonic constellations which may build up new habitats for species but also for invading species from former disconnected continents (Renema et al., 2008). A relevant example is the closure of the Panamanian Isthmus in the Upper Plicocene which provided an increase of diversity in the warm waters of the Caribbean Sea mainly by the subsequent changes in oceanographic circulations (based on Collins et al., 1996 and Collins, 1999). Consequently, a discrete fauna could have been developed in the tropical and subtropical South East Pacific. High rates of endemism like it has been described by Miloslavich et al. (2011) for this area could be explained by the complex bathymetric and coastal structure and by the steep gradients in oxygen concentrations of the Peruvian OMZ which demand distinct adaptations by its inhabiting fauna.

A biological approach is the hypothesis of propagules as resting stages of benthic foraminifera which has been described by Alve and Goldstein (2002, 2010). Propagules are able to drift over long distances. This could be one key to explain the wide range exchange and dispersal of benthic foraminiferal species. It is likely that benthic foraminiferal diversification in the East Pacific is partly linked to transportation of propagules from the West Pacific biodiversity hotspot.

Further, anomalous oceanographic conditions like El Niño events may facilitate the exchange of species between the West and East Pacific like it has been demonstrated for pelagic larvae (Miloslavich et al., 2011 and references therein).

4. Living benthic foraminifera of the Peruvian and Ecuadorian continental margin

5.

The response of benthic foraminifera to low-oxygen conditions of the Peruvian oxygen minimum zone

Accepted in: Altenbach, A.V., Bernhard, J.M. and Seckbach, J. (eds.), ANOXIA: Evidence for eukaryote survival and paleontological strategies, Springer.

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5. The response of benthic foraminifera to low-oxygen conditions of the Peruvian oxygen minimum zone

5.1. Abstract

Recent benthic foraminifera and their distribution in surface sediments were studied on a transect through the Peruvian oxygen minimum zone (OMZ) between 10 and 12°S. The OMZ with its steep gradients of oxygen concentrations allows determining the oxygen-dependent changes of species compositions in a relatively small area. Our results from sediments of thirteen multicorer stations from 79 to 823 m water depth demonstrate that calcareous species, especially bolivinids dominate the assemblages throughout the OMZ. The depth distribution of several species matches distinct ranges of bottom water oxygen levels. The distribution pattern inferred a proxy which allows to estimate dissolved oxygen concentrations for reconstructing oxygen levels in the geological past.

5.2. Introduction

The upwelling system off the NW coast of South America constitutes one of the most widespread oxygen minimum zones. Severe oxygen depletion extends over large volumes of subsurface water masses between 80 and about 550 m water depth and effects a horizontal zonation of specially adapted faunal assemblages. The vertical distribution of population density and diversity of benthic foraminifera changes dramatically following the bottom water oxygen gradient. Many studies in areas where dissolved oxygen levels are low or even anoxic revealed that foraminiferal life flourishes under oxygen depleted conditions, resulting in conspicuously high foraminiferal population density but low species diversity (e.g. Phleger and Soutar, 1973, Bernhard et al. 1997, Gooday et al., 2000, Levin et al., 2002). The inhabiting fauna of such kind of oxygen depleted environment like the Peruvian OMZ requires special adaptations. Some benthic foraminiferal species we found in this study are known to be able to withstand anoxic or even sulfidic conditions for several weeks (Bernhard and Reimers, 1991; Bernhard and Sen Gupta, 1999; Geslin et al., 2004; Moodley et al., 1997).

Some of these adaptations, which have been observed in benthic foraminifera at low oxygen levels were the use of chloroplasts (Bernhard and Alve, 1996; Bernhard and Bowser, 1999; Grzymski et al., 2002), bacterial endo- and ectosymbionts (Bernhard and Reimers, 1991; Bernhard et al., 2001, 2009), intracellular nitrate storage (Risgaard-Petersen et al., 2006; Glud et al., 2009; Piña-Ochoa et al., 2010), peroxisomes (Bernhard and Bowser, 2008), clustering of mitochondria behind pore plugs (Leutenegger and Hansen, 1979; Bernhard et al., 2001) and high pore-density values of the tests (Glock et al., 2011).

On the sea floor bathed by OMZs, high amounts of organic matter accumulate due to enhanced preservation and provide a high supply of food for deposit feeders like benthic foraminifera. A concept which describes the effect of these two interacting parameters on the vertical distribution of living benthic foraminifera is the TROX-model of Jorissen et al. (1995). The maximum living depth of foraminifera in an oligotrophic environment depends on the available organic matter in the sediment. Oxygen availability is, on the other hand, the controlling factor which confines the maximum living depth of benthic foraminifera in eutrophic environments. The distribution patterns of living (Rose Bengal stained) species in this study mostly follow the TROX-model.

In this study, we describe the faunal composition and distribution patterns of living benthic foraminifera from surface sediments of thirteen multicorer stations along a composite depth section off Peru, consisting of a main transect at 11°S, three stations at 12°S and one at 10°S. The data were compared with bottom water [O_2] in order to depict the relationship between species distribution and [O_2]. A further aim of this study is the development of a benthic foraminiferal proxy for reconstruction of ancient bottom water [O_2] for the Peruvian OMZ.

5.3. Study area

The study area is located in the central part of the Peruvian OMZ between 10°S and 12°S off Peru (Fig. 5.1). Coastal water masses are subjected to wind-driven upwelling and carry cold nutrient-rich deep water to the surface. High primary production rates in the euphotic zone cause oxygen depletion resulting in an OMZ extending from northern Chile to near equatorial latitudes off the west coast of South-America. Dissolved oxygen values, derived from conductivity-temperature-depth-profiler (CTD) measurements between 10°S and 12°S, show oxic (>45 µmol/kg) values down to 31 m water depth. Beneath these surface waters, dissolved oxygen levels decrease to dysoxic conditions (5-45 µmol/kg), and even reach microxic to anoxic levels with values <5 µmol/kg[1] between 88 - 522 m. At least as deep as 944 m, levels begin to increase again to dysoxic conditions. For the classification of microxic, dysoxic and oxic conditions, we refer to limits of <5, 5-45 and >45 µmol/kg (Bernhard and Sen Gupta, 1999), respectively. The classification and ordering of different oxygen levels into several groups is not defined in a common sense. Therefore, different classifications are in use, for a further example Kaiho (1994), who subdivided four levels of oxygen conditions – anoxic (<0.1 ml/l), dysoxic (0.1-0.3 ml/l), suboxic (0.3-1.5 ml/l) and oxic (>1.5 ml/l). It is important to note that the actual oxygen concentration in the OMZ core certainly reach anoxic levels (<2 nmol/l, Revsbech et al. 2009), but the resolution of the CTD sensors used on R/V Meteor cruise M77 did not resolve extremely low dissolved oxygen concentrations (<2 µmol/kg). Consequently, we should assume that the CTD derived [O_2] values for the levels between 214 and 375 m water depth and values slightly lower than 2.5 µmol/kg were even lower. It is likely that they were in fact anoxic (Revsbech et al., 2009).

The sediments in this area are predominantly olive-green, organic-rich muds. High amounts of filamentous sulfide-oxidizing, nitrate-reducing bacteria (mainly *Thioploca* spp. and *Beggiatoa* spp.) form dense mats in some areas. Nematodes, annelids and small oligochaetes, together with benthic calcareous foraminifera, are common organisms in samples of the central part of the OMZ. Recent bioturbation by macroinvertebrates is nearly absent. The first bioturbating macroinvertebrates, e.g. small gastropods, occur at stations deeper than ca. 460 m water depth (at 11°S transect). Further characteristic features found in few sediment samples at the lower OMZ boundary are phosphorite nodules. They occurred at 465 and 516 m.

The degradation of sinking organic material is strongly attenuated in oxygen depleted environments. Thus, the organic matter accumulates and leads to high organic carbon values. The organic carbon content (C_{org}) at 11°S varies between 3 and 11 % in the upper 0.5 cm sediment interval and shows an inverse relationship to [O_2] within the OMZ but from the lower OMZ boundary to the deeper stations follows the increasing trend of [O_2] (Fig. 5.3). Highest C_{org} contents with 10.6 and 10.9 % were observed at the 319 and 376 m stations.

5.4. Materials and Methods

5.4.1. Sample processing

Thirteen sediment cores from the west coast off Peru between 10 and 12°S were analyzed for this study (Tab. 5.1). They were recovered during October and November 2008 by using a multicorer with 10 cm tube diameter. Immediately after recovery one tube of the array with the most even sediment surface was selected and brought to a laboratory container with ambient temperature of 4°C where the sediment core was sliced with a shuffle spatula in 2 mm, 3 mm or 5 mm intervals from 0 to 10 mm, in 5 mm intervals from 10 to 40 mm and in 10 mm intervals from 40 to 50 mm sediment depth. Subsamples were filled in Kautex™ bottles and stained with ethanol + Rose Bengal (2 g/l) for distinguishing living from dead individuals. Under cool and dark conditions they were transported and stored for further procedures.

Stained subsamples were gently wet sieved with tap water through 2000 and 63 µm screens. To beware of contamination, the sieves were thoroughly cleaned and treated with Metyhlene Blue before every use. The >2000 µm fraction (pebbles, gastropode shells etc.) were dried and archived in polyethylene bags. The 63-2000 µm fractions were dried at 40℃ and weighed before they were picked. If >63 µm fractions contained large amounts of sand, they were soaked again with tap water and wet picked. At least 100 stained specimens were picked per subsample in order to attain statistically reliable values. Some subsamples contained less than 100 stained specimens. In some cases it was necessary to split the subsamples into manageable aliquots by using an ASC™ sample microsplitter. Only individuals containing at least 50 % of all chambers brightly stained were considered as individuals that were living at the time of sampling. After they were picked, the specimens were sorted, fixed in Plummer cells and counted. In our study we concentrated on the topmost multicorer subsamples, whereas the faunal census data of subsurface samples are provided online at: http://doi.pangaea.de/10.1594/PANGAEA.757092

5.4.2. Environmental data

For a comparison of foraminiferal distribution patterns with the bottom water dissolved oxygen concentrations, we used only the top-slices of every multicorer. The [O_2] was measured with an optode sensor mounted to a conductivity-temperature-depth profiler (CTD) at station M77/1-424-RO9 from 928 m water depth further off shore. The concentrations of dissolved oxygen as displayed by the sensor were calibrated by Dr. S. Sommer and S. Kriwanek using Winkler-titration method. The [O_2] from the CTD were projected to the respective water depths of stations were the multicorer for foraminiferal studies has been deployed. The underlying assumption of near-horizontal oxygen isolines was corroborated by in-situ measurements from benthic chamber lander deployments (S. Sommer, pers. comm.). Sedimentary organic carbon concentrations (C_{org}), which were obtained with a flush combustion element analyzer on freeze-dried surface sediment samples by Dr. C. Hensen.

5.5. Species distribution patterns of benthic foraminifera in the OMZ off Peru

The sampling transect of our study comprises a depth range from 79 to 823 m and intersects the OMZ. Sixty-nine living benthic foraminiferal species were identified from the multicorer samples but in the five samples subjected to [O_2] lower than 2,5 µmol/kg just eight to fourteen living species were found. Calcareous taxa were dominating the assemblages throughout the OMZ. Agglutinated taxa were negligible within the OMZ (<3% of the total to a water depth of 579 m). However, at stations deeper than 579 m with [O_2] exceeds 8.5 µmol/kg, they comprised more than 11% of the fauna and reached their maximum with 19.7% at 697 m water depth.

The comparatively low diversities in the OMZ are displayed by the averaged *Fisher's α* index. The stations within the OMZ core (214-375 m water depth, [O_2] <2.5 µmol/kg) yielded values around 1.9, whereas the *α* index was 3.8 at stations with higher oxygen values.

Highest values of foraminiferal population densities occurred in the surface sediments. All of the examined samples that were considered in this study showed the highest population densities between 2 and 3 mm sediment depth. The population densities showed a marked, inverse correlation with ambient bottom water [O_2] (Fig. 5.2). The stations of the OMZ core showed population densities between 473 and 1045 ind./ccm, reaching a maximum at 317 m water depth.

Although most of the species abundances as observed in our samples varied among the stations, several species showed conspicuous density patterns which compare to the dissolved bottom water oxygen concentrations. Systematic variations of species percentages with respect to water depth dependent [O_2] showed the most common species of the Peruvian OMZ, in particular *Angulogerina angulosa*, *Bolivina costata*, *Bolivina interjuncta*, *Bolivina plicata*, *Bolivina seminuda*, *Bolivinita minuta*, *Cancris carmenensis, Fursenkoina fusiformis*, *Nonionella stella*, *Uvigerina peregrina* and *Valvulineria glabra*. The majority of species within the immediate OMZ belong to the family *Bolivinitidae*. These species comprise 76-95% of the living assemblages in the samples between 214-375 m water depth (Fig. 5.3).

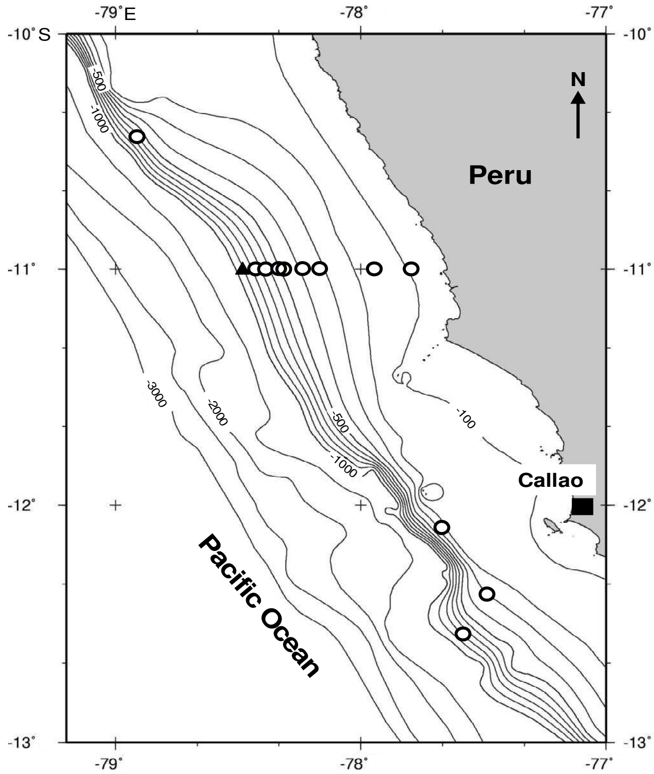

Figure 5.1. Study area with sampling locations (black dots) and CTD station (black triangle) offshore Peru.

At OMZ stations between 302 and 375 m water depth, *Bolivina seminuda* was the dominant species and accounted for 42 to 76% of the living fauna. This demonstrated that maximum values of *B. seminuda* in samples where the diversity was very low mutually indicate very low [O_2] as previously demonstrated by Oberhänsli et al. (1990). *Bolivina plicata* was more restricted to very low oxygen concentrations and occurred with 5 to 25% in 302-375 m water depth. It showed values of <1% or even disappears at higher oxygen concentrations. Another dominating bolivinid which reached its maximum abundance at slightly higher oxygen concentrations was *B. interjuncta*. This species showed two maxima with 52% at 465 m water depth and 20% at 521 m water depth. *Bolivina interjuncta* is restricted to the lower part of the OMZ. Other characteristic bolivinids were *Bolivina alata* and *Bolivina spissa*. They occurred also at the lower part of the OMZ. *B. alata* was found between 511 and 576 m water depth. It reached its maximum at 521 m water depth with 15.9% and < 2.2% at 511 and 576 m water depth. *Bolivina spissa* occurred at 521 m water depth and below but reached not more than 3.3%.

Site	Longitude (W)	Latitude (S)	water depth [m]	Bottom water oxygen concentration [µmol/kg]
M77/1-540/MUC-49	77°47.40'	11°00.01'	79	5.28
M77/1-470/MUC-29	77°56.60'	11°00.02'	145	3.33
M77/2-635/MUC-5-4	77°40.07'	12°05.66'	214	2.37
M77/1-616/MUC-81	77°29.05'	12°22.69'	302	2.20
M77/1-473/MUC-32	78°09.94'	11°00.01'	317	2.25
M77/1-449/MUC-19	78°09.97'	11°00.01'	319	2.25
M77/1-482/MUC-34	78°14.17'	11°00.01'	375	2.26
M77/1-456/MUC-22	78°19.23'	11°00.01'	465	3.79
M77/1-516/MUC-40	78°20.00'	11°00.00'	511	4.83
M77/1-553/MUC-54	78°54.07'	10°26.38'	521	4.83
M77/1-487/MUC-38	78°23.17'	11°00.00'	579	8.59
M77/1-459/MUC-25	78°25.60'	11°00.03'	697	15.72
M77/1-622/MUC-86	77°34.74'	12°32.75'	823	27.67

Table 5.1. Sampling locations.

Living specimens of *Bolivina costata*, which is a characteristic species of the Peru Margin (Resig; 1981 and references therein; Resig, 1990) were found only in a depth range from 79 to 521 m water depth. Its relative abundance varied significantly throughout the transect and reached two maxima with 11 and 14.7 to 14.9% at 79 and 317-319 m water depth, respectively. The upper OMZ boundary was dominated by *Nonionella stella* and *Fursenkoina fusiformis*. Interestingly, *N. stella* was found only at the shallowest station with 44% and with 1% at 375 m water depth. *Fursenkoina fusiformis* accounts for 29.6% at 79 m water depth but then decreases rapidly with decreasing [O_2] and becomes absent at 302 m water depth. This species re-occurred in a second interval from 375 to 579 m water depth. However, it did not account for more than 7.5% there. A further common species of the OMZ is *C. carmenensis*. It occurred between 214 and 521 m water depth, whereas it reached its maximum abundance of 37.4% at 511 m water depth. At the shallower stations with lower [O_2], *C. carmenensis* just comprised 0.3-8% of the living assemblages. Stations below the lower OMZ boundary were, in particular, dominated by four species which were absent or very rare within the OMZ core and at shallower stations. *Uvigerina peregrina* and *Bolivinita minuta* appeared at 521 m water depth and 511 m water depth ([O_2] > 4.8 µmol/kg), respectively. They reached their maximum relative abundances at 823 and 579 m water depth, with corresponding [O_2] of 27.7 and 8.6 µmol/kg. Maximum values were 45.8% and

31% for *U. peregrina* and *B. minuta*, respectively. The relative abundance of *Angulogerina angulosa*, absent in all stations at shallower than 697 m depth, increased

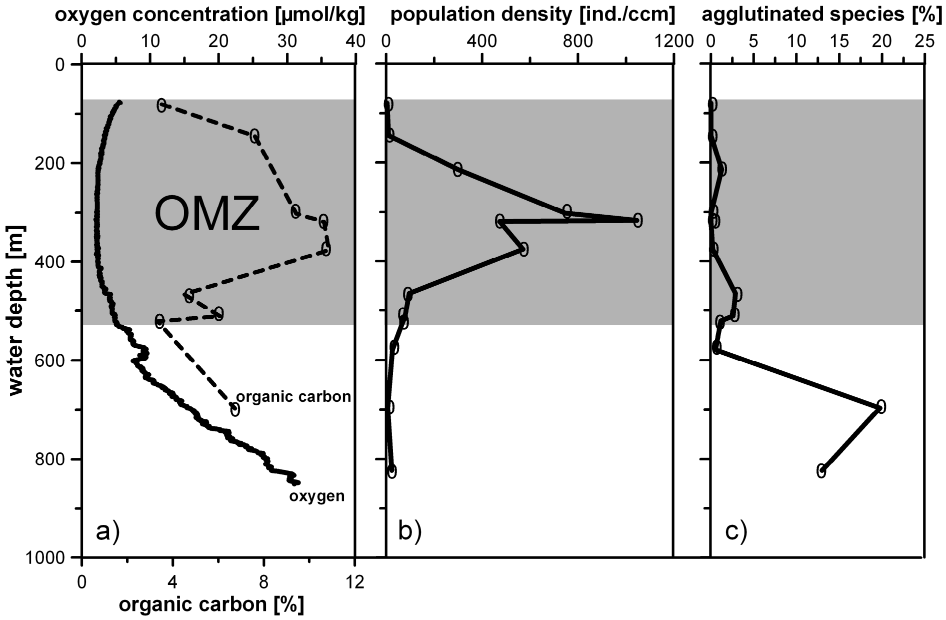

Figure 5.2. Oxygen concentration and organic carbon (a and b), population density (b) and percentage of agglutinated species (c) plotted against water depth. Density data were derived from samples taken from 10-12°S and sediment depth intervals from 0-6 mm. Organic carbon content is represented by the top 10 mm of each sediment core and obtained from 9 stations between 11 and 12°S. Winkler-calibrated dissolved oxygen concentration measured at 11°S.

from 2.5% at 697 m water depth to 7.7% at 823 m. *Cassidulina crassa* first occurred at 465 m water depth and reached abundances between 0.5 and 1.9% down to 579 m water depth. At 697 m it reached 19.1% and 6.6% at 823 m. Together with *B. minuta*, *U. peregrina* and *A. angulosa* dominated the 697 and 823 m stations.

Living specimens of the deep infaunal species *Globobulimina pacifica*, which was usually common under nearly anoxic conditions, were found in our study only at 3 stations and sediment depths greater than 4 mm and at stations deeper than 697 m water depth.

The lower OMZ boundary, where [O_2] exceeds 3.8 µmol/kg, seems to provide optimum conditions for many species which are absent within the immediate OMZ core. A good preservation of available organic matter prevailed at this depth, and together with a higher oxygen contents this may lead to the conspicuously higher species richness.

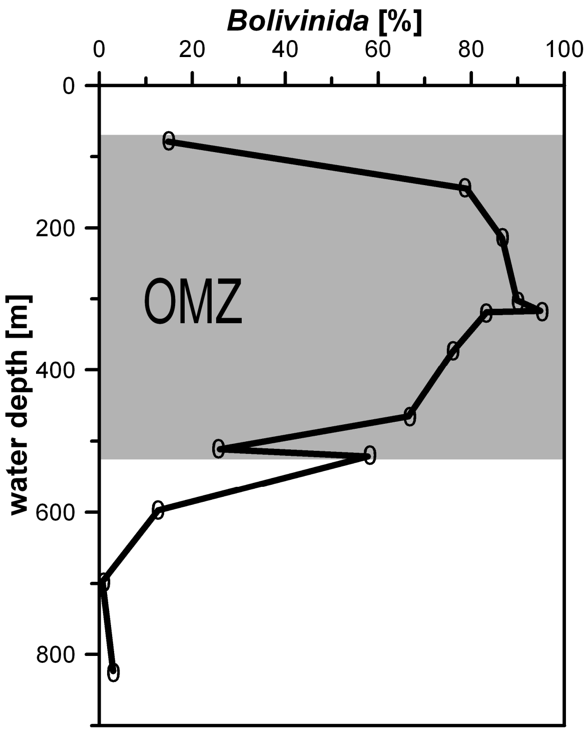

Figure 5.3. Percentages of stained *Bolivinida* (*B. alata*, *B. costata*, *B. interjuncta*, *B. pacifica*, *B. plicata*, *B. seminuda, B. serrata* and *B. spissa*) as fraction of total stained calcareous species in relation to oxygen concentration of a CTD profile along 11°S off Peru.

5.6. Discussion

5.6.1. Species patterns

The foraminiferal distribution patterns from the Peruvian OMZ seemingly followed the ambient bottom water oxygen concentrations. Species diversity and population density were inversely correlated. The abundance of agglutinated taxa showed a positive correlation with [O_2]. It seems that most agglutinated species require [O_2] >8.5 µmol/kg. This confirms the results of previous studies (Gooday et al., 2000; Levin et al. 2002) which showed that agglutinated taxa are not well adapted to extremely low oxygen conditions. Probably, these taxa are disadvantaged by the absence of pores or low pore-density of their tests.

We found a predominance of *Bolivinitidae* at stations with lowest oxygen concentrations. Obviously, some species of this family are well adapted to low oxygen conditions. But it is important to consider that not bolivinids in general are typical inhabitants of oxygen depleted environments. Instead, each species has its characteristic oxygen requirement. Figure 4 shows that *Bolivina seminuda* has been found in all stations, from 79 to 823 m water depth. Thus, it is able not only to live under normal oxygen conditions but also under extreme low oxygen concentrations where it reaches its highest abundance.

Bolivina costata, which is a characteristic species of the Peru Margin (Resig; 1981 and references therein; Resig, 1990) was found in a depth range from 79 to 521 m. This is in agreement with previous studies where this species has been found at even shallower stations but also down to a water depth of >2000 m (Resig, 1981 and references therein). However, these studies did not use any method for distinguishing live from dead fauna. Based on our study, we assume that *B. costata* is actually restricted to the upper Bathyal of the OMZ-affected Peruvian Margin.

Living specimens of *C. carmenensis* were found between 214 and 521 m water depth and showed highest abundance at 511 m water depth (37.4%). This is consistent with the studies of Resig (1981, 1990) who characterized *C. carmenensis* as an upper bathyal species ranging from 151 to 500 m. The highest abundances correlate with oxygen concentrations of 4.8 µmol/kg. The distribution of *Nonionella stella* we found in the Peruvian OMZ corresponded to the observed depth range of *N. stella* (denominated as *N. miocenica)* in the study of Resig (1990). She found specimens only to a depth of about 80 m. We cannot confirm that *N. stella* is restricted to extremely low [O_2] like it has been observed by Bernhard et al. (1997), where *N. stella* dominated the assemblages in all the samples with [O_2] <2 µM.

The distributions of most infaunal and epifaunal species from the surface sediments is in agreement with the TROX-model by Jorissen et al. (1995). At stations with lowest [O_2] between 79 and 317 m water depth, the fauna of the topmost subsamples was composed of infaunal taxa (i. e. *Bolivina seminuda*, *B. plicata*, *B. interjuncta*, *B. costata*, *Fursenkoina fusiformis*, *Nonionella stella*) whereas species of the genera *Planulina* and *Cibicidoides,* which prefer an epibenthic lifestyle or, at least, dwell on the sediment surface were very scarce or absent in these samples.

The deep infaunal species *G. pacifica,* which is adaptated to extremely low or even anoxic conditions, has not been found in any of the OMZ samples but just in deeper sediment intervals of the deepest stations where [O_2] again was relatively high. This observation was in disagreement with the conceptual model of Jorissen et al. (1995). They assumed an upward migration of this species resulting in a sub-surface maximum under low-oxygen conditions. Probably, *G. pacifica* lived deeper in the sediment or might be restricted by redox fronts in the upper few millimetres or centimetres. A similar process has been invoked by Jannink et al. (1998) for *G. pacifica* in the northern Arabian Sea.

The lower OMZ boundary, where [O_2] exceeds 3.8 µmol/kg, seems to provide optimum conditions for few opportunistic species, which were absent within the OMZ core like *A. angulosa*, *U. peregrina* and *B. minuta*. Good preservation of available organic matter together with higher oxygen contents may have lead to the enhanced species richness at stations deeper than 597 m where oxygen concentrations exceeded 8.5 µmol/kg.

When comparing the species composition from the Peruvian OMZ with the faunas from other oceanic low oxygen habitats, it emerges that just a few species dominate these assemblages. This results in low diversities but high population densities which were generally recognized, also in other OMZs (Phleger and Soutar, 1973, Baja California, Mexico; Gooday et al., 2000, Schumacher et al., 2007, den Dulk et al., 1998 and Jannink et al., 1998 for the Arabian Sea OMZ). The extremely high population densities of a very few species within the OMZ core was certainly an interplay of different factors. Low predation pressure coupled with high food availability and low competition over a long time period may lead to development of specially adapted species which can inhabit and successfully reproduce under such extreme oxygen deficiently (Gooday, 1986). Another concept for a successful life under low-oxygen conditions may be a radiative reproduction strategy (r-strategy) which results in a very high reproduction rate and thus in high standing stocks (Sjoerdsma and van der Zwaan, 1992, Jannink et al., 1998). Further, high diversity patterns of the lower OMZ boundary and below is explainable with a predominance of “k-strategic” species. They need much energy for competition against many other species.

The distinct faunal change of benthic species across the Peruvian OMZ is comparable with the observations from the Arabian Sea. As described in Schumacher et al. (2007) for the OMZ off Pakistan, we also found a specific fauna within the OMZ (e.g. *B. seminuda*, *B. costata*, *B. interjuncta*) and a more cosmopolitan fauna in the lower part and below the OMZ (*U. peregrina*, *B. minuta*, *A. angulosa*). An oxygen dependent, horizontal zonation of cosmopolitan and specific species was considered to result from stable conditions in an upwelling system, in which a very few species have adapted to extreme oxygen depleted conditions (Schumacher et al. 2007).

Many of the above mentioned species, especially those from the low-oxygen habitats, are known to be able to store nitrate in cell-bound vacuoles and use it for respiration. This has been proven for *Nonionella* cf. *stella* by Risgaard-Petersen et al. (2006). But also *Bolivina alata, Bolivina plicata*, *Bolivina seminuda, Cyclammina cancellata* and *Uvigerina peregrina*, which were common in our samples, are able to store and respire nitrate (Piña-Ochoa et al., 2010). The ability to use nitrate as an alternative energy source may certainly be an advantage for these species to live in this extreme environment.

5.6.2. A new proxy for estimation of bottom water oxygen concentrations

Some of the dominating Peruvian OMZ species showed a conspicuous trend of their abundance and population density patterns which corresponded to the ambient bottom water oxygen concentrations. Due to their [O_2] requirements, each species showed its maximum abundance at a distinct water depth (Fig. 5.4.). This resulted in a distinct species succession with oxygen levels. The following main species were involved: *Angulogerina angulosa*, *Bolivina alata*, *Bolivina costata*, *Bolivina interjuncta*, *Bolivina plicata*, *Bolivina seminuda*, *Bolivinita minuta*, *Cancris carmenensis, Cassidulina crassa, Fursenkoina fusiformis*, *Uvigerina peregrine and Valvulineria glabra*. Their abundances exhibited an overlapping pattern which allowed estimations of the prevailing [O_2] on a relatively fine scale (Fig. 5.4.).

We observed six distinct assemblages indicating different levels of [O_2]. The first assemblage indicating [O_2] <2.5 µmol/kg is dominated by *B. seminuda* (42-85%) with co-occurrence of *B. plicata* (5-25%), *B. costata* (1-14%) and *V. glabra* (1-6-6%). At slightly higher [O_2], between 3.3 and 4.8 µmol/kg, *B. seminuda* (9.5 -76%) dominated this assemblage together with *B. interjuncta* (up to 52%). *B. alata* appeared with 2 to 15%., whereas *B. plicata* disappeared. The third assemblage at [O_2] 8.6 µmol/kg was characterised by *U. peregrina* and *B. minuta* with 45.7% and >10%, respectively. *B. seminuda* and *B. alata* became very rare (<2%). *B. interjuncta* decreased to 7.5 %, *B. costata* and *Valvulineria glabra* were absent. At [O_2] of 15.7 µmol/kg, we found a fourth assemblage with dominance of *U. peregrina* (35.7%) together with *C. crassa* (19%) and *B. minuta* (12.7%). *B. seminuda* further decreased (<1%) and *B. interjuncta* disappeared. *Angulogerina angulosa* first occurred (2.5%) at this level. Agglutinated species, which were barely found at lower [O_2], strongly increased from <3% to 19%. The fifth assemblage indicated [O_2] 27.7 µmol/kg. Here we found still a dominance of *U. peregrina* with *B. minuta* but with a higher proportion of *B. minuta* (22.7%) than *U. peregrina* (25.6%). *Angulogerina angulosa* increased to 7.7% and *C. crassa* decreased to 6.6%). Agglutinated species were making up 13% in this assemblage.

Due to their recent occurrence it is important to mention that the assemblages which are dominated by *C. carmenensis*, *B. minuta* and *A. angulosa* may serve as indicator for reconstructing oxygen values prevailing at the lower OMZ boundary.

The upper OMZ boundary was characterised by high abundances of *N. stella* and *F. fusiformis*. At the two shallowest station (79 m water depth [O_2] 5.3 µmol/kg) *N. stella* and *F. fusiformis* reached relative abundances of 44% and 29.6%. At deeper stations, *N. stella* was absent in the surface sediment samples except for 375 m water depth where it occurred with 1.1%. *Fursenkoina fusiformis* decreased at deeper stations but occasionally occurred with low abundances (<5%) throughout the OMZ to a water depth of 579 m. In a former study by Bernhard et al. (1997), *N. stella* from the Santa Barbara Basin was referred as the dominating species of all stations with [O_2] <2 µM and thus, leading to the conclusion that *N. stella* may serve as a proxy for oxygen concentrations <2 µM. Our observation cannot support this conclusion for the Peruvian OMZ. It appears that the distribution pattern is more likely to be explained by the requirement of the availability of labile organic matter which was reported to be highest at the upper OMZ boundary off Peru (Neira et al., 2001 and Levin et al., 2002).

Our observations on the distribution of *U. peregina* suggest that this species may be used as an indicator-species for lower OMZ boundary conditions where organic carbon concentrations are relatively high but [O_2] rather low (Altenbach and Sarnthein, 1989; and Rathburn and Corliss, 1994).

The distribution patterns of the described species can together be used as valuable tool for reconstructing past bottom water oxygen levels on a relative scale. However, it has to be proven that the sediments are not seriously affected by dissolution, and that fossil assemblages are not seriously biased by the taphonomic loss of arenaceous or delicate calcareous species.

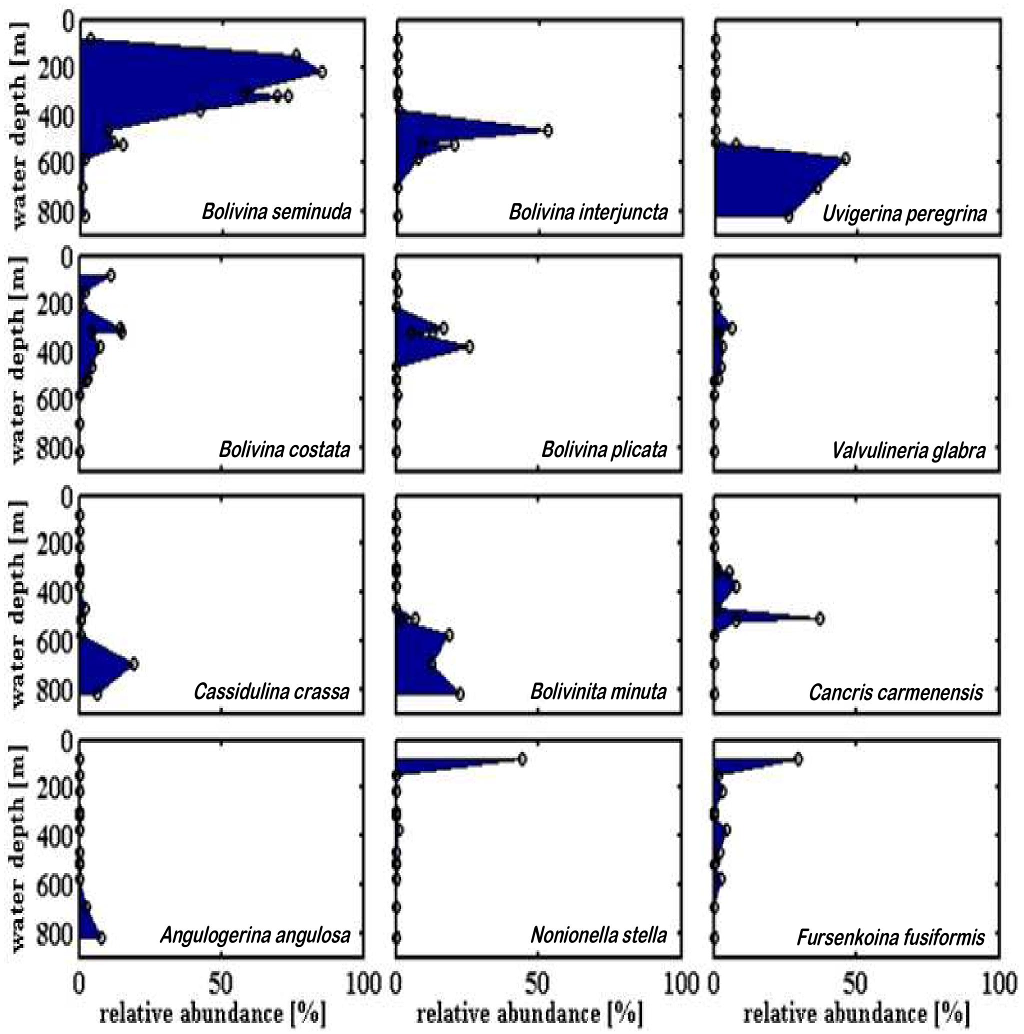

Figure 5.4. The relative abundance of some "living" calcareous species vs. water depth dependent [O_2] distribution (relative abundance obtained from surface sediment samples: 0-2 mm, 0-5 mm, 2-4 mm or 3-6 mm).

5.7. Acknowledgements

We thank Dr. S. Sommer and S. Kriwanek for providing us with the calibrated oxygen data and Dr. C. Hensen for providing the C_{org} and [NO_3] data. A. Bleyer, B. Domeyer and R. Ebbinghaus are gratefully acknowledged for the analytical work onboard. Very special thanks go to Dr. M. E. Perez and Dr. M Kaminski for support us with taxonomy but also for fruitful discussions and for providing us access to the foraminiferal collections at The National History Museum, London and of the Paleontological Institute of Krakow. This study was financially supported by the DFG through the Sonderforschungsbereich 754: "Climate – Biogeochemistry Interactions in the Tropical Ocean".

Appendix A. Faunal reference list

Species	References
Angulogerina angulosa (Williamson, 1858)	Loeblich & Tappan (1994): p. 487, pl. 250, figs. 13-20.
Bolivina alata (Seguenza, 1862)	van Marle (1991): p. 305, pl. 17, figs. 1-2.
Bolivina costata (d'Orbigny, 1839)	Resig (1981): p. 647, pl. 1, fig. 1.
Bolivina interjuncta (Cushman, 1926)	Boltovskoy & Theyer (1970): p. 304, pl. 1, figs. 8, 9.
Bolivina plicata (d'Orbigny, 1839)	Resig (1981): p. 647, pl. 1, figs. 3, 4.
Bolivina seminuda (Cushman, 1911)	Resig (1981): p. 655, pl. 5, fig. 14.
Bolivina serrata (Natland, 1938)	Whittaker (1988): p. 100, pl. 13, figs. 1-3.
Bolivina spissa (Cushman, 1926)	Resig (1981): p. 647, pl. 1, fig. 7.
Bolivinita minuta (Natland, 1938)	Resig (1981): p. 647, pl. 1, fig. 9.
Cancris carmenensis (Natland, 1950)	Resig (1981): p. 649, pl. 2, fig. 9-11.
Cassidulina crassa (d'Orbigny, 1839)	van Marle (1991): p. 289, pl. 9, figs. 13-15.
Cyclammina cancellata (Brady, 1879)	Zheng (2001): pl. 52, figs. 3-6.
Fursenkoina fusiformis (Williamson, 1858)	Murray (1971): p.184, pl. 77, figs. 1-5.
Globobulimina pacifica (Cushman, 1927)	Loeblich & Tappan (1994): p. 480, pl. 243, figs. 13-16.
Nonionella stella (Cushman & Moyer, 1930)	Narayan et al.(2005): p. 147, pl. 4, fig. 23.
Uvigerina peregrina (Cushman, 1923)	Frezza & Carboni (2009): p. 56, pl. 2, fig. 15.
Valvulineria glabra (Cushman, 1927)	Loeblich & Tappan (1994): p. 505, pl. 268, figs. 1-3.

Appendix B. Supplementary data

Supplementary data to this article can be found online at: http://doi.pangaea.de/10.1594/PANGAEA.757092.

5. The response of benthic foraminifera to low-oxygen conditions of the Peruvian oxygen minimum zone

6.

Application of the new benthic foraminiferal proxy to the fossil record of core SO147-106KL

6.1. Introduction

To apply the new proxy described in chapter 4 we chose a long sediment core from the Peruvian OMZ which goes back into the last glacial maximum (LGM). Core SO147-106KL was taken from 184 m water depth off Callao, Peru in June 2000 during *R/V Sonne* cruise 147. The coordinates of the station is 12.030'S and 77.664'W.

Wolf (2002) and Rein et al. (2005) presented age-models for the upper 965 cm based on accelerated mass spectrometry (AMS) ^{14}C measurements which were deployed on 5 cm steps. Interpolated ages were calculated and reveal an ^{14}C age of 19.6 ky BP at 965 cm sediment depth (Rein et al., 2005). Opal, total organic carbon (TOC) and chlorins were measured as proxies for bioproductivity but also $\delta^{18}O$ data from benthic foraminifera (*Bolivina seminuda* from size fraction 125 to 250 µm) for paleotemperature reconstruction were available from Wolf (2002). High resolution data obtained by in situ reflectance spectroscopy revealed high variabilities of El Niño activity. We used these data to compare and correlate them with our findings.

6.2. A brief overview about previous work and its results on core SO147-106KL

A sedimentological and stratigraphical description by Wolf (2002) of this core section (0-965 cm) revealed a non-continuous sedimentation. Sediments predominantly consist of finely laminated silty clay with two unconformities reaching from 4.2 to 8.9 ky BP and from 17.9 to 124.9 ky BP. The younger hiatus is characterized by a homogeneous layer of silt with an erosive base. It has been observed in recent studies off Peru (e.g. Reimers and Suess, 1983; Biebow, 1996; Rein et al., 2005). The earlier hiatus is characterized by silty sediments with an intercalated layer rich in mollusc fragments between 964 and 967 cm.

Based on Rein et al. (2005) the deepest ^{14}C dating point at 965 cm depth showed an age of 19.6 ky BP and thus represents high-glacial conditions. A significant decrease of TOC and opal lead to reduced productivity between 11 and 10 ky BP which corresponds with low sea surface temperatures measured for 12.6-11.2 ky BP by Rein et al. (2005). This period represents the climatic conditions of the Younger Dryas. A Holocene unconformity reaches from 8.5-4.4 ky BP (after Wolf, 2002; 8.8-5.6 ky BP after Rein et al., 2005). From 1.8 ky BP on, a further increase of all three parameters points to very high productivity typical for conditions in OMZs. Wolf (2002) suggests an enhancement of upwelling by intensifying of the SE trade winds. Eventually the core location was influenced by the expanding upwelling area.

6.3. Material and Methods

Working halves of the upper 12 m were sampled in intervals of about in steps of about 20 cm by using 10 ml cut-off syringes. In total we obtained 57 samples between 52 and 1153 cm sediments depth. Samples were weighted and wet-sieved with tap water over 63 and 2000 µm screens. Afterwards they were dried at 50℃. The dry residues were not fractionated but if necessary they were splitted into manageable aliquots to obtain ca. 300 benthic foraminiferal individuals per sample. The specimens were taxonomically sorted to species level, fixed in plummer cells and counted. Species identification bases on Ellis and Messina online catalogues (1942-2006), Barker (1960), Jones (1994), Uchio (1960), Whittaker (1988), Resig (1981, 1990) and Loeblich & Tappan (1994).

Based on defined bottom water oxygen ranges of benthic foraminiferal assemblages presented in chapter 5, we estimated averaged oxygen concentrations for each sample depth. The CTD derived oxygen concentrations at the determined multicorer stations were ordered by concentration and the most prominent species at one concentration level were merged as a foraminiferal assemblage. Each foraminiferal assemblage stands for an oxygen concentration range which is bordered by maximum and minimum value. Averaged values of each concentration range were defined as the averaged benthic foraminiferal oxygen concentration. Finally, the assemblages found in SO-147-106KL were compared with these of the M77-1 and- 2 cruises and were grouped into same assemblages. For each sample we could allocate the averaged oxygen concentration and the interpolated ^{14}C ages.

The recalculated ^{14}C ages used in this study bases on Rein et al. (2004, 2005) who used a reservoir age of 800 years for all data points. Therefore we used the linearly interpolated ages from Rein et al. (2005) between the calibrated ^{14}C ages and calculated our data points (every sample depth) by linear interpolation.

6.4. Results and discussion

Distribution of benthic foraminifera in core SO147-106KL was scattered. From 56 samples, only 25 contained foraminiferal tests (Tab. 6.1). Long barren were observed in a depth range from 563 to 802 cm which comprises a time interval from 14-10.6 ky BP and from 847-948 cm depth (17.1-14.6 ky BP). Smaller gaps were observed at 83, 138-183, 223-240, 337-362, 443-463, 504, 988-1013 and 1089 cm sediment depth. The upper 123 cm of the core contained white, irregular formed calcareous ooids.

core depth	reservoir age	averaged bottom water oxygen concentration	core depth	age	averaged bottom water oxygen concentration
[cm]	[ky BP]	[µmol/kg]	[cm]	[ky BP]	[µmol/kg]
52	1.23	2.85	584	10.61	
58	1.27	2.85	605	10.86	
78	1.37	3.55	627	11.13	
83	1.40		646	14.69	
103	1.49	3.55	673	11.67	
123	1.59	6.7	690	11.88	
139	1.69		703	12.06	
163	1.84	6.7	728	12.59	
183	2.09		762	13.31	
203	2.41	2.5	788	13.84	
223	2.68		802	14.04	
243	3.13		823	14.35	2.5
263	2.90	2.5	847	14.69	
288	3.91	4.8	877	15.16	
303	4.31	4.8	898	15.48	
323	4.96	2.5	913	15.74	
337	7.10		928	16.02	
362	8.49		948	17.10	
377	8.93	2.5	968	19.60	6.7
407	9.06	2.5	988	?	
423	9.14	2.5	1013	?	
443	9.33		1038	?	2.5
463	9.49		1053	?	6.7
483	9.54	2.5	1069	?	6.7
504	9.77		1089	?	
524	10.0	2.5	1113	?	6.7
544	10.20	2.5	1133	?	6.7
563	10.36		1154	?	4.3

Table 6.1. Sampling list, shaded intervals contain no benthic foraminiferal tests

The record showed unexpected low values in oxygen concentrations throughout. Averaged oxygen concentrations reached not more than 7 µmol/kg. Lowermost values were 2.5 µmol/kg. As mentioned in chapter 5, the oxygen sensor reached its lower resolution limit at this concentration, so we may assume even anoxic conditions for these low concentrations.

There are no ^{14}C measurements for the core deeper 965 cm, which correspond to ages of >19.6 ky BP. As already mentioned above a unconformity from 955 to 1059 cm sediment depth would adulterates the reliability of the age model for deeper sediment intervals. Because of these unreliabilities we will focus on the core section which comprises the past 19.6 ky BP and will not further discuss the deeper part of the core.

On a first view, the variability of bottom water oxygen concentration over the whole record (Fig. 6.2.) is characterized by only a few excursions. The glacial section at 19.6 ka BP is characterized by relatively high oxygen concentration of 6.7 µmol/kg whereas the post-glacial samples between 5 and 14.3 ky BP show low values of 2.5 µmol/kg, or even lower. Two prominent peaks are intercalated at 3.9-4.3 and 1.6-1.8 ky BP and indicate averaged concentrations of 4.8 and 6.7 µmol/kg, respectively. The youngest data point at 1.3 ky BP shows a concentration of 3.8 µmol/kg. The recent oxygen concentration at the coring site is 1 µmol/kg (measured at 184 m water depth with CDT at station M77-1-609 and -628 at 12°S).

A decreasing trend in bottom water oxygen concentration between 19.6 and 14.3 ky BP may represent the deglacial phase with rising sea-level so that the core location became influenced by the onshore shifting upwelling water masses like it has been proposed by Wolf (2002). For the section between 14.3 and 5 ky BP there is no fluctuation in bottom water oxygen concentration. Instead, values stay at 2.5 µmol/kg although $\delta^{18}O$, carbonate and opal show high variabilities. It is likely that fluctuations within low oxygen concentrations as displayed in Fig 6.2. are more influenced by factors like dissolution effects or sedimentological inhomogeneities than by variability in oxygen concentration itself.

The reconstruction of large scale variabilities in bottom water oxygen concentrations shows correlations with $\delta^{18}O$ (Wolf, 2002) and strong El Niño activity (Rein et al., 2005) for the last 5 ky BP. Rein et al. (2005) described highest El Niño activities during the late Holocene.

Due to low values of terrigenous material coupled with peaks in opal and carbonate at 3.8-4.3 and 1.8-1.6 ky BP we assume high bioproductivity and low oxygen concentrations by enhanced upwelling. High frequent variabilities on shorter scales could not be resolved because benthic foraminiferal sampling intervals were not spaced dense enough.

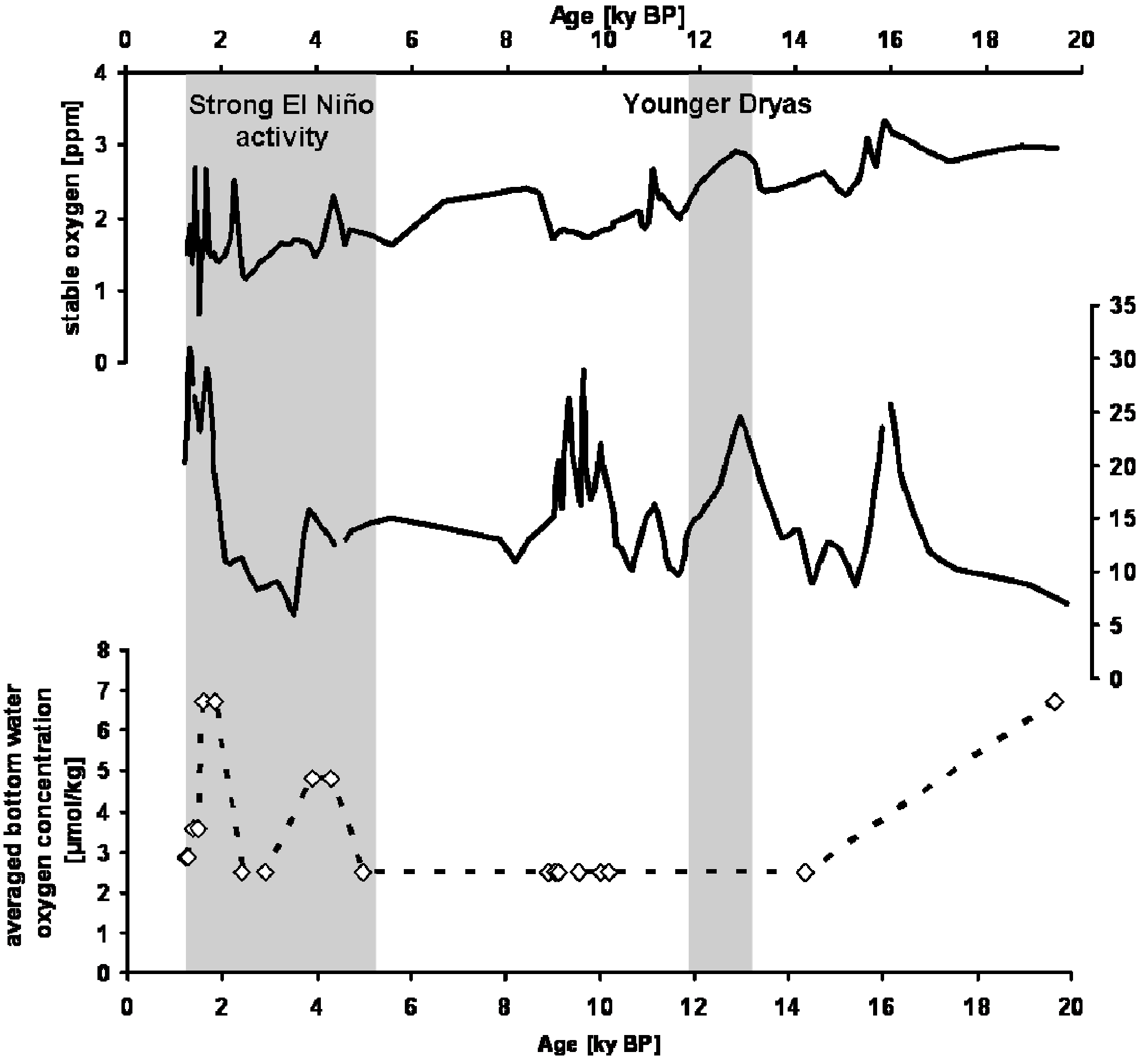

Figure 6.2. Downcore proxies of SO147-106KL for the last 19.6 ky BP. Data for stable oxygen and opal base on Wolf (2002) whereas ages were correlated after Rein et al. (2005).

We conclude that the bottom water oxygen concentration on station 147-106KL did not vary significantly during the past 20 kyrs BP and remained at dysoxic levels between ≤2.5-6.7 µmol/kg. Our results show that during the last 4.3 ky BP, distinct fluctuations occurred in bottom water oxygen concentration. For early Holocene core sections it is rather uncertain whether bottom water oxygen concentrations prevailed on a very low level of 2.5 µmol/kg. Due to lacking tests in more than half of samples, it was not possible to conduct a high resolution reconstruction of oxygen variability, especially for the record older than 4.3 ky BP. For future work it could be worthwhile to sample the Holocene section in denser-spaced intervals for reconstructing short scale variabilities in bottom water oxygen concentration.

7.

Conclusions & Outlook

The third chapter presents a taxonomical outline of the most important species which occurred in our study area and gives a biogeographical overview about the provincial patterns.

It was possible to re-evaluate the biogeographical constraints of faunal province borders. Based on comparisons with other studies it was possible to confirm that there exists a latitudinal transition from a temperate fauna south of Ecuador (Chilean-Peruvian province) to a warm water fauna in the northernmost stations off Ecuador (Panamanian province). However, an exact definition of a border between them was not possible due to the limited number of samples from this area. The taxonomical work on living benthic foraminifera from the Ecuadorian shelf area needs to be intensified in the future.

The results presented in chapter 5 show that the distribution of dominant living benthic species in surface sediments which provide a proxy for the reconstruction of past bottom water oxygen concentrations. To evaluate the usability of this new proxy, a long core from 12°S off Peru (SO147-106KL), which has already been considered in former studies (Wolf, 2002; Rein et al., 2005), was sampled.

Despite the fact that variability in $[O_2]_{bw}$ during the last 19.6 ky BP is unexpected low, the results show that the newly introduced proxy indeed is applicable for reconstructions of large-scale variations in bottom water oxygen concentration in the Peruvian upwelling system. The relatively strong fluctuations during the last 5 ky BP reflect the productivity variations and increased El Niño activity showed in the study of Wolf (2002) and Rein et al. (2005). A perspective for future work could be to apply this new proxy for late Holocene to historical reconstructions of $[O_2]_{bw}$ at high temporal resolution.

A further aim for future studies may be to analyse the data from the already existing subsurface samples taken during cruise M77 Leg 1 and 2 in order to determine the depth distribution of species. Probably, additional species will be found and would supplement the knowledge about living benthic foraminiferal diversity and distribution of that area. Eventually, these results may yield supplementary findings in combination with geochemical data (e.g. nitrate, sulfide, manganese etc.).

The depth distributions within the top 50 mm at four stations for the most common species were investigated. As described in chapter 5, I found certain density-maxima between 2 and 5 mm which are explainable with geochemical zonations of different electron acceptors (e.g. oxygen, nitrate, sulphide etc.) in the upper sediment column. However, sampling deep-sea sediments at mm-resolution is a challenging task and requires new technologies to be accomplished.

8.

References

8. References

Altenbach, A. V., Sarnthein, M., 1989. Productivity record in benthic foraminifera. In: W. H. Berger, V. S. Smetacek, G. Wefer, (eds.) Production in the Ocean: Present and Past. Wiley, New York, pp. 255-269.

Alve, E., Murray, J. W., 2001. Temporal variability in vertical distributions of live (stained) intertidal foraminifera, Southern England. Journal of Foraminiferal Research: 31 (1), pp. 12-24.

Alve, E., Goldstein, S. T., 2002. Resting stage in benthic foraminiferal propagules: a key feature for dispersal? Evidence from two shallow-water species. Journal of Micropalaeontology: 21, pp. 95-96.

Alve, E., Goldstein, S. T., 2010. Dispersal, survival and delayed growth of benthic foraminiferal propagules. Journal of Sea Research: 63, pp. 36-51.

Arntz, W., Fahrbach, E., 1991. El Niño - Klimaexperiment der Natur. Physikalische Ursache und biologische Folgen. Birkhäuser, 264 pp.

Bandy, O. L., Arnal, R. E., 1957. Distribution of recent foraminifera off west coast of Central America. Bull. AAPG: 41, 9, pp. 2037-2053.

Bandy, O. L., Rodolfo, K. S., 1964. Distribution of foraminifera and sediments, Peru-Chile Trench area. Deep Sea Res.: 11, pp. 817-837.

Bandy, O. L., Ingle, J. C., Jr., Resig, J. M., 1965. Foraminiferal trends, Hyperion Outfall, California. Limnology and Oceanography: 10 (3), pp. 314-332.

Barker, R. W., 1960. Taxonomic notes on the species figured by A. B. Brady in his report on the Foraminifera dredged by H.M.S. Challenger during 1873 - 1876. Tulsa, Oklahoma, Society of Economic Paleontologists and Mineralogists, 238 pp.

Basak, C., Rathburn, A. E., Pérez, M. E., Martin, J. B., Kluesner, J. W., Levin, L. A., De Deckker, P., Gieskes, J. M., Abriani, M., 2009. Carbon and oxygen isotope geochemistry of live (stained) benthic foraminifera from the Aleutian Margin and the Southern Australian Margin. Marine Micropaleontology: 70, pp. 89-101.

Belford, D. J., 1966. Miocene and Pliocene smaller foraminifera from Papua and New Guinea. Austr. Bur. Min. Res., Geol. Geoph., Bull.: 79, pp. 1-306.

Bernhard, J. M., Reimers, C. E., 1991. Benthic foraminiferal population fluctuations related to anoxia: Santa Barbara Basin. Biogeochemistry: 15, pp. 127-149.

Bernhard, J. M., Alve, E., 1996. Survival, ATP pool, and ultrastructural characterization of foraminifera from Drammensfjord (Norway): response to anoxia. Marine Micropaleontology: 28, pp. 5-17.

Bernhard, J. M., Sen Gupta, B. S., Borne, P. F., 1997. Benthic foraminiferal proxy to estimate Dysoxic bottom-water oxygen concentrations. Santa Barbara Basin, U.S. Pacific continental margin. Journal of Foraminiferal Research: 27, pp. 301-310.

Bernhard, J. M., Bowser, S. S., 1999. Benthic foraminifera of dysoxic sediments: chloroplast sequestration and functional morphology. Earth-Science Revs.: 46, pp. 149-165.

Bernhard, J. M., Sen Guta, B. K., 1999. Foraminifera of oxygen-depleted environments. In: Modern Foraminifera. B. K. Sen Gupta (ed.), Kluwer Academic Publishers, Great Britain, pp. 201-216.

Bernhard, J. M., Buck, K. R., Barry, J. P., 2001. Monterey Bay cold-seep biota: assemblages, abundance, and ultrastructure of living foraminifera. Deep-Sea Research I: 48, pp. 2233-2249.

Bernhard, J. M., Bowser, S. S., 2008. Peroxisome proliferation in foraminifera inhabiting the chemocline: An adaptation to reactive oxygen species exposure?. Journal of Eukaryotic Microbiology: 55, pp. 135-144.

Bernhard, J. M., Bowser, S., Goldstein, S., 2010. An ectobiont-bearing foraminiferan, *Bolivina pacifica*, that inhabits microxic pore waters: cell-biological and paleoceanographic insights. Environmental Microbiology: 12, pp. 2107-2119.

Berthold, W.-U., 1976. Ultrastructure and function of wall perforations in *Patellina corrugate* Williamson, Foraminiferida. Journal of Foraminiferal Research: 6, pp. 22-29.

Biebow, N., 1996. Dinoflagellatenzysten als Indikatoren der spät- und postglazialen Entwicklung des Auftriebsgeschehens vor Peru. GEOMAR Reports: 57, Kiel

Blanc-Vernet, L., 2007. Benthic foraminifers of Site 533, Leg 76 of the Deep Sea Drilling Project – Faunal variations during the Pliocene and Pleistocene on the Blake Outer Ridge (western North Atlantic). DSPD: 76, pp. 497-509.

Boltovskoy, E., Theyer, F., 1970. Foraminiferos recientes de Chile Central. Revista del Museo Argentino de Ciencias Natururales "Bernardino Rivadavia: 2 (9), pp. 280-397.

Boltovskoy, E., Gualancañay, E., 1975. Foraminiferos bentonicos actuales de Ecuador 1. Provincia Esmeraldas. Armada del Ecuador Instituto de Oceanographico Publication, pp. 1-56.

Boltovskoy, E., 1976. Distribution of Recent Foraminifera of the South American Region. In: Hedley, R. H., Adams, C. G. (eds.). Foraminifera, 2. Academic Press, London, pp. 171-236.

Boomgaart, L., 1949. Smaller Foraminifera from Bodjonegoro (Java). Thesis Univ. Utrecht, Smit and Dontje Publ., Sappemer, Netherlands, 175 p.

Bornemann, J. G., 1855. Die mikroskopische Fauna des Septarienthones von Hermsdorf bei Berlin. Zeitschrigt der Deutschen Geologischen Gesellschaft, Berlin: 7 (2), pp. 307-371.

Boyer, T. P., Antonov, J. I., Baranova, O. K., Garcia, H. E., Johnson, D. R., Locarnini, R. A., Mishonov, A. V., Seidov, I., Smolyar, I. V., and Zweng, M. M., 2009. World Ocean Database 2009, Chapter 1: Introduction, in Levitus, S. (ed.), NOAA Atlas NESDIS 66: U.S. Government Printing Office, Washington, D.C., 216 pp. (on DVDs).

Bradv, H. B., 1879. Notes on some of the reticularian Rhizopoda of the "Challenger" Expedition. Part 1. On new or little known arenaceous types. Quarterly Journal of Microscopical Science, London, new ser.: 19.

Brady, H. B., 1881. Notes on some of the reticularian Rhizopoda of the Challenger Expedition. Part III. 1. Classification. 2. Further Notes on new species. 3. Note on *Biloculina* mud. Quarterly Journal of Microscopical Science, new. Ser.: 21, pp. 31-71.

Brady, H. B., 1884. Report on the Foraminifera dredged by H.M.S. "Challenger" during the years 1873-1876. Reports of the scientific results of the voyage H.M.S. Challenger. Zoology: 9, pp. 1873-1876.

Bramlette, M. N., 1951. Foraminifera. In: Woodring, W. P., and Bramlette, M. N., Geology and Paleontology of the Santa Maria district, California. Geological Survey Professional Paper: 222.

Brânzilâ, M., Chira, C., 2005. Microfossils assemblages from the Badenian/Sarmatian boundary in

Boreholes from the Moldavian Platform. Acta Palaeontologica Romaniae: 5, pp. 17-26.

Briggs, J., 1974. Marine zoogeography. New York: McGraw-Hill, 475 pp.

Brönnimann, P., Whittaker, J. E., 1988. The Trochamminacea of the Discovery Reports. A review of The Trochamminacea (Protozoa: Foraminiferida) described from South Atlantic and Antarctic waters by Heron-Allen and Earland (1932) and Earland (1933; 1934; 1936). London, British Museum Natural History), 152 pp.

Brotzen, F., 1936. Foraminiferen aus dem schwedischen, untersten Senon von Eriksdal in Schonen. Arsbok Sveriges Geologiska Undersögning: 30 (3), pp. 1-206.

Bubenshchikova, N., Nürnberg, D., Lembke-Jene, L., Pavlova, G., 2008. Living benthic foraminifera of the Okhotsk Sea: Faunal composition, standing stocks and microhabitats. Marine Micropaleontology: 69, pp. 314-333.

Bubenshchikova, N. V. Nürnberg, N., Gorbarenko, S. A., Lembke-Jene, L., 2010. Variations of the Oxygen Minimum Zone of the Okhotsk Sea during the Last 50 ka as Indicated by Benthic Foraminiferal and Biogeochemical Data. Marine Geology: 50 (1), pp. 93-106.

Chapman, F., 1941. Report on foraminiferal soundings and dredging of the F.I.S. “Endeavour” along The continental shelf of the southeast coast of Australia. Trans. Royal Soc. Victoria, Proc., new. ser.: 43 (2), pp. 236-240.

Collins, A. C., 1974. Port Phillip Survey 1957-63, Foraminferida. Memoirs of the National Museum of Victoria: 35, pp. 1-62.

Collins, L. S., Budd, A. F., Coates, A. G., 1996. Earliest evolution associated with closure of the Tropical American Seaway. Proceedings of the National Academy of Sciences of the United States of America: 93, pp. 6069-6072.

Collins, L. S., 1999/2000. The Miocene to Recent diversity of Caribbean benthic foraminifera from the Central American Isthmus. Bulletin of American Paleontology: 357, pp. 91-107.

Corliss, B. H., 1979. Taxonomy of Recent deep-sea benthonic foraminifera from the southeast Indian Ocean. Micropaleontology: 25 (1), pp. 1-19.

Cornelius, N., Gooday, A. J., 2004. ‘Live’ (stained) deep-sea benthic foraminiferans in the western Weddell Sea: trends in abundance, diversity and taxonomic composition along a depth transect. Deep-Sea Research II: 51, pp. 1571-1602.

Coryell, H. N., Mossman, R. W., 1926. Foraminifera from the Charco Azul formation, Pliocene of Panama. Journal of Paleontology: 16, pp. ?

Crouch, R. W., Poag, C. W., 1987. Benthic foraminifera of the Panamanian Province: Distribution and origins. Journal of Foraminiferal Research: 17 (2), pp. 153-176.

Culver, S. J., Buzas, M. A., 1982. Distribution of Recent Benthic Foraminifera in the Caribbean Region. Smithonian Institution Press, Washington D.C.: 14, 382 pp.

Cushman, J. A., 1910. A monograph of the foraminifera of the North Pacific Ocean; Part 1 – *Astrorhizidae* and *Lituolidae*. Bulletin of the United States National Museum: 71 (1), pp. 1-134.

Cushman, J. A., 1911. A monograph of the foraminifera of the North Pacific Ocean. Part 2. *Textulariidae*. Bulletin of the United States National Museum: 71 (2), pp. 1-108.

Cushman, J. A., 1913. A monograph of the Foraminifera of the North Pacific Ocean. Part 3.

Lagenidae. Bulletin of the United States National Museum: 71 (3), 125 p.

Cushman, J. A., 1920. The foraminifera of the Atlantic Ocean. Pert 2. *Lituolidae*. Bulletin of the United States National Museum: 104 (2), pp. 1-111.

Cushman, J. A., 1921. Foraminifera of the Philippine and adjacent seas. Bulletin of the United States National Museum: 100 (4), pp. 1-608.

Cushman, J. A., 1922. Results of the Hudson Bay Expedition. Part 1 - The foraminifera. Contributions To Canadian Biology: 9, pp. 135-147.

Cushman J. A., 1923. The foraminifera of the Atlantic Ocean. Part 4 – *Lagenidae*. Bulletin of the United States National Museum: 104 (4), pp. 1-228.

Cushman, J. A., 1925. Some Textulariidae from the Miocene of California. Contributions from the Cushman Laboratory for Foraminiferal Research: 1 (8), pp. 29-35.

Cushman, J. A., 1926. Some Pliocene Bolivinas from California. Contributions from the Cushman Laboratory for Foraminiferal Research: 2, pp. 40-46.

Cushman, J. A., 1927. Recent foraminifera from off the West coast of America. Bulletin of the Scripps Institution of Oceanography, Technical ser.: 1 (10), 119-188.

Cushman, J. A., 1931. The foraminifera of the Atlantic Ocean. Part VIII. *Rotaliidae*, *Amphisteginidae*, *Calcarinidae*, *Cymbaloporettidae*, *Globorotaliidae*, *Anomalinidae*, *Planorbulinidae*, *Rupertiidae* and *Homotremidae*. Bulletin of the United States National Museum: 104, 179 pp.

Cushman, J. A., 1932. Some Recent *angulogerinas* from the eastern Pacific. Contr. Cushman Lab. foramin. Res., Sharon: 8, pp. 44-48.

Cushman, J. A., 1933. The Foraminifera of the tropical Pacific collections of the “Albatross”, 1899 1900. Part II: *Lagenidae* to *Alveolinidae*. Bulletin of the United States National Museum: 161 (2), pp. 1-79.

Cushman, J. A., McCulloch, I., 1939. A report on some arenaceous Foraminifera. Allan Hancock Pacific Expeditions: 6 (1), pp. 1-113.

Cushman, J. A., McCulloch, I., 1940. Some Nonionidae in the collections of the Allan Hancock Foundation. Allan Hancock Pacific Expeditions: 6 (3), pp. 145-178.

Cushman, J. A., McCulloch, I., 1948. The species of *Bulimina* and related genera in the collections of the Allan Hancock Foundation. Southern California, Univ., Publ., Allan Hancock Pacific Exped., Los Angeles, Calif.: 6 (5), 238 pp.

Cushman, J. A. and Moyer, D. A., 1930. Some Recent foraminifera from off San Pedro, California. Contr. Cushman Lab. Foram. Res., Sharon, Hass., U. S. A.: 6 part 3, no. 93.

Cushman, J. A., Parker, F. L., 1947. Bulimina and related foraminiferal genera. Professional Papers U. S. Geological Survey: 210-D, pp. 55-176.

Cushman, J. A., Parker, F. L., 1948. The species of Bulimina and related genera in the collections of the Allan Hancock Foundation. Allan Hancock Pacific Expeditions: 6 (5), pp. 211-294.

Cushman, J. A., Stevenson, F. V., 1948. A Miocene foraminiferal fauna from Ecuador. Contributions from the Cushman Laboratory for Foraminiferal Research: 24, pp. 50-68.

Czjzek, J., 1848. Beitrag zur Kenntnis der fossilen Foraminiferen des Wiener Beckens. Heidinger’s Naturwissenschaftliche Abhandlungen, Wien, Österreich: 2 (1), pp. 137-150.

Decrouez, D., Radoicic, R., 1977. Nummoloculina irregularis n. sp., nouveau Foraminifère du Sénonien (Santonien) de la Serbie occidentale (Dinarides yougoslaves). Genève, Univ., Lab. Pal., Notes, Geneva: 1, no. 7.

den Dulk, M., Reichart, G. J., Memon, G. M., Roelofs, E. M. P., Zachariasse, W. J., van der Zwaan, G. J., 1998. Benthic foraminiferal response to variations in surface water productivity and oxygenation in the northern Arabian Sea. Marine Micropaleontology: 35, pp. 43-66.

del Carmen Morales, M., Field, D., Mayor Pastor, S., Gutierrez, D., Sifeddine, A., Ortlieb, L., Ferreira, V., Salvatteci, R., Velazco, F., 2006. Variaciones de foraminiferos de ultimos 460 años en sedimentos laminados de la plataforma continental Peruana. Bol. Soc. geol. Perú: 101, pp. 5-18.

Doyle, W. L., 1935. Distribution of mitochondria in the foraminiferan, *Iridia diaphana*. Science: 81, p. 387.

Duijnstee, I. A. P., Ernst, S. R., Van der Zwaan, G. J., 2003. Effects of anoxia on the vertical distribution of benthic Foraminifera. Marine Ecology Progress Series: 246, pp. 85-94.

Earland, A., 1933. Foraminifera, Part 2 – South Georgia. Discovery Reports, Cambridge, England: 7, ? pp.

Earland, A., 1934. Foraminifera, Part. 3. The Falklands sector of the Antarctic (excluding South Georgia). Discovery Reports: 10, 208 pp.

Eberwein, A., Mackensen, A., 2006. Regional primary productivity differences off Morocco (NW-Africa) recorded by modern benthic foraminifera and their stable carbon isotopic composition. Deep-Sea Research I: 53, pp. 1379-1405.

Egger, J. G., 1893. Foraminiferen aus Meeresgrundproben, gelothet von 1874 bis 1876 S. M. Sch. Gazelle.
Abhandlungen der Bayrischen Akademie der Wissenschaften, München, Math.-Physik. Cl.: 18 (2), pp. 266-311.

Ellis & Messina online catalogues, 1942-2006. Micropaleontology Press.

Erbacher, J, Nelskamp, S., 2006. Comparison of benthic foraminifera inside and outside a sulphur Oxidizing bacterial mat from the present oxygen-minimum zone off Pakistan (NE Arabian Sea). Deep-Sea Research I 53, pp. 751-775.

Erez, J., 2003. The source of ions for biomineralization in foraminifera and their implications for paleoceanographic proxies. In: Dove, P. M., De Yoreo, J. J., and Weiner, S. (eds.), Biomineralization: Mineralogical Society of America, Washington, D. C., pp. 115-149.

Fariduddin, M. Loubere, P., 1997. The surface ocean productivity response of deeper water benthic foraminifera in the Atlantic Ocean. Marine Micropaleontology: 32, pp. 298-310.

Figueroa, S., Marchant, M., Giglio, S., Ramírez, M., 2005. Benthic rotaliinan foraminiferans of the Central South of Chile (36ºS-44ºS). Gayana: 69 (2), pp. 329-363.

Finger, K. L., 1990. Atlas of California Neogene Foraminifera. Cushman Foundation for Foraminiferal Research, Special Publication: 28, 271 pp.

Finlay, B. J., Span, A. S. W., and Harman, J. M. P., 1983. Nitrate respiration in primitive eukaryotes. Nature: 303, pp. 333-335.

8. References

Flint, J. M., 1899. Recent Foraminifera. A descriptive catalogue of specimens dredged by the U.S. Fish Commission Steamer Albatross. Smithonian Institution, U.S. National Museum, Washington, pp. 249-349.

Fontanier, C., Jorissen, F. J., Licari, L., Alexandre, A., Anschutz, P., Carbonel, P., 2002. Live Benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition, and microhabitats. Deep-Sea Research I: 49, pp. 751-785.

Fontanier, C., Jorissen, F. J., Lansard, B., Mouret, A., Buscail, R., Schmidt, S., Kerherve, P., Buron, F., Zaragosi, S., Hunault, G., Ernoult, E., Artero, C., Anschutz, P., Rabouille, C., 2008. Live foraminifera from the open slope between Grand Rhône and Petit Rhône Canyons (Gulf of Lions, NW Mediterranean). Deep-Sea Research I: 55, pp. 1532-1553.

Francis, C. A., Beman, J. M., Kuypers, M. M. M., 2007. New processes and players in the nitrogen cycle: the microbial ecology of anaerobic and archaeal ammonia oxidation. ISME Journal: 1, pp. 19-27.

Frenzel, P., Tech, T., Bartholdy, J., 2005. Checklist and annotated bibliography of Recent Foraminiferida from the German Baltic Sea coast. Studia Geologica Polonica: 124, pp. 67-86.

Frezza, V., Carboni, M.G., 2009. Distribution of recent foraminiferal assemblages near the Ombrone River mouth (Northern Tyrrhenian Sea, Italy). Revue de micropaleontology: 52, pp. 43-66.

Frezza, V., Pignatti, J. S., Matteucci, R., 2010. Benthic foraminiferal biofacies in temperate Carbonate sediment in the western Pontine Archipelago (Tyrrhenian Sea, Italy). Journal of Foraminiferal Research: 40 (4), pp. 313-326.

Froelich, P. N., Arhur, M. A., Burnett, W. C., Deakin, M., Hensley, V., Jahnke, R., Kaul, L., Kim, K., Roe, K., Soutar, A., Vathakanon, C., 1988. Early diagenesis of organic matter in Peru continental margin sediments: phosphorite precipitation. Marine Geology: 80, pp. 309-343.

Gallardo, V.A., 1977. Large benthic microbial communities in sulfide biota under Peru-Chile Subsurface countercurrent. Nature: 268, pp. 331-332.

Galloway, J. J., Wissler, S. G., 1927. Pleistocene foraminifera from the Lomita Quarry, Palos Verdes Hills, California. Journal of Paleontology: 1, pp. 35-87.

Galloway, J. J., Morrey, M., 1929. A Lower Tertiary foraminiferal fauna from Manta, Ecuador. Bull. American Paleontology: 15, pp. 1-56.

Garrison, T. S., 2003. Essentials of Oceanography. Brooks/Cole; 3rd edition, 352 pp.

Geslin, E., Heinz, P., Jorissen, F., Hemleben, Ch., 2004. Migratory responses of deep-sea benthic foraminifera to variable oxygen conditions: laboratory investigations. Marine Micropaleontology: 53, pp. 227-243.

Glock, N., Eisenhauer, A., Milker, Y., Liebetrau, V., Schönfeld, J., Mallon, J., Sommer, S., Hensen, C., 2011. Environmental influences on the pore-density of *Bolivina spissa* (Cushman). Journal of Foraminiferal Research: 41 (1), pp. 22-32.

Glud, R. N., Thamdrup, B., Stahl, H., Wenzhoefer, F., Glud, A., Nomaki, H., Oguri, K., Revsbech, N. P., Kitazato, H., 2009. Nitrogen cycling in a deep ocean margin sediment (Sagami Bay, Japan). Limnology and Oceanography: 54, pp. 723-734.

Goës, A., 1896. Reports on the dredging operations off the West Coast of Central America to the

Galapagos, to the West Coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by U.S. Fish Commission Steamer "Albatros", during 1891, Lieut. Commander Z. L. Tanner, U.S.N., commanding. Bulletin of the Museum of Comparative Zoology at Harvard College: 29 (1), pp. 1-103.

Gooday, A. J., 1986. Meiofaunal foraminiferans from the bathyal Porcupine Seabight (northeast Atlantic): size structure, standing stock, taxonomic composition, species diversity and vertical distribution in the sediment. Deep Sea-Research: 33 (10), pp. 1345-1373.

Gooday, A. J., Bernhard, J. M., Levin, L. A., Suhr, S. B., 2000. Foraminifera in the Arabian Sea Oxygen minimum zone and other oxygen deficient settings: taxonomic composition, diversity, and relation to metazoan faunas. Deep-Sea Res. II: 47, pp. 25-54.

Gooday, A. J., Bett, B. J., Shires, R., Lambshead, P. J. D., 2005. Deep-sea benthic foraminiferal Species diversity in the NE Atlantic and NW Arabian sea: a synthesis. Deep-Sea Research II:45, 165 -201.

Grasshoff, K., 1983. Determination of oxygen. In: Grasshoff, K., Ehrhardt, M., and Kremling, K. (eds.), Methods of Seawater Analysis. Verlag Chemie Weinheim, New York, pp. 61-72.

Grzybowski, J., 1896. Foraminifera of the red clay of Wadowice. In: Kaminski, M. A. et al. (eds.), The Origins of Applied Micropalaeontology: The School of Josef Grzybowski. The Grzybowski Foundation Special Publication: 1. The Alden Press, Ltd. Oxford, pp. 49-84.

Grzymski, J., Schofield, O. M., Falkowski, P. G., Bernhard, J. M., 2002. The function of plastids in the deep sea benthic foraminifer, *Nonionella stella*. Limnology and Oceanography: 47 (6), pp. 1569-1580.

Harmann, R. A., 1964. Distribution of foraminifera in the Santa Barbara Basin, California. Micropaleontology: 10, pp. 81-96.

Hayward, B. W., Grenfell, H. R., Reid, C. M., Hayward, K. A., 1999. Recent New Zealand shallow Water benthic foraminifera: Taxonomy, ecologic distribution, biogeography, and use in paleoenvironmental assessment. New Zealand Geological Survey Paleontological Bulletin: 75, 258 pp.

Hayward, B. W., Johnson, K., Sabaa, A. T., Kawagata, S., Thomas, E., 2010. Cenozoic record of elongate, cylindrical, deep-sea benthic foraminifera in the North Atlantic and equatorial Pacific Oceans. Marine Micropaleontology :74, pp. 75-95.

Heinz, P., Sommer, S., Pfannkuche, O., Hemleben, Chr., 2005. Living benthic foraminifera in Sediments influenced by gas hydrates at the Cascadia convergent margin, NE Pacific. Mar. Ecol. Prog. Ser.: 304, pp. 77-89.

Heinz, P., Ruschmeier,W., Hemleben, Chr., 2008. Live benthic foraminiferal assemblages at the Pacific Continental Margin of Costa Rica and Nicaragua. J. Foram. Res.: 38 (3), pp. 215-227.

Hendrix, W. E., 1958. Foraminiferal shell form, a key to sedimentary Environment. Journal of Paleontology: 32, pp. 649-659.

Henrichs, S. M., Farrington, J. W., 1984. Peru upwelling region sediments near 15°S. 1. Remineralization and accumulation of organic matter. Limnology and Oceanography: 29, pp. 1-19.

8. References

Herguera, J. C., 2000. Last glacial paleoproductivity patterns in the eastern equatorial Pacific: benthic foraminifera records. Marine Micropaleontology: 40, pp. 259-275.

Hermelin, J. O. R., 1987. Distribution of Holocene benthic foraminifera in the Baltic Sea. Journal of Foraminiferal Research: 17 (1), pp. 62-73.

Hermelin, J. O. R., Shimmield, G. B., 1990. The Importance of the Oxygen Minimum Zone and Sediment Geochemistry in the Distribution of Recent Benthic Foraminifera in the Northwest Indian Ocean. Marine Geology: 91, pp. 1-29.

Heron-Allen, E., Earland, A., 1922. Protozoa; part II – Foraminifera. British-Antarctic ("Terra Nova") Expedition, 1910, Zoology: 35, pp. 599-647.

Heron-Allen, E., Earland, A., 1932. Foraminifera, part I – The ice-free area of the Falkland Islands and adjacent seas. Discovery Reports: 4, pp. 291-460.

Hess, S., Kuhnt, W., 2005. Neogene and Quaternary paleoceanographic changes in the southern South China Sea (Site 1143): the benthic foraminiferal record. Marine Micropaleontology: 54, pp. 63-87.

Hessland, I., 1943. Marine Schalenablagerungen Nord-Bohusläns. Uppsala, Univ., Geol. Inst., Bull., Uppsala: 31.

Hodgkinson, R. L., 1992. W. K. Parker's collections of foraminifera in the British Museum (Natural History). Bulletin British Museum Natural History (Geology): 48, pp. 45-78.

Hoffmeister, W. S., Berry, C. T., 1937. A new genus of Foraminifera from the Miocene of Venezuela And Trinidad. Journal of Paleontology: 11 (1), pp. 29-30.

Hofker, J., 1951. The Foraminifera of the Siboga Expedition. Part III: Ordo Dentata. Siboga Expedition Monograph: 4a, pp. 1-513.

Höglund, H., 1947. Foraminifera in the Gullmar Fjord and the Skagerak. Zoologiska Bidrag Från Uppsala: 26, pp. 1-328.

Høgslund, S., Revsbech, N. P., Cedhagen, T., Nielsen, L. P., Gallardo, V. A., 2008. Denitrification, nitrate turnover, and aerobic respiration by benthic foraminiferans in the oxygen minimum zone off Chile. Journal of Experimental Marine Biology and Ecology: 359, pp. 85-91.

Holbourn, A. E., Henderson, A. S., 2002. Re-Illustration and Revised Taxonomy for selected Deep Sea Benthic Foraminifers. Palaeontologia Electronica: 4 (2), pp. 1-36.

Hooper, K., Jones, P., 1977. Preliminary Report on Benthonic Foraminifera from the Mid-Atlantic Ridge: Leg 37 DSDP. Init. Rep. Deep-Sea Drill. Proj. 37, 963-965.

Hottinger, L., Dreher, D., 1974. Differentiation of protoplasm in Nummulitidae (Foraminifera) from Elat, Red Sea. Marine Biology: 25, pp. 41-61.

Ingle, J., Jr., Keller, G., Kolpack, R. L., 1980. Benthic Foraminiferal Biofacies, Sediments and Water Masses of the Southern Peru-Chile Trench Area, Southeastern Pacific Ocean. Micropaleontology: 26 (2), pp. 113-150.

Jannink, N. T., Zachariasse, W. J., van der Zwaan, G. J., 1998. Living (Rose bengal stained) Benthic foraminifera from the Pakistan continental margin (northern Arabian Sea). Deep-Sea Research I: 45, pp. 1483-1513.

Jian, Z., Wang, L., 1997. Late Quaternary benthic foraminifera and deep-water paleoceanography in the South China Sea. Marine Micropaleontology: 32, pp. 127-154.

Jian, Z., Wang, L., Kienast, M., Sarnthein, M., Kuhnt, W., Lin, H., Wang, P., 1999. Benthic Foraminiferal paleoceanography of the South China Sea over the last 40,000 years. Marine Geology: 156, pp. 159-186.

Jones, R. J., 1984. A revised classification of the unilocular Nodosariida and Buliminida (Foraminifera). Revista Española de Micropaleontología: 5 (2), pp. 93-105.

Jones, R. J., 1994. The Challenger Foraminifera. Oxford, University Press, 149 pp.

Jones, T. R., Parker, W. K., 1860. On the rhizopodal fauna of the Mediterranean, compared with that of the Italian and some other Tertiary deposits. Geol. Soc. London, Quart. Journ.: 16, 292-307.

Jorissen, F. J., de Stigter, H. C., Widmark, J. G. V., 1995. A conceptual model explaining benthic foraminiferal microhabitats. Marine Micropaleontology: 26, pp. 3-15.

Jorissen, F. J., Wittling, I., Peypouquet, J. P., Rabouille, C., Relexans, J. C., 1998. Live benthic foraminiferal faunas off Cape Blanc, NW-Africa: Community structure and microhabitats. Deep Sea Research I: 45, pp. 2157-2188.

Kaiho, K., 1994. Benthic foraminiferal dissolved-oxygen index and dissolved-oxygen levels in the Modern ocean. Geology: 22, pp. 719-722.

Kato, M., 1992. Benthic foraminifers from the Japan Sea: Leg 128. Proceedings of the Ocean Drilling Program, Scientific Results: 127 (12), pp. 365-392.

Keijzer, C. J., 1935. On variability in East Indian Foraminifera. Thesis Univ. Leiden, Brill. Publ. Leiden, p. 1-79.

Kim, K. H., Burnett, W., 1988. Accumulation and biological mixing of Peru margin sediments. Marine Geology: 80, pp. 181-194.

Kleinpell, R. M., 1938. Miocene stratigraphy of California. American Association of Petroleum Geologists, Tulsa: 450 pp.

Klitgaard Kristensen, D., Sejdrup, H. P., 1996. Modern benthic foraminiferal biofacies across the northern North Sea. Sarsia: 81, pp. 97-106.

Kornfeld, M. M., 1931. Recent littoral foraminifera from Texas and Louisiana. Stanford Univ. Dept. Geol., Contr., Stanford Univ., Calif.,U. S. A.: 1, pp.?

Krissek, L. A., Scheidegger, K. F., 1983. Environmental controls on sediments texture and composition in low oxygen zones off Peru and Oregon. In: J. Thiede and E. Suess: Coastal upwelling – ist sediment record, Part B: Sedimentary records of ancient coastal upwelling. Nato Conference Series, Ser. 4: Marine Sciences: 10b, 610 pp.

Kristan-Tollmann, E., 1964. Die Foraminiferen aus den rhätischen Zlambachmergeln der Fischerwiese bei Aussee. Jahrbuch der Geologischen Bundesanstalt, Wien, Sonderband: 10, pp. 1-189.

Lamarck, J. B., 1804. Suite des mémoires sur les fossiles des environs de Paris. Annales Muséum National d' Historie Naturelle: 5, pp. 349-357.

Langer, M. R., Lipps, J. H., 2003. Foraminiferal distribution and diversity, Madang Reef and Lagoon, Papua New Guinea. Coral Reefs: 22, pp. 143-154.

Lankester, E.R., 1885. Protozoa, **in:** The Encyclopaedia Britannica , 19 (9th ed.), pp. 830-866.

Lankford, R. R., Phleger, F. B., 1973. Foraminifera from the nearshore turbulent zone, western North America. Journal of Foraminiferal Research: 3 (3), pp. 101-132.

Lecroix, E., 1931. Microtexture du test des *Textularidae*. Bulletin of the Oceanographic Institute of Monaco: 582.

Leth, O., Shaffer, G., Ulloa, O., 2004. Hydrography of the eastern South Pacific Ocean: results from the Sonne 102 cruise, May–June 1995. Deep-Sea Research II: 51, pp. 2349-2369.

Leutenegger, S., Hansen, H. J., 1979. Ultrastructural and radiotracer studies of pore function in foraminifera. Marine Biology: 54, pp. 11-16.

Levin, L.A., Huggett, C.L., Wishner, K.F., 1991. Control of deep-sea benthic community structure by Oxygen and organic-matter gradients in the eastern Pacific Ocean. Journal of Marine Research: 49, pp. 763-800.

Levin, L. A., Gutiérrez, D., Rathburn, A., Neira, C., Sellanes, J., Muñoz, P., Gallardo, V., Salamanca, M., 2002. Benthic processes on the Peru margin: a transect across the oxygen minimum zone during the 1997-98 El Niño. Progr. Oceanography: 53, pp 1-27.

Li, Q., Wang, J., Chen, J., Wie, Q., 2010. Stable carbon isotopes of benthic foraminifers from IODP Expedition 311 as possible indicators of episodic methane seep events in a gas hydrate geosystem. PALAIOS: 25, pp. 671-681.

Linnaeus, C., 1758. Systema naturae. 10th Edidtion, 1, Holmiae (Stockholm), L. Salvii, 824 pp.

Lobegeier, M. K., Sen Gupta, B. K., 2008. Foraminifera of hydrocarbon seeps, Gulf of Mexico. Journal of Foraminiferal Research: 38 (2), pp. 93-116.

Loeblich, A. R., Tappan, H., 1988. Foraminiferal Genera and their Classification. Van Nostrand Reinhold, New York, 2 vols.

Loeblich, A. R., Tappan, H., 1994. Foraminifera of the Sahul Shelf and Timor Sea. Cushman Foundation for Foraminiferal Research, Special Publication: 31, 661 pp.

Lutze, G. F., 1962. Variiationsstatistik und Ökologie bei rezenten Foraminiferen. Paläontologische Zeitschrift: 36, pp. 252-264.

Lutze, G. F., 1986. *Uvigerina* species of the eastern North Atlantic. In: van der Zwaan, G. J., Jorissen, F. J., Verhallen, P. J. J. M., and von Daniels, C. H. (eds.), Atlantic-European Oligocene to Recent *Uvigerina*. Utrecht Micropaleontological Bulletins: 35, pp. 21-46.

Lutze, G. F., 2007. Benthic foraminifers at side 397: faunal fluctuations and ranges in the Quaternary. Deep Sea Drilling Project, Reports and Publications:47, pp. 419-431.

Lutze, G. F., Coulbourn, W. T., 1983/84.Recent benthic foraminifera from the continental margin of Northwest Africa: community structure and distribution. Marine Micropaleontology: 8, pp. 361-401.

Maas, M., 2000. Verteilung lebendgefärbter benthischer Foraminiferen in einer intensivierten Sauerstoffminimumzone, Indo-Pakistanischer Kontinentalrand, nördliches Arabisches Meer. Meyniana: 52, pp. 101-129.

Mackensen, A., Grobe, H., Kuhn, G., Fütterer, D. K., 1990. Benthic foraminiferal assemblages from The eastern Weddell Sea between 68 and 73°S: Distribution, ecology and fossilization potential. Marine Micropaleontology:16, pp. 241-283.

8. References

Mackensen, A., Fütterer, D. K., Grobe, H., Schmiedl, G., 1993. Benthic foraminiferal assemblages from the eastern South Atlantic Polar Front region between 35 ° and 57°S: Distribution, ecology and fossilization potential. Marine Micropaleontology: 22, pp. 33-69.

Majewski, W., 2010. Benthic foraminifera from West Antarctic fiord environments: An overview. Polish Polar Research: 31 (1), pp. 61-82.

Makled, W. A., Langer, M. R., 2011. Benthic Foraminifera from the Chuuk Lagoon Atoll System (Caroline Islands, Pacific Ocean) Neues Jahrbuch Geol. Paläont., Abhandlungen: 259 (2), pp. 231-249.

Manheim, F., Rowe, G. T., Jipa, D., 1975. Marine Phosphorite Formation off Peru. Journal of Sedimentary Petrology: 45 (1), pp. 243-251.

Martin, R. A., Nesbitt, E. A., Campbell, K. A., 2010. The effects of anaerobic methane oxidation on Benthic foraminiferal assemblages and stable isotopes on the Hikurangi Margin of eastern New Zealand. Marine Geology: 272, pp. 270-284.

McCulloch, I., 1977. Qualitative observations of on recent foraminiferal tests with emphasis on the Eastern Pacific. Parts 1-3. Los Angeles, University of Southern California: x + 1079 pp.

Millett, F. W., 1898. Report on the recent foraminifera of the Malay Archipelago collected by Mr. A. Durrand; Part III. Journal of the Royal Microscopical Society, London, England, pp. 607-614.

Miloslavich, P., Klein, E., Díaz, J. M., Hernández, C. E., Bigatti, G., Campos, L., Artigas, F., Castillo, J., Penchaszadeh, P. E., Neill, P. E., Carranza, A., Retana, M. V., Díaz de Astarloa, J. M., Lewis, M., Yorio, P., Piriz, M. L., Rodríguez, D., Yoneshigue-Valentin, Y., Gamboa, L., Martín, A., 2011. Marine Biodiversity in the Atlantic and Pacific Coasts of South America: Knowledge and Gaps. PLoS ONE: 6 (1), pp. 1-43; e14631. doi:10.1371/journal.pone.0014631.

Mojtahid, M, Jorissen, F., Durrieu, J., Galgani, F., Howa, H., Redois, F., Camps, R., 2006. Benthic foraminifera as bio-indicators of drill cutting disposal in tropical east Atlantic outer shelf environments. Marine Micropaleontology: 61, pp. 58-75.

Montagu, G., 1803. Testacea Britannica, or Natural History of British Shells, Marina, Land and Fresh Water, Including the Most Minute. Romsey, England, J. S. Hollis, 606 pp.

Montagu, G., 1808. Testacea Britannica, Supplement. S. Woolmer, Exeter, England.

de Montfort, P. D., 1808. Conchyliologie Systématique et Classification Méthodique des Coquilles. F. Schoell, Paris, France, 1, 409 pp.

Moodley, L., Hess, C., 1992. Tolerance of infaunal benthic foraminifera for low and high oxygen concentrations. Biological Bulletin: 183, pp. 94-98.

Moodley, L., Van der Zwaan, G. J., Herman, P. M. J., Kempers, L., Van Breugel, P., 1997. Differential response of benthic meiofauna to anoxia with special reference to Foraminifera (Protista: Sarcodina). Marine Ecol. Progr. Series: 158, pp. 151-163.

Morales, M., Field, D., Mayor Pastor3, S., Gutierrez, D., Sifeddine, A., Ortlieb, L., Ferreira, V., Salvatteci, R., Velazco, F., 2006. Variations in Foraminifera over the last 460 years from laminated sediments off the coast of Peru. Boletín de la Sociedad Geológica del Perú: 101, pp. 5-18.

Morigi, C., Jorissen, F. J., Fraticelli, S., Horton, B. P., Principi, M., Sabbatini A., Capotondi, L., Curzi, P. V., Negri, A., 2005. Benthic foraminiferal evidence for the formation of the Holocene mud-belt and bathymetrical evolution in the central Adriatic Sea. Marine Micropaleontology: 57, p.25-49.

Muñoz, P., Lange, C. B., Gutiérrez, D., Hebbeln, D., Salamanca, M. A., Dezileau, L., Reyss, J. L., Benninger, L. K., 2004. Recent sedimentation and mass accumulation rates based on ^{210}Pb along the Peru-Chile continental margin. Deep-Sea Research II: 51, pp., 2523-2541.

Murgese, D. S., De Deckker, P., 2005. The distribution of deep-sea benthic foraminifera in core tops from the eastern Indian Ocean. Marine Micropaleontology: 56, pp. 25-49.

Murray, J. W., 1971. An atlas of British Recent foraminiferids. Heinemann Educational Books, London, Xii+244 pp.

Murray, J. W., 2003. An illustrated guide to the benthic foraminifera of the Hebridean Shelf, west of Scotland, with notes on their mode of life. Palaeontologia Electronica: 5 (1), 31 pp.

Narayan, Y. R., Barnes, C. R., Johns, M. J., 2005. Taxonomy and biostratigraphy of Cenozoic Foraminifers from Shell Canada wells, Tofino Basin, offshore Vancouver Island, British Columbia. Micropaleontology: 51 (2) pp. 101-167.

Natland, M. L., 1938. New species of foraminifera from off the west coast of North America and from the later Tertiary of the Los Angeles Basin. University of California, Scripps Institution of Oceanography Bulletin, Technical ser.: 4 (5), pp. 137-163.

Natland, M. L., 1950. Reports on the Pleistocene and Pliocene foraminifera. In: Anderson, C. A. et al., 1940 E. W., Scripps cruise to the Gulf of California. Memoires of the Geological Society of America, New York: 43 (4), pp. 1-55.

Neira, C., Sellanes, J., Levin, L. A., Arntz, W. E., 2001. Meiofaunal distributions on the Peru margin: relationship to oxygen and organic matter availability Deep-Sea Research I: 48, pp. 2453-2472.

Nigam, R., Prasad, V., Mazumder, A., Garg, R., Saraswat, R., Henriques, P. J., 2009. Late Holocene changes in hypoxia off the west coast of India: Micropalaeontological evidences. Science: 96 (5), pp. 708-712.

Nomaki, H., Heinz, Nakatsuka, T., Shimanaga, M., Ohkouchi, N., Ogawa, N. O., Kogure, K., Ikemoto, E., Kitazato, H., 2006. Different ingestion patterns of ^{13}C-labeled bacteria and algae by deep-sea benthic foraminifera. Marine Ecology Progress Series: 310, pp. 95-108.

Nomura, R., 1983. Cassidulinidae (Foraminiferida) from the Uppermost Cenozoic of Japan. Part I. Tohoku Univ., Sci. Rep., 2nd ser. (Geol.): 53 (1), pp. 1-101.

Nomura, R., 1983. Cassidulinidae (Foraminiferida) from the Uppermost Cenozoic of Japan. Part II. Tohoku Univ., Sci. Rep., 2nd ser. (Geol.): 54 (1), pp. 1-93.

Oberhänsli, H., Heinze, P., Diester-Haass, L., Wefer, G., 1990. Upwelling off Peru during the last 430,000 yr and its relationship to the bottom-water environment, as deduced from coarse grain-size distributions and analyses of benthic foraminifers at holes 679D, 680B, and 681B, Leg 112. Proceedings of the Ocean Drilling Program, Scientific Results: 112, pp. 369-390.

Ohga, T., Kitazato, H., 1997. Seasonal changes in bathyal foraminiferal populations in response to the flux of organic matter (Sagami Bay, Japan). Terra Nova: 9 (1), pp. 33-37.

de Orbigny, A., 1826. Tableau méthodique de la classe de Céphalopodes. Annales des Sciences

Naturelles: 7, pp.245-314.
de Orbigny, A., 1839a. Foraminiferés. In: Ramon de la Sagra, Histoire physique et naturelle de l' île de Cuba. A Bertrand, Paris, France, pp. 1-224.
de Orbigny, A., 1839b. Voyage dans l' Amérique méridionale-Foraminifères, 5, part 5, pp. 1-86.
de Orbigny, A., 1846. Foraminiferes fossils du basin tertiaire de Vienne (Austriche). Paris: Gide et Comp., 312 pp.
Parker, W. K., Jones, T. R., 1865. On some foraminifera from the North Atlantic and Arctic Oceans, Including Davis Straits and Baffin's Bay. Philosophical Transactions of the Royal Society: 155, pp. 325-441.
Parr, W. J., 1950. Foraminifera. Reports B.A.N.Z. Antarctic Research Expedition 1929-1931, ser. B (Zoology, Botany): 5 (6), pp. 232-392.
Patterson, R.T., Burbidge, S. M., Luternauer, J. L., 1998. Atlas of common benthic foraminiferal species for Quaternary shelf environments of Western Canada, Bulletin of the Geological Survey of Canada: 503, 91 pp.
Perez-Cruz, L. L., Machain-Castillo, M. L., 1990. Benthic foraminifera of the oxygen minimum zone, continental shelf of the Gulf of Tehuantepec, Mexico. Journal of Foraminiferal Research: 20, pp. 312-325.
Philander, S. G., 1990. El Niño, La Niña, and the Southern Oscillation. Academic Press, International Geophysics Series: 46, 293 pp.
Phleger, F. B., 1964. Patterns of living benthonic foraminifera, Gulf of California. AAPG Special Volumes: M 3: Marine Geology of the Gulf of California, pp. 377-394.
Phleger, F. B., Parker, F. L., 1951. Ecology of foraminifera, northwest Gulf of Mexico. Part II. Foraminiferal species. Memoirs of the Geological Society of America: 46, pp. 1-46.
Phleger, F. B., Soutar, A., 1973. Production of benthic foraminifera in three east Pacific oxygen minima. Micropaleontology: 19, pp. 110-115.
Piña-Ochoa, E., Høgslund, S., Geslin, E., Cedhagen, T., Revsbech, N. P., Nielsen, L. P., Schweizer, M., Jorissen, F., Rysgaard, S., Risgaard-Petersen, N. (2010) Widespread occurence of nitrate storage and denitrification among Foraminifera and Gromiida. PNAS: 19, pp. 1148-1153.
Poag, C. W., 1966. Paynes Hammock (Lower Miocene?) foraminifera of Alabama and Mississippi. Micropaleontology: 12 (4).
Rasmussen, T.L., 2005. Systematic paleontology and ecology of benthic foraminifera from the Plio Pleistocene Kallithea Bay section, Rhodes, Greece. Cushman Foundation Special Publication: 39, pp. 53-157.
Rathburn, A. E., Corliss, B. H., 1994. The ecology of living (stained) deep-sea from the Sulu Sea. Paleoceanography: 9 (1), pp. 87-150.
Reimers, C. E., Suess, E., 1983. Spatial and temporal patterns of organic matter accumulation on the Peru continental margin. In: J. Thiede, E. Suess (eds.), Coastal upwelling – its sediment record, Part B: Sedimentary records of ancient coastal upwelling, Plenum Press, NY, pp. 331-346.
Rein, B., Lückge, A., Sirocko, F., 2004. A major Holocene ENSO anomaly during the Medieval

period. Geophysical Research Letters: 31, L17211, doi:10.1029/2004GL020161.

Rein, B., Lückge, A., Reinhardt, L., Sirocko, F., Wolf, A., Dullo, W.-C., 2005. El Niño variability off Peru during the last 20,000 years. Paleoceanography: 20, PA4003, doi:10.1029/2004PA001099.

Renema, W., Bellwood, D. R., Braga, J. C., Bromfield, K., Hall, R., Johnson,, K. G., Lunt, P., Meyer, C. P., McMonagle, L. B., Morley, R. J., O'Dea, A., Todd, J. A., Wesselingh, F. P., Wilson, M. E. J., Pandolfi, J. M., 2008. Hopping Hotspots: Global Shifts in Marine Biodiversity. Science: 321, pp. 645-657.

Resig, J. M., 1981. Biogeography of benthic foraminifera of the northern Nazca Plate and adjacent Continental margin. Geological Society of America, Memoir: 154, pp. 619-665.

Resig, J. M., 1990. Benthic Foraminiferal Stratigraphy and Paleoenvironments off Peru, Leg 112. Proceedings of the Ocean Drilling Program, Scientific Results: 112, pp. 263-296.

Reuss, A. E., 1851. Über die fossilen Foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin. Zeitschrift der Deutschen Geologischen Gesellschaft, Berlin: 3, pp. 49-91.

Revets, S. A., 1990. The revision of *Buliminella* Cushman, 1911. Journal of Foraminiferal Research: 20 (4), pp. 336-348.

Revsbech, N. P., Larsen, L. H., Gundersen, J., Dalsgaard, T., Ulloa, O., Thamdrup, B., 2009. Determination of ultra-low oxygen concentrations in oxygen minimum zones by the STOX sensor. Limnology and Oceanography: Methods: 7, pp. 371-381.

Risgaard-Petersen, N., Langezaal, A. M., Ingvardsen, S., Schmid, M. C., Jetten, M. S. M., Op den Camp, H. J. M., Derksen, J. W. M., Piña-Ochoa, E., Eriksson, S. P., Nielsen, L. P., Revsbech, N. P., Cedhagen, T. van der Zwaan, G. J., 2006. Evidence for complete denitrification in a benthic foraminifer. Nature: 443, pp. 93-96.

Saidova, K. M., 1970. Bentosnye Foraminifery rayona Kurilo-Kamchatskogo zheloba (po materialam 39-goreysa e/s "Vityaz"). Trudy Instituta Okeanologii: 86, pp. 134-161.

Saidova, K. M., 1975. Bentosnye Foraminifery Tikhogo Okeana, 3 vol. Moscow: Institut Okeanologii P P. Shirshova, Akademiya Nauk SSSR, 875 pp.

Sars, K. M., 1869 (1868). Fortsatte bemaerkninger over det dyriske livs udbredning i havets dybder. Forhandlinger I videnskasselskabet i Kristiania 1868: pp. 246-275.

Sars, G. O., 1872. Undersøgelser over Hardangerfjordens Fauna. Forhandlinger i Videnskasselskabet I Kristiania. 1871: pp. 246-255.

Schmiedl, G., 1995. Late Quaternary benthic foraminiferal assemblages from the eastern South Atlantic Ocean: Reconstruction of deep water circulation and productivity changes. Reports on Polar Research: 160, 208 pp.

Schönfeld, J., Spiegler, D., 1995. Benthic foraminiferal biostratigraphy of site 861, Chile triple junction, southeastern Pacific. Proceedings of the Ocean Drilling Program, Scientific Results: 141, pp. 213-221.

Schönfeld, J., 2006. Taxonomy and distribution of the *Uvigerina peregrina* plexus in the tropical to northeastern Atlantic. Journal of Foraminiferal Research: 36 (4), pp. 355-367.

Schönfeld, J., Dullo, W.-Chr., Pfannkuche, O., Freiwald, A., Rüggenberg, A., Schmidt, S., Weston, J., 2010. Recent benthic foraminiferal assemblages from cold-water coral mounds in the Porcupine Seabight; Atlantic. Facies: 56 (4), DOI: 10.1007/s10347-010-0234-0.

Schröder, C. J., 2007. Changes in benthic foraminifer assemblages across the Holocene/Pleistocene boundary, Sites 619, 620, 621, 622 and 624; Deep Sea Drilling Project Leg 96. Deep Sea Drilling Project Reports and Publications: 96, pp. 631-642.

Schumacher, S., 2001. Microhabitat preferences of benthic foraminifera in South Atlantic Ocean sediments. Ber. Polarforsch. Meeresforsch., Alfred-Wegener-Institut für Polar- und Meeresforschung: 403, 151 pp.

Schumacher, S., Jorissen, F. J., Dissard, D., Larkin, K. E., Gooday, A. J., 2007. Live (Rose Bengal stained) and dead benthic foraminifera from the oxygen minimum zone of the Pakistan continental margin (Arabian Sea). Marine Micropaleontology: 62, pp. 45-73.

Schwager, C., 1866. Fossile Foraminiferen von Kar Nikobar, Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859 unter den Befehlen des Commodore B. von Wüllerstorf-Urbair, Geologischer Theil: 2 (1), Paläontologische Mitteilungen, pp. 187-268.

Schwager, C., 1878. Nota su alcuni foraminiferi nuovi del tufo di Stretto presso Girgenti. Bolletino R. Comitato Geologico d' Italia: 9, pp. 519-529.

Seguenza, G., 1862. Prime richerche intorno ai rizopodi fossili delle argille Pleistoceniche die dintorni Di Catania. Atti Accad. gioenia Sei, nat., Catania, ser. 2: 18, pp. 84-126.

Seiglie, G. A., 1967. Systematics of the Foraminifers from Araya Los Testigos shelf and upper slope, Venezuela, with special reference to Suborder *Rotaliina* and its distribution. Carib. J. Sci.: 7 (3 4), pp. 95-133.

Sen Gupta, B. K., Machain-Castillo, M. L., 1993. Benthic foraminifera in oxygen-poor habitats. Marine Micropaleontology: 20, pp. 183-201.

Shepherd, A. S., Rathburn, A. E., Pérez, M. E., 2007. Living foraminiferal assemblages from the Southern California margin: A comparison of the >150, 63–150, and >63 μm fractions. Marine Micropaleontology: 65, pp. 54-77.

Silva, K. A., Corliss, B. H., Rathburn, A. E., Thunnel, R. C., 1996. Seasonality of living benthic Foraminifera from the San Pedro Basin, California Borderland. Journal of Foraminiferal Research: 26, pp. 71-93.

Silvestri, A., 1898. Foraminiferi pliocenici della Provincia di Siena. Part II. Memorie dell' Academia Ponteficia dei NuoviLincei, Roma, Italia: 15.

Sjoerdsma, P. G. and van der Zwaan, G. J., 1992. Simulating the effect of changing organic flux and Oxygen content on the distribution of benthic foraminifera. Marine Micropaleontology: 19, pp. 163-180.

Smith, P. B., 1963. Quantitative and Qualitative Analysis of the Family *Bolivinidae*. Recent Foraminifera off
Central America. Geological Survey Professional Paper: 429-A.

Sprovieri, R., Hasegawa, S., 1990. Plio-Pleistocene benthic foraminifera stratigraphic distribution in the deep sea record of the Tyrrhenian Sea (ODP Leg 107). Proceedings of the Ocean Drilling Program, Scientific Results: 28, pp. 429-459.

Stewart, R. E. & K. C., 1930. Post-Miocene foraminifera from the Ventura Quadrangle, Ventura County, California. Journal of Paleontology: 4 (1), pp. 60-72.

Strub, P. T. Mesías, J.M., Montecino, V., Rutllant, J., Salinas, S., 1998. Coastal ocean circulation off western South America. In: Robinson, A.R., Brink, K.H. (Eds.), The Sea, vol. 11. J. Wiley and Sons, New York, pp. 273-314.

Sverdrup, H. U., Johnson, M. W., Fleming, R. H., 1942. The Oceans, Their Physics, Chemistry, and General Biology. Prentice Hall, New York, 1087 pp.

Tapia, R, Lange, C. B., Marchant, M., 2008. Living (stained) calcareous benthic foraminifera from Recent sediments off Concepción, central-southern Chile (~36º S). Revista Chilena de Historia Natural: 81, pp. 403-416.

Todd, R., 1952. Vicksburg (Oligocene) smaller foraminifera from Mississippi. Geological Survey Professional Paper: 241, pp. ?.

Todd, R., 1965. The Foraminifera of the Tropical Pacific Collections of the "Albatross" 1894-1900, Part 4, rotaliform families and planktonic families. Bulletin of the United States National Museum: 161, pp. x-139.

Todd, R., Brönnimann, P., 1957. Recent foraminifera and thecamoebina from the eastern Gulf of Paria. Special Publications Cushman Foundation for Foraminiferal Research: 3, pp. 1-43.

Uchio, T., 1960. Ecology of living benthonic foraminifera from the San Diego, California, Area. Cushman Foundation for Foraminiferal Research. Special Publication: 5, 1-72 pp.

Van Marle, L. J., 1991. Eastern Indonesian, Late Cenozoic Smaller Benthic Foraminifera. Verh. K. Nederl. Akad. Wetensch., North Holland, Amsterdam: 34, 328 pp.

Walker, G., Boys, W., 1784. Testacea minuta varioa, nuperime detecta in arena littoris Sandvicensis a Gul. Boys, arm. SA.S. Multa addidit, et omnium figures ope microscopii ampliatus accurate delineavit Geo. Walker. London, pp. 1-24.

Walker, G., Jacob, E., 1789. In: Adams, E.: Essays on the microscope; 2nd Edition with considerable Additions and improvements by F. Kanmacher, Dillon & Keating, London, 712 pp.

Whittaker, J., 1988. Benthic Cenozoic Foraminifera from Ecuador. British Museum (Natural History), London, Great Britain, 194 pp.

Williamson, W. C., 1848. On the recent British species of *Lagena*. Annales and Magazine of Natural History, ser. 2: 1, pp. 1-20.

Williamson, W. C., 1858. On the recent foraminifera of Great Britain. London, England, Ray Society: pp. X-107.

Wolf, A., 2002. Zeitliche Variationen im peruanischen Küstenauftrieb seit dem Letzten Glazialen Maximum – Steuerung durch globale Klimadynamik. Ph.D. Thesis, University of Kiel, Germany.

Wollenburg, J., 1995. Benthic foraminiferal assemblages in the Arctic Ocean: indicators for water Mass distribution, productivity, and sea ice drift. Reports on Polar Research: 179, 227 pp.

Zheng, S.-Y., 1988. The agglutinated and porcelaneous Foraminifera of the East China Sea. China Ocean Press, Beijing.

8. References

Zheng, S.-Y., Zhaoxian, F., 2001. Granuloreticulosa: Foraminifera, Agglutinated Foraminifera. Fauna Sinica: Invertebrata: 26, 788 pp, Science Press.

Appendix

1 – 2

A1

Species protocols M77 leg 1 and 2

sample	**403_1**	**406_1**	**410_1**	**421_1**	**449_1**	**449_2**	**449_3**	**456_1**	**456_2**
sediment depth [mm]	**0-2**	**0-2**	**0-2**	**0-5**	**0-5**	**5-10**	**10-15**	**0-2**	**2-4**
Split / **Species**	**1/2**	**1/1**	**1/2**	**1/1**	**1/32**	**1/4**	**1/1**	**1/4**	**1/8**
Adercotryma glomerata									
Alveolophragmium scitulum									
Alveolophragmium subglobosum			1						
Ammobaculites agglutinans									
Ammobaculites americanus									
Ammodiscus incertus									
Ammodiscus tenuis									
Ammoglobigerina globigeriniformis			1						
Ammoglobigerina globulosa			3						
Ammolagena clavata									
Ammomarginulina foliaceus									
Ammomassilina alveoliniformis			1						
Ammosphaeroidina grandis						2			
Angulogerina angulosa		4							
Angulogerina carinata	6							2	7
Bathysiphon sp.									
Bolivina alata var. A									6
Bolivina alata var. B						1			8
Bolivina costata	25			5	19	46	19	9	11
Bolivina hantkeniana									
Bolivina interjuncta	90	2		78				110	140
Bolivina plicata	13			3	21	33	20		3
Bolivina (Loxostomum) boltovskoyi									1
Bolivina (Loxostomum) salvadorensis									1
Bolivina seminuda	94			10	294	127	167	20	99
Bolivina spinescens									
Bolivina spissa		4		6					
Bolivina subadvena									
Bolivina subadvena serrata									
Bolivina subaenariensis									
Bolivinita minuta		12							
Bulimina ovata var. *primitiva*									
Bulimina pagoda									
Bulimina pupoides					16	1		11	1
Buliminella curta					1				
Buliminella curta basispinata									12
Buliminella elegantissima limbosa						8	2		
Buliminella elegantissima tenuis					20	25	6		
Buzasina sp.									
Cancris carmenensis	14				22	23	15	2	14
Cassidulina auka		1				1		8	1
Cassidulina crassa	17							4	5
Cassidulina delicata		2							
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									1
Cibicidoides mckannai									
Cibicidoides wuellerstorfi		14							
Cribrogoesella pacifica									
Cyclammina cancellata									
Cyclammina trullissata									
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra									
Eggerella humboldti									
Ehrenbergina compressa	3	2							1
Ehrenbergina trigona									
Epistominella exigua									

sample	403_1	406_1	410_1	421_1	449_1	449_2	449_3	456_1	456_2
sediment depth [mm]	0-2	0-2	0-2	0-5	0-5	5-10	10-15	0-2	2-4
Split / Species	1/2	1/1	1/2	1/1	1/32	1/4	1/1	1/4	1/8
Epistominella obesa	9					1			
Epistominella pacifica		6		31					
Eponides sp.									
Fissurina annectens									
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis	4					15	6	4	18
Gaudryina baccata									
Gaudryina bradyi									
Globobulimina hoeglundi									
Globobulimina pacifica									
Glomospira gordialis									
Gyroidina neosoldanii									
Gyroidina soldanii	2		1						
Gyroidina soldanii multilocula	26							7	4
Hanzawaia boueana									
Hanzawaia mexicana									
Hanzawaia prona									
Haplophragmoides canariensis mexicana									
Haplophragmoides columbiense evolutum									3
Haplophragmoides pusillus				2					
Haplophragmoides rotulatum									
Haplophragmoides sphaeriloculum									
Hoeglundina elegans									3
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima									
Lagena hispidula									
Lagena laevis		1	2						
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens									
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum									
Marsipella granulosa								3	
Martinottiella nodulosa									
Melonis barleeanum									
Nonion commune									
Nonionella auris									
Nonionella japonica mexicana									
Nonionella stella									
Nonionides grateloupii						27	11		
Nubeculina sp.				1					
Nummoloculina irregularis									
Oolina apiculata									
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus		4							
Parafissurina lateralis									
Planispirinoides bucculentus									
Planulina ecuadorana									
Pleurostomella brevis									
Pseudobrizalina lobata									
Pullenia elegans								3	
Pullenia bulloides									
Pullenia subcarinata									4

sample	403_1	406_1	410_1	421_1	449_1	449_2	449_3	456_1	456_2
sediment depth [mm]	0-2	0-2	0-2	0-5	0-5	5-10	10-15	0-2	2-4
Species / Split	1/2	1/1	1/2	1/1	1/32	1/4	1/1	1/4	1/8
Pulvinulinella subperuviana		2					1	3	
Pyrgo murrhyna			1						
Quinqueloculina seminula									
Recurvoides contortus									
Recurvoides turbinatus									
Reophax apiculatus									
Reophax dentaliniformis								3	
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis		1							
Reophax guttifer									
Reophax insectus									
Reophax pilulifer									
Reophax pisiformis									
Reophax scorpiurus									2
Robertina oceanica									
Robulus thalmanni									
Rosalina vilardeboana									
Saccammina sphaerica		1							
Saccorhiza ramosa									
Saracenaria stolidota									
Spiroplectammina biformis									
Suggrunda eckisi									1
Suggrunda kleinpelli						2			
Suggrunda porosa									
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									1
Textularia porrecta									
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis									
Trochammina inflata									
Trochammina nana									
Trochammina nitida		3							
Trochammina squamata			1						
Trochammina triloba									
Uvigerina auberiana									
Uvigerina semiornata									
Uvigerina canariensis									
Uvigerina peregrina	7	23	1	25					
Uvigerina striata								15	4
Vaginulina americana									
Valvulina oblonga		1							
Valvulineria vilardeboana glabra	35				8	2		5	13
Verneuilina advena									
Verneuilina bradyi	1	1		1		2	1		
Verneuilina propinqua									
Virgulina bradyi									
Virgulina schreibersiana									
Virgulina texturata									
Σ	**346**	**84**	**12**	**162**	**401**	**316**	**248**	**209**	**364**

Taxa_S	15	18	9	10	8	16	10	16	26
Fisher_alpha	3,2	7,0	16,4	2,4	1,4	3,6	2,1	4,0	6,4
Population density [#/ccm]	17	22	3	9	473	44	8	96	139
Volume of sample [ccm]	40.6	3.9	7.4	17.2	27.1	29.0	30.7	8.7	21.0
bottom water oxygen concentration [µmol/kg]					2.25	2.25	2.25	3.79	3.79

sample	456_3	456_4	456_5	459_1	459_2	459_3	459_4	459_5	470_1
sediment depth [mm]	4-6	6-8	8-10	0-2	2-4	4-6	6-8	8-10	0-2
Species / Split	1/4	1/4	1/2	1/1	1/2	1/1	1/1	1/1	1/1
Adercotryma glomerata									
Alveolophragmium scitulum									
Alveolophragmium subglobosum									
Ammobaculites agglutinans					2	1	1		
Ammobaculites americanus									
Ammodiscus incertus	1			2					
Ammodiscus tenuis					3				
Ammoglobigerina globigeriniformis									
Ammoglobigerina globulosa									
Ammolagena clavata									
Ammomarginulina foliaceus					36	1			
Ammomassilina alveoliniformis									
Ammosphaeroidina grandis									
Angulogerina angulosa				4	3	3			
Angulogerina carinata	1	1							
Bathysiphon sp.	3								
Bolivina alata var. A	3				1				
Bolivina alata var. B	8								
Bolivina costata	2	3			4				4
Bolivina hantkeniana									
Bolivina interjuncta	98	67	58						
Bolivina plicata	4								1
Bolivina (Loxostomum) boltovskoyi	2								
Bolivina (Loxostomum) salvadorensis									
Bolivina seminuda	54	11	9	1					134
Bolivina spinescens									
Bolivina spissa					30	65	42	48	
Bolivina subadvena									
Bolivina subadvena serrata									
Bolivina subaenariensis									
Bolivinita minuta				20	30	5			
Bulimina ovata var. *primitiva*									
Bulimina pagoda									
Bulimina pupoides	1	2	3						
Buliminella curta									
Buliminella curta basispinata									
Buliminella elegantissima limbosa									
Buliminella elegantissima tenuis									3
Buzasina sp.									
Cancris carmenensis		2	7						
Cassidulina auka	4	1	2						
Cassidulina crassa	3		2	30	37	18	4		
Cassidulina delicata				10	68	25	8	1	
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									
Cibicidoides mckannai									
Cibicidoides wuellerstorfi	1								
Cribrogoesella pacifica									
Cyclammina cancellata				9	4	4			
Cyclammina trullissata									
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra						4		1	
Eggerella humboldti									
Ehrenbergina compressa	1								
Ehrenbergina trigona									
Epistominella exigua									

sample	456_3	456_4	456_5	459_1	459_2	459_3	459_4	459_5	470_1
sediment depth [mm]	4-6	6-8	8-10	0-2	2-4	4-6	6-8	8-10	0-2
Species / Split	1/4	1/4	1/2	1/1	1/2	1/1	1/1	1/1	1/1
Epistominella obesa	1	1				2	1	1	
Epistominella pacifica					2	2			
Eponides sp.									
Fissurina annectens					1				
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis	25	10	8		17	19	10	5	3
Gaudryina baccata									
Gaudryina bradyi									
Globobulimina hoeglundi									
Globobulimina pacifica						9	4		
Glomospira gordialis									
Gyroidina neosoldanii					1				
Gyroidina soldanii	4			1					
Gyroidina soldanii multilocula	2	1	3						
Hanzawaia boueana									
Hanzawaia mexicana									
Hanzawaia prona									
Haplophragmoides canariensis mexicana									
Haplophragmoides columbiense evolutum	1								
Haplophragmoides pusillus									
Haplophragmoides rotulatum									
Haplophragmoides sphaeriloculum									
Hoeglundina elegans	2								
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima						1			
Lagena hispidula									
Lagena laevis						1			
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens									
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum									
Marsipella granulosa									
Martinottiella nodulosa									
Melonis barleeanum									
Nonion commune									
Nonionella auris									31
Nonionella japonica mexicana									
Nonionella stella									
Nonionides grateloupii									
Nubeculina sp.									
Nummoloculina irregularis									
Oolina apiculata									
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus									
Parafissurina lateralis									
Planispirinoides bucculentus									
Planulina ecuadorana									
Pleurostomella brevis									
Pseudobrizalina lobata									
Pullenia elegans				1					
Pullenia bulloides									
Pullenia subcarinata	1	1			2				

sample	456_3	456_4	456_5	459_1	459_2	459_3	459_4	459_5	470_1
sediment depth [mm]	**4-6**	**6-8**	**8-10**	**0-2**	**2-4**	**4-6**	**6-8**	**8-10**	**0-2**
Split / **Species**	**1/4**	**1/4**	**1/2**	**1/1**	**1/2**	**1/1**	**1/1**	**1/1**	**1/1**
Pulvinulinella subperuviana									
Pyrgo murrhyna									
Quinqueloculina seminula					2				
Recurvoides contortus									
Recurvoides turbinatus									
Reophax apiculatus				20	42	3	1		
Reophax dentaliniformis									
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis									
Reophax guttifer									
Reophax insectus									
Reophax pilulifer									
Reophax pisiformis									
Reophax scorpiurus	1								
Robertina oceanica									
Robulus thalmanni									
Rosalina vilardeboana									
Saccammina sphaerica									
Saccorhiza ramosa									
Saracenaria stolidota						1			
Spiroplectammina biformis									
Suggrunda eckisi									
Suggrunda kleinpelli									
Suggrunda porosa									
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									
Textularia porrecta									
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis									
Trochammina inflata									
Trochammina nana									
Trochammina nitida									
Trochammina squamata									
Trochammina triloba									
Uvigerina auberiana				2	1				
Uvigerina semiornata									
Uvigerina canariensis				1			1		
Uvigerina peregrina				56	66	19	18	1	
Uvigerina striata	17	4	6			1			
Vaginulina americana									
Valvulina oblonga					2	5	18	13	
Valvulineria vilardeboana glabra	17		1					4	
Verneuilina advena									
Verneuilina bradyi									
Verneuilina propinqua									
Virgulina bradyi	1								
Virgulina schreibersiana								2	
Virgulina texturata									
Σ	**258**	**104**	**99**	**157**	**354**	**189**	**108**	**76**	**176**

Taxa_S	26	12	10	13	21	20	11	9	6
Fisher_alpha	7,2	3,5	2,8	3,4	4,9	5,7	3,1	2,7	1,2
Population density [#/ccm]	57	10	6	10	35	9	5	4	10
Volume of sample [ccm]	18.13	40.9	35.6	15.8	20.5	21.2	20.2	18.1	18.1
bottom water oxygen concentration [µmol/kg]	3.79	3.79	3.79	15.72	15.72	15.72	15.72	15.72	3.33

sample	473_1	482_1	482_2	487_1	516_1	540_1	540_2	540_3	540_4
sediment depth [mm]	0-5	0-2	2-4	0-2	0-5	0-2	2-4	4-7	7-10
Split / Species	1/64	1/1	1/16	1/4	1/8	1/1	1/16	1/8	1/2
Adercotryma glomerata									
Alveolophragmium scitulum									
Alveolophragmium subglobosum									
Ammobaculites agglutinans									
Ammobaculites americanus									
Ammodiscus incertus									
Ammodiscus tenuis									
Ammoglobigerina globigeriniformis									
Ammoglobigerina globulosa									
Ammolagena clavata									
Ammomarginulina foliaceus									
Ammomassilina alveoliniformis									
Ammosphaeroidina grandis									
Angulogerina angulosa									
Angulogerina carinata					1				
Bathysiphon sp.									
Bolivina alata var. A				3	6				
Bolivina alata var. B			8						
Bolivina costata	72	14	97		9	3	153	473	132
Bolivina hantkeniana									
Bolivina interjuncta		1	2	14	24				
Bolivina plicata	63	48	36	1					
Bolivina (Loxostomum) boltovskoyi									
Bolivina (Loxostomum) salvadorensis									
Bolivina seminuda	324	79	250	3	31	1	30	74	7
Bolivina spinescens									
Bolivina spissa				3					
Bolivina subadvena									
Bolivina subadvena serrata									
Bolivina subaenariensis									
Bolivinita minuta				36	19				
Bulimina ovata var. *primitiva*									
Bulimina pagoda									
Bulimina pupoides		1	1			1		4	
Buliminella curta	4								
Buliminella curta basispinata				1					
Buliminella elegantissima limbosa	1						2	4	1
Buliminella elegantissima tenuis	5	1	14					1	
Buzasina sp.									
Cancris carmenensis	8	15	15		101				
Cassidulina auka	1		1	3					
Cassidulina crassa				1	2				
Cassidulina delicata				4					
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									
Cibicidoides mckannai									
Cibicidoides wuellerstorfi				12	1				
Cribrogoesella pacifica									
Cyclammina cancellata									
Cyclammina trullissata									
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra									
Eggerella humboldti									
Ehrenbergina compressa					1				
Ehrenbergina trigona									
Epistominella exigua							1		

sample	473_1	482_1	482_2	487_1	516_1	540_1	540_2	540_3	540_4
sediment depth [mm]	**0-5**	**0-2**	**2-4**	**0-2**	**0-5**	**0-2**	**2-4**	**4-7**	**7-10**
Split / **Species**	**1/64**	**1/1**	**1/16**	**1/4**	**1/8**	**1/1**	**1/16**	**1/8**	**1/2**
Epistominella obesa	1		27						
Epistominella pacifica					1				
Eponides sp.									
Fissurina annectens									
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis		8	22	5	2	8	20		7
Gaudryina baccata									
Gaudryina bradyi			1	1					
Globobulimina hoeglundi									
Globobulimina pacifica									
Glomospira gordialis									
Gyroidina neosoldanii									
Gyroidina soldanii									
Gyroidina soldanii multilocula		5	1	1	45				
Hanzawaia boueana									
Hanzawaia mexicana				1					
Hanzawaia prona									
Haplophragmoides canariensis mexicana					2				
Haplophragmoides columbiense evolutum					1				
Haplophragmoides pusillus									
Haplophragmoides rotulatum									
Haplophragmoides sphaeriloculum									
Hoeglundina elegans									
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima									
Lagena hispidula									
Lagena laevis									
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens									
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum									1
Marsipella granulosa									
Martinottiella nodulosa									
Melonis barleeanum									
Nonion commune									
Nonionella auris									
Nonionella japonica mexicana									
Nonionella stella		2				12	169	122	45
Nonionides grateloupii									
Nubeculina sp.									
Nummoloculina irregularis									
Oolina apiculata									
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus				5					
Parafissurina lateralis									
Planispirinoides bucculentus									
Planulina ecuadorana									
Pleurostomella brevis					1				
Pseudobrizalina lobata									
Pullenia elegans		3		7	13				
Pullenia bulloides									
Pullenia subcarinata									

sample	473_1	482_1	482_2	487_1	516_1	540_1	540_2	540_3	540_4
sediment depth [mm]	0-5	0-2	2-4	0-2	0-5	0-2	2-4	4-7	7-10
Split / Species	1/64	1/1	1/16	1/4	1/8	1/1	1/16	1/8	1/2
Pulvinulinella subperuviana					1			2	
Pyrgo murrhyna									
Quinqueloculina seminula									
Recurvoides contortus					1				
Recurvoides turbinatus									
Reophax apiculatus									
Reophax dentaliniformis									
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis									
Reophax guttifer									
Reophax insectus									
Reophax pilulifer									
Reophax pisiformis									
Reophax scorpiurus									
Robertina oceanica									
Robulus thalmanni									
Rosalina vilardeboana									
Saccammina sphaerica									
Saccorhiza ramosa									
Saracenaria stolidota									
Spiroplectammina biformis									
Suggrunda eckisi									
Suggrunda kleinpelli									
Suggrunda porosa		1							
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									
Textularia porrecta									
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis									
Trochammina inflata									
Trochammina nana									
Trochammina nitida									
Trochammina squamata									
Trochammina triloba									
Uvigerina auberiana									
Uvigerina semiornata									
Uvigerina canariensis									
Uvigerina peregrina				87					
Uvigerina striata									
Vaginulina americana									
Valvulina oblonga				2					
Valvulineria vilardeboana glabra	5	9	15		5				
Verneuilina advena									
Verneuilina bradyi					3				
Verneuilina propinqua									
Virgulina bradyi									
Virgulina schreibersiana									
Virgulina texturata						2	10	7	
Σ	**484**	**187**	**490**	**190**	**270**	**27**	**385**	**687**	**193**

Taxa_S	10	13	14	19	21	6	7	8	6
Fisher_alpha	1,8	3,2	2,7	5,3	5,3	2,4	1,2	1,3	1,2
Population density [#/ccm]	1045	14	570	48	79	3	508	168	14
Volume of sample [ccm]	29.6	13.7	13.7	15.7	27.4	7.83	12.1	32.7	28.5
bottom water oxygen concentration [µmol/kg]	2.25	2.26	2.26	8.59	4.83	5.28	5.28	5.28	5.28

sample	540_5	540_6	540_7	540_8	540_9	540_10	540_11	549_1	553_1
sediment depth [mm]	10-15	15-20	20-25	25-30	30-35	35-40	40-50	0-2	0-5
Split / Species	1/1	1/16	1/2	1/1	1/1	1/8	1/4	1/1	1/8
Adercotryma glomerata									1
Alveolophragmium scitulum									
Alveolophragmium subglobosum								2	
Ammobaculites agglutinans								2	
Ammobaculites americanus								6	
Ammodiscus incertus								1	
Ammodiscus tenuis									
Ammoglobigerina globigeriniformis									
Ammoglobigerina globulosa									
Ammolagena clavata								1	
Ammomarginulina foliaceus									
Ammomassilina alveoliniformis									
Ammosphaeroidina grandis									
Angulogerina angulosa									
Angulogerina carinata									5
Bathysiphon sp.								2	
Bolivina alata var. A									68
Bolivina alata var. B									
Bolivina costata	337	379	636	315	93	738	1139	3	11
Bolivina hantkeniana									
Bolivina interjuncta									86
Bolivina plicata									
Bolivina (Loxostomum) boltovskoyi									
Bolivina (Loxostomum) salvadorensis									
Bolivina seminuda	18	3	3	8	33		1	2	65
Bolivina spinescens									
Bolivina spissa								7	14
Bolivina subadvena									
Bolivina subadvena serrata									3
Bolivina subaenariensis									
Bolivinita minuta								2	10
Bulimina ovata var. *primitiva*									
Bulimina pagoda									
Bulimina pupoides									3
Buliminella curta									
Buliminella curta basispinata									
Buliminella elegantissima limbosa		1	6	15	4	8	106		
Buliminella elegantissima tenuis	5		1						
Buzasina sp.									
Cancris carmenensis									34
Cassidulina auka									
Cassidulina crassa									3
Cassidulina delicata								32	
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									
Cibicidoides mckannai									
Cibicidoides wuellerstorfi									1
Cribrogoesella pacifica									
Cyclammina cancellata									
Cyclammina trullissata								6	
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra									
Eggerella humboldti									
Ehrenbergina compressa									
Ehrenbergina trigona									
Epistominella exigua									

sample	540_5	540_6	540_7	540_8	540_9	540_10	540_11	549_1	553_1
sediment depth [mm]	10-15	15-20	20-25	25-30	30-35	35-40	40-50	0-2	0-5
Species / Split	1/1	1/16	1/2	1/1	1/1	1/8	1/4	1/1	1/8
Epistominella obesa									
Epistominella pacifica									
Eponides sp.									
Fissurina annectens									
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis	9		4	3	6			1	32
Gaudryina baccata									
Gaudryina bradyi									
Globobulimina hoeglundi									
Globobulimina pacifica									
Glomospira gordialis								1	
Gyroidina neosoldanii									6
Gyroidina soldanii									3
Gyroidina soldanii multilocula									1
Hanzawaia boueana									
Hanzawaia mexicana									
Hanzawaia prona									
Haplophragmoides canariensis mexicana								2	
Haplophragmoides columbiense evolutum									1
Haplophragmoides pusillus									
Haplophragmoides rotulatum								5	
Haplophragmoides sphaeriloculum									
Hoeglundina elegans									29
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima									
Lagena hispidula								1	
Lagena laevis									
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens									
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum					1		1		
Marsipella granulosa									
Martinottiella nodulosa									
Melonis barleeanum								4	
Nonion commune									
Nonionella auris									
Nonionella japonica mexicana									
Nonionella stella		5	8	11	8	1	11		
Nonionides grateloupii									
Nubeculina sp.									
Nummoloculina irregularis								2	
Oolina apiculata								1	
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus									
Parafissurina lateralis								1	
Planispirinoides bucculentus									
Planulina ecuadorana									4
Pleurostomella brevis									
Pseudobrizalina lobata									
Pullenia elegans									9
Pullenia bulloides									
Pullenia subcarinata									

sample	540_5	540_6	540_7	540_8	540_9	540_10	540_11	549_1	553_1
sediment depth [mm]	10-15	15-20	20-25	25-30	30-35	35-40	40-50	0-2	0-5
Split / Species	1/1	1/16	1/2	1/1	1/1	1/8	1/4	1/1	1/8
Pulvinulinella subperuviana	4		10	6	3		1	3	
Pyrgo murrhyna								5	
Quinqueloculina seminula									
Recurvoides contortus									
Recurvoides turbinatus									
Reophax apiculatus									
Reophax dentaliniformis									
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis									
Reophax guttifer								5	
Reophax insectus								2	
Reophax pilulifer								7	
Reophax pisiformis									
Reophax scorpiurus								48	2
Robertina oceanica									
Robulus thalmanni								1	
Rosalina vilardeboana								3	
Saccammina sphaerica									
Saccorhiza ramosa									
Saracenaria stolidota									
Spiroplectammina biformis								2	
Suggrunda eckisi									
Suggrunda kleinpelli									
Suggrunda porosa									
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									
Textularia porrecta								7	
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis									
Trochammina inflata									
Trochammina nana									
Trochammina nitida									
Trochammina squamata									1
Trochammina triloba									
Uvigerina auberiana									
Uvigerina semiornata								2	
Uvigerina canariensis								2	
Uvigerina peregrina									32
Uvigerina striata									5
Vaginulina americana									
Valvulina oblonga									
Valvulineria vilardeboana glabra									
Verneuilina advena									
Verneuilina bradyi									
Verneuilina propinqua									
Virgulina bradyi									
Virgulina schreibersiana									
Virgulina texturata				1					
Σ	**373**	**388**	**668**	**359**	**148**	**747**	**1259**	**171**	**428**

Taxa_S	5	4	7	7	7	3	6	33	25
Fisher_alpha	0,8	0,6	1,1	1,2	1,5	0,4	0,8	12,2	5,8
Population density [#/ccm]	5	111	24	5	3	98	60	22	70
Volume of sample [ccm]	81.3	56.13	55.13	74.13	45.6	60.9	84.1	7.8	48.7
bottom water oxygen concentration [µmol/kg]	5.28	5.28	5.28	5.28	5.28	5.28	5.28		4.83

sample	582_2	583_1	583_2	616_2	616_3	616_4	616_5	616_6	616_7
sediment depth [mm]	5-10	0-10	10-15	2-4	4-6	6-8	8-10	10-15	15-20
Split / Species	1/64	1/16	1/4	1/32	1/1	1/2	1/2	1/2	1/2
Adercotryma glomerata									
Alveolophragmium scitulum									
Alveolophragmium subglobosum									4
Ammobaculites agglutinans									
Ammobaculites americanus									
Ammodiscus incertus	1								
Ammodiscus tenuis									
Ammoglobigerina globigeriniformis									
Ammoglobigerina globulosa									
Ammolagena clavata									
Ammomarginulina foliaceus									
Ammomassilina alveoliniformis									
Ammosphaeroidina grandis									
Angulogerina angulosa								1	
Angulogerina carinata									
Bathysiphon sp.									
Bolivina alata var. A									
Bolivina alata var. B			1						10
Bolivina costata	54	42	14	69	85	31	30	54	13
Bolivina hantkeniana									
Bolivina interjuncta				1	2	2	2		
Bolivina plicata	27	6	6	80	147	27	30	43	25
Bolivina (Loxostomum) boltovskoyi									
Bolivina (Loxostomum) salvadorensis									
Bolivina seminuda	228	1146	389	272	334	119	113	190	142
Bolivina spinescens									
Bolivina spissa		1							
Bolivina subadvena									
Bolivina subadvena serrata									
Bolivina subaenariensis									
Bolivinita minuta									
Bulimina ovata var. *primitiva*									
Bulimina pagoda									
Bulimina pupoides	2	1							
Buliminella curta									
Buliminella curta basispinata									
Buliminella elegantissima limbosa		17	47	1				2	2
Buliminella elegantissima tenuis	21	5	7						
Buzasina sp.									
Cancris carmenensis	9	1	14	6	17	7	5	4	
Cassidulina auka	2	14	6	4					
Cassidulina crassa									
Cassidulina delicata									
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									
Cibicidoides mckannai									
Cibicidoides wuellerstorfi		1							
Cribrogoesella pacifica									
Cyclammina cancellata									
Cyclammina trullissata									
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra									
Eggerella humboldti									
Ehrenbergina compressa									
Ehrenbergina trigona									
Epistominella exigua									

sample	**582_2**	**583_1**	**583_2**	**616_2**	**616_3**	**616_4**	**616_5**	**616_6**	**616_7**
sediment depth [mm]	**5-10**	**0-10**	**10-15**	**2-4**	**4-6**	**6-8**	**8-10**	**10-15**	**15-20**
Species / Split	**1/64**	**1/16**	**1/4**	**1/32**	**1/1**	**1/2**	**1/2**	**1/2**	**1/2**
Epistominella obesa	5	36	2			12		37	95
Epistominella pacifica								1	
Eponides sp.									
Fissurina annectens									
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis	11		11		10	5	3	7	4
Gaudryina baccata									
Gaudryina bradyi									
Globobulimina hoeglundi									
Globobulimina pacifica									
Glomospira gordialis									2
Gyroidina neosoldanii									
Gyroidina soldanii									
Gyroidina soldanii multilocula				3	4	1		2	
Hanzawaia boueana									
Hanzawaia mexicana									
Hanzawaia prona									
Haplophragmoides canariensis mexicana									
Haplophragmoides columbiense evolutum									
Haplophragmoides pusillus									1
Haplophragmoides rotulatum									
Haplophragmoides sphaeriloculum									
Hoeglundina elegans									
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima									
Lagena hispidula									
Lagena laevis									
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens									
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum									
Marsipella granulosa									
Martinottiella nodulosa									
Melonis barleeanum									
Nonion commune						5	3	3	
Nonionella auris									
Nonionella japonica mexicana	1								
Nonionella stella									
Nonionides grateloupii									
Nubeculina sp.								1	
Nummoloculina irregularis									
Oolina apiculata									
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus									
Parafissurina lateralis									
Planispirinoides bucculentus									
Planulina ecuadorana									
Pleurostomella brevis									
Pseudobrizalina lobata									
Pullenia elegans									
Pullenia bulloides									
Pullenia subcarinata								1	

sample	582_2	583_1	583_2	616_2	616_3	616_4	616_5	616_6	616_7
sediment depth [mm]	5-10	0-10	10-15	2-4	4-6	6-8	8-10	10-15	15-20
Split / Species	1/64	1/16	1/4	1/32	1/1	1/2	1/2	1/2	1/2
Pulvinulinella subperuviana				3				3	1
Pyrgo murrhyna									
Quinqueloculina seminula									
Recurvoides contortus	1								
Recurvoides turbinatus									
Reophax apiculatus									
Reophax dentaliniformis									
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis									
Reophax guttifer									
Reophax insectus									
Reophax pilulifer									
Reophax pisiformis									
Reophax scorpiurus									
Robertina oceanica									
Robulus thalmanni									
Rosalina vilardeboana									
Saccammina sphaerica									
Saccorhiza ramosa									
Saracenaria stolidota									
Spiroplectammina biformis									
Suggrunda eckisi									
Suggrunda kleinpelli									
Suggrunda porosa									
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									2
Textularia porrecta									
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis									
Trochammina inflata									
Trochammina nana			4						
Trochammina nitida									
Trochammina squamata									
Trochammina triloba									
Uvigerina auberiana									
Uvigerina semiornata									
Uvigerina canariensis									
Uvigerina peregrina									
Uvigerina striata									
Vaginulina americana									
Valvulina oblonga									
Valvulineria vilardeboana glabra				31	34	29	22	53	22
Verneuilina advena									
Verneuilina bradyi						1			
Verneuilina propinqua					1	1		4	15
Virgulina bradyi									
Virgulina schreibersiana									
Virgulina texturata									
Σ	**362**	**1270**	**501**	**470**	**634**	**240**	**208**	**406**	**338**

Taxa_S	12	11	11	10	9	12	8	16	14
Fisher_alpha	2,4	1,7	2,0	1,8	1,5	2,7	1,7	3,3	2,9
Population density [#/ccm]	1333	600	40	757	38	22	16	11	14
Volume of sample [ccm]	38.5	33.9	50.1	19.9	16.6	21.7	26.1	74.6	48.4
bottom water oxygen concentration [µmol/kg]				2.20	2.20	2.20	2.20	2.20	2.20

sample	619_3	619_4	619_6	622_1	622_2	622_3	622_4	635_1	635_2
sediment depth [mm]	10-15	15-20	25-30	0-5	5-10	10-15	15-20	0-3	3-6
Split / Species	1/1	1/1	1/1	1/4	1/2	1/1	1/1	1/8	1/8
Adercotryma glomerata				3					
Alveolophragmium scitulum							1		
Alveolophragmium subglobosum									
Ammobaculites agglutinans				13					
Ammobaculites americanus									
Ammodiscus incertus				1					
Ammodiscus tenuis									2
Ammoglobigerina globigeriniformis					1				
Ammoglobigerina globulosa									
Ammolagena clavata									
Ammomarginulina foliaceus									
Ammomassilina alveoliniformis									
Ammosphaeroidina grandis									
Angulogerina angulosa				21	8	1	1		
Angulogerina carinata				1					
Bathysiphon sp.					3				
Bolivina alata var. A									
Bolivina alata var. B									
Bolivina costata	1								9
Bolivina hantkeniana									
Bolivina interjuncta									
Bolivina plicata								1	1
Bolivina (Loxostomum) boltovskoyi									
Bolivina (Loxostomum) salvadorensis									
Bolivina seminuda	23	15	4	5				18	546
Bolivina spinescens									
Bolivina spissa				1	22	44	18		
Bolivina subadvena									
Bolivina subadvena serrata				2	1				
Bolivina subaenariensis									
Bolivinita minuta				62	21	10	5		
Bulimina ovata var. *primitiva*					1	6	7		
Bulimina pagoda									
Bulimina pupoides									
Buliminella curta									
Buliminella curta basispinata									
Buliminella elegantissima limbosa									3
Buliminella elegantissima tenuis									14
Buzasina sp.									
Cancris carmenensis									2
Cassidulina auka									8
Cassidulina crassa				18	5	7			
Cassidulina delicata				7	18				
Cassidulina laevigata carinata									
Cassidulina subglobosa									
Chilostomella oolina									
Cibicidoides mckannai									
Cibicidoides wuellerstorfi				11	8	3			
Cribrogoesella pacifica				4					
Cyclammina cancellata				8	2	2			
Cyclammina trullissata									
Dentalina filiformis									
Dorothia pseudoturris									
Eggerella scabra				2	1	1			
Eggerella humboldti									
Ehrenbergina compressa									
Ehrenbergina trigona									
Epistominella exigua									

sample	619_3	619_4	619_6	622_1	622_2	622_3	622_4	635_1	635_2
sediment depth [mm]	10-15	15-20	25-30	0-5	5-10	10-15	15-20	0-3	3-6
Species / Split	1/1	1/1	1/1	1/4	1/2	1/1	1/1	1/8	1/8
Epistominella obesa					2				
Epistominella pacifica									
Eponides sp.									
Fissurina annectens					1				
Fissurina submarginata									
Fissurina orbignyana var. *baccata*									
Fissurina sp.									
Fursenkoina fusiformis					24	7	8		19
Gaudryina baccata									
Gaudryina bradyi									
Globobulimina hoeglundi									
Globobulimina pacifica					1		2		
Glomospira gordialis									4
Gyroidina neosoldanii									
Gyroidina soldanii									
Gyroidina soldanii multilocula									
Hanzawaia boueana									
Hanzawaia mexicana									
Hanzawaia prona									
Haplophragmoides canariensis mexicana									2
Haplophragmoides columbiense evolutum					1				
Haplophragmoides pusillus									
Haplophragmoides rotulatum					1	1			
Haplophragmoides sphaeriloculum									
Hoeglundina elegans				34	7	2			
Hormosina globulifera									
Hormosinella distans									
Hyperammina echinata									
Hyperammina friabilis									
Lagena gracillima									
Lagena hispidula									
Lagena laevis									
Lagena substriata									
Lagena sulcata									
Lagenosolenia inflatiperforata									
Lenticulina convergens				1	1				
Lenticulina gibba									
Lenticulina pliocaena									
Loxostomum limbatum									
Marsipella granulosa									
Martinottiella nodulosa									
Melonis barleeanum									
Nonion commune									
Nonionella auris									
Nonionella japonica mexicana									
Nonionella stella			1						
Nonionides grateloupii									
Nubeculina sp.					9	7	1		
Nummoloculina irregularis				1					
Oolina apiculata									
Oridorsalis cf. *pauciapertura*									
Oridorsalis tenerus subsp. *profundus.*									
Oridorsalis umbonatus									
Parafissurina lateralis									
Planispirinoides bucculentus									
Planulina ecuadorana									
Pleurostomella brevis									
Pseudobrizalina lobata									
Pullenia elegans									
Pullenia bulloides									
Pullenia subcarinata							1		

sample	619_3	619_4	619_6	622_1	622_2	622_3	622_4	635_1	635_2
sediment depth [mm]	10-15	15-20	25-30	0-5	5-10	10-15	15-20	0-3	3-6
Species / Split	1/1	1/1	1/1	1/4	1/2	1/1	1/1	1/8	1/8
Pulvinulinella subperuviana									5
Pyrgo murrhyna									
Quinqueloculina seminula					1				
Recurvoides contortus					2				
Recurvoides turbinatus									
Reophax apiculatus									
Reophax dentaliniformis									
Reophax difflugiformis									
Reophax duplex									
Reophax fusiformis									
Reophax guttifer									
Reophax insectus									
Reophax pilulifer									
Reophax pisiformis									
Reophax scorpiurus									
Robertina oceanica									
Robulus thalmanni									
Rosalina vilardeboana									
Saccammina sphaerica									
Saccorhiza ramosa									
Saracenaria stolidota									
Spiroplectammina biformis									
Suggrunda eckisi									
Suggrunda kleinpelli									
Suggrunda porosa									
Technitella sp.									
Textularia agglutinans var. *porrecta*									
Textularia conica									
Textularia porrecta									
Textularia tenuissima									
Thurammina albicans									
Trochammina globorotaliformis				4					
Trochammina inflata									
Trochammina nana									
Trochammina nitida									
Trochammina squamata									
Trochammina triloba									
Uvigerina auberiana									
Uvigerina semiornata					9	2			
Uvigerina canariensis									
Uvigerina peregrina				70	16				
Uvigerina striata									
Vaginulina americana									
Valvulina oblonga				6	16	14	9		
Valvulineria vilardeboana glabra						16	3	1	9
Verneuilina advena									
Verneuilina bradyi					5	1			
Verneuilina propinqua				1					
Virgulina bradyi					10		3		
Virgulina schreibersiana									
Virgulina texturata									18
Σ	**24**	**15**	**5**	**273**	**197**	**124**	**59**	**20**	**642**

Taxa_S	2		2	22	28	16	12	3	14
Fisher_alpha	0,5		1,2	5,6	8,9	4,9	4,6	1,0	2,5
Population density [#/ccm]	0,4	0,4	0,1	23	7	2	1	7	289
Volume of sample [ccm]	49	52.9	35.4	47.8	52.9	53.2	56	24	17.8
bottom water oxygen concentration [µmol/kg]				27.67	27.67	27.67	27.67	2.37	2.37

sample	669_1	676_1	676_2	684_1	692_1	694_1	716_1	723_1
sediment depth [mm]	0-2	0-5	5-10	0-2	1/8	0-2	0-2	0-3
Species / Split	1/1	1/1	1/1	1/1	1/8	1/128	1/2	1/2
Adercotryma glomerata	17							
Alveolophragmium scitulum								
Alveolophragmium subglobosum	3			3				
Ammobaculites agglutinans	18							
Ammobaculites americanus	1			1				
Ammodiscus incertus	1							1
Ammodiscus tenuis								
Ammoglobigerina globigeriniformis	2			2				12
Ammoglobigerina globulosa								
Ammolagena clavata								
Ammomarginulina foliaceus								
Ammomassilina alveoliniformis								
Ammosphaeroidina grandis								
Angulogerina angulosa								
Angulogerina carinata								
Bathysiphon sp.								
Bolivina alata var. A								
Bolivina alata var. B								
Bolivina costata	5			2	19	23		
Bolivina hantkeniana								
Bolivina interjuncta	1				249		3	95
Bolivina plicata					44		36	
Bolivina (Loxostomum) boltovskoyi								
Bolivina (Loxostomum) salvadorensis								
Bolivina seminuda	3	36	105	1	540	428	930	1
Bolivina spinescens					2			
Bolivina spissa						1		38
Bolivina subadvena								
Bolivina subadvena serrata								
Bolivina subaenariensis								
Bolivinita minuta								
Bulimina ovata var. *primitiva*								
Bulimina pagoda								
Bulimina pupoides								
Buliminella curta							4	
Buliminella curta basispinata					3			
Buliminella elegantissima limbosa			8			1		
Buliminella elegantissima tenuis			3			2		
Buzasina sp.								
Cancris carmenensis					14		7	12
Cassidulina auka					1	18	1	
Cassidulina crassa								1
Cassidulina delicata								1
Cassidulina laevigata carinata								
Cassidulina subglobosa				1				
Chilostomella oolina					2			
Cibicidoides mckannai								
Cibicidoides wuellerstorfi					3			2
Cribrogoesella pacifica								
Cyclammina cancellata	3			3				
Cyclammina trullissata								
Dentalina filiformis								
Dorothia pseudoturris								
Eggerella scabra								
Eggerella humboldti								
Ehrenbergina compressa								
Ehrenbergina trigona								
Epistominella exigua								3

sample	669_1	676_1	676_2	684_1	692_1	694_1	716_1	723_1
sediment depth [mm]	0-2	0-5	5-10	0-2	1/8	0-2	0-2	0-3
Split / Species	1/1	1/1	1/1	1/1	1/8	1/128	1/2	1/2
Epistominella obesa			1		51		3	3
Epistominella pacifica	6			31				2
Eponides sp.								
Fissurina annectens				1				
Fissurina submarginata				1				
Fissurina orbignyana var. *baccata*	1			2				
Fissurina sp.								
Fursenkoina fusiformis		1	4		24	3		1
Gaudryina baccata								
Gaudryina bradyi								
Globobulimina hoeglundi								
Globobulimina pacifica								
Glomospira gordialis	3							
Gyroidina neosoldanii						3		
Gyroidina soldanii	1			1				
Gyroidina soldanii multilocula					27		12	
Hanzawaia boueana								
Hanzawaia mexicana								
Hanzawaia prona						4		
Haplophragmoides canariensis mexicana	1							
Haplophragmoides columbiense evolutum								
Haplophragmoides pusillus								
Haplophragmoides rotulatum								
Haplophragmoides sphaeriloculum								1
Hoeglundina elegans	29			1				
Hormosina globulifera								
Hormosinella distans								
Hyperammina echinata	10							
Hyperammina friabilis								
Lagena gracillima								
Lagena hispidula								
Lagena laevis								
Lagena substriata	1							
Lagena sulcata	1							
Lagenosolenia inflatiperforata								
Lenticulina convergens								
Lenticulina gibba								
Lenticulina pliocaena								
Loxostomum limbatum								
Marsipella granulosa								
Martinottiella nodulosa								
Melonis barleeanum				7				
Nonion commune	4					2		
Nonionella auris								
Nonionella japonica mexicana								
Nonionella stella			3					
Nonionides grateloupii								
Nubeculina sp.								
Nummoloculina irregularis								
Oolina apiculata								
Oridorsalis cf. *pauciapertura*	1							
Oridorsalis tenerus subsp. *profundus.*								1
Oridorsalis umbonatus								
Parafissurina lateralis								
Planispirinoides bucculentus								
Planulina ecuadorana								
Pleurostomella brevis								
Pseudobrizalina lobata	2					2		
Pullenia elegans					15			
Pullenia bulloides	4							
Pullenia subcarinata							8	

sample	669_1	676_1	676_2	684_1	692_1	694_1	716_1	723_1
sediment depth [mm]	**0-2**	**0-5**	**5-10**	**0-2**	**1/8**	**0-2**	**0-2**	**0-3**
Species \ Split	**1/1**	**1/1**	**1/1**	**1/1**	**1/8**	**1/128**	**1/2**	**1/2**
Pulvinulinella subperuviana		1	1					
Pyrgo murrhyna	3			4				
Quinqueloculina seminula								
Recurvoides contortus	5							
Recurvoides turbinatus								
Reophax apiculatus								
Reophax dentaliniformis								1
Reophax difflugiformis	1							
Reophax duplex	3			1				
Reophax fusiformis								
Reophax guttifer								
Reophax insectus								
Reophax pilulifer								
Reophax pisiformis								
Reophax scorpiurus	6							
Robertina oceanica								
Robulus thalmanni								
Rosalina vilardeboana								
Saccammina sphaerica								
Saccorhiza ramosa								
Saracenaria stolidota								
Spiroplectammina biformis								
Suggrunda eckisi								
Suggrunda kleinpelli								
Suggrunda porosa					25			
Technitella sp.								
Textularia agglutinans var. *porrecta*								
Textularia conica								
Textularia porrecta								
Textularia tenuissima	2							
Thurammina albicans								
Trochammina globorotaliformis								
Trochammina inflata	5							
Trochammina nana								
Trochammina nitida								
Trochammina squamata								
Trochammina triloba								
Uvigerina auberiana	1			1				
Uvigerina semiornata								
Uvigerina canariensis								
Uvigerina peregrina	1				5	26		17
Uvigerina striata				2				
Vaginulina americana								
Valvulina oblonga								
Valvulineria vilardeboana glabra					81	38	23	
Verneuilina advena								
Verneuilina bradyi								
Verneuilina propinqua								
Virgulina bradyi								
Virgulina schreibersiana								
Virgulina texturata								
Σ	**145**	**38**	**125**	**65**	**1105**	**551**	**1027**	**192**

Taxa_S	32	3	7	18	17	13	10	17
Fisher_alpha	12,7	0,8	1,6	8,2	2,9	2,4	1,5	4,5
Population density [#/ccm]	12	2	4	4	384	1454	107	9
Volume of sample [ccm]	11.8	20.9	33.8	15.6	23.0	48.5	19.1	44.0
bottom water oxygen concentration [µmol/kg]								

sample	744_1	753_1	757_1	767_1	772_1	776_1
sediment depth [mm]	0-5	0-5	0-2	0-3	0-2	0-5
Species / Split	1/1	1/1	1/1	1/2	1/2	1/1
Adercotryma glomerata						
Alveolophragmium scitulum				2		
Alveolophragmium subglobosum						
Ammobaculites agglutinans		2				1
Ammobaculites americanus						3
Ammodiscus incertus					5	2
Ammodiscus tenuis						
Ammoglobigerina globigeriniformis		14			2	2
Ammoglobigerina globulosa						
Ammolagena clavata						
Ammomarginulina foliaceus						
Ammomassilina alveoliniformis						
Ammosphaeroidina grandis						
Angulogerina angulosa						
Angulogerina carinata				8	92	
Bathysiphon sp.						
Bolivina alata var. A					2	
Bolivina alata var. B						
Bolivina costata	4	1	1	5	5	
Bolivina hantkeniana		2				
Bolivina interjuncta					114	1
Bolivina plicata	11					
Bolivina (Loxostomum) boltovskoyi						
Bolivina (Loxostomum) salvadorensis						
Bolivina seminuda		3	3	5	7	1
Bolivina spinescens						
Bolivina spissa		1	186	9		
Bolivina subadvena				1		
Bolivina subadvena serrata	9				41	
Bolivina subaenariensis	39					
Bolivinita minuta				3		
Bulimina ovata var. *primitiva*						
Bulimina pagoda			2	9		
Bulimina pupoides						
Buliminella curta						
Buliminella curta basispinata	6			6		
Buliminella elegantissima limbosa						
Buliminella elegantissima tenuis						
Buzasina sp.						1
Cancris carmenensis						
Cassidulina auka						
Cassidulina crassa				31		
Cassidulina delicata				17	2	
Cassidulina laevigata carinata		8				
Cassidulina subglobosa						
Chilostomella oolina						
Cibicidoides mckannai		16				
Cibicidoides wuellerstorfi		8		1	6	2
Cribrogoesella pacifica						
Cyclammina cancellata		1				
Cyclammina trullissata						
Dentalina filiformis					2	
Dorothia pseudoturris		3				
Eggerella scabra		4	1	28	4	
Eggerella humboldti				1	22	
Ehrenbergina compressa						
Ehrenbergina trigona						1
Epistominella exigua		2		1	170	

sample	744_1	753_1	757_1	767_1	772_1	776_1
sediment depth [mm]	0-5	0-5	0-2	0-3	0-2	0-5
Species / Split	1/1	1/1	1/1	1/2	1/2	1/1
Epistominella obesa	3					
Epistominella pacifica			8	12	1	
Eponides sp.						2
Fissurina annectens		3				2
Fissurina submarginata				2		
Fissurina orbignyana var. *baccata*						
Fissurina sp.				1		
Fursenkoina fusiformis		1		8		
Gaudryina baccata			1		1	
Gaudryina bradyi						
Globobulimina hoeglundi			2			
Globobulimina pacifica						1
Glomospira gordialis		2				
Gyroidina neosoldanii	40		1	4		
Gyroidina soldanii	63	6		33		
Gyroidina soldanii multilocula		4		13		
Hanzawaia boueana	5					
Hanzawaia mexicana				1	34	
Hanzawaia prona						
Haplophragmoides canariensis mexicana						
Haplophragmoides columbiense evolutum		4				
Haplophragmoides pusillus						
Haplophragmoides rotulatum		1				
Haplophragmoides sphaeriloculum						1
Hoeglundina elegans		18		3		3
Hormosina globulifera						4
Hormosinella distans						4
Hyperammina echinata						
Hyperammina friabilis		2				
Lagena gracillima		2		1		1
Lagena hispidula		1				
Lagena laevis		1		1		4
Lagena substriata						
Lagena sulcata						
Lagenosolenia inflatiperforata			1			
Lenticulina convergens	3				2	
Lenticulina gibba				1		
Lenticulina pliocaena					5	
Loxostomum limbatum						
Marsipella granulosa						
Martinottiella nodulosa						2
Melonis barleeanum		6				2
Nonion commune				1		2
Nonionella auris						
Nonionella japonica mexicana						
Nonionella stella						
Nonionides grateloupii						
Nubeculina sp.						
Nummoloculina irregularis						
Oolina apiculata						
Oridorsalis cf. *pauciapertura*						
Oridorsalis tenerus subsp. *profundus.*						
Oridorsalis umbonatus						
Parafissurina lateralis						
Planispirinoides bucculentus						1
Planulina ecuadorana						
Pleurostomella brevis						
Pseudobrizalina lobata					3	1
Pullenia elegans			3	5		1
Pullenia bulloides		15				
Pullenia subcarinata						

sample	744_1	753_1	757_1	767_1	772_1	776_1
sediment depth [mm]	**0-5**	**0-5**	**0-2**	**0-3**	**0-2**	**0-5**
Split / Species	**1/1**	**1/1**	**1/1**	**1/2**	**1/2**	**1/1**
Pulvinulinella subperuviana				52		
Pyrgo murrhyna		1				3
Quinqueloculina seminula		1				8
Recurvoides contortus		8		4		3
Recurvoides turbinatus		3				
Reophax apiculatus						
Reophax dentaliniformis		1		1		14
Reophax difflugiformis					4	12
Reophax duplex						
Reophax fusiformis						
Reophax guttifer						
Reophax insectus						
Reophax pilulifer						9
Reophax pisiformis						2
Reophax scorpiurus		1			23	1
Robertina oceanica		2				
Robulus thalmanni						
Rosalina vilardeboana						
Saccammina sphaerica						
Saccorhiza ramosa						7
Saracenaria stolidota						
Spiroplectammina biformis						
Suggrunda eckisi						
Suggrunda kleinpelli						
Suggrunda porosa						
Technitella sp.						1
Textularia agglutinans var. *porrecta*						8
Textularia conica		2			3	
Textularia porrecta						
Textularia tenuissima						
Thurammina albicans						1
Trochammina globorotaliformis						
Trochammina inflata						
Trochammina nana						
Trochammina nitida						
Trochammina squamata						1
Trochammina triloba		17				6
Uvigerina auberiana						2
Uvigerina semiornata						
Uvigerina canariensis		2	6	1		
Uvigerina peregrina	4	3	40	10	30	
Uvigerina striata	7					
Vaginulina americana					4	
Valvulina oblonga						
Valvulineria vilardeboana glabra		2		4		
Verneuilina advena					16	
Verneuilina bradyi		1				1
Verneuilina propinqua						
Virgulina bradyi						
Virgulina schreibersiana						
Virgulina texturata						
Σ	**194**	**175**	**255**	**285**	**600**	**123**

Taxa_S	12	40	13	35	27	41
Fisher_alpha	2,8	16,2	2,9	10,5	5,8	21,4
Population density [#/ccm]	8	4	11	17	44	4
Volume of sample [ccm]	25.5	44.7	23.0	33.6	27.0	31.0
bottom water oxygen concentration [µmol/kg]						

A2

Species protocol for samples of core

SO147-106KL

species distribution sediment core SO147-106KL	sediment depth [cm]																									
	52	58	78	103	123	163	203	263	288	303	323	377	407	424	483	524	544	747	823	968	1038	1053	1069	1113	1133	1154
species / split	1/256	1/128	1/512	1/256	1/128	1/256	1/1	1/1	1/1	1/32	1/128	1/512	1/1	1/256	1/64	1/4	1/256	1/1	1/2	1/64	1/512	1/4	1/32	1/1024	1/64	1/128
Angulogerina angulosa														1												
Bolivina seminuda	124	141	79	98	234	411	276	90	106	84	351	41	5	123	400	127	236	6	117	150	216	439	254	185	491	233
Bolivina costata	7	6	20	22	3	8	8	5	11	9	32	2				6	17		9	2	1	6	7	1	9	3
Bolivina plicata	1										1															
Bolivina cf. *spathulata*															1											
Bolivinita minuta		1			1	1								1								1		1		
Bulimina marginata																							6		1	
Bulimina pupoides		5	11			26									44									1		
Buliminella curta basispinata																							1			
Buliminella elegantissima limbosa						1														4	1	1	3			
Buliminella elegantissima tenuis	1	1		3	1																					1
Cancris carmenensis				1			1		4	3															2	
Cassidulina auka	6	5	1	4	4	17					13	1		1			1			3	1	6		2		9
Cassidulina auka var. A																				10			1			
Cassidulina delicata		2																			1		1	1		
Epistominella obesa	14	11		1		2					38			5			10			1		5	4		4	5
Epistominella pacifica							1				4				44	2	2			8						
Fursenkoina fusiformis	62	20	25	21	126	258					110	12		16	89		13			9	31	22	3	13	7	7
Globobulimina pacifica											1	1										3				
Gyroidina neosoldanii					1																					
Lagena laevis																							1			
Nonionella auris				18	2						7									18			1			
Nonionides grateloupii				1																						
Nonionella stella	17	17	19	9	33	6						6	1	2	57		25			1				2	2	4

species distribution sediment core SO147-106KL	sediment depth [cm]																									
	52	**58**	**78**	**103**	**123**	**163**	**203**	**263**	**288**	**303**	**323**	**377**	**407**	**424**	**483**	**524**	**544**	**747**	**823**	**968**	**1038**	**1053**	**1069**	**1113**	**1133**	**1154**
split / **species**	**1/256**	**1/128**	**1/512**	**1/256**	**1/128**	**1/256**	**1/1**	**1/1**	**1/1**	**1/32**	**1/128**	**1/512**	**1/1**	**1/256**	**1/64**	**1/4**	**1/256**	**1/1**	**1/2**	**1/64**	**1/512**	**1/4**	**1/32**	**1/1024**	**1/64**	**1/128**
Pleurostomella brevis					11																					
Pulvinulinella subperuviana	3	2			10	26	4	12	45	25	46	7		16	36	13	8		10	30	14	53	45	16	33	12
Reophax difflugiformis																						32	1			
Suggrunda californica		1			1	3																				
Suggrunda kleinpelli										1														1		1
Suggrunda porosa	8	1	2	3	18	93				1	52	14		6	13		5			1						1
Triloculina trigonula																				2						
Uvigerina peregrina																				1		1	4	1	1	
Uvigerina semiornata						2																				
Valvulina oblonga	1										10										5					
Valvulineria glabra		1																		5						2
Virgulina bradyi	15		17	24	49	99					29	20	1		23		12				2					
Virgulina rotundata						3									5											
Virgulina texturata		18		7																						5
Stainforthia complanata	3	1			3	47						12					1			2						
Σ	**262**	**233**	**174**	**212**	**497**	**1003**	**290**	**107**	**166**	**123**	**694**	**116**	**7**	**171**	**712**	**148**	**330**	**6**	**136**	**247**	**272**	**569**	**332**	**224**	**550**	**283**

Taxa_S	13	16	8	13	15	16	5	3	4	6	14	10	3	9	10	4	11		3	16	9	11	15	11	9	12
Individuals	262	233	174	212	497	1003	290	107	166	123	694	116	7	171	712	148	330		136	247	272	569	337	224	550	283
Fisher_alpha	2,9	3,9	1,7	3,1	2,9	2,7	0,9	0,6	0,7	1,3	2,5	2,6	2,0	2,0	1,6	0,8	2,2		0,5	3,8	1,8	1,9	3,2	2,4	1,5	2,5
Population density [#/ccm]	4626	2376	7467	4719	6723	21483	25	10	15	271	5922	3832	1	3243	3505	38	5450	1	28	1020	8985	163	687	15890	2279	2415
Sample weight, wet	29	28	28	26	25	30	28	29	28	32	32	32	29	31	29	33	31	28	27	41	35	32	36	34	32	33
Sample weight, dry, fraction >63 µm [g]	0,27	0,24	0,33	0,47	0,18	0,13	0,08	0,52	0,12	0,51	0,44	0,38	0,46	0,36	0,65	0,36	1,01	0,19	0,16	10,83	0,65	0,41	0,54	0,67	0,25	0,61
Individuals / g sediment	988	959	529	453	2805	7861	3791	204	1365	242	1591	303	15	478	1101	412	327	32	874	23	416	1399	611	333	2196	463
Volume of sample [ccm]	14.5	12.5	12.0	11.5	9.5	12	11.5	10.5	11	14.5	15.0	15.5	13.0	13.5	13	15.8	15.5	10.3	9.8	15.5	15.5	14.0	15.7	14.5	15.5	15.0