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Temporal variability of live (stained) benthic foraminiferal faunas in a river-dominated shelf – faunal response to rapid changes of the river influence (Rhône prodelta, NW Mediterranean)

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Abstract

In the context of the French research project CHACCRA (Climate and Human-induced Alterations in Carbon Cycling at the River-seA connection), living (rose Bengal-stained) benthic foraminifera were investigated at two stations (24 and 67 m depth) in the Rhône prodelta (NW Mediterranean, Gulf of Lions). The aim of this study was to precise the response of benthic foraminiferal faunas to temporal changes of the Rhône River inputs (e.g. organic and terrigenous material). Each site was sampled in April 2007, September 2007, May 2008 and December 2008, permitting to observe foraminiferal faunas of the 63–150 and >150 µm size fractions under a wide range of environmental conditions. Obvious variations in foraminiferal faunal composition were observed during the four investigated periods at the shallowest Station A located in the close vicinity of the Rhône River mouth. Different colonisation stages were observed after major Rhône River flood events, foraminiferal faunas responding with an opportunistic strategy few days to weeks after the creation of a peculiar sedimentary environment (*Leptohalysis scottii*, May 2008) or high amounts of organic matter supplied by a river flood (*Ammonia tepida*, December 2008). Under more stable conditions, relatively diverse and equilibrated faunas grew in the sediments. Species benefited from noticeable input of riverine phytodetritus to the sediment during spring bloom conditions (April 2007; e.g. *Bolivina dilatata*, *Nonionella stella*, *Stainforthia fusiformis*), or high amounts of still bio-available organic matter under more oligotrophic conditions (September 2007; e.g. *Ammonia tepida*, *Psammosphaera fusca*). The reduced influence of the Rhône River input at the farther Station N led to less contrasted environmental conditions during the four sampling periods, and so to less obvious variations in foraminiferal faunal composition. During reduced riverine influence (i.e. low Rhône discharge), species able to feed on fresh phytodetritus (e.g. *Clavulina cylindrica*, *Hopkinsina atlantica*, *Nonionella iridea* and *Nonionella turgida*) benefited from eutrophic conditions of the spring bloom (April 2007, May 2008). Conversely, the occurrence of *Nouria polymorphinoides* under oligotrophic conditions (September 2007, December

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2008) was indicative of a benthic environment potentially disturbed by bottom currents. This study put into evidence the extremely rapid response of benthic foraminiferal faunas to strong variations in environmental conditions, especially close to the river mouth (Station A), response noticeably reduced farther from the mouth (Station N) due to a weaker impact of riverine input.

1 Introduction

River-dominated shelves constitute dynamic environments at the interface between the continent and the ocean. In these areas, dissolved nutrients supplied by the river induce a local increase in primary production and in fresh organic matter export to the sea floor (Lohrenz et al., 1990, 1997; Dagg and Breed, 2003). Moreover, the high variability over time of riverine discharge leads to contrasted environmental conditions in the coastal ocean. In the Rhône River prodelta, high sediment input (continental organic and inorganic material) related to flood events disturbs the benthic environment by modifying geochemical processes (Cathalot et al., 2010; Pastor et al., 2011) and macrofaunal activity (Salen-Picard et al., 2002; Hermand et al., 2008). In such a dynamic environment, benthic foraminiferal faunas may also vary significantly in space and in time. Small-scale spatial variability has been investigated at two stations (24 and 67 m depth) sampled on the shelf under the influence of the Rhône River in September 2007 (Goineau et al., 2011b). In that study, the authors show that significant patchiness exists in absolute foraminiferal abundances of replicate cores at one site, but much less in major species relative abundances (i.e. percentages). Consequently, the authors recommend using preferentially species relative abundances to compare benthic foraminiferal communities in temporal surveys. Benthic foraminiferal assemblages have also been analysed at a larger scale in the Rhône prodelta (15 to 100 m depth, 1 to 22.4 km off the mouth) during two sampling seasons (Mojtahid et al., 2009; Goineau et al., 2011a). These studies put into evidence a bio-zonation of the area depending on hydro-sedimentary processes, sediment grainsize, and on the quality and quantity

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of sedimentary organic matter. A preliminary comparison based on major species relative abundances observed the two sampling seasons shows a positive response of the most opportunistic species (e.g. *Bulimina aculeata*, *Cassidulina carinata*, *Valvulineria bradyana*) to fresher and/or more marine phytodetritus input related to spring bloom conditions (June 2005). Yet, no long-term temporal survey for a single site has been performed in the Rhône prodelta until now. Such an investigation would allow us to determine the impact of changing environmental conditions (e.g. hydro-sedimentary processes, quality/quantity of the organic matter) on the foraminiferal faunas. Furthermore, the dynamics of foraminiferal assemblages and associated time scales for ecosystem adaptation is needed to relate abrupt changes of river delivery (floods) to ecosystems dynamics.

In this paper, we investigate the temporal variability of live (stained) benthic foraminiferal faunas from the Rhône prodelta at two sites sampled during four periods with contrasted environmental conditions. Sites A and N (24 and 67 m depth, respectively) were both visited in April 2007, September 2007, May 2008 and December 2008, these sampling dates cover a wide range of environmental conditions from low to high discharge (flood), and from oligotrophic to spring bloom conditions. We have analysed both 63–150 μm and $>150 \mu\text{m}$ size fractions of one core per site for each sampling period. These analyses are combined with various environmental measurements such as sediment oxygenation (oxygen penetration depth, oxygen uptake) and sedimentary organic matter quantity (organic carbon content) and quality (Chl-*a*, amino acids and lipids contents, carbon and nitrogen stable isotopes). The aim of this study is to gain insight of the ecosystem dynamics with regards of changes in river input to the coastal zone. We describe the complex relationship between (1) changes in river discharge including extreme events (floods), (2) changes in environmental conditions in the water column and sediments and (3) the response of benthic foraminiferal faunas in the Rhône prodelta in terms of standing stocks, diversity and composition.

2 Material and methods

2.1 Study area

The Rhône River flows into the Gulf of Lions, a large crescent-shaped continental shelf located in the North-Western Mediterranean Sea (Berné and Gorini, 2005). At the river mouth, a turbid river plume spreads out. According to Naudin et al. (1997), its offshore extension and shape depend on the Rhône outflow (low/high discharge), wind regime (Mistral and Tramontane; Millot, 1999) and the intensity of the North Mediterranean Current flowing westward along the continental slope (Béthoux and Prieur, 1983; Millot, 1990). The mixing between riverine (low salinity) and marine waters (high salinity) in the Rhône channel is typical of a microtidal saltwedge estuary. The salt water forms a wedge in the river bed underneath the freshwater layer. The landward extension of this wedge is mainly controlled by the river discharge. During low water discharge periods (about $500 \text{ m}^3 \text{ s}^{-1}$), the salt intrusion can extend up to 20 km inland, whereas marine waters are pushed seaward to the river mouth during high water discharge ($>3000 \text{ m}^3 \text{ s}^{-1}$), without any influence on bottom water salinity off the river mouth (Eisma, 1993). The Rhône River carries 90 % of the terrigenous material and 80 % of the fresh water introduced into the Gulf of Lions (Durrieu de Madron et al., 2000, 2003). Thanks to these riverine supplies, the Gulf of Lions is one of the most productive areas of the Mediterranean Sea (Diaz, 2000), the Rhône River supplying 50 % of the total nutrients needed for primary production into the Gulf (Lochet and Leveau, 1990). Phytoplankton primary production is maximal from March to May with Chl-*a* concentrations in sea-surface waters of $1 \text{ mg Chl-}a \text{ m}^{-3}$ (Bosc et al., 2004). The summer season is the most oligotrophic period with $0.1\text{--}0.2 \text{ mg Chl-}a \text{ m}^{-3}$ in surface waters. In the Rhône River, riverine phytoplankton blooms also during spring. This riverine production can be exported to the open sea in the surface waters of the river plume (Harmelin-Vivien et al., 2008).

The mean annual flow of the Rhône River is about $1700 \text{ m}^3 \text{ s}^{-1}$, with maximum discharge values $>3000 \text{ m}^3 \text{ s}^{-1}$ in autumn and spring during major flood events (Pont et

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al., 2002). The terrigenous material carried during these events is transferred to the marine environment essentially in a bottom nepheloid layer above the sea floor, but also in suspension in the surface waters of the river plume (Naudin et al., 1997). Although 30 % of the introduced particles are transferred to the slope and to the deeper basin (Got and Aloisi, 1990), a major part of the riverine terrigenous input is deposited close to the river outlet, from 0 to 60 m depth and from 0 to 6 km off the mouth, thus forming a delta front and a prodeltaic area (Rabineau et al., 2005). This zone is subject to very high deposition rates ranging from 30 to 50 cm yr⁻¹ (Calmet and Fernandez, 1990; Charmasson et al., 1998; Rabineau et al., 2005).

2.2 Sediment sampling

Stations A and N were sampled on the *R/V Téthys II* in April 2007 (RiOMar 1 cruise), September 2007 (RIOTECH cruise), May 2008 (CHACCRA-bent 1 cruise) and December 2008 (CHACCRA-bent 2 cruise). The two stations were respectively located at 24 and 67 m depth in the Rhône prodelta (Fig. 1, Table 1). At each station and during each sampling period, one core (72 cm² surface area) was recovered with a multicorer MUC 8/100 (Oktopus GmbH) that permits to collect cores with an undisturbed sediment – water interface. We studied live benthic foraminiferal faunas in all cores. Various environmental parameters were also analysed at each site for the different sampling periods.

2.3 Rhône River discharge and supplies

Daily Rhône River discharges (Q in m³ s⁻¹) in Arles (SORA station, 30 km from the mouth) were available thanks to the Compagnie Nationale du Rhône (CNR) through a convention with the Institut de Radioprotection et de Sécurité Nucléaire (IRSN) in the EXTREMA ANR project (ANR-06-VULN-005, 2007–2010). Suspended particulate material contents (SPM in mg l⁻¹) in the Rhône River were measured daily by the CNR and/or IRSN at the SORA station in Arles in the framework of the ANR CHACCRA

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and other projects. For each sampling period, we calculated the mean Rhône River discharge (Q_{mean}) and the mean suspended particulate material load (SPM_{mean}) for the 15 days prior to sampling. We also determined the time lapse since the last major flood (i.e. $>3000 \text{ m}^3 \text{ s}^{-1}$) expressed in days.

2.4 Geochemical analyses

For both stations, Total Nitrogen and Organic Carbon concentrations (TN and OC, respectively), total hydrolysable amino acids (THAA) and total lipids contents, and carbon and nitrogen stable isotopic ratios of organic matter ($\delta^{13}\text{C}_{\text{OC}}$ and $\delta^{15}\text{N}$) were measured on milled and freeze-dried sediment samples from the top 0–0.5 cm of one sediment core (Buscail et al., 2011). Chlorophyll-*a* (Chl-*a*) concentrations were also determined on thawed sediments sampled in the top half-centimetre of three cores (see Bourgeois et al., 2011).

In situ profiles of O_2 in the pore water were obtained by a benthic microprofiler using Clark micro-electrodes (Rabouille et al., 2003; Cathalot et al., 2010). Bottom waters were sampled 2 m above the sea floor by a Niskin bottle, for determination of temperature (T_{BW}) and dissolved oxygen ($[\text{O}_2]_{\text{BW}}$) (Table 1).

2.5 Benthic foraminiferal faunas

For foraminiferal faunal analysis, each replicate core was sliced on board, every 0.5 cm until 2 cm depth, and every 1 cm from 2 to 5 cm depth. Each sample was preserved in a plastic bottle with a solution of 95 % ethanol and 1 g L^{-1} Rose Bengal stain. In the laboratory, samples were sieved through 63 and $150 \mu\text{m}$ mesh screens and the sieve residues were again preserved in 95 % ethanol. All stained specimens of the $>150 \mu\text{m}$ size fraction were handpicked down to 5 cm depth under wet conditions under a binocular microscope and stored in micropaleontological slides (Table A1). Foraminifera belonging to the 63– $150 \mu\text{m}$ size fraction were only investigated in the topmost 0.5 cm (Table B1). Samples of this size fraction were dried and split with an Ottomicrosplitter

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(until $\sim 4800 \text{ m}^3 \text{ s}^{-1}$). Q_{mean} values were maximal during the latter sampling period, with $\sim 1700 \text{ m}^3 \text{ s}^{-1}$ (May 2008) and $\sim 1450 \text{ m}^3 \text{ s}^{-1}$ (December 2008). A minimal mean suspended material load (SPM_{mean}) was recorded in April 2007, with only $5 \text{ mg l}^{-1} \text{ d}^{-1}$. In May 2008, SPM_{mean} was maximal reaching $115 \text{ mg l}^{-1} \text{ d}^{-1}$.

3.2 Bottom water characteristics – sediment oxygenation and oxygen uptake

At Station A, bottom water temperature (T_{bw}) varied between 14.8 (December 2008) and 17.7 °C (September 2007) (Table 1). Bottom waters were well-oxygenated, with values $>200 \mu\text{mol l}^{-1}$ ($237\text{--}259 \mu\text{mol l}^{-1}$). Oxygen penetration depth (OPD) was minimal and exhibited minor variation between April 2007, September 2007 and December 2008, with values ranging from 1.4 to 1.7 mm (Table 1). A deepening of the OPD was observed in May 2008 when a 5.8 mm-thick oxygenated level was observed. Dissolved oxygen uptake (DOU) was maximal in April 2007 and December 2008 with 21.5 and 20.6 $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$, respectively. A minimal uptake was measured in May 2008 with 9.2 $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$.

At Station N, no data are available for December 2008. At the other three sampling periods, bottom water temperature ranged from 14.5 to 16.3 °C. Bottom water oxygen concentration was also high, with values varying between 217 and 253 $\mu\text{mol l}^{-1}$. OPD was deeper than at Station A, with values ranging from 3.3 to 3.8 in April 2007 and May 2008 to 4.9 mm in September 2007. DOU was lower than at Station A, with similar values of 9.2 and 9.5 $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$ in April 2007 and May 2008. DOU was minimal in September 2007 with 6.6 $\text{mmol O}_2 \text{ m}^{-2} \text{ d}^{-1}$.

3.3 Sedimentary particulate organic matter and chlorophyll-a concentrations

At Station A, lowest organic carbon (OC) contents in the top half-centimetre of sediment were recorded in May and December 2008, with values of 1.13 % d.w. and 1.22 % d.w., respectively (Fig. 3a, Table 2). The highest concentration was measured in April 2007, with a content of 2.05 % d.w. Lowest concentrations of the sum of amino

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acids and lipids were observed in December and May 2008, with values of 1.8 and 1.9 mg g⁻¹ d.w. (i.e. 14.7 and 16.7 % of the OC, respectively). The highest content (4.2 mg g⁻¹ d.w, 20.4 % of the OC) was recorded in April 2007. $\delta^{13}\text{C}_{\text{OC}}$ ranged from -27.18 ‰ in April 2007 to -24.79 ‰ in December 2008. Intermediate values of -26.64 to -26.30 ‰ were recorded in September 2007 and May 2008. The C:N ratio showed important variations, with values ranging between 12.5 in September 2007 and 28.1 in December 2008. Unfortunately, no $\delta^{15}\text{N}$ value is available for December 2008. During the three other sampling periods, $\delta^{15}\text{N}$ was less variable than $\delta^{13}\text{C}_{\text{OC}}$, values ranging between 2.90 and 3.92 ‰. Chl-*a* concentrations in the top first centimetre of the sediment varied between 2.14 and 9.78 $\mu\text{g g}^{-1}$ d.w., with minimal values in April 2007 and maximum contents in December 2008.

At Station N, OC content was minimal in May 2008 with only 1.00 % d.w., and reached its maximum value in April 2007 and December 2008 with 1.4 % d.w. (Fig. 3b, Table 2). The sum of amino acids and lipids had comparable concentrations in April 2007, September 2007 and May 2008, with values of 2.7 mg g⁻¹ d.w. (from 19.2 to 27.0 % of the OC). The highest concentrations were recorded in December 2008 with 3.8 mg g⁻¹ d.w. (27.8 % of the OC). Also $\delta^{13}\text{C}_{\text{OC}}$ and $\delta^{15}\text{N}$ were very constant, ranging from -26.12 to -25.82 ‰ and from 3.46 to 3.90 ‰ respectively. The lowest C:N ratio was measured in May 2008 with a value of 12.0. Maximal values were recorded in December 2008 and April 2007, with 16.2 and 17.4, respectively. Sedimentary Chl-*a* content showed small variations between the investigated sampling dates. The highest concentration was measured in April 2007 with 2.57 $\mu\text{g g}^{-1}$ d.w., whereas values were fairly similar for the three other sampling periods, ranging between 1.23 and 1.62 $\mu\text{g g}^{-1}$ d.w.

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3.4 Foraminiferal faunas

3.4.1 Station A (24 m)

In the $>150\mu\text{m}$ fauna, total foraminiferal standing stocks in the 0 to 5 cm sediment interval varied from 286 (September 2007) to 7767 ind. 100 cm^{-2} (May 2008) (Fig. 4a). The species richness S varied from 8 (May 2008) to 19 (April 2007) (Fig. 4b). The Shannon index H ranged from 0.11–0.33 in May and December 2008 to 1.47–1.77 in April and September 2007 (Fig. 4c). The Evenness index followed the same trend with minimum values of 0.10–0.12 in May and December 2008 and maximal index in September 2007 (0.35) (Fig. 4d).

A total of 31 taxa were recognised at Station A, with 5 major species: *Ammonia tepida*, *Nonion fabum*, *Nonionella turgida*, *Eggerella scabra* and *Leptohalysis scottii* (Fig. 5a). In April 2007, the fauna was characterised by elevated percentages of *L. scottii* ($>50\%$), *N. turgida* (18.7%), *E. scabra* (12.5%) and *N. fabum* (9.8%). In September 2007, the contribution of *L. scottii* was much lower (8.3%), whereas *A. tepida* accounted for 50.5% of the total fauna. In May 2008, the abundance of *L. scottii* reached 7538 ind. 100 cm^{-2} , i.e. 98.2% of the total assemblage. In December 2008, this species was absent whereas *A. tepida* strongly dominated the fauna, with 1438 ind. 100 cm^{-2} or 93.9% of the total assemblage.

In the 63–150 μm size fraction, the foraminiferal abundances in the top most 0.5 cm ranged from ~ 140 (May 2008) to ~ 5120 ind. 100 cm^{-2} (April 2007) (Fig. 4a). The species richness S varied from 1 (May 2008) to 21 (April 2007) (Fig. 4b). A maximal Shannon index was recorded in April and September 2007, with values of 2.11 and 2.04, respectively. The lowest diversity was observed in May 2008 when only one species was identified ($H = 0$) (Fig. 4c). Except for the peculiar period of May 2008, the Evenness index was fairly constant with values ranging between 0.37 and 0.43 (Fig. 4d).

The foraminiferal faunal composition was quite variable. A total of 29 taxa were recognised, with 8 species presenting relative abundances $>5\%$ in at least one core:

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Ammonia tepida, *Bolivina dilatata*, *Haynesina germanica*, *Nonionella stella*, *Nonionella turgida*, *Stainforthia fusiformis*, *Leptohalysis scottii* and *Psammosphaera fusca* (Fig. 5b). In April 2007, foraminiferal faunas were characterised by *L. scottii* (~26.5%), *S. fusiformis* (~21%) and *B. dilatata* (~16%). We noted the presence of *N. turgida* (~11.5%) and *N. stella* (~8%). In September 2007, *P. fusca* accounted for ~45% of total living faunas, and *L. scottii* was relatively abundant (~17%). In May 2008, foraminiferal faunas were totally dominated by *L. scottii* which composed 100% of the total living assemblage. In December 2008, *L. scottii* was low frequent (~3%), whereas *A. tepida* dominated the fauna (~43.5%). *Psammosphaera fusca* was the second most abundant species with a relative abundance of ~30%. *Haynesina germanica* accounted for ~6.5% of the total living fauna.

3.4.2 Station N (67 m)

In the >150 μm size fraction, foraminiferal abundances varied between 1092 (April 2007) and 2753 ind. 100 cm^{-2} (May 2008) (Fig. 6a). The number of taxa varied between 37 (May 2008) and 59 (April 2007) (Fig. 6b). The Shannon and Evenness indices were quite similar, with values ranging from 2.13 to 2.63 and from 0.23 to 0.29, respectively (Fig. 6c–d).

A total of 72 species was recognised, with 9 major species: *Nonion fabum*, *Nonionella turgida*, *Rectuvigerina phlegeri*, *Valvulineria bradyana*, *Clavulina cylindrica*, *Cribostromoides wiesneri*, *Eggerella scabra*, *Leptohalysis scottii* and *Nouria polymorphinoides* (Fig. 7a). In April 2007, agglutinated taxa were dominant (64.4%) with *E. scabra* (45.9%), *C. cylindrica* (7.4%) and *C. wiesneri* (5.1%). In September 2007, *C. cylindrica* (10.7%) and *E. scabra* (18.3%) were abundant, together with *V. bradyana* (21.2%), *N. fabum* (13.7%), *R. phlegeri* (7.1%) and *N. polymorphinoides* (5.6%). In May 2008, high percentages of *E. scabra* (20.0%), *V. bradyana* (19.2%), but also *N. turgida* (14.7%) were observed. In December 2008, high contributions of *N. polymorphinoides* (15.2%), *R. phlegeri* (11.1%) and *L. scottii* (5.3%) were noticed.

In the 63–150 μm fauna, foraminiferal standing stocks ranged between ~2580

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(December 2008) and ~ 11640 ind. 100 cm^{-2} May 2008) (Fig. 6a). The species richness S varied from 40 (April 2007, May and December 2008) to 59 (September 2007) (Fig. 6b). Comparable Shannon index H values were measured during the four periods, between 2.90 and 3.11 (Fig. 6c). The Evenness index showed quite similar values in April 2007, May and December 2008 (0.45–0.53), and a minimum of 0.38 recorded in September 2007 (Fig. 6d).

A total of 57 taxa were recognised at this station, with 10 species accounting for more than 5% of total living faunas in at least one core: *Bolivina dilatata*, *Bolivina seminuda*, *Bolivina spathulata*, *Hopkinsina atlantica*, *Nonionella iridea*, *Nonionella turgida*, *Rectuvigerina phlegeri*, *Textularia porrecta*, *Eggerella scabra* and *Leptohalysis scottii* (Fig. 7b). In April 2007, foraminiferal faunas were characterised by a high contribution of *B. dilatata* ($\sim 21\%$), *N. turgida* ($\sim 7.5\%$) and *H. atlantica* ($\sim 7\%$). In September 2007, *H. atlantica* ($\sim 8.5\%$) and *N. turgida* ($\sim 6.5\%$) were associated with *B. spathulata* ($\sim 8\%$), *R. phlegeri* ($\sim 8\%$) and *E. scabra* ($\sim 13.5\%$). In May 2008, *N. turgida* ($\sim 16\%$) and *L. scottii* ($\sim 12\%$) were the most abundant species, together with *N. iridea* ($\sim 11.5\%$) and *T. porrecta* ($\sim 7\%$). Finally, in December 2008, high abundances of *B. seminuda* ($\sim 5.5\%$) and *T. porrecta* ($\sim 12\%$) were recorded.

4 Discussion

4.1 Environmental setting

The overall environmental dataset shows contrasted conditions for the four sampling periods and between the two investigated stations. In all investigated periods, the sediment at Station A (24 m depth) presented a high content in OC, lipids, amino acids and Chl-*a* in comparison with the deeper Station N (67 m depth). This reflects a concentration of organic-rich deposits close to the Rhône River mouth, in agreement with observations presented in previous studies (Lansard et al., 2009; Cathalot et al., 2010; Goineau et al., 2011a).

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In Fig. 8, $\delta^{13}\text{C}_{\text{OC}}$ has been plotted versus $\delta^{15}\text{N}$ for both stations and all sampling periods, together with isotopic signatures of different potential particulate organic matter (POM) sources in our study area (Darnaude et al., 2004; Harmelin–Vivien et al., 2008; Kerhervé et al., 2011). Both Stations A and N plot between Rhône River and Offshore sea water POM, but much closer to the Rhône source (low $\delta^{13}\text{C}_{\text{OC}}$). However, important isotopic variations were recorded at Station A, with measures plotting either close to “Rhône POM” (i.e. mixture between riverine phytoplankton, vascular plants and soil detritus) or to “terrestrial detritus” (i.e. vascular plants and soil detritus) end members. In April and September 2007, both sampled during low Rhône discharge conditions ($Q_{\text{mean}} < 1000 \text{ m}^3 \text{ s}^{-1}$; $\text{SPM}_{\text{mean}} < 15 \text{ mg l}^{-1} \text{ d}^{-1}$), sedimentary organic matter (OM) measured at Station A plotted close to the Rhône POM end-member. Therefore, the maximal sediment Chl-*a* contents measured during these sampling periods suggest a major contribution of continental OM and riverine phytoplankton. On the contrary, May and December 2008, sampled during and after a flood ($Q_{\text{mean}} > 1400 \text{ m}^3 \text{ s}^{-1}$; $\text{SPM}_{\text{mean}} = 17 \text{ to } 115 \text{ mg l}^{-1} \text{ d}^{-1}$), showed a stronger contribution of terrestrial plant detritus. According to Cathalot et al. (2010) and Kerhervé et al. (2011), the slightly higher $\delta^{13}\text{C}_{\text{OC}}$ values ($> -26.5\text{‰}$) recorded after the flood in May also pointed out the contribution of soil-derived organic material brought by the river. Station N also received an organic matter with a strong contribution of the Rhône-derived organic detritus. The isotopic signatures were comparable for the four sampling periods, suggesting a weaker impact of fluctuating Rhône River discharge compared to Station A.

$\delta^{13}\text{C}_{\text{OC}}$ versus N:C atomic ratio is presented on Fig. 9 together with complementary measurements performed in the Rhône prodelta in October 2004, April 2005 (23–68 m depth, ~1 to 8 km off the river mouth; Tesi et al., 2007), June 2005 (20–98 m depth, ~2 to 16 km off the mouth; Lansard et al., 2009) and September 2006 (18–100 m depth, ~1 to 22 km off the mouth; Goineau et al., 2011a). Stations A and N were both characterised by a mixture of soil and plant-derived OM in all four sampling periods, and plotted close to the samples collected in October 2004 and September 2006 conditions. Consequently, no clear marine influence was recorded at our two stations, in none

of the four sampling periods. It appears that variations in Chl-*a* contents between sampling periods were mainly due to changes in the Rhône River regime (high/low discharge) and riverine phytoplankton dynamics which appears to bloom at the same time as marine phytoplankton (Harmelin–Vivien et al., 2008). At both stations, the accumulation of labile (i.e. bioavailable) Rhône-derived material at the river mouth and in the proximal prodelta, not necessarily linked to river phytoplankton blooms, led to an important sediment oxygen consumption, due to organic carbon mineralisation (high DOU, shallow OPD), during the four investigated periods (Table 1).

4.2 Temporal dynamics of benthic foraminiferal faunas

Small-scale spatial variability of benthic foraminiferal faunas have been investigated through the study of four replicate cores sampled at the same Stations A and N (Goineau et al., 2011b). In that study, the authors have shown that absolute foraminiferal abundances (i.e. D) may present significant differences between replicate cores at a same station. However, variations of the major taxa percentages were not significantly different. Since our temporal survey of benthic foraminiferal faunas was performed on only one core per investigated site and per sampling period, the following discussion is based on percentage data of the major species.

4.2.1 Station A

The foraminiferal faunas observed at Station A, dominated by *Ammonia tepida*, *Bolivina dilatata*, *Eggerella scabra*, *Haynesina germanica*, *Leptohalysis scottii*, *Nonion fabum*, *Nonionella stella*, *Nonionella turgida*, *Psammosphaera fusca* and *Stainforthia fusiformis*, are typical of river-dominated shelves (e.g. Jorissen, 1987; Van der Zwaan and Jorissen, 1991; Barmawidjaja et al., 1992; Jorissen et al., 1992; Donnici and Serandrei Barbero, 2002; Diz et al., 2006; Diz and Francés, 2008; Frezza and Carboni, 2009), and especially of the Rhône prodelta (Mojtahid et al., 2009; Goineau et al., 2011a).

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In April 2007, sampling is performed during a low Rhône discharge and spring bloom conditions in the Gulf of Lions (SeaWifs images: “Ocean Colour” website, http://oceancolour.jrc.ec.europa.eu/data_portal/oc_portal/main.php). The very rich foraminiferal faunas are dominated by *Bolivina dilatata*, *Nonionella stella*, *Nonionella turgida*, *Stainforthia fusiformis* and *Leptohalysis scottii* in the 63–150 µm size fraction, and *Nonion fabum*, *Nonionella turgida*, *Eggerella scabra* and *Leptohalysis scottii* in the >150 µm size fraction (Fig. 5). Both size fractions present well diversified faunas with a maximal biodiversity (Shannon index) and standing stocks in the 63–150 µm size fraction (Fig. 4). In the Rhône prodelta, *N. fabum* seems to be adapted to a wide range of environments, thriving preferentially in sediments enriched in both continental and more marine OM under the river plume (Mojtahid et al., 2009; Goineau et al., 2011a). *Bolivina dilatata*, *N. turgida* and *E. scabra* are abundant in a restricted area close to the Rhône River mouth, receiving important amounts of continental OM (Mojtahid et al., 2009; Goineau et al., 2011a). However, these species would also be able to feed on fresh phytodetritus inputs, especially diatoms (Hohenegger et al., 1993; Gustafsson and Nordberg, 2001; Diz et al., 2006; Diz and Francés, 2008; Duchemin et al., 2008; Hyams–Kaphzan et al., 2009). *Bolivina dilatata* is known to proliferate, due to an opportunistic behaviour after fresh phytodetritus inputs in river-influenced environments (Barmawidjaja et al., 1992; Jorissen et al., 1992; Duchemin et al., 2007, 2008). Therefore, its occurrence in April 2007 would suggest a recent deposition of fresh phytodetritus possibly originating from the river. This hypothesis is corroborated by the occurrence of *N. stella*, *N. turgida* and *S. fusiformis* which have also been reported in the Ría de Vigo (Spain) and in the Bay of Biscay responding to fresh OM inputs by enhanced reproduction (Gustafsson and Nordberg, 2001; Diz et al., 2006; Diz and Francés, 2008). At Station A, we observe specimens of *N. turgida* and *L. scottii* in both size fractions, showing the presence of both adult and juvenile forms, probably as a result of reproduction shortly before sampling. *Stainforthia fusiformis* has been observed close to the Rhône River mouth during late spring bloom conditions (June 2005; Mojtahid et al., 2009). It appears therefore that the above-mentioned group of

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taxa constitutes a highly reactive and diverse fauna responding to the eutrophic conditions in the vicinity of the Rhône River mouth, following riverine phytoplankton blooms.

In September 2007, no major flood had occurred for the last 6 months, and the last significant phytoplankton bloom ended more than 3 months before sampling. The much poorer foraminiferal fauna is mainly composed of *B. dilatata*, *L. scottii* and *Psammosphaera fusca* in the 63–150 µm size fraction, and *Ammonia tepida*, *N. turgida*, *E. scabra* and *L. scottii* in the larger size fraction (Fig. 5). *Ammonia tepida* is a very common taxon in shallow open marine environments, especially at the vicinity of river mouths (e.g. Jorissen, 1987, 1988; Donnici and Serandrei Barbero, 2002; Rossi and Vaiani, 2008; Frezza and Carboni, 2009; Goineau et al., 2011a). *Psammosphaera fusca* is a monothalamous agglutinated taxon observed from deep-sea (Kaminski, 1985; Jones, 1988; Kaminski et al., 1995; Harloff and Mackensen, 1997) to shelf environments (Canadian fjord, Antarctic coast, Laptev Sea; Lukina, 2001; Gaździcki and Majewski, 2003; Vázquez Riveiros and Patterson, 2007). *Psammosphaera fusca* has been reported as a pioneer opportunistic species in high energy environment (Kaminski, 1985; Kaminski et al., 1995). Thus, the dominance (~50%) of *P. fusca* in the 63–150 µm-sized fauna could suggest a possible physical disturbance of the benthic environment by moderate to strong currents. In parallel, the association of *B. dilatata*, *N. turgida*, *E. scabra* and *L. scottii* contributing to diverse ($H > 1.8$) and relatively equilibrated faunas ($E \approx 0.35$) could be linked to the important amounts of labile organic compounds (lipids, THAA, Chl-*a*; Table 2) measured in the sediment. To summarise, the low-abundant but well-diversified fauna observed in September 2007 suggests an environment which is characterised by a larger proportion of bio-available organic matter, possibly disturbed by more or less high energy conditions.

Sampling of Station A in May 2008 took place during very peculiar conditions. A major Rhône River flood characterised by very high SPM load (until $867 \text{ mg l}^{-1} \text{ d}^{-1}$; SORA Station data) started two days before sampling. A 4 cm-thick flood deposit constituted by very light liquid mud (mean particle diameter = 6.74 µm ; Cathalot et al., 2010) was observed at the surface of all cores sampled at this station. The huge accumulation

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rate induced by the flood led to a strong dilution of OM and much lower OC, labile organic compounds and Chl-*a* contents (Fig. 3). These extreme conditions were probably responsible for the almost monospecific foraminiferal faunas, constituted by almost 100 % of *L. scottii* in both size fractions (Fig. 5). In the >150 µm size fraction, *L. scottii* reached huge abundances of ~7500 ind. 100 cm⁻², and the densities increased with sediment depth (Fig. 6a). This virtually monospecific *L. scottii* assemblage can be explained in two different ways: (1) the specimens present at the site or in surrounding areas before the flood responded to the disturbance induced by the flood deposit by an extremely fast reproduction (strongly opportunistic behaviour); (2) individuals were transported together with terrigenous material from the Rhône River during the flood (allochthonous origin). The first scenario implies that massive reproduction had to take place in less than 2 days, the time-lapse between the beginning of the flood and sediment sampling. In culture experiments performed on sediments sampled in the northern Adriatic Sea near the Po outlet (32 m water depth), Ernst et al. (2002) showed that *L. scottii* could enlarge its population by 80 % in the three weeks following a simulated physical disturbance consisting in a gentle mixing of the sediment. It seems therefore unlikely that more than 7000 individuals 100 cm⁻², most of them adults or pre-adults found in the >150 µm size fraction, were produced in only 2 days, in an environment impoverished in OM. The second assumption of an allochthonous origin of *L. scottii* would imply a massive transport from the continental part of the Rhône River to the proximal prodelta. *L. scottii* has earlier been reported from estuarine environments living in turbid and high-energy waters (Scott et al., 2005; Diz and Francés, 2008). Unfortunately, we have no data on the foraminiferal community living upstream from the Rhône River mouth. However, the hypothesis of an allochthonous origin of the thousands of individuals of *L. scottii* seems most probable. This taxon is a very early recoloniser of a newly deposited sediment surface as earlier described in the Oslofjord where individuals of *L. scottii* rapidly immigrated from neighbouring environments to massively colonise newly deposited sediments.

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In December 2008, a major flood occurred 1 month before sampling, responsible for a new terrigenous deposit close to the river mouth (Cathalot et al., 2010) rich in OC and plant debris. At Station A, we observe an approximately 3 cm-thick surficial deposit of silty sediments (R. Buscail, unpublished data). Foraminiferal faunas are essentially composed by *A. tepida*, *Haynesina germanica* and *P. fusca* (Fig. 5). The low diversity ($H < 0.4$) but high abundances observed in the $> 150 \mu\text{m}$ size fraction went together with a strong dominance ($E \approx 0.1$) of *A. tepida* in both absolute ($\sim 1400 \text{ ind. } 100 \text{ cm}^{-2}$) and relative abundances ($\sim 94\%$). The associated species *H. germanica* is a typical estuarine species, thriving in intertidal and subtidal areas (e.g. Alve and Murray, 1999; Debenay et al., 2000; Diz and Francés, 2008). It appears therefore that the association of *A. tepida*, *H. germanica* and *P. fusca* is indicative of a very high riverine influence. The flood recorded 1 month before (Q until $\sim 4800 \text{ m}^3 \text{ s}^{-1}$; SORA Station) may have significantly disturbed the benthic environment by the deposit of organic-rich terrigenous material close to the river mouth (OC content = 6 % d.w.; Cathalot et al., 2010). Since *H. germanica* is typical of brackish water environments, it can be supposed that juvenile specimens of this taxon have been transported by the flood from habitats in the inner part of the Rhône River channel to our study site. At a slightly later stage, *A. tepida* and *P. fusca* may have colonised the newly deposited organic-rich flood deposit, profiting from their high tolerance for high-energy conditions.

To synthesise, foraminiferal faunas observed at this shallow Station A were obviously influenced by the Rhône River in some way during all four periods. Sedimentary disturbance appears to be periodically disturbing the benthic environment. Stable environmental conditions, without major sediment input, which prevailed in April and September 2007 allowed the establishment of diverse and equilibrated faunas. The availability of fresh OM and the hydrodynamic conditions above the sea floor were the main factors influencing foraminiferal faunal composition. Conversely, highly unstable conditions with massive sediment input characterise the environment in May and December 2008. The particular conditions led to the presence of faunas typical for the early stages of ecosystem colonisation. In these faunas, the foraminiferal composition

appears to depend on the time lapse since the last flood deposit, and on the OM content of the recently deposited sediments. A few days after such a massive sediment input (May 2008), an extremely rich monospecific assemblage of pioneer species already inhabited the newly deposited flood layer impoverished in labile OM. Conversely, an input of OM enriched sediments in December 2008 led to the observation, a few weeks later, of a more advanced colonisation stage. In both cases, foraminiferal faunas responded with an opportunistic strategy to the deposition of a thick layer of new sediment (*Leptohalysis scottii*, May 2008) and/or to the high amounts of OM supplied by the river flood (*Ammonia tepida*, December 2008).

4.2.2 Station N

At Station N, environmental conditions are much less contrasted than at the shallower Station A (see Sect. 4.1.). Foraminiferal faunas of both size fractions were diverse (Shannon index $H > 2$) and relatively equilibrated ($E > 0.2$) during the four investigated periods, depicting the absence of opportunistic behaviour and/or recolonisation phenomena. Four taxa were abundant in all assemblages: *Bolivina dilatata*, *Eggerella scabra*, *Nonion fabum* and *Valvulineria bradyana*. These four taxa are common in the Rhône prodeltaic area, present in sediments close to the Rhône River mouth with important continental OM supplies (Station A, see above), but also at sites more offshore, under the Rhône River plume (Mojtahid et al., 2009; Goineau et al., 2011a). *Bolivina dilatata* is described as an ubiquitous taxon adapted to a wide range of environmental conditions in the Ría de Vigo (Spain) and in the Bay of Biscay (Diz and Francés, 2008; Duchemin et al., 2008), also able to respond to fresh phytodetritus input (Barmawidjaja et al., 1992; Jorissen et al., 1992; Duchemin et al., 2007, 2008).

As for Station A, sampling in April 2007 took place during the early spring bloom and under low Rhône discharge conditions. At Station N, these conditions led to relatively high OC (1.42 % d.w.) and Chl-*a* contents in surficial sediments ($2.57 \mu\text{g g}^{-1}$; Table 2). The small-sized (63–150 μm) benthic foraminiferal fauna of the topmost 0.5 cm was very abundant and highly diverse compared to the $>150 \mu\text{m}$ size fraction of the

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upper 5 cm (Fig. 6). These faunas were characterised by high relative abundances of *Clavulina cylindrica*, *Cribrostomoides wiesneri* and *Hopkinsina atlantica*. As suggested for Station A at the same sampling period, the very high contribution of *Eggerella scabra* in the >150 µm-sized fauna (>40%) would be due to its ability to respond to fresh phytodetritus inputs. *C. cylindrica* was considered typical of eutrophic conditions on the continental shelf of the Bay of Biscay (Fontanier et al., 2002). *Hopkinsina atlantica* has been described in river-influenced shelves (Barmawidjaja et al., 1992; Jorissen et al., 1992; Diz and Francés, 2008; Mojtahid et al., 2009), where it was usually considered as an opportunistic taxon responding to fresh OM input (Ernst et al., 2002; Duijnsteet et al., 2005). When considering the moderate enrichment in Chl-*a* of the top half centimetre of sediment at this period, we assume that this association of foraminiferal species would benefit from an input of fresh phytodetritus, such as has been suggested for the shallower Station A at the same period.

In September 2007, high percentages of *Bolivina spathulata*, *C. cylindrica*, *H. atlantica*, *Rectuvigerina phlegeri*, and especially of *Nouria polymorphinoides* were noticed (Fig. 7) Goineau et al. (2011a) reported *N. polymorphinoides* during another sampling period (September 2006) in coarse sediments from the coast west of the Rhône River mouth, close to Station N. According to Sabatier and Suanez (2003), this area is submitted to strong bottom currents. At Station A, the foraminiferal faunas observed in September 2007 suggested possibly high energy conditions. Therefore, the contribution of *N. polymorphinoides* in September 2007 could indicate the possible action of bottom currents as at Station A. These currents could possibly have transported living individuals of *N. polymorphinoides* from sandy coastal sediments to our Station N.

In May 2008, Station N was sampled 3 days after the beginning of a major flood carrying important amounts of organic and inorganic terrestrial material close to the river mouth. However, contrary to Station A, no flood deposit was observed at the surface of any of the sampled cores. Consequently, we assumed that Station N had not been impacted by the deposits of terrigenous material. Therefore, just as in April 2007, the late spring bloom conditions prevailing in the Gulf of Lions at the time of sampling

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(SeaWifs images) would have been the main controlling parameter at the study site. In May 2008, the foraminiferal faunas were characterised by a high contribution of *Nonionella iridea*, *Nonionella turgida* and *Leptohalysis scottii* in the 63–150 μm size fraction, and of *N. turgida* in the large-sized fauna (Fig. 7) Gustafsson and Nordberg (2001) demonstrated that *N. turgida* could reproduce and grow from juvenile to adult form in less than 1 month after a fresh OM deposit. In the present study, high abundances of *N. turgida* in both size fractions ($\sim 15\%$), together with the occurrence of *N. iridea*, which was rare to totally absent during the three other seasons, suggest the recent input of fresh OM at the study site (Gooday, 1986; Mackensen et al., 1990; Gooday and Hughes, 2002; Duchemin et al., 2007, 2008). At the same Station N, Goineau et al. (2011b) proposed that local accumulation of food particles in decimetric depressions could favour the growth of the most opportunistic taxa (e.g. *N. turgida*) by enhanced reproduction and growth. In May 2008, surficial sediments were enriched in fresher OM (C:N=12, labile OM = 27.0% OC; Table 2) than in April 2007 under similar spring bloom conditions (C:N=17.4, labile OM=19.2% OC; Table 2).

In December 2008, sediment samples were recovered 1 month after a major Rhône flood. The high amounts of fresh water and organic-rich suspended material ($Q > 2000 \text{ m}^3 \text{ s}^{-1}$ and $\text{SPM}_{\text{mean}} \sim 172 \text{ mg l}^{-1} \text{ d}^{-1}$ during 12 days) carried to the Gulf of Lions during this flood would explain the high contents in labile OM measured in the surficial sediments of Station N (Table 2). In the foraminiferal faunas, *B. spathulata*, *R. phlegeri* and *N. polymorphinoides* were abundant, but a high contribution of *Bolivina seminuda* and *Textularia porrecta* was also observed in the 63–150 μm size fraction (Fig. 7). The occurrence of *N. polymorphinoides* would plead for a noticeable action of bottom currents as in September 2007. In the Mediterranean Sea, the association of *B. seminuda* and *B. spathulata* has frequently been reported in meso- to eutrophic environments (e.g. Barmawidjaja et al., 1992; Jorissen et al., 1995; De Rijk et al., 2000; Schmiedl et al., 2000; Duijnste, 2001). In the Bay of Biscay, this association of bolivinid species characterised spring bloom conditions after phytodetritus input (Fontanier et al., 2003; Langezaal et al., 2006). Therefore, the occurrence of these

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species is coherent with the high labile OM content of the sediment resulting from a recent input of riverine organic material deposited by a major Rhône River flood.

To summarise, slight variations noticed in the foraminiferal faunas of Station N would be linked either to fresh OM supplies from surface primary production and/or to the Rhône River regime. In April 2007 and May 2008, spring bloom conditions allowed the growth of species able to feed on fresh phytodetritus (e.g. *Clavulina cylindrica*, *Hopkinsina atlantica*, *Nonionella iridea*, *Nonionella turgida*). In September 2007 and December 2008, the establishment of the taxon *Nouria polymorphinoides* was indicative of a potential disturbance of the benthic environment by bottom currents. The additional input of riverine organic matter after a major flood in December 2008 was beneficial for taxa visibly able to thrive in environments submitted to a noticeable riverine influence (e.g. *Bolivina seminuda*, *Bolivina spathulata*, *Textularia porrecta*). Despite these putative environmental forcings, the recurrent occurrence of the four same taxa (i.e. *Bolivina dilatata*, *Eggerella scabra*, *Nonion fabum*, *Valvulineria bradyana*) in relatively high abundances at any period in diverse and equilibrated faunas depicts the relatively stable state of the environment at this site.

5 Conclusions

Sampling sediments from the Rhône prodelta in April 2007, September 2007, May 2008 and December 2008 permitted us to observe foraminiferal faunas under a wide range of environmental conditions. Foraminiferal communities were able to respond extremely quickly (days to weeks) to strong variations in organic supplies and riverine discharge, especially close to the river mouth (Station A). This response was noticeable but significantly reduced ~5 km off the mouth (Station N), probably due to a reduced impact of riverine input out of the proximal prodeltaic area.

Major disturbance of the benthic environment induced by massive sediment deposits at the shallowest Station A after Rhône River floods allowed the development of opportunistic species. Two days after a major flood event, thousands of individuals of

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Leptohalysis scottii were observed in newly deposited flood sediment, constituting an assemblage of very early recolonisers. A few weeks after another major flood (December 2008), typical species of river-dominated shelves (*Ammonia tepida*) and high-energy environments (*Psammospaera fusca*) benefited from the high amounts of continental organic matter supplied by the flood. More stable conditions (i.e. no sediment deposit) allowed the growth of diverse and quite equilibrated faunas. Under the eutrophic conditions resulting from the spring phytoplankton bloom (April 2007), abundant and diverse fauna were composed of species feeding on fresh phytodetritus (e.g. *Bolivina dilatata*, *Nonionella stella*, *Stainforthia fusiformis*). Also in September 2007, diverse faunas were observed despite the oligotrophic conditions in surface water and/or the assumed high energy conditions prevailing above the sea floor. At the farther station N, *Clavulina cylindrica*, *Hopkinsina atlantica*, *Nonionella iridea* and *Nonionella turgida* are indicative of fresh OM input during eutrophic spring bloom conditions (April 2007, May 2008). On the contrary, the occurrence of *Nouria polymorphinoides* under oligotrophic conditions (September 2007, December 2008) was indicative of a benthic environment potentially disturbed by bottom currents.

Appendix A

See Table A1.

Appendix B

See Table B1.

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Appendix C

Taxonomic reference list for major taxa.

Ammonia tepida (Cushman) = *Rotalia beccarii* Linnaeus var. *tepida* Cushman, 1926; in Jorissen, 1988, Plate 2, Fig. 8a–b (as *Ammonia parkinsoniana* f. *tepida*)

5 *Bolivina dilatata* (Reuss) = *Brizalina dilatata* Reuss, 1850; in Colom, 1974, Fig. 18j–n

Bolivina seminuda Cushman, 1911; in Mojtahid et al., 2008, Plate 1, Fig. 5

Bolivina spathulata (Williamson) = *Textularia variabilis* Williamson var. *spathulata* Williamson, 1858; in Jorissen, 1988, Plate 1, Fig. 5

Clavulina cylindrica d'Orbigny, 1952; in Jones, 1994, Plate 44, Figs. 19–24

10 *Cribrostomoides wiesneri* (Parr) = *Labrospira wiesneri* Parr, 1950; in Jones, 1994, Plate 40, Figs. 14–15

Eggerella scabra (Williamson) = *Bulimina scabra* Williamson, 1858; in Jones, 1994, Plate 47, Figs. 15–17

15 *Haynesina germanica* (Ehrenberg) = *Nonionina germanica* Ehrenberg, 1840; in Diz and Francès, 2008, Plate II, Fig. 5

Hopkinsina atlantica (Cushman) = *Hopkinsina pacifica* Cushman var. *atlantica* Cushman, 1944; in Diz and Francès, 2008, Plate II, Fig. 8

Leptohalysis scottii (Chaster) = *Reophax scottii* Chaster, 1892; in Sgarella and Montcharmont Zei, 1993, Plate 2, Fig. 5

20 *Nonion fabum* (Fichtel and Moll) = *Nautilus faba* Fichtel and Moll, 1798; in Jones, 1994, Plate 109, Figs. 12–13

Nonionella iridea Heron–Allen and Earland, 1932; in “Discovery” Rept., 4, 438, Plate 16, Figs. 14–16

Nonionella stella Cushman and Moyer, 1930; in Diz and Francès, 2008, Plate 2, Fig. 6

25 *Nonionella turgida* (Williamson) = *Rotalina turgida* Williamson, 1858; in Jorissen, 1988, Plate 4, Figs. 11–13

Nouria polymorphinoides Heron–Allen and Earland, 1914; in Barmawidjaja et al., 1992, Plate 4, Fig. 4

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Psammosphaera fusca Schulze, 1875; in Hglund, 1947, Plate 4, Figs. 9–10
Rectuvigerina phlegeri Le Calvez, 1959; in Schiebel, 1992, Plate 3, Fig. 10a, d
Stainforthia fusiformis (Williamson) = *Bulimina pupoides* d'Orbigny var. *fusiformis*
 Williamson, 1858; in Gooday and Alve, 2001, Plate 3, Figs. A, B and C

5 *Textularia porrecta* (Brady) = *Textularia agglutinans* d'Orbigny var. *porrecta* Brady, 1884; in Rept. Challenger Expedition, London, England, 364, Plate 43, Fig. 4
Valvulineria bradyana (Fornasini) = *Discorbina bradyana* Fornasini, 1900; in Jorissen, 1988, Plate 4, Figs. 1–2

10 *Acknowledgements.* We would like to thank the crews and the captain of the R/V Téthys II (CNRS-INSU) during the RiOMar, RIOTECH, CHACCRA-bent 1 and CHACCRA-bent 2 campaigns. This work was supported by the French National Research Agency, program “Vulnérabilités: Milieux et climat”, under the grant no. ANR-06-VULN-001 to the CHACCRA project (Climate and Human-induced Alterations in Carbon Cycling at the River-seA connec-
 15 tion) and by the Regional Council of Pays de la Loire.

References

Alve, E. and Murray, J. W.: Marginal marine environments of the Skagerrak and Kattegat: a baseline study of living (stained) benthic foraminiferal ecology, *Palaeogeogr. Palaeoclimatol.*, 146, 171–193, 1999.

20 Barmawidjaja, D. M., Jorissen, F. J., Puskaric, S., and Van Der Zwaan, G. J.: Microhabitat selection by benthic foraminifera in the northern Adriatic Sea, *J. Foramin. Res.*, 22, 297–317, 1992.

Berné, S. and Gorini, C.: The Gulf of Lions: An overview of recent studies within the French “Margins” programme, *Mar. Petrol. Geol.*, 22, 691–693, 2005.

25 Bernhard, J. M.: Postmortem vital staining in benthic foraminifera: duration and importance in population and distributional studies, *J. Foramin. Res.*, 18, 143–146, 1988.

Bernhard, J. M.: Distinguishing live from dead foraminifera: Methods review and proper applications, *Micropaleontology*, 46, 38–46, 2000.

Temporal variability of live benthic foraminifera in a river-dominated shelf

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- Béthoux, J.-P. and Prieur, L.: Hydrologie et circulation en Méditerranée Nord-Occidentale, *Pétrole et techniques*, 229, 25–34, 1983.
- Bosc, E., Bricaud, A., and Antoine, D.: Seasonal and interannual variability in algal biomass and primary production in the Mediterranean Sea, as derived from 4 years of SeaWiFS observations, *Global Biogeochem. Cy.*, 18, 1–17, 2004.
- Bourgeois, S., Pruski, A. M., Sun, M.-Y., Buscail, R., Lantoiné, F., Vtion, G., Rivière, B., and Charles, F.: Distribution and lability of land-derived organic matter in the surface sediments of the Rhône prodelta and the adjacent shelf (Mediterranean sea, France): a multi proxy study, *Biogeosciences Discuss.*, 8, 3353–3402, doi:10.5194/bgd-8-3353-2011, 2011.
- Buscail, R., Kerhervé, P., Kim, J. H., Roussiez, V., Bourrin, F., Artero, C., Bossard, N., Pischedda, L., Jeanty, G., Desmousseaux, M., and Saragoni, G.: Sources and distribution of organic matter delivered by two contrasted river systems (Rhône and Têt) to continental shelf sediments (Gulf of Lions, NW Mediterranean), *Biogeosciences*, in preparation, 2011.
- Calmet, D. and Fernandez, J.-M.: Caesium distribution in northwest Mediterranean seawater, suspended particles and sediments, *Cont. Shelf Res.*, 10, 895–913, 1990.
- Cathalot, C., Rabouille, C., Pastor, L., Deflandre, B., Viollier, E., Buscail, R., Grémare, A., Treignier, C., and Pruski, A.: Temporal variability of carbon recycling in coastal sediments influenced by rivers: assessing the impact of flood inputs in the Rhône River prodelta, *Biogeosciences*, 7, 1187–1205, doi:10.5194/bg-7-1187-2010, 2010.
- Charmasson, S., Radakovitch, O., Arnaud, M., Bouisset, P., and Pruchon, A.-S.: Long-core profiles of ¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co and ²¹⁰Pb in sediment near the Rhône River (Northwestern Mediterranean Sea), *Estuaries Coasts*, 21, 367–378, 1998.
- Corliss, B. H. and Emerson, S.: Distribution of Rose Bengal stained deep-sea benthic foraminifera from the Nova Scotia continental margin and Gulf of Maine, *Deep Sea Res.*, 37, 381–400, 1990.
- Dagg, M. J. and Breed, G. A.: Biological effects of Mississippi River nitrogen on the northern gulf of Mexico—a review and synthesis, *J. Marine Syst.*, 43, 133–152, 2003.
- Darnaude, A., Salen-Picard, C., Polunin, N. C., and Harmelin-Vivien, M.: Trophodynamic linkage between river runoff and coastal fishery yield elucidated by stable isotope data in the Gulf of Lions (NW Mediterranean), *Oecologia*, 138, 325–332, 2004.
- De Rijk, S., Jorissen, F. J., Rohling, E. J., and Troelstra, S. R.: Organic flux control on bathymetric zonation of Mediterranean benthic foraminifera, *Mar. Micropaleontol.*, 40, 151–166, 2000.

Temporal variability of live benthic foraminifera in a river-dominated shelf

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Debenay, J.-P., Guillou, J.-J., Redois, F., and Geslin, E.: Distributional trends offoraminiferal assemblages in paralic environments-A base for using foraminifera as bioindicators, in: Environmental micropaleontology, edited by: Martin, R. E., Kluwer Academic/Plenum Publishers, New York, 39–67, 2000.

5 Diaz, F.: Evolution saisonnière de la production primaire et des processus d'assimilation-régénération de l'azote dans le Golfe du Lion. Estimation d'un bilan de carbone. Approches in situ et modélisation, PhD Thesis, Aix-Marseille II University, 351 pp., 2000.

Diz, P. and Francés, G.: Distribution of live benthic foraminifera in the Ra de Vigo (NW Spain), Mar. Micropaleontol., 66, 165–191, 2008.

10 Diz, P., Francés, G., and Roson, G.: Effects of contrasting upwelling-downwelling on benthic foraminiferal distribution in the Ria de Vigo (NW Spain), J. Marine Syst., 60, 1–18, 2006.

Donnici, S. and Serandrei Barbero, R.: The benthic foraminiferal communities of the northern Adriatic continental shelf, Mar. Micropaleontol., 44, 93–123, 2002.

15 Duchemin, G., Fontanier, C., Jorissen, F. J., Barras, C., and Griveaud, C.: Living small-sized (63–150 μm) foraminifera from mid-shelf to mid-slope environments in the Bay of Biscay, J. Foramin. Res., 37, 12–32, 2007.

Duchemin, G., Jorissen, F. J., Le Loc'h, F., Andrieux-Loyer, F., Hily, C., and Thouzeau, G.: Seasonal variability of living benthic foraminifera from the outer continental shelf of the Bay of Biscay, J. Sea Res., 59, 297–319, 2008.

20 Duijnste, I. A. P.: Experimental ecology of foraminifera: towards better quantitative paleoecological reconstructions, PhD Thesis, Nijmegen and Utrecht Universities, 149 pp., 2001.

Duijnste, I. A. P., de Nooijer, L. J., Ernst, S. R., and van der Zwaan, G. J.: Population dynamics of benthic shallow-water foraminifera: effects of a simulated marine snow event, Mar. Ecol. Prog. Ser., 285, 29–42, 2005.

25 Durrieu de Madron, X., Abassi, A., Heussner, S., Monaco, A., Aloisi, J. C., Radakovitch, O., Giresse, P., Buscail, R., and Kerherve, P.: Particulate matter and organic carbon budgets for the Gulf of Lions (NW Mediterranean), Oceanol. Acta, 23, 717–730, 2000.

Durrieu de Madron, X., Denis, L., Diaz, F., Garcia, N., Guieu, C., Grenz, C., Loe-Pilot, M.-D., Ludwig, W., Moutin, T., Raimbault, P., and Ridame, C.: Nutrients and carbon budgets for the Gulf of Lion during the Moogli cruises, Oceanol. Acta, 26, 421–433, 2003.

30 Eisma, D.: Suspended matter in the aquatic environment, edited by: Springer, Berlin, New York, 315 pp., 1993.

Ernst, S., Duijnste, I., and van der Zwaan, B.: The dynamics of the benthic foraminiferal

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microhabitat: recovery after experimental disturbance, *Mar. Micropaleontol.*, 46, 343–361, 2002.

Fontanier, C., Jorissen, F. J., Licari, L., Alexandre, A., Anschutz, P., and Carbonel, P.: Live benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition, and microhabitats, *Deep Sea Res. Pt. I*, 49, 751–785, 2002.

Fontanier, C., Jorissen, F. J., Chaillou, G., David, C., Anschutz, P., and Lafon, V.: Seasonal and interannual variability of benthic foraminiferal faunas at 550 m depth in the Bay of Biscay, *Deep Sea Res. Pt. I*, 50, 457–494, 2003.

Frezza, V. and Carboni, M. G.: Distribution of recent foraminiferal assemblages near the Ombrone River mouth (Northern Tyrrhenian Sea, Italy), *Rev. Micropaleontol.*, 52, 43–66, 2009.

Gaździcki, A. and Majewski, W.: Recent foraminifera from Goulden Cove of King George Island, Antarctica, *Pol. Polar Res.*, 24, 3–12, 2003.

Goineau, A., Fontanier, C., Jorissen, F. J., Lansard, B., Buscail, R., Mouret, A., Kerhervé, P., Zaragosi, S., Ernoult, E., Artéro, C., Anschutz, P., Metzger, E., and Rabouille, C.: Live (stained) benthic foraminifera from the Rhône prodelta (Gulf of Lion, NW Mediterranean): Environmental controls on a river-dominated shelf, *J. Sea Res.*, 65, 58–75, 2011a.

Goineau, A., Fontanier, C., Jorissen, F. J., Hunault, G., Buscail, R., Kerhervé, P., Cathalot, C., and Rabouille, C.: Spatial variability (decimetric-scale) of live (stained) benthic foraminifera from a river-dominated shelf (Rhône prodelta, Gulf of Lions): applications for foraminiferal studies, *J. Foramin. Res.*, submitted, 2011b.

Gooday, A. J.: Meiofaunal foraminiferans from the bathyal Porcupine Seabight (northeast Atlantic): size structure, standing stock, taxonomy composition, species diversity and vertical distribution in the sediment, *Deep Sea Res.*, 33, 1345–1373, 1986.

Gooday, A. J. and Hughes, J. A.: Foraminifera associated with phytodetritus deposits at a bathyal site in the northern Rockall Trough (NE Atlantic): seasonal contrasts and a comparison of stained and dead assemblages, *Mar. Micropaleontol.*, 46, 83–110, 2002.

Gordon, E. S. and Goñi, M. A.: Sources and distribution of terrigenous organic matter delivered by the Atchafalaya River to sediments in the northern Gulf of Mexico, *Geochim. Cosmochim. Ac.*, 67, 2359–2375, 2003.

Got, H. and Aloisi, J. C.: The Holocene sedimentation on Gulf of Lions margin: a quantitative approach, *Cont. Shelf Res.*, 10, 841–855, 1990.

Gustafsson, M. and Nordberg, K.: Living (stained) benthic foraminiferal response to primary production and hydrography in the deepest part of the Gullmar fjord, Swedish west coast,

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with comparison to Hglund’s 1927 material, *J. Foramin. Res.*, 31, 2–11, 2001.

Harloff, J. and Mackensen, A.: Recent benthic foraminiferal associations and ecology of the Scotia Sea and Argentine Basin, *Mar. Micropaleontol.*, 31, 1–29, 1997.

Harmelin-Vivien, M., Loizeau, V., Mellon, C., Beker, B., Arlhac, D., Bodiguel, X., Ferraton, F., Hermand, R., Philippon, X., and Salen-Picard, C.: Comparison of C and N stable isotope ratios between surface particulate organic matter and microphytoplankton in the Gulf of Lions (NW Mediterranean), *Cont. Shelf Res.*, 28, 1911–1919, 2008.

Hayek, L. E. C. and Buzas, M. A.: *Surveying Natural Populations*, edited by: Columbia University Press, New York, 563 pp., 1997.

Hermand, R., Salen-Picard, C., Alliot, E., and Degiovanni, C.: Macrofaunal density, biomass and composition of estuarine sediments and their relationship to the river plume of the Rhone River (NW Mediterranean), *Estuar. Coast. Shelf S.*, 79, 367–376, 2008.

Hohenegger, J., Piller, W. E., and Baal, C.: Horizontal and vertical spatial microdistribution of foraminifers in the shallow subtidal Gulf of Trieste, northern Adriatic Sea, *J. Foramin. Res.*, 23, 79–101, 1993.

Hyams-Kaphzan, O., Almogi-Labin, A., Benjamini, C., and Herut, B.: Natural oligotrophy vs. pollution-induced eutrophy on the SE Mediterranean shallow shelf (Israel): Environmental parameters and benthic foraminifera, *Mar. Pollut. Bull.*, 58, 1888–1902, 2009.

Jones, G. D.: A paleoecological model of late Paleocene “fysch-type” agglutinated foraminifera using the paleoslope transect approach, Viking Graben, North Sea, *Abhandlungen der Geologischen Bundesanstalt*, 41, 143–153, 1988.

Jorissen, F. J.: The distribution of benthic foraminifera in the Adriatic Sea, *Mar. Micropaleontol.*, 12, 21–48, 1987.

Jorissen, F. J.: Benthic foraminifera from the Adriatic Sea; Principles of phenotypic variation, *Utrecht Micropaleontology Bulletin*, 37, 176 pp., 1988.

Jorissen, F. J., Barmawidjaja, D. M., Puskaric, S., and van der Zwaan, G. J.: Vertical distribution of benthic foraminifera in the northern Adriatic Sea: The relation with the organic flux, *Mar. Micropaleontol.*, 19, 131–146, 1992.

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

Kaminski, M. A.: Evidence for control of abyssal agglutinated foraminiferal community structure by substrate disturbance: Results from the HEBBLE area, *Mar. Geol.*, 66, 113–131, 1985.

Kaminski, M. A., Boersma, A., Tyszkza, J., and Holbourn, A. E. L.: Response of deep-water

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- agglutinated foraminifera to dysoxic conditions in the California Borderland basins, in: Proceedings of the Fourth International Workshop on Agglutinated Foraminifera, Krakow, Poland, edited by: Kaminski, M. A., Geroch, S., and Gasiski, M. A., Grzybowski Foundation Special Publication no. 3, 131–140, 1995.
- 5 Kerhervé, P., Ludwig, W., Pischedda, L., Carbonne, J., and Jeanty, G.: Stable isotopic tracers ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of riverine inputs into the Gulf of Lions: results from a one-year survey, in preparation, 2011.
- Langezaal, A. M., Jorissen, F. J., Braun, B., Chaillou, G., Fontanier, C., Anschutz, P., and van der Zwaan, G. J.: The influence of seasonal processes on geochemical profiles and
10 foraminiferal assemblages on the outer shelf of the Bay of Biscay, *Cont. Shelf Res.*, 26, 1730–1755, 2006.
- Lansard, B., Rabouille, C., Denis, L., and Grenz, C.: Benthic remineralization at the land-ocean interface: A case study of the Rhône River (NW Mediterranean Sea), *Estuar. Coast. Shelf S.*, 81, 544–554, 2009.
- 15 Lochet, F. and Leveau, M.: Transfers between a eutrophic ecosystem, the river Rhône, and an oligotrophic ecosystem, the north-western Mediterranean Sea, *Hydrobiologia*, 207, 95–103, 1990.
- Lohrenz, S. E., Dagg, M. J., and Whitley, T. E.: Enhanced primary production at the plume/oceanic interface of the Mississippi River, *Cont. Shelf Res.*, 10, 639–664, 1990.
- 20 Lohrenz, S. E., Fahnenstiel, G. L., Redalje, D. G., Lang, G. A., Chen, X., and Dagg, M. J.: Variations in primary production of northern Gulf of Mexico continental shelf waters linked to nutrient inputs from the Mississippi River, *Mar. Ecol. Prog. Ser.*, 155, 45–54, 1997.
- Lukina, T. G.: Foraminifera of the Laptev Sea, *Protistology*, 2, 105–122, 2001.
- Mackensen, A., Grobe, H., Kuhn, G., and Ffiterer, D. K.: Benthic foraminiferal assemblages from the eastern Weddell Sea between 68 and 73°S: Distribution, ecology and fossilization potential, *Mar. Micropaleontol.*, 16, 241–283, 1990.
- 25 Millot, C.: The Gulf of Lions' hydrodynamics, *Cont. Shelf Res.*, 10, 885–894, 1990.
- Millot, C.: Circulation in the Western Mediterranean Sea, *J. Marine Syst.*, 20, 423–442, 1999.
- Mojtahid, M., Jorissen, F., Lansard, B., Fontanier, C., Bombled, B., and Rabouille, C.: Spatial distribution of live benthic foraminifera in the Rhône prodelta: Faunal response to a continental-marine organic matter gradient, *Mar. Micropaleontol.*, 70, 177–200, 2009.
- 30 Murray, J. W.: *Ecology and Applications of Benthic Foraminifera*, edited by: Cambridge University Press, Cambridge, 426 pp., 2006.

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- Murray, J. W. and Bowser, S. S.: Mortality, protoplasm decay rate, and reliability of staining techniques to recognize 'living' foraminifera: a review, *J. Foramin. Res.*, 30, 66–70, 2000.
- Naudin, J. J., Cauwet, G., Chrétiennot-Dinet, M. J., Deniaux, B., Devenon, J. L., and Pauc, H.: River Discharge and Wind Influence Upon Particulate Transfer at the Land-Ocean Interaction: Case Study of the Rhône River Plume, *Estuar. Coast. Shelf S.*, 45, 303–316, 1997.
- Pastor, L., Deflandre, B., Viollier, E., Cathalot, C., Metzger, E., Rabouille, C., Escoubeyrou, K., Lloret, E., Pruski, A. M., Vétion, G., Desmalades, M., Buscail, R., and Grémare, A.: Influence of the organic matter composition on benthic oxygen demand in the Rhône River prodelta (NW Mediterranean Sea), *Cont. Shelf Res.*, 31, 1008–1019, 2011.
- Pont, D., Simonnet, J. P., and Walter, A. V.: Medium-term Changes in Suspended Sediment Delivery to the Ocean: Consequences of Catchment Heterogeneity and River Management (Rhône River, France), *Estuar. Coast. Shelf S.*, 54, 1–18, 2002.
- Rabineau, M., Berné, S., Aslanian, D., Olivet, J.-L., Joseph, P., Guillocheau, F., Bourillet, J.-F., Ledrezen, E., and Granjeon, D.: Sedimentary sequences in the Gulf of Lion: A record of 100,000 years climatic cycles, *Mar. Petrol. Geol.*, 22, 775–804, 2005.
- Rabouille, C., Denis, L., Dedieu, K., Stora, G., Lansard, B., and Grenz, C.: Oxygen demand in coastal marine sediments: comparing in situ microelectrodes and laboratory core incubations, *J. Exp. Mar. Biol. Ecol.*, 285–286, 49–69, 2003.
- Rossi, V. and Vaiani, S. C.: Benthic foraminiferal evidence of sediment supply changes and fluvial drainage reorganization in Holocene deposits of the Po Delta, Italy, *Mar. Micropaleontol.*, 69, 106–118, 2008.
- Sabatier, F. and Suanez, S.: Evolution of the Rhône delta coast since the end of the 19th century, *Géomorphologie: Relief, Processus, Environnement*, 47, 283–300, 2003.
- Salen-Picard, C., Darnaude, A. M., Arlhac, D., and Harmelin-Vivien, M. L.: Fluctuations of macrobenthic populations: a link between climate-driven river runoff and sole fishery yields in the Gulf of Lions, *Oecologia*, 133, 380–388, 2002.
- Schmiedl, G., de Bovée, F., Buscail, R., Charrière, B., Hemleben, C., Medernach, L., and Picon, P.: Trophic control of benthic foraminiferal abundance and microhabitat in the bathyal Gulf of Lions, western Mediterranean Sea, *Mar. Micropaleontol.*, 40, 167–188, 2000.
- Scott, D. B., Tobin, R., Williamson, M., Medioli, F. S., Latimer, J. S., Boothman, W. A., Asioli, A., and Hauray, V.: Pollution monitoring in two North American estuaries: Historical reconstructions using benthic foraminifera, *J. Foramin. Res.*, 35, 65–82, 2005.
- Tesi, T., Miserocchi, S., Goi, M. A., and Langone, L.: Source, transport and fate of terrestrial

organic carbon on the western Mediterranean Sea, Gulf of Lions, France, *Mar. Chem.*, 105, 101–117, 2007.

Van der Zwaan, G. J. and Jorissen, F.: Biofacial patterns in river-induced shelf anoxia, In: *Modern and Ancient Continental Shelf Anoxia*, Geological Society, Special Publication, 58, 65–82, 1991.

Vázquez Riveiros, N. and Patterson, R. T.: An illustrated guide to fjord foraminifera from the Seymour-Belize inlet complex, Northern British Columbia, Canada, *Palaeontol. Electron.*, 11, 2A, 45 pp., 2007.

Walton, W. R.: Techniques for recognition of living Foraminifera, *Contributions from the Cushman Foundation for Foraminiferal Research*, 3, 56–60, 1952.

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8, 9033–9086, 2011

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Table 1. Location and environmental characteristics of both Stations A and N over the four sampling campaigns. Q_{mean} and SPM_{mean} are mean Rhône River discharge and suspended material load, respectively, calculated over the 15 days prior to sampling. $\Delta t/\text{last major flood}$ is the time interval since the last Rhône River flood $>3000 \text{ m}^3 \text{ s}^{-1}$. T_{BW} and $[\text{O}_2]_{\text{BW}}$ correspond to bottom water temperature and oxygenation, respectively.

Station	Lat. (°N)	Long. (°E)	Water depth (m)	Dist./river mouth (km)	Period	Q_{mean} ($\text{m}^3 \text{ s}^{-1} \text{ d}^{-1}$)	$\Delta t/\text{last major flood}$ (d)	SPM_{mean} ($\text{mg l}^{-1} \text{ d}^{-1}$)	T_{BW} (°C)	$[\text{O}_2]_{\text{BW}}$ ($\mu\text{mol l}^{-1}$)
A	43°18'47"	4°51'4"	24	1.9	Apr. 07	1018	42	5	14.9	259
					Sept. 07	768	188	13	17.7	244
					May. 08	1718	2	115	16.8	238
					Dec. 08	1461	27	17	14.8	237
N	43° 17' 33"	4°47'59"	67	5.5	Apr. 07	1018	42	5	14.5	253
					Sept. 07	768	188	13	14.5	217
					May. 08	1718	38	115	16.3	240
					Dec. 08	1461	27	17	–	–

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Table 2. Results of the different environmental parameters analysed within sediments of both Stations A and N over the four sampling campaigns. Oxygen penetration depth (OPD), dissolved oxygen uptake (DOU) and analyses on particulate organic matter from the top half-centimetre of sediment: organic carbon (OC), carbon and nitrogen stable isotopic ratios ($\delta^{13}\text{C}_{\text{OC}}$ vs. $\delta^{15}\text{N}$), sum of lipids and total hydrolysable amino-acids (THAA) contents for dry-weight sediment (d.w.) and contribution to the OC (% OC).

Station	Period	OPD (mm)	DOU (mmol O ₂ m ⁻² d ⁻¹)	OC (% d.w.)	C:N (Atomic ratio)	$\delta^{13}\text{C}_{\text{OC}}$ (‰)	$\delta^{15}\text{N}$ (‰)	Lipids+THAA		Chl- <i>a</i> ($\mu\text{g g}^{-1}$)
								(mg g ⁻¹ d.w.)	(% OC)	
A	Apr. 07	1.4 ± 0.2	21.5 ± 3.9	2.05	15.2	-27.18	3.58	4.2	20.4	9.78
	Sept. 07	1.7 ± 0.1	15.3 ± 1.5	1.40	12.5	-26.64	3.92	3.7	26.5	4.66
	May 08	5.8 ± 0.8	9.2 ± 3.1	1.13	14.8	-26.3	2.90	1.9	16.7	3.07
	Dec. 08	1.6 ± 0.3	20.6 ± 2.6	1.22	28.1	-24.79	-	1.8	14.7	2.14
N	Apr. 07	3.3 ± 0.6	9.5 ± 1.2	1.42	17.4	-25.94	3.89	2.7	19.2	2.57
	Sept. 07	4.9 ± 1.1	6.6 ± 0.9	1.20	13.2	-25.82	3.90	2.7	22.9	1.23
	May 08	3.8 ± 0.6	9.2 ± 1.9	1.00	12.0	-26.115	3.46	2.7	27.0	1.62
	Dec. 08	-	-	1.36	16.2	-25.88	3.67	3.8	27.8	1.47



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Table A1. Total benthic foraminiferal counts on the >150 µm size fraction. For each species in each core, “r.d.” and “D” correspond to non-standardised (raw data) and standardised (for a surface area of 100 cm²) total absolute abundances, respectively, and “%” indicates relative abundance.

Station	Station A											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Taxa	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
<i>Ammonia beccarii</i> f. <i>beccarii</i>	3	4	0.5	–	–	–	–	–	–	–	–	–
<i>Ammonia beccarii</i> f. <i>inflata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Ammonia parkinsoniana</i>	–	–	–	–	–	–	–	–	–	1	1	0.1
<i>Ammonia tepida</i>	1	1	0.2	104	144	50.5	32	44	0.6	1035	1438	93.9
<i>Amphicoryna scalaris</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Astacolus crepidulus</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bolivina</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bolivina alata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bolivina dilatata</i>	1	1	0.2	–	–	–	5	7	0.1	1	1	0.1
<i>Bolivina striatula</i>	–	–	–	–	–	–	–	–	–	1	1	0.1
<i>Bolivina subaenariensis</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Buccella granulata</i>	–	–	–	1	1	0.5	–	–	–	–	–	–
<i>Bulimina aculeata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bulimina elongata</i>	11	15	2.0	6	8	2.9	4	6	0.1	–	–	–
<i>Bulimina gibba</i>	–	–	–	1	1	0.5	–	–	–	–	–	–
<i>Bulimina marginata</i>	–	–	–	1	1	0.5	–	–	–	2	3	0.2
<i>Cancris oriculus</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cassidulina carinata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cassidulina crassa</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Chilostomella ovoidea</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Dentalina filiformis</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Elphidium advenum</i>	1	1	0.2	–	–	–	–	–	–	–	–	–
<i>Elphidium crispum</i>	–	–	–	1	1	0.5	–	–	–	–	–	–
<i>Elphidium poeyanum</i> f. <i>decipiens</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Epistominella vitrea</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Fursenkoina</i> sp.	3	4	0.5	–	–	–	–	–	–	–	–	–
<i>Gavelinopsis praegeri</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Globobulimina pyrula</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Gyroidina umbonata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Haynesina</i> spp.	–	–	–	–	–	–	–	–	–	30	42	2.7
<i>Hopkinsina atlantica</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Hyalinea bathica</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Lenticulina atlantica</i>	–	–	–	–	–	–	–	–	–	–	–	–

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Table A1. Continued.

Station	Station A													
	Sampling period			Apr. 07			Sept. 07			May. 08			Dec. 08	
Taxa	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%		
Perforates														
<i>Lenticulina peregrina</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Nonion fabum</i>	54	75	9.8	2	3	1.0	5	7	0.1	–	–	–		
<i>Nonionella iridea</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Nonionella stella</i>	9	13	1.6	–	–	–	11	15	0.2	–	–	–		
<i>Nonionella turgida</i>	103	143	18.7	13	18	6.3	28	39	0.5	–	–	–		
<i>Pseudoeponides falsobeccarii</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Rectuvigerina phlegeri</i>	1	1	0.2	–	–	–	–	–	–	–	–	–		
<i>Robertina translucens</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Rosalina vilardeboana</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Saidovina karreriana</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Stainforthiaconcava</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Valvulineria bradyana</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Virgulinella fragilis</i>	1	1	0.2	–	–	–	–	–	–	–	–	–		
Miliolids														
Indet.	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Adelosina longirostra</i>	2	3	0.4	–	–	–	–	–	–	–	–	–		
<i>Bilocolinella labiata</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Miliolinella subrotunda</i>	–	–	–	–	–	–	–	–	–	1	1	0.1		
<i>Pseudotriloculina</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Pyrgo elongata</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Pyrgo oblonga</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Quinqueloculina aspera</i>	1	1	0.2	10	14	4.9	–	–	–	–	–	–		
<i>Quinqueloculina lata</i>	2	3	0.4	4	6	1.9	3	4	0.1	4	6	0.4		
<i>Quinqueloculina milletti</i>	–	–	–	7	10	3.4	–	–	–	–	–	–		
<i>Quinqueloculina pygmaea</i>	–	–	–	1	1	0.5	–	–	–	–	–	–		
<i>Quinqueloculina seminula</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Quinqueloculina stalkerii</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Sigmollinita tenuis</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Sigmoilopsis schlumbergeri</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Triloculina tricarinata</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Triloculina trigonula</i>	–	–	–	–	–	–	–	–	–	–	–	–		
Fossilising agglutinated														
<i>Textularia agglutinans</i>	–	–	–	–	–	–	–	–	–	–	–	–		
Non fossilising agglutinated														
Indet.	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Agglutinate</i> sp. 333	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Adercotryma glomerata</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Ammoscalaria foliaceae</i>	1	1	0.2	–	–	–	–	–	–	–	–	–		
<i>Clavulina cylindrica</i>	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Cribrostomoides wiesneri</i>	1	1	0.2	–	–	–	–	–	–	–	–	–		
<i>Eggerella scabra</i>	69	96	12.5	27	38	13.1	–	–	–	2	3	0.2		
<i>Haplophragmoides</i> spp.	–	–	–	–	–	–	–	–	–	–	–	–		
<i>Lagenammina difflugiformis</i>	–	–	–	1	1	0.5	–	–	–	3	4	0.3		
<i>Leptohalysis scottii</i>	287	399	52.0	17	24	8.3	5427	7538	98.2	4	6	0.4		
<i>Nouria polymorphinoides</i>	1	1	0.2	–	–	–	3	4	0.1	–	–	–		

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Table A1. Continued.

Station	Station A											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
<i>Psammosphaera bowmani</i>	–	–	–	9	13	4.4	1	1	0.0	18	25	1.6
<i>Pseudobolivina fusiformis</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Reophax fusiformis</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Reophax nana</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Spirolectammina</i> sp.1	–	–	–	1	1	0.5	1	1	0.0	–	–	–
<i>Trochammina globigeriniformis</i>	–	–	–	–	–	–	–	–	–	–	–	–
Organic foraminifera	–	–	–	–	–	–	–	–	–	–	–	–
Total No Perforates	188	261	34.1	129	179	62.6	85	118	1.5	1070	1486	97.1
Total No Miliolids	5	7	0.9	22	31	10.7	3	4	0.1	5	7	0.5
Tot. No Fossilising Agglutinates	–	–	–	–	–	–	–	–	–	–	–	–
Tot. No Non-fossilising Agglutinates	359	499	65.0	55	76	26.7	5432	7544	98.4	27	38	2.5
Total No Organic	–	–	–	–	–	–	–	–	–	–	–	–
Total No individuals	552	767		206	286		5520	7667		1102	1531	

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Table A1. Continued.

Station	Station N											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
<i>Ammonia beccarii</i> f. <i>beccarii</i>	1	1	0.1	23	32	1.8	15	21	0.8	–	–	–
<i>Ammonia beccarii</i> f. <i>inflata</i>	19	26	2.4	–	–	–	10	14	0.5	38	53	4.1
<i>Ammonia parkinsoniana</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Ammonia tepida</i>	1	1	0.1	–	–	–	–	–	–	–	–	–
<i>Amphicoryna scalaris</i>	–	–	–	–	–	–	1	1	0.1	3	4	0.3
<i>Astacolus crepidulus</i>	2	3	0.3	1	1	0.1	1	1	0.1	–	–	–
<i>Bolivina</i> sp.	–	–	–	2	3	0.2	–	–	–	1	1	0.1
<i>Bolivina alata</i>	–	–	–	1	1	0.1	1	1	0.1	–	–	–
<i>Bolivina dilatata</i>	–	–	–	1	1	0.1	–	–	–	–	–	–
<i>Bolivina striatula</i>	–	–	–	1	1	0.1	3	4	0.2	5	7	0.5
<i>Bolivina subaenariensis</i>	–	–	–	2	3	0.2	1	1	0.1	–	–	–
<i>Buccella granulata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bulimina aculeata</i>	1	1	0.1	1	1	0.1	5	7	0.3	–	–	–
<i>Bulimina elongata</i>	2	3	0.3	–	–	–	1	1	0.1	3	4	0.3
<i>Bulimina gibba</i>	1	1	0.1	–	–	–	5	7	0.3	2	3	0.2
<i>Bulimina marginata</i>	3	4	0.4	1	1	0.1	21	29	1.1	3	4	0.3
<i>Cancris oriculus</i>	1	1	0.1	–	–	–	–	–	–	–	–	–
<i>Cassidulina carinata</i>	6	8	0.8	24	33	1.8	86	119	4.4	1	1	0.1
<i>Cassidulina crassa</i>	–	–	–	4	6	0.3	–	–	–	–	–	–
<i>Chilostomella ovoidea</i>	–	–	–	–	–	–	1	1	0.1	1	1	0.1
<i>Dentalina filiformis</i>	1	1	0.1	–	–	–	–	–	–	–	–	–
<i>Elphidium advenum</i>	4	6	0.5	1	1	0.1	11	15	0.6	4	6	0.4
<i>Elphidium crispum</i>	–	–	–	1	1	0.1	3	4	0.2	–	–	–
<i>Elphidium poeyanum</i> f. <i>decipiens</i>	–	–	–	–	–	–	6	8	0.3	2	3	0.2
<i>Epistominella vitrea</i>	–	–	–	–	–	–	1	1	0.1	–	–	–
<i>Fursenkoina</i> sp.	–	–	–	–	–	–	1	1	0.1	4	6	0.4
<i>Gavelinopsis praegeri</i>	–	–	–	1	1	0.1	–	–	–	–	–	–
<i>Globobulimina pyrula</i>	–	–	–	–	–	–	–	–	–	1	1	0.1
<i>Gyroidina umbonata</i>	–	–	–	4	6	0.3	1	1	0.1	–	–	–
<i>Haynesina</i> spp.	–	–	–	–	–	–	–	–	–	–	–	–
<i>Hopkinsina atlantica</i>	1	1	0.1	–	–	–	–	–	–	–	–	–
<i>Hyalinea bathica</i>	1	1	0.1	2	3	0.2	3	4	0.2	–	–	–
<i>Lenticulina atlantica</i>	2	3	0.3	–	–	–	5	7	0.3	–	–	–
<i>Lenticulina peregrina</i>	–	–	–	1	1	0.1	–	–	–	–	–	–
<i>Nonion fabum</i>	54	75	6.9	178	247	13.7	172	239	8.7	179	249	19.4
<i>Nonionella iridea</i>	–	–	–	–	–	–	1	1	0.1	–	–	–
<i>Nonionella stella</i>	–	–	–	–	–	–	45	63	2.3	–	–	–
<i>Nonionella turgida</i>	41	57	5.2	30	42	2.3	291	404	14.7	69	96	7.5
<i>Pseudoepionides falsobeccarii</i>	–	–	–	2	3	0.2	–	–	–	3	4	0.3
<i>Rectuvigerina phlegeri</i>	19	26	2.4	92	128	7.1	132	183	6.7	102	142	11.1
<i>Robertina translucens</i>	3	4	0.4	1	1	0.1	3	4	0.2	–	–	–
<i>Rosalina vilardeboana</i>	–	–	–	–	–	–	1	1	0.1	–	–	–
<i>Saidovina karreriana</i>	–	–	–	–	–	–	1	1	0.1	1	1	0.1
<i>Stainforthiaconcava</i>	–	–	–	–	–	–	3	4	0.2	–	–	–
<i>Valvulineria bradyana</i>	82	114	10.4	275	382	21.2	380	528	19.2	160	222	17.3
<i>Virgulinella fragilis</i>	–	–	–	–	–	–	–	–	–	–	–	–
Miliolids												
Indet.	–	–	–	–	–	–	1	1	0.1	–	–	–
<i>Adelosina longirostrata</i>	8	11	1.0	7	10	0.5	11	15	0.6	4	6	0.4
<i>Biloculinella labiata</i>	–	–	–	1	1	0.1	1	1	0.1	1	1	0.1

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Table A1. Continued.

Station	Station N											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
<i>Miliolinella subrotunda</i>	-	-	-	-	-	-	2	3	0.1	-	-	-
<i>Pseudotriloculina</i> sp.	-	-	-	-	-	-	1	1	0.1	-	-	-
<i>Pyrgo elongata</i>	-	-	-	3	4	0.2	-	-	-	-	-	-
<i>Pyrgo oblonga</i>	-	-	-	7	10	0.5	2	3	0.1	2	3	0.2
<i>Quinqueloculina aspera</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Quinqueloculina lata</i>	1	1	0.1	-	-	-	3	4	0.2	1	1	0.1
<i>Quinqueloculina milletti</i>	-	-	-	1	1	0.1	-	-	-	-	-	-
<i>Quinqueloculina pygmaea</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Quinqueloculina seminula</i>	4	6	0.5	6	8	0.5	2	3	0.1	3	-	0.3
<i>Quinqueloculina stalkerii</i>	-	-	-	-	-	-	-	-	-	1	0	0.1
<i>Sigmoilinita tenuis</i>	-	-	-	-	-	-	-	-	-	1	0	0.1
<i>Sigmoilopsis schlumbergeri</i>	3	4	0.4	-	-	-	1	0	0.1	-	-	-
<i>Triloculina tricarinata</i>	-	-	-	-	-	-	1	0	0.1	-	-	-
<i>Triloculina trigonula</i>	-	-	-	-	-	-	2	0	0.1	1	0	0.1
Fossilising agglutinated												
<i>Textularia agglutinans</i>	19	-	2.4	23	0	1.8	69	0	3.5	11	0	1.2
Non fossilising agglutinated												
Indet.	-	-	-	2	3	0.2	1	1	0.1	-	-	-
Agglutinate sp.333	-	-	-	42	58	3.2	5	7	0.3	-	-	-
<i>Adercotryma glomerata</i>	3	4	0.4	6	8	0.5	33	46	1.7	1	1	0.1
<i>Ammoscalaria foliacea</i>	11	15	1.4	20	28	1.5	18	25	0.9	6	8	0.7
<i>Clavulina cylindrica</i>	58	81	7.4	139	193	10.7	38	53	1.9	17	24	1.8
<i>Cribrostomoides wiesneri</i>	40	56	5.1	16	22	1.2	38	53	1.9	-	-	-
<i>Eggerella scabra</i>	361	501	45.9	238	331	18.3	396	550	20.0	86	119	9.3
<i>Haplophragmoides</i> spp.	3	4	0.4	1	1	0.1	1	1	0.1	4	6	0.4
<i>Lagenammina diffligiformis</i>	1	1	0.1	10	14	0.8	1	1	0.1	1	1	0.1
<i>Leptohalysis scottii</i>	-	-	-	1	1	0.1	39	54	2.0	49	68	5.3
<i>Nouria polymorphinoides</i>	16	22	2.0	73	101	5.6	16	22	0.8	140	194	15.2
<i>Psammosphaera bowmani</i>	9	13	1.1	6	8	0.5	14	19	0.7	3	4	0.3
<i>Pseudobolivina fusiformis</i>	-	-	-	-	-	-	1	1	0.1	-	-	-
<i>Reophax fusiformis</i>	1	1	0.1	17	24	1.3	12	17	0.6	2	3	0.2
<i>Reophax nana</i>	1	1	0.1	-	-	-	-	-	-	-	-	-
<i>Spiroplectammina</i> sp.1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tochammina globigeriniformis</i>	2	3	0.3	30	42	2.3	22	31	1.1	7	10	0.8
Organic foraminifera												
Total No Perforates	245	340	31.2	649	901	50.0	1211	1682	61.3	582	808	63.1
Total No Miliolids	16	22	2.0	25	35	1.9	27	38	1.4	14	19	1.5
Tot. No Fossilising Agglutinates	19	26	2.4	23	32	1.8	69	96	3.5	11	15	1.2
Tot. No Non-fossilising Agglutinates	506	703	64.4	601	835	46.3	635	882	32.1	316	439	34.2
Total No Organic	-	-	-	1	1	0.1	40	56	2.0	-	-	-
Total No individuals	786	1092		1299	1804		1982	2753		923	1282	

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Table B1. Total benthic foraminiferal counts on the 63–150 µm size fraction. For each species in each core, “r.d.” and “D” correspond to non-standardised (raw data) and standardised (for a surface area of 100 cm²) total absolute abundances, respectively, and “%” indicates relative abundance.

Station	Station A											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
Indet.	–	–	–	4	6	0.9	–	–	–	–	–	–
<i>Ammonia beccarii f. beccarii</i>	11	15	0.3	12	17	2.6	–	–	–	24	33	2.4
<i>Ammonia tepida</i>	–	–	–	28	39	4.3	–	–	–	432	600	43.5
<i>Amphicoryna scalaris</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Astacolus crepidulus</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bolivina dilatata</i>	597	830	16.2	36	50	6.0	–	–	–	40	56	4.0
<i>Bolivina seminuda</i>	96	133	2.6	–	–	–	–	–	–	–	–	–
<i>Bolivina spathulata</i>	21	30	0.6	–	–	–	–	–	–	–	–	–
<i>Bolivina striatula</i>	11	15	0.3	4	6	0.5	–	–	–	–	–	–
<i>Bulimina aculeata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Bulimina elongata</i>	21	30	0.6	–	–	–	–	–	–	–	–	–
<i>Bulimina marginata</i>	11	15	0.3	–	–	–	–	–	–	–	–	–
<i>Buliminella elegantissima</i>	11	15	0.3	4	6	0.5	–	–	–	–	–	–
<i>Cancris oriculus</i>	–	–	–	4	6	0.9	–	–	–	16	22	1.6
<i>Cassidulina carinata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cassidulina crassa</i>	11	15	0.3	–	–	–	–	–	–	–	–	–
<i>Cassidulina minuta</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cassidulina oblonga</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Elphidium poeyanum</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Epistominella vitrea</i>	11	15	0.3	–	–	–	–	–	–	–	–	–
<i>Fissurina sp.</i>	–	–	–	–	–	–	–	–	–	8	11	0.8
<i>Fursenkoina sp.</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Gavelinopsis praegeri</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Gyroidina umbonata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Hanzawaia boueana</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Haynesina germanica</i>	–	–	–	–	–	–	–	–	–	64	89	6.5
<i>Hopkinsina atlantica</i>	139	193	3.8	–	–	–	–	–	–	–	–	–
<i>Hyalinea balthica</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Lenticulina atlantica</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Nonion sp.1</i>	–	–	–	4	6	0.5	–	–	–	–	–	–
<i>Nonion fabum</i>	11	15	0.3	–	–	–	–	–	–	–	–	–
<i>Nonionella sp.1</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Nonionella bradyi</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Nonionella iridea</i>	75	104	2.0	4	6	0.5	–	–	–	–	–	–
<i>Nonionella stella</i>	415	576	8.1	–	–	–	–	–	–	–	–	–
<i>Nonionella turgida</i>	593	823	11.6	–	–	–	–	–	–	8	11	0.8
<i>Rectuvigerina phlegeri</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Robertina translucens</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Saidovina karreriana</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Stainforthia complanata</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Stainforthia concava</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Stainforthia fusiformis</i>	1081	1502	21.1	20	28	3.3	–	–	–	–	–	–
<i>Valvulineria bradyana</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Virgulineria fragilis</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Virgulopsis sp.</i>	–	–	–	–	–	–	–	–	–	–	–	–

Table B1. Continued.

Station	Station A											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
Miliolids	-	-	-	-	-	-	-	-	-	-	-	-
Indet.												
<i>Adelosina longirostra</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cornuspira involvens</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Miliolinella subrotunda</i>	-	-	-	4	6	0.9	-	-	-	-	-	-
<i>Quinqueloculina lata</i>	-	-	-	24	33	3.8	-	-	-	-	-	-
<i>Quinqueloculina milletti</i>	-	-	-	28	39	4.3	-	-	-	-	-	-
<i>Quinqueloculina pygmaea</i>	44	62	0.9	-	-	-	-	-	-	-	-	-
<i>Quinqueloculina seminula</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Quinqueloculina stalkerii</i>	-	-	-	4	6	0.5	-	-	-	-	-	-
<i>Quinqueloculina tenuicollis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sigmoilopsis schlumbergeri</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Siphonaperta aspera</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Triloculina sp.</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Triloculina tricarinata</i>	-	-	-	-	-	-	-	-	-	-	-	-
Fossilising agglutinated												
<i>Textularia agglutinans</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Textularia porrecta</i>	128	178	3.5	4	6	0.5	-	-	-	-	-	-
Non fossilising agglutinated												
Indet.	-	-	-	8	11	1.4	-	-	-	40	56	4.0
<i>Agglutinate sp.</i>	333	-	-	-	-	-	-	-	-	-	-	-
<i>Adercotryma glomerata</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ammoscalaria foliacea</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Clavulina cylindrica</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cribrostomoides wiesneri</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Eggerella scabra</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Leptohalysis scottii</i>	971	1348	26.3	104	144	16.9	99	138	100	32	44	3.2
<i>Nouria polymorphinoides</i>	-	-	-	-	-	-	-	-	-	24	33	2.4
<i>Psammosphaera bowmani</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Psammosphaera fusca</i>	11	15	0.3	276	383	44.9	-	-	-	296	411	29.8
<i>Pseudobolivina fusiformis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Reophax fusiformis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Reophax nana</i>	21	30	0.6	24	33	3.4	-	-	-	-	-	-
<i>Trochammina globigeriniformis</i>	-	-	-	8	11	1.4	-	-	-	8	11	0.8
Organic foraminifera	-	-	-	16	22	2.1	-	-	-	-	-	-
Total No Perforates	2528	3511	68.5	120	167	20.0	-	-	-	592	822	59.7
Total No Miliolids	32	44	0.9	60	83	9.5	-	-	-	-	-	-
Tot. No Fossilising Agglutinates	128	178	3.5	4	6	0.5	-	-	-	-	-	-
Tot. No Non-fossilising Agglutinates	1003	1393	27.2	420	583	68.0	99	138	100	400	556	40.3
Total No Organic	-	-	-	16	22	2.1	-	-	-	-	-	-
Total No individuals	3691	5126	-	620	861	-	99	138	-	992	1378	-

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Table B1. Continued.

Station	Station N											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
Indet.	48	67	0.8	8	11	0.2	208	289	2.5	–	–	–
<i>Ammonia beccarii f. beccarii</i>	16	22	0.3	28	39	0.7	–	–	–	24	33	1.3
<i>Ammonia tepida</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Amphicoryna scalaris</i>	48	67	0.8	4	6	0.1	–	–	–	4	6	0.2
<i>Astacolus crepidulus</i>	32	44	0.6	4	6	0.1	16	22	0.2	–	–	–
<i>Bolivina dilatata</i>	1200	1667	21.1	556	772	13.4	880	1222	10.5	268	372	14.4
<i>Bolivina seminuda</i>	48	67	0.8	28	39	0.6	176	244	2.1	104	144	5.6
<i>Bolivina spathulata</i>	304	422	5.4	348	483	8.1	288	400	3.4	200	278	10.8
<i>Bolivina striatula</i>	272	378	4.8	84	117	2.0	80	111	1.0	76	106	4.1
<i>Bulimina aculeata</i>	–	–	–	20	28	0.5	–	–	–	–	–	–
<i>Bulimina elongata</i>	32	44	0.6	24	33	0.6	48	67	0.6	16	22	0.9
<i>Bulimina marginata</i>	64	89	1.1	8	11	0.2	80	111	1.0	8	11	0.4
<i>Buliminella elegantissima</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cancris oriculus</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Cassidulina carinata</i>	–	–	–	48	67	1.1	48	67	0.6	4	6	0.2
<i>Cassidulina crassa</i>	–	–	–	8	11	0.2	32	44	0.4	8	11	0.4
<i>Cassidulina minuta</i>	–	–	–	8	11	0.2	16	22	0.2	–	–	–
<i>Cassidulina oblonga</i>	16	22	0.3	–	–	–	16	22	0.2	–	–	–
<i>Elphidium poeyanum</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Epistominella vitrea</i>	208	289	3.7	172	239	4.1	240	333	2.9	60	83	3.2
<i>Fissurina sp.</i>	–	–	–	–	–	–	16	22	0.9	–	–	–
<i>Fursenkoina sp.</i>	–	–	–	4	6	0.1	–	–	–	16	22	0.9
<i>Gavelinopsis praegeri</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Gyroidina umbonata</i>	–	–	–	12	17	0.3	–	–	–	–	–	–
<i>Hanzawaia boueana</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Haynesina germanica</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Hopkinsina atlantica</i>	416	578	7.3	380	528	8.5	208	289	2.5	72	100	3.9
<i>Hyalinea balthica</i>	16	22	0.3	4	6	0.1	–	–	–	–	–	–
<i>Lenticulina atlantica</i>	48	67	0.8	12	17	0.3	32	44	0.4	28	39	1.5
<i>Nonion sp.1</i>	–	–	–	28	39	0.7	–	–	–	–	–	–
<i>Nonion fabum</i>	–	–	–	36	50	0.8	112	156	1.3	12	17	0.6
<i>Nonionella sp.1</i>	–	–	–	–	–	–	240	333	2.9	16	22	0.9
<i>Nonionella bradyi</i>	224	311	3.9	4	6	0.1	–	–	–	–	–	–
<i>Nonionella iridea</i>	80	111	1.4	–	–	–	944	1311	11.3	20	28	1.1
<i>Nonionella stella</i>	240	333	4.2	72	100	1.6	304	422	3.6	–	–	–
<i>Nonionella turgida</i>	432	600	7.6	272	378	6.4	1360	1889	16.2	28	39	1.5
<i>Rectuvigerina phlegeri</i>	256	356	4.5	344	478	7.8	64	89	0.8	88	122	4.7
<i>Robertina translucens</i>	–	–	–	16	22	0.4	–	–	–	–	–	–
<i>Saidovina karreriana</i>	–	–	–	48	67	1.1	–	–	–	8	11	0.4
<i>Stainforthia complanata</i>	80	111	1.4	8	11	0.2	96	133	1.1	–	–	–
<i>Stainforthia concava</i>	–	–	–	56	78	1.4	–	–	–	88	122	4.7
<i>Stainforthia fusiformis</i>	32	44	0.6	148	206	4.0	192	267	2.3	72	100	3.9
<i>Valvulineria bradyana</i>	80	111	1.4	96	133	1.9	16	22	0.2	16	22	0.9
<i>Virgulineria fragilis</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Virgulopsis sp.</i>	16	22	0.3	–	–	–	–	–	–	–	–	–
Miliolids												
Indet.	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Adelosina longirostra</i>	16	22	0.3	4	6	0.1	–	–	–	4	6	0.2
<i>Cornuspira involvens</i>	–	–	–	–	–	–	–	–	–	16	22	0.9
<i>Miliolinella subrotunda</i>	–	–	–	4	6	0.1	32	44	0.4	–	–	–

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Table B1. Continued.

Station	Station N											
	Apr. 07			Sept. 07			May. 08			Dec. 08		
Sampling period	r.d.	D	%	r.d.	D	%	r.d.	D	%	r.d.	D	%
Perforates												
<i>Quinqueloculina lata</i>	32	44	0.6	12	17	0.2	16	22	0.2	–	–	–
<i>Quinqueloculina milletti</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Quinqueloculina pygmaea</i>	32	44	0.6	–	–	–	–	–	–	8	11	0.4
<i>Quinqueloculina seminula</i>	–	–	–	8	11	0.2	–	–	–	4	6	0.2
<i>Quinqueloculina stalkerii</i>	48	67	0.8	40	56	1.1	112	156	1.3	4	6	0.2
<i>Quinqueloculina tenuicollis</i>	–	–	–	–	–	–	16	22	0.2	–	–	–
<i>Sigmoilopsis schlumbergeri</i>	–	–	–	8	11	0.2	–	–	–	–	–	–
<i>Siphonaperta aspera</i>	–	–	–	–	–	–	–	–	–	4	6	0.2
<i>Triloculina</i> sp.	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Triloculina tricarinata</i>	–	–	–	–	–	–	16	22	0.2	–	–	–
Fossilising agglutinated												
<i>Textularia agglutinans</i>	–	–	–	–	–	–	16	22	0.2	–	–	–
<i>Textularia porrecta</i>	304	422	5.4	80	111	2.1	608	844	7.3	228	317	12.3
Non fossilising agglutinated												
Indet.	48	67	0.8	–	–	–	–	–	–	–	–	–
<i>Agglutinate</i> sp.333	96	133	1.7	104	144	2.5	64	89	0.8	84	117	4.5
<i>Adercotryma glomerata</i>	32	44	0.6	8	11	0.2	48	67	0.6	4	6	0.2
<i>Ammoscalaria foliacea</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Clavulina cylindrica</i>	96	133	1.7	44	61	1.0	96	133	1.1	–	–	–
<i>Cribrostomoides wiesneri</i>	112	156	2.0	40	56	1.0	32	44	0.4	–	–	–
<i>Eggerella scabra</i>	304	422	5.4	552	767	13.3	528	733	6.3	128	178	6.9
<i>Leptohalysis scottii</i>	176	244	3.1	144	200	3.6	1008	1400	12.0	52	72	2.8
<i>Nouria polymorphinoides</i>	–	–	–	32	44	0.7	–	–	–	8	11	0.4
<i>Psammosphaera bowmani</i>	64	89	1.1	96	133	2.1	16	22	0.2	4	6	0.2
<i>Psammosphaera fusca</i>	–	–	–	–	–	–	–	–	–	–	–	–
<i>Pseudobolivina fusiformis</i>	32	44	0.6	4	6	0.1	32	44	0.4	16	22	0.9
<i>Reophax fusiformis</i>	–	–	–	4	6	0.1	–	–	–	–	–	–
<i>Reophax nana</i>	48	67	0.8	28	39	0.7	48	67	0.6	8	11	0.4
<i>Trochammina globigeriniformis</i>	32	44	0.6	104	144	2.2	–	–	–	36	50	1.9
Organic foraminifera												
Total No Perforates	4208	5844	74.1	2904	4033	67.9	5696	7911	67.9	1252	1739	67.3
Total No Miliolids	128	178	2.3	88	122	2.2	192	267	2.3	40	56	2.2
Tot. No Fossilising Agglutinates	304	422	5.4	80	111	2.1	624	867	7.4	228	317	12.3
Tot. No Non-fossilising Agglutinates	1040	1444	18.3	1164	1617	27.8	1872	2600	22.3	340	472	18.3
Total No Organic	–	–	–	–	–	–	–	–	–	–	–	–
Total No individuals	5680	7889	–	4236	5883	–	8384	11644	–	1860	2583	–

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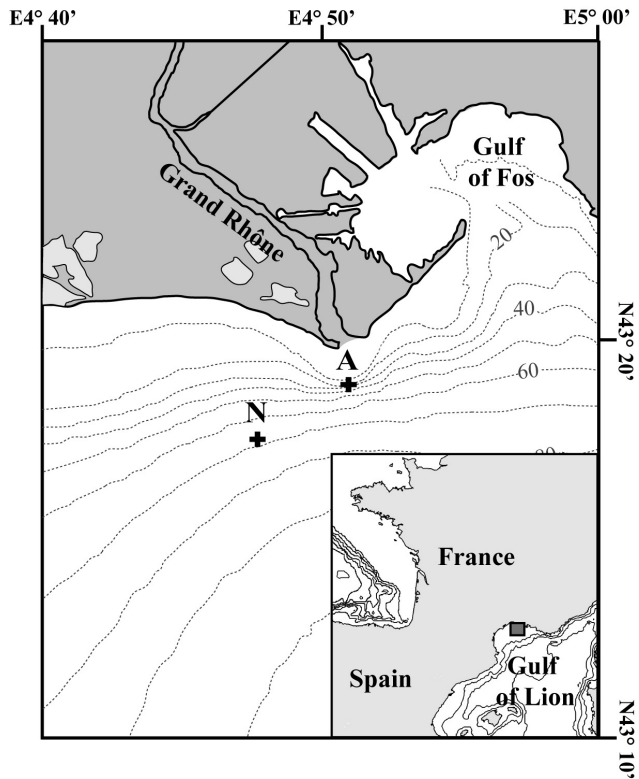


Fig. 1. Study area and location of both investigated Stations A and N.

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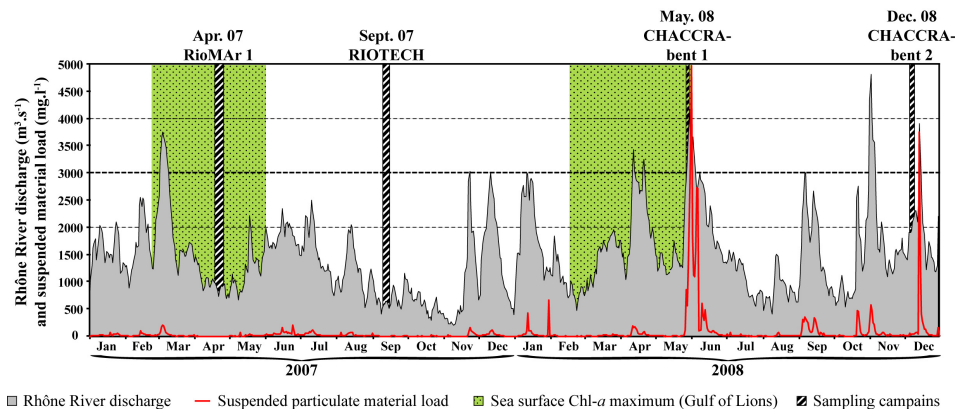


Fig. 2. Mean daily discharge (light-grey area) and suspended particulate material load (red curve) of the Rhône River recorded by the Compagnie Nationale du Rhône and the IRSN at SORA station (Arles), located 30 km upstream from the river mouth from January 2007 to December 2008. Different sampling campaigns are represented by black-dashed areas; green dotted areas represent spring blooms in the Gulf of Lions (SeaWiFS images).

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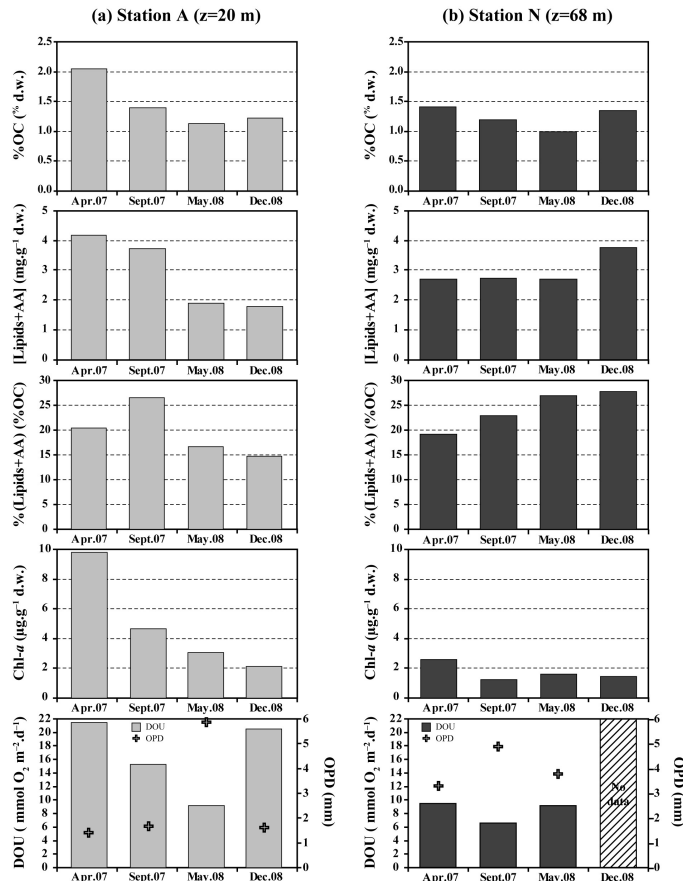


Fig. 3. Descriptors of the organic matter and oxygen parameters measured at both Stations A (a) and N (b).

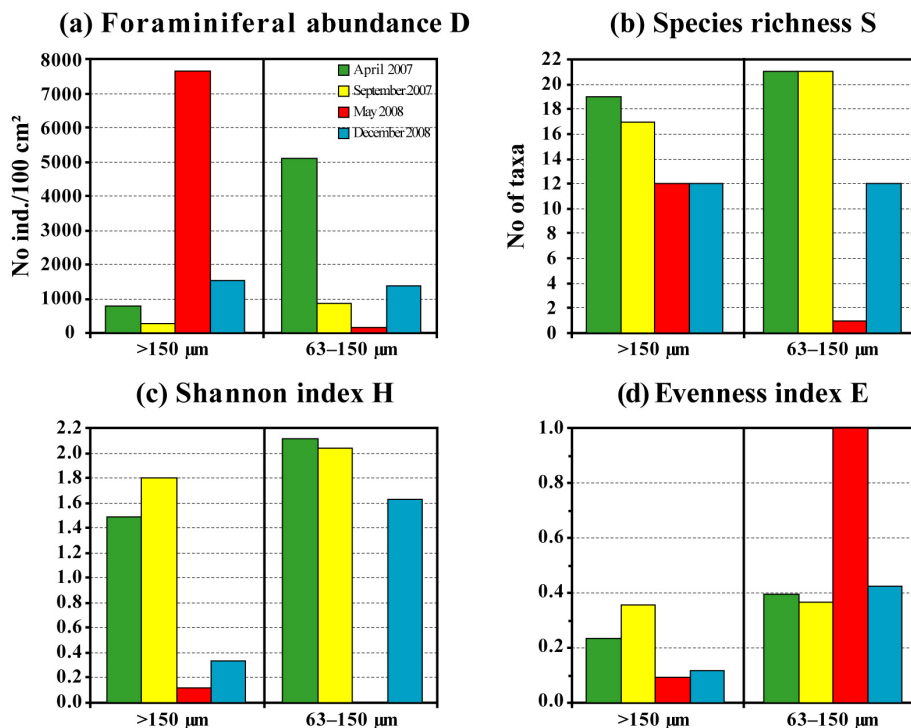
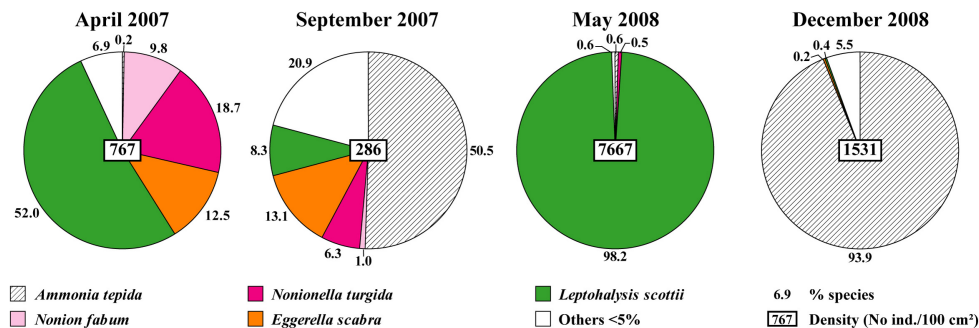


Fig. 4. Foraminiferal abundance D standardised for a surface area of 100 cm^{-2} (core surface: 72 cm^{-2} ; sediment depth: 0.5 cm for the $63\text{--}150\text{ }\mu\text{m}$ size fraction and 5 cm for the $>150\text{ }\mu\text{m}$ size fraction) **(a)**, species richness S **(b)**, Shannon index H **(c)** and Evenness index E **(d)** of the total living foraminiferal faunas in the $>150\text{ }\mu\text{m}$ and $63\text{--}150\text{ }\mu\text{m}$ size fractions at Station A for the four sampling periods.

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(a) >150 μm size fraction



(b) 63–150 μm size fraction

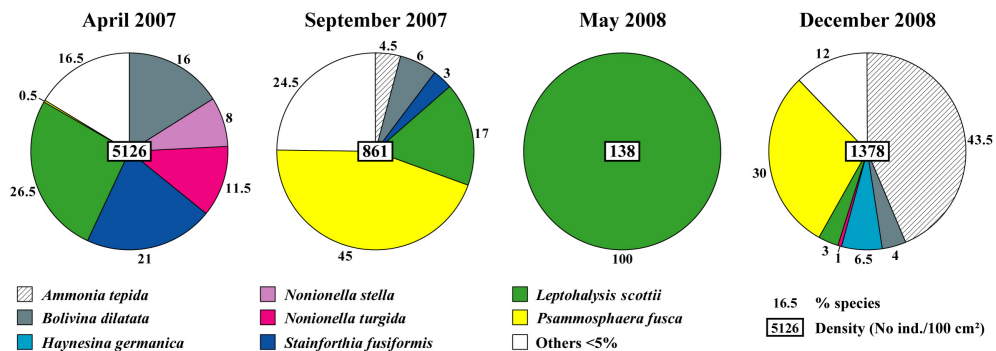


Fig. 5. Relative abundances of the major species in the >150 μm (a) and the 63–150 μm size fractions (b) at Station A for the four sampling periods.

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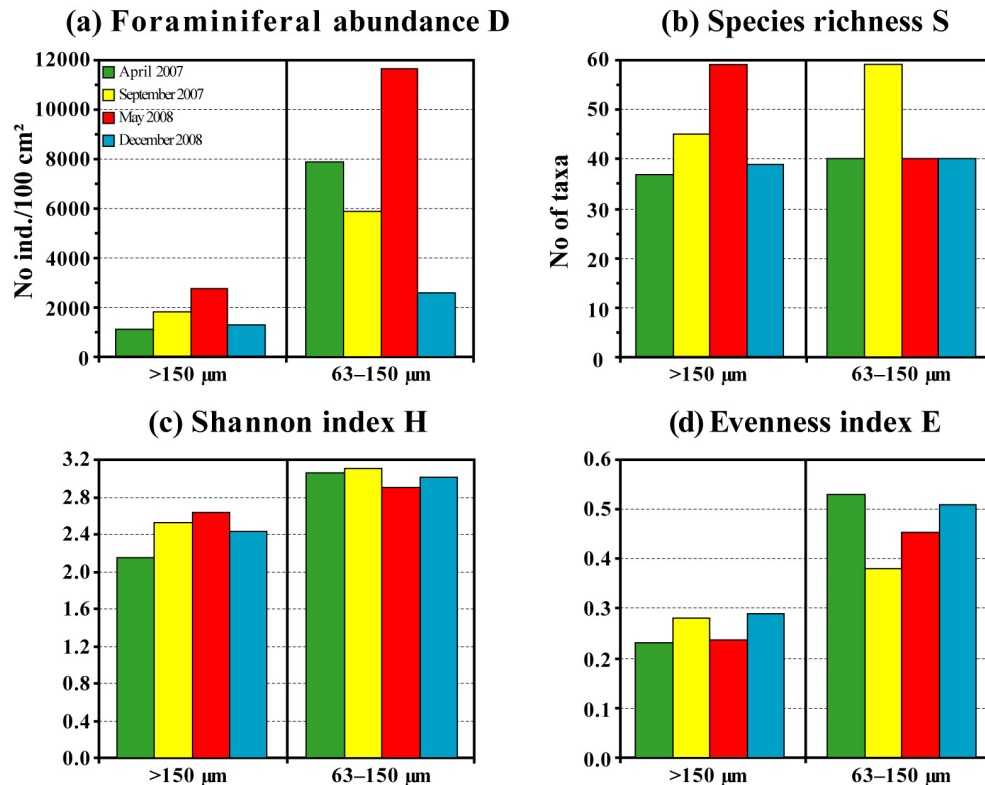


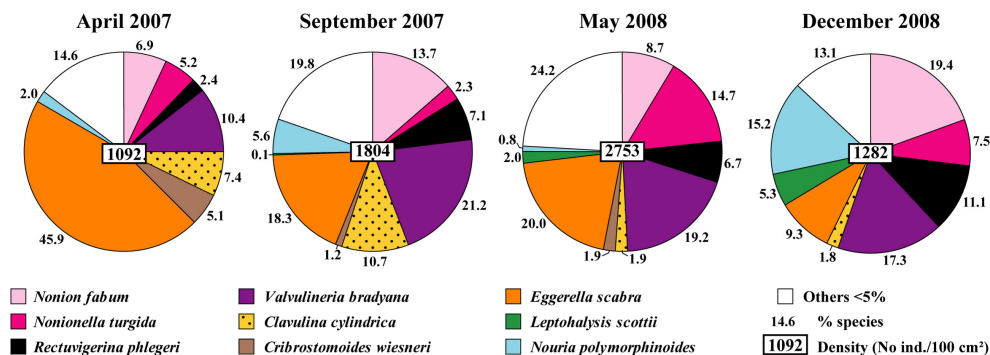
Fig. 6. Foraminiferal abundance D standardised for a surface area of 100 cm^{-2} (core surface: 72 cm^{-2} ; sediment depth: 0.5 cm for the 63–150 µm size fraction and 5 cm for the >150 µm size fraction) (a), species richness S (b), Shannon index H (c) and Evenness index E (d) of the total living foraminiferal faunas in the >150 µm and 63–150 µm size fractions at Station N for the four sampling periods.

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(a) >150 μm size fraction



(b) 63–150 μm size fraction

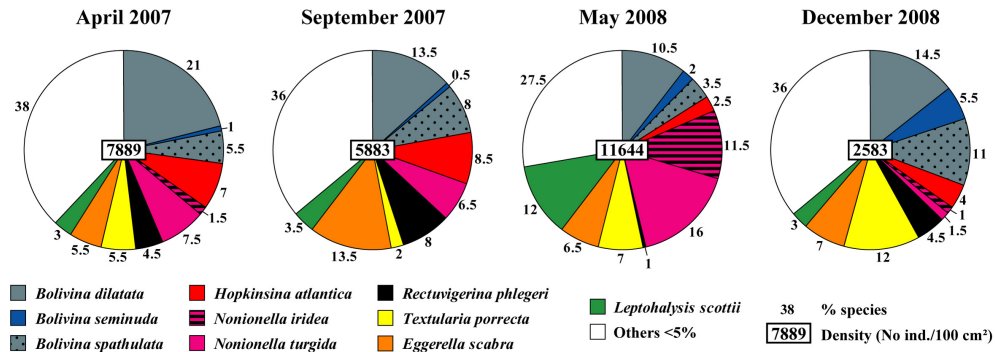


Fig. 7. Relative abundances of the major species in the >150 μm (a) and the 63–150 μm size fractions (b) at Station N for the four sampling periods.

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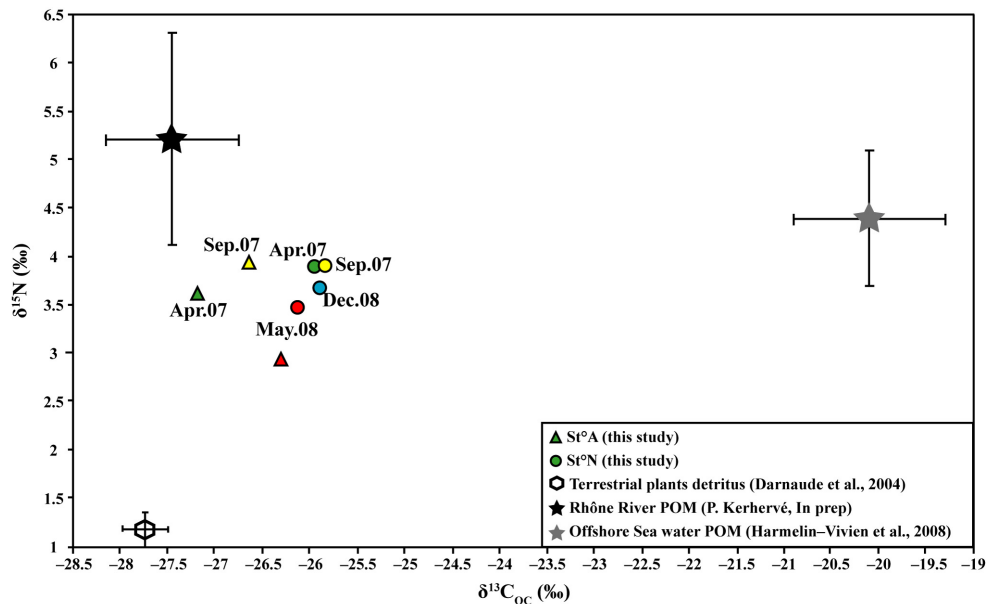


Fig. 8. Stable isotopic composition of the organic matter ($\delta^{13}C_{OC}$ vs. $\delta^{15}N$) from the first half-centimetre of sediment at both Stations A and N (except for December 2008 at Station A; no available $\delta^{15}N$ and offshore seawater POM) are also plotted to illustrate the relative influence of each source. The Rhône River POM is the mean signature of the river between 2006 and 2008 (monthly sampling; Kerhervé et al., 2011.).

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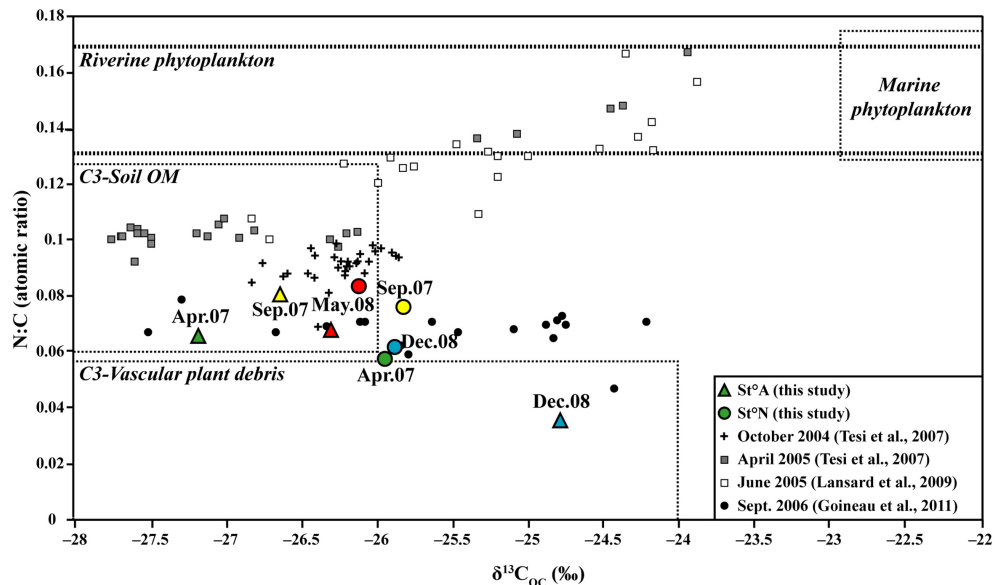


Fig. 9. Stable isotopic composition of the organic carbon ($\delta^{13}C_{OC}$) vs. N:C atomic ratio for the first half-centimetre of sediment measured at Stations A and N during the four sampling periods. The four other databases represented were collected in September 2006 (Goineau et al., 2011a), October 2004 and April 2005 (Tesi et al., 2007), and June 2005 (Lansard et al., 2009). The composition of four possible OC sources (C3-vascular plant detritus, C3-soil OM, marine and riverine phytoplankton detritus) is also plotted to illustrate the relative influence of each source. The N:C ratio was used rather than the classical C:N ratio because the former are more robust statistically and behave linearly in a mixing model (Gordon and Goñi, 2003).