

# Environmental biomonitoring using benthic foraminiferal faunas

C. Barras, E. Bicchi, C. Fontanier, E. Geslin, F. Jorissen, R. Schiebel, M.P. Nardelli, M. Denoyelle

*Traditionnellement, l'indice biotique privilégié pour les études de bio-monitoring dans les environnements de sédiment meuble est basé sur l'étude de la macrofaune. Cependant, cet outil présente plusieurs inconvénients (taxonomie difficile, densités relativement faibles en milieu profond, difficulté à définir des conditions de référence). Afin de pallier à ces problèmes, nous travaillons avec divers organismes (Agence de l'eau, Ifremer, Total...) pour développer un nouvel indice biotique basé sur les faunes de foraminifères. La conservation des tests de foraminifères morts dans le sédiment pourrait servir à établir les conditions de référence, permettant d'estimer l'ampleur de la perturbation du milieu étudié. Nous travaillons activement au sein d'un groupe de chercheurs internationaux spécialisés dans ce domaine (FOBIMO) afin de standardiser nos méthodes de travail. Nous étudions aussi de nouvelles approches biologiques (bio-essais, bio-marqueurs).*

## 1: The FOBIMO initiative

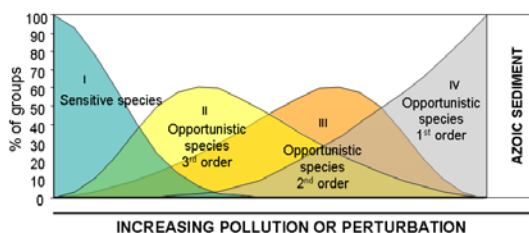
Foraminifera are now widely used for biomonitoring, but a wide range of very different methods is used for sample preparation, faunal inventory and data interpretation. This observation led to the birth of the FOBIMO (FOraminiferal BloMOnitoring) group, which combines the efforts of ~40 international scientists (Europe, USA and Japan) working on foraminifera as bio-indicators of environmental quality. Since 2011, 3 workshops were organized to standardize methods [6]. The newly defined sampling protocol will certainly be the standard for many decades.

## 2: Impact of discharge of industrial waste in marine environments

Since 2005, scientists of LPG-BIAF have been collaborating with TOTAL, in order to establish a bio-monitoring method based on foraminifera, capable to provide a quantitative description of the impact of offshore oil drilling activities on the benthic ecosystem.

Around oil platforms, strongly reduced faunas testify of severely impacted

conditions close to the disposal site. Then a typical benthic foraminiferal succession develops in response to the disposal of drill cuttings with adhering hydrocarbons (Fig. 1). The cumulative percentage of opportunistic taxa adequately describes the state of the benthic ecosystem.



**Fig. 1:** Typical succession of indicative foraminiferal species along a gradient of pollution regarding oil drilling activities.

This applied research has already led to four publications in international journals (e.g. [3]). Our expertise has also been requested to study the potential impact on deep-sea foraminiferal faunas of aluminium factory waste discharges (red muds) in Cassidaigne Canyon [4].

### 3: Development of a foraminiferal biotic index in the context of the Water Framework Directive

The Water Framework Directive aims to reach good ecological status of coastal water masses in 2015. Water Agencies are therefore looking for biotic indices to evaluate the water quality of transitional and coastal waters. Since 2009, our team is involved in the development of a new biotic index based of foraminiferal faunas in the coastal French Mediterranean Sea [1]. This index is based on the percentage of tolerant species standardized for the proportion of silt and clay in the sediment. A preliminary study was also conducted in the western Mont St Michel Bay in 2012. In both study areas, we investigate the potential use of dead fauna as reference conditions of pre-impacted conditions.

### 4: New biological approaches

A chronic bioassay was performed to evaluate the toxicity of cadmium, crude oil and drilling mud on benthic foraminifera [2]. Observations of growth and pseudopodal activities show that foraminifera have a strong physiological response to high concentrations of all tested pollutants (Fig. 2).

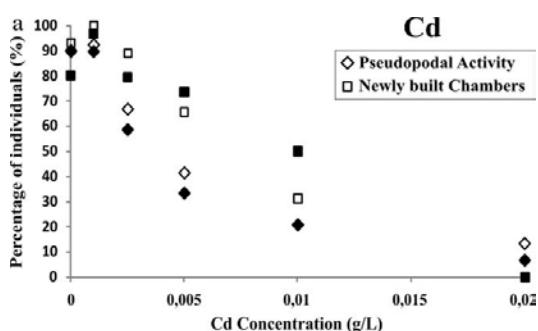


Fig. 2 : Effect of cadmium on growth and pseudopodal activities of foraminifera.

In addition, foraminifera are evaluated for their potential use as biomarkers. For the first time, the 70 kD stress protein (Hsp70) has been detected in foraminifera and revealed a temperature-dependent expression pattern [5].

### 5: Impact of microplastics

In collaboration with Ifremer, we study the colonization of floating plastic debris by benthic foraminifera. The main questions are 1) why only a few species are capable to colonize the plastics, 2) whether foraminifera contribute to the degradation of these plastics, and 3) whether the ubiquitous presence of floating plastics modifies the dispersal patterns of benthic foraminifera.

## Collaborations

J. Miné (TOTAL)  
P. Boissery (Agence de l'eau RMC)  
B. Andral, F. Galgani (Ifremer)  
Petra Heinz (Univ. Vienna, Austria)

## Associated publications

- [1] **Barras, C., Jorissen, F.J.**, Labrune, C., Andral, B., Boissery, P., 2014. Live benthic foraminiferal faunas from the French Mediterranean Coast: toward a new biotic index of environmental quality. *Ecological indicators*, 36, 719-743.
- [2] **Denoyelle M., Geslin E., Jorissen F.J.**, Cazes L., Galgani F., 2012. Innovative use of foraminifera in ecotoxicology: a marine chronic bioassay for testing potential toxicity of drilling muds. *Ecological indicators*, 12, 17-25.
- [3] **Denoyelle M., Jorissen F.J., et al.**, 2010. Comparison of benthic foraminifera and macrofaunal indicators of the impact of oil-based drill mud disposal. *Marine Pollution Bulletin*, 60, 11, 2007-2021.
- [4] **Fontanier, C. et al.**, 2012. Deep-sea foraminifera from the Cassidaigne Canyon (NW Mediterranean): Assessing the environmental impact of bauxite red mud disposal. *Marine Pollution Bulletin*, 64, 1895-1910.
- [5] Heinz, P., Marten, R., Linshy, VN., Haap, T., **Geslin, E.** and Kohler, HR., 2012, 70 kD stress protein (Hsp70) analysis in living shallow-water benthic Foraminifera. *Marine Biology Research*, 2012; 8: 677-681.
- [6] Schönfeld J., et al., incl., **Geslin E., Jorissen F.J., Barras C., Bicchi E.**, 2012. The FOBIMO (FORaminiferal Blo-MONitoring) initiative—Towards a standardised protocol for soft-bottom benthic foraminiferal monitoring studies. *Marine Micropaleontology*, 94-95, 1-13.