

# Benthic foraminifera as bio-indicators of drill cuttings disposal

Meryem Mojtahid, Erica Bicchi, Gérald Duchemin, Frans Jorissen, Josiane Durrieu, François Galgani, Roger Camps, Laurent Cazes

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# Comparison of benthic foraminiferal and macrofaunal indicators of oily drill mud disposal

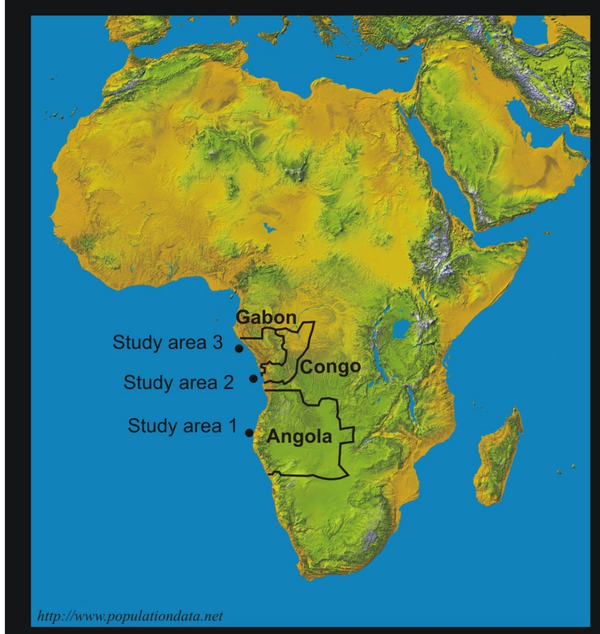

Mojtahid, M.[1], Denoyelle, M.[1], Bicchi, E.[1], Duchemin, G.[1], Durrieu, J.[2], Galgani, F.[3], Camps, R.[2], Cazes, L.[4], Jorissen, F.[1]

[1]Laboratoire des Bio-Indicateurs Actuels et Fossiles (BIAF), Université d'Angers, France

[2]TOTAL, Département Environnement Opérations, Pau, France

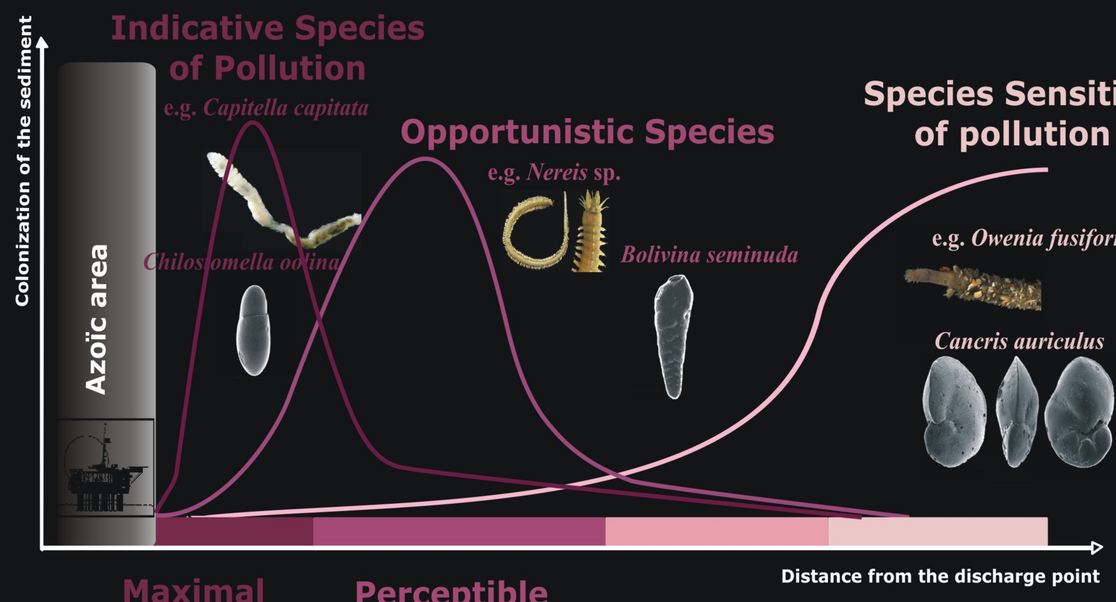
[3]IFREMER, La Seyne sur Mer, France

[4]AJILLON Engineering, Blagnac, France

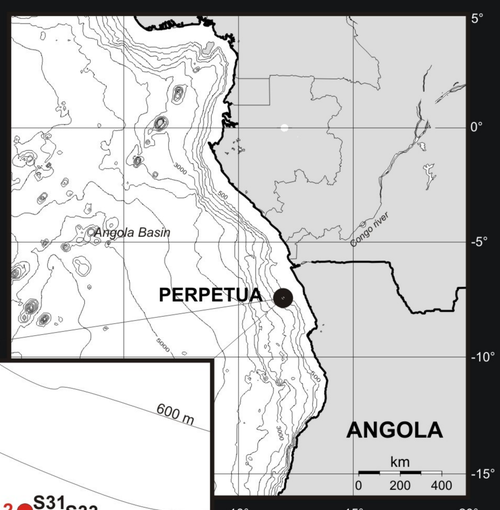

**Drill cutting components (Hydrocarbons, Heavy metals) may affect benthic faunal abundances and benthic biodiversity. Under stressed conditions, sensitive taxa will disappear whereas more tolerant or opportunistic taxa may appear. When the pollution is maximal, an azoic zone may appear.**

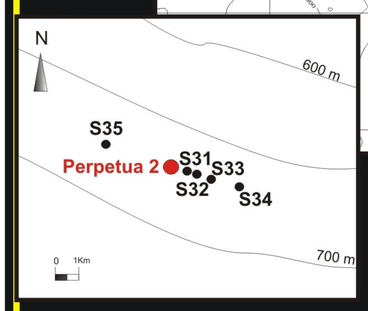
**We compare the response of living foraminifera and macrofauna to drill cutting disposals at the sea floor off Angola, Congo and Gabon.**

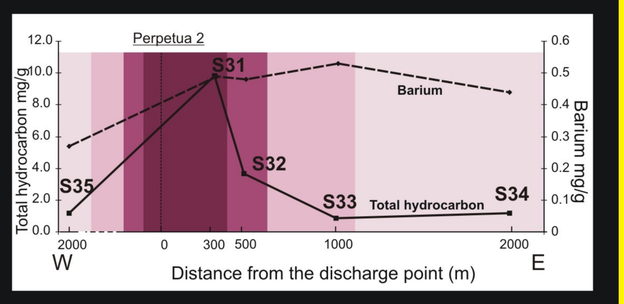


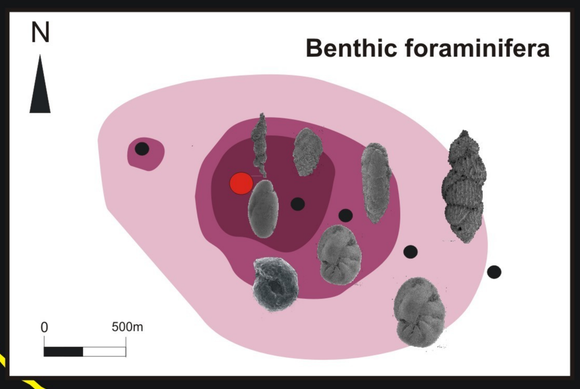

## Study area 1: Upper Slope (690 m depth) off Angola

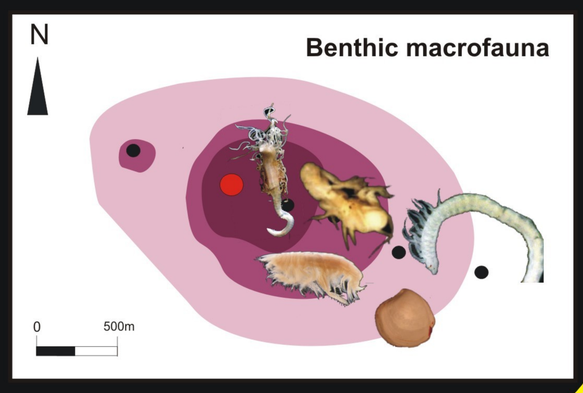
Discharge of cuttings ended in 2004. 5 stations (300 to 2000 m from discharge point) were sampled in 2006; 2 years after the end of disposal activities.



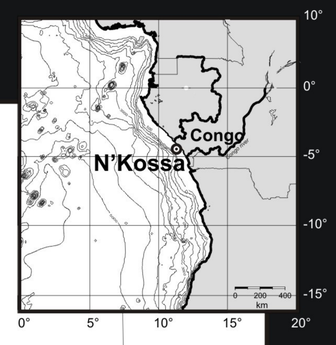



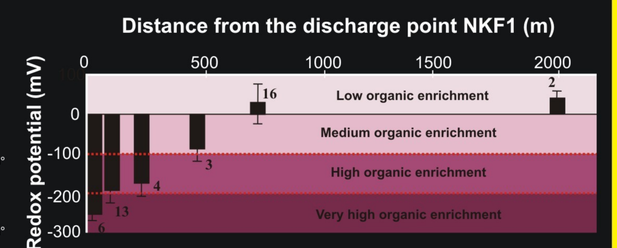




## Study area 2: Outer Shelf (180 m depth) off Congo

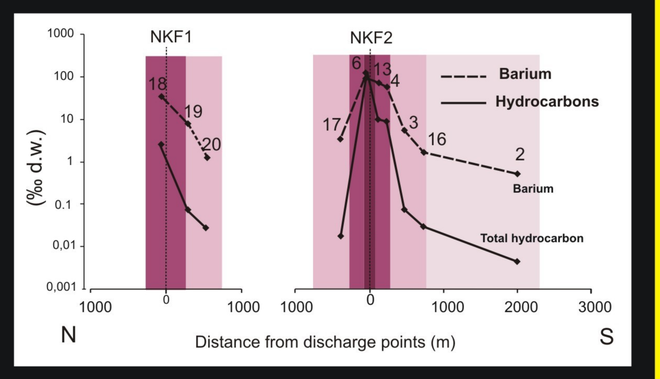
Two oil operating platforms, NKF1 and NKF2 (N'Kossa field) were active from 1993 to 1999. 10 stations (70 to 2000 m from the disposals) were sampled in 2004; 5 years after the end of disposal activities.

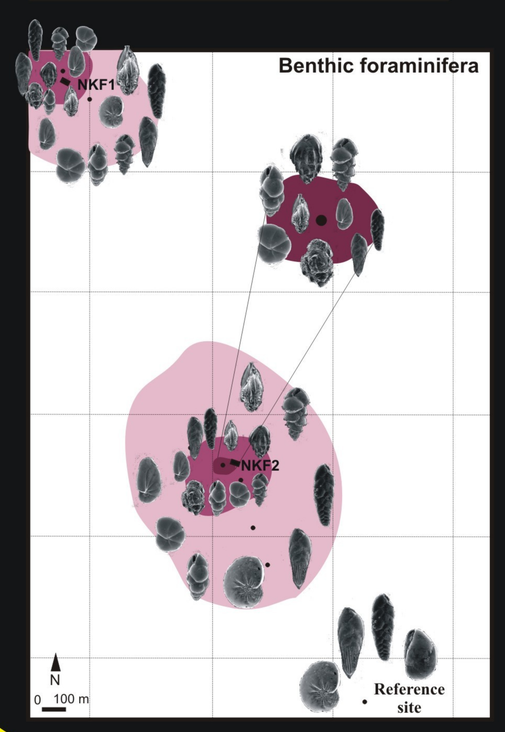


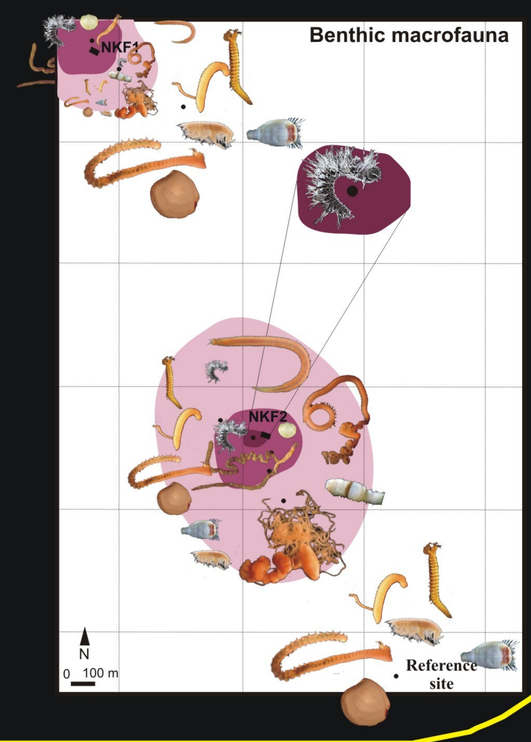







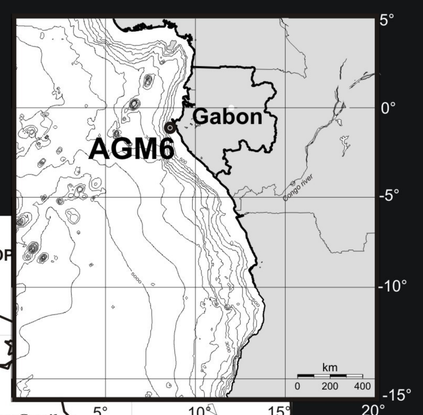


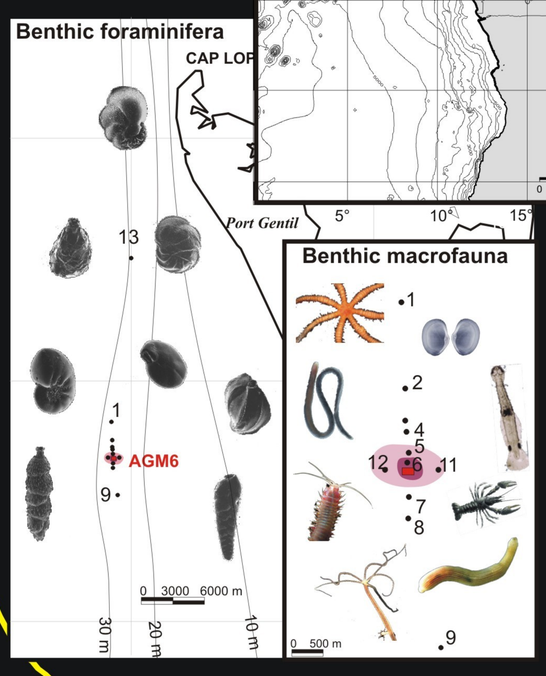




## Study area 3: Inner Shelf (30 m depth) off Gabon

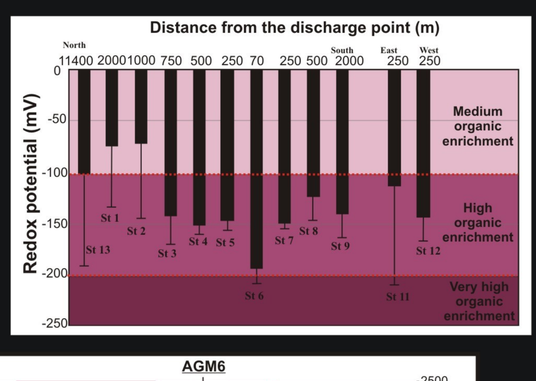
Old dumping area 50 km off Port Gentil. The main phase of drill cutting disposal ended in 1992. Additional well drilled in 2003. 12 stations (70 and 11400 m from the discharge point) were sampled in 2004; 12 years after the end of disposal activities.

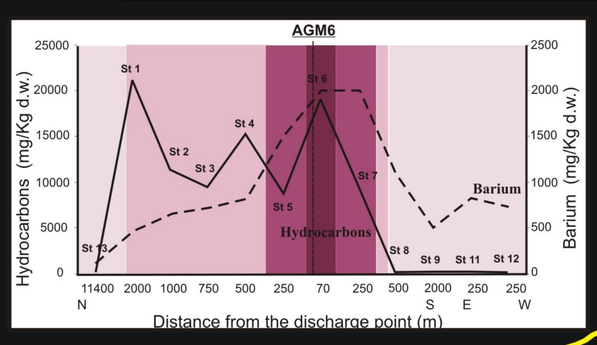









## CONCLUSIONS

1) **Monitoring with living benthic foraminifera is particularly attractive since their faunas contain a large numbers of individuals, which minimalizes the size of the sample needed for a reliable analysis.**

2) **Foraminiferal faunas and macrofauna both show a highly characteristic zonation in response to eutrophication due to disposal of oily drill mud.**

3) **Our bio-indicator method combining the use of foraminifera and macrofauna allows a reliable quantitative description of the impact of oil exploitation activities on marine benthic ecosystems.**

### Zone of high stress conditions
-Very high amounts of hydrocarbons

**Study area 1**
Rich benthic foraminiferal fauna and macrofauna:
* Foraminifera: the deep infaunal taxon *Chilostomella oolina* is dominant. Small-sized bolivinids and buliminids (ex. *Bulimina albatrossi*) are present.
* Macrofauna: dominance of the highly opportunistic polychaete: *Cirratulus* sp.

**Study area 2**
Poor benthic foraminiferal fauna and very rich benthic macrofauna:
* Foraminifera: opportunistic species resistant to oxygen depletion: *Bulimina* spp., *Bolivina* spp., *Gyroidina* sp. and *Trifarina pauperata* are present.
* Macrofauna: dominance of the highly opportunistic polychaete: *Sigambra* sp.

### Zone of slightly stress conditions
-Intermediate amounts of hydrocarbons

**Study area 1**
Rich benthic foraminiferal fauna and macrofauna
* Foraminifera: *Karreriella bradyi*, *Cribostomoides subglobosus* and *Cancris auriculus* are dominant.
* Macrofauna: *Harpinia* sp., *Agathotanais* sp., *Tachytrypane* sp., *Desmosomatidae* and *Eugerdellatinae* are dominant.

**Study area 2**
Very rich benthic foraminiferal fauna and macrofauna
Strong concentrations of opportunistic species:
* Foraminifera: *Bulimina* spp., *Bolivina* spp., *Gyroidina* sp. and *T. pauperata* are dominant.
* Macrofauna: the highly opportunistic polychaetes *Sigambra* sp., *Capitella capitata* and *Ampharetidae* sp. together with the bivalves *Anodontia edentula* and *Loripes* sp. are present.

**Study area 3**
Poor benthic foraminiferal fauna and rich macrofauna
* Foraminifera: *Cancris congolensis*, *Epistominella vitrea*, *Lagenammina* sp., *Bolivina seminuda* and *Rectuvigerina phlegeri* are dominant.

### Transition zone
- Species found in the zone of slightly stress conditions still present accompanied by species found at the reference

### Non-impacted area
- "Natural" fauna

**Study area 1**
* Foraminifera: *Uvigerina peregrina* and *Cancris auriculus* are dominant.
* Macrofauna: *Onchnesoma steenstrupi*, *Aricidea* sp., *Genaxinus eumyarius*, *Minuspio* sp., *Thyasira* spp. are present.

**Study area 2**
* Foraminifera: *Nonion scaphum, Bolivina striatula, Bolivina seminuda* and *Cassidulinoides bradyi* are present.
* Macrofauna: *Amphicteis gunneri*, *Anobothrus gracilis, Cossura* cf. *coasta*, *Prionospio ehlersi, Thyasira* sp., *Sternaspis scutata, Harpinia agna* are present.

**Study area 3**
* Foraminifera: the density increases.
* Macrofauna: suspension and deposit feeders are dominant.