# Can meiofauna be a good biological indicator of the impacts of eutrophication caused by green macroalgal blooms?

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**Abstract**

In Brittany, the eutrophication of coastal river waters leads to the development of harmful green macroalgal blooms that affect numerous sandy beaches. For the monitoring of coastal ecosystems the most widely used benthic ecological indicators are derived from macrofauna, seagrass populations parameters and epiphytes communities. Meiofauna has been a neglected component of the benthos mainly due to the small size of its component and the associated difficulty for species identification, so far. However this benthic compartment, and especially its dominant group, nematodes, has, in other circumstances shown many advantages as a biological indicator. In this study we investigate the impacts of green tides on meiofauna. Two beaches have been selected in the bay of Douarnenez (south of Finistère, France): the beach of Saint-Nic (impacted beach) and the cove of Dinan (un-impacted beach). We observed large differences in assemblage composition and diversity of meiofauna comparing the impacted and the un-impacted beaches. This study suggests that meiofauna could be a useful tool as biological indicator of the impacts of eutrophication caused by green macroalgae blooms.

**Keywords: meiofauna; nematodes; benthos; biological indicator; eutrophication; macroalgae blooms**

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## La méiofaune benthique, bon indicateur biologique des impacts de l'eutrophisation par les macroalgues vertes ?


### Résumé

En Bretagne, l'eutrophisation des cours d'eau côtiers induit la prolifération de macroalgues vertes dans de nombreuses baies sableuses. Les indicateurs écologiques benthiques les plus employés pour le suivi des écosystèmes côtiers sont dérivés des paramètres écologiques des communautés d'herbiers de phanérogames marines, de macrofaune et d'épiphytes. Du fait des difficultés d'identification taxinomique dues à la très petite taille des individus, la méiofaune est peu utilisée pour ces suivis. Pourtant, ce compartiment benthique, et notamment le groupe majoritaire des nématodes, possède de nombreux intérêts en tant qu'indicateur biologique. Dans notre étude, nous nous intéressons à l'impact des marées d'algues vertes sur la méiofaune des plages de sables fins. Deux sites ont été choisis en baie de Douarnenez (sud du Finistère, France) : la plage de Saint-Nic (site impacté) et l'anse de Dinan (site non impacté). De grandes différences de composition et de diversité de la méiofaune ont été observées entre le site impacté et le site non impacté. Cette étude suggère que la méiofaune pourrait être un bon indicateur pour les études d'impact de l'eutrophisation due aux blooms de macroalgues vertes.


**Mots-clés : méiofaune ; nématodes ; benthos ; indicateur biologique ; eutrophisation ; bloom de macroalgues**

Marine eutrophication of coastal waters is a direct consequence of increasing population densities along coastlines, and the use of fertilizers for agriculture. This higher nutrient loading leads to increasing primary production resulting in high organic matter inputs to the sediment, that is immediately available for the benthic organisms like bacteria, meio- and macrofauna grazers or detritus feeders (Grall & Chauvaud, 2002). In particular conditions (shallow areas, low water turnover) such eutrophication process may lead to the development of green macroalgae blooms, a phenomenon that has been affecting Brittany beaches for over 20 years. These green tides cause large inputs of organic matter to the bottom and are often associated with oxygen deficiency (Balsamo *et al.,* 2012). Such hypoxia may affect the benthic compartment and consequently the whole ecosystem. Indeed benthic communities are extremely sensitive to eutrophication and hypoxia, thus benthic species have been used in several studies as indicators of organic enrichment (Grall & Chauvaud, 2002). The majority of monitoring programs have been using as biological indicators data derived from seagrass beds, macrofauna as well as epiphyte communities (Kennedy & Jacoby, 1999). Nevertheless, meiofauna that had so far been a relatively neglected component of the ecosystem in such studies, has recently started to be used as a biological indicator for the assessment and monitoring of aquatic ecosystems.

Some of the arguments against the use of meiofauna are their small size which makes their sorting and identification difficult and time consuming, as well as their high level of spatial and temporal variability, but also the limited taxonomic literature accessible to non-specialist workers (Kennedy & Jacoby, 1999; Balsamo *et al.,* 2012). Nevertheless new technologies and tools, such as electronic identification keys, molecular approaches and the potential usefulness of newly created indices, presently allow and even promote the use of meiofauna in ecological studies (Balsamo *et al.,* 2012).

Meiofauna advantages to be a suitable tool as biological indicator for changes in coastal ecosystems are that: i) they can be sampled within a relatively small amount of sediment (especially free-living marine nematodes); ii) they are ubiquitously distributed and show high diversity in marine sediments; iii) they are an important component of marine benthic ecosystems because of their high abundance and fast turnover rates which makes they play an important role in marine benthic food chains, not only as consumers (they feed upon detritus, diatoms and algae, and prey other small metazoans) but also as producers (they are a food source for macrofauna and for commercially important fish) (Kennedy & Jacoby, 1999). The dominant meiofaunal group in terms of diversity and abundance is nematoda, in which most species have direct development phase, and a short life-cycle of one to three months. Therefore, changes in the community structure can be readily observed in short-term studies (Liu, 2009).

Several studies comparing meiofauna with the widely used biological indicator macrofauna have shown that on one hand macrofauna is more sensitive to disturbance than meiofauna, but that on the other hand meiofauna is much more responsive to the initial impacts of disturbance (Schratzberger *et al.,* 2000; Whomersley *et al.,* 2009). However, several studies regarding the effects of organic enrichment have found similar responses in both macro- and meiofauna (Coull & Chandler, 1992; Austen & Widdicombe, 2006). It appears that nematodes would be more sensitive to the effects of dredge disposal (Somerfield *et al.,* 1995) while macrofauna would be more sensitive to sewage pollution (Austen *et al.,* 1989) as well as burial (Bolam *et al.,* 2006). Indeed, shorter generation times and all year round reproduction displayed by nematodes may allow early indications of disturbance. Conversely, the longevity of some macrofaunal species may result in changes in community structure taking longer to materialize and occasional impacts being overlooked.

Studying the responses of shallow ecosystems to the eutrophication by the accumulation of green macroalgae is the main question asked through the MAVERIQ project (Impact de l'eutrophisation par les MAcroalgues VERtes sur les réseaux trophIQues et en particulier sur la fonction de nurserie des plages de sable fin en baie de Douarnenez). More particularly, this project aims at establishing the biogeochemical, ecological and functional characteristics of beaches affected by green tides, compared to environmentally comparable control beaches (i.e. without green tides). More specifically this study will try to assess the impacts of the accumulation of green macroalgae on specific diversity communities of one essential functional benthic entity: meiofauna. Sampling took place within two beaches from the bay of Douarnenez (south of Finistère, France): the beach of Saint-Nic (impacted one) and the cove of Dinan (un-impacted one) (figure 1). These two sites are fine sandy beaches (median particle-size ranging from 140 to 200 µm) with a very low silt content (0.2 %) and a fraction of dead shells ranging from 2 to 9 %. Sampling was conducted from May to October 2012 using a sediment corer (10 $cm^2$) in the intertidal zone. Each sample consisted of three separated replicates of 15 cm depth cores. Samples were frozen (−20°C) then sieved on a 40 µm mesh size and centrifuged with LUDOX HS40 in order to separate meiofauna from sediment. Supernatant containing animals was then sorted under a stereomicroscope (×60 magnitude) and organisms of the different taxa were identified to the lower possible taxonomic level and numbered.

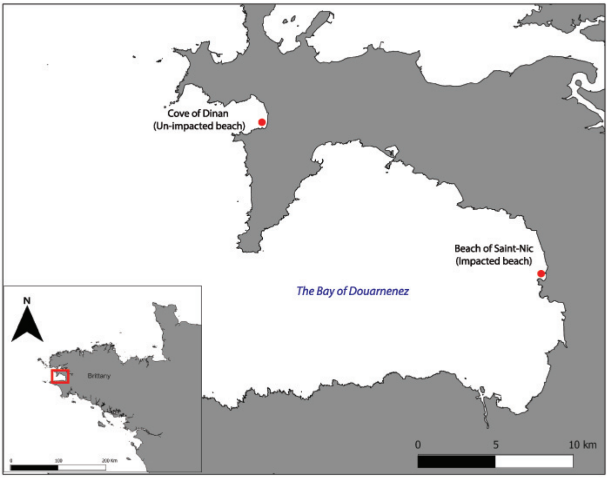


**Figure 1:** Location of the investigated sites.

Meiofauna taxa composition is reported in table 1. Nematoda and Copepoda were significantly present in both sites. Several taxa (Ostracoda, Turbellaria, Tardigrada, Gastrotricha, Cumacea and Isopoda) were only observed within the un-impacted site (Dinan) while Bivalvia were encountered only in the impacted site (Saint-Nic). The biodiversity (here expressed as richness of higher taxa) was thus highest at the un-impacted site (Dinan): 8 taxa have been determined there *versus* 3 in the impacted beach.

**Table 1:** Meiofaunal taxa composition (presence - absence) in the Dinan (un-impacted) and Saint-Nic (impacted) beaches.

| **Meiofaunal taxa** | **Dinan (un-impacted)** | **Saint-Nic (impacted)** |
|---|---|---|
| Turbellaria | 1 | 0 |
| Gastrotricha | 1 | 0 |
| Nematoda | 1 | 1 |
| Tardigrada | 1 | 0 |
| Ostracoda | 1 | 0 |
| Copepoda | 1 | 1 |
| Cumacea | 1 | 0 |
| Isopoda | 1 | 0 |
| Bivalvia | 0 | 1 |

Nematode genus composition is reported in table 2. The genus *Richtersia* (figure 2)

**Figure 2:** *Richtersia spp.*

dominates the meiofauna within the un-impacted beach (Dinan), representing 48 % of the nematode abundance. Within the impacted beach, *Trileptium* (figure 3) represent 18 % of the nematode community, followed by *Microlaimus* (15 %) and *Promonhystera* (10 %).

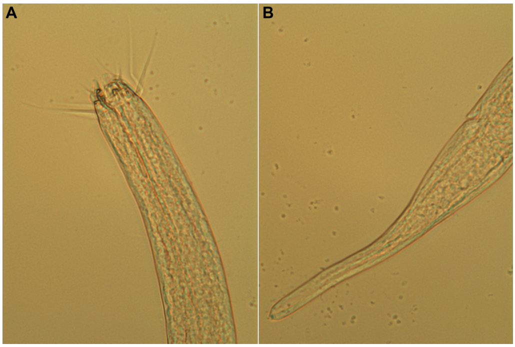


**Figure 3:** *Trileptium spp.* A. head and B. tail.

Several genus are reported as unique of either of the investigated sites. 13 genus are only present on the impacted beach and some of them are abundant in the community (*Microlaimus* and *Daptonema* that represent respectively 8 % and 4 % of the nematode abundance in Saint-Nic) and 9 genus have been reported in the un-impacted beach (*Syn-odontium* and the group composed of *Dasynemoides*, *Desmodora* and *Chaetonema* that represent respectively 4 % and 3 % of the abundance of nematode in the un-impacted site). As shown by figure 4 it is clear that both sites, although showing very close habitats and environmental conditions (at the exception of the presence of the green algae), harbor very different nematode communities. Indeed, the family of the Ceramonematidae dominates the nematode community in the un-impacted site whereas the Xyalidae is the nematoda family the most represented in the impacted site. These data suggest that under eutrophic conditions, a specific nematode community with the presence of some particular genus would be favored. This will have to be demonstrated through the seasonal survey that will be held within the MAVERIQ project.

**Table 2:** Nematode genus composition (ind.10 cm$^{-2}$) in the Dinan (un-impacted) and Saint-Nic (impacted) beaches.

| Order | Family | Genus | Dinan (un-impacted) | Saint-Nic (impacted) |
|---|---|---|---|---|
| Araeolaimida | Axonolaimidae | *Synodontium* | 7.84 | 0 |
| Araeolaimida | Comesomatidae | *Comesoma* | 0.98 | 1.96 |
| Araeolaimida | Comesomatidae | *Paracomesoma* | 0.98 | 3.92 |
| Chromadorida | Ceramonematidae | *Dasynemoides* | 1.96 | 0 |
| Chromadorida | Chromadoridae | *Neochromadora* | 7.84 | 2.94 |
| Chromadorida | Cyatholaimidae | *Marylynnia* | 0 | 15.68 |
| Chromadorida | Cyatholaimidae | *Nannolaimoides* | 0 | 0.98 |
| Chromadorida | Cyatholaimidae | *Paralongicyatholaimus* | 0 | 0.98 |
| Chromadorida | Selachinematidae | *Richtersia* | 91.14 | 2.94 |
| Desmodorida | Desmodoridae | *Desmodora* | 1.96 | 0 |
| Desmodorida | Desmodoridae | *Molgolaimus* | 0.98 | 0 |
| Desmodorida | Desmodoridae | *Psammonema* | 0.98 | 0 |
| Desmodorida | Desmodoridae | *Spirinia* | 0.98 | 0 |
| Desmodorida | Microlaimidae | *Microlaimus* | 9.80 | 29.40 |
| Monhysterida | Linhomoeidae | *Disconema* | 0 | 0.98 |
| Monhysterida | Linhomoeidae | *Linhomoeus* | 0 | 8.82 |
| Monhysterida | Monhysterida | *Halomonhystera* | 0 | 0.98 |
| Monhysterida | Siphonolaimidae | *Astomonema* | 0 | 1.96 |
| Monhysterida | Sphaerolaimidae | *Doliolaimus* | 0 | 0.98 |
| Monhysterida | Sphaerolaimidae | *Stylotheristus* | 0.98 | 0 |
| Monhysterida | Sphaerolaimidae | *Xyala* | 15.68 | 12.74 |
| Monhysterida | Xyalidae | *Daptonema* | 13.72 | 12.74 |
| Monhysterida | Xyalidae | *Gonionchus* | 0.98 | 0 |
| Monhysterida | Xyalidae | *Promonhystera* | 4.90 | 19.60 |
| Monhysterida | Xyalidae | *Scaptrella* | 0 | 4.90 |
| Monhysterida | Xyalidae | *Trichotheristus* | 0.98 | 2.94 |
| Enoplida | Oncholaimidae | *Adoncholaimus* | 0 | 1.96 |
| Enoplida | Anoplostomatidae | *Chaetonema* | 1.96 | 0 |
| Enoplida | Ironidae | *Dolicholaimus* | 0 | 1.96 |
| Enoplida | Oncholaimidae | *Oncholaimus* | 0 | 3.92 |
| Enoplida | Oxystominidae | *Oxystomina* | 0 | 0.98 |
| Enoplida | Ironidae | *Thalassironus* | 1.96 | 7.84 |
| Enoplida | Rhabdodemaniidae | *Trileptium* | 15.68 | 36.26 |
| Enoplida | Oncholaimidae | *Viscosia* | 6.86 | 15.68 |

Diversity and richness of taxa are generally lower in polluted and stressed environments, due to the disappearance of sensitive taxa (e.g. ostracods, gastrotriches, hydrozoans, tardigrades, etc…) and the overwhelming abundance of tolerant taxa (e.g. nematodes) (Pusceddu *et al.,* 2007). The study of the meiofauna living in the beaches of Saint-Nic and Dinan brought to light sharp differences within the taxa diversity between the impacted site and the control environment. Thus, 8 taxa have been counted in the un-impacted beach against 3 in the beach affected by green algae accumulations.

Regarding nematode assemblages, several studies have reported changes in nematode

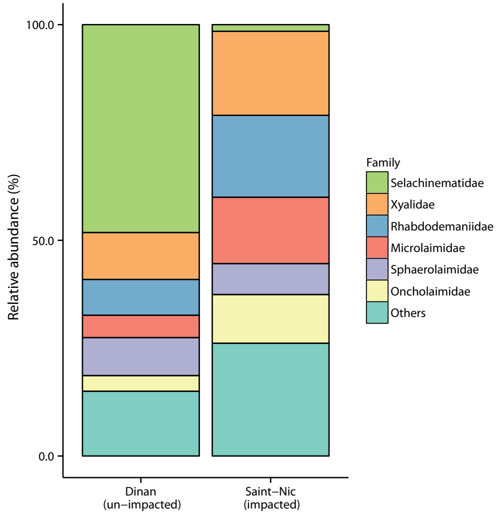


**Figure 4:** Relative abundance of nematode families in Dinan (un-impacted) and Saint-Nic (impacted) sites.

diversity under eutrophication stress (Balsamo *et al.,* 2012). Our results show large differences within the nematode genus identity and abundance between the two beaches, whereas the environmental conditions (except the presence of green tides) are the same within the two sites. It has to be underlined here that the impacted site does not seem to bear lower nematoda diversity when compared to the impacted site, at least at the genus level.

Consequently, we hypothesize that meiofauna could be a good biological indicator of the effects of eutrophication of coastal ecosystem and more specifically of *Ulva sp.* accumulations on sandy beaches. Further studies within the MAVERIQ project should help in the advance of this question. Moreover, next challenge will be to combine the study of the meio and the macrofauna, two benthic compartments of importance, in order to improve our comprehension of soft bottom systems and more precisely the evaluation of the ecological status of coastal zones.

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