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Effect of short-term hypoxia on marine nematode community structure and vertical distribution pattern in three different sediment types of the North Sea

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ABSTRACT

The responses of nematode communities to short-term hypoxia (1 and 7 days) were investigated in three North Sea stations with different sediment types (coarse silt, fine sand and medium sand). In the field, nematode density, diversity, vertical distribution and community structure differ among the stations. In the laboratory, oxic and hypoxic treatments were established for 1 and 7 days for all sediment types. Comparison between field control and oxic day 1 treatments showed that experimental sediment handling did not affect nematode characteristics. Our results revealed that short-term hypoxia did not affect total density, diversity, community composition, vertical density profiles (except in the fine sand) and densities of five dominant species in all sediment types.

1. Introduction

Coastal hypoxia (oxygen concentration <63 μmol l^{-1} or <2 mg l^{-1}) is increasing worldwide due to natural and anthropogenic impacts (Diaz and Rosenberg, 2008). The number of coastal areas where hypoxia has been reported increased exponentially with 5.5% $year^{-1}$ from 1916 till 2006 (Vaquer-Sunyer and Duarte, 2008).

While coastal hypoxia is an environmental phenomenon occurring mainly in the water column, low oxygen concentration in the bottom water affects the benthic ecosystem as well, as increasing organic matter accumulation rates, decreasing macrofaunal bioirrigation and bioturbation activities and changes in sediment biogeochemistry in hypoxic environments have been reported (Diaz and Rosenberg, 2008; Middelburg and Levin, 2009; Smith et al., 2000). While oxygen penetration depth in sediment is generally limited to the upper centimetres (Rasmussen and Jørgensen, 1992) or even millimetres (Wenzhöfer and Glud, 2002), marine hypoxia can affect the community structure and the vertical distribution of meiofauna (Gambi et al., 2009; Levin et al., 2009). The response of free-living marine nematodes to hypoxia is not uniform (Modig and Olafsson, 1998; Wetzel et al., 2001). Research on intertidal nematode communities showed that they prefer oxic conditions (Steyaert et al., 2005). The response of free-living marine nematodes to hypoxia is not uniform (Modig and Olafsson, 1998; Wetzel et al., 2001). Research on intertidal nematode communities showed that they prefer oxic conditions (Steyaert et al., 2005). Hypoxic condition resulted in mortality of about one third of the intertidal nematode communities and reduced the activity level (measured as feeding activity) of the surviving nematodes after 2 weeks (Steyaert et al., 2007). In the northern Baltic Sea, short-term (6 days) hypoxia caused a decline in nematode abundance coinciding with a change in community structure and functional diversity (Arroyo et al., 2012). Mortality of about 75% of the nematode community was observed within 9 days of laboratory-induced hypoxia as well (Wetzel et al., 2001). Furthermore, response of nematodes from different sediment depths to overlaying water oxygen stress is different. Within five days, 90% mortality was observed in non-thiobiotic nematodes which are living in top centimetres of sediment, while thiobiotic nematodes (i.e., *Sabatieria pulchra*) from deeper sediment layer survived up to seven weeks in an anoxic treatment (Jensen, 1984). In a tidal flat of the Westerschelde estuary (the Netherlands), long-term hypoxia (6 months) drastically changed nematode community structure and reduced diversity and abundance of some

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dominant species (Van Colen et al., 2009). In the Mediterranean Sea, nematodes species richness was not affected by long-term hypoxic-anoxic conditions (5 months), though species composition and trophic structure changed significantly (Gambi et al., 2009). Nematode survival against hypoxia was observed in the Black Sea (Muresan and Gomoiu, 2012) as well and both studies revealed that nematodes belonging to the genus *Sabatieria* were the most frequent and abundant group in hypoxic conditions. Moodley et al. (2000) showed that the vertical distribution of nematodes was primarily related to macrofaunal activity, rather than to sediment oxygen concentration. In the Gulf of Oman, nematode abundances were more affected by food quality than by sediment oxygen concentration too (Cook et al., 2000).

The contrasting results mentioned above might be caused by the lack of spatial resolution in most of the mentioned studies. Apart from oxygen concentration in the bottom water, nematode community structure is known to be affected by sediment conditions as well (Vanaverbeke et al., 2011). While most studies on the effect of hypoxia on nematodes did not take into account spatial variability, in present study we think that the effect of hypoxia depends on the characteristics of the ambient nematode community, which is in turn affected by sediment granulometry. Under low oxygen conditions, nematodes from coarser sediments, thriving in oxic conditions to relatively deep sediment layers (Vanaverbeke et al., 2004), may be stronger affected than species inhabiting in fine sediments. Therefore, we investigate the response of different nematode communities from different sediment types to the same level of hypoxia in the overlying water. We test the hypothesis that sediment composition and duration of hypoxia effect on the nematode community characteristics.

2. Materials and methods

2.1. Study area

Three types of sediment were studied from the Belgian Part of the North Sea (BPNS). The shallow BPNS (average depth about 20 m; maximum depth ≤40 m) is characterised by a highly variable and complex topography, i.e. presence of sandbanks, and by different sediment types (Verfaillie et al., 2006). Sampling was carried out in three different stations with different oxygen regimes. St. 700 (12 m water depth, 51°22′618″N, 3°13′148″E), characterized by muddy sediment with annual average oxygen penetration depth 3.7 mm, St. 330 (23 m water depth, 51°25′984″N, 2°48′502″E), typically medium grained sediment with maximum oxygen penetration depth 25 mm, and St. 115bis (25 m water depth, 51°09′151″N, 2°37′029″E), a station with fine sandy sediment and maximum oxygen penetration depth 4.9 mm (Fig. 1).

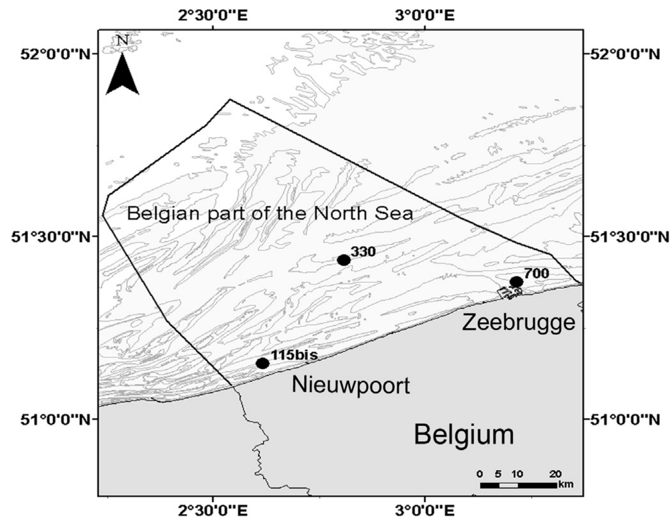

Fig. 1. Map indicating sampling stations in the Belgian part of the North Sea.

2.2. Sampling strategy

Sediment was collected with a Reineck boxcorer from the *RV* Zeeleeuw in June 2011. The boxcorer was deployed five times in

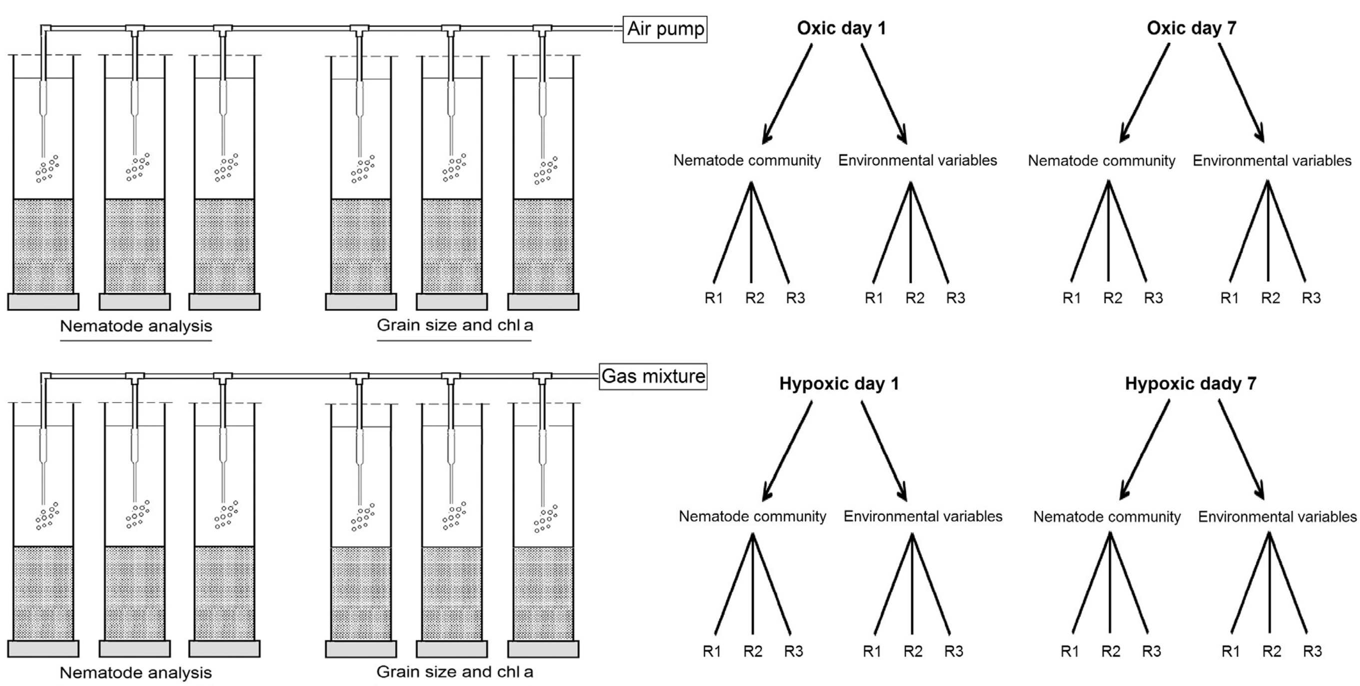

Fig. 2. Schematic drawing of the experimental set up in every sediment types (cores were randomly allocated) for 1 and 7 days. Overlying water was continuously bubbled with air (Oxic treatment) or a gas mixture (Hypoxic treatment).

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