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Does the *Phaeocystis* bloom affect the diel migration of the suprabenthos community?

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Abstract

The suprabenthos comprises all bottom-dependent animals, mainly crustaceans (including decapods and peracarids), which perform – with varying amplitude, intensity and regularity – seasonal or daily vertical migrations above the sea floor. The presence of organisms in the Benthic Boundary Layer is determined by two general factors: (1) organism behaviour, which depends on the light penetration in the water column and (2) boundary-layer hydrodynamics. In the coastal zone of the eastern English Channel, during the spring *Phaeocystis* bloom, the presence of gelatinous colonies modifies the penetration of light in the water column, which may seriously affect the abundance and/or the behaviour of the suprabenthos community. To clarify this point, 19 suprabenthic hauls were taken with a modified Macer-GIROQ sledge both during the day and during the night, from March to June 2002 (i.e., before, during and after the bloom). Two sites, located in the coastal and offshore areas of the *Ophelia* medium sand macrobenthic community were investigated. The bloom had no effect on species richness and abundance in either site. However, the diel migrations of some dominant species – such as the cumaceans *Pseudocuma longicornis* and *Pseudocuma similis*, the mysid *Gastrosaccus spinifer* and the amphipod *Stenothoe marina* – were modified. During the bloom, diurnal and nocturnal suprabenthic abundances were similar, and in the absence of bloom, species remained benthic during the day. The permanent presence of suprabenthic species in the Benthic Boundary Layer could have a consequence on their predation by fish (mainly juveniles which preferentially consume small crustaceans in their diet), unless fish behaviour and predation efficiency – especially for visual predators – are also disturbed by changes in light intensity.

Keywords: Suprabenthos; English Channel; *Phaeocystis* bloom; Diel migration

1. Introduction

As defined by Brunel et al. (1978), the suprabenthos comprises all bottom-dependent animals (mainly crustaceans, especially decapods and peracarids) that, with variable regularity, perform daily or seasonal vertical migrations. This biological compartment is particularly present in the Benthic Boundary Layer (BBL), which exhibits an accumulation and diversity of organisms swimming near the sea bottom in all marine environments (Mees and Jones, 1997). The presence of organisms in this layer is determined by two general factors: (1) organism behaviour, including swimming activities in response to changes in the light penetration in coastal area water columns, and (2) boundary-layer hydrodynamics (Mees and Jones, 1997; Dauvin and Vallet, 2006). The diel vertical migration is perhaps the most broadly distributed trait occurring in the diverse animal phyla living in aquatic environments. This phenomenon is sufficient in magnitude to affect whole populations and indeed whole ecosystems (Ohman et al., 1983; Ohman, 1990; Chekley et al., 1992; Hays, 2003).

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However, such migrations involve major selective advantages for the participants: (i) a capacity to avoid diurnal visual predators (Macquart-Moulin et al., 1987; Chekley et al., 1992), (ii) the ability to decrease metabolic consumption in deeper colder waters during the day (Longhurst, 1976), (iii) the use of other habitats during the pelagic phase, which may provide additional food resources (Fosså and Brattegard, 1990) and/or (iv) aids for species dispersal, increasing the possibility of meeting a sexual partner (Hesthagen, 1973). But the nature of such advantages is controversial, and part of the confusion stems from the variable characteristics of such behaviour (Ohman, 1990). The diel vertical migration may vary depending on the stage of development of a species; it may also vary in time or place within a single species and between coexisting species (Ohman, 1990; Dauvin and Zouhiri, 1996; Zouhiri et al., 1998). For example, Hesthagen (1973), Macquart-Moulin et al. (1987), and Zouhiri et al. (1998) all show different diel vertical migration patterns for BBL macrofauna. All of these studies clearly demonstrate that the selection pressure on this fauna varies in time and space, and among species. Though each species has its own behaviour, most suprabenthic species display a nocturnal emergency response to light extinction near the sea bottom (Ringelberg, 1995; Mees and Jones, 1997), which could be intrinsic to the species since diel migrations also occur at greater depths despite the lack of light changes throughout the day (Mees and Jones, 1997).

Along the French coast of the eastern English Channel, running from the Bay of Somme to the southern Bay of the North Sea, a *Phaeocystis* bloom of variable intensity has occurred in the spring every year for several decades (1980), beginning at the earliest in the end of February and at the latest in June (Gypens et al., 2007). The presence of these gelatinous colonies modifies the viscosity (Seuront et al., 2006) and the transparency of the seawater, affecting the entire water column due to the mixed tidal regime in the eastern part of the Channel (Lagadeuc et al, 1997). Given these facts, the question is whether or not the change in light penetration in the water column has an effect on the suprabenthic community in areas affected by the spring *Phaeocystis* bloom.

The present study of the suprabenthic compartment is part of a larger 5-year investigation (2001–2006) of the causes and consequences of the *Phaeocystis* bloom on the scale of the eastern English Channel. The results obtained for the suprabenthos during the 2002 campaigns (two stations, one coastal and one offshore), can be compared to a large data set from more than 500 suprabenthic hauls taken with a modified Macer-GIROQ sledge in the coastal zone of the English Channel (Vallet and Dauvin, 1998, 1999; Dauvin et al., 2000; Dauvin and Vallet, 2006), particularly two stations that were previously studied in May 1993 in the Dover strait (Fig. 1), respectively, station 5 on a pebble substrate (50°54.50′N–1°34.00′E) and station 6 on a medium sand substrate (50°48.00′N–1°19.50′E) (Vallet, 1997; Vallet and Dauvin, 1998).

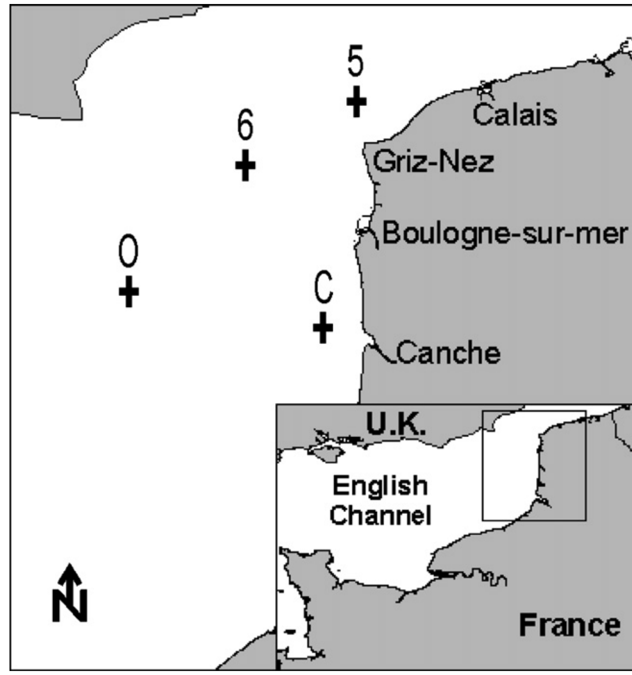

Fig. 1. Map of the studied area in the eastern part of the Channel.

2. Materials and methods

2.1. Main aspects of the Phaeocystis bloom

Phaeocystis is one of the most widespread marine haptophyte genus (Schoemann et al., 2005) and is exceptional not only for the very high carbon biomass values commonly attained by its monospecific blooms (up to 10 mg C l^{-1}), but also for its unique physiology, which has a serious impact on the structure and functioning of the pelagic and benthic food webs, as well as biogeochemical cycles (Lancelot and Rousseau, 1994; Janse et al., 1996; Hamm, 2000). The *Phaeocystis* genus has been studied extensively, and is characterized by a life cycle that alternates between free-living cells and gelatinous colonies. The latter produce large amounts of mucilaginous polysaccharides (Lancelot et al., 1994), which represent a large fraction of the overall colony biomass (Rousseau et al., 1990).

Due to the numerous and marked consequences on the coastal ecosystem, causes of variability in *Phaeocystis* blooms have been widely studied since several decades. Among them, nutrient enrichment and meteorological conditions have commonly been pointed out as key factors controlling the initiation and the intensity of *Phaeocystis* blooms. Even if the colony matrix might also give a competitive advantage to *Phaeocystis* when resources are scarce or highly fluctuating (Schoemann et al., 2001), the major contribution of anthropogenic eutrophication of coastal ecosystems to the bloom dynamics of this genus is well recognized (Lancelot et al., 1987). Based on a multi-box model, Gypens et al. (2007) have recently demonstrated the tight link between changing nutrient loads and *Phaeocystis* blooms