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Effects of oyster farming on macrofaunal assemblages associated with *Lanice conchilega* tubeworm populations: A trophic analysis using natural stable isotopes

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Abstract

The macrobenthic assemblages associated with aggregations of *Lanice conchilega* polychaetes under and near oyster culture tables were investigated with regard to the food web. Samples were collected from a reference site without oyster influence and from a site beneath oyster tables. While no changes in species diversity were observed, we showed a profound effect of shellfish structures both on the composition of macrobenthic assemblages, and on the trophic structure of the food web. Predators predominated in sediments beneath oyster tables, both in number of individuals and in biomass, and other suspension-feeders were excluded. Oysters are seen here as key species in exerting a top–down control on water quality and food resources. Stable isotopic analysis allowed calculation of trophic position for organisms and provided an in-depth understanding of interspecific relationships, especially among polychaetes. We showed two distinct trophic pathways, one dominated by *Nephtys hombergii* in reference sediments, and the other dominated by *Lumbrineris tetraura* beneath oyster tables. Microphytobenthos and detritus of macroalgae seemed to contribute most to the suspension-feeders' diets, but we observed high $\delta^{15}N$ values in surface and sub-surface deposit-feeders, which indicated they utilized sedimentary organic matter after bacterial processing and subsequent isotopic fractionation.

Keywords: Diversity; Trophic pathway; $\delta^{13}C$ and $\delta^{15}N$; Polychaetes; Feeding guilds; Shellfish farming; English Channel

1. Introduction

Aquaculture has been increasing exponentially in marine and estuarine waters, raising the question of its impact on benthic environments (Kaiser, 2000; Forrest and Creese, 2006 and references therein). While oyster and mussel cultures (e.g. mussel ropes, oysters beds) are generally recognized to have clear effects on sedimentary processes by lowering current flows and enhancing sediment and biological deposition (Grant et al., 1995; Hayakawa et al., 2001), the effects of shellfish farming on the benthic macrofaunal assemblages are strongly debated; effects on the diversity of soft-bottom assemblages are especially controversial, since both positive

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and negative influences have been claimed, as reviewed by Crawford et al. (2003). To date, most studies have indicated that the overall impacts of aquaculture on benthic communities are minor, but they generally tend to increase species diversity in cultivated mussel or oyster sites (Grant et al., 1995; Crawford et al., 2003). On the French coasts, oyster culture (Pacific oysters *Crassostrea gigas*) is extensive and gregarious benthic invertebrates often colonize culture areas. The sand mason, *Lanice conchilega*, is one of the most common tube-building polychaetes on European coasts (Holthe, 1978), it is widely distributed in the English Channel, where it can cover several hectares in both intertidal and subtidal soft sediments, in particular where oyster culture structures are located (Ropert and Dauvin, 2000). Accumulations of *L. conchilega* tubes can form massive sand banks.

Polychaete tubes are known to have near-bed hydrodynamic effects (Jumars and Nowell, 1984) that influence sediment stabilization (Bolam and Fernandes, 2002) or destabilization (Eckman et al., 1981), but which also increase surface heterogeneity and provide habitat and refuges for numerous species (Woodin, 1978; Dauer et al., 1982; Gallagher et al., 1983; Trueblood, 1991; Dubois et al., 2002). *L. conchilega* worms (adult length ca. 10 cm; Ropert and Goulletquer, 2000) build a characteristic tube (ca. 50 cm deep), consisting of cemented sand grains and small shell fragments, with a typical fringe at the upper end (Hayward and Ryland, 1995). These fringe-like extensions of the tube protrude several centimetres above the sediment (Fig. 1D), depending on the hydrodynamics conditions and sand resuspension processes. Previous studies on *L. conchilega* aggregations have shown clear differences in soft-sediment communities between tube aggregations and tube-free areas both in terms of diversity and composition of species assemblages (Zühlke et al., 1998; Zühlke, 2001). For example, it has been recently shown that even at a low density (single tubes or small groups of 2 to 5 tubes), this tube-dweller may significantly affect populations of associated macrofauna such as the amphipod *Urothoe poseidonis* or the polychaete *Eumida sanguinea*: the fringe filaments of the tube top or the tube itself create microhabitats that facilitate the development of these populations (Callaway, 2006).

Nevertheless, little attention has been paid to food webs and food resource partitioning among infauna associated with *L. conchilega* aggregations, even though

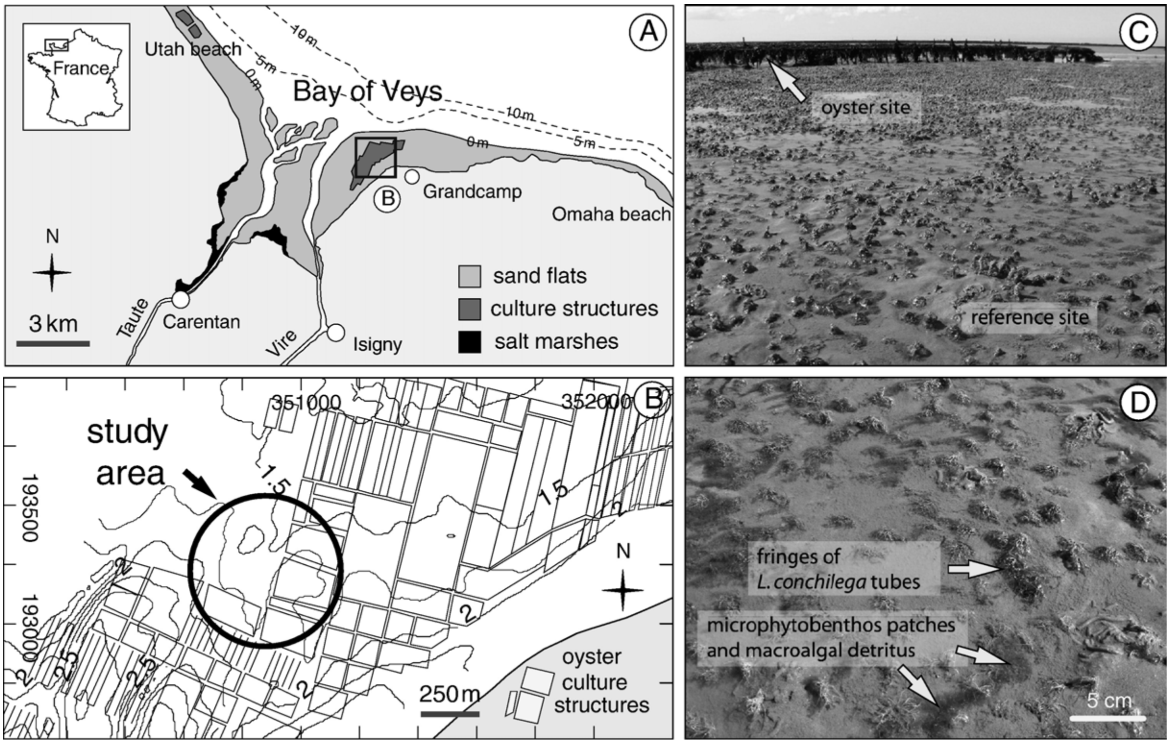

Fig. 1. (A) General localisation of the oyster farm within the Bay of Veys, northern French coast. (B) Detailed map showing location of the sampling site where oyster cultures structures have been superimposed with bathymetry levels. Geographical coordinates are given using WGS84 references and Lambert II system. (C) General view of reference and oyster site (oyster tables). (D) Close-up of *Lanice conchilega* tube fringes (protrude 3 or 4 cm above the sediment when immersed). Note the accumulation of benthic microalgae as well as macroalgae fragments within *L. conchilega* aggregations.