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Fish otolith assemblages from Recent NE Atlantic sea bottoms: A comparative study of palaeoecology

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ABSTRACT

Reconstruction of the paleoenvironment, using fish otolith assemblages and depending on the modern analogue to provide precise reference information, has been applied on many marine Cenozoic sediments, although the composition of such assemblages on Recent sea bottoms in various environmental settings is still poorly known. This study aims at better understanding the characteristics of otolith thanatocoenoses from Recent sea bottoms. Otolith assemblages taken by box corers or Van Veen grabs on Recent sea bottoms of the Northeastern Atlantic and the North Sea, at various depths and at various latitudes, were analysed. The results reveal that the pelagic and benthic–benthopelagic taxa in the sea bottoms differ markedly in quantity and diversity. The composition of an otolith assemblage differs from location to location, reflecting its biogeographic characteristic, which is mainly determined by pelagic taxa in the oceanic assemblages. The bathymetry, on the contrary, can be better explained from the benthic–benthopelagic taxa, especially in the shallow water assemblages. In addition, otolith size-related distribution along the isobaths is discovered in *Lampanyctus crocodilus*, in which the proportion of larger specimens in deeper waters increases markedly, confirming the observations of its population stratification in the actual assemblages. The biogeography and bathymetry obtained from the otolith assemblages could therefore, in some cases, be used as an indicator of the present ecology.

1. Introduction

The morphology of otoliths is very characteristic, which allows assignment of an otolith to a specific taxon in most cases with a relative degree of certainty. In paleontology, paleobathymetric interpretation using fossil otolith assemblages have been reported from many Cenozoic localities. Nolf and Brzobohaty (1992) proposed a method to determine the paleobathymetry based on the comparison of the identified taxa in a fossil assemblage with their Recent counterparts. In this analysis, the total number of potential presences of the taxa in each 100 m interval is counted and the interval with the highest total number determines the bathymetry (see 2.4 for detailed explanations of the method). Since then, this method has been applied in various studies estimating the paleobathymetry, e.g. from the Oligocene of northern Italy (Nolf, 1995) and Mississippi (USA) (Stringer and Miller, 2001), the Middle Miocene of the Central Paratethys (Brzobohaty, 1997, 2001), the Miocene to Pleistocene Caribbean coast (Aguilera and Rodrigues de Aguilera, 1999), the Plio-Pleistocene deposits from the western and eastern Mediterranean (Agiadi et al., 2010; Girone, 2000, 2003, 2005, 2007; Nolf et al. 1998). The paleobathymetric approach appears to be more applicable for the deep shelf and bathyal fossil otolith assemblages (Girone, 2005; Nolf and Brzobohaty, 1992). Girone (2003, 2005) proposed an integrated approach for Pleistocene associations, which contain a high percentage of extant species, in combination with a paleoecological analysis of the benthic–benthopelagic elements. This results in a more precise interpretation of the shallower environmental settings. In addition, several studies have focused on the paleobiogeographical and paleoclimatological significance of Cenozoic otolith assemblages: the Mediterranean area (e.g. Agiadi et al., 2011, 2013; Girone and Nolf, 2009; Girone et al., 2010; Hoedemakers and Batllori, 2005; Lin et al., 2015; Reichenbacher and Cappetta,1999), the Parathethys (e.g. Brzobohaty and Krhovsky, 1998; Nolf and Brzobohaty, 1994) the Aquitaine basin (e.g. Nolf and Brzobohaty, 2002; Nolf and Steurbaut, 2002) and the North Sea (e.g. Schwarzhans, 2010).

In spite of all the studies including a paleoecological and paleobiogeographical interpretation, it is, however, not certain whether fossil otolith assemblages directly reflect the ecology of a given time in the past. The mechanisms of otoliths entering the sediment and their transportation during taphonomic processes are not yet fully understood (Nolf, 1985, 1995). Otoliths discovered in Recent sea bottom sediments are derived from fishes, whose ecology is well-known. The study of such assemblages can provide elements for a better understanding of the paleoecology of fossil otolith assemblages, deposited in similar conditions. Wigley and Stinton (1973) reported on otoliths from the sea

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bottom sediments off Massachusetts, Martini (1974) from the top core sediments of two west Indian Ocean drilling sites, Gaemers (1978) described Recent otoliths from sea bottoms off Norway at depths varying from 77 to 407 m, Martini and Gaemers (1986) reported otoliths from southwest Pacific Quaternary sediments, and, more recently, Schwarzhans (2013) published a detailed case study on Recent sea bottom otoliths from the Gulf of Guinea and the Azores Islands, but these are about the only papers treating the subject.

In this study, we describe otolith assemblages from various depth ranges to understand better the characteristics of otolith thanatocoenoses from Recent sea bottoms. The analyses were performed in order to (i) identify the composition of otolith assemblages; (ii) determine how otolith assemblages can reflect both the depth and the biogeography; (iii) test the bathymetric method with known depth intervals to evaluate its precision.

2. Materials and methods

2.1. Sediment sampling and otolith preparation

The samples were collected and screenwashed through mesh sizes of 425 μm to 1 mm during the preparation, following the procedures of Prof. André Freiwald.

Sediments were collected from Recent North East Atlantic (NEA) sea bottoms. A locality map of the stations is shown in Fig. 1. Each station provided one single sample with otoliths. Several shallow water samples to the East of South Soester Island, off Norway, were collected during the ALKOR 232 (Alk232) cruise in 2003 (Pfannkuche et al., 2004b). Samples were collected from the Belgica Mound Area and the Kiel Mount of the high-latitude NEA during the METEOR Cruise M61/1 (Pfannkuche et al., 2004a) and the GeoB8045-1 cruises. The middle-latitude NEA samples include those from the Seine Seamount which were collected by the METEOR Cruise M60/1 (Christiansen, 2004), from the Ampère Seamount by the cruise R/V Victor Hensen VH-97, and from the Gulf of Cadiz (Cruise GeoB9002-1).

The Van Veen grab and box corer were employed during the sampling on board. Both devices were designed for sampling the uppermost bottom sediments, but it cannot be entirely excluded that some underlying sediments were grabbed in the process. There is, however, no positive evidence that this has occurred during the studied survey. The sediment samples with otoliths, ranging from depths of 64 to 1059 m, were used in the study. Table 1 gives a summary of the samples and the Appendix gives the coordinates and depth of each sample.

2.2. Quantitative analyses

Sampling procedures were not standardised, due to the use of different gears and to different cruise purposes. Therefore, the absolute otolith abundance (as in the Appendix) in a given quantity of sediment is not used, and the proportion of otoliths counted for a taxon in relation to others is presented to indicate abundance throughout the study, as in Schwarzhans (2013).

Otolith abundance of each taxon is expressed as a depth range to show any discussed taxon in relation to others in the sea bottom sediments. Samples from the high- and middle-latitude NEA were lumped together per 100 m interval, e.g. samples from depths of 130 m and 149 m were grouped together in the 100–200 m interval. Samples from the North Sea were lumped together per 25 m interval in order to enhance the analyses of the otolith assemblages. Additionally, taxa were divided into pelagic and benthic–benthopelagic groups, as

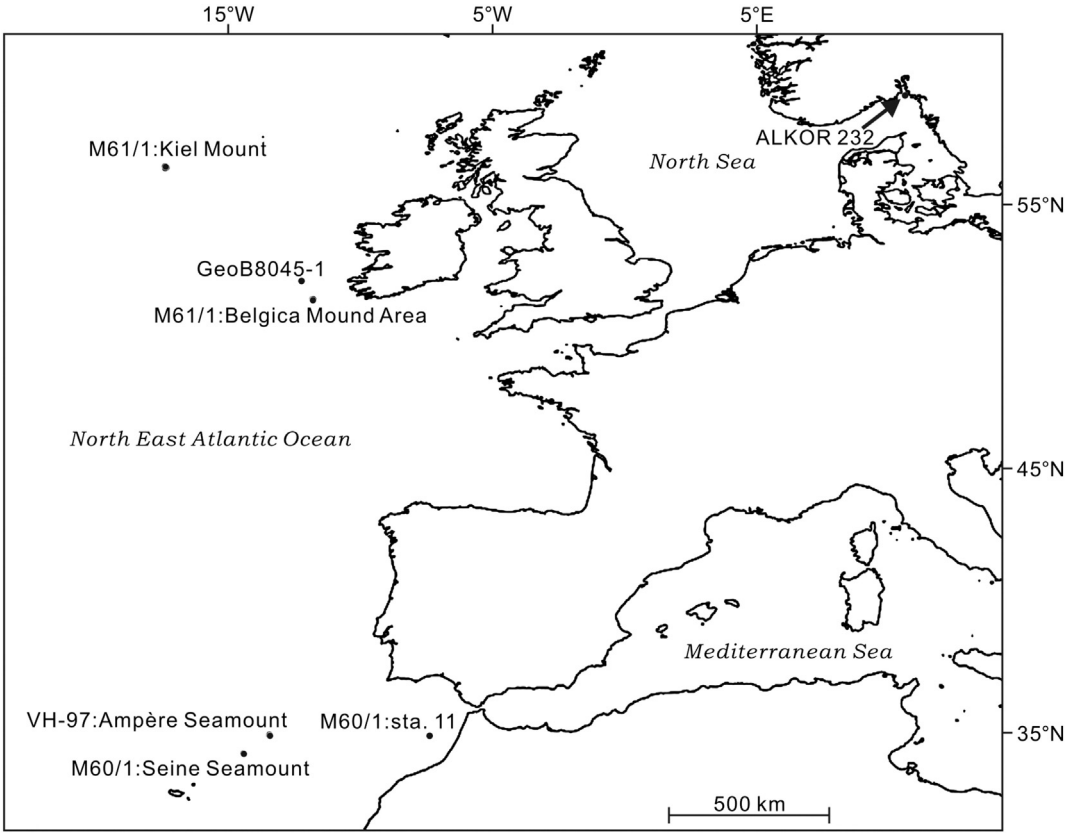

Fig. 1. Map showing the study areas: The North Sea, high (Belgica Mound Area, the Kiel Mount, and GeoB8045-1) and middle (Ampère Seamount, Seine Seamount, and Gulf of Cadiz) latitude North East Atlantic (NEA). See text for corresponding cruise names and Appendix for the coordinates and depth of each sample. Map derived from the EMODnet Bathymetry portal: http://www.emodnet-bathymetry.eu.