Deep-Sea Research I 57 (2010) 1561–1572

Contents lists available at ScienceDirect

Deep-Sea Research I

journal homepage: www.elsevier.com/locate/dsri

Environmental setting of deep-water oysters in the Bay of Biscay

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ARTICLE INFO

Article history:
Received 27 January 2010
Received in revised form
2 September 2010
Accepted 8 September 2010
Available online 16 September 2010

Keywords:
Bay of Biscay
Deep-water oysters
Canyons
Habitat
Resuspension
MOW
Neopycnodonte zibrowii

ABSTRACT

We report the northernmost and deepest known occurrence of deep-water pycnodontine oysters, based on two surveys along the French Atlantic continental margin to the La Chapelle continental slope (2006) and the Guilvinec Canyon (2008). The combined use of multibeam bathymetry, seismic profiling, CTD casts and a remotely operated vehicle (ROV) made it possible to describe the physical habitat and to assess the oceanographic control for the recently described species *Neopycnodonte zibrowii*. These oysters have been observed in vivo in depths from 540 to 846 m, colonizing overhanging banks or escarpments protruding from steep canyon flanks. Especially in the Bay of Biscay, such physical habitats may only be observed within canyons, where they are created by both long-term turbiditic and contouritic processes. Frequent observations of sand ripples on the seabed indicate the presence of a steady, but enhanced bottom current of about 40 cm/s. The occurrence of oysters also coincides with the interface between the Eastern North Atlantic Water and the Mediterranean Outflow Water. A combination of this water mass mixing, internal tide generation and a strong primary surface productivity may generate an enhanced nutrient flux, which is funnelled through the canyon. When the ideal environmental conditions are met, up to 100 individuals per m^2 may be observed. These deep-water oysters require a vertical habitat, which is often incompatible with the requirements of other sessile organisms, and are only sparsely distributed along the continental margins. The discovery of these giant oyster banks illustrates the rich biodiversity of deep-sea canyons and their underestimation as true ecosystem hotspots.

1. Introduction

Ocean margins are dynamic environments that host valuable deep-water benthic ecosystems. Along the Eastern Atlantic margin from Morocco to Norway, several 'deep-water ecosystem hotspots', associated with a complex interplay of oceanography, geology and seabed morphology, have been identified (Weaver and Gunn, 2009). One of these hotspots is represented by canyon ecosystems, which often feature cold-water coral reefs (Arzola et al., 2008; Canals et al., 2006; De Mol et al., in press; de Stigter et al., 2007; Dorschel et al., 2009; Palanques et al., 2009). The main ecosystem driver within canyons involves a careful balance of the hydrodynamic environment controlling sediment and nutrient supply (Dorschel et al., 2009; Mienis et al., 2007; Roberts et al., 2006). As such, canyons play a critical role since they are the most important mechanism of focussed nutrient input into the deep marine environment (Canals et al., 2006; de Stigter et al., 2007; Duineveld et al., 2001; Palanques et al., 2009). Moreover, due to frequent incisions during glacial sea-level lowstands (Bourillet et al., 2006; Toucanne et al., 2009; Zaragosi et al., 2000), the eroded canyon flanks may offer an environment that promotes the settling of sessile organisms, which profit from the enhanced nutrient flux. Already in the late 19th and the mid-20th century fisheries research had demonstrated the presence of cold-water corals and associated species in the vicinity of the canyons in the northern Bay of Biscay (Reveillaud et al., 2008). Sporadically, scientists and fishermen also reported dead or sub-fossil oyster specimens from this part of the margin (Le Danois, 1948; Reveillaud et al., 2008), which was not given the appropriate attention at that time.

Although oysters are commonly referred to as typical shallow-water and occasionally reef-forming molluscs, a number of samples have also been recovered from the deeper realm (Wisshak et al., 2009a). The deep-water oyster, *Neopycnodonte zibrowii* Gofas, Salas and Taviani 2009 was formally described only recently in Wisshak et al. (2009a) based on submersible observations and sampling of

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0967-0637/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.dsr.2010.09.002

live specimens in the Azores Archipelago between 2002 and 2007. Further isolated records of this species stem from steep open slopes such as the Gorringe Bank off Portugal (Auzende et al., 1984), south of Madeira (Hoernle et al., 2001) and in the Central Mediterranean Sea, where they occur as prominent (sub-) fossil oyster banks (Gofas et al., 2007). This 'living fossil' oyster is most unusual with respect to its habitat, size, geochemical signature and its particularly pronounced centennial longevity (Wisshak et al., 2009a, b). It stands in strong contrast to all other extant oyster species, such as *Neopycnodonte cochlear* (Poli, 1791), which are relatively short-lived. The smaller (4–5 cm) *N. cochlear* was reported by Le Danois (1948) on the upper slope of the Bay of Biscay (200–500 m). It is usually associated with hard substrates and in certain places colonizes *Dendrophyllia cornigera* (Lamarck, 1816) coral reefs (Le Danois, 1948). *N. cochlear* certainly has the largest distribution worldwide, both in ancient (Videt and Neraudeau, 2003) and modern environments (Harry, 1981). The recently described *N. zibrowii* can be regarded as a distinct deep-sea relative of *N. cochlear* with specific adaptations allowing it to thrive in upper bathyal depths. Most recently, Delongueville and Sciallet (2009), reinvestigated two unusually large specimens sampled alive from the Bay of Biscay margin and previously identified as *N. cochlear* (Delongueville and Sciallet, 1999). These can now be attributed to *N. zibrowii*.

In this paper, we describe the physical and oceanographic setting of the northernmost and deepest occurrence of *N. zibrowii* oysters within two canyons along the French Atlantic margin (Fig. 1). Seabed observations with the remotely operated vehicle (ROV) *Genesis* resulted in the discovery of giant deep-water oyster banks and cliffs at depths between 540 and 846 m (Table 1). These observations were performed with R/V *Belgica* during the HERMES Geo cruise in June 2006 (La Chapelle continental slope) and the BiSCOSYSTEMS cruise in June 2008 (Guilvinec Canyon). Although no samples could

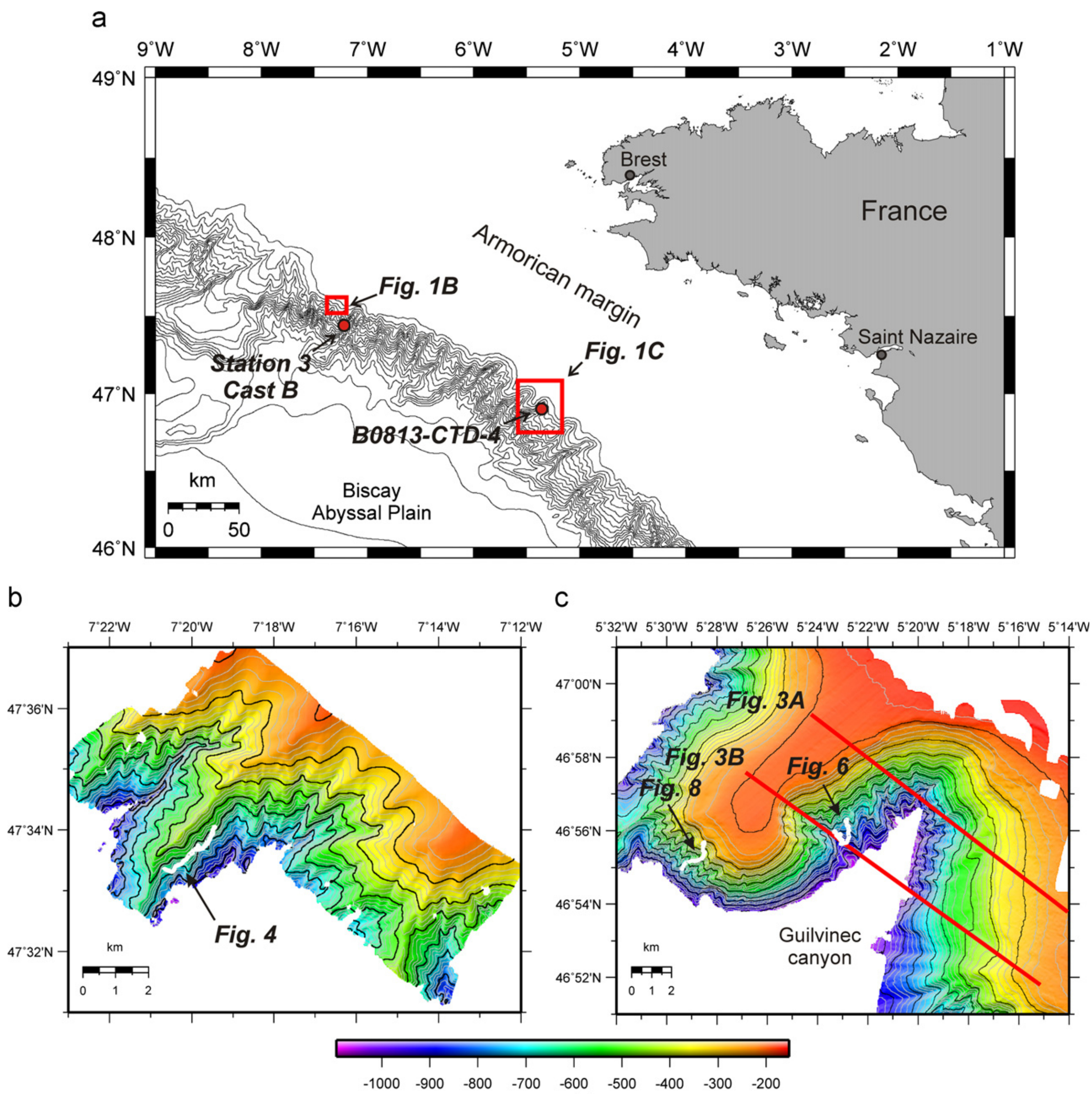

Fig. 1. (a). Location of the study areas along the French Atlantic continental margin (GEBCO bathymetry, contour lines every 250 m), with indication of the CTD locations (Table 2). (b). Detail of the La Chapelle slope area with EM1002 bathymetry (contour spacing 25 m) and the location of ROV dive B06-02 (white). (c). Detail of the Guilvinec Canyon area with EM1002 bathymetry (contour spacing 25 m), with the location of seismic profiles (red) and ROV dives B08-02 and B08-05 (white).