Deep-Sea Research II 137 (2017) 113–130

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Effects of latitudinal changes in the oxygen minimum zone of the northeast Pacific on the distribution of bathyal benthic decapod crustaceans

Vanesa Papiol [a,*], Michel E. Hendrickx [a], David Serrano [b]

[a] Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, P.O. Box 811, Mazatlán, Sinaloa 82000, Mexico

[b] Facultad de Ciencias del Mar, Universidad Autónoma de Sinaloa, 82000, México

ARTICLE INFO

Available online 13 May 2016

Keywords:
Oxygen minimum layer
North-eastern Pacific
Mexican Pacific
Decapod crustaceans
Water masses
Deep sea

ABSTRACT

The presence of an Oxygen Minimum Zone (OMZ) is one of the major characteristics of the eastern Pacific. The OMZ changes strongly adjacent to Mexico in its thickness and intensity. The ecological impacts of those changes were studied by examining the community structures of bathyal benthic and bentho-pelagic decapod crustaceans, and their oceanographic contexts, on the Mexican Pacific slope along a wide latitudinal range (16–32°N). Decapod crustaceans were collected with a benthic sledge from 48 stations between 865 and 2165 m in three main areas: offshore of northern Baja California (NBC), off southern Baja California (SBC) and in the southern Mexican Pacific (SMP). Physical–chemical parameters were measured in the water column, and sediment composition was analyzed for each station. The narrowing and weakening of the OMZ north of ca. 26°N was confirmed. Water with dissolved oxygen <0.5 ml l^{-1} occupied a stratum of 1231 m in the SMP vs. only 664 m off NBC. The strongest changes coincided with a region of surface, subsurface and intermediate water mass transitions, where less saline waters from the north extended to depths of ca. 1000 m. Sand proportions were higher in sediments to the south, whereas silt dominated offshore of NBC. A strong latitudinal shift in decapod community composition and bathymetric distribution occurred from off SBC to off NBC, coinciding with changes in oceanographic conditions. The dominant genera of decapod crustaceans at slope depths were cognate to those dominating slope areas in other tropical and subtropical regions of the world. In the SMP and off SBC, large aggregations of organisms were observed at 900–1300 m, with a sharp decrease in abundance at greater depth. Off NBC, the density of organisms was intermediate at all depths. The combined effects of dissolved oxygen concentration and characteristics of water masses affected the distribution of organisms. The faunal patterns were also related with sediment grain size.

1. Introduction

Oxygen minimum zones (OMZs) are typically characterized by dissolved oxygen concentration (DO) <0.5 ml l^{-1} (22 μmol l^{-1}) (Levin, 2003). The largest permanent OMZ on the planet (ca. 26 million km^2) occurs in the eastern Pacific (Helly and Levin, 2004; Paulmier and Ruiz-Pino, 2009). This OMZ is not homogenous, and its thickness, intensity, and vertical distribution vary with latitude (Helly and Levin, 2004). The most marked variations in these three parameters in the northeast Pacific take place around latitudes 24–26°N, off the Mexican Pacific coast. From the south to ca. 26°N the OMZ is vertically thickest and most intense, with DO <0.5 ml l^{-1} between depths of ca. 100 and 1000 m, and DO <0.2 ml l^{-1} between ca. 100 and 800 m. North of 26°N (to ca. 32°N) the OMZ is narrower and moderate; water with DO <0.5 ml l^{-1} only occupies a thin layer of 100 m at about 550–650 m, and values of DO <0.2 ml l^{-1} are not recorded (Helly and Levin, 2004).

OMZs are often associated with eastern boundary current systems, such as the California and Humboldt currents in the eastern Pacific (Gutknecht et al., 2013). The massive surface production of these regions translates to large fluxes of labile organic material through the water column (Gutknecht et al., 2013; Rouiller et al., 2014). In OMZ areas, the magnitude of these fluxes is sustained downward by the low remineralization rates due to the low oxygen availability (Rouiller et al., 2014). As a result, slope sediments beneath the core of the OMZ (DO <0.15 ml l^{-1} or 6.6 μM: Levin, 2003) are particularly rich in labile organic material (Cowie et al., 1999; Devol and Hartnett, 2001; Honjo et al., 2008). However,

* Corresponding author. Tel.: +52 55 21052175; fax: +52 669 9856133.
E-mail address: vpapioln@gmail.com (V. Papiol).

http://dx.doi.org/10.1016/j.dsr2.2016.04.023
0967-0645/

along the bottom below those strongest DO minima, a gradual increase in DO is accompanied by steep bathymetric gradients in organic-matter availability (Cowie, 2005). Although the little knowledge available of fauna distribution in areas under the influence of OMZs is mainly dedicated to meiofauna (Wishner et al., 1990, 1995; Saltzman and Wishner, 1997) and macrofauna (Levin et al., 2009, 2010; Hughes et al., 2009; Ingole et al., 2010), some studies on benthic megafauna have identified the linked patterns in DO and food quality as the main drivers of their patterns of distribution in highly productive, oxygen-depleted areas (Murty et al., 2009; Hunter et al., 2011; Papiol and Hendrickx, 2016). Low DO within the core of the OMZ prevents the survival of both macro- and megafaunal taxa, despite the large availability of food. Within the lower OMZ boundary (DO between 0.15 ml l^{-1} and 0.5 ml l^{-1}), the release in oxygen restriction and the large availability of labile organic material in the sediments favor large aggregations of macro- and megafaunal benthic and benthopelagic invertebrates (Diaz and Rosenberg, 1995; Levin, 2003; Murty et al., 2009; Hunter et al., 2011) and high levels of biological activity (Wishner et al., 1995). At greater depth, beneath the OMZ boundary (DO >0.5 ml l^{-1}), the decrease in the availability of labile food sources is likely responsible for decreasing megafaunal abundance, despite a continuous increase in DO with depth. These faunal responses to environmental characteristics of OMZs have usually been described from bathymetric transect studies in which stations at the same depth along different transects are located within a latitudinally narrow and stable OMZ area (i.e., homogenous width, intensity and vertical distribution). However, it is expected that regional-scale variations in OMZ characteristics will influence faunal patterns. Changes in the distribution of DO in the water column and in the transfer of organic material to bathyal depths would be key factors driving such patterns. To the authors' knowledge, this issue has only been addressed in one study performed by Witte (2000) in the Arabian Sea. She detected spatial variations in macrofaunal biomass associated with variations in food availability. To date, no similar information is available for megafaunal taxonomic groups.

The megafauna of lower OMZ boundaries is dominated by polychaetes, ophiuroids and decapod crustaceans (Wishner et al., 1990; Murty et al., 2009; Hunter et al., 2011). Those play important roles in structuring the marine benthos through physical disturbance of sediment (e.g., Hunter et al., 2011), predation upon meio- and macrofauna (Jeffreys et al., 2009a) and selective removal of both suspended and sedimented labile organic matter (Wishner et al., 1995; Smallwood et al., 1999; Jeffreys et al., 2009b). Among these bathyal taxa, decapod crustaceans are the most sensitive to oxygen depletion (Vaquer-Sunyer and Duarte, 2008) and, although they feed at multiple trophic levels (Jeffreys et al., 2009a), their dynamics depend directly or indirectly on surface production and particle flux to bathyal depths (e.g., Cartes et al., 2008; Fanelli et al., 2013). Thus, crustaceans are expected to be highly susceptible to regional changes in OMZ characteristics.

We have examined the regional distribution patterns of the OMZ and of megafaunal decapod crustaceans below the OMZ core along the Mexican slope in the northeastern Pacific. The OMZ there features important changes in its main attributes, allowing us to analyze the influence of those changes on the faunal patterns. Beside providing baseline knowledge of the structure and function of the megafaunal communities of the region, the results may provide insights about the potential consequences of impending oxygen minima expansions (Stramma et al., 2008; 2010) and of changes in marine production and vertical export (Bopp et al., 2001; Doney et al., 2012) possibly associated with climate change.

2. Materials and methods

2.1. Sampling locations

Within the TALUD project, three multidisciplinary research cruises were carried out over the Pacific slopes off western Mexico (northeast Pacific: Fig. 1). Samplings aboard the R/V "El Puma" of the Universidad Nacional Autónoma de México (UNAM) were performed off both the northern (NBC) (TALUD

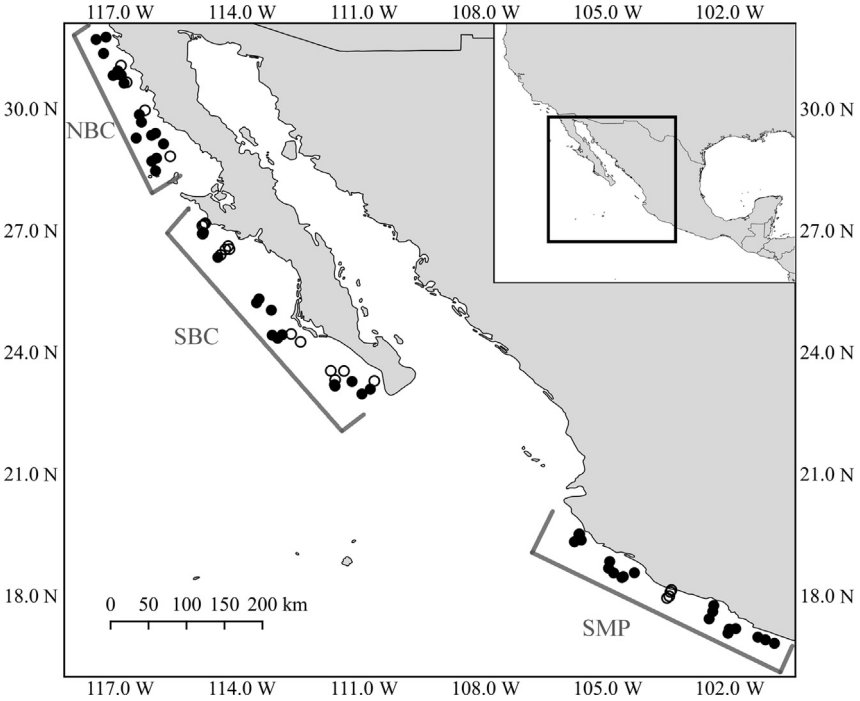

Fig. 1. Study area and sampling sites. Open symbols for stations with CTD casts only; solid symbols for stations with CTD casts and benthic sledge hauls.