



# Potential respiration estimated by electron transport system activity in deep-sea suprabenthic crustaceans off Balearic Islands (Western Mediterranean)



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## ABSTRACT

ETS is an acronym for the activity of the respiratory electron transport system; the ETS assay is a biochemical method for estimating the “potential” respiration ( $\Phi$ ). We apply this technique to suprabenthic species captured at three depths (250 m, 650 m and 850 m) in two different locations: Cabrera (Algerian subbasin) and Sóller (Balearic subbasin) during the IDEADOS survey during summer 2010. The aim of this study was to compare specific  $\Phi$  between areas and between three depths to identify differences in the suprabenthos physiological state related to nutritional conditions. Specific  $\Phi$ , expressed in unit of  $\mu\text{l O}_2 \text{ h}^{-1} \text{ mg prot}^{-1}$  was not significantly different between species. Mean values were for the decapods: *Plesionika heterocarpus*,  $8.4 \pm 7.9$ ; *Gennadas elegans*,  $8.3 \pm 2.9$ ; and *Sergestes arcticus*  $7.3 \pm 4.6$ . Within the euphausiids specific  $\Phi$  averaged  $6.5 \pm 4.2$  for *Thysanopoda aequalis* and  $9.8 \pm 5.1$  for *Meganycitiphanes norvegica*; while for the mysids it ranged from  $7.7 \pm 4.4$  for *Boreomysis arctica* and  $2.1 \pm 0.6$  for *Eucopeia unguiculata*. The comparison of specific potential respiration ( $\Phi$ ), with the pooling of the data of all the species, showed differences between the two locations, being higher in Cabrera. However, no significant differences between the different depths of each locality were found. The slope of the log  $\Phi$ -log biomass plot was  $0.93 \pm 0.09$  for Cabrera and  $0.64 \pm 0.11$  in Sóller. We interpret these differences as indicating that the suprabenthos in the Cabrera area, as compared to the Sóller area, has been well-nourished.

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## 1. Introduction

Respiration rates are fundamental measures of biological activity and especially of its energy production process. In metazoans these rates are limited by their mitochondria and the biochemical mechanisms that control them.

Historically, biomass has served as an easily measured proxy for respiration (Ikeda, 1970; Prosser and Brown, 1961) even though it was well known that the function of the biomass was to package the mitochondria (Fرتون and Simmonds, 1958; Nelson and Cox, 2005; Packard and Gómez, 2008). The role of temperature in modulating respiration has been recognized, at least since the time of Arrhenius (1915), but has its own history in oceanography (Ikeda, 1985; Packard et al., 1975; Seiwel, 1937). From these studies it was clear that respiration increased with the weight and size associated with biomass and with the warmth of a temperature increase. Respiratory rates are also

related to swimming activity, when zooplankton are slowly maintaining their position in the water column their respiration is low, when they swim rapidly to escape predators or capture prey their respiration speeds up. Cowles and Childress (1988) observed this respiratory shift in mysids. In addition, respiration is stimulated during feeding and mating (Bohrer and Lampert, 1988; Hernández-León and Gómez, 1996; Kiorboe et al., 1985; Lampert, 1986; Thor, 2003). All these factors modulate respiration and should be considered when using respiration to make ecological or oceanographic calculations.

The direct measurement of respiration rates in the oceanic environment is difficult because the rates are so low. Furthermore, they cannot be made by using incubations in the laboratory because the conditions cannot exactly reproduce the natural conditions. The ETS technique was developed by Packard (Packard, 1971; Packard et al., 1971, 1974) and then has been applied to estimate respiration in zooplankton (Bämsted, 1980; Hirsch et al., 2009; King and Packard, 1975; King et al., 1978; Minutoli and Guglielmo, 2009; Owens and King, 1975; Packard et al., 1974; Schalk, 1988), phytoplankton (Kenner and Ahmed, 1975; Packard, 1971) and bacteria (Aristegui and Montero, 1995; Packard et al., 1983; Packard et al., 1996). Since its inception the ETS method has been investigated and improved to provide increasingly reliable

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estimates of respiration (Gómez et al., 1996; Hernández-León and Gómez, 1996; Maldonado et al., 2012; Packard and Gómez, 2008). The basis of this technique is that the ETS is the biochemical origin of respiration and controls energy production via oxidative phosphorylation. This technique uses the reduction of an artificial electron acceptor, a tetrazolium-salt (INT), to stoichiometrically measure the capacity of the mitochondria to consume  $O_2$ . This can be done because the reduction of 2 mol of INT by the ETS is equivalent of the ETS-driven reduction of 2 atoms of oxygen (or 1 molecule of  $O_2$ ) (Packard, 1971). The respiratory enzymatic system is saturated with substrates (NADH, NADPH and succinate) to obtain the “potential” activity or maximum activity of the electron transport system ( $\Phi$ ), as demonstrated in a recent study by Maldonado et al. (2012). ETS, as an ecological measure of respiration, is as reliable as any other proxy or index used in aquatic ecology or ocean geochemistry (Del Giorgio and Williams, 2005).

Suprabenthos or hyperbenthos, characterized by their swimming capacity, occupy the 2 m nephloid layer immediately above the seabed (Mees and Jones, 1997). Permanent suprabenthos consist of peracaridan crustaceans such as amphipods, cumacean, isopods and mysids; and eucaridan crustaceans as euphausiids and decapods (Sainte-Marie and Brunel, 1985). Other groups, defined as not permanent and more likely to zooplankton community, are also abundant and frequent, as copepods, chaetognaths, fish larvae, etc. As free swimming metazoans, the suprabenthos are an important community in coastal ecosystems exploiting a diversity of food resources near the bottom. They consume organic particles, detritus, phytoplankton and zooplankton (Cartes et al., 2001; Cunha et al., 1999) and have great importance in the transfer of organic matter and energy due their particular population dynamics related to their swarming behavior, their high activity level, and their tendency to make vertical and horizontal migrations (Mees and Jones, 1997). Their presence supports many demersal fish and epibenthic

crustaceans, such as *Merluccius merluccius* (Bozzano et al., 1997; Cartes et al., 2004), and the red shrimp *Aristeus antennatus* (Cartes, 1994).

In the deep waters around the Balearic Islands, suprabenthic assemblages and some aspects of their trophic relationships have been described (Cartes et al., 2001; Cartes et al., 2008; Madurell et al., 2008; Maynou and Cartes, 2000; Polunin et al., 2001). These deep waters are located on the continental slopes of two subbasins in the western Mediterranean Sea off the NE Spanish coast (Fig. 1). The subbasins (Algerian and Balearic) have different geomorphological and oceanographic characteristics and their boundaries are influenced by both seasonal and mesoscale processes in the adjacent areas (López-Jurado et al., 2008; Pinot et al., 2002). The Balearic Islands are the natural boundary between two subbasins, the topographic conditions and channels between islands influence the regional circulation water (Lüdmann et al., 2012). The Algerian subbasin is characterized by a smooth slope, receives warmer and less saline water from the Atlantic Ocean and the circulation is mainly driven by density gradients. In the Balearic subbasin the abrupt slope is irregular, with numerous small canyons, more influenced by atmospheric forcing and Mediterranean waters, which are colder and more saline (Hopkins, 1978; López-Jurado et al., 2008; Pinot et al., 2002). The processes mentioned above mark the differences between the two locations, which are reflected in the water column structure. Both temperature and salinity show more variability in the north than in the south (López-Jurado et al., 2008). In addition, the northwest location is affected by colder and more productive waters of the Gulf of Lion (Monserat et al., 2008), that can act as an external fertilization mechanism that influences productivity (Fernández de Puelles et al., 2004).

Previous studies have demonstrated differences in trophic web structure between the subbasins (Cartes et al., 2001; Maynou and Cartes, 2000). Suprabenthos assemblages and abundance seem to be a

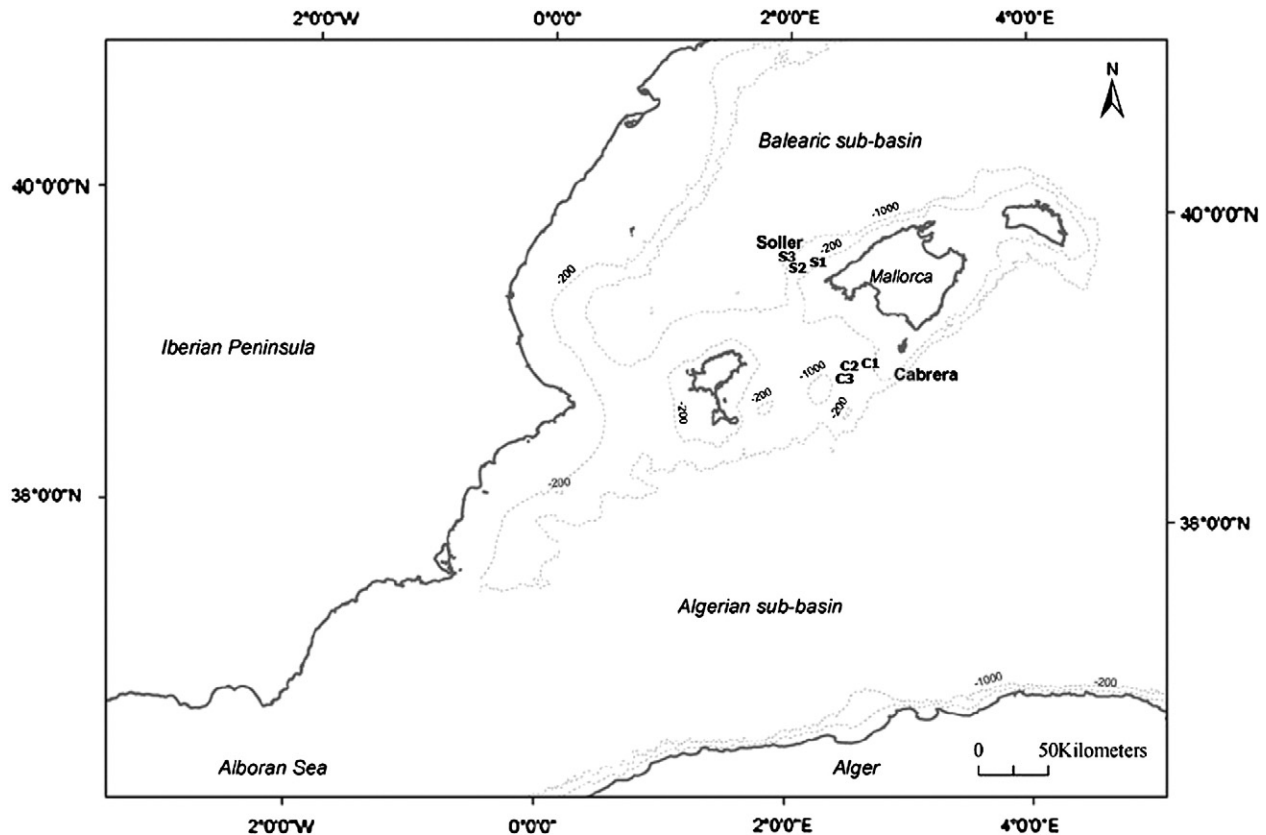


Fig. 1. Map of study area, indicating the locations of the suprabenthos sampling areas: Soller (Balearic subbasin) and Cabrera (Algerian subbasin); and stations: S1. Soller 250 m, S2. Soller 650 m, and S3. Soller 850 m, C1. Cabrera 250 m, C2. Cabrera 650 m and C3. Cabrera 850 m.

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