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Response of planktonic cladocerans (Class: Branchiopoda) to short-term changes in environmental variables in the surface waters of the Bay of Biscay

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ABSTRACT

From January 2001 to December 2008, 73 surface plankton samples and 45 vertical profiles of sea temperature, salinity, dissolved oxygen and pH were collected on a monthly basis from a single sampling station located in the Bay of Biscay (43°37N; 1°43W) (North-East Atlantic). Two types of North Atlantic Oscillation (NAO) indexes were included in the data set and submitted to a Canonical Correspondence Analysis and Spearman non-parametric test. Significant breaks and levels in time series were tested using a data segmentation method.

The temperature range varies from 11 °C to 25 °C. It begins to rise from April until August and then decline. Low salinity values occur in mid-spring (< 34 PSU) and high values (> 36 PSU) in autumn. Dissolved oxygen mean values were around 8 mg/l. In summer, when temperature and salinity are high, surface water layer is always accompanied with a significant deoxygenation, and the process reverses in winter. pH mean values range was 7.78–8.33. Seasonal and inter-annual variations of the two NAO indexes are strongly correlated to one another, but do not correlate with any hydrological or biological variable.

Five of the seven cladocerans species which are present in the Bay of Biscay were found in this study.

There is a strong pattern in species succession throughout the year: *Evadne nordmanni* is a vernal species, while *Penilia avirostris* and *Pseudevadne tergestina* occur mainly in summer and autumn. *Evadne spinifera* has a maximum abundance in spring, *Podon intermedius* in autumn, but they both occur throughout the year. However, for some thirty years, the presence of species has tended to become significantly extended throughout the year. During the 2001–2008 period, there was a noticeable decline and even a disappearance of the categories involved in sexual reproduction as well as those involved in parthenogenesis, in favor of non-breeding individuals.

1. Introduction

Of the 600 currently recorded cladoceran species in the world (Onbé, 1999), only eight are marine and seven of them are present in the Bay of Biscay (Alcaraz, 1981; d'Elbée and Castel, 1995). Despite the low number of marine species, compared to other groups such as copepods, many authors (Alonso, 1996; Egloff et al., 1997; Onbé, 1999) have stressed the importance of studying these species due to their position in the pelagic ecosystem. These studies highlighted several aspects of their biology: seasonal succession of species, rapid population growth, alternating phases of sexual and asexual reproduction. However, cladoceran studies in the Bay of Biscay are scarce. In 1976, Alcaraz (1981) began studying successions of species and their abundances on the Spanish Cantabrian coast. In 1979, Villate and Orive (1981) analyzed the interactions between environmental variables and the development of cladocerans in the Estuary of Plencia near Bilbao. More recently, studies have been conducted in the Arcachon Basin and the nearby neritic zone (d'Elbée and Castel, 1995). The aim of this work is to add to current knowledge about the population dynamics of these microcrustaceans in the Bay of Biscay: variations of abundance alongside seasonal succession of

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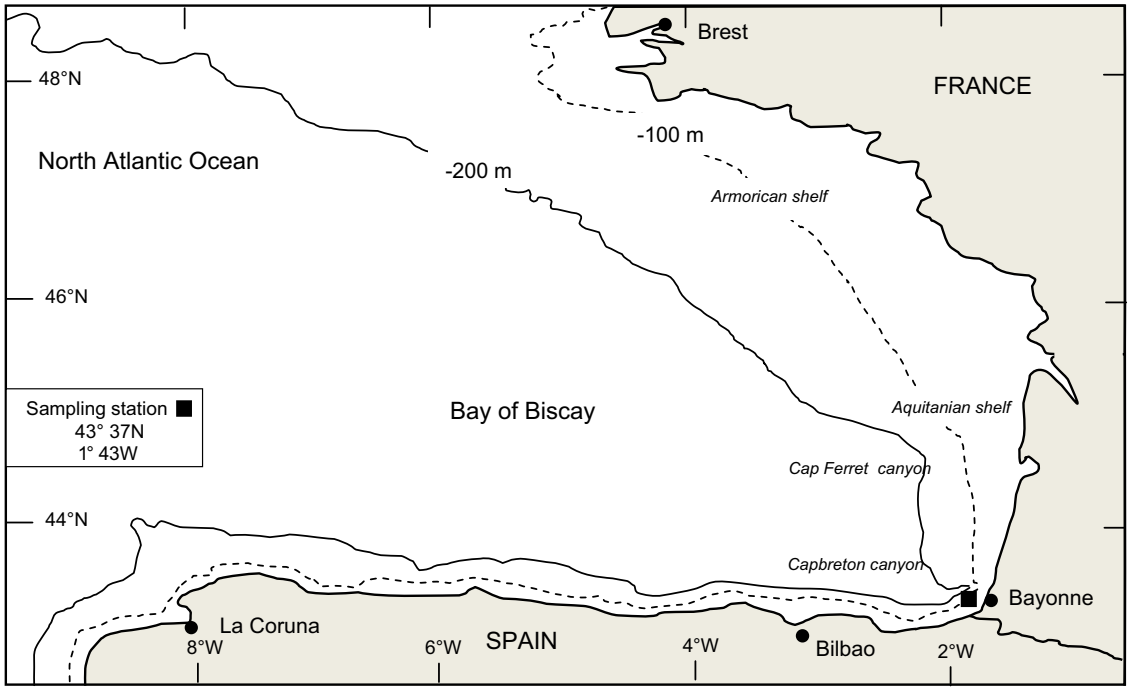

Fig. 1. Location of the sampling station (dark square) in the southern Bay of Biscay.

the species are described and compared with the aforementioned studies.

However, none of the previous studies extended longer than one annual cycle. Our study was carried out over eight years with a monthly sampling frequency, which allowed us to clarify some features of the ecology of these cladocerans, and investigate the role of climatic and environmental variables in the development of these populations on a quasi-decadal scale. Finally, some aspects of parthenogenetic and gamogenetic reproduction of these species are presented for the first time in this geographical area.

2. Material and methods

2.1. Study area

The single sampling station (43°37N; 1°43W) for plankton and hydrological data was located in the Bay of Biscay on the southern border of Capbreton canyon at 20 km (≈ 10.7 nm) from the coast, near the city of Bayonne (Fig. 1). Water depth at the sampling site was around 540 m. The planktonic community at this site is highly diverse and well-balanced between surface and deep water influences (d'Elbée, 2001; d'Elbée et al., 2009).

2.2. Field and laboratory work

From January 2001 to December 2008 (i.e. 96 months), 73 plankton samples were collected on a monthly basis from this station. All months have therefore not been sampled because of logistical constraints and unfavorable meteorological conditions (Table 1). The sampling surveys were carried out by the vessel "Haize Hegoa" (30 m length) belonging to the French Coast Guard (Douanes françaises). Plankton was always sampled at the same time of day (between 0900 and 1000), using a WP2-type net with 200 μm mesh size. Horizontal hauls were collected at 2 m below the sea surface and the net was towed at a speed of 0.5 m s^{-1}. The volume of water filtered through the net was estimated with a General Oceanics flowmeter. Plankton was preserved in 4% seawater formalin following Griffiths et al. (1976).

Table 1
Distribution of the 73 plankton samples during the study period (January 2001–December 2008). Months with plankton sampling only are shown with one asterisk (*), thoses with additional hydrological data are shown with two asterisks (**).

	2001	2002	2003	2004	2005	2006	2007	2008	Total
January		*	*		**	**	**	**	6
February	*	*	*	**		**		**	6
March		*	*	**	**	**			5
April			*	**	**	*	**	**	6
May	*	*	*	**		**	**	**	7
June	*	*	*			**		**	5
July	*	*	*	**		**	**	**	7
August	*			**	*			**	4
September	*	*	*	**	**	**	**	**	8
October			*		**	**	**		4
November	*	*		**	**	**	**	**	7
December	*	*	**	**	**	**	**	**	8
Total	8	9	10	9	8	11	8	10	73

In addition, from December 2003 to December 2008, after the sampling of plankton, we used a YSI 556 MPS multiparametric probe to measure four hydrological variables: temperature (°C), salinity (PSU), dissolved oxygen (mg/l) and pH, at seven depths: 0.5 m, 1 m, 2 m, 3 m, 5 m, 10 m, and 15 m. Thus, during this period, 45 months were sampled (Table 1).

Plankton samples were sorted in the laboratory, using a LEICA/WILD M10 stereo microscope. When concentrations were high, subsamples were taken with a Motoda box. Identification of cladocerans species was carried out using specialized literature (Alonso, 1996; Margaritora, 1985; Onbé, 1999). For each species, we distinguished the four following categories: males, parthenogenetic females (bearing parthenogenetic eggs or embryos), gamogenetic females (with resting eggs) and non-breeding females without any eggs (Marazzo and Valentin, 2004a; Atienza et al., 2008). Abundances were expressed as number of individuals (*N*) per m^3 of water (N m^{-3}).