Estuarine, Coastal and Shelf Science 87 (2010) 431–441

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

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

High resolution characterization of northwest Mediterranean coastal waters thermal regimes: To better understand responses of benthic communities to climate change

Nathaniel Bensoussan [a,*,1], Jean-Claude Romano [b], Jean-Georges Harmelin [a], Joaquim Garrabou [a,c]

[a] UMR 6540 DIMAR CNRS-Université de la Méditerranée, Centre d'Océanologie de Marseille, Station Marine d'Endoume, rue de la Batterie des Lions, 13007 Marseille, France
[b] UMR 6134 CNRS-Université de Corse, Laboratoire Systèmes physiques pour l'environnement, Vignola, route des Sanguinaires, 20000 Ajaccio, France
[c] Institut de Ciencies del Mar-CSIC, Passeig Maritim de la Barceloneta 37-49, 08003 Barcelona, Spain

ARTICLE INFO

Article history:
Received 2 September 2009
Accepted 7 January 2010
Available online 2 February 2010

Keywords:
effects of climate change
coastal oceanography
thermal structure
thermal regime
mortality outbreak
positive temperature anomalies
Mediterranean
France
Spain
Gulf of Lions

ABSTRACT

In the North West Mediterranean (NWM), mass mortality events (MME) of long-lived benthic species that have occurred over the last two decades have been related to regional warming trend. Gaining robust data sets on thermal regimes is critical to assess conditions to which species have adapted, detect extreme events and critically evaluate biological impacts. High resolution temperature (T) time series obtained during 1999–2006 from 5 to 40 m depth at four contrasted sites of the NWM were analyzed: Area Marina Protegida de les Illes Medes (NE Spain), Riou (Marseilles, France), Parc National de Port-Cros (France), and Réserve Naturelle de Scandola (Corsica, France). The seasonal pattern showed winter T around 11–13 °C, and summer T mainly around 22–24 °C near surface to 18–20 °C at depth. Stratification dynamics showed recurrent downwellings (>40 m) at Medes, frequent observation (1/3rd of the summer) of deep and cold upwelled waters at Riou, while Scandola exhibited stable summer stratification and highest suprathermoclinal T. Port-Cros showed an intermediate regime that oscillated between Riou and Scandola depending on the occurrence of northern winds. Data distribution study permitted to identify and to characterize 3 large scale positive anomalies concomitant with the mass mortality outbreaks of summers 1999, 2003 and 2006. The analysis of biological surveys on gorgonian populations showed significant impacts during the 3 years with temperature anomalies. Besides the degree of impact showed inter-annual differences which could be related to different T conditions concomitant to mortality events, from slight increase in T extreme of only 1–2 °C over short duration, to lengthened more classical summer conditions. Our results therefore support the hypothesis that shallow NWM populations of long-lived benthic species are living near their upper thermal thresholds. Given actual trends and projections in NWM, the repetition of new MMEs in the next decades is extremely likely. In such context, the acquisition of dedicated high resolution T series proves to be crucial for increasing our detection, understanding and forecasting abilities.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

The impacts of recent climatic trends on marine biodiversity conservation are of concern in many coastal areas (Karl and Trenberth, 2003; Harley et al., 2006). The magnitude of the actual warming is still subject to large uncertainties, particularly in coastal waters. However, in the Mediterranean region, all models converge towards a warming that is larger than average (Lionello et al., 2006; GIEC, 2007). These models suggest an increase in mean T and in climatic variability, including actual and future extreme events such as heat waves (Meehl and Tebaldi, 2004; Stott et al., 2004; Fischer and Schär, 2008). Face to the current warming trend the coastal ecosystems could be suffering serious changes in their structure and dynamics (Harley et al., 2006).

In the NW Mediterranean changes in species distribution and mass mortality events during the last several decades have been related to the warming trend observed in this area (Francour et al., 1994; Bianchi and Morri, 2000; Cerrano et al., 2000; Pérez et al., 2000; Salat and Pascual, 2002; Chevaldonné and Lejeusne, 2003; Bianchi, 2007; Garrabou et al., 2009). In particular, two recent large

* Corresponding author at: Institut de Physique du Globe de Paris, Géochimie des Eaux, 35 rue Hélène Brion, case 7052, 75205 Paris cedex 13 France.
E-mail address: bensoussan@ipgp.fr (N. Bensoussan).
[1] Present address: UMR 7154 IPGP, Laboratoire de Géochimie des Eaux, 35 rue Hélène Brion, case 7052, 75205 Paris cedex 13, France.

0272-7714/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecss.2010.01.008

scale (>1000 km of coastline) mass mortality events (MME) were observed during the summers of 1999 and 2003 in association with two positive thermal anomalies (Romano et al., 2000; Harmelin, 2004; Garrabou et al., 2009). These large scale events affected more than 30 species of benthic invertebrates, particularly gorgonians and sponges (Cerrano et al., 2000; Pérez et al., 2000; Garrabou et al., 2009).

As a micro-tidal, semi-enclosed temperate warm sea, the Mediterranean experiences strong seasonality with the development of a marked seasonal stratification and annual oscillations that may reach 15 °C at the surface (Lacombe and Tchernia, 1972; Margalef, 1985). Synthesis of oceanographic data indicates notable West to East and North to South positive seawater *T* gradients in the Western Mediterranean (Fig. 1).

All the processes involved in the annual cycle work at short time scales which confer irregular and rough signatures in several physico-chemical parameters. In the coastal waters of the Northwest Mediterranean (NWM), the temperature can show an even larger variability, especially during summer, because hydrology is highly dependent on the topographical, meteorological, and hydrodynamical conditions (Margalef, 1985). Nevertheless and despite the notable exceptions of local temperature series (Prieur, 2002; Salat and Pascual, 2002; Harmelin, 2004), there is an enormous gap of knowledge on temperature regime in coastal waters due to the lack of data sets covering the appropriate (high resolution) temporal and spatial scales. At present, the few limited time-resolved *T* series prevent the characterization of the spatial and inter-annual variability in the water column.

Since we can consider that populations are locally adapted to different temperature conditions, characterizing temperature regimes (mean, variability and extremes) could provide key clues about the populations' adaptation potential. Without these data, the analysis of the consequences of climate change in marine coastal ecosystems will be unsuccessful in providing reliable basis to assess conservation risks under the present warming scenario.

In this study, we analyse for the very first time high resolution *T* time series obtained over 4–8 years between 5 and 40 m depth at four sites located in areas of the NW Mediterranean with differing hydrological conditions. The data analysis mainly focused on characterising temperature regimes in each of the four locations through the study of different temperature descriptors and in deciphering the local and regional relevance of our observations. Likewise, the analysis of positive temperature anomalies jointly with biological data allowed the identification of the conditions concomitant with the occurrence of recent mass mortality events.

2. Materials and methods

2.1. Temperature data collection and validation

2.1.1. Study area

The study areas are located in the northern part of the Western Mediterranean basin and distributed (Fig. 1) from Area Marina Protegida de les Illes Medes in the West (L'Estartit, NE Spain) to Réserve Naturelle de Scandola in the South (Galeria, Western Corsica, France).

2.1.2. Measuring strategy

Temperature was recorded *in situ* by Stowaway Tidbits autonomous sensors (precision 0.2 °C, resolution 0.15 °C) and recovered annually or semi-annually by divers. Deployment periods and depths are shown in Table 1. Before 2004 (2003 at Riou), the sampling interval was set to 2 h and data were recorded only at 12, 24, and 40 m depths at Port-Cros and Riou and at 10, 25, and 35 m at Medes. Since 2004, measurements have been standardised at all sites to collect hourly records every 5 m from 5 to 40 m depth.

2.1.3. Time series standardization

Calibrations of the sensors were performed since 2003 against SeaBird SBE39-T recorder during periodical sensor recoveries. The

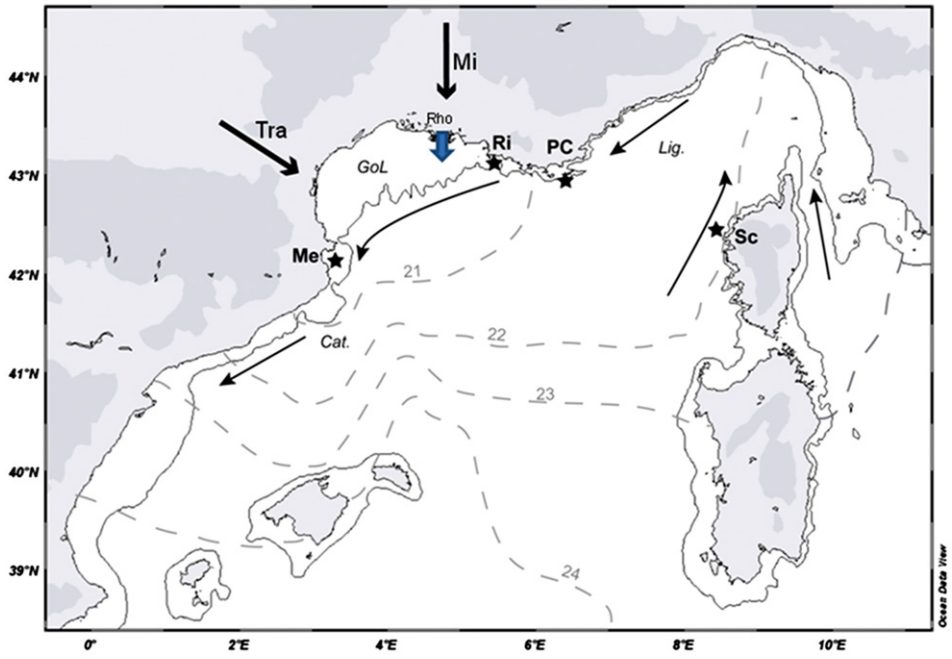

Fig. 1. The northwestern Mediterranean region with major relief (>400 m, dark grey) and dominant forcings: Mistral (Mi) and Tramontane (Tra) winds (dark arrows), freshwater inputs from the Rhône river (Rho), and main mesoscale surface circulation known as the northern current (thin arrows, adapted from Millot, 1990). The four study areas are indicated by black stars: Medes (Me), Riou (Ri), Port-Cros (PC), and Scandola (Sc). The 200 m isobath (solid line) and isotherms of summer seawater mean temperature at 10 m depth are also indicated (dashed lines; adapted from Antonov et al., 1998).

Download English Version:

https://daneshyari.com/en/article/4540930

Download Persian Version:

https://daneshyari.com/article/4540930

Daneshyari.com