Deep-Sea Research II 106 (2014) 1–4

Contents lists available at ScienceDirect

Deep-Sea Research II

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

# A new look at the oceanography of the Bay of Biscay

Carlos Garcia-Soto [a,b,*], Robin D. Pingree [c,d]

[a] Spanish Institute of Oceanography (IEO), Corazón de María 8, 28002 Madrid, Spain
[b] Plentziako Itsas Estazioa/Euskal Herriko Unibetsitatea (PIE/EHU), Areatza z/g, 48620 Plentzia, Spain
[c] Plymouth Marine Laboratory, Prospect Place, Plymouth, Devon PL1 3DH, UK
[d] Marine Biological Association of UK (MBA), Citadel Hill, Plymouth PL1 2PB, UK

ARTICLE INFO

Available online 25 July 2014

*Keywords:*
Bay of Biscay
Phytoplankton
Spring bloom
Climate variability
Cycles

ABSTRACT

Some results of the Bay of Biscay regional oceanography presented at ISOBAY are summarized including contributions to physical oceanography, chemical and biological oceanography, marine geology, deep water ecology, marine pollution, fisheries research and cetacean studies. A long-term analysis of the spring bloom of phytoplankton in the area during the last 17 years (1997–2014) is presented as an example of Bay of Biscay climate research. The Spring Bloom presents cycles of 4–6 years reflecting probably the availability of nutrients from the previous winter and has increased in peak intensity during the last decades.



## 1. Introduction

The International Symposium of the Bay of Biscay (ISOBAY) offers every two years a unique opportunity to reexamine and advance many observations and concepts of this important large marine ecosystem region of the North Atlantic, the Bay of Biscay. This special issue of Deep-Sea Research II presents the best contributions presented and discussed during the XIIII edition of ISOBAY organized in Santander (11–13 April 2012) by IEO. The issue, as a whole, represents one of the best and most complete compilations of the Bay of Biscay regional oceanography up to date and thus an essential reading for any scientist first approaching this region.

A major emphasis of the editors while preparing the issue has been to highlight the implications of the new findings of the region with respect to the present scenario of climate change and climate variability. We know now for example that the spring bloom of phytoplankton presents cycles of 4–6 years and has increased in intensity during the last decades as shown now by Fig. 1 (17 years of observations). This variability is thought to be related to the availability of nutrients from the previous winter, and probably has an effect on the subsequent zooplankton outburst and thus on the food availability for early life fish stages (larvae) and for planktivorous fish adults in the region. With a

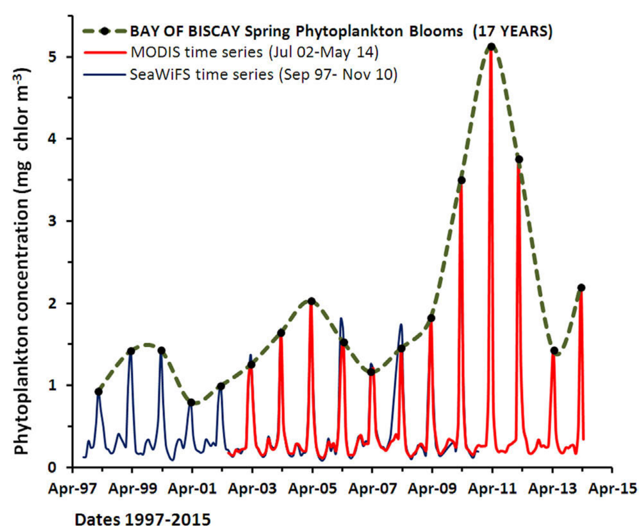


**Fig. 1.** Time series of chlorophyll concentration showing the development of the spring bloom of phytoplankton in the central Bay of Biscay (44.5–46°N, 5°–8°W) during the last 17 years (1997–2014). It is notable in the figure the variability in the intensity of the spring bloom peak (usually in April) that shows three weakening–strengthening cycles of 4–6 years and a tendency to increase during the last decades. Within the cycles maximum spring blooms are observed in the years 1999–2000 (1.4 mg Chlor m$^{-3}$), 2005 (2.0 mg Chlor m$^{-3}$) and 2011 (5.1 mg Chlor m$^{-3}$). The figure has been elaborated using satellite data from the color sensors SeaWiFS (1997/09 to 2010/12; 13 years) shown in blue and MODIS-Aqua (2002/07–2014/05, 12 years) shown in red. The satellite time series are shown separately in Fig. 2 (see caption for further details).

* Corresponding author.
*E-mail address:* carlos.soto@md.ieo.es (C. Garcia-Soto).

http://dx.doi.org/10.1016/j.dsr2.2014.07.010
0967-0645/

similar aim, bridging the long term Climate and the Regional Oceanography, we have included in this special issue an introductory Review that presents to the reader additionally the physical oceanography that orientates the following papers. Overall this Review by Pingree and Garcia-Soto (2014) and the subsequent manuscripts, summarized below, provide *A New Look at the Oceanography of the Bay of Biscay*.

## 2. The new ISOBAY studies

### 2.1. Physical oceanography

Caballero et al. (2014) investigate the 4°W eddy of the southeastern Bay of Biscay reported on various occasions in the bibliography using satellite, *in situ* and model results for the period 2003–2010. An eddy tracking method applied to the outputs of a numerical model shows that the model is able to reproduce this type of eddy with similar 2D characteristics and lifetimes to those suggested by observations and previous works. Detailed monitoring from *in situ* and remote sensing data in 2008 shows the origin of the structure of this year from a warm water current located around 43°42′N–3°30′W in mid-January. Álvarez et al. (2014) compare buoy wind data in the southern Bay of Biscay and different wind datasets during the years 2000–2009. The statistics show the best results, especially in nearshore areas, for the datasets with the highest spatial resolution: QuikSCAT, NCEP Climate Forecast System Reanalysis (CFSR) and Cross-Calibrated Multi-Platform (CCMP). These datasets are more accurate at moderate wind speeds and show a similar mean wind speed error. Laiz et al. (2014) investigate the effect of river runoff on sea level of the Bay of Biscay using long term river runoff records, tide gauge data and the ROMS numerical model. The authors suggest that the low salinity plume resulting from river discharge storm events produces a sea-level increase around the river mouth and along the coast generating a coastal density current.

### 2.2. Chemical and biological oceanography

Hartman et al. (2014) analyze the seasonal and inter-annual variability in nutrient supply in relation to the mixing of the Bay of Biscay. Off shelf in the Bay of Biscay, the mixed layer depth assessed using Argo floats is found to vary from 212 m in relatively mild winters (such as 2007/2008) to 476 m in cold winters (2009/2010). Years with deeper mixing are associated with an increase in nitrate concentrations in the surface waters. Smythe-Wright et al. (2014) investigate the composition of phytoplankton and pigments in the Bay of Biscay and English Channel during the last year (2010) of ferry operation between Portsmouth and Bilbao. The biological patterns relate, not unexpectedly, to the hydrographic conditions, and the observed pigment distributions are indicative in general of the taxonomy. d'Elbée et al. (2014) investigate the response of planktonic cladocerans to short-term changes in environmental variables in the surface waters of the Bay of Biscay. The authors notice during the 2001–2008 period, a decline, and even a disappearance, of the categories involved in sexual reproduction or parthenogenesis in favor of non-breeding individuals.

### 2.3. Marine geology

Gómez-Ballesteros et al. (2014) present a high resolution multibeam map detailing the complexity of the Avilés Canyon System (Cantabrian Sea, southern Bay of Biscay). The Avilés Canyon System includes three major canyons of different structural and morphological character: La Gaviera Canyon, El Corbiro Canyon and Avilés Canyon. These three canyons have an opening origin associated to NW–SE structures (Ventaniella Fault zone). La

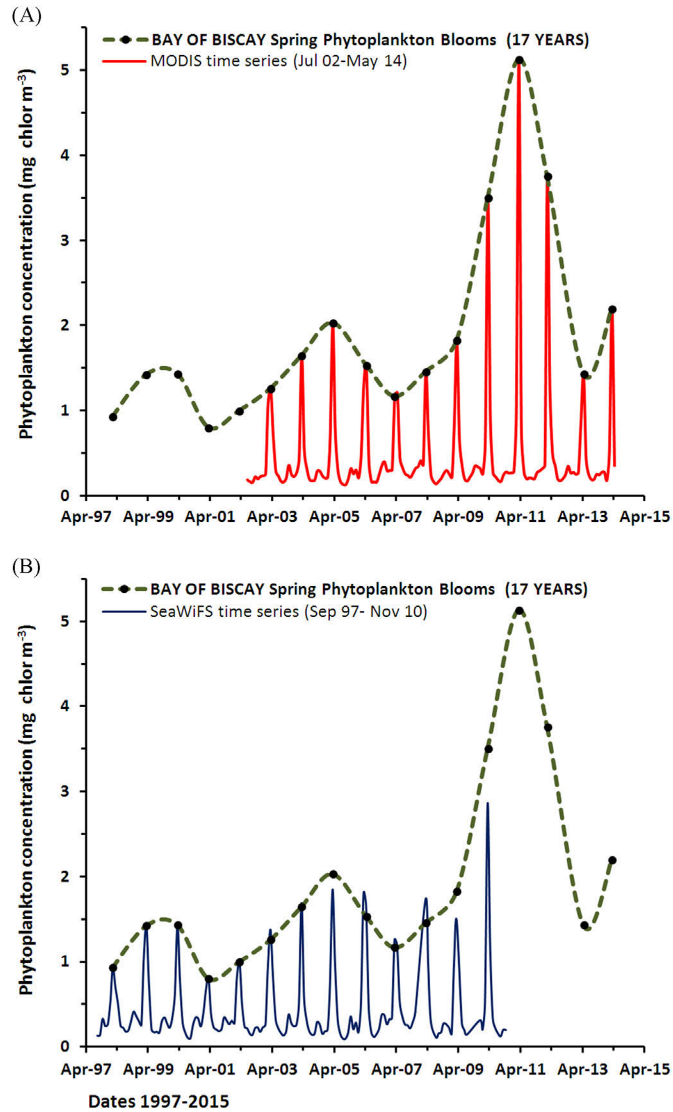


**Fig. 2.** Same as Fig. 1 showing separately the time series of phytoplankton concentration from the MODIS (red) and SeaWiFS (blue) satellite sensors. The peak of the spring phytoplankton bloom (dots and green line) correspond to MODIS measurements for the period July 2002 to May 2014 (12 years) and to SeaWiFS measurements for previous dates starting September 1997. The satellite data has a temporal resolution of 1 month and a spatial resolution of 9 km. In order to merge both satellite time series (SeaWiFS and MODIS) the SeaWiFS chlorophyll data have been scaled using the 8 years of simultaneous measurements that rendered the following relationship (MODIS=1.296* SeaWiFS −0.094; r2:0.947, n:90). The spring peak of phytoplankton takes place usually in April but during some years takes place in March (2008 and 2012) or May (2006 and 2013). The peak phytoplankton concentration in spring ranges from a minimum 0.8 mg Chlor m-3–3 (year 2001) to the record high 5.1 mg Chlor m-3–3 (year 2011), and has a mean concentration for the 17 years of observations of 1.9 mg Chlor m-3–3. A much smaller autumn bloom is also observed in October–November–December. A first SeaWiFS time series (1997–2001) describing the spring and autumn blooms in the oceanic Bay of Biscay (45.5°N 6°W) can be found in Garcia-Soto et al. (2002). Garcia-Soto and Pingree (2009) describes the northward or southward progression of the spring and autumn blooms of the Bay of Biscay using SeaWiFS data along the track of the ferry Pride of Bilbao from Bilbao to Portsmouth during 11 years (1997–2007).

Gaviera Canyon and El Corbiro Canyon are additionally influenced by E–W structures. The U-shaped profile of La Gaviera Canyon appears to be related to the initial fault systems that controlled their morphology, to the different nature of their substrate rocks and to the special hydrography. The continental shelf shows a flat, uniform slope with local and well defined rock outcrops south of Aviles Canyon head. Sedimentary processes in this part of the Bay of Biscay margin seem to be conditioned by strong hydrodynamics