The meridional gradients of the S-SE Brazilian continental shelf: 
Introduction to the special volume

Continental Shelf Research, v. 89, 2014, p. 1-4
http://www.producao.usp.br/handle/BDPI/46358

Downloaded from: Biblioteca Digital da Produção Intelectual - BDPI, Universidade de São Paulo
Introduction

The meridional gradients of the S-SE Brazilian continental shelf: Introduction to the special volume

A B S T R A C T

This Special Issue is dedicated to the southern and southeastern Brazilian continental shelf. The works comprising the Issue review, substantiate or improve the description of the mechanisms that drive oceanographic processes known to date, and also report new findings. The works support that the strong meridional gradient of physical-chemical characteristics observed in this region is driven by the La Plata River plume at the south and by a marked influence of oceanic water masses in the north. The importance of the annual cycle of the wind field modulating the volumes of the distinct waters masses on the shelf is consolidated. The results gathered by this Special Issue strongly support that the continental shelf area near São Sebastião Island delimits two main oceanographic regimes with contrasting sedimentation rates and distinct primary and secondary production mechanisms. Nonetheless, it became clear that process-oriented studies are imperative for understanding how this region functions.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

This special issue focuses on oceanographic processes observed along the southern and southeastern Brazilian continental shelf that extend from the Rio Grande do Sul to Rio de Janeiro States (Fig. 1), and hereafter will be referred to as the S-SE Brazilian continental shelf. As described in Mahiques et al. (2010), within these geographical limits the width of the continental shelf varies between 100 and 230 km, its declivity varies between 1:600 and 1:300, and the shelf break lies between 100 and 180 m. Due to its meridional extension and NE-SW orientation, the S-SE Brazilian continental shelf is strongly influenced by NE winds year round, but especially during spring and summer. During autumn and winter, both the frequency and the strength of SW winds increase due to the passage of atmospheric frontal systems (Möller et al., 2001; Piola et al., 2005). Important freshwater inputs are confined to the south, which drive a northward flow in the inner shelf. Moderate coastal upwelling events are documented for restricted areas in Santa Catarina and Rio de Janeiro states but most of the work to date on coastal upwelling have been done in the Cabo Frio region. For this section of the Brazilian Continental shelf, the wind field is the major driver for inner, mid and outer shelf circulation, as tides are of low importance, particularly in the south. Long-term biological data over this region is restricted to surface chlorophyll concentration estimated by ocean color remote sensing, and analyses of this dataset reveals a S-N decrease in both chlorophyll concentration and the importance of the annual cycles on its temporal variability (Ciotti et al., 2010). Fisheries are more profitable in the south, with a clear shift from anchovy to sardine northern (Acha et al., 2004).

Much of the overview presented above is based on results discussed in M.Sc and Ph.D. dissertations, institutional reports or scientific articles published in Portuguese. The goals of this special volume are to make this knowledge available to a wider scientific community at the same time that novel findings are presented. Therefore, our approach was to select contributions that review, substantiate or improve the description of the spatial variability of the oceanographic processes observed over the southern and southeastern Brazilian continental shelf. Some results on the temporal variability of these processes are also presented.

2. Scope of the volume: physical-chemical and biological meridional gradients

In the S-SE Brazilian continental shelf, the number of the water masses present decreases from south to north (see Table 1 for names and thermohaline characteristics). From Chuí (33° 44’ S) to Cabo de Santa Marta Grande (28° 36’ S, SMGC) five different water masses interact (Möller et al., 2008; Piola et al., 2008a) as both the Subantarctic Shelf Water (SASW) and the Plata Plume Water (PPW) have a limited latitudinal reach (see Fig. 1). The entire region is influenced by two oceanic water masses that flow with the Brazil Current, creating a strong alongshore front in most of its outer shelf.

The Subtropical Shelf Front (STSF) separates Tropical and Subtropical Waters from Subantarctic Shelf Waters, transported by the Brazilian Current and the Patagonian Current, respectively. The position of the STSF, around 33° S (Piola et al., 2000), apparently changes very little throughout the year. The results from Eichler et al. (2014) discusses the the distribution of benthic foraminifera in relation to the near stationary position of the STSF, and report the thermohaline contrasts of the inner shelf waters masses between summer and winter. A major player in the maintenance of the meridional gradient of physical-chemical
properties on the southern and southeastern Brazilian continental shelf is the large freshwater input that generates the La Plata Plume Water (PPW). During autumn and winter, the prevailing SW winds (i.e., downwelling favorable winds) force both the northward displacement of the PPW and its maintenance inshore by Ekman transport. As a consequence, the Tropical Water (TW), the South Atlantic Central Water (SACW) and the Sub Tropical Shelf Water (STSW) will be kept away from the inner and mid shelf. During spring and summer, NE and upwelling favorable winds force the plume to retreat to south of 32°S. This retreat also enhances cross-shelf exchanges of shelf waters with the open ocean, and PPW can be found at distances larger than 200 km from the coast (Möller et al., 2008). Although the northernmost limit for the PPW is usually related to the wind field, seasonal rainfall fluctuations determine the La Plata River discharge (Piola et al., 2000, 2005). Pimenta and Kirwan (2014) present simulations from a 3-dimensional numerical model for the La Plata Plume displacement over the S-SE Brazilian continental shelf as a function of both freshwater input and changes in the wind field. Their model describes a mechanism that gives an explanation for the seasonal behavior of PPW. The presence of PPW in the shelf increases vertical stability (Castello and Möller, 1977; Zavialov et al. 2003) and thus buoyancy, which in turn facilitate the northward flow of the plume even further (Zavialov et al., 2002). PPW is responsible for the introduction of silicates and phosphates in the shelf (Ciotti et al., 1995).

Earlier works show that the distribution of sediments over the inner and middle continental shelves in the interest area showed strong influence of La Plata River to about 27°S (Mahiques et al., 2008). The presence of relict surfaces at the bottom north of 25°S suggest that deposition of sediments was suppressed (Mahiques et al., 2004) due to mechanisms latter associated with mesoscale instabilities from the Brazil Current (Mahiques et al., 2011). Nagai et al. (2014) present new data confirming the existence of two main geochemical and mineralogical provinces delimited by the São Sebastião Island.

At the northern limit of the S-SE Brazilian continental shelf, Costal Water (CW), TW and SACW dominate due to reduced freshwater sources and distance from the STSF. Cerda and Castro (2014) present the first comprehensive climatology of the water masses found north off São Sebastião Island showing the efficient mixing of SACW and TW during the summer. The authors discuss that these two water masses are in permanent proximity of the inner shelf around Cabo Frio, making it the preferential site for wind-driven SACW intrusions, and TW offshore displacements, during most of the year. In some occasions during winter, the combination of downwelling winds and the remote contribution of estuarine waters originated from Guanabara Bay restrict SACW intrusions in Cabo Frio. For the first time, a secondary pathway for SACW intrusions during spring is described next to Ubatuba (São Paulo state), which is facilitated by the overall weaker vertical stratification in the area at this season.

Fig. 1. Topographic map of the study area, based on E-topo 1° data (available at, http://www.ngdc.noaa.gov). The 50- and 100-m isobaths are marked as continuous lines. Letters correspond to: A) Frio Cape, B) São Sebastião Island, C) Santa Marta Grande Cape, D) Chui (Brazil-Uruguay international border), E) La Plata River mouth.
For the region between Cabo de Santa Marta Grande and Cabo Frio, Castro (2014) illustrates the contrasting summer and winter stratification, concluding that vertical mixing in the region is controlled by both advection and buoyancy. While in the inner shelf, the along shelf flow of low-salinity water originated from the south guide buoyancy, in the mid-shelf buoyancy is a result of cross-shelf intrusions of SACW.

The Intrusions of SACW observed in Cabo Frio, as a result of NE winds and local bathymetry, were the subject of a large body of literature in both physical and biological oceanography. North of Cabo Frio, evidences from remote sensing images suggest the occurrence of SACW intrusion events at Cabo de São Tomé (22°S), even larger than those documented at Cabo Frio. Palóczy et al. (2014) analyzed the combined effects of the wind field and bathymetry as well as that of the meanders of the Brazil Current on the SACW shelf intrusions. The authors demonstrate that quasi-standing BC meanders are able to enhance SACW intrusions near Cabo de São Tomé by preconditioning the shelf water masses to respond promptly to favorable winds.

SACW intrusions as a response to NE winds occur also in Cabo de Santa Marta Grande (Fig. 1), especially when the plume of the La Plata River is retracted to the south. Although the potential importance of SACW intrusions for enhancing the biological processes in the SE portions of continental shelf is commonly accepted, their actual effects on the plankton dynamics are not well understood yet. The intrusions of SACW over the mid and inner shelf facilitate the development of a deep chlorophyll maximum, and Brandini et al. (2014) shows that near Cabo de Santa Marta Grande, the mid shelf deep chlorophyll maxima is composed mainly of coastal and estuarine diatom species. The authors suggest that the production of resting spores, which are suspended back in the water column when upwelling conditions are set, is a mechanism for retention of these species near the coast, ensuring phytoplankton accumulation. Although mid-shelf deep chlorophyll maxima are common features over the entire region of interest of this Special Issue, the taxonomic composition of these primary producers is poorly known. Off Cabo Frio, however, deep chlorophyll maxima seem to be mainly composed of prokaryotic algae and very small cells (Guenter et al., 2008).

Grazing rates on phytoplankton are unknown for the entire Brazilian continental shelf. However, despite the lack of experimental work, it is commonly assumed that SACW intrusions increase not only phytoplankton biomass but also primary and secondary production. Nogueira et al. (2014), hypothesize that SACW intrusions in the mid-shelf off Santa Catarina with local growth of cnidarians in the mid shelf deep chlorophyll maxima, which was suggested by the increases in abundance of oceanic species relative to coastal species. Sousa et al. (2014) associate both the intrusions of the SACW and mesoscale features of the Brazil Current, such as meanders and vortices, to the distribution, abundance and diversity of planktonic foraminifers, highlighting the responses of one particular species (Globigerinella ruber) to the depth of the mixed layer. Indeed, surveys of this species and others from this genus may reveal past vertical structures of the water masses in the region.

The overall meridional gradient over the S-SE Brazilian continental shelf is also manifested on the distribution of fish larvae (Katsuragawa et al., 2014), which differs significantly between waters south and north from São Sebastião Island, markedly during their fall observations. These authors stress as well the role of mesoscale eddies derived from the Brazil current in the north portion.

3. Conclusions

The compilation of works presented in this Special Issue consolidates the concept that the S-SE Brazilian continental shelf encompasses a strong meridional gradient of physical-chemical characteristics, which is largely influenced by the plume of the La Plata River at the south, and the interaction of oceanic water masses at the north, modulated by the annual cycle of the wind.
field. The N-S gradient of physical-chemical characteristics establishes over the southern and southeastern Brazilian continental shelf at least two distinct biogeochemical regions, in which different primary and secondary production magnitudes and mechanisms, as well as sedimentation patterns, are expected. All evidences gathered by the works presented in this Special Issue suggest that these two regimes are limited in space at a location near São Sebastião Island. Nonetheless the extension and temporal variability of this limit, as well as the existence of a potential intermediary region has yet to be accessed.

4. Future perspectives

Oceanography is a rather young science in Brazil, and the data collected by the few oceanography institutes and marine biology stations to date are mainly descriptive. A mechanistic understanding of how this region works, as well as its vulnerability to environmental change, depend on the design and the execution of process-oriented multidisciplinary research. Some of the critical problems to be solved include the implementation of robust and long-term monitoring programs for a proper characterization of shelf waters at multiple spatial and temporal scales along the southern and southeastern Brazilian coast.

References


Piola, A.R., Möller Jr., O.O., Freitas, A.C., Campos, E.J.D., 2008a. Variability of the physical-chemical characteristics estab-


Áurea Maria Ciotti*  
Centro de Biologia Marinha da Universidade de São Paulo, Brazil  
E-mail address: ciotti@usp.br

Michel de Mahiques  
Instituto Oceanográfico da Universidade de São Paulo, Brazil  
O. Osmar Möller  
Instituto Oceanográfico da Universidade Federal do Rio Grande, USA

Available online 6 September 2014

* Corresponding author. Tel.: +55 12 38628461.