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Patterns in larval fish assemblages under the influence of the Brazil current

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ABSTRACT

The present work investigates the composition of larval fish assemblages in the area under the influence of the Brazil Current (BC) off the Southeastern Brazilian Bight. Ichthyoplankton was sampled during two oceanographic cruises (November–December/1997 – spring; May/2001 – autumn) with bongo nets oblique tows. Seasonal variation and a coastal-ocean pattern in the distribution of larval fish was observed and was influenced by the dynamics of the water masses, Coastal Water (CW), Tropical Water (TW) and South Atlantic Central Water (SACW), the last two of which were transported by the BC. During spring, the shelf assemblage was dominated by larvae of small pelagic fishes, such as *Sardinella brasiliensis*, *Engraulis anchoita and Trachurus lathami,* and was associated with the enrichment of shallow water by the SACW upwelling. In autumn, the abundance of coastal species larvae was reduced, and the shelf assemblage was dominated by *Bregmaceros cantori.* A transitional assemblage occurred during the spring, and comprised mesopelagic and coastal species. In both seasons, the oceanic assemblage was dominated by the mesopelagic families, Myctophidae, Sternopthychidae and Phosichthyidae. The oceanographic conditions also demonstrated clear differences between the northern and southern subareas, particularly in the shelf zone. This was especially the case during autumn when a latitudinal gradient in larval fish assemblages became more pronounced.

1. Introduction

The Southeastern Brazilian Bight (SBB), located between 23° and 28°S, is largely influenced by the occurrence of mesoscale eddies from the Brazil Current (BC) and seasonal upwelling (Silveira et al., 2000). The BC flows southward along the continental slope near the shelf edge, where vertical current shear, bottom topography and strong change of coastal orientation near 23°S contribute to the development of meandering and eddies (Campos et al., 1995, Castelao et al., 2004). The cyclonic eddies of BC may promote upwelling in the shelf break along the SBB, as well as favor the movement of the upwelling frontal zone toward the inshore area (Campos et al.,1995, 2000). The position of the bottom thermal front changes seasonally and is closer to the coast during summer and farther offshore during winter. Additionally, depending on the strength of the South Atlantic Central Water (SACW) intrusion, coastal upwelling may also occur (Castro and Miranda, 1998).

Physical processes, in all scales, can affect the distribution and abundance of animal populations in the sea (Harrison and Parsons, 2001), especially the plankton community. The occurrence of upwelling is known to drive the ichthyoplankton assemblages in the eastern boundary coastal systems (Olivar and Shelton, 1993; Landaeta et al., 2008) and in the SBB (Katsuragawa et al., 2006), although it is generally considered weaker than the previous systems. The intrusion of the SACW toward the coast in the bottom layer is a hydrographic feature that enhances regional primary productivity and consequently, the fisheries (Brandini, 1990; Gasalla and Rossi-Wongtschowski, 2004). Studies have shown the tendency of the peak spawning period for some small pelagic fish species, as sardine and rough scad, during the spring and summer, when the intrusion of SACW over the continental shelf becomes more frequent (Matsuura et al., 1992; Katsuragawa et al., 2006).

The mesoscale meanders and eddies may transport fish larvae from one area to another, such as from the shelf to the ocean and vice-versa, which influences the composition and abundance of larval fish assemblages (Wroblewski and Cheney, 1984; Fleirl and Wroblewski, 1985; Myers and Drinkwater, 1989; Franco et al., 2006). Despite the importance of these features, their influence on ichthyoplankton in the Brazilian coast is poorly studied. However, for the southern region, approximately 31°S, Franco et al. (2006) previously observed that larval fish are advected with tropical offshore waters toward the inner shelf by an anticyclonic eddy.

To improve the understanding of larval fish distribution, the present study compares the spatial changes in larval fish assemblages

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in SBB under the influence of spring and autumn oceanographic conditions.

2. Material and methods

Biological and hydrographic data were obtained during two oceanographic cruises (November–December/1997 – spring; May/2001 – autumn) carried out with the R/V “Prof. W. Besnard” off the Southeastern Brazilian Bight, from cape Frio (23°S) to the cape of Santa Marta Grande (29°S). The samples are stored at the ColBIO – IOUSP (Biological Collection “Prof. Edmundo F. Nonato” – Oceanographic Institute, São Paulo University). Each survey comprised 15 across-shelf transects with a total of 47 stations in the spring cruise and 46 stations in autumn cruise (Fig. 1). Ichthyoplankton was collected with bongo nets according to Smith and Richardson (1977). The maximum sampling depth of the tows was limited to 5 m above the bottom at shallow stations and to the upper 210 m of the water column at offshore stations. Flow meters in the net mouths measured the volumes of water sampled to estimate the levels of larval abundance. Only samples of 333 μm mesh nets were analyzed. All samples were fixed in a buffered, 4% formaldehyde–seawater solution.

A CTD (conductivity–temperature depth profiler) cast provided hydrographic data for each station, and temperature–salinity diagrams (T–S) provided the identification of the water masses (Emílsson, 1961). The maps of horizontal distribution of temperature and salinity was created with 81–91 rows and 100 columns grid size, using the Kriging method of the Surfer software.

Maps of the program, “Simple Ocean Data Assimilation – SODA” (version 2.2.4), were analyzed. This is a collaborative project that has been ongoing since the 1990s, and has the goal of providing an improved estimate of the ocean state that is based on observations and numerical simulations. Presently, it covers the period, 1871–2008, with several improvements since its first version (Carton and Giese, 2008). This oceanic reanalysis data set consists of monthly means of gridded state variables for the global ocean with a resolution of approximately 0.25° × 0.4° horizontally and 40 levels vertically. It provides several oceanic fields, including sea surface height, temperature, salinity and currents, and is based on the meteorological data produced by reanalysis from the European Center for Medium-Range Weather Forecasts (ECMRWF). The maps of the mean values of the meteorological and oceanographic data in the Southeastern Brazilian Bight were selected and were compared to those based on the samplings in this region, at the depths of 25 m (near to the average depth of TW, 20 m) and 317 m (near to the average depth of SACW, 300 m).

In the laboratory, the fish larvae were identified to the lowest possible taxon based on several guides, including Fahay (1983), Moser et al. (1984), Leis and Trnski (1989) and Moser (1996).

The occurrence frequency of larvae (FO%) was calculated based on Guille (1970), and the abundance of fish larvae (larvae m^{-2}) was estimated according to Tanaka (1973). The volume of filtered water (m^3) was estimated by the expression, V=a.n.c, where a=bongo net mouth area; n=flow meter rotation number; and c=calibration index of each flow meter. Community structure indicators, including Shannon–Wiener and Simpson diversity indexes and equitability, were calculated by BioEstat (Ayres et al., 2007) using the base 10 of logarithms.

Based on previous oceanographic studies (Miranda and Katsuragawa, 1991; Mahiques et al., 2004), the area was divided in two subareas as follows: the northern part, from Cape Frio to São Sebastião Island, and the southern part, from São Sebastião Island to the Cape of Santa Marta Grande. The area was also subdivided in the three following zones based on bathymetry: (a) the shelf zone, for stations near 100 m depth; (b) the transition zone, for stations between 100 and 500 m depth; and (c) the oceanic zone, for stations located along the shelf break and the slope area and > 500 m depth (Fig. 1).

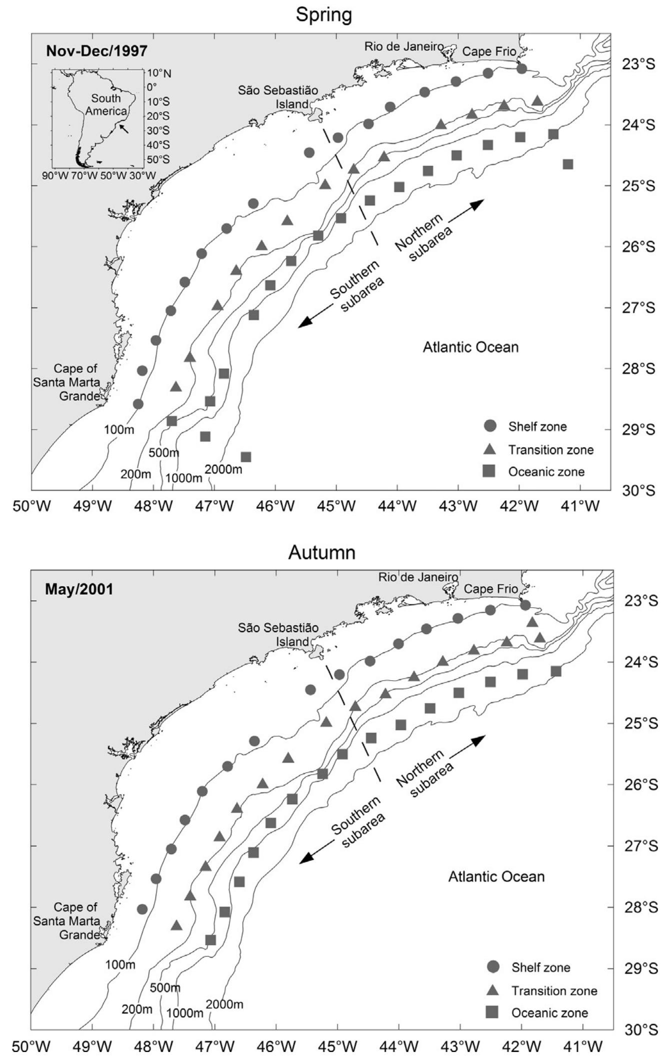

Fig. 1. Study area showing the oceanographic stations in the Southeastern Brazilian Bight during the spring (November–December/ 1997) and autumn (May/2001).

One-way analysis of similarity (ANOSIM) (Clarke, 1993) was used to test whether the larval fish composition differed significantly between the shelf, transition and oceanic stations, using the PRIMER software. This analysis compares the average rank similarities within the pre-defined groups of samples with the average similarity between groups. R-values close to 1 indicate a strong separation between the groups, while an R-value of 0 indicates no differences between the groups. Prior to analysis, the larval abundances were $\log(x+1)$ transformed to reduce the weighting of dominant species, and the similarity matrices used were based on the Bray–Curtis similarity index. The similarity percentage routine (SIMPER) was applied to the data to identify the species characteristic of each larval fish assemblage.

Detrended correspondence analysis (DCA) was performed, and showed lengths of gradients > 3 (spring=4.803; autumn=4.038) that indicate an unimodal trend (ter Braak, 1994). Based on the DCA results, canonical correspondence analysis (CCA) using CANOCO 4.5 was employed to investigate the relationships between larval fish and their environment (ter Braak and Verdonschot, 1995). Larval abundances were $\log(x+1)$ transformed to reduce the weighting of dominant species. Taxa with a frequency of occurrence of less than 10% were eliminated, and rare taxa were down weighted prior to analysis. Five environmental variables, temperature and salinity at