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Ichthyoplankton of Arvoredo Biological Marine Reserve, Santa Catarina, Brazil

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Arvoredo Island, located in Santa Catarina state - south Brazil, and its surrounding area were defined as a Conservation Unit (CU) in the category of Biological Reserve since 1990. This research aimed to analyze the inter-annual and seasonal (winter and summer) variations of ichthyoplankton densities at Arvoredo Biology Marine Reserve (ABMR), and their relationship with environmental variables in 1997/1998 (Campaign 1), 2007/2008 (Campaign 2) and 2008/2009 (Campaign 3). Fish eggs and larvae were sampled using a WP-2 net with 200 µm mesh size. The study area was influenced by three water masses, (i) Coastal Water throughout the whole year, (ii) Subtropical Shelf Water during the winter, and (iii) South Atlantic Central Water mainly in summer. A total of 4,891 eggs were collected and classified as Engraulidae and *Sardinella brasiliensis* (Clupeidae). The total number of larvae was 467 belonging to 5 orders, 19 families, and 21 species. Taxonomic composition demonstrated a seasonal pattern among periods, with the highest densities of Engraulidae occurring in winter and the families Carangidae, Clupeidae and Gerreidae in summer. The high number of families and abundance of ichthyoplankton observed in ABMR may be important in supplying the adjacent coastal areas impacted by fishing.

A Ilha do Arvoredo, localizada em Santa Catarina, Brasil, e sua região de entorno foram definidas como Unidade de Conservação, na Categoria de Reserva Biológica Marinha, em 1990. Este trabalho teve como objetivo analisar as variações sazonais (inverno e verão) e interanuais das densidades do ictioplâncton na região da Reserva Biológica Marinha do Arvoredo (RBMA), e suas relações com as variáveis ambientais em 1997/1998 (Campanha 1), 2007/2008 (Campanha 2) e 2008/2009 (Campanha 3). Os ovos e larvas de peixes foram coletados com uma rede WP-2 de 200 µm. A área de estudo foi influenciada por três massas d'água, (i) Água Costeira durante o ano todo, (ii) Água de Plataforma Subtropical durante o inverno, e (iii) Água Central do Atlântico Sul principalmente no verão. Um total de 4.891 ovos foram amostrados e classificados como Engraulidae e *Sardinella brasiliensis* (Clupeidae). Um total de 467 larvas foram coletadas e identificadas em 5 ordens, com 19 famílias e 21 espécies. A composição taxonômica mostrou sazonalidade entre os períodos, com as maiores densidades de Engraulidae no inverno e de Carangidae, Clupeidae e Gerreidae no verão. O número elevado de famílias e a abundância do ictioplâncton observada na RBMA podem ser importantes para o enriquecimento das áreas costeiras adjacentes impactadas pela pesca.

Key words: Biodiversity, Conservation Unit, Fish eggs, Fish larvae.

Introduction

Conservation units (CU) are protected areas that have their own rules for use and management, with the purpose of preservation and protection of plant or animal species, the scenic beauty and conservation of cultural and physical resources (IBAMA/GTZ, 1999). On the coast of Santa Catarina State, south Brazil, Arvoredo Island and its surrounding region were classified as Conservation Unit (CU) in the category Biological Reserve (IBAMA, 2006).

Arvoredo Biology Marine Reserve (ABMR) is located 11 km north of the island of Santa Catarina, in the coordinates of 27°09'30''S 48°18'30''W and 27°17'57''S 48°25'30''W (Fig. 1). This region covers a large area in the Atlantic Ocean, with 17,800 hectares and comprises a small archipelago of Arvoredo, Galé, Deserta, and Calhau de São Pedro islands (IBAMA, 2006). The ABMR is influenced by oceanographic processes that promote daily, seasonal and annual variations in the structure of water masses in this region and by physical and chemical changes promoted

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by continental discharge (Matsuura, 1986; Braga & Niencheski, 2006).

Marine Protected Areas (MPA) acts as tools for both biodiversity conservation and fishery management. One example is the increased productivity of the areas surrounding the reserves, which can occur in two ways: (1) larger fish can migrate out of protected areas and be caught with a larger size, and (2) larger fish in protected areas can contribute with a larger number of eggs and larvae to the environment. Therefore, extensive marine reserves that are off limits for fishing activity, can contribute to management strategies, increasing productivity, reducing environmental impacts, increasing the stocks of sedentary organisms, size and age structure, fecundity, and potential spawning (Hilborn *et al*., 2004; Roberts *et al*. 2005, Bohnsack, 1999).

Hilborn *et al*. (2004) describe the lack of scientific studies in the areas of marine reserves, what makes it difficult to understand and evaluate the efficiency and success of these sites. In this sense, Rowely *et al*. (1994) demonstrate that studies are needed to understand the patterns of displacement and habitat for all stages of life cycle (larval, settlement, juvenile, adult, feeding, and reproduction) to implement more effective marine reserves. With this in mind this study proposed the description of the ichthyoplankton community in the ABMR and the influence of physical and chemical processes on the distribution and abundance of species which could serve as a basis for sizing the importance and efficiency of CU to adjacent areas.

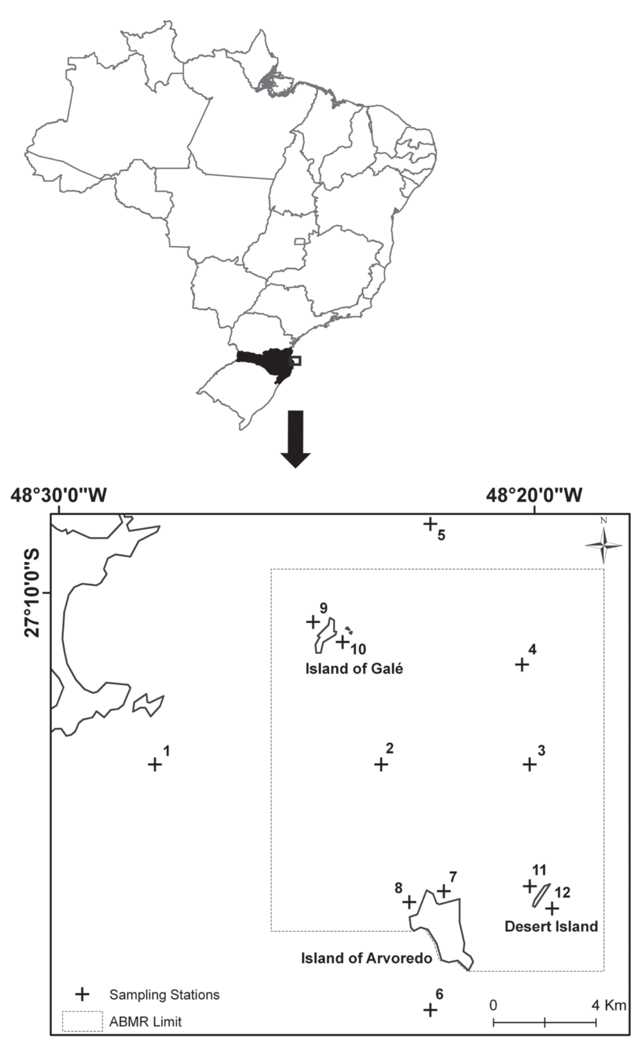

Fig. 1. Location of sampling stations in the Arvoredo Biology Marine Reserve region and adjacent areas in campaign 1 (1997/1998) (stations 7-12), campaign 2 (2007/2008) (stations 1-12) and campaign 3 (2008/2009) (stations 1-12).

Material and Methods

Sampling were conducted during the daytime in the legal limits of the Arvoredo Biology Marine Reserve (ABMR) and along the adjacent area, during the winter and summer in six stations in Campaign 1 (winter 1997 and summer 1998), twelve stations in Campaign 2 (winter 2007 and summer 2008) and twelve stations in Campaign 3 (winter 2008 and summer 2009). The campaigns in 2008 and 2009 used the same sampling stations of the previous year and six additional. The sampling sites were distributed at depths that ranged from 6 to 40 meters (Fig. 1, Table 1). Zooplankton was collected using a WP-2 net which is two meters long with 30 cm in mouth diameter and 200 µm in mesh size, equipped with a flowmeter to determine the volume of water filtered. Horizontal hauls were done near the surface with maximum speed of 2 knots and samples were immediately preserved in a formalin-seawater solution (4%). In order to characterize the region of the ABMR ichthyoplankton samples were analyzed in a laboratory with eggs and fish larvae separated and quantified on Bogorov plates under binocular stereo microscopes. The identifications of ichthyoplankton were made at the lowest possible taxon, using specialized references (*e.g.* Fahay, 1983; Ré, 1999; Moser, 1996).

In Campaign 2 and 3 temperature and salinity were measured with a conductivity, temperature, depth (CTD) sensors (model SD-202, Saiv A/S™), allowing the identification of which water bodies were present at the ABMR, and generate vertical profiles of water column. Water masses were classified according to Castro *et al*. (2006) and Piola *et al*. (2000). The transparency was determined using a Secchi Disk and chlorophyll-*a* was sampled in these two campaigns using 120 mL of sea surface water filtered *in situ* on glass filter of 25 mm in diameter. In the laboratory chlorophyll-*a* was calculated using the technique of high performance liquid chromatography efficiency (CLAE) (Proença, 2002).

A one-way analysis of variance was applied to compare the interannual variation of egg and larvae densities among sampling campaigns in two situations: between three winters (1997, 2007, 2008) and three summers (1998, 2008, 2009) using only six sites (7-12) that were coincident for the three campaigns. In addition, seasonal differences within each campaign were tested using all the sample points. Because data did not show homogeneity of variances by Bartlett's

Table 1. Sampling period described in the Arvoredo Biology Marine Reserve (Brazil) region.

Sampling Campaign	Date	Sampling Stations
Campaign 1	14/08/1997 (winter) 24/01/1998 (summer)	06 (7-12)
Campaign 2	14/08/2007 (winter) 13/02/2008 (summer)	12 (1-12)
Campaign 3	26/09/2008 (winter) 23/03/2009 (summer)	12 (1-12)

test, variables were transformed to $\log_{10}(x+1)$ (Zar, 1984). The posterior Tukey Unequal test was applied to identify significant differences (Gotelli & Ellison, 2004). A cluster analysis was performed to identify similarities among sample locations, based on the abundance of different *taxa* that comprise the ichthyoplankton community. Similarity was measured by using the Euclidean Distance and Ward's Connection Method. In order to determine whether the number of larvae collected was sufficient to represent the species richness, rarefaction curves were generated (Ludwig & Reynolds, 1988). A canonical correspondence analysis was applied to verify correlations between the physical and biological variables on the data matrix of larval abundance for each species (Ter Braak, 1986).

Results

In Arvoredo Biology Marine Reserve (ABMR) a total of 4,166 fish eggs were collected during the winter and 725 during the summer. During the winter of 1997, higher densities of eggs were observed reaching averages values of 181.5 eggs.10m^{-3}. In the winter of 2007, such density was lower, when was registered an average of 2.5 eggs.10m^{-3}, while in 2008 this value increased to 248.9 eggs.10m^{-3} (Fig. 2a). In summer, a similar pattern was observed, with the lowest densities occurring in 2008 (7.1 eggs.10m^{-3}) and the highest in 1998 and 2009 (21.0 and 26.3 eggs.10m^{-3}, respectively). The analysis of variance showed significant differences between the average densities of eggs (F=4.52 e P=0.019) during the sampling period in the winter of 2007 compared with the winters of 1997 and 2008 (Fig. 2a). For the summer period the density of eggs showed no significant difference between the years (Fig. 2a). Regarding seasonality, the analysis of variance showed a significant difference in the campaign, between winter 1997 and summer of 1998 (Campaign 1) and between winter 2008 and summer 2009 (Campaign 3) (F=11.93 e P=0.00005) (Fig. 3a).

Eggs collected belonged to Engraulidae, Clupeidae (*Sardinella brasiliensis*), and not identified species (SI). In winter, the eggs of the Engraulidae were collected in the three years analyzed, representing 95.1% (1997), 12.5% (2007), and 60.6% (2008) of relative abundance (RA) (Fig. 4a). In summer, the family Engraulidae has represented 20.3% in 1998 and 5% in 2008 The specie *S. brasiliensis* occurred only in summer with RA of 29.0% in 1998, 21.7% in 2008, and 4.7% in 2009 (Fig. 4b).

A total of 263 fish larvae were collected during the winter and 204 during the summer. In the winter of 1997, larvae occurred at low densities, an average of 3.7 eggs.10m^{-3}. In the winter of 2007, the average density observed was 6.8 eggs.10m^{-3}, and in 2008 it reached an average of 19.2 eggs.10m^{-3}. The analysis of variance didn't showed significant differences among winter samples in the three campaign (Fig. 2b) (F=7.24 e P=0.003). In the summer of 1998, the average density of larvae was 1.7 eggs.10m^{-3}, and higher values were observed for 2008 and 2009, with 15.2 and 6.0 eggs.10m^{-3}, respectively. The analysis of variance showed significant differences among between summer the 1998 and summer the 2008 (Fig 2b). Seasonal comparisons for each campaign showed significant differences in larval densities for Campaign 3 (Fig. 3b) (F=9.74 e P=0.0002).

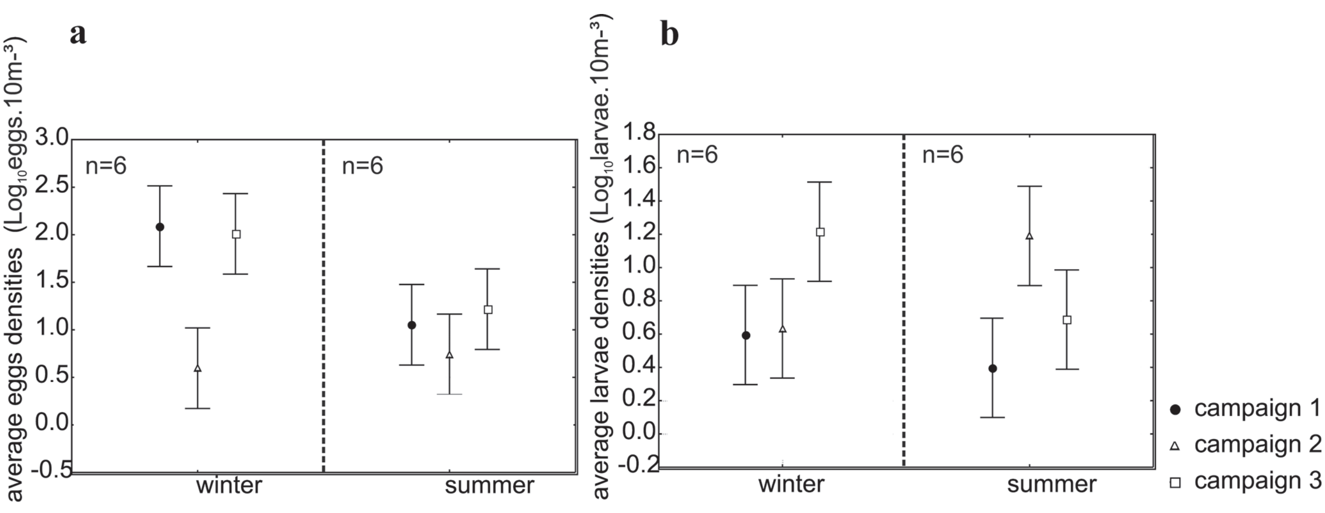

Fig. 2. Average densities of (**a**) eggs and (**b**) larvae collected during the winter and summer periods to six stations in the Arvoredo Biology Marine Reserve (Brazil) in different campaign (1- 1997/1998, 2- 2007/2008, and 3- 2008/2009). The vertical bar represents the confidence interval.

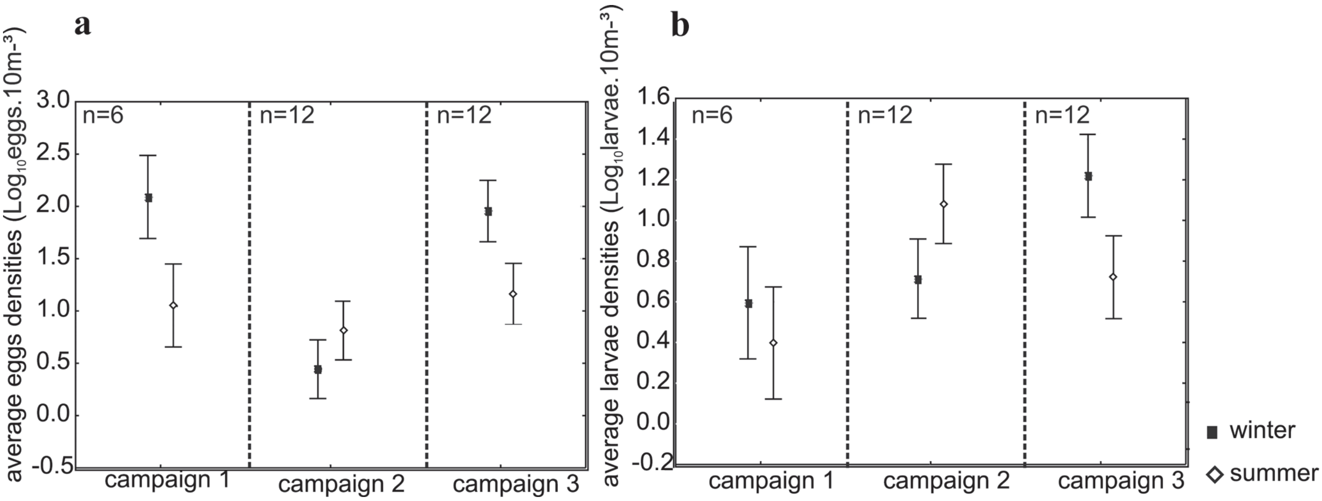

Fig. 3. Average densities of (**a**) eggs and (**b**) larvae collected in the Arvoredo Biology Marine Reserve (Brazil) in to six stations in campaign 1 (1997/1998), twelve stations in campaign 2 (2007/2008) and twelve stations in campaign 3 (2008/2009), during the winter and summer periods. The vertical bar represents the confidence interval.

In relation to larval stage, preflexion was predominant in the samples, which has resulted in taxonomic classification, for most individuals, in the family level. After the whole material of the three campaigns was indentified 19 families and 21 species were found (Table 2), being the taxa *Mugil* sp., Gerreidae, *Harengula clupeola*, *Hypleurochilus fissicornis*, *Scartella cristata*, Gobiidae, Sciaenidae, and Engraulidae the ones who showed the highest frequencies of occurrence (FO) (≥ 10%) and relative abundance (RA) (≥2%). In winter, the families that had the highest values of FO and RA were Blenniidae, Engraulidae, Gobiidae, and Sciaenidae (Fig. 5a), opposing from those found in summer that were represented by Carangidae, Clupeidae, Gerreidae, Paralichthyidae, and Synodontidae. Engraulidae larvae were the most abundant in winter, ranging from 61.3 to 90.5%. On the other hand, Clupeidae were the most abundant family in the summer of 1998 (39.3%), Gerreidae in 2008 (26.4%) and Carangidae in 2009 (24.4%) (Fig. 5b). The analysis of similarity allowed the identification of two groups, one in summer and other in winter (Fig. 6), indicating a strong seasonality in the composition of ichthyoplankton, showing the same pattern of density of species in the three campaigns for each period. Through the rarefaction curves reconstructed, the largest number of species occurred during summer, when the curves remained growing, while in winter such curves tended to stabilize (Fig. 7).

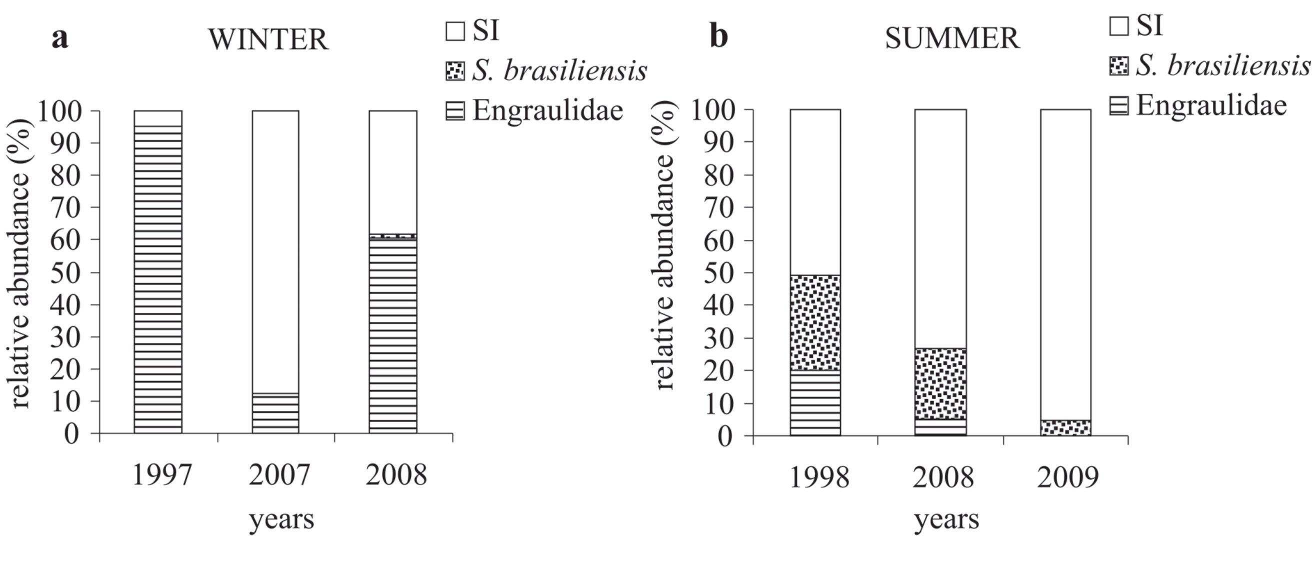

Fig. 4. Relative abundance (%) of eggs collected in the Arvoredo Biology Marine Reserve (Brazil) during the winter (**a**) and summer (**b**) in campaign 1 (1997/1998), 2 (2007/2008) and 3 (2008/2009). SI: not identified species.

Table 2. Larval fish collected the Arvoredo Biology Marine Reserve (Brazil) region, during the winter and summer period in campaign 1 (1997/1998), 2 (2007/2008), and 3 (2008/2009). Note: RA - Relative Abundance; FO - Frequencies of Occurrence; SE - Standard Error.

	WINTER				SUMMER			
			Density				Density	
Taxa	RA (%)	FO (%)	Mean	SE (±)	RA (%)	FO (%)	Mean	SE (±)
Clupeiformes	1.5	6.7	0.07	0.05				
Clupeidae					0.5	3.3	0.09	0.09
Sardinella brasiliensis (Steindachner, 1879)					7.8	13.3	0.31	0.19
Opisthonema oglinum (Lesueur, 1818)					3.4	13.3	0.28	0.17
Harengula clupeola (Cuvier, 1829)					7.8	30.0	0.78	0.25
Engraulidae	68.4	89.7	7.44	1.32	9.8	23.3	0.98	0.46
Synodus intermedius (Spix, 1829)					2.5	10.0	0.25	0.17
Cosmocampus elucens (Poey, 1868)					0.5	3.3	0.02	0.02
Serranidae					1.0	6.7	0.09	0.06
Carangidae					2.9	3.3	0.27	0.27
Chloroscombrus chrysurus (Linnaeus, 1766)					2.5	16.7	0.18	0.09
Oligoplites sp.					2.5	10.0	0.26	0.16
Selene sp.					2.9	16.7	0.29	0.14
Gerreidae					15.2	20.0	1.46	0.67
Haemulidae					1.5	10.0	0.20	0.11
Sciaenidae	4.9	27.6	0.49	0.28	5.9	33.3	0.51	0.16
Stellifer sp.	1.1	10.3	0.15	0.08				
Stegastes sp.					1.0	6.7	0.10	0.07
Mugil sp.	1.1	3.4	0.14	0.14	2.5	16.7	0.22	0.09
Labrisomidae	0.4	3.4	0.06	0.06	0.5	3.3	0.04	0.04
Malacoctenus delalandii (Valenciennes, 1836)					2.0	10.0	0.19	0.12
Blenniidae					1.0	3.3	0.02	0.02
Hypleurochilus fissicornis (Quoy & Gaimard, 1824)	3.4	20.7	0.22	0.09	3.4	10.0	0.31	0.26
Parablennius pilicornis (Cuvier, 1829)	2.3	6.7	0.31	0.23				
Scartella cristata (Linnaeus, 1758)	0.4	3.4	0.03	0.03	5.4	36.7	0.59	0.15
Gobiidae	8.7	24.3	1.09	0.50	5.9	20.0	0.58	0.28
Sphyraena sp.					1.0	6.7	0.04	0.04
Trichiuridae					0.5	3.3	0.05	0.05
Trichiurus lepturus Linnaeus, 1758	0.4	3.4	0.06	0.06				
Paralichthyidae	0.4	3.4	0.04	0.04	3.4	13.3	0.36	0.19
Etropus crossotus Jordan & Gilbert, 1882	0.8	3.4	0.05	0.05				
Etropus sp.	0.4	3.4	0.05	0.05				
Paralichthys sp.	1.5	10.3	0.19	0.11				
Pleuronectidae	0.4	3.4	0.05	0.05				
Achiridae	0.4	3.4	0.04	0.04				
Not identified species	3.0	20.7	0.35	0.14	6.9	26.7	0.32	0.15

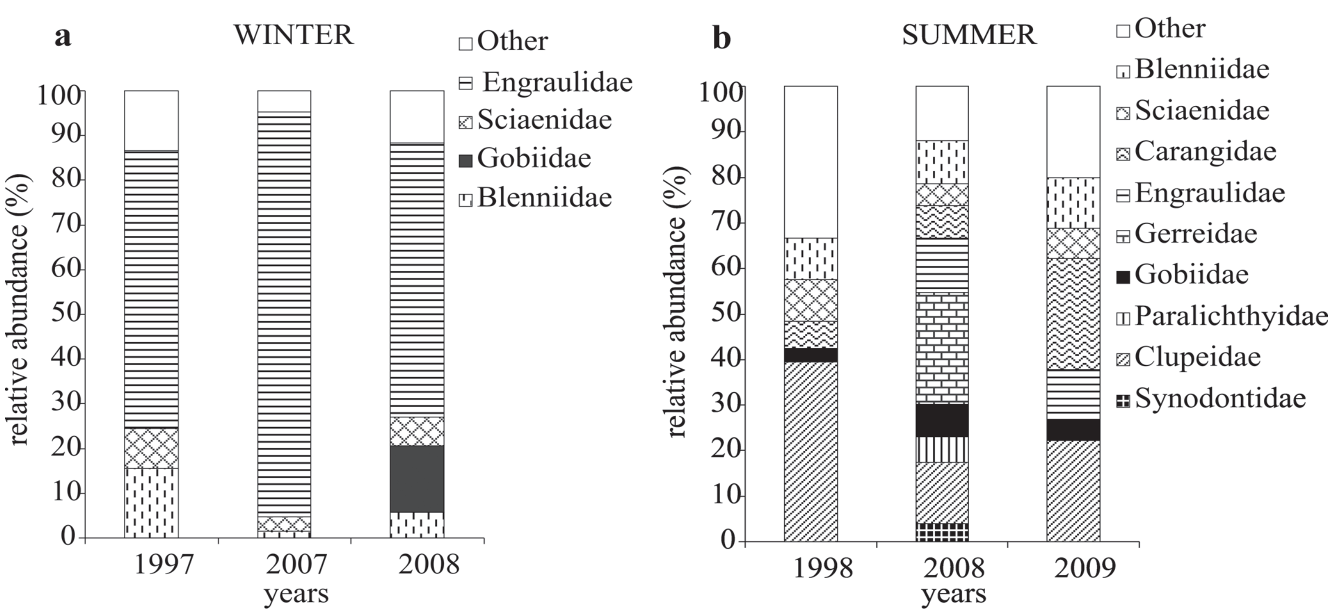

Fig. 5. Relative abundance (%) of larvae collected in Arvoredo Biology Marine Reserve (Brazil) during winter (**a**) and summer (**b**). In campaign 1 (1997/1998), 2 (2007/2008) and 3 (2008/2009).

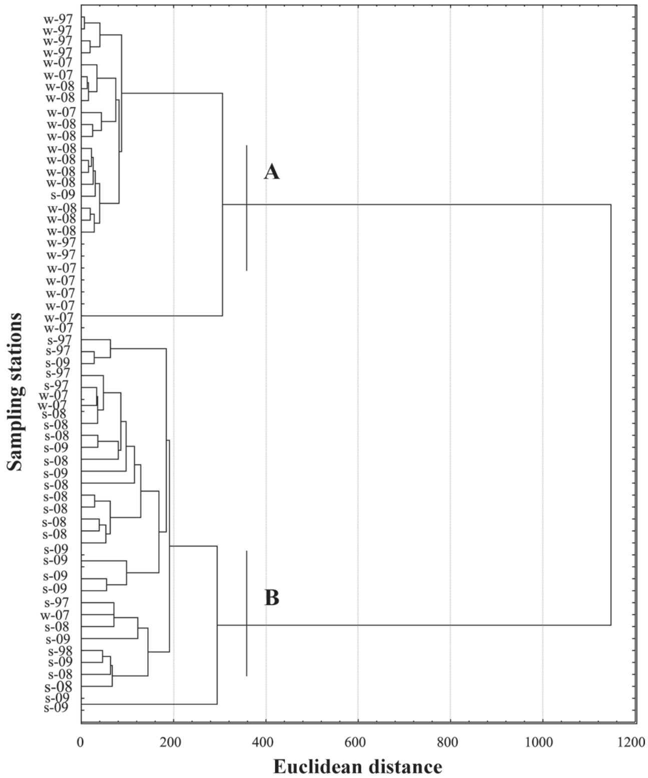

Fig. 6. Cluster analysis of 59 samples collected in the Arvoredo Biology Marine Reserve (Brazil) region during the summer (1998, 2008 and 2009) and winter (1997, 2007, and 2008), based on relative abundance of the different taxa fish larvae identified. Note: w - Winter; s - Summer

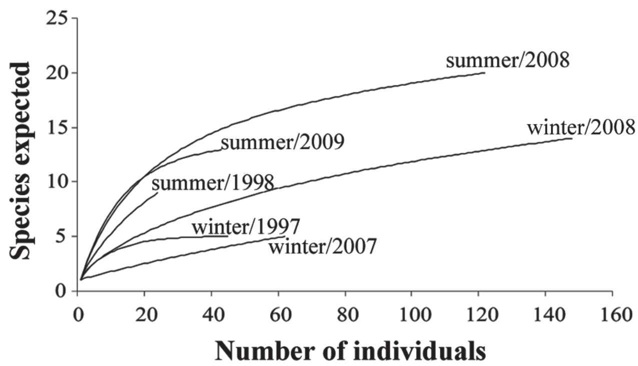

Fig. 7. Rarefaction curve of larval fish species collected during six sampling periods in the Arvoredo Biology Marine Reserve (Brazil) region.

The study area was characterized by the presence of three water masses: Coastal Water (CW), Subtropical Shelf Water (STSW) and South Atlantic Central Water (SACW). In winter period, two water masses were registered, the CW with salinities varying from 29 to 31 and temperatures from 15 to 19°C, and the STSW with salinities varying from 33 to 36 and temperatures from 17 to 20°C (Fig. 8a-b). In summer the CW was present with salinities varying from 27 to 32 and temperatures from 25 to 27°C. In this period was also recorded the SACW, with salinities varying from 35 to 36 and temperatures from 17 and 19°C (Fig. 8c-d). The water column profile observed demonstrate a thermohaline stratification during summer in Campaigns 2 and 3 (Fig. 9).

When both biotic and environmental data were analised through a canonical correspondence, a direct relationship between the abundance of Engraulidae and chlorophyll-*a* was found, with a preference for lower water temperatures. Clupeidae occurred mainly when the water transparency was higher, while the Sciaenidae was associated with higher salinities. It was also confirmed that at higher temperatures a greater number of families was present in the ABMR (Fig. 10).

Discussion

The ichthyoplankton in the region of the Arvoredo Biology Marine Reserve (ABMR) showed different patterns in densities between winter and summer, and among years as well. The highest densities of eggs were registered during the winter, mostly represented by the family Engraulidae. The winter of 2007 showed low density of eggs, significantly difference to the other winter campaigns, fact that reflects the low occurrence of the Engraulidae eggs in this period. This family has a short life cycle and high reproductive capacity (r-strategists), standing out as one of the most abundant in southeastern Brazil, especially in winter months (Matsuura *et al*., 1992; Matsuura & Kitahara, 1995; Katsuragawa *et al*., 1993). Moreover, eggs of Clupeidae (*Sardinella brasiliensis*) were recorded only in the summer months, with a decrease tendency in the density of the years analyzed. Several authors (Lluch-Belga *et al*., 1989; Barange & Hampton, 1997) reported that when anchovies occur together with sardine species in temperate waters their abundances seems to be inversely correlated, fact that can be verified in ABMR.

Anchovy and sardine species presumably compete for food, at least at some stage in their life history (Blaxter & Hunter, 1982; Whitehead *et al*., 1988). Their relative abundance may oscillate as a result of complex ecological relationships between the two species, also affected by predation mortality and human exploitation (Schwingel, 1998). Studies on the food spectrum of adult and larvae of Clupeidae and Engraulidae show that are planktophagous (Blaxter & Hunter, 1982; Schwingel, 1998; Schneider & Schwingel, 1999). Although these families compete for food, the patterns observed in the ABMR could be a reflection of the quality of food available. Vasconcellos *et al*. (1998) show that the feeding success of anchovy larvae off southern Brazil was higher during austral winter. Higher feeding success rates during winter are apparently related to the combined effects of freshwater run-off and the flow of cold waters of Subantartic origin, which result in a strong vertical water stability over the shelf, fact related in the present study for the winter 2007 and 2008, where the Engraulidae represented 90% and 60% of the fish larvae in ABMR, respectively.

The identification of larvae in the region of the ABMR was difficult in the lowest levels. This fact may reflect the methodology used, the net with a mesh of 200mm. Smith & Richardson (1977) describe that the most appropriate methodology for ichthyoplankton sampling are Bongo nets with meshes of 300 and 500mm. However, the 200mm net was used to collect the zooplankton community around the island in ABMR, being a great opportunity to study de ichthyoplankton assemblages in the conservation unit.

The family Engraulidae was the most abundant in winter (> 50%), resulting in a low variability and high dominance of this species in the environment. Conversely, a greater number of taxa were observed in summer, with similar abundances and lower dominance. During the summer, even if with low number of individuals, the richness of species was higher compared to the winter period. This pattern was observed in the three campaigns. Therefore, winter and summer seasons contribute to reproductive processes of different fish assemblages in the ABMR, including pelagic, demersal, and reef species.

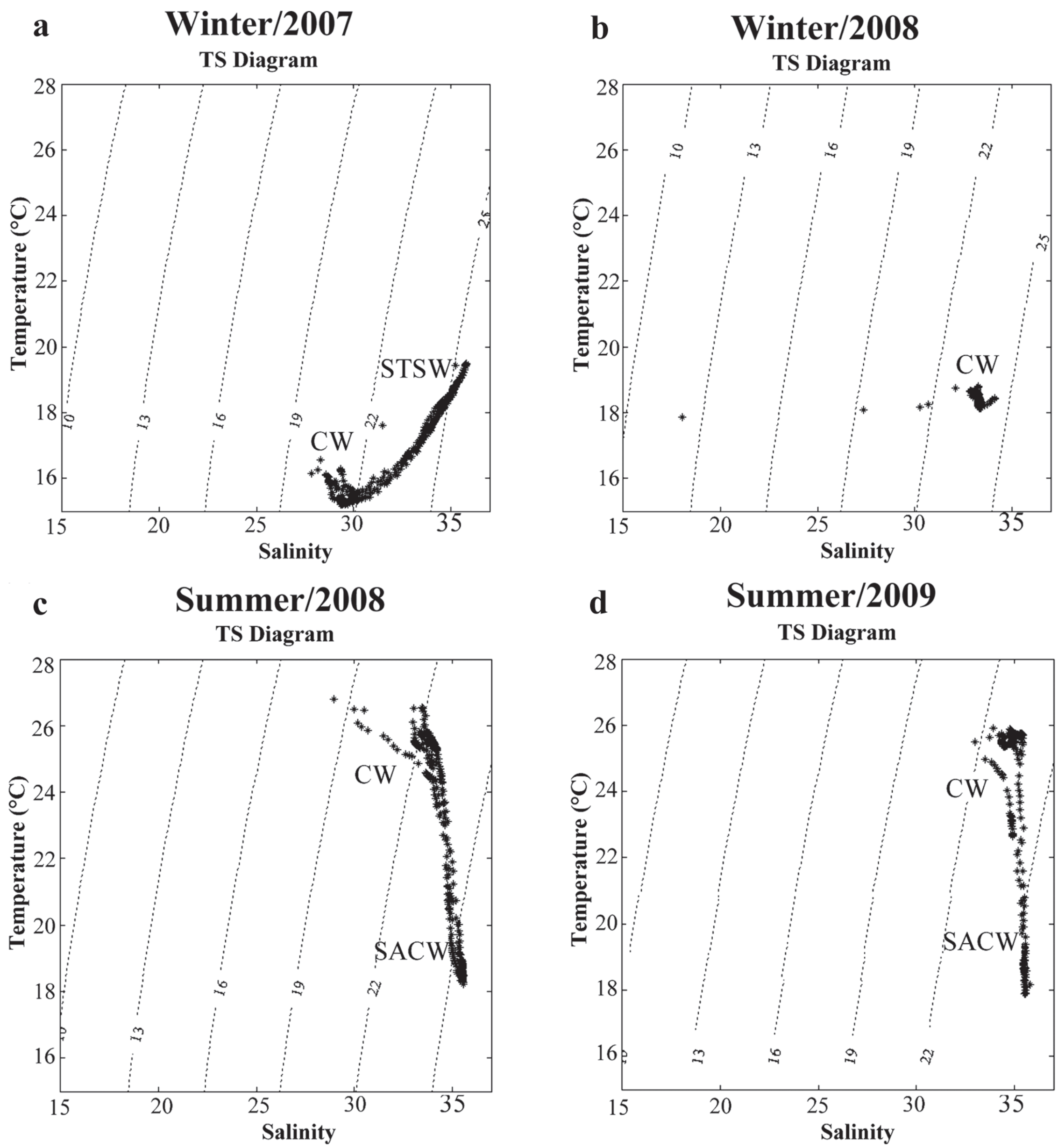

Fig. 8. Temperature and salinity of the water column (Diagram TS) recorded in Arvoredo Biology Marine Reserve (Brazil) region during winter/2007 (**a**), winter/2008 (**b**), summer/2008 (**c**), and summer/2009 (**d**). CW = Coastal Water; SACW = South Atlantic Central Water; STSW = Subtropical Shelf Water.

The variation in densities of ichthyoplankton in the ABMR is influenced by environmental factors such as the dynamics of water masses that occur in the region. The thermohaline conditions verified in Campaign 3 showed a homogeneous water column in winter and stratified in summer, a typical pattern on the continental shelf of Santa Catarina - Brazil (Carvalho *et al*., 1998, Hille *et al*., 2008), what could explain the differences in the densities of ichthyoplankton. In addition, the larvae composition revealed that the greatest abundance of Engraulidae and Gobiidae (representing 76.1%) occurred during the winter and of Carangidae and Clupeidae (representing 46.6%) during the summer. On the other hand, in Campaign 2 was verified the influence of the STSW during the winter, formed by mixing the SACW and the continental input of Rio de la Plata and Patos Lagoon (Piola *et al*., 2000). In the summer period, thermohaline stratification was observed, with the SACW always present in the deeper layer, as also described by Matsuura (1986). In this campaign there was no significant difference in the densities of ichthyoplankton among winter and summer, however, fish larvae assemblages in winter was compose by 90.5% of Engraulidae and in summer, nine families (Gerreidae, Clupeidae, Engraulidae, Blenniidae, Carangidae, Gobiidae, Paralichthyidae, Sciaenidae, and Synodontidae) represented 88.1%. According to Freitas & Muelbert (2004), the narrow width of the continental shelf between Itajaí (27°S) to Cabo de Santa Marta Grande (29°S), increase the influence of SACW on the coast in summer. Braga & Niencheski (2006) described that the rise of SACW promotes a coastal upwelling increasing the nutrients in the photic zone, resulting in a high primary production, favoring the quantity and quality of the food supply for the ichthyoplankton.

In this sense, Kimberley & Suthers (1999) and Rodriguez *et al*. (2004) described that high diversity and an

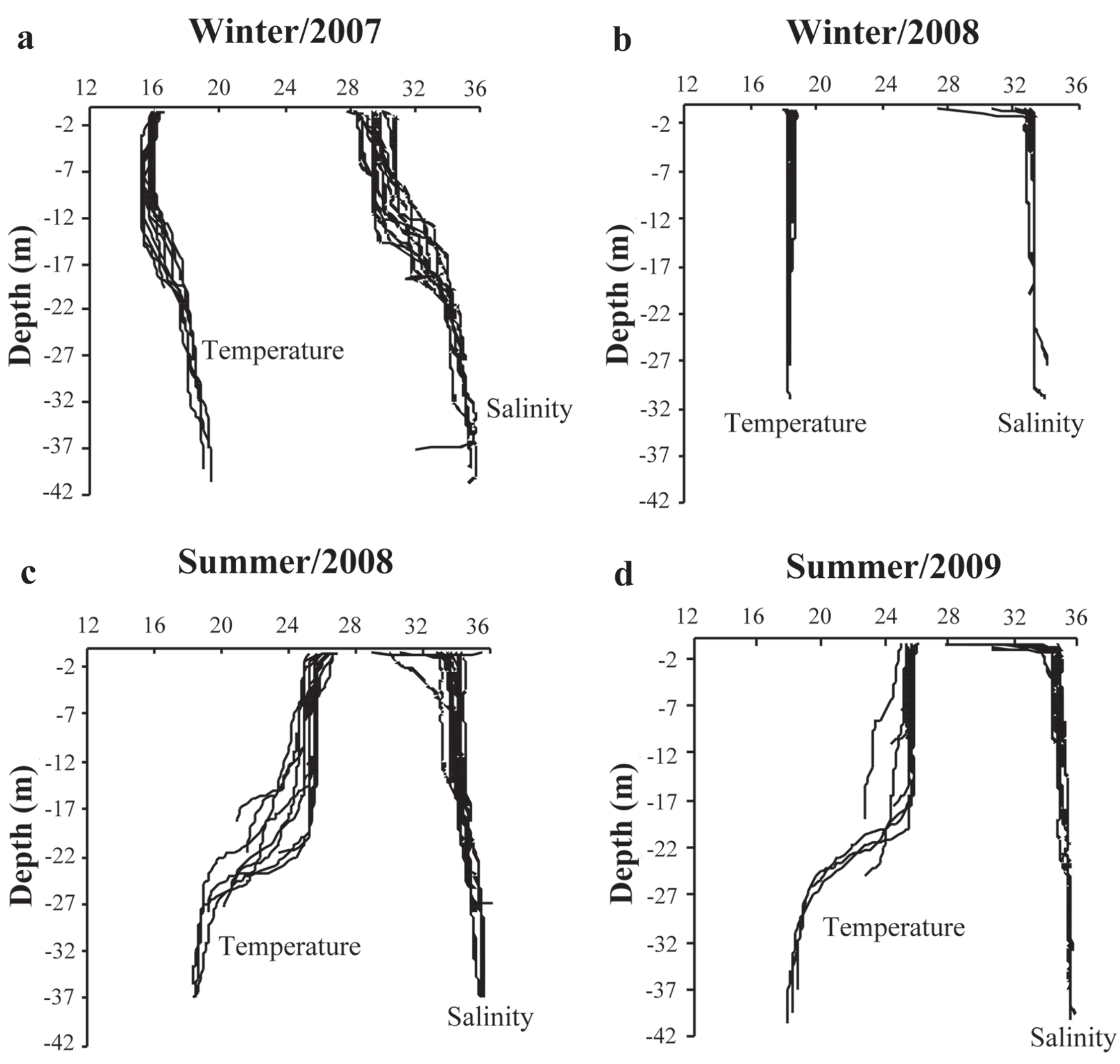

Fig. 9. Profile the temperature and salinity of the water column (Diagram TS) recorded in Arvoredo Biology Marine Reserve (Brazil) region during winter/2007 (**a**), winter/2008 (**b**), summer/2008 (**c**), and summer/2009 (**d**).

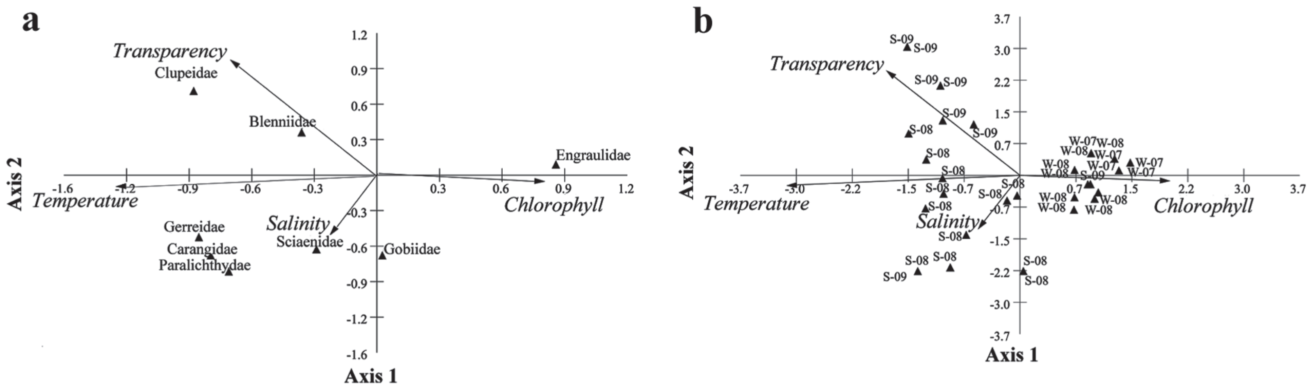

Fig. 10. Canonical Correspondence Analysis of the (**a**) eight most abundant families, and (**b**) stations in Arvoredo Biology Marine Reserve (Brazil) region in relation to temperature, salinity and chlorophyll-*a*. Note: W-07 - Winter/2007; S-08 - Summer/2008; W-08 - Winter/2008 and S-09 - Summer/2009

abundance of fish larvae can be seen in areas where coastal upwelling occurs. The occurrence of the SACW close to the islands of ABMR may be related to the mass effect on those promote on the local hydrodynamics. According Gilmart & Revelante (1974), the mass island effect favors the increase of local primary production, associated to the local hydrodynamics with cyclonic and anticyclonic vortices (Barkley, 1972 *apud* Longhurts & Pauly, 2007). Sabatés *et al*. (2003) showed that the effects of water mass transport may play an important role in the distribution of fish during the early life cycle. Franco-Gordo *et al*. (2003) confirmed this conclusion, identifying relationships between assemblages of ichthyoplankton and environment oceanographic pattern.

A canonical correspondence analysis and cluster analysis showed a strong seasonality in the region, and the thermohaline structure responsible for the taxonomic composition of the ABMR. The family Engraulidae occurred mainly at low temperatures and high concentrations of chlorophyll-a. According Noernberg *et al.* (2007) high values of chlorophyll during the winter season in Itajaí occurred due to fertilization of shelf-waters caused by cold water coming from the South. The distribution of the taxa at ABMR reflects the influence of the local environment however, the standard spawning of adults should also be considered, which reflects the formation of assemblages of fish larvae (Somarakis *et al*. 2002). Hostim-Silva *et al*. (2006) listed the adult fish species found in ABMR, which is consistent with the types of larvae identified in this work. Taxonomic composition of ichthyoplankton in ABMR showed seasonal patterns in the 3 periods sampled. The ichthyoplanktonic assemblage remained at the same rate and abundance after a period of 10 years. This may be a condition to use this area as a reference for future studies of environmental impact on the marine environment in the region.

The high number of families and abundance of plankton observed in ABMR may play a role in enriching the adjacent coastal areas impacted by fishing. This relationship was observed by Sabatés *et al*. (2003) in the Medes Island Marine Reserve (Mediterranean), where species richness and large concentrations of fish larvae were distinct from the nearby coastal regions. Pelc *et al.* (2010), suggests that export of larvae, which are produced in the reserves to adjacent areas may be sufficient to offset the increased mortality due to fishing effort outside reserves. On the other hand, the benefits of marine protected areas do not apply to all species of fish, and the answers to the protection can be highly variable (Claudet, *et al.*, 2006). Russ *et al.* (2004) observed for Reserve Apo Island (Philippines) that biomass of Carangidae and Acanthuridae tripled in a protected area in the period of 18 years, however, fishing in the adjacent area did not change significantly during the same period. Authors also described the benefits of marine reserves for the region: higher catch rates, less fishing effort and enhancement or at least maintenance of total catch. In a review, Gell & Roberts (2003) showed that 24 years after the implementation of Merritt Island National Wildlife Refuge (USA), fishes of family Sciaenidae and Centropomidae were more abundant and bigger, where compared with surrounding fishery areas. In the case of the ABMR, the fact that fish larvae composition and abundance was similar after 10 years, indicated a important role of the reserve for the conservation, considering the high fishing effort off southern Brazil. At the same time, the management measures in the surrounding areas of the reserves are needed to supply the protection offered by conservation areas (Roberts *et al.*, 2005). However, the elucidation of the relationships between the productivity of fisheries and conservation of natural resources need further research, especially to define the maintenance or enlargement of ABMR area.

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