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ICHTHYOPLANKTON DISTRIBUTION AND ABUNDANCE IN THE NORTHERN TODOS OS SANTOS AND CAMAMU BAYS, BAHIA STATE – BRAZIL

Mario Katsuragawa, Maria de Lourdes Zani-Teixeira, Cássia Gôngora Goçalo, Marcio Hidekazu Ohkawara and Michael Kengo Itagaki*

Instituto Oceanográfico da Universidade de São Paulo
(Praça do Oceanográfico 191, 05508-120 São Paulo, SP, Brasil)

*Corresponding author: mkatsura@usp.br

ABSTRACT

The occurrence, distribution and abundance of ichthyoplankton in Todos os Santos and Camamu Bays were analyzed based on four samplings (winter 2003, summer 2003, winter 2004 and summer 2005). Samples were obtained by surface horizontal hauls, using a 200-µm mesh conical-cylinder plankton net. The distribution and abundance of eggs indicate a remarkable seasonal and annual variation of spawning activity in the region, especially when the two summer campaigns are compared. In summer 2003 the highest quantitative values were recorded, especially for Camamu, where the maximum reached 106.56 eggs.m^{-3}, with an overall average of 43.46 eggs.m^{-3} for the two areas. In summer 2005 values were relatively low, the overall average being 3.49 eggs.m^{-3}. The larval taxonomic composition is characterized by the predominance of gobiids, with small variation from summer to winter. Considering all the campaigns and samplings undertaken in both areas, larvae of 11 families were identified: Engraulidae, Clupeidae, Mugilidae, Atherinopsidae, Hemiramphidae, Syngnathidae, Blenniidae, Carangidae, Gobiidae, Achiridae and Tetraodontidae.

RESUMO

O ictioplâncton coletado ao norte da baía de Todos os Santos e na baía de Camamu (Inverno 2003, Verão 2003, Inverno 2004 e Verão 2005) é analisado de forma comparativa. As amostras foram obtidas com redes de plâncton do tipo cônica-cilíndrica de 200 µm de malhagem, em arrastos horizontais de subsuperfície. Os resultados sobre a distribuição e abundância de ovos de peixes sugerem uma ampla variação sazonal e anual da desova. Entre os verões as diferenças foram especialmente visíveis, sendo observados no primeiro verão (dez/03) os maiores valores quantitativos do projeto (máximo = 106,56 ovos.m^{-3}; média = 43,46 ovos.m^{-3}), enquanto que no segundo verão (jan/05) os valores foram em geral baixos (média geral = 3,49 ovos.m^{-3}). A composição taxonômica é caracterizada pela predominância de gobiídeos, com pequenas variações entre o verão e o inverno. Considerando-se todas as campanhas e as duas áreas, foram identificadas larvas de 11 famílias: Engraulidae, Clupeidae, Mugilidae, Atherinopsidae, Hemiramphidae, Syngnathidae, Blenniidae, Carangidae, Gobiidae, Achiridae e Tetraodontidae.

Descriptors: Ichthyoplankton; Fish eggs; Fish larvae; Spawning; RLAM; Camamu; Bahia State coast.
Descritores: Ictioplâncton; Ovos de peixes; Larvas de peixes; Desova; RLAM; Camamu; Costa da Bahia.

INTRODUCTION

The importance of studying estuarine ichthyoplankton resides in the fact that this environment has a great impact in the life cycle of some fish species (RÉ, 1999). Quantitative studies may, therefore, clarify whether a certain species reproduces preferentially in the area, or whether there exist specific strategies of transportation, retention or permanence of planktonic stages within the estuary. Several studies have shown that these environments serve as protection and feeding sites during the initial phases of the life cycle (BARLETTA-BERGAN et al., 2002, GONZALEZ-BENCOMO et al., 2003, BONECKER et al., 2007). The larval fishes are quite fragile and especially susceptible to environmental and water quality variations so that any environmental impact may be catastrophic to these populations.

The ichthyoplankton in Todos os Santos Bay and on the northern coast of Bahia State have been poorly investigated, the main studies so far being those by MAFALDA JUNIOR (1995) and MAFALDA JUNIOR et al. (2003, 2004, 2008). MAFALDA JUNIOR et al. (2004) underscore the need for further investigation into the ecology of ichthyoplankton in this region. For instance, investigations of fish eggs and larvae in the area under the influence of the Landulfo Alves Oil Refinery (RLAM) would contribute to a better understanding of the structure and function of the local ecosystem, providing grounds for environmental monitoring in the area as well. Thus, the present work aims at reporting on the spatial and temporal variations in the specific composition and abundance of ichthyoplankton, through a comparative discussion of the data set. To that end, samplings were carried out in August 2003 (winter 2003), December 2003 (summer 2003), August 2004 (winter 2004) and January 2005 (summer 2005), in the northern Todos os Santos Bay near the Landulfo Alves Oil Refinery and in Camamu Bay. This study is part of the "Program of Environmental Monitoring of the Estuarine Ecosystem in the Area of Influence of the Landulfo Alves Refinery" – PROMARLAM (a joint project under the auspices of PETROBRAS-CENPES/IOUSP).

Material and Methods

A total of 108 ichthyoplankton samples were collected with a 200-µm mesh conical-cylindrical plankton net using surface horizontal hauls lasting 3 minutes each. On each campaign 15 samples were obtained in the RLAM area in the northern Todos os Santos Bay (TSB), including triplicates, in 5 sections (TSB 5-6; TSB 7-8; TSB 14-15; TSB 15-16; TSB 19-20). In Camamu Bay, a total of 12 samples were collected, i.e., triplicate samples at each of 4 stations (CAM 1, CAM 2, CAM 3, CAM 4) (Fig. 1). The 200-µm mesh conical-cylindrical plankton net, although not commonly used for ichthyoplankton, was suitable for sampling in a very shallow area, and for towing with a small boat, for zooplankton collection.

Samples were fixed, on board, in a 4% buffered formalin solution. In the laboratory, the samples were sorted under the binocular stereomicroscope to separate eggs and larvae from other zooplanktonic organisms. Larvae identification was performed in accordance with MOSER et al. (1984), FAHAY (1983), LEIS and RENNIS (1983), LEIS and TRNSKI (1989) and MOSER (1996).

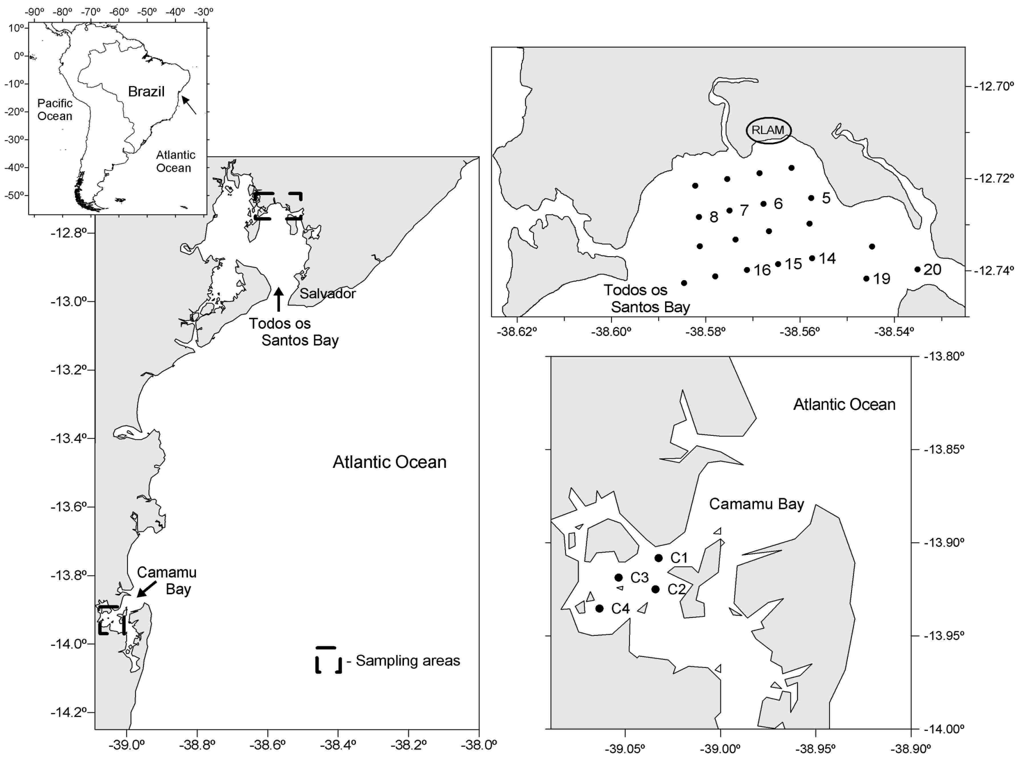

Fig. 1. Map of Bahia State coast, showing the sampling stations in Todos os Santos Bay and Camamu Bay.

The density of eggs or larvae was calculated by $\mathbf{N = X.v^{-1}}$, where **N** is the number of eggs or larvae per m^3, **X** the number of individuals at the sampling station, and **v** the volume of filtered water. The water volume **v** was obtained by **v = a.n.c**, where **a** = area of net mouth (m^2), **n** = fluxometer rotation number, and **c** = fluxometer calibration rate (m/rotation).

A nonparametric Mann-Whitney U-test was used to analyze differences in abundance between the TSB and Camamu. Differences of abundance over the four campaigns were tested with the nonparametric Kruskal-Wallis test and when significant, the Dunn test was also applied. The nonparametric tests were used after checking whether the variances were unequal (ZAR, 1999).

Results

Fish egg Density

The average egg density in the TSB was found to be highly variable (Figs 2 and 3), ranging from 0.09 eggs.m^{-3} (section 5-6, winter 2004) to 52.71 eggs.m^{-3} (section 15-16, summer 2003). For instance, there were some samplings in which no eggs were observed (section 5-6, summer 2005; section 19-20, summer 2003 and summer 2005). However, the highest value was observed in section 15-16, summer 2003 (84.01 eggs.m^{-3}). In Camamu Bay (Figs 2 and 4), the average density varied from 0.03 eggs.m^{-3} (station 4, winter 2004) to 106.56 eggs.m^{-3} (station 2, summer 2003). Considering the four campaigns, sections 5-6 and 19-20 were the poorest in egg density with overall averages of 0.65 eggs.m^{-3} (sd = 0.79) and 1.03 eggs.m^{-3} (sd = 1.07), respectively. On the other hand, sections 15-16 (19.30 eggs.m^{-3}, sd = 23.01) and 14-15 (11.50 eggs.m^{-3}, sd = 5.58) were those with the highest abundance.

The egg abundance in summer 2003 was significantly higher than those of the other campaigns (H = 12.838; p = 0.005), while winter 2003 was the lowest in abundance if both areas are analyzed together (Fig. 2). Comparing both areas (Fig. 5), it can be seen that TSB was the most important area for fish spawning, although statistically no significant difference was found between TSB and Camamu, except for summer 2003. This campaign was an exception, the eggs being more abundant in Camamu (U = 1; p = 0.027) (Table 1).

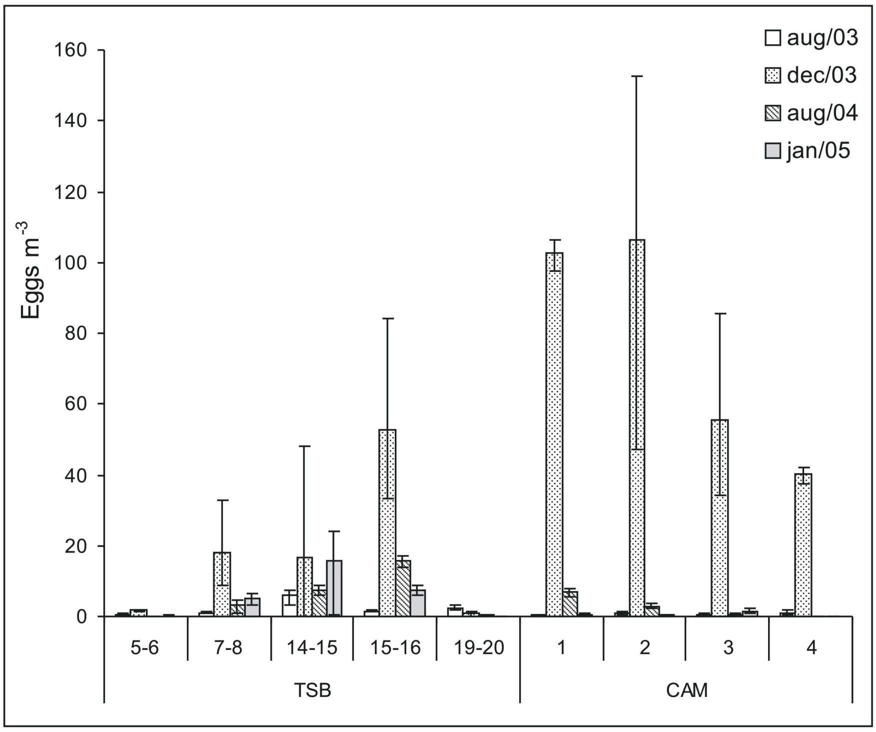

Fig. 2. Egg density (eggs.m^{-3}) in the different sampling sections in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities)

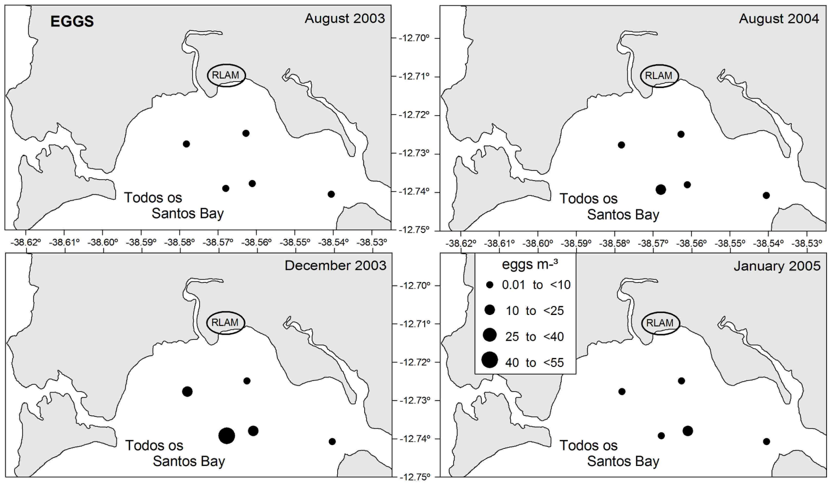

Fig. 3. Horizontal distribution of egg density (eggs.m^{-3}) in Todos os Santos Bay area in the August and December 2003, August 2004 and January 2005 campaigns.

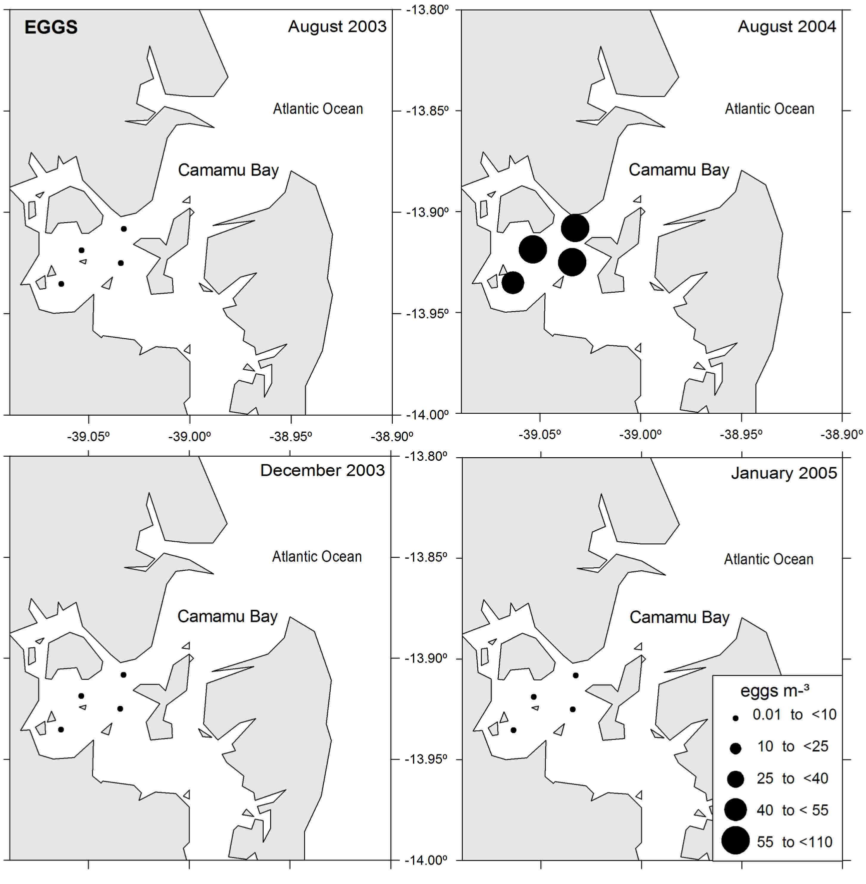

Fig. 4. Horizontal distribution of egg density (eggs.m^{-3}) in Camamu Bay area in the August and December 2003, August 2004 and January 2005 campaigns.

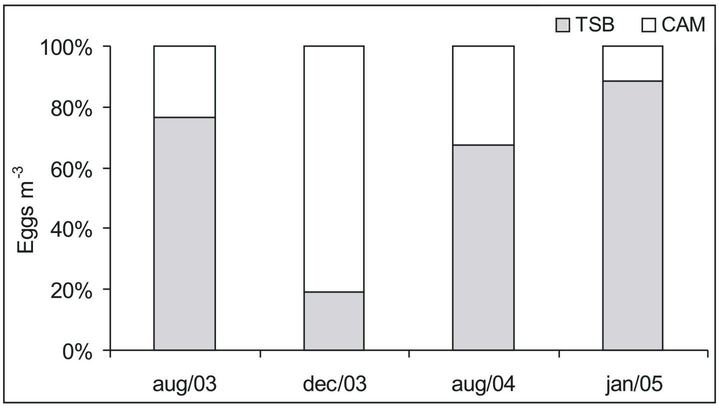

Fig. 5. Comparison of fish egg density in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns.

Table 1. Results of Mann-Whitney U-test comparing the fish eggs density between Todos os Santos Bay (TSB) and Camamu Bay (CAM) in each sampling period.

TSB x CAM	U	Z	p-value
August 2003	2	1.960	0.050
December 2003	1	2.205	0.027
August 2004	7	0.735	0.462
January 2005	8	0.490	0.624

Occurrence, Distribution and Abundance of Fish Larvae

Considering all the campaigns and samplings undertaken in both areas, larvae of 15 taxonomic groups were identified: Achiridae, Atherinopsidae, Blenniidae, Carangidae, Clupeidae, Engraulidae, Gobiidae, Hemiramphidae, Mugilidae, Syngnathidae, Tetraodontidae, Clupeiformes, Perciformes, Pleuronectiformes and Tetraodontiformes. Taxa richness was higher in the TSB area than in Camamu. In fact, in addition to families common to both areas (Achiridae, Blenniidae, Carangidae, Clupeidae, Engraulidae, Gobiidae and Hemiramphidae), families such as Atherinopsidae, Mugilidae, Syngnathidae and Tetraodontidae were present exclusively in the TSB area (Table 2).

Gobiidae were found to be the predominant ichthyoplanktonic group in all the campaigns for both areas when pooled. Considering the sum of the four campaigns, the total abundance of this family was 29.34 larvae.m^{-3}, corresponding to 71.07% of all the larvae collected. Moreover, for the TSB area the relative value was 50.85%, and for Camamu 73.84%. Gobiids were present in both areas on all the campaigns (Figs 6 and 7). In the TSB area the highest abundance was recorded in winter 2003 (2.11 larvae.m^{-3}, sd = 1.28) and the lowest in summer 2005 (0.84 larvae.m^{-3}, sd = 0.56), although the difference between the campaigns was not significant (H = 7.663; p = 0.054). On the other hand, summer 2003 was the period when the highest Camamu abundance was recorded (25.39 larvae.m^{-3}, sd = 15.87). This result was partially due to the exceptionally high figure recorded at station 1, in which one sampling yielded 78.82 larvae .m^{-3} (Fig 8). The lowest average larval density in Camamu was observed in summer 2005 (0.99 larvae.m^{-3}, sd = 0.79) (H=12.507; $p<0.05$). In the TSB area, section 7-8 was the one with the highest average abundance (1.61 larvae.m^{-3}, sd = 1.83), and section 14-15 that with the lowest (0.99 larvae.m^{-3}, sd = 0.62). The maps of gobiid larval spatial distribution in the TSB (Fig. 6) and Camamu (Fig. 7) areas show the variation in abundance that occurred in each section over the sampling period. In the TSB area, it is worth noting that the highest abundance in winter 2003 was not observed in the following winter. Moreover, in summer 2003 the occurrence of gobiid larvae was restricted only to three sections of low abundance, whereas in the following summer they occurred in all the sections and in greater abundance. The difference in abundance between the two areas is very great on all the campaigns (Fig. 8). The advantage of the gobiid larval abundance of Camamu over that of the TSB is clear.

Engraulidae was the second family in abundance, yielding a total value of 1.21 larvae.m^{-3} for all campaigns (Table 2). The occurrence of engraulid larvae was observed in both areas on all the campaigns, except in Camamu in winter 2004. In the TSB area they occurred constantly in sections 5-6, 7-8 and 14-15, but in section 15-16 they were absent in winter 2003, summer 2003 and summer 2005, and in section 19-20 they were absent in summer 2003 and winter 2004. Considering all the campaigns, the highest average abundance value (0.13 larvae.m^{-3}, sd = 0.18) was recorded on the winter 2004 campaign, whereas the highest abundance index, with an average of 0.14 larvae.m^{-3} (sd = 0.20), was obtained in section 14-15. In this area no signs of seasonal variation in larval abundance were observed. The variability of engraulid larval occurrence and abundance was greater in the Camamu than in the TSB area. For instance, this family was totally absent in winter 2004 and at CAM 1 station in summer 2003, whereas a comparatively high abundance was observed in summer 2005 (0.68 larvae.m^{-3}, sd = 0.68). The station with the lowest occurrence and the lowest average abundance (0.06 larvae.m^{-3}, sd = 0.08) was CAM 1, no observation being made in either summer 2003 or winter 2004. On the other hand, CAM 3 station had the highest average abundance (0.45 larvae.m^{-3}, sd = 0.72), the highest quantitative larval value for this family among all the samplings (2.87 larvae.m^{-3}) being recorded in summer 2005. In the Camamu area engraulid larvae were more abundant in summer (Fig. 9).

The average abundance estimated for larvae of the Blenniidae family was 0.33 larvae.m^{-3}, thus ranking third by order of abundance among all the taxonomic groups in the study area (Table 2). Larvae of this family were a little more frequent and abundant in the TSB area than in Camamu (Fig. 10). Concerning the sampling periods in TSB, the highest frequency of blenniids was observed in summer 2003, which was also the period of highest abundance (0.12 larvae.m^{-3}, sd = 0.05). Winter 2004 was the period of lowest frequency, with occurrence only in two sections (7-8 and 14-15). The lowest abundance was recorded in summer 2005 (0.03 larvae.m^{-3}, sd = 0.03). Section 5-6 displayed the highest average abundance value (0.12 larvae.m^{-3}, sd = 0.16) and section 15-16 the lowest (0.02 larvas.m^{-3}, sd = 0.03). In Camamu, their occurrence was restricted to stations CAM 2, CAM 3 and CAM 4, and to the winter 2003, summer 2003 and winter 2004 periods, in general with extremely low abundance. The highest values were observed in summer 2003 (0.05 larvae.m^{-3}, sd = 0.01) and at CAM 2 station (0.03 larvae.m^{-3}, sd = 0.02).

Table 2. Average density of fish larvae (larvae.m^{-3}) by taxon, in the sections sampled in Todos os Santos Bay (TSB) and Camamu Bay (CAM), during the August and December 2003, August 2005 and January 2005 campaigns. (N.I. - fish larvae not identified).

Groups	Aug/03			Dec/03			Aug/04			Jan/05			TOTAL		
	TSB	CAM	Total	TSB	CAM	Total	TSB	CAM	Total	TSB	CAM	Total	TSB	CAM	Total
Engraulidae	0.048	0.081	0.129	0.072	0.201	0.272	0.130		0.130	0.037	0.643	0.680	0.287	0.924	1.211
Clupeidae	0.011	0.093	0.104				0.016	0.007	0.023		0.004	0.004	0.028	0.104	0.132
Clupeiformes							0.016	0.003	0.019				0.016	0.003	0.019
Mugilidae							0.004		0.004				0.004		0.004
Atherinopsidae	0.005		0.005	0.010		0.010							0.015		0.015
Hemiramphidae	0.005	0.008	0.013	0.004		0.004	0.008	0.037	0.045				0.017	0.045	0.062
Syngnathidae				0.005		0.005				0.008		0.008	0.013		0.013
Blenniidae	0.096		0.096	0.121	0.024	0.145	0.044	0.019	0.063	0.025		0.025	0.285	0.043	0.328
Carangidae	0.005	0.043	0.048	0.023	0.010	0.033	0.016		0.016	0.030	0.009	0.039	0.075	0.062	0.136
Gobiidae	1.488	1.357	2.845	0.078	18.367	18.446	0.171	6.952	7.122	0.781	0.150	0.931	2.518	26.826	29.344
Perciformes	0.005	0.017	0.022	0.002		0.002	0.043	0.009	0.052	0.005		0.005	0.055	0.026	0.081
Achiridae	0.004	0.004	0.009		0.007	0.007	0.003		0.003		0.014	0.014	0.007	0.025	0.032
Pleuronectiformes	0.005		0.005				0.006	0.007	0.013		0.006	0.006	0.011	0.013	0.024
Tetraodontidae	0.015		0.015										0.015		0.015
Tetraodontiformes	0.003		0.003										0.003		0.003
NI	0.417	0.232	0.649	0.624	6.136	6.760	0.382	1.761	2.143	0.180	0.139	0.320	1.603	8.268	9.871
Total	2.108	1.835	3.943	0.939	24.745	25.684	0.838	8.794	9.632	1.067	0.965	2.032	4.953	36.338	41.291

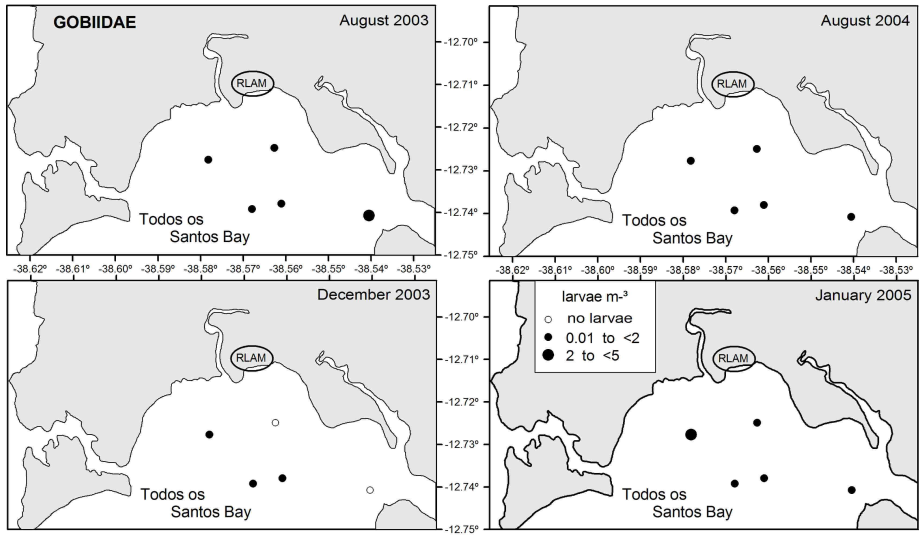

Fig. 6. Horizontal distribution of Gobiidae larval density in Todos os Santos Bay area in the August and December 2003, August 2004 and January 2005 campaigns.

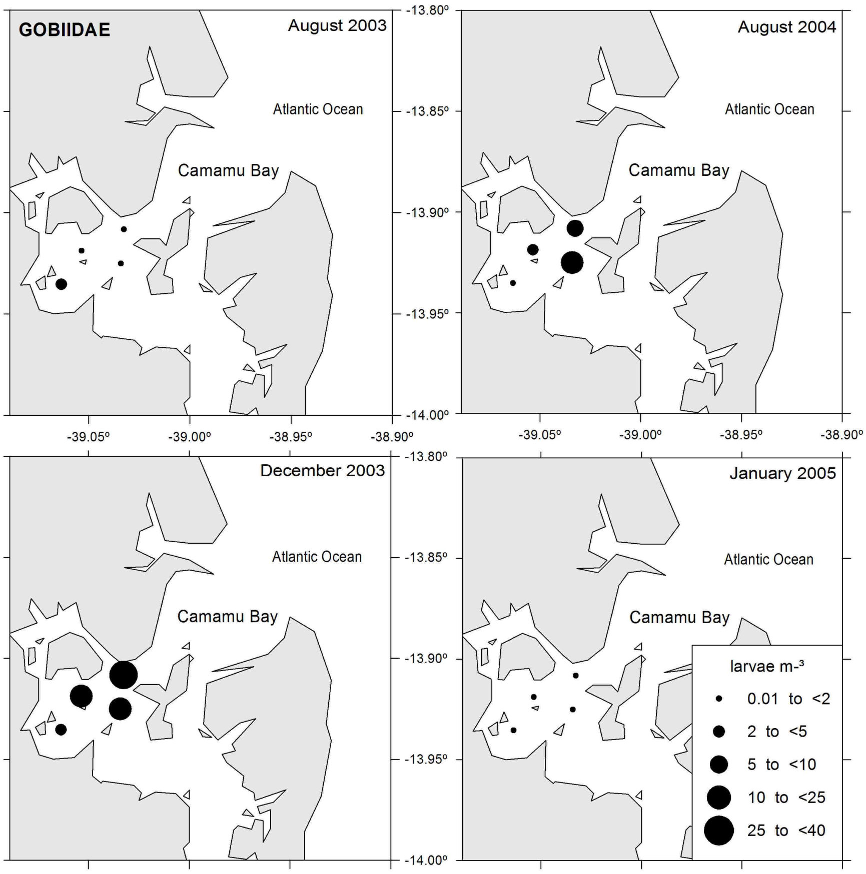

Fig. 7. Horizontal distribution of Gobiidae larval density in Camamu Bay area in the August and December 2003, August 2004 and January 2005 campaigns.

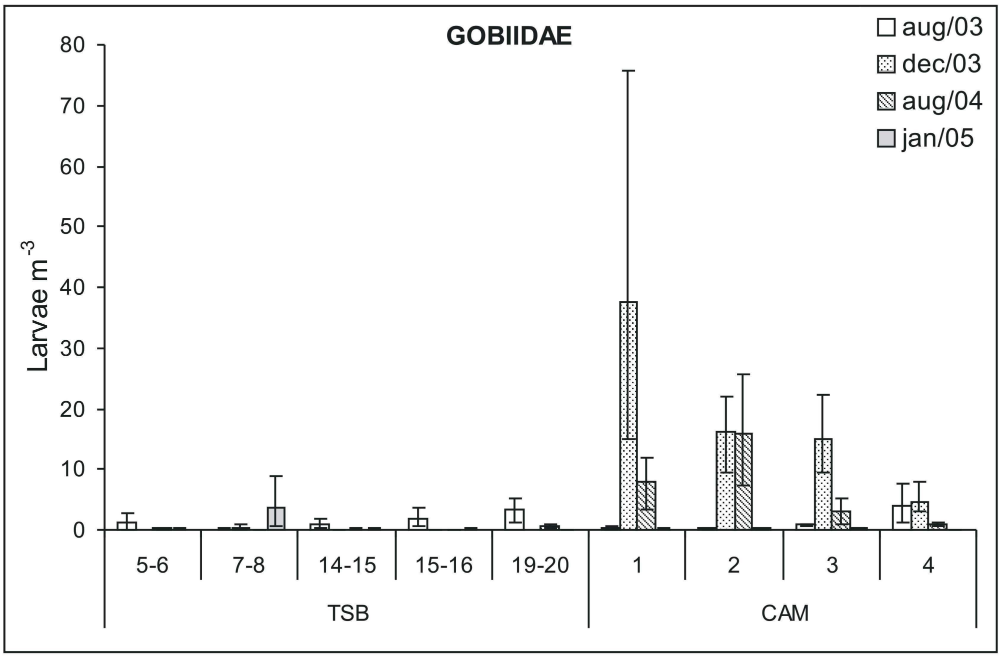

Fig. 8. Density of Gobiidae larvae (larvae.m^{-3}) at the different sampling points in the in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities).

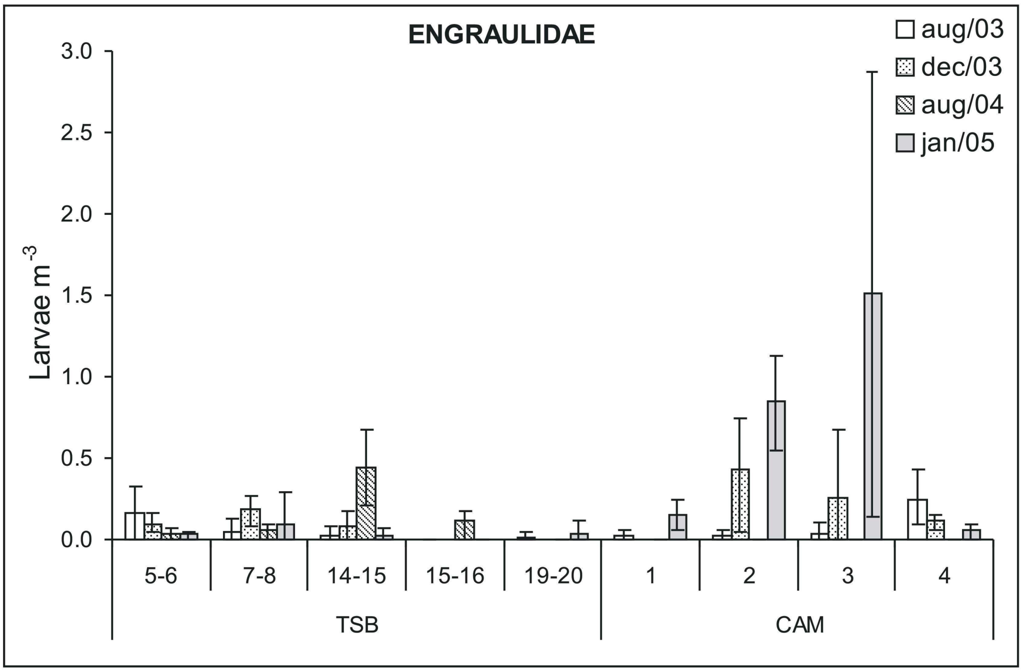

Fig. 9. Density of Engraulidae larvae (larvae.m^{-3}) at the different sampling points in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities).

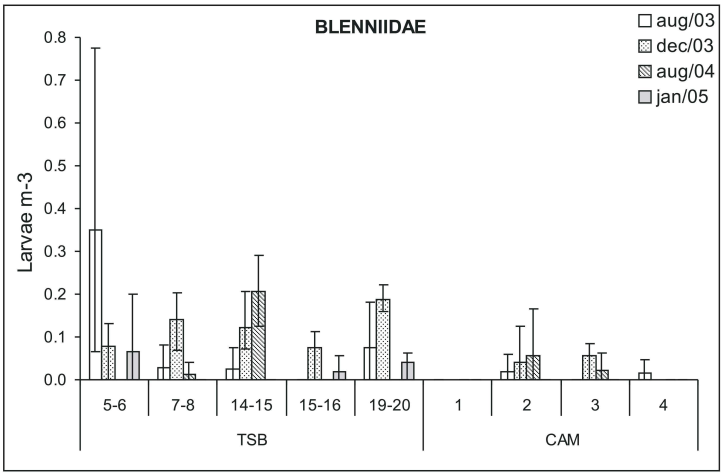

Fig. 10. Density of Bleniidae larvae (larvae.m^{-3}) at the different sampling points in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities).

The total abundance estimated for Carangidae was 0.136 larvae.m^{-3}, the taxonomic group being the fourth in order of importance in the study areas (Table 2). Carangid larvae were more frequent in the TSB area than in Camamu, occurring mainly on the summer campaigns (Fig. 11). The maximum frequency per campaign in TSB was observed in four sections of positive occurrence in summer 2003 and summer 2005, followed by two positive sections in winter 2004 and just one section in winter 2003. Section 14-15 was the only one to feature larval occurrence on all the campaigns. In Camamu, carangids were completely absent in winter 2004, but were present at one station in summer 2005 and at two stations of the winter 2003 and summer 2003 campaigns. Abundance was generally very low in practically all samplings. The highest average abundance value was 0.15 larvae.m^{-3}, observed only at the CAM 4 station.

Clupeids were ranked the fifth most important group, with total abundance of 0.13 larvae.m^{-3}, slightly below that of the carangids (Table 2). Larvae of this family were quite rare (Fig. 12), especially in the TSB area where occurrence was restricted to section 15-16 in winter 2003 and to sections 5-6 and 14-15 in winter 2004. In Camamu, clupeid larvae were collected at CAM 3 and CAM 4 stations in winter 2003, at CAM 2 in winter 2004 and at CAM 1 in summer 2005. In the TSB area abundance was always low, between 0.03 and 0.06 larvae.m^{-3}. In Camamu, abundance values were not much higher, attaining a maximum of 0.60 larvae.m^{-3} in a sampling at CAM 3 in winter 2003. These larvae were collected almost exclusively in winter.

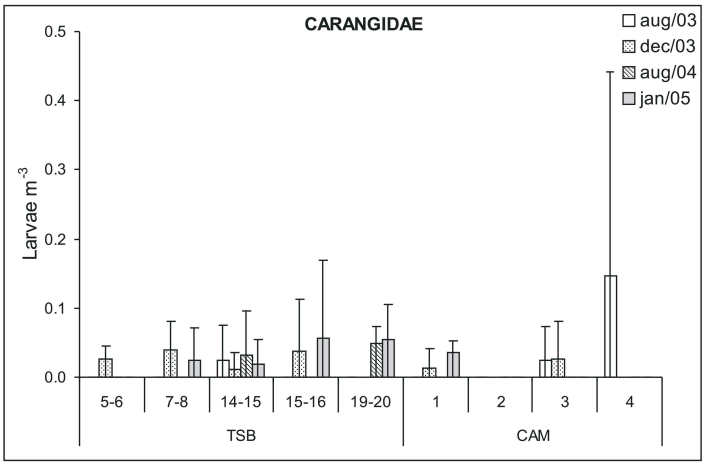

Fig. 11. Density of Carangidae larvae (larvae.m^{-3}) at the different sampling points in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities).

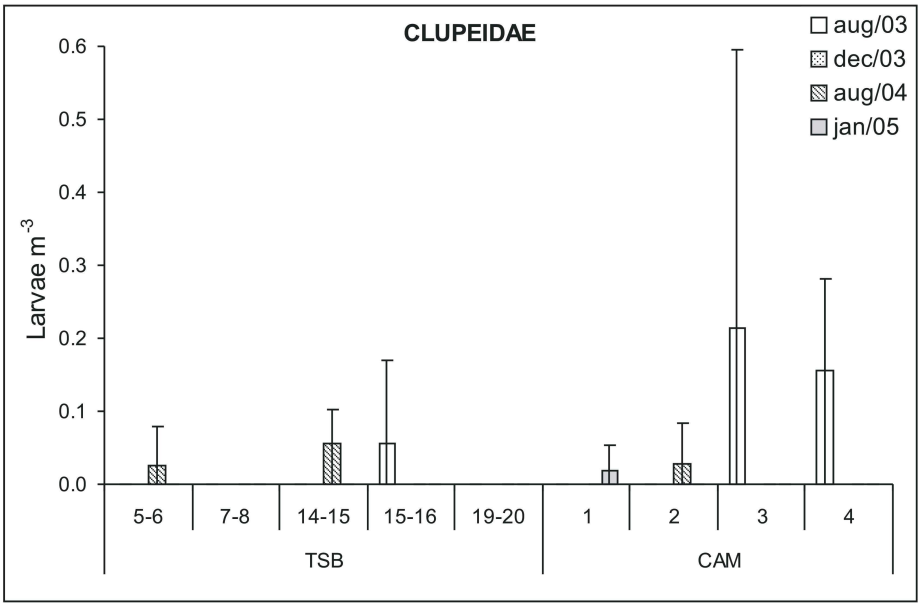

Fig. 12. Density of Clupeidae larvae (larvae.m^{-3}) at the different sampling points in Todos os Santos Bay (TSB) and Camamu Bay (CAM) in the August and December 2003, August 2004 and January 2005 campaigns. (I - minimum-maximum densities)

DISCUSSION

Although no statistically significant difference was found in egg abundance as between the two winters, the results suggest a more heterogeneous spawning activity in the region in 2004/2005 than in 2003. On the 2004 winter campaign, the variability of the fish egg density was found to be high in the TSB area (varying from 0.09 to 15.59 eggs.m^{-3}), as well as in Camamu (from 0.03 to 6.70 eggs.m^{-3}). In the winter 2003 campaign relatively homogeneous data were observed in both areas (0.65 to 5.89 eggs.m^{-3} in TSB and 0.24 to 1.09 eggs.m^{-3} in Camamu). In the summer campaigns, on the other hand, differences in terms of abundance were visible for both areas, although only Camamu presented a statistically significant difference**.** For example, the highest quantitative values were observed in Camamu in summer 2003, where they reached a maximum of 106.56 eggs.m^{-3}. The overall average for both areas was 43.46 eggs.m^{-3}. In summer 2005, by contrast, values were generally low, yielding an average of 3.49 eggs.m^{-3}. There are no previous data of fish egg abundance for this region such as would permit a comparison with the present results; however, the average (3.49 eggs.m^{-3}) approximates to those found in other areas, *e.g.* by JOYEUX et al. (2004) (*ca.* 5.47 eggs.m^{-3}) in the estuarine system of Baía de Vitória, state of Espírito Santo.

In the present study it was not possible to identify a great part of the larvae, due to the small size of the specimens and to taxonomic problems, so that we cannot use our results to discuss the hypothesis that in estuarine regions the ichthyofauna tends to present low diversity (HAEDRICH, 1983). The coastal marine or oceanic areas of tropical regions are known to be characterized by high diversity, as can be seen on the southeastern coast (KATSURAGAWA et al., 1993) or on the eastern coast (NONAKA et al., 2000) of Brazil. KATSURAGAWA et al. (2008), studying the ichthyoplankton around São Sebastião Island on the São Paulo State coast, identified around 30 families of fish larvae on a single cruise. However, our result in terms of taxonomic grouping is important as a first approach as regards the two areas concerned. If we may compare it with a region close to the RLAM, MAFALDA JUNIOR et al. (2004) identified 18 families in the fall, 20 in winter, 17 in spring and 26 in summer, a number that varied according to the time of the year, but which was no higher than that obtained in this study. In the study carried out in Todos os Santos Bay, on the other hand, the 12 families identified by MAFALDA JUNIOR et al. (2008) were quite close to those identified in the present study. Further, the taxonomic composition found by this present study was quite similar to that observed in the Cananéia region by SINQUE and YAMANAKA (1982), in spite of the difference in latitude.

An important aspect of the taxonomic composition of the areas investigated in this study is the vast predominance of gobiid larvae (which was seen on almost all the campaigns) in contrast to what is seen in oceanic regions, which are generally characterized by the predominance of Clupeiformes (KATSURAGAWA et al., 1993, 2008). On Brazil's southeastern coast, gobiid larvae occur throughout the year, but tend to be more abundant in summer (KATSURAGAWA et al., 1993). However, in the areas examined in the present study, this tendency was observed only during the first year, thus preventing us from reaching a definitive conclusion as to the group's reproductive periodicity. Gobiids are oviparous with demersal, adhesive eggs, while the larvae are planktonic. Parental egg care is common (WATSON, 1996a). According to the literature, more than ten genera of the family occur on the Brazilian coast (MENEZES et al., 2003), but so far the larval phases of only two species are known. Larvae of *Gobionellus boleosoma* were recorded by CASTRO et al. (2005) in Guanabara Bay. KITAHARA[1] identified *Gobionellus oceanicus* larvae in the Cananéia-Iguape system. The fact that the larvae collected in the TSB and Camamu areas were all of reduced size and in the yolk-sac stage, rendered identification to species level impossible. MAFALDA JUNIOR et al. (2004) also analyzed the group to the family level, describing its occurrence for all the seasons of the year, observing a relatively high abundance in December, in agreement with the results obtained in December (summer) 2003 in Camamu.

Part of the families observed in the larval collection of the present study included small-sized fish, *e.g.* blenniids, gobiibs, atherinopsids and syngnathids, typically inhabiting shallow waters from intertidal rocky shores to estuaries and bays. No adult specimens of these groups were collected in the RLAM area (DIAS et al., 2011), but they are all of special interest because their early development is associated with a variety of adaptations, such as eggs carried by males, demersal eggs adhering to substrates and eggs protected by parents until hatching (BALON, 1975; WATSON, 1996b,c; WATSON and SANDKNOP, 1996). It seems, therefore, that these fish groups are particularly dependent on the local ecosystem during the initial phase of their life cycle, so that any impact on coastal environments may cause severe damage to stocks, whether directly on the eggs and larvae, or by destroying the environments that act as nursery grounds for the species.

(1) KITAHARA, E. M. 2009 Laboratory of Planktonic Systems, Oceanographic Institute of the University of São Paulo. Praça do Oceanográfico, 191; ZIP 05508-120 São Paulo-SP, Brazil. Personal commun.

It is known that many species present in the study area constitute important fishery resources for riverside dwellers, whether by subsistence or artisanal fishing. Among the groups that occurred in the ichthyoplankton, the following families whose adults are used as food items are noteworthy: Clupeidae and Engraulidae, Carangidae and Achiridae. This group includes small to medium-size pelagic fishes, all of them oviparous with planktonic eggs and larvae. For instance, engraulids are also considered of vital importance for marine ecosystems because they belong to lower trophic levels and act as links in the trophic chains, between the producers at the base and predators such as larger fishes or birds. The diversity of occurrence of this group is characterized by some families such as carangids present at all stations, albeit in low abundance, to those restricted to a specific period of the year, such as the Clupeidae family, sampled only in the winter campaigns in the TSB area. This periodicity of occurrence does not always coincide with data collected elsewhere on the Brazilian coast. The results of MAFALDA JUNIOR et al. (2004) on the northern coast of Bahia State, for instance, show that engraulid larvae were present as the most abundant group in fall and winter, while they did not occur in spring, and were present in relatively low abundance in summer. In the present study, these larvae always occurred in low abundance, tending to larger numbers in summer. These data indicate that different groups adopt different spawning strategies in the area and, in view of the fact that they are exploited by fisheries, further investigations should be carried out in order to improve our knowledge of their stock dynamics.

The present results indicate that the fish species, especially those of the Engraulidae family, inhabiting the northern TSB and Camamu areas use these environments intensively as spawning grounds or, in the case of at least 11 families, as an area for feeding and growing during the initial phase of their life cycle. This picture is similar to the descriptions of other estuarine regions and related habitats in various parts of Brazil and the world (WEINSTEIN and BROOKS, 1983; TOLAN et al., 1997; RÉ, 1999; GONZALEZ-BENCOMO et al., 2003; BONECKER et al., 2007; ITAGAKI et al.[2], *undergoing preparation*). The use of the site for spawning can also be confirmed by the presence of females with gonads in an advanced state of development. This feature has been observed for the carangid *Oligoplites saurus* in the TSB, where females in an advanced stage of gonadal maturation (hydrated females) have occurred

(2) ITAGAKI, M. K.; KATSURAGAWA, M.; PIMENTEL, C. M. M.; OLIVEIRA, I. da R.; OHKAWARA, M. H. Early development of fat snook, *Centropomus parallelus* (Teleostei: Centropomidae) from southeastern Brazil. (undergoing preparation) .

(DIAS et al., in this volume). Larvae of *Oligoplites spp*. were present among the carangids, showing that in this case the larvae are the result of a successful local spawning.

The presence of eggs and larvae may be the result of the spawning of fish either in these regions or elsewhere, they then being transported into the bay to develop, the region acting as a nursery. Several physical processes, such as tidal currents, double-layer circulation, coastal currents and wind-driven surface currents, involved in the transport of organisms, are considered in the conceptual model of dispersal (HETTLER and HARE, 1998). For example, MIRANDA et al. (2011) observed that the movement of surface currents in the estuarine area affected by the Landulfo Alves Refinery took place in a N-S direction, driven by the tide in both periods (maximum intensity of 0.22 m/s in the winter and 0.73 m/s in the summer). These currents could contribute to the dispersal of the fish eggs and larvae within the estuary and also to their transportation out of the region. For instance, the lowest values in the area, in terms of egg density in both periods, as well as of larvae in the summer campaign, were observed in section 5-6 of the TSB, the section closest to the refinery. However, on the winter campaign the larval values in this section were above the area's overall average.

Hydrographic factors are of fundamental importance in the process of fish reproduction, incubation and larval development. Results from physical oceanography (MIRANDA et al., op. cit.) indicate thermal and haline structures with the following configurations in the TSB area: in winter 2003 extreme values ranged from 25.58 to 26.3°C and from 31.99 to 32.66; in summer 2003 from 28.94 to 29.72°C and from 33.99 to 36.37; in winter 2004 from 23.80 to 24.12°C and from 31.67 to 33.07; and in summer 2005 from 29.20 to 30.13°C and from 34.08 to 35.64. Both temperature and salinity were, therefore, higher in summer than in winter. This seasonal variation in hydrographic data did not, apparently, affect the taxonomic composition. In terms of reproductive activity, clear differences were observed in the first year with a significant increase in egg numbers in December, but in the second year the variations were not as evident. MAFALDA JUNIOR et al. (2004) suggest that the cycle between rainy and dry periods may be correlated to the greater or lesser density of fish eggs and larvae in the region. The high salinity value between 34 and 36 indicates a strong marine contribution and a weaker influence of continental waters in the TSB area, which may contribute to the transport of organisms, including fish eggs and larvae, from the marine region into the estuary. It is possible that the fish reproduction process and the abundance of fish eggs and larvae in these places do not constitute purely seasonal events, but are related to several other factors, both biotic and abiotic, affecting the dynamics of the ecosystem, either favoring or hindering the embryonic and larval development of fish species.

When the results of the ichthyoplankton are compared with those relating to the ichthyofauna, some disagreement may be observed. For example, engraulids with abundant eggs and larvae were not frequent in the ichthyofauna samplings. There may be many reasons for this, *e.g.* adults leaving the area, adults not being captured by the "abalo" nets (a local kind of gillnet), or spawning not taking place during the campaigns. The lack of information concerning the early life stages of local fish species greatly limited the identification of both eggs and larvae. However, after the analysis of the results, it has became clear that the area affected by the RLAM is one of spawning and/or development for many fish species such as gobiids, engraulids, blenniids, carangids and clupeids, among others.

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