BRAZILIAN JOURNAL OF OCEANOGRAPHY, 55(2):97-107, 2007

ZOOPLANKTON ASSEMBLAGES FROM A TIDAL CHANNEL IN THE BAHÍA BLANCA ESTUARY, ARGENTINA*

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ABSTRACT

In this study we investigate for the first time the zooplankton assemblages in a relatively small tidal channel called Bahía del Medio, situated in the middle-outer area of the Bahía Blanca Estuary, South of the Main channel. We focused the study on micro- and mesozooplankton assemblages with emphasis on tintinnids, copepods and meroplankton along the annual cycle 1997-1998. Fifteen species of tintinnids belonging to 6 genera were observed in the study area, the mean total tintinnid abundance fluctuating between 3.4 x 10^6 ind. m^{-3} and 5.1 x 10^6 ind m^{-3}. The mesozooplankton comprised 11 taxa, total abundance fluctuating between 449 ind m^{-3} in March 1997 and only 1 ind m^{-3} in October 1997. The channel proved to be spatially homogeneous in its physical and biochemical features. Micro- and mesozooplankton abundance displayed a high degree of spatial homogeneity, though the seasonal variation in both environment and zooplankton was significant. Comparison with the zooplankton observed at a station in the Main channel of the estuary showed differences in number of taxa represented, a general lower abundance of both assemblages and the presence of some rare species, a fact which is discussed.

RESUMO

Neste estudo pesquisamos pela primeira vez as associações do zooplâncton num pequeno canal de maré, relativamente novo e chamado Bahía del Medio, localizado na região média-exterior do estuário da Bahía Blanca e ao sul do canal principal. Focalizamos o estudo no micro- e mesozooplâncton com ênfase nos grupos Tintinnida, Copepoda e meroplâncton, ao longo do ciclo anual 1997-1998. Foram observadas 15 espécies de Tintinnida pertencentes a 6 gêneros; a abundância média total de Tintinnida variou entre 3,4 x 10^6 ind. m^{-3} e 5,1 x 10^6 ind. m^{-3}. O mesozooplâncton apresentou 11 taxa e uma abundância total entre 449 ind. m^{-3} em março de1997 e 1 ind. m^{-3} em outubro de 1997. O canal provou ser espacialmente homogêneo em suas características biológicas, químicas e físicas. A abundância do micro- e mesozooplâncton mostrou um alto grau de homogeneidade espacial, embora a variaçao estacional fosse significativa nas características do meio ambiente e do zooplâncton. A comparação com o zooplâncton observado em uma estação de amostragem no canal principal do estuário mostrou diferenças no número de taxa, na abundância, em geral mais baixa, e na presença de algumas espécies raras , fato esse comentado.

Descriptors: Tidal channel, MICROZOOPLANKTON, Tintinnids, MESOZOOPLANKTON, Copepods, Meroplankton, Estuary, Seasonal variation.
Descritores: Canal de maré, Microzooplâncton, Tintinnida, Mesozooplâncton, Copepoda, Meroplâncton, Estuário, Variaçao estacional.

INTRODUCTION

In estuaries, zooplankton assemblage characteristics and its spatial distribution are mainly influenced by the circulation pattern and tides (Valiela, 1995). These factors produce strong effects on the horizontal distribution of meroplankton forms (Seliger *et al*., 1982). The complex hydrodynamics of the Bahía Blanca estuary combined with other factors influence both biodiversity of microzooplankton (Barría de Cao *et al*., 2006) and horizontal distribution by means of the passive transport of planktonic larvae (Cervellini, 2001).

The study environment is a turbid and temperate estuary classified as mesotidal, located on the Atlantic coast of Argentina at 38º42´-39º25´S;

(*) Paper presented at the 2nd Brazilian Congress of Oceanography, on 09-12 October 2005. Vitória, Brazil.

61º50´-62º22´W (Fig. 1) and comprising an area of 2,300 km^2 at low tide (Angeles, 2002). It is made up of a complex network of tidal channels, extensive tidal flats, low marshes and islands (Ginsberg & Perillo, 2004). The general circulation is dominated by a stationary and semidiurnal tidal wave (Serman, 1985). The Sauce Chico River (basin of 1,600 km^2), the Napostá Grande Stream (920 km^2) and other minor creeks provide a less freshwater flow increasing along the year only during rainfall periods. (Pettigrosso *et al*., 1997). The Main channel of the estuary constitutes the access to an important harbour complex (Galvan, White & Rosales Ports) on the Argentine coast; its mean depth is 10 m, maintained by means of dredging, with depths up to about 22 m at the mouth (Aliotta & Perillo, 1987).

Piccolo & Perillo (1990) distinguished two sectors in the Main channel of the estuary based on the distribution of temperature and salinity values. The inner area extends from Ing. White Port up to the estuarine head and is partially mixed during normal-high runoff conditions, with a strong tendency to become transversely homogeneous during low runoff.

Though abundant data on the plankton from the Main channel are available, there is a comparative lack of knowledge on plankton from the channel systems located at the southernmost part of the Bahía Blanca Estuary (Falsa Bay, Verde Bay, Brightman Cove and secondary small channels towards the south from the Main channel which is an almost unexplored region (Piccolo & Hoffmeyer, 2004).

The different types of channels occurring within the Bahía Blanca estuary are large tidal channels, creeks and gullies and smaller channels in general, presenting a reversible circulation (Ginsberg & Perillo, 2004). Different plankton associations can inhabit these channels, depending on the geomorphologic and hydrodynamic characteristics, with some differences in composition from those known to occur along the Main channel of the estuary, and perhaps giving rise to some differences in the particular spatial and seasonal pattern.

In this study we investigate, for the first time, the zooplankton assemblages at a relatively small tidal channel named Bahía del Medio, situated in the middle-outer area of the Bahía Blanca estuary. This channel forms part of a particular looping channel system in the southern area of the Main channel (La Lista - Cabeza de Buey channels), with interconnected islands, channels of different sizes and tidal flats (Fig. 1). Its course is sinuous and meandering, and its depth varies between 1 and 8 m; during spring tides the tidal amplitude reaches up to 4 m (Cuadrado *et al.*, 2000).

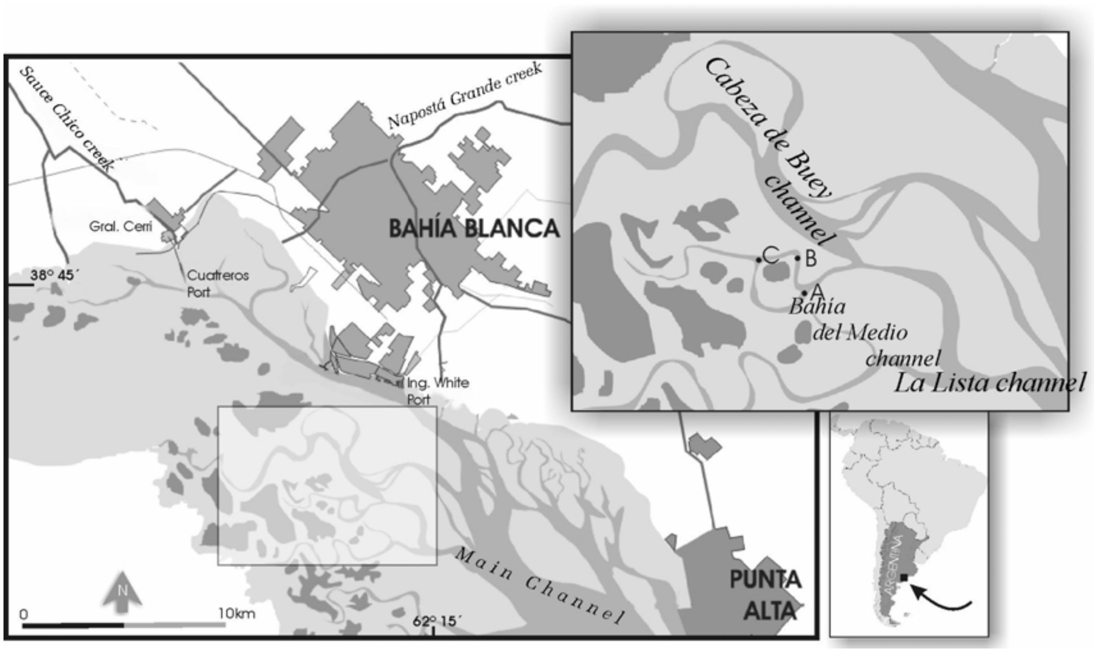

Fig. 1. Map of the study area. Bahía del Medio tidal channel and its location within the Bahía Blanca Estuary.

The bottom of the channel is formed mainly by fine sediments, slime and sand (Aliotta *et al.,* 1998). A high content of suspended sediments is also a common feature of the water column. Based on the estimating bedload net sediment transport, a circulation model was inferred for the La Lista - Cabeza de Buey channels system with a net dominance of ebb tide effects on its hydrodynamics (Ginsberg, pers. comm.). Despite its location close to the most polluted zone in the estuary (innermost zone towards the NW), the channel's features make it favourable for aquaculture development (low concentration of heavy metals and hydrocarbons, geomorphologic conditions providing protection against storms, strong winds and large waves). From the microbiological point of view it has also been demonstrated to be suitable for aquaculture (Baldini *et al.*, 1999).

The work focuses particularly on the zooplankton composition, number of taxa, their abundance and seasonal variation in relation to physical, chemical and biochemical variables all along the annual cycle 1997-1998. Particular emphasis is placed on tintinnids, the main group within the microzooplankton, and on copepods and meroplankton, the two major groups among the mesozooplankton in the Bahía Blanca estuary (Barría de Cao, 1992; Hoffmeyer, 1983; 1994; 2004 a, b). The zooplankton characteristics found at this tidal channel are compared with those observed in previous years at Ing. White Port station (Fig. 1) which is located in the innermost zone of Main channel estuary. The working hypothesis is that the differences found in the zooplankton assemblages of the tidal channel with respect to those of the Main channel are due to the particular hydrodynamics of that channel.

Materials and Methods

Monthly sampling was carried out during daylight and ebb tide from 03/18/97 to 05/20/98 at three fixed stations A, B and C located at Bahía del Medio tidal channel (Fig. 1).

Microzooplankton samples were collected at subsurface level with a Van-Dorn bottle and fixed with Lugol´s solution. Further samples were collected with a small 30 μm mesh plankton net. Mesozooplankton samples were collected with a 200 μm mesh- 0.30 m open-mouth net, through horizontal tows in the 5 m - surface layer during 5 min at two knots velocity. Surface temperature values were measured *in situ* and salinity, particulate organic carbon (POM), dissolved oxygen, inorganic nutrients (nitrites, nitrates, phosphates and silicates), chlorophyll *a* and phaeopigments of surface samples were determined in the laboratory following the techniques of Strickland & Parsons (1968) and Lorenzen (1967).

For tintinnid counting, 50 ml subsamples representing material from 250 ml were concentrated after settling in a combined plate chamber. The entire bottom chamber was scanned for each subsample using an inverted microscope following the Utermöhl method after Hasle (1978). Mesozooplankton samples were qualitatively and quantitatively analysed under stereomicroscope. Identification was done up to the lowest taxonomic level.

Basic descriptive parametric statistics was applied to physico-chemical and biochemical variables and zooplankton abundance data. The "t" test was used on environmental variable data to analyse differences among stations. Pearson linear correlation coefficient (Sokal & Rohlf, 1981) was calculated to analyse the relationships among all the variables for each station and micro- and mesozooplankton. The correlation between total tintinnid abundance and the abundance of the omnivorous copepod *Acartia tonsa* was also calculated. Two-way analysis of variance (ANOVA) was applied to micro- and mesozooplankton abundance data as well as to variable data to test for significant differences between dates and sites in both the zooplankton seasonal and spatial distribution pattern and the environmental pattern. Correlations and ANOVA were calculated using log transformed data (Nº ind m^{-3} + 1).

The results obtained on mean abundance and seasonality of micro and mesozooplantkon for this tidal channel were compared with those reported by Barría de Cao (1992) and Hoffmeyer (2004) for the Main channel.

Results

Maximum temperature was registered at A (Table 1) and maximum values of nitrites and phosphates, and the minimum of POM, dissolved oxygen and silicates also occurred at this station. Maximum values of salinity, POM, nitrate and chlorophyll *a* as well as the minimum values of temperature, salinity, nitrites, nitrates, phosphates and chlorophyll *a* were registered at B. At C maximum values of silicates and phaeopigments were registered.

Maximum values of nutrients were registered during the autumn, excepting those of silicates obtained during the summer. The maximum value of POM was also obtained during the autumn whereas the maximum value of chlorophyll *a* was registered during the winter. According to the "t" test results, no significant differences exist among stations for most of the variables. However, significant differences were found in the concentration of phosphates and silicates between stations A and B; of nitrates and silicates between B and C; and of phaeopigments, phosphates and silicates between C and A.

Table 1. Annual mean and range values of surface physico chemical and biochemical variables determined at the three stations.

Variable	St. A		St. B		St. C	
	Mean	Range	Mean	Range	Mean	Range
Temperature (ºC)	15.30	7.9-19.5	15.51	7.19-19.3	15.51	8-19.4
Salinity (psu)	32.06	28.67-36.98	31.99	27.78-37.02	32.29	28.38-36.98
Dissolved Oxigen (mg l^{-1})	6.05	4.84-8.39	6.33	5.04-7.79	6.40	5.46-8.1
Chlorophyll "a" (µg l^{-1})	8.40	1.38-13.45	9.06	1.1-24.98	9.29	1.56-22.79
Phaeopigments (µg l^{-1})	2.86	0-9.12	3.05	0-6.09	4.25	0-9.66
Particulate organic matter (µg l^{-1})	1,643.25	522-2,386	1,771.17	810-3,839	1,701.17	1,089-2,371
Nitrites (N- µM)	1.95	0.1-7.3	1.78	0.06-3.91	1.51	0.12-6.25
Nitrates (N- µM)	7.45	0.75-14.16	9.62	0.2-33.15	6.52	0.39-21.11
Phosphates (P- µM)	1.74	0.63-3.15	1.63	0.56-2.54	1.59	0.57-2.35
Silicates (Si- µM)	81.80	52.88-99.52	83.24	57.5-99.16	90.40	60.71-107.17

Values obtained for all the physical and chemical variables measured at the three stations show them had very similar characteristics (Table 1) during the analysed annual cycle (1997-1998). Maximum salinity values were relatively high at the three stations of this channel and the range wider than that of the Main channel.

Fifteen species of tintinnids belonging to 6 microzooplankton genera were observed in the study area (Table 2). The maximum number of species (9) was registered at station C. The mean total tintinnid abundance during the period analysed fluctuated between 3.4 x 10^6 and 5.1 x 10^6 ind m^{-3} at A and at C, respectively. The maximum abundance value in the tidal channel in 1997 was 33.6 ind m^{-3} registered at C during the autumn with 19.4ºC. The abundance peaks observed in 1998 reached up to 16.4 x 10^6 ind at B and 15.8 x 10^6 ind m^{-3} at A. They occurred at the beginning of autumn coinciding with temperature values of 19.5ºC and 19.3ºC (Fig. 2). Minimum abundance values, such as 0.9 x 10^6 ind m^{-3}, were registered at A during winter with a temperature of 10.5ºC and at A and B during spring with temperatures of 13.7ºC and 21.6ºC, respectively. The first peak, in 1997, was dominated by *Metacylis* sp. *aff. mereschkovskyi* (96.1 %). The abundance peaks in 1998 were dominated by *Tintinnidium balechi* (93 % and 92 %) at A and B.

Total abundance of tintinnids did not correlate with any of the variables measured at station A; the correlations between abundance and dissolved oxygen as well as between abundance and nutrients (nitrites, nitrates and phosphates) were significant ($p < 0.05$) at station B. At C the correlation between abundance and salinity was significant whereas that between abundance and nitrites and abundance and nitrates was highly significant ($p < 0.01$). The correlation between the abundances of tintinnids and *A. tonsa* was highly significant ($p < 0.01$) at stations A and B, but was not significant ($p > 0.05$) at St. C.

Table 2. Presence of microzooplankton taxa at the three stations of Bahía del Medio channel, Bahía Blanca Estuary, in 1997-1998 annual cycle.

Microzooplankton	Station		
	A	B	C
Tintinnida			
Tintinnidium balechi	x	x	x
T. sp. aff. semiciliatum	x	x	x
Tintinnopsis amphora			x
T. baltica	x	x	x
T. brasiliensis	x	x	x
T. beroidea	x	x	x
T. glans	x	x	x
T. gracilis		x	x
T. levigata		x	x
T. parva	x	x	x
T. parvula	x	x	x
Codonellopsis lusitanica	x	x	x
Eutintinnus lususundae			x
Favella taraikaensis	x	x	x
Metacylis sp. aff. mereschkovsky		x	x

ANOVA results of total tintinnid abundance did not show significant differences among stations but showed highly significant differences among sampling dates (F 3.7056, $p < 0.01$). ANOVA results of the number of tintinnid species revealed the same trend with non-significant differences among stations but with significant differences among sampling dates (F 2.9622, $p < 0.05$).

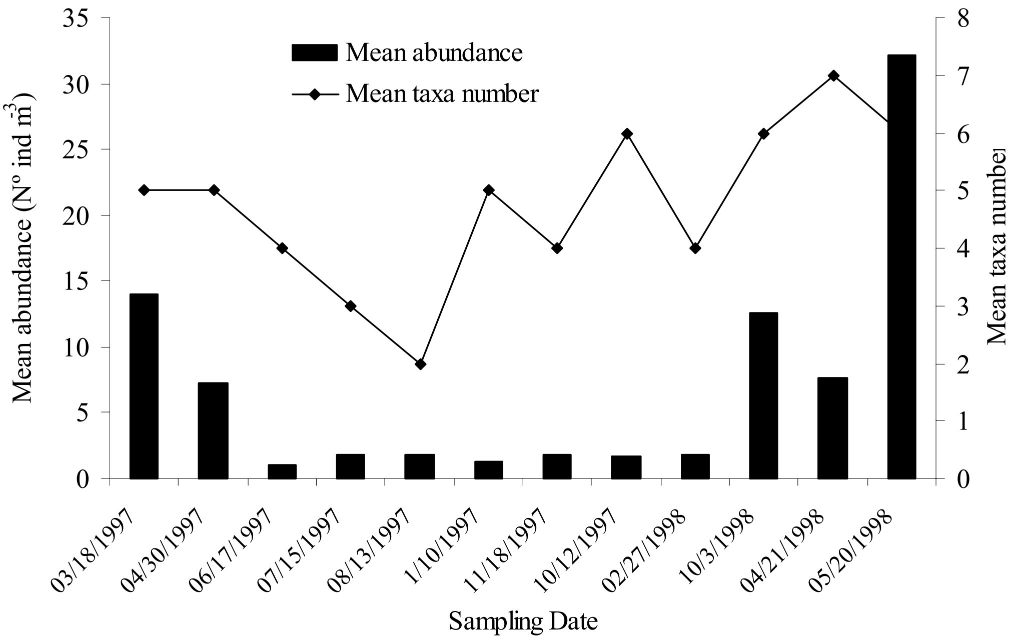

Fig. 2. Seasonal variation of mean taxa number and mean abundance of microzooplankton at Bahía del Medio channel.

The mesozooplankton observed in this study area comprised 11 taxa (Table 3). The maximal numbers (9-11) were registered at all stations in August and November 1997 and the minimal during February- March and May-June 1998. The abundance of total mesozooplankton fluctuated between 449 at station. B in March 1997 and only 1 ind m^{-3} in October 1997 (Fig. 3). Minimal abundances were found during May-June 1997 and maximal at the end of spring 1997 and the end of summer-autumn of 1998.

Abundance of the total mesozooplankton did not correlate with any of the variables measured at stations A and C. The relationship with surface temperature was in general important for the three stations data, though a significant correlation ($p < 0.05$) was only observed at St. B. Two-way ANOVA of total abundance did not show significant differences among stations but highly significant differences were found among dates (F 3.5677, $p < 0.01$). ANOVA results of the number of mesozooplanktonic taxa showed the same behaviour (F 10.3246, $p < 0.01$).

Discussion

Maximum concentrations of chlorophyll *a* were obtained during the winter. Gayoso (1999) also reports maximum concentrations of chlorophyll during the winter and early spring in other parts of the estuary's Main channel owing to a phytoplankton bloom occurring yearly which is the most important event in the planktonic seasonal succession in the estuary.

This channel is highly turbid partially due to the large amount of fine sediments in suspension probably coming from the flooding of the tidal flats during high tide. The maximum concentration of total suspended materials can reach 175 mg l^{-1} in conditions of ebb tide (Cuadrado *et al.,* 2000). The high concentration of particulate organic matter observed in this study is related to the large volume of organic detritus generated in this estuary.

The species richness of tintinnids found in the area was slightly lower than that registered in the Main channel (19) (Barría de Cao, 1992). The maximum was recorded at C. Most of the tintinnid species observed in this study have been reported before for the inner part of the estuary (Barría de Cao, 1992), though some of them, such as *Favella taraikaensis*, *Eutintinnus lususundae* and *M. mereschkovskyi*, are typical of the outer zone of the estuary which has more marine influence than the inner shelf (Barría de Cao, 1986).

The mesozooplankton richness at this tidal channel was higher than that reported for the Main channel (Hoffmeyer, 1994; 2004 a, b), the maximum being registered at stations A and B. This fact could be related to new taxa linked to water from the outer

Table 3. Presence of mesozooplankton taxa at the three stations of Bahía del Medio channel, Bahía Blanca estuary in 1997-1998 annual cycle. Copepods and other groups without indication: adults. Copep: copepodids, N-C: nauplius and cypris larva, V: veliger, N1 and N2: nectochaet larva, M: mysis, E: ephira, Z: zoea and megalopa larvae, C: cerinula larva, A: actinula larva and Ci: ciphonautes larva.

Mesozooplankton	Station		
	A	B	C
Copepoda Calanoida			
Acartia tonsa	x	x	x
Eurytemora americana	x	x	x
Paracalanus parvus	x	x	x
Labidocera fluviatilis	x		
Calanoides carinatus (Copep)		x	x
Diaptomidae	x		x
Copepoda Cyclopoida			
Oithona nana			x
Cyclopina sp.		x	
Halicyclops crassicornis	x	x	
Copepoda Harpacticoida			
Euterpina acutifrons	x	x	x
Amonardia nordmani	x		
Tisbe varians	x	x	x
Harpacticus chelifer		x	
Canthocamptidae sp.			x
Harpacticoida 1 sp.	x	x	x
Harpacticoida 2 sp.	x	x	x
Copepoda Monstrilloida			
Monstrilla sp.			x
M. aff. serricornis		x	
M. helgolandica	x	x	x
Amphipoda	x		
Amphipoda sp.			
Cirripedia			
Balanus a. amphitrite (N-C)			x
B. glandula (N-C)	x	x	x
Decapoda			
Beteus lilianae (M)	x	x	
Chasmagnathus granulatus (Z)	x	x	x
Mollusca			
Gastropoda sp. (V)	x		
Bivalvia sp. (V)	x		
Cnidaria			
Tubularia crocea (A)		x	
Olindias sambaquiensis (E)	x		
Obelia sp.	x		
Ceriantharia sp. (C)			
Polychaeta			
Polychaeta sp.	x		x
Spionidae sp.1 (N1)	x	x	x
Spionidae sp. 2 (N2)	x	x	
Bryozoa			
Bryozoa sp. (Ci)		x	

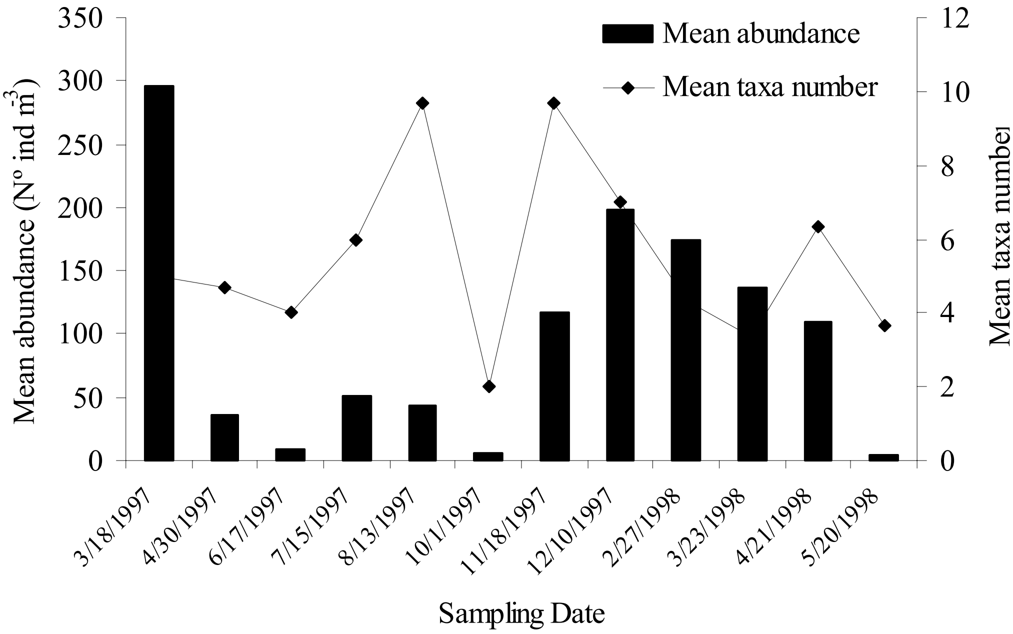

Fig. 3. Seasonal variation of mean taxa number and mean abundance of mesozooplankton at Bahía del Medio channel.

estuarine areas and others linked to the flooding of the tidal flats. On the other hand, an inverse relationship between mesozooplankton richness and total abundance was observed which is similar to the inverse relationship between zooplankton abundance and diversity according to the Shannon-Wiener index, reported by Osore *et al*. (2004) for Mida Creek on the Kenya coast all year round.

All peaks of tintinnid abundance were observed in the autumn (Fig. 2) and were coincident with the highest temperatures, which is in agreement with the results obtained in previous works carried out in the inner part of the estuary (Barría de Cao, 1992), where peaks in abundance due to the presence of *Tindinnidium balechi* are common. The maximum abundance peak, however, corresponded to *M. mereschkowskyi*, a species typical of the outer part of the estuary. The peak occurred at C, the most distant sampling point from the Main channel. This species was observed at B and C but never at A which is closer to the Main channel. The presence of other species typical of the outer zone at the same stations (B and C) -*Favella taraikaensis* and *Eutintinnus lususundae*- indicates the influence of a different external water mass moving across the Main channel up to the estuarine head. Similar observations were made for mesozooplanktonic species such as some first development stages of *Calanoides carinatus* (copepodids I and II), zoeae stages of the decapod *Beteus liliana,* juvenils (ephirae) of the medusa *Olindias sambaquiensis*. The former is a large calanoid copepod dominant in the adjacent inner shelf, whereas the other forms are also typical of the outer estuarine waters and inner shelf.

With the exception of the above-mentioned taxa, most of the mesozooplankton groups and species found in this channel are common in the inner estuarine zone. Furthermore, the most abundant species have been frequently reported by Hoffmeyer (1983; 1994; 2004 a, b) for the inner zone of the main estuary's channel. Even though the seasonal succession pattern was similar in this tidal channel, their maximal-minimal abundance peaks were lower than those previously reported for the inner zone of the estuary (Hoffmeyer, 1994). The small native calanoid copepod *A. tonsa* and the invaders *E. americana* and *B. glandula* larvae displayed a similar cycle, though the observed abundances were in general lower (Hoffmeyer, 2004 a).

The comparison between the present data for Bahía del Medio channel and those reported for Ing. White Port, at the Main channel, showed some differences (Tables 4; 5). In general, the succession of the tintinnids in the tidal channel showed a trend similar to that observed at the Main channel, the only difference being that some species such as *Tintinnopsis levigata* and *T. baltica* which showed seasonal restrictions at the Main channel were recorded here throughout the year (Table 4). The number of mesopanktonic taxa (32) found in this study was greater than that reported for Ing. White Port (18) during 1990-1991 (Hoffmeyer, 2004 a) (Table 5). Only 14 of them were common to both channels. The number of taxa recorded only at the Bahía del Medio channel (17, though in much lower abundance) was higher than the number reported for Ing. White Port station (3). A lower overall mesozooplankton abundance was also evident at this channel, whereas no important differences were found in the seasonality of the most abundant and common taxa.

The presence as well as the dominance of some zooplankton species in this secondary channel, different from others which are common to the inner part of the Main channel estuary, could be explained by the origin of the water mass circulating in this particular zone of the estuary. The water mass during the flow may arrive at the estuary via the southern coast of the Main channel, discharging into La Lista channel and then into this small secondary channel (Bahía del Medio) (Ginsberg, pers. comm.). It could also come from the South via Falsa Bay, a southern creek within this estuarine complex, or via the large channels (affluents to the Main channel) such as El Embudo, Tres Brazas or Cabeza de Buey at the North, before finally flowing during the ebb into the Main channel (Fig. 1; Falsa Bay, El Embudo and Tres Brazas channels are not shown in the map). The major penetration of these sporadic external water masses into the flats and tidal channels situated South of the Main channel could increase as a consequence of events such as extraordinary high tides and/or strong South-East winds. The fact that the highest salinity values were registered in this area during the autumn (a season of extraordinary tides) is probably an evidence of this phenomenon.

The occurrence of some mixohaline mesozooplankton species such as Diaptomidae sp., *Halicyclops crassicornis* and *Cyclopina* sp. in November and April-May, could be related to the connection of this tidal channel with small temporary lagoons formed during high rainfall periods.

The low density of tintinnids observed during the winter in this area is coincident with the results obtained in the inner part of the estuary (Barría de Cao, 1992). This can be explained by the dominance of thread-bearing diatoms during the phytoplankton bloom occurring annually in the estuary which in general, are not adequate food for tintinnids (Barría de Cao *et al.,* 1997). Heterotrophic marine bacteria with peaks exceeding 100,000 CFU ml^{-1} and heterotrophic terrestrial bacteria which exceed 10,000 CFU ml^{-1} in winter (Baldini *et al*., 1999) would be the most important source of food during this season. Such bacteria are suitable food mainly for those species with small peristome, thus favoring the presence of only certain species.

Table 4. Comparison of the mean annual abundance data of tintinnids (Nº ind x 106 ind m^{-3}) registered at the tidal channel (in decreasing order) with the historic data for de Main channel, for the Ing. White Port only dominant species. * Species present-no data on abundance. Au, autumn; Wi, winter; Sp, spring; Su, summer.

Taxa	Barría de Cao (1992)					This study					
	Abundance	1986-1987				Abundance		1997-1998			
	Mean	Au	Wi	Sp	Su	Mean	SD	Au	Wi	Sp	Su
Tintinnidium balechi	0.48					2.65	3.35				
Metacylis sp. aff. mereschkovsky	*					0.91	3.15				
Tintinnopsis parva	0.23					0.53	0.64				
T. baltica	0.26					0.12	0.11				
Codonellopsis lusitanica	0.18					0.08	0.10				
Tintinnidium sp. aff. semiciliatum	*					0.07	0.09				
Tintinnopsis brasiliensis	0.28					0.06	0.06				
T. glans	0.25					0.06	0.06				
T. levigata (=pusilla)	0.13					0.03	0.07				
Favella taraikaensis	*					0.03	0.12				
Tintinnopsis beroidea	0.1					0.02	0.04				
T. amphora	*					0.01	0.02				
T. gracilis	0.24					0.01	0.02				
T. parvula	*					0.01	0.02				
Eutintinnus lususundae	*					0.01	0.03				
Total abundance	0.24					0.31	0.53				

Table 5. Comparison of mean annual abundance data (Nº ind.m^{-3}) and SD (standard deviation) of mesozooplankton taxa, in decreasing order and seasonality data obtained in this study, with those reported for Ing White station (into the Main channel) from 1990-1991 years. * only one value; ** mean = 1. Stage abbreviations as in Table 3. Ci: ciphonautes larva. Season abbreviations as in Table 4.

Taxa	Hoffmeyer (2004)					This study					
	Abundance	1990-1991				Abundance		1997-1998			
	Mean	Au	Wi	Sp	Su	Mean	SD	Au	Wi	Sp	Su
Acartia tonsa	1,257.92	::	::	::	::	72.99	85.52	::	::	::	::
Chasmagnathus granulatus (Z)	2.08	::		::	::	33.06	49.76	::		::	::
Eurytemora americana	30.33		::	::		12.96	9.48		::	::	
Balanus glandula (N)	1.33		::	::		11.25	10.92		::	::	
Spionidae (N1)	0.50		::	::		4.12	3.28	::	::	::	::
Paracalanus parvus	77.42	::	::	::		3.98	4.76	::	::	::	::
Euterpina acutifrons	10.33		::	::		2.37	2.38	::	::	::	
Gastropoda (V)	0.75	::			::	2.25	1.10	::			::
Balanus a. amphitrite (N)						2.11	2.44	::		::	::
Diaptomidae						2.00	*				::
Tisbe varians	10.00			::		1.25	0.57			::	
Spionidae (N2)						1.21	*		::		
Labidocera fluviatilis	77.00		::	::		1	*	::			
Oithona nana	20.08		::	::		1	*				::
Halicyclops crassicornis						1	0**	::		::	
Cyclopina sp						1	*			::	
Amonardia nordmani						1	*			::	
Chantocamptidae						1	0.00	::			
Monstrilla sp						1	*	::			
Monstrilla aff. serricornis						1	*			::	
Beteus liliana (M)						1	0**				::
Ceriantharia (C)	2.08			::		1	*			::	
Obelia sp						1	*			::	
Polychaeta						1	*	::		::	
Amphipoda						1	*	::		::	
Harpacticoida 1						0.89	0.51		::		::
Calanoides carinatus	43.08		::	::							
C. carinatus (Copep)						0.83	0.24		::		::
Harpacticoida 2						0.83	0.71		::		::
Monstrilla helgolandica	4.50			::	::	0.78	0.19		::	::	::
Olindias sambaquiensis (E)						0.33	*			::	
Tubularia crocea (A)	1.00			::		0.33	*			::	
Harpacticus chelifer	4.58				::						
Bivalvia (V)	0.83			::	::						
Bryozoa (Ci)	0.67				::						
Total abundance	1,544.48					101.6	89.81				

The high correlation between the abundances of tintinnids and of the omnivorous copepod *Acartia tonsa* found in two of the three stations analysed could be an evidence of trophic coupling. Other works (Robertson, 1983) indicate that under certain conditions, tintinnids can be an important food source for the estuarine copepod *A. tonsa*.

We have observed that hydrodynamics and tides influence the zooplankton spatial distribution; also other authors have mentioned this influence on the vertical distribution of some zooplankters inducing their migration (Kopacks, 1994).

Finally, the Bahía del Medio channel is shown to be spatially homogeneous in its physical and biochemical features. Micro and mesozooplankton abundance also displayed a high degree of spatial homogeneity, though the seasonal variation in both environment and zooplankton was significant. Comparison with the zooplankton observed at Ing. White station (in the Main channel of the estuary) showed some interesting differences in the number of taxa represented (increase), a generally lower abundance of micro- and mesozoopankton, and the presence of some rare species from the outer area of the estuary and others related with temporary mixohaline environments. Despite these differences, the general seasonal pattern of the two assemblages and the most abundant type of taxa were similar.

In conclusion, the differences observed in the zooplankton of the tidal channel could be the consequence of a different circulation pattern, which would also explain the physical and chemical differences between the two sites. Further coordinated studies on water mass circulation and plankton are required to corroborate this hypothesis.

Acknowledgements

We are grateful for the support provided by personnel of the oceanographic boat during the sampling surveys and staff of the Chemistry Lab of IADO. The suggestions of two anonymous reviewers on the first version of the manuscript are gratefully acknowledged. This research project was made possible by funding from UNS (Universidad Nacional del Sur), CIC (Comisión de Investigaciones Científicas, Pcia. de Buenos Aires) and (CONICET, PIP 3003/1999) grants.

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(Manuscript received 16 February 2006; revised 07 August 2006; accepted 23 February 2007)