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LONG TERM FISH ASSEMBLAGES AS UNITS OF MANAGEMENT IN A TEMPERATE ESTUARY (RIO DE LA PLATA - SW ATLANTIC OCEAN)

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ABSTRACT

Demersal fish assemblages from trawl surveys in the Rio de la Plata estuary and its inner continental shelf were analyzed from 1975 to 1995. The first two factors of Principal Component Analysis explained 48% of the variance in species distribution, and they are consistent with the results of a cluster analysis. The analysis indicated the existence of three spatially and temporally distinct fish assemblages: internal and external estuarine and inner continental shelf (Uruguayan coastal assemblages). These assemblages were persistent considering the environmental characteristics and their species composition. Despite the changes registered in the species density during the period surveyed, the fish assemblages tend to persist over time. It was demonstrated that the assemblages can be considered as open systems and that there exists a reciprocal flow of organisms between adjacent associations. However, each assemblage showed high spatial and temporal persistence in accordance with the environmental characteristics of the system analyzed. Therefore, and according to the multispecies fisheries operating in the system, each assemblage defined could be considered a unit of management.

RESUMO

Foram analisadas as associações dos peixes demersais provenientes de arrastos de prospecção no estuário do Rio de la Plata e sua plataforma interna no período de 1975 a 1995. Os dois primeiros fatores da Análise de Componentes Principais explicaram 48% da variância na distribuição das espécies sendo consistentes com os resultados da análise de agrupamento. Os resultados mostraram a existência de três associações de peixes espacial e temporalmente distintas: uruguaia costeira, estuarina externa e estuarina interna. Essas associações foram consistentes quanto às características ambientais e de composição de espécies. A despeito das mudanças registradas na densidade das espécies ao longo do período analisado, as associações de peixes foram persistentes ao longo do tempo. No presente trabalho foi demonstrado que embora as associações sejam consideradas um sistema aberto, um fluxo recíproco de organismos acontece entre associações adjacentes. Contudo, cada associação apresenta diferentes graus de estabilidade, dependentes da estabilidade física e temporal do habitat, e das interações das espécies nas associações. No entanto, cada associação mostrou alta persistência espacial e temporal, apesar da variabilidade ambiental no sistema analisado. Nesse sentido, e de acordo com a pesca multiespecífica que opera neste sistema, cada associação poderá ser considerada como uma unidade de gestão.

Descriptors: Persistence, Fisheries, Demersal fish assemblages, Uruguay, Multivariate analysis.
Descritores: Persistência, Pescarias, Assembléias de peixes demersais, Uruguai, Análise multivarida.

INTRODUCTION

Estuaries have been the subject of considerable research, some of which has focused on the key environmental factors affecting estuarine fish community structure (JAUREGUIZAR et al., 2004, 2006). Estuaries are regarded as highly dynamic environments and their physical features can change over scales varying from hours to years. Estuarine fish assemblages often exhibit large year-to-year variation in abundance, species and size composition (METHVEN et al., 2001). The importance of long-term studies for the understanding of the community

changes in estuaries that are caused by environmental variations and habitat alteration has been shown by James et al. (2008). Those authors found that although individual species showed large interannual variations in abundance, driven primarily by changing environmental conditions, the basic community structure remained relatively stable. The Rio de la Plata is a large estuarine system with a coastal plain, micro tide and naturally rich in nutrients. Because of its large size and morphological diversity it can be divided into fluvial-tidal (internal) and estuarine regions, with different depths, circulation patterns and stratification, sharing B, influx of nutrients, turbidity gradient, mixing state and trophic status (NAGY, 2005). The Rio de la Plata and Uruguayan Atlantic coastal regions are impacted by steadily increasing human pressure and weather, nitrification, change of land use, and soil erosion, supplying urban emissions and leading to rising atmospheric temperature (~ 0.8°C), precipitation (~ 23%), river flows (25-40%), and the El Niño southern oscillation (NAGY et al., 2002).

Long-term studies have shown that the co-occurrence of a given set of fish species over broad geographical areas is usually not an accidental phenomenon (GOMES et al., 2001). Fish assemblages are persistent; they appear to retain their species composition for periods of time that are at least comparable with the life span of most of the species in the assemblage. Examples of long term studies (> 10 years) are those conducted by Gabriel (1992), Mahon; Smith (1989), Mahon et al. (1998), and Gomes et al., (1995), for the north Atlantic, Roel (1987) for the west coast of South Africa, Bianchi (1992 a,b) for both the continental shelf of Angola and the shelf off Congo and Gabon. In the south Atlantic studies have been made by Jaureguizar et al. (2006). In recent years, attention has started to shift towards determining the role of species in their respective ecosystem and the likely impact of fishing them Gislason et al. (2000). New approaches to the study of exploited populations have been suggested, including the study of fish assemblage structures in relation to environmental variables, and the characterization of seasonal changes to improve management practices (LABROPOULOU; PAPACONSTANTINOU, 2005). Trawl fleet fisheries target several demersal and benthic species. The study of exploited populations has been including the analysis of the fish assemblage structure and the characterization of seasonal changes to improve not only management practices (GISLASON et al., 2000) but also the understanding of the dynamics of multispecies stocks (CADDY; SHARP, 1988).

In this study we analyzed seasonally the demersal fish assemblages of the Rio de la Plata and its inner continental shelf from 1975 to 1995 using the available information of 25 survey assessments in the area surveyed. The analysis resulted in the definition of the persistence of the fish community, its temporal evolution and some of the causes that determine and explain its persistence. We discuss the usefulness of these results in assessing the impact of fisheries on the ecosystem and the use of fish assemblages as management units.

MATERIAL AND METHODS

Study Area and Sampling Procedure

The Rio de la Plata estuary is situated between Argentina and Uruguay (35ºS, 56ºW), is one of the few largest permanently open estuaries of the world, covering an area of 35000 km^2. This river drains the second largest basin in South America (the Parana and Uruguay river basins), discharging an average of 22000 m^3 s^{-1} of freshwater over the continental shelf through a 230 km-wide mouth (FRAMIÑAN; BROWN, 1996). Water stratification is determined by the confluence of a high buoyancy continental discharge advecting offshore, lying over denser shelf water that intrudes into the estuary as a topographically controlled wedge. This saline wedge is from 150-250 km in length (GUERRERO et al., 1997). The offshore limit of the saline wedge forms a surface salinity front, where a high horizontal salinity gradient marks the encounter between the estuarine and marine systems (GUERRERO et al., 1997; MIANZAN et al., 2001). The inner continental shelf is influenced both by the “run-off” of the Rio de la Plata and marine waters (NAGY, 2005).

The data were obtained seasonally during bottom trawl research cruises carried out between 1975 and 1995 by the RVs “Cruz del Sur”, “Lamatra” and “Aldebarán” (operated by DINARA, Uruguay) (Table 1). Those surveys were designed for the assessment of demersal fisheries resources between latitudes 34º30’ S and 39º30’S in the Argentinian-Uruguayan Common Fishing Zone (AUCFZ) (Fig. 1). At each sampling location, a 30 min tow was conducted at a speed of approximately 3 knots during daylight. A high-opening ‘Engel’ type net of 80 mm stretch mesh-size cod-end was used. Trawl stations were selected using a stratified random sample design, defined by depth and latitude. At each site position (latitude and longitude), depth (m), catch weight (kg) and number of individuals by species, were recorded. Fishes were identified to species level and taxonomically listed in accordance with Ringuelet; Aramburu (1960) and Menni et al. (1984) (Table 2).

Table 1. Year, season, date, number of trawl stations (TS) and depth range (m) (DR) the survey analyzed.

Year	Season	Date	TS	DR
1975	spring	Nov 20 - Dec 2	69	7.0 - 72
1976	summer	Jan 13 - Feb 08	72	9.0 - 70
	winter	Sep 20 - Oct 11	69	4.0 - 68
1977	summer	Jan 17 - Feb 09	73	3.0 - 47
	autumn	Apr 07 - 25	73	5.0 - 64
1981	autumn	Apr 17 - 29	66	3.0 - 60
	spring	Oct 23 - Nov 10	74	3.0 - 58
1982	summer	Feb 03 - 19	64	4.0 - 60
	spring	Oct 15 - 23	68	4.0 - 74
1983	summer	Mar 03 - 22	71	3.4 - 65
	winter	Sep 05 - 23	62	4.0 - 64
1984	spring	Oct 19 - 30	73	4.0 - 64
1985	summer	Jan 23 - Feb 06	74	4.0 - 61
	winter	Set 06 - Oct 1	81	4.0 - 46
1986	summer	Feb 26 - Mar 16	80	3.6 - 60
1987	winter	Aug 27 - Sep 05	55	3.0 - 65
1988	summer	Feb 19 - 27	70	5.0 - 65
1991	autumn	Mar 14 - 23	43	4.0 - 62
	winter	Jun 29 - Jul 08	91	3.7 - 61
	spring	Nov 14 - Dec 03	91	3.5 - 62
1992	spring	Oct 15 - Nov 04	95	3.6 - 64
1993	spring	Oct 26 - Nov 17	84	4.2 - 63
1994	spring	Nov 05 - 22	100	3.0 - 59
1995	summer	Feb 26 - Mar 16	97	3.5 - 62
	spring	Dec 10 - 20	64	3.5 - 63

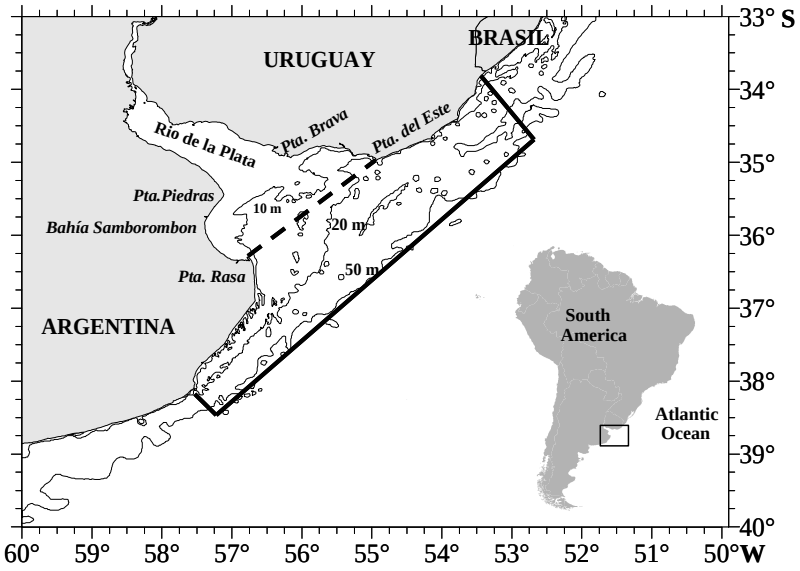

Fig. 1. Location and bathymetry of the study area: the Rio de la Plata estuary (delimited by broken line) and the adjacent Inner Continental Shelf (ICS).

Table 2. List of demersal taxa caught in survey between 1975 and 1995.

Family	Specie	Code
Callorhinchidae	*Callorhinchus callorhinchus*	*Cca*
Triakidae	*Mustelus schmitti*	*Msc*
	Galeorhinus galeus	*Gga*
Squalidae	*Squalus acanthias*	*Sac*
Squatinidae	*Squatina guggenheim*	*Sgu*
Narcinidae	*Discopype tschudii*	*Dts*
Rhinobatidae	*Rhinobatos horkelli*	*Rho*
	Zapteryx brevirostris	*Zbr*
Rajidae	*Atlantoraja castelnaui*	*Aca*
	Sympterygia bonapartii	*Sbo*
	Atlantoraja cyclophora	*Acy*
	Dipturus chilensis	*Dch*
	Rioraja agassizzi	*Rag*
Myliobatidae	*Myliobatis goodei*	*Mgo*
Ariidae	*Genidens barbus*	*Gba*
Atherinopsidae	*Odontesthes incisa*	*Oin*
Balistidae	*Balistes capriscus*	*Bca*
Batrachoididae	*Porichthys porosissimus*	*Ppo*
Carangidae	*Parona signata*	*Psi*
	Trachurus lathami	*Tla*
Centrolophidae	*Seriolella porosa*	*Spo*
Cheilodactydae	*Nemadactylus bergi*	*Nbe*
Clupeidae	*Brevoortia aurea*	*Bau*
Congridae	*Conger orbinyanus*	*Cor*
Engraulidae	*Engraulis anchoita*	*Ean*
Merluccidae	*Merluccius hubbsi*	*Mhu*
Mugilidae	*Mugil platanus*	*Mpl*
Mullidae	*Mullus argentinae*	*Mar*
Ophidiidae	*Genypterus blacodes*	*Gbl*
Paralichthyidae	*Paralichthys patagonicus*	*Ppat*
	Paralichthys orbignyanus	*Por*
	Paralichthys isosceles	*Pis*
	Xystreurys rasile	*Xra*
	Paralichthys spp	*Pspp*
Percophidae	*Percophis brasiliensis*	*Pbra*
Phycidae	*Urophycis brasiliensis*	*Ubr*
Pinguipedidae	*Pseudopercis semifasciata*	*Pse*
	Pinguipes brasilianus	*Pin*
Pleuronoctidae	*Oncopterus darwini*	*Oda*
Polyprionidae	*Poliprion americanus*	*Pam*
Pomatomidae	*Pomatomus saltatrix*	*Psa*
Sciaenidae	*Umbrina canosai*	*Uca*
	Cynoscion guatucupa	*Cgu*
	Macrodon ancylodon	*Man*
	Micropogonias furnieri	*Mfu*
	Pogonias cromis	*Pcr*
	Menticirrhus americanus	*Mam*
	Paralonchurus brasiliensis	*Pbr*
Scombridae	*Scomber japonicus*	*Sja*
Serranidae	*Dules auriga*	*Dau*
	Acanthisthius brasilianus	*Abr*
Sparidae	*Diplodus argenteus*	*Dar*
	Sparus pagrus	*Spa*
Stromateidae	*Peprilus paru*	*Ppa*
	Stromateus brasiliensis	*Sbr*
Trichiuridae	*Trichiurus lepturus*	*Tle*
Triglidae	*Prionotus nudigula*	*Pnu*
	Prionotus punctatus	*Ppu*
Uranoscopidae	*Astroscopus sexspinosus*	*Ase*
Zeidae	*Zenopsis conchifer*	*Zco*

Community Multivariate Analysis

A site-species matrix was constructed for each season. At each site, density of individuals (kg/mn^2) was calculated using the formula C/A where C= individuals captured per haul and A= area swept (velocity x time x horizontal opening x 1852 m). Species that did not occur in at least 5 % of the samples were not considered in the analysis to prevent their exercising an undue influence on the results (GAUCH, 1982). Data were log-transformed ln (x+1) before the analysis, in order to reduce the variability and the influence of the most abundant taxa on the results (TAYLOR, 1961). This was of considerable importance as regards the effects of the subsequent comparison of the results of each survey on the same scale.

Two different multivariate approaches were used to identify fish assemblages: Cluster Analysis (CA) and Principal Component Analysis (PCA). CA and PCA together provide a powerful statistical tool for identifying the community structure pattern (GAUCH, 1982) and particularly the fish assemblage in accordance with the criteria proposed by Mahon et al. (1998). These analyses allow the identification of fish species groups of similar distribution, characterizing species associations of multispecies matrixes. CA was performed using Pearson´s correlation coefficient similitude (r) and the UPGMA algorithm. Clusters of sites were mapped and geographical continuity of stations belonging to the same group was seen as an indicator of the validity of the group. According to Gomes et al., (2001) the recurring appearance of fish groups with the same composition and geographical location over the years, indicated that these groups were neither sporadic nor an artifact of the method.

PCA is an indirect gradient analysis that employs a linear response model, which is a simple approximation of the species response along an environmental gradient. PCA analysis was conducted using a correlation matrix of fish community abundance. Species loading of principal components was used to identify groups of species that tend to co-occur. The eingenvalues associated with a principal component indicate the relative importance of that component. Principal components with eingenvalues > 1 are considered to represent significant assemblages (JOLLIFFE, 1986). For the selection of variables and/or main sites in the formation of the axes, load factors (or contributions) > 0.5 were considered (MAHON et al., 1998), and those between 0.3 and 0.5 (ARAUJO; COSTA DE AZEVEDO, 2001). Separate analyses were performed for each survey data matrix.

The range, mean and standard deviation of depth, temperature and salinity were calculated to characterize each site group defined by the CA and PCA. To determine the percentage of each species recorded in each site group, and which of these species were predominant in each group, we calculated the relative density of each species in each group with respect to the total area sampled in the survey.

Similarity or percentage analysis (SIMPER) was used to identify the species which typified groups and those responsible for the discrimination between groups (CLARKE, 1993). This procedure indicates the average contribution of each species to the similarity (typifying species) and dissimilarity (discriminating species) between site groups.

RESULTS

Overall two uncorrelated dichotomies formed in the CA that integrated three assemblages of sites and species (r between 0.019 and 0.097) for the 21-year time series analyzed. Species with similar spatial distribution patterns were highly consistent from year to year and constituted three assemblages: Internal Estuarine Assemblage (IEA), External Estuarine Assemblage (EEA) and Uruguayan Coastal Assemblage (UCA) (Fig. 2). These spatial groups were highly persistent over time and seasonally (Fig. 3) and the major dichotomy in the multivariate analysis was always between the sampling stations shallower than 19 m (IEA) and the deeper ones, commonly up to 40 m (UCA).

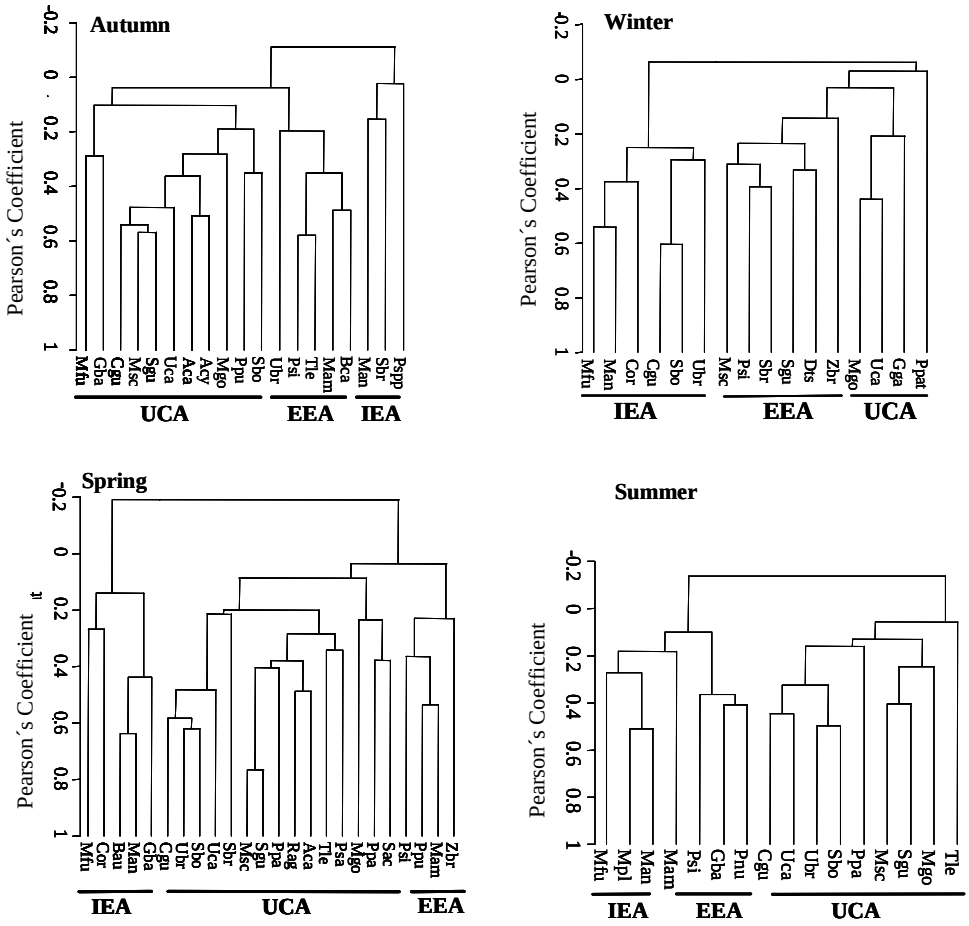

Fig. 2. Typical result of CA with Pearson´s similarity coefficient. IEA: Internal Estuarine Assemblage; EEA: External Estuarine Assemblage; UCA: Uruguayan Coastal Assemblage. (We have given only four season as an example: Autumn 1991; Winter 1987; Spring 1995, Summer 1983).

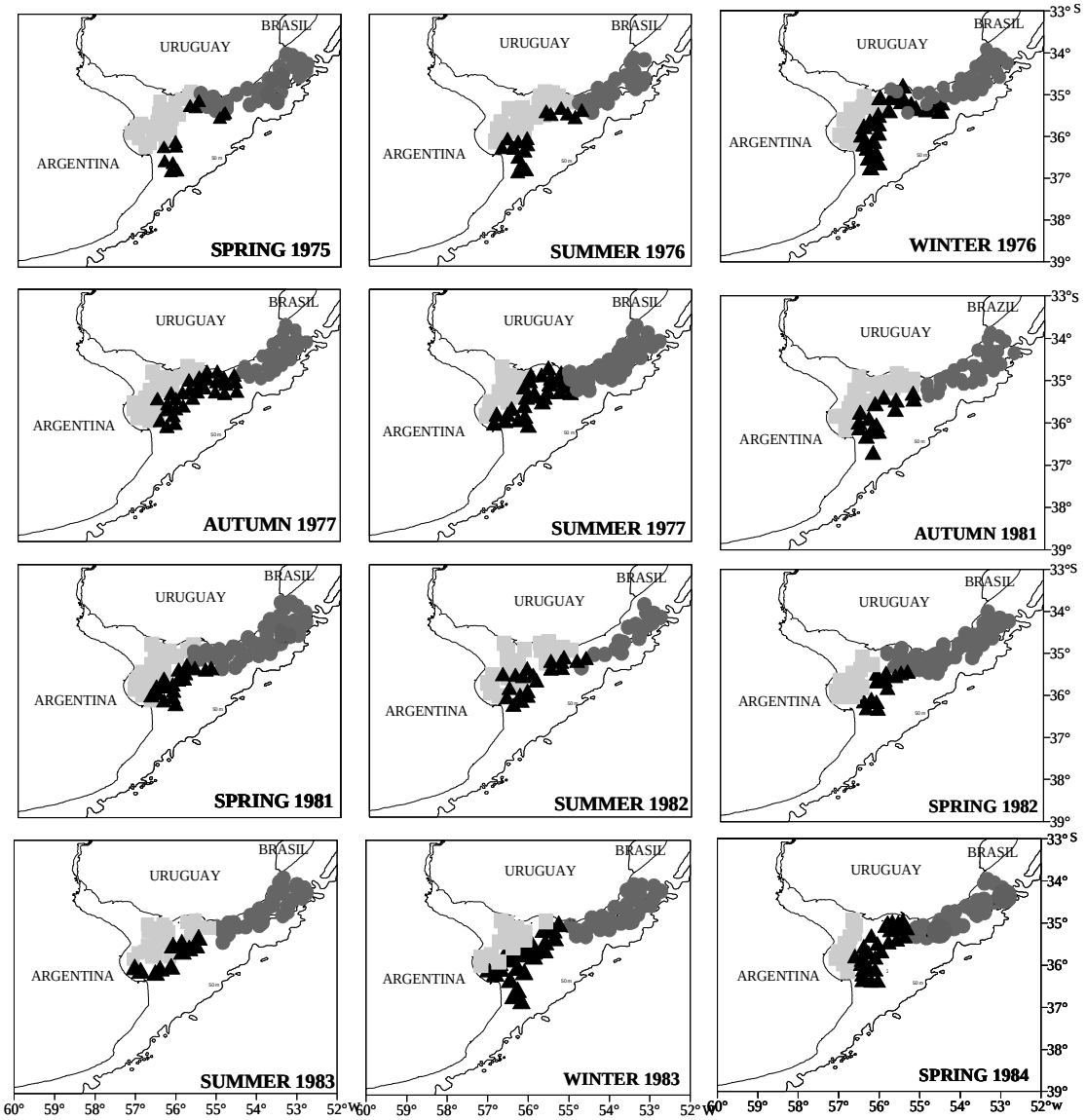

Fig. 3. Fish assemblages of the Rio de la Plata estuary and its inner continental shelf throughout the period analyzed. ●: Internal Estuarine Assemblage; ▲: External Estuarine Assemblage; ●: Uruguayan Coastal Assemblage.

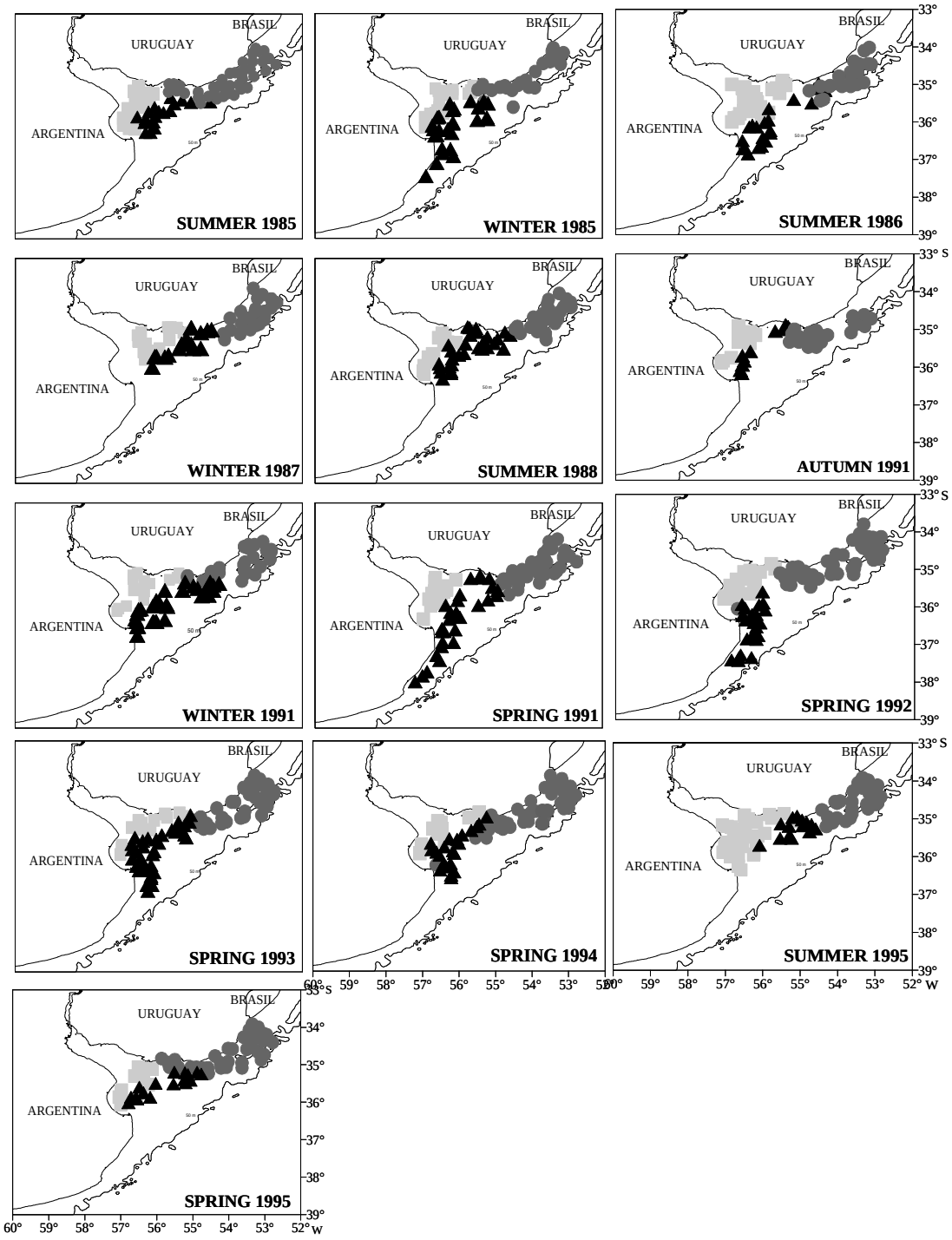

Fig. 3. Continuated.

The IEA was localized in the internal estuarine zone. This area had the shallowest depth range (3 to 19 m), temperature between 16.1 and 20.1ºC and salinity between 13.5 and 22.5 ups. *Micropogonias furnieri* (Desmarest, 1823), *Macrodon ancylodon* (Bloch & Schneider, 1801) (with 100%

persistence) and *Brevoortia aurea* (Spix & Agassiz, 1829) (with 57% persistence) were the most abundant species in this assemblage (Fig. 4). Five species occurred in at least 15% of the survey: *Trichiurus lepturus* (Linnaeus, 1758), *Genidens barbus* (Lacepède, 1803), *Uropycis brasiliensis* (Kaup, 1858), *Mugil platanus* Gunther, 1880 and *Parona signata* (Jenyns, 1841) predominated in spring (Fig. 4). *Micropogonias furnieri* and *M. ancylodon* characterized this assemblage for 21 and 16 years, respectively. This assemblage was distinguished by *B. aurea* and *M. ancylodon* (Table 3). *Macrodon ancylodon* tended to dominate in winter and spring and *B. aurea* in spring, whereas *M. furnieri* was the most abundant in autumn and winter. The EEA was located in the external estuarine zone of Rio de la Plata, at depths between 9.8 and 24.2 m; with salinity between 25.6 and 32.8 ups and temperature between 14.2 to 18.4ºC. This assemblage was characterized by eight species with higher abundance: *Micropogonias furnieri* and *Myliobatis goodei* (Garman, 1885) (100% persistence), *P. signata* and *Mustelus schmitti* Springer, 1939 (86% persistence), *Percophis brasiliensis* Quoy & Gaimard, 1825. *Prionotus nudigula* Guinsburg, 1950 and *Stromateus brasiliensis* Fowler, 1906 (46% persistence), and *Prionotus puntactus* (Bloch, 1793) (30% persistence) (Fig. 4). This assemblage was typified mainly by *M. furnieri* (for 20 years), *M. goodei* (for 11 years) and *M. ancylodon*, *M. schmitti*, *P. signata*, *S. brasiliensis*, *Cynoscion guatucupa* (Cuvier, 1830) and *Squatina guggenheim* (Marini, 1936) over almost six years. This assemblage was distinguished by *P. nudigula* and *P. puntactus* (Table 3). The UCA was located on the inner continental shelf of the Uruguayan Atlantic coast at depths of between 17.3 and 40.3 m, temperature between 12.3 and 17.6ºC and salinity ranging from 28.9 and 33.1°C. The main species with the highest densities were *M. goodei*, *C. guatucupa* and *M. schmitti* in all the years analyzed; *M. furnieri* (except in spring 1993), *Umbrina canosai* Berg, 1895, *S. guggenheim* (except in summer 1976) and *T. lepturus* (Fig. 4). The species *M. schmitti* (for 22 years), *C. guatucupa* (for 23 year), *S. guggenheim* and *M. furnieri* (for 17 years), *T. lepturus* and *Discopyge tschudii* Heckel 1846 *in all but one* survey, typified the UCA. This assemblage was distinguished by *S. guggenheim*, *T. lepturus*, *C. guatucupa* and *U. canosai* (Table 3).

Several species were not clearly affiliated to any of the three major groups. When observations from entire time series were combined, however, those species were seen to be linked to major groups consistent with long term-individual distribution patterns. *Myliobatis goodei* and *Menticirrhus americanus* (Linnaeus, 1758) were affiliated to EEA and *Conger orbignyanus* Valenciennes, 1837 (minor group UCA) occurred occasionally as a member of IEA, principally in spring and summer.

As with the general pattern in all surveys, two principal axes were considered in the PCA, with eigenvalues higher than 1, which explained between 40.6% and 47.7% of the species variance. The sites and species that contributed with values > 0.3 in the formation of factors, always grouped along the depth gradient, ranked between shallow (usually < 12 m) and deeper (usually > 30m) waters (Fig. 5). In general, for the whole period analyzed an examination of the column scores of depth, temperature and salinity in relation to the first axis of the PCA displayed a spatial pattern for both stations and species that conformed to that of the IEA assemblages. No further spatial pattern was found for the first and third axis of the PCA (data not shown). Most of the sites that were negatively correlated with the first axis were located at depths *of less than* 20 m (Fig. 5).

The trend in relative abundance of fish increased, for all the three assemblages, only between spring 1991 and spring 1993 (Fig. 6). In the IEA, the greatest increase in abundance was determined principally by *G. barbus*. In the EEA two increments were observed, both in spring, one in 1981, characterized by *P. nudigula* and *Paralonchurus brasiliensis* (Steindachner, 1875), and the second in 1992, determined by *P. puntactus* and *M. schmitti* (Fig. 6). In the UCA the variation in the abundance showed three peaks in the summers of 1977, 1985 and 1995 and another in spring 1992 (Fig. 6).

DISCUSSION

Three spatially distinct and temporally persistent fish assemblages were identified in the Rio de la Plata estuary and on its inner continental shelf during the period from 1975 to 1995. In this study a single trawl type was used and the cluster formation and subsequent location of assemblage regional boundaries is likely to be sensitive to the random station spacing associated with the survey design. However, the spatial pattern tended to permanence over the seasons despite the environmental variability described for the Rio de la Plata (FRAMIÑAN; BROWN, 1996). According to Mahon et al. (1998), fish assemblages identified by CA and PCA methods were spatially coherent and adaptable entities rather than rigged ecological structures, even when they are persistent. The results of multivariate techniques indicated that these assemblages were associated primarily with a depth gradient, a pattern already reported for the Atlantic continental shelf species assemblages (BIANCHI, 1992a; FARIÑA et al., 1997; SOUSA et al., 2005). Overall, the geographical contours of the areas identified in this analysis did not change greatly from year to year, although the relative

abundance of species within each assemblage changed as a result of changes in the abundance of species, especially in the estuarine assemblages (IEA and EEA). These assemblages retain their species compositions over periods of time at least as long as the average life span of their component species. There is also strong evidence for the mesoscale persistence of the geographical boundaries of the assemblages. The geographical limits were usually relatively predictable and may be associated principally with the bottom topography or other physical features of the area. The results revealed a spatial gradient from shallow to deeper waters determining two major groups with particular characteristics: one estuarine and the other typical of the inner continental shelf. It may, therefore, be assumed that assemblages represented by the CA and PCA are a response to the environmental variation found between shallow estuarine and continental shelf waters with marine influence. These fish assemblages detected in the Rio de la Plata and on its inner continental shelf, generally agreed with the fish groups described by Díaz de Astarloa et al. (1999) based on presence-absence data, and with Jaureguizar et al. (2003, 2004) for the Rio de la Plata estuary. Analysis of springtime data for six different years with a different methodology, showed a temporal persistence of the assemblages with respect to species composition and geographical location (JAUREGUIZAR et al., 2006).

The temperature decrease and salinity increase in the area of the coastal continental shelf, correlated with a greater abundance of marine species. The dominant species in the UCA were *Urophycis brasiliensis*, *Cynoscion guatucupa*, *Umbrina canosai*, *Mustelus schmitti* and *Squatina guggenheim*. Within the inner estuary (IEA) with higher temperature and lower salinity, the dominant species were *Brevoortia aurea*, *Mugil platanus*, *Menticirrhus americanus* and *Genidens barbus*, while in the section towards the external estuary (EEA) *Prionotus punctactus*, *Parona signata*, *M. schmitti* and *Discopyge tschudii* prevailed. Changes in the dominant species between assemblages could be a result of a temporary partition of resources that reduces competition for food or may also reflect the response of the species to optimal environmental conditions or a combination of both (AKIN et al., 2003). These species have preferences for certain factors, which influence the composition of the assemblages (MAHON et al., 1998, OBERDORFF et al., 2001).

Several factors seemed to contribute to the geographical differentiation between the estuary and the inner continental shelf. These included the influence of fresh water discharge, differences in both temperature and salinity, and differences in the extent and type of background areas (GUERRERO et al., 1997). The changes in the abundance and species occurrence could be associated with depth (e.g., as with *M. schmitti*, *Stromateus brasiliensis* and *Percophis brasiliensis*). Other species such as *P. puntactus*, *Micropogonias furnieri*, *Conger orbignyanus*, *U. brasiliensis*, *Paralonchurus brasiliensis*, *U. canosai*, *Myliobatis goodei*, *Galeorhinus galeus* (Linneaus 1758), *Cynoscion guatucupa*, *Mustelus schmitti* and *Parona signata* are linked to more than one assemblage and do not appear to be restricted to just one. While the abundance changed with depth, it was noted that species range distributions overlapped, and the maximum abundance changed according to temperature and salinity ranges. The salinity preferences of *C. orbignyanus*, *U. brasiliensis*, *U. canosai*, *M. goodei* and *R. agassizi* were markedly different. These species prevailed in salinities between 29 and 31 ups and temperatures between 12 and 17.6°C. Although the salinity could be a key factor for identifying assemblages (VORWERK et al., 2003; PAPERNO; BRODIE, 2004), it is difficult to demonstrate the role of a single variable in analyzing the structure of a community of fish in estuaries and especially considering that many species involved several associations at a time. Many of these variables are confused and individual species of fish react differently to changes in each factor. The species composition and structure of the community in estuaries can be deeply influenced by the tide, wind and turbidity (SCULLY et al., 2005). The Rio de la Plata has a northwest-southwest geographical direction, so when is affected by a strong Southeast wind, the water level rises. Furthermore, the shape and size of the estuary and the micro tide regime give atmospheric processes, especially the wind regime, important key roles in the dynamics of the river. In winter, the northward shift of intense pressure in subtropical fronts causes an increase in the frequency of winds from the west, while in spring and summer flows affect the east and southeast. The characteristic Southwest and Southeast winds associated with the passage of meteorological fronts kept the industrial and artisanal fleet in port for 3-4 days (NAGY et al., 2007), but did not affect the distribution of some fish species Although interannual fish assemblage variation may be observed due to environmental variability (mainly salinity and temperature), long term climate trends, such us El Niño events and climatic changes can result in a restructuring of fish assemblages (GARCIA et al., 2001). In this study we have shown that the fish assemblages were persistent throughout the period analyzed although the increment in abundance of the groups IEA and EEA (principally due to the species *B. aurea* and *Macrodon ancylodon*) for the springs 1991-1992-1993 and 1983 could be related to the El Niño effect over the area of the Parana and Uruguay river basin (NAGY et al., 2002).

Table 3. Typifying species (gray), discriminating species (underlined) in the time-series. IEA: Internal Estuarine Assemblage; EEA: External Estuarine Assemblage; UCA: Uruguayan Coastal Assemblage.

Internal Estuarine Assemblage

	SP 75	SU 76	W 76	SU 77	A 77	A 81	SP 81	SU 82	SP 82	SU 83	W 83	SP 84	SU 85	W 85	SU 86	W 87	SU 88	W 89	A 91	W 91	SP 91	SP 92	SP 93	SP 94	SP 95	SU 95
Brevoortia aurea	1.04	1.04	**2.69**		1.18	1.29			**2.23**			1.83		1.69			1.37			1.28	**1.89**	**1.92**	**2.73**	**2.05**		**3.55**
Macrodon ancylodon	**3.14**	1.74	1.56	**2.47**	**2.41**	**3.16**	**3.15**	1.57	**2.85**	**2.78**	1.35	**3.35**	2.84	**2.16**	**2.51**	1.88	2.50	1.94	**2.52**	1.46	**3.31**	**3.06**	**3.18**	**3.37**	**1.77**	**2.75**
Micropogonias furnieri	1.18	**3.48**	**3.66**	**3.80**	**3.70**	**3.77**	1.56	**3.32**	2.03	**3.35**	**2.78**	**1.95**	**3.32**	**3.28**	**3.46**	**3.51**	**3.26**	**3.11**	**3.21**	**2.92**	**2.18**	**1.69**	**2.17**	1.44	**2.42**	1.47
Myliobatis goodei	**2.26**	2.77	1.95	1.98	2.59	2.16	1.77	**2.81**	**2.63**	1.62		1.92	2.29	1.15	**2.13**		**2.87**		0.93	0.91	1.91	1.48	1.80	1.50	1.31	
Parona signata	1.83	**2.63**	**3.24**	1.65	1.47	1.34	1.89	1.15	2.26		1.50				1.57	1.44		0.82			1.58	1.60			1.55	
Paralichthys spp.	0.92		1.02		1.14	1.25	1.42	0.96	1.35	0.94	1.52			1.36	0.98	1.83		**2.28**	**2.06**	**2.07**		1.55	1.54		1.06	
Cynoscion guatucupa	1.22				1.52			1.33							1.68	**2.44**		1.39		1.46				1.35		
Mustelus schmitti	1.46				1.18		0.95				0.76															
Rajidae																1.89										
Sympterygia bonapartii																		1.16		1.11						
Stromateus brasiliensis									0.88					1.18				0.91								
Squatina guggenheim																					1.44					
Trichiurus lepturus		1.69				**1.96**		1.59		1.64					1.43		1.25	1.08	1.35						**1.89**	1.65
Genidens barbus				1.63				0.94									1.76		1.14		**1.87**		1.72		1.39	
Prionotus punctatus															1.71			1.02								
Paralonchurus brasiliensis					1.13				0.97																	
Prionotus nudigula	1.17	1.22	1.64							0.99							1.06									
Umbrina canosai																										
Percophis brasiliensis	1.04																									
Pagrus pagrus																										
Atlantoraja castelnaui																										
Conger orbignyanus							0.65													0.82		1.13		1.01		
Discopyge tschudii																										
Urophycis brasiliensis												1.00				1.06		0.86			1.01	1.12	1.15			
Zapteryx brevirostris																										
Paralichthys patagonicus																					1.12					
Pomatomus saltator																										
Mugil platanus									0.95	0.81			1.76								1.55		1.48	1.06	0.91	
Menticirrhus americanus																						1.07				

Table 3. Continuated.

External Estuarine Assemblage

	SP 75	SU 76	W 76	SU 77	A 77	A 81	SP 81	SU 82	SP 82	SU 83	W 83	SP 84	SU 85	W 85	SU 86	W 87	SU 88	W 89	A 91	W 91	SP 91	SP 92	SP 93	SP 94	SP 95	SU 95
Brevoortia aurea		1.95		2.32				1.86		1.60			2.14		1.51		1.41									
Macrodon ancylodon		**3.05**		**3.64**				**3.23**		**3.07**			**2.43**		**3.08**		**2.92**						1.04		**3.35**	
Micropogonias furnieri	1.77	**2.63**	1.41	**3.59**	**2.83**	**2.40**	1.61	**2.95**	**2.60**	2.65	**2.56**	**2.65**	**3.11**	**2.56**	**2.75**	**2.36**	**2.09**	**2.76**	**3.03**	1.87	**2.30**	**3.05**	**3.00**	**2.14**	**2.63**	**3.31**
Myliobatis goodei	2.08		**1.32**		**2.24**	1.64	**2.89**		**3.01**		**1.93**	**2.51**		**2.35**		**2.72**		**2.14**	1.15	1.82	2.09	1.51	**2.44**	1.75		**2.58**
Parona signata	**2.29**		1.36	1.77	1.46	**1.81**	1.25	2.25	2.00	1.60	1.63	1.31	1.58	1.78			1.23	1.72	1.84	1.48	**2.29**	**2.31**	1.83	**2.02**	1.53	1.73
Paralichthys spp.	1.52		**1.36**			1.16	**2.34**		**1.97**		1.45	**2.02**		1.20		1.30	1.66	**2.00**	1.04	**1.84**		1.99	1.90	1.44		
Cynoscion guatucupa	1.21	1.77	1.38	1.63	**2.47**			1.85	1.39	1.45	**2.70**	2.10	1.84	**2.52**	2.23	**2.46**	1.43	1.56	1.85	**2.95**	1.39	2.13	1.11	1.29	**2.67**	1.00
Mustelus schmitti	**2.82**		1.66	1.39	1.72	1.40	**3.07**		2.38		1.59	**2.74**		**2.52**	1.76	1.23	1.48	**2.34**	2.24	**2.22**	**3.37**	**3.86**	**2.96**	**3.07**	**3.13**	**2.50**
Rajidae			0.67				1.35				1.37	1.63		1.94		**1.97**									2.34	
Sympeterygia bonapartii																		1.91	2.07	1.66	1.32	1.80	1.67	1.74		
Stromateus brasiliensis	1.73		**1.60**				1.35		**2.29**			1.29		1.27		1.57			1.22	1.27		1.82		1.13		
Squatina guggenheim							1.72			1.17	1.18	1.97		1.23		1.77		1.45	0.99	1.70	**2.66**	**2.40**	**2.41**	**2.41**		**2.57**
Trichiurus lepturus					**2.25**	**2.29**												1.79	**3.05**							**2.03**
Genidens barbus				1.73	0.95			**2.61**		1.39			1.96				**1.72**									
Prionotus punctactus														1.32				**2.20**	1.70		1.72	1.91	2.04	**2.49**		1.74
Paralonchurus brasiliensis																										
Prionotus nudigula	1.37		**1.33**		0.86	**1.66**	**2.74**		2.19		1.27							1.12							1.32	
Umbrina canosai								1.96													0.96				1.61	
Percophis brasiliensis			1.24				2.15		1.27														**2.96**	**3.07**		**2.50**
Pagrus pagrus			0.76																							
Atlantoraja castelnaui																		1.34		**2.05**	1.90	**2.42**	1.58	1.20		
Conger orbignyanus																										
Discopyge tschudii																				**1.91**	1.11	**2.44**				
Urophycis brasiliensis																					0.81		1.33	1.03		**2.02**
Zapteryx brevirostris																				1.70	1.06	2.02	1.15			
Paralichthys patagonicus																										2.00
Pomatomus saltator		2.28		**2.36**				**2.27**		**2.67**			**2.12**		1.82		**1.88**								1.59	1.40
Mugil platanus																										
Menticirrhus americanus																										

Table 3. Continuated.

Uruguayan Coastal Assemblage

	SP 75	SU 76	W 76	SU 77	A 77	A 81	SP 81	SU 82	SP 82	SU 83	W 83	SP 84	SU 85	W 85	SU 86	W 87	SU 88	W 89	A 91	W 91	SP 91	SP 92	SP 93	SP 94	SP 95	SU 95
Brevoortia aurea								1.35																		
Macrodon ancylodon																				1.10						
Micropogonias furnieri	**2.26**	1.78	1.55	**2.67**	**3.24**	**3.62**	1.85	**3.28**	2.75	2.64	**2.50**	1.86	1.17	**2.21**	2.35	**2.97**	**2.54**	**2.70**	**2.93**	**2.93**	**2.42**	**2.45**		**2.57**	**2.89**	**2.77**
Myliobatis goodei	1.80	1.68	**2.58**	**2.81**	**3.05**	1.93	**2.75**	2.27	1.67	**3.04**	**2.79**	**2.36**	**3.05**	2.07	**2.99**	2.06	**2.70**	2.10	**3.17**	1.84		2.00	**2.62**	2.03	2.19	1.87
Parona signata			**1.88**					1.49									1.23		1.97	1.01						
Paralichthys spp.			1.25	1.87	1.37		1.22	1.37		1.38		1.71	1.93	**1.93**			1.52		1.38			**1.89**	**2.39**			
Cynoscion guatucupa	**3.21**	2.41	**2.79**	**3.37**	**3.19**	**3.32**	**2.27**	**3.04**	**3.34**	**3.32**	**3.13**	**2.69**	**2.29**	**3.43**	**3.04**	**2.95**	**3.46**	**2.81**	**2.77**	**3.01**	**2.95**	**2.65**	2.54	**3.38**	2.93	**3.29**
Mustelus schmitti	**2.31**	**2.74**	**2.18**	**2.92**	**2.99**	1.77	**2.82**	**2.59**	**3.17**	**3.23**	2.21	**2.35**	**3.03**	1.93	**2.73**	**2.43**	2.35	**2.72**	**2.63**	**2.52**	**3.08**	**2.69**	**3.30**	**2.94**	**2.78**	**2.75**
Rajidae	1.25		1.39	2.17	20.1	2.09	1.88		1.77	1.54	2.00	2.02	1.87	2.02	2.08	1.82	2.05						**2.47**			
Sympeterygia bonapartii								1.12											1.13		1.56	1.69		2.07		**2.24**
Stromateus brasiliensis			1.26																				1.62			
Squatina guggenheim	1.21		1.21	2.22	1.63	1.77	1.36	2.17	1.93	1.74	1.92	1.71	1.94	**2.10**	1.99	1.44	1.57	2.23	**2.26**	1.19	**2.50**	**2.34**	**2.93**	**2.57**	**2.62**	**2.61**
Trichiurus lepturus	1.35	**2.83**		1.88	2.25	2.4		2.42	**2.61**		1.73			1.45		2.30		2.03	1.99		1.20				**2.91**	2.14
Genidens barbus						1.59		1.08																		
Prionotus punctactus																										
Paralonchurus brasiliensis																										
Prionotus nudigula							0.84																			
Umbrina canosai	1.73	1.37		1.89	**2.88**	2.31			2.73		1.88					2.07	2.15	2.09	2.40	1.27	1.70			**2.64**	2.28	1.95
Percophis brasiliensis																										
Pagrus pagrus																										
Atlantoraja castelnaui																			1.51	1.54	1.75	1.93		2.13		
Conger orbignyanus										1.11											1.51			1.27		
Discopyge tschudii																					**2.17**	1.28	1.98			
Urophycis brasiliensis							1.08			1.34			1.17		0.90				1.37		1.61	1.20	1.88	1.56		1.84
Zapteryx brevirostris																										
Paralichthys patagonicus																					1.84					1.76
Pomatomus saltator																										
Mugil platanus																										
Menticirrhus americanus																										

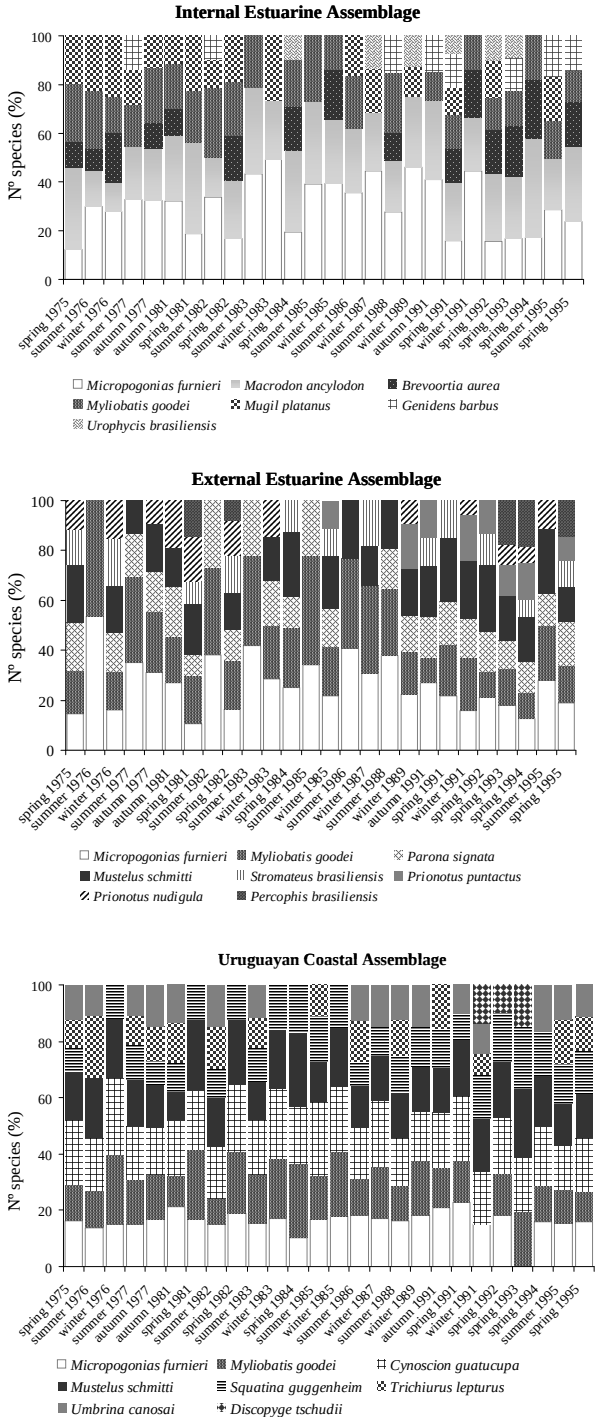

Fig. 4. Species relative compositions (%) of the total catch of the assemblage. Species codes in Table 2.

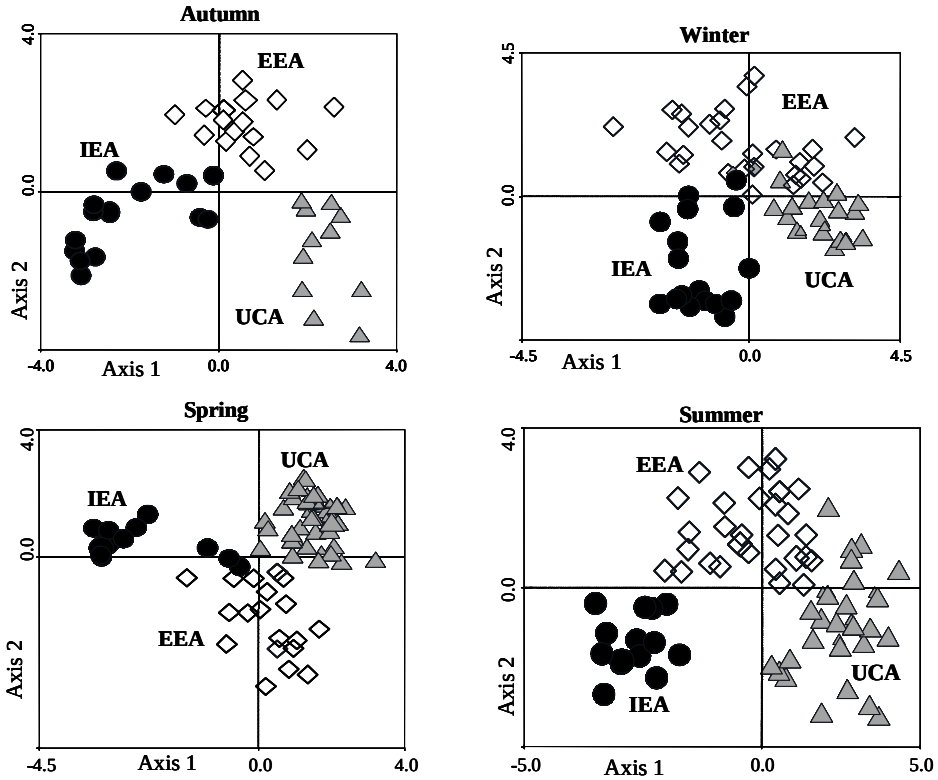

Fig. 5. Plot of two axes of PCA ordination for different seasons. The axes 1 and 2 differentiate between shallow and deep stations (assemblages have been indicated according to cluster analysis results). IEA: Internal Estuarine Assemblage; EEA: External Estuarine Assemblage; UCA: Uruguayan Coastal Assemblage. (We have given four seasons as an example: Autumn 1991; Winter 1987; Spring 1995, Summer 1983). See also Figure 3 for spatial distribution of assemblages.)

Our results suggest that other factors, both physical and biological, could be influencing the community structure though not the persistence of assemblages: (e.g. sediment) (GIBBONS et al., 2002), food availability (BARRY et al., 1996), turbidity (ARAUJO et al., 1999), pH (WHITFIELD, 1999) or biological interactions (*e.g.* competition or predation). The feeding habits of most species that inhabit the Rio de la Plata estuary cover several trophic levels: planktofagous (*B. aurea*, *Engraulis anchoita*); detritivorous (*M. platanus*); benthofagous (*M. schmitti*, *Sympterygia bonapartii*, *M. goodei*, *U. brasiliensis*, *M. furnieri*, *P. puntactus*, *Prionotus nudigula*, *U. canosai*) and nectopelagic (*C. guatucupa*, *Macrodon ancylodon*, *Pomatomus saltatrix*, *P. signata*) (COUSSEAU; PERROTTA, 2004) . However, the species composition in each assemblage structure suggests that the trophic relationship among species may be weak.

The persistence of species associations observed over the 21 years analyzed is remarkable, given the history of fishery exploitation and the environmental variability in the Rio de la Plata (NAGY, 2005). The most striking seasonal patterns in demersal assemblages took place within the assemblages themselves, rather than in the positioning of their geographical limits. The boundaries of the groups, particularly the shallow ones, did not vary substantially over the year. Seasonality was more pronounced within the shallow southern assemblage, but differences between seasons were also observed in the shallow northern and in the intermediate southern assemblage. Patterns of species assemblages could be representative of aquatic eco-regions and may thus be used as important tools for resource management and conservation. Fish groups can be viewed as ecological entities, such as the assemblage production units proposed by Tyler et al., (1982) and management strategies could be adapted to optimize the harvest of assemblages, rather than the harvest of a single species (MAHON et al., 1998). According to the latter authors, additional analysis focusing on trophic studies are required to determine whether or not the groups have a functional relationship (PAULY et al., 2001) and in which ways assemblages are affected by fishing activity.

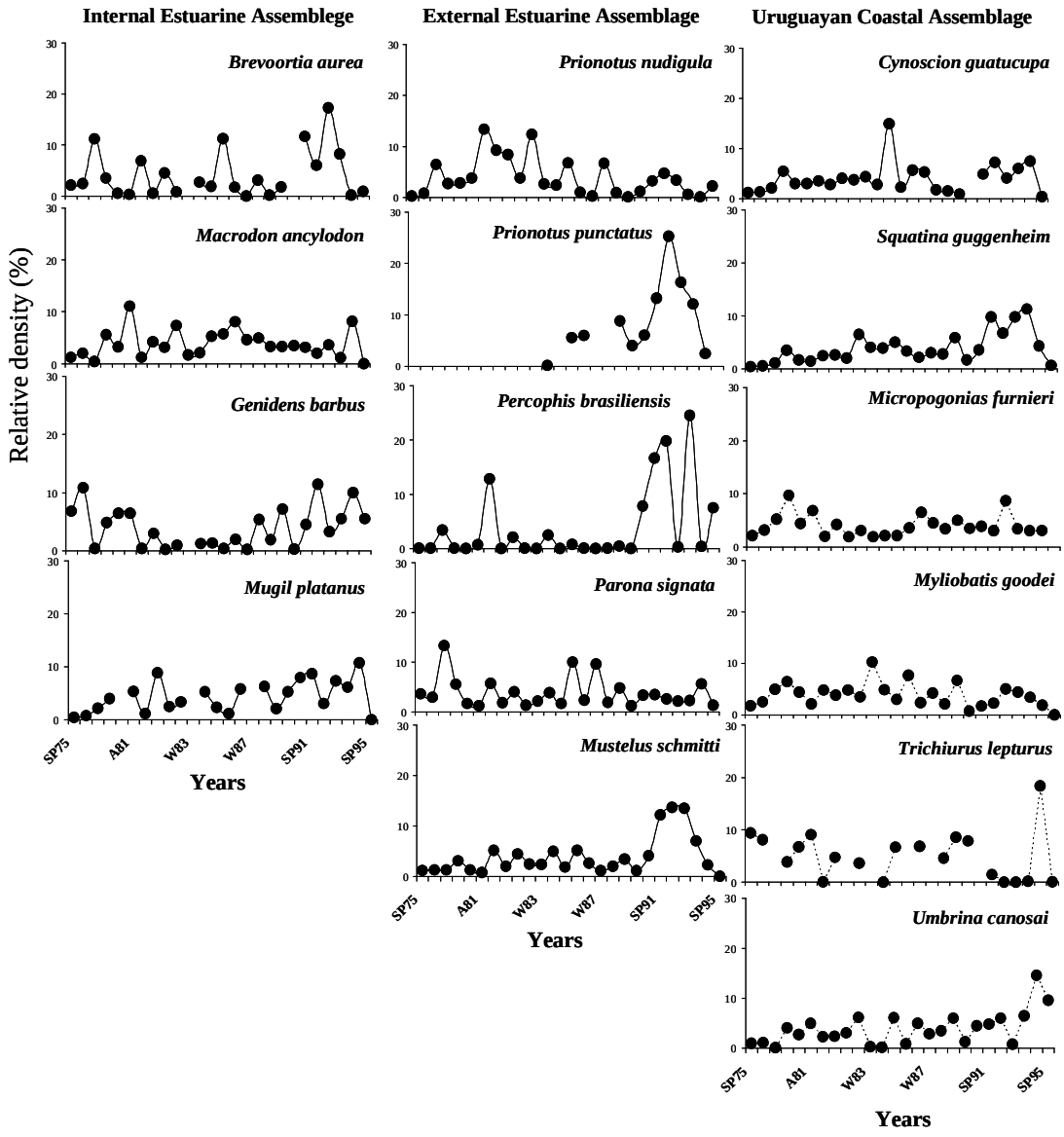

Fig. 6. Relative abundance (%) of principal species characteristic of each assemblage throughout the time series 1975-1995.

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