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Aquatic Ecology of the Mondego River Basin
Global Importance of Local Experience

Coimbra • Imprensa da Universidade

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COORDENAÇÃO EDITORIAL
Imprensa da Universidade de Coimbra

CONCEPÇÃO GRÁFICA
António Barros

INFOGRAFIA
António Resende
Estímulus [design] • Coimbra

EXECUÇÃO GRÁFICA
GRAFIASA

ILUSTRAÇÃO DA CAPA
P. P. Cunha e J. Dinis

ISBN
972-8704-04-6

DEPÓSITO LEGAL
175038/02

OBRA PUBLICADA COM O PATROCÍNIO DE:
IMAR – INSTITUTO DO MAR
IPIMAR – INSTITUTO DE INVESTIGAÇÃO DAS PESCAS E DO MAR

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FISH COMMUNITY OF MONDEGO ESTUARY: SPACE-TEMPORAL ORGANISATION

Abstract

Sampling fish community and abiotic characteristics of water was done in five stations each month, during 1988, 1991 and 1992. The structure of the community is organised in four components status: occasional marine, occasional freshwater, sedentary and migrant. Calendar of presence of this last group is given. Three habitats: marine, brackish, and freshwater were characterised with discriminant function analysis. AFC and communities indexes gave results about the space temporal variability of ichthyofauna. Interpretations about functioning ecosystem are given in relation with habitat characteristics and migrant status of population that represents the maximum abundance.

Introduction

The estuary of Mondego river is composed of two arms (north and south) limiting the Morraceira island (Fig. 1). Its upstream communication is silted up, allowing the change of water only in high tide or in a overflow situation. As a consequence of important hydraulic works carried out upstream, the freshwater affluence to the estuary proceeds partly from the artificial streams of the bridge-dam of Coimbra and Bizorreiro sluice. Whereas the regime of the latter is related with agriculture activity and is opened when there is too much water upstream, causing sometimes sharp disturbances in downstream system, the former has a continuous but variable flow, along the year. These two water control systems contribute to the different hydrological conditions of the two arms: northern one has a strong hydrodynamism affected by the tides and by the Mondego river flow, and the southern arm shows a lower water circulation, mainly affected by tidal currents (Duarte and Pena dos Reis 1993).

The estuary has been the place for an important fishing activity involving different sorts of gears and about one hundred of local boats, distributed by two small natural

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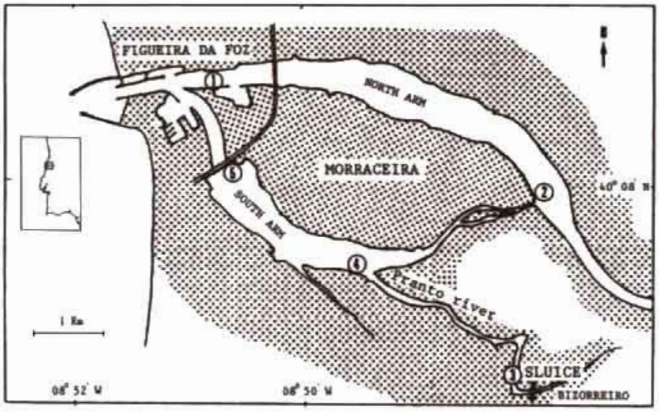

Fig. 1. The estuary of Mondego river and the ichthyofauna sampling places: 1 - Porto Comercial (C); 2 - Vila Verde (V); 3 - Pranto (P); 4 - Braço Sul (S); 5 - Gala (G).

harbours, Vila Verde and Gala. The local fishing is directed to a variety of resources like flatfish (flounder and soles), sea-bass, eel, mullets, green crab, bivalves, etc.

The exploitation of the seasonal migrants like lamprey, shad and glass-eel are very important estuarine activities owing to its high demand, providing important profits to the local fishermen. This is the main reason for the use of illegal gears and nets, of high efficiency, like the typical case of the fyke net for glass-eel and lamprey. In this system it has been traditionally developed the salt exploration, an activity that is in deep declining. For that reason the salt-marsh are being transformed into fish farming units where the seabass and gilthhead seabream are the most important cultivated species being eel farming supplied with glass-eel from the estuary.

A gradual decrease of landings from littoral coast of Figueira da Foz reflects a certain depletion of some resources mainly, due to the intensive fishing, not only in the coast but in estuaries too. The great importance of estuaries in fish production is a strong reason to protect them from human impact. This role emphasises the necessity of understanding the environment of fish and its interrelationships.

In the scope of the Integrated Programme for the Regional Development of Baixo Mondego, a study was carried out in 1988, 1991 and 1992, before the dredging of north arm, for characterising the ichthyological fauna and understanding the space-temporal variability of fish community and its relation with abiotic factors.

Methodology

Sampling stations

Information concerning some abiotic variables such as temperature and salinity was registered in ebb tide conditions for posterior environmental characterisation in the following five stations, selected by its different potential environmental conditions and distance from the sea (Fig. 1):

Porto Comercial (C) – on the left edge of north channel, at about 2 km from the entrance and near the sewage effluent of Figueira da Foz, is daily submitted to a marine influence save when a great freshwater discharge takes place.

Vila Verde (V) – in northern channel near the upstream division of the estuary in two arms is located in a permanent freshwater region, at about 7 Km from the sea.

Gala (G) – in the downstream region of south arm, at about 3 km from the sea is exposed to the marine influence except in overflow conditions.

Braço Sul (S) – in the inner part of south channel and submitted to marine influence except when the sluice of Pranto is open. It is the station with lowest depth and greatest water transparency.

Pranto (P) – situated in a tributary (Pranto river) of south channel, at about 8 km from the entrance and near Bizorreiro sluice.

Environmental variables

The 1991 and 1992 temperature and salinity values, with another complementary abiotic information like tide coefficient, monthly distribution of rain, flow in Coimbra bridge-dam in three days before sampling, percentage of sand in substratum, depth and distance from the sea, were organised in matrix and then transformed by centrage and reduction using a commercial computer program (NTSYS-pc). Based on the principles of cluster analysis the stations where assembled according similarities, using correlation coefficient. A discriminant analysis was after applied to research the capacity of environmental variables in discriminating stations assemblages identified by the above classification method.

Fish fauna

Fish fauna population study was based on sequential monthly sampling, referred to three hauls of beach seine in each of the three estuarine habitats identified by the analyse of abiotic parameters: marine, brackish and freshwater represented respectively by Gala/Porto Comercial, Pranto and Vila Verde stations.

Community index like specific richness represented by species number, Shannon-Wiener diversity index (Legendre and Legendre 1984) and evenness were used to characterise in a global way the fish populations. They were calculated by sampling zone and month to point out space-temporal variations.

Cluster analysis based on Jaccard coeficient were used to find similitudes between lagoons and estuaries based in fish fauna lists.

A correspondence factor analysis was applied to identify changes in fish community structure in a space temporal scale and to relate those variations with species, sampling regions and seasons. In the graphics the species are represented by a numerical code and the fish samples by a mixed code with a letter identifying the zones.

Environmental characteristics

Surface temperature in all years and stations had the same trend with the lowest values in winter and the greatest in summer or beginning of autumn, with extreme values upstream (Fig. 2).

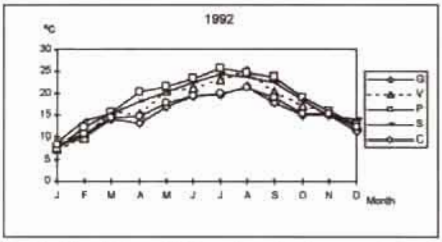

Fig. 2. Monthly evolution of water temperature at surface for each different stations.

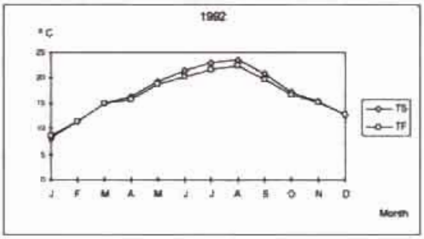

Fig. 3. Yearly cycle of temperature at surface (TS) and near the bottom (TF) averaged over all stations.

From spring till autumn the lowest values correspond to the stations nearest the sea, and the most disperse values were observed in Pranto station. The yearly average of bottom water temperature was similar to the correspondent at surface and its monthly values at the bottom follow closely the seasonal fluctuation of those at surface (Fig. 3).

The salinity had an irregular variation from year to year with an evolution closely related with the atmospheric precipitation and flow of Coimbra bridge-dam (Fig. 4). In

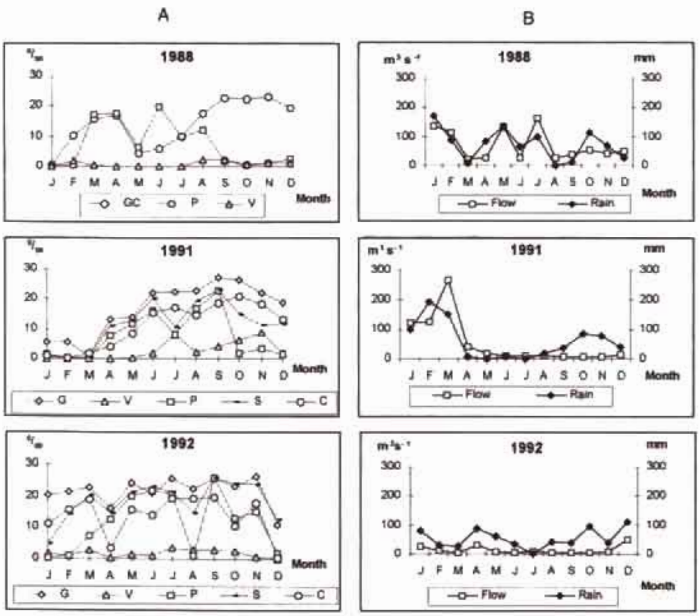

Fig. 4. A - Monthly water salinity at surface for each different stations; B - Monthly distribution of rain and average of flow at bridge-dam of Coimbra in three days before sampling.

1991 the monthly evolution of surface salinity showed very low values in winter, especially in March in all stations. The decreasing observed in July in Pranto and Braço Sul stations is related with the Pranto sluice regime. The 1992 year was drier than 1991, but some rain noted in January, April, October and December, together with greater flows in the dam of Coimbra, led to a diminution in salinity in all stations. In August the salinity in Pranto had a very accentuated decreasing whose influence was propagated as far as Gala station. The vertical gradient of salinity (Fig. 5) had only some importance in Porto Commercial area, where the depth is the greatest. In south arm the depth is small and the water column is homogeneous. The salinity decreases when the distance from the sea increases, being higher in south arm for stations almost equidistant from the entrance.

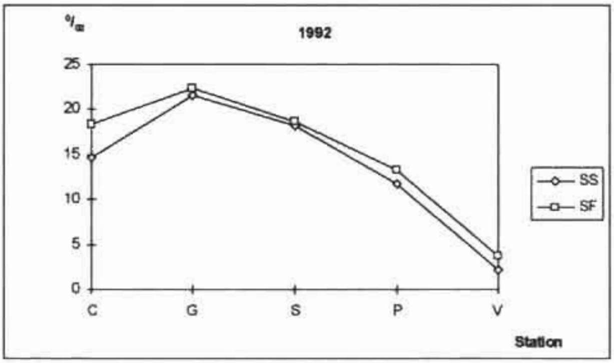

Fig. 5. Annual average of salinity at surface (SS) and near the bottom (SF) for each station.

The discriminant function analysis kept as variables of primary interest the tide coefficient, the average of debits in the Coimbra bridge-dam and the water salinity near the bottom, to build the model to discriminate the groups previously established. The Fig. 6 shows the projection of the five groups obtained by hierarchical classification on the plan of the first and second discriminant functions, at which are associated 89 % of discriminatory power, mainly based respectively in tide coefficient and salinity near the bottom. The first function discriminated the group of marine stations (Gala and Porto Comercial – G 4:4) from that of brackish stations (Pranto – G 3:3 – and Braço Sul – G 5:5) and the second discriminated the freshwater station of Vila Verde (G 2:2) from those of marine and from Braço Sul stations based mainly in the bottom salinity. The third function with a weaker discriminatory power differentiated the group of Vila Verde, in freshwater conditions, from the group that include all stations in the months that occurs greater discharges in Coimbra dam and great pluviosity. It can be noted on this picture some affinity between Pranto and Braço Sul stations, being the difference between them only suggested by the trend of Pranto points to fall above the central line (0).

Summarising it can be said that the freshwater discharges at Coimbra dam and atmospheric precipitation are two covariables whose effects, in the rainy periods, led to attenuate the differences among the several regions of the system. The persistence of the affinity among abiotic factors from Gala and Porto Commercial and the identity of remainder stations were observed, being noted also some approach among the

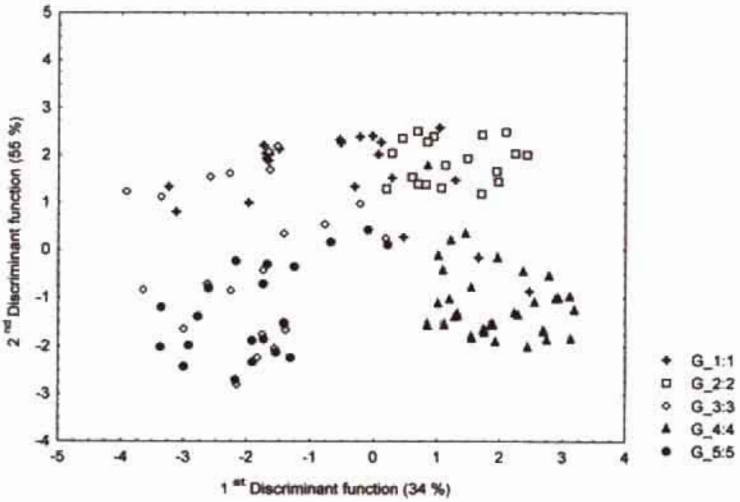

Fig. 6. Plot of discriminant function analysis showing how the two first functions discriminate the five groups of stations identified by hierarchycal classification (G_1:1 stations in overflow months; G_2:2 Vila Verde; G_3:3 Pranto; G_4:4 Gala e Porto Comercial; G_5:5 Braço Sul).

characteristics of Pranto and Braço Sul stations. Therefore, three space units can be considered corresponding to a freshwater habitat in the upstream region of north arm (Vila Verde), a marine one in Gala/Porto Comercial zone and a brackish area on the inner part of south arm which continues by the downstream section of Pranto river up to the Bizorreiro sluice. In consequence for fish community analysis: Gala and Porto Comercial are marine habitats (M), Pranto and Braço Sul are brackish habitats (S) and Vila Verde is freshwater habitat (D).

Fish fauna composition and situation

The simplest way to study the fish fauna is to obtain a list, which indicates the species of fish that use estuaries. In this study were identified 62 species distributed by 27 families according to the criterions of Whitehead et al. (1986).

a) List of species

A number of classifications scheme for estuarine fish species have been referred by several authors (Claridge et al. 1986, Costa 1982, Monteiro 1989, Paris and Quignard 1971, Bach 1986, Rebelo 1993). Based on the occurrence of sampling species and in the characteristics of their life cycles, there were considered the following community status group, represented in Table1:

Table 1. Fish fauna list of each community group (code of each species in brackets)

Sedentary (SED.)	Occas. Freshwater (O.D.)	Occas. Marine (O.M.)	Migrants (MIG.) Anadromous (Mig. an.)	Migrants (MIG.) Catadromous (Mig. ca.)	Migrants (MIG.) Cyclic (Mig. cy.)
Atherina boyeri (64)	*Barbus bocagei* (7)	*Ammodytes tobianus* (45)	*Alosa alosa* (3)	*Anguilla anguilla* (15)	*Chelon labrosus* (62)
Atherina presbyter (66)	*Carassius auratus* (8)	*Aphia minuta* (48)	*Alosa fallax* (4)		*Dicentrarchus labrax* (32)
Gobius niger (50)	*Carassius carassius* (9)	*Belone belone* (17)			*Diplodus sargus* (35)
Pomatoschistus minutus (54)	*Chondrostoma polylepis* (10)	*Boops boops* (40)			*Diplodus vulgaris* (36)
Pomatoschistus microps (53)	*Cyprinus carpio* (11)	*Callionymus lyra* (57)			*Engraulis encrasicolus* (6)
Syngnathus abaster (24)	*Gambusia affinis* (18)	*Ciliata mustela* (29)			*Liza aurata* (63)
Syngnathus acus (25)	*Gasterosteus aculeatus* (27)	*Echiichthys vipera* (46)			*Liza ramada* (64)
	Gobio gobio (13)	*Entelurus aequoreus* (19)			*Mugil cephalus* (65)
	Micropterus salmoides (14)	*Gobius cobitis* (49)			*Mullus surmuletus* (34)
	Rutilus macrolepidotus (12)	*Hyppocampus ramulosus* (21)			*Platichthys flesus* (70)
		Labrus merula (41)			*Sardina pilchardus* (5)
		Labrus viridis (42)			*Scophthalmus rhombus* (69)
		Nerophis lumbriciformis (22)			*Solea senegalensis* (72)
		Nerophis ophidion (23)			*Solea vulgaris* (73)
		Pagrus pagrus (38)			*Sparus aurata* (37)
		Parablennius gattorugine (58)			*Spondyliosoma cantharus* (39)
		Pomatoschistus knerii (56)			*Trigla lucerna* (68)
		Pomatoschistus lozanoi (52)			
		Pomatoschistus pictus (56)			
		Scomber japonicus (47)			
		Spinachia spinachia (28)			
		Symphodus bailloni (43)			
		Symphodus melops (44)			
		Syngnathus typhle (26)			
		Trachurus trachurus (33)			

Sedentary species (Sed): have a great tolerance to salinity changes and can complete their entire life cycles within the estuary, and are represented by seven species.

Migrants which includes: the anadromous species (M. an.) migrating from the sea to fresh water for breeding (*Alosa alosa* and *Alosa fallax*); the catadromous species (M. ca.) – migrating from freshwater to the sea to breed (*Anguilla anguilla*); the cycling migrants (M. cy.) with a marine origin, occupies temporarily the estuarine waters for feeding, protection or spawning, are represented by 17 species generally juvenile forms. This important group dominated in biomass and abundance during all the year in marine, freshwater and brackish habitats.

Occasional visitors from sea-water (O. m.): intolerant to the salinity changes, appear irregularly in the estuary when the environmental conditions are favourable. They correspond to 25 species with a strong preference for marine environment and the less rainy years.

Occasional visitors with a freshwater origin (O. d.) have, consequently, a freshwater affinity occurring mainly in freshwater conditions in rainy periods and with freshwater discharges in Coimbra bridge-dam and Bizorreiro sluice. They are represented by 10 species.

Based on the evolution of length frequency distributions and age readings, an attempt was made to represent migration flows for the main marine cyclic migrants (Fig. 7). For the most of considered species (*Trigla lucerna, Plathichthys flesus, Sardina pilchardus, Dicentrarchus labrax, Sparus aurata, Solea vulgaris, Chelon labrosus, Liza ramada* and *Scophthalmus rhombus*) the recruitment starts in spring which means that their spawning periods occur in winter. A second recruitment takes place in summer with *Diplodus sargus* and *Diplodus vulgaris* in the beginning of the season and later, in August, *Mullus surmuletus* and *Engraulis encrasicolus*. The youngs of *L. aurata* begins to appear in the third recruitment in autumn.

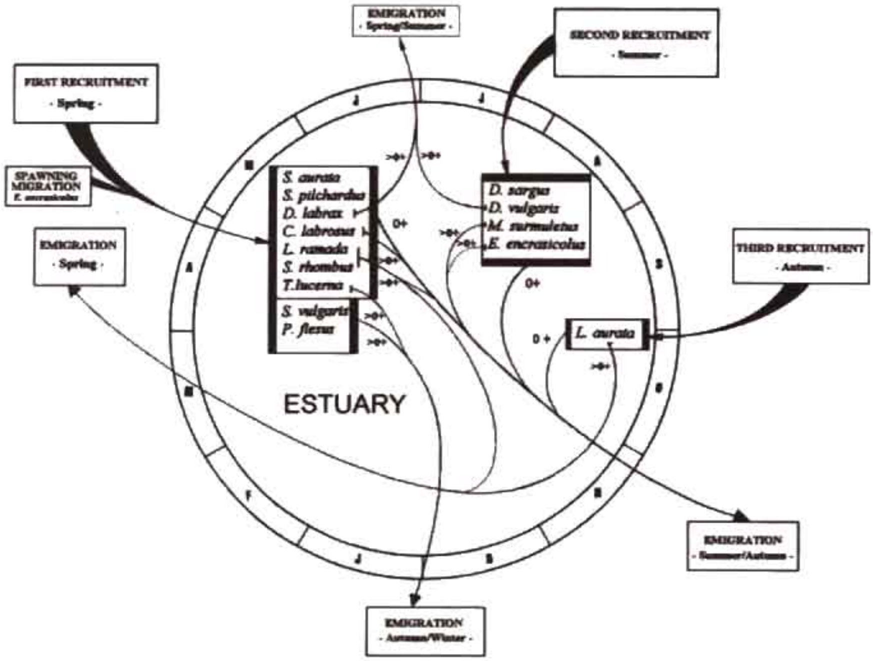

Fig. 7. Scheme indicating the beginning of migrations for the main marine species which use the estuary as a nursery ground.

Sparus aurata, Diplodus sargus, Mullus surmuletus, Engraulis encrasicolus, and *Sardina pilchardus* seems to stay in the estuary for few months and *Plathichthys flesus, Liza ramada*, and *Chelon labrosus* for more than three years, generally at about four years. Another species have a intermediate period of colonisation, normally one year, like *Dicentrarchus labrax, Trigla lucerna, Diplodus vulgaris, Scophthalmus rhombus*, or less than three years as *Solea vulgaris* and *Liza aurata*. In fact it was the calendar of the disponibility of the young fish to the estuary.

b) Comparison of species list of Mondego estuary with those of other european systems

The fish fauna composition was compared with those of Severn estuary in Southwest coast of Great Britain (Claridge et al. 1986), Étang de Thau in Mediterranean coast (Paris and Quignard 1971, Bach 1986), Ria de Aveiro (Rebelo 1993) and Tejo estuary in the western coast of Portugal (Costa 1982), and Ria Formosa in the southern portuguese coast) (Monteiro 1989) (Fig. 8).

One can verify that the sedentary proportion of species from portuguese systems are in intermediate position between the Étang de Thau (18%) and the Severn estuary (3%).

Excepting for Tejo estuary, the percentage of occasional marine species are greater in the atlantic systems and the marine migrants that use estuaries or lagoons as nursery grounds have more importance in southern systems – Tejo estuary, Ria

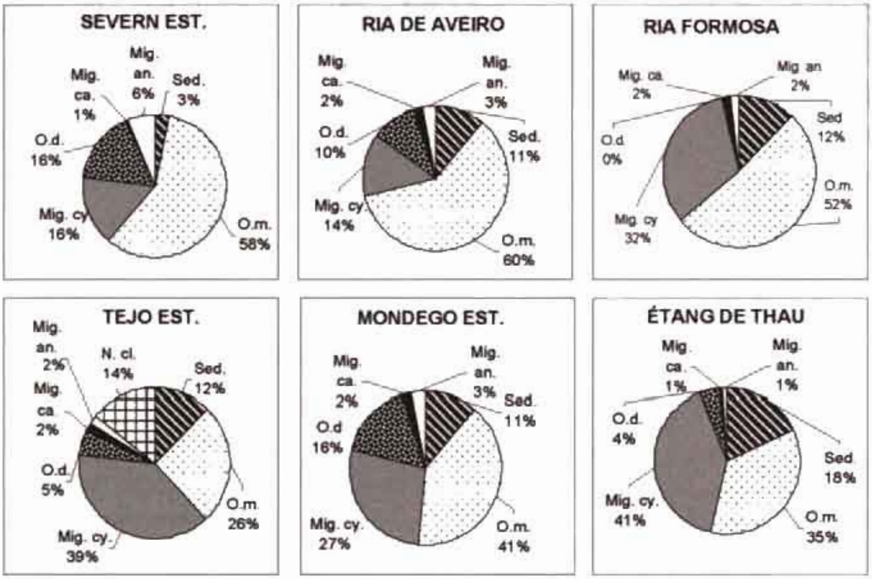

Fig. 8. Comparison of community components of fish fauna from different european coastal systems: sedentary (Sed.), marine occasional (O.m.), marine cyclic migrant (M.cy.), occasional freshwater (O.d.), migrant catadromous (Mig. ca.) migrant anadromous (Mig. an.), non classified (N.cl.).

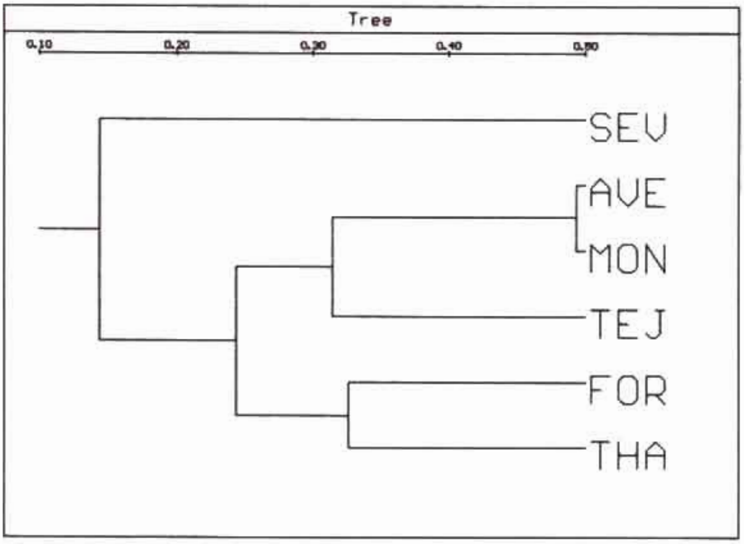

Fig. 9. Dendrogram obtained by comparison of fish fauna lists from different european coastal systems: Severn estuary (SEV), Ria de Aveiro (AVE), Ria Formosa (FOR), Tejo estuary (TEJ), Mondego estuary (MON), Étang de Thau (THA).

Formosa, and Étang de Thau – perhaps related with most favourable and stable conditions that lasts for a long period.

The anadromous and catadromous species had the lowest values in all cases and the freshwater species had the highest in the northern ones, especially in Severn and Mondego estuaries, probably due to strong freshwater discharges.

The classification analysis (Fig. 9) separate the estuary of Severn from the others which are distributed in two groups, one with Ria Formosa and Étang de Thau and another with remainder systems showing a strong association between Mondego estuary and Ria de Aveiro. The resembling lists of Ria Formosa and Étang de Thau, reflects the influence of climatic characteristics of Mediterranean and southern coast of Portugal, which are different from those of west coast.

The assemblages of the remainder portuguese systems, with a greater homogeneity of Mondego and Aveiro lists seems to be determined by its proximity and the size of sea entrance which is lesser (up to a 1 km) than that of the Tejo estuary (about 4 km). The difference of list from Severn estuary is probably due to its situation in a different biogeography region with large river and its vast sea entrance. Thau and Ria Formosa being lagoons with no permanent river they are different from Ria de Aveiro and are not estuaries like Mondego and Tejo.

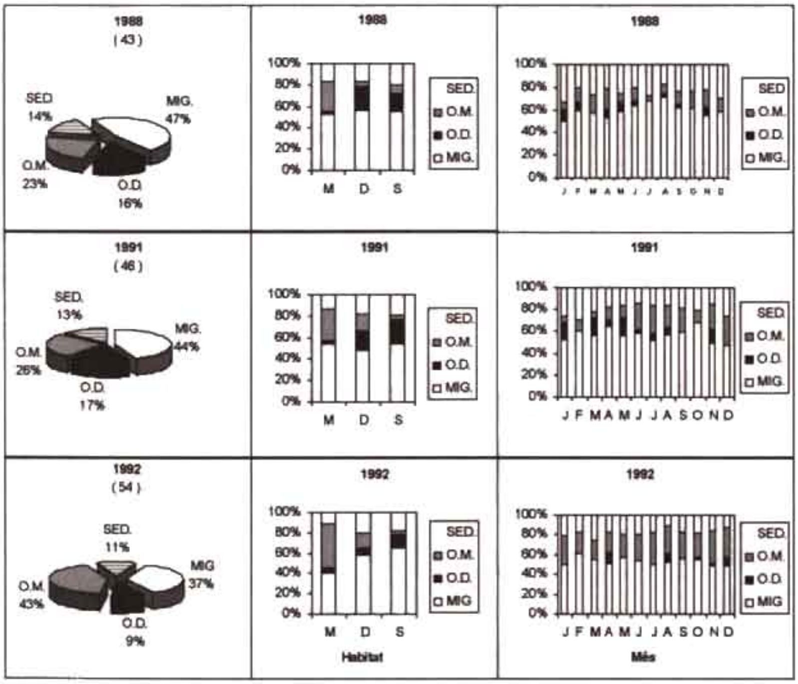

Fig. 10. Variation of species number (%) of each community group: sedentary (SED.), occasional marine (O.M.), occasional freshwater (O.D.) and marine migrant (MIG.). A - in the estuary as a whole; B - by habitat: marine (M), freshwater (D) and brackish (S); C - by month.

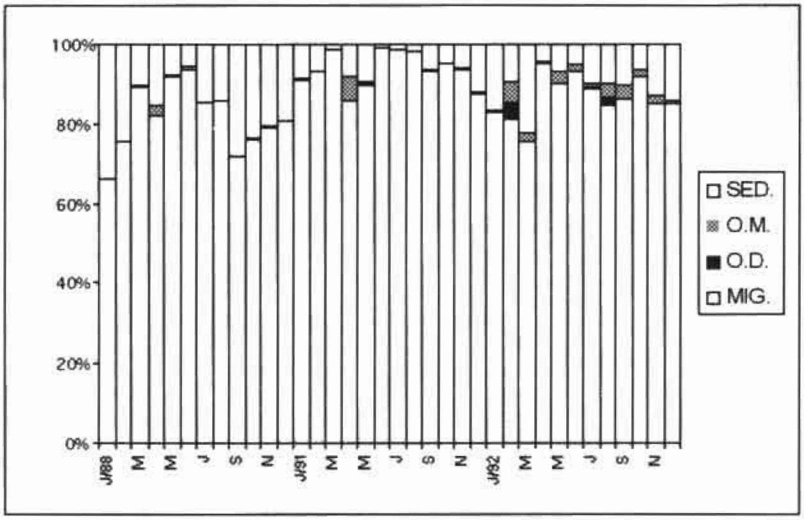

Fig. 11. Variation of abundance (%) of each community group: sedentary (SED.), occasional marine (O.M.), occasional freshwater (O.D.) and marine migrant (MIG.).

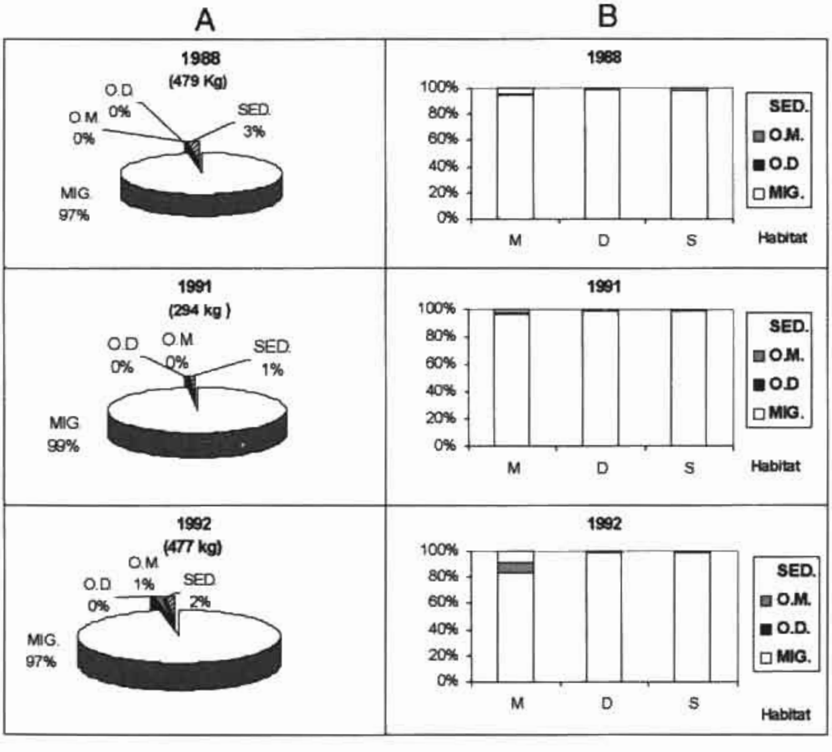

Fig. 12. Variation of biomass (%) of each community group: sedentary (SED.), occasional marine (O.M.), occasional freshwater (O.D.) and marine migrant (MIG.). A - in the estuary; B - in each habitat: marine (M), freshwater (D) and brackish (S).

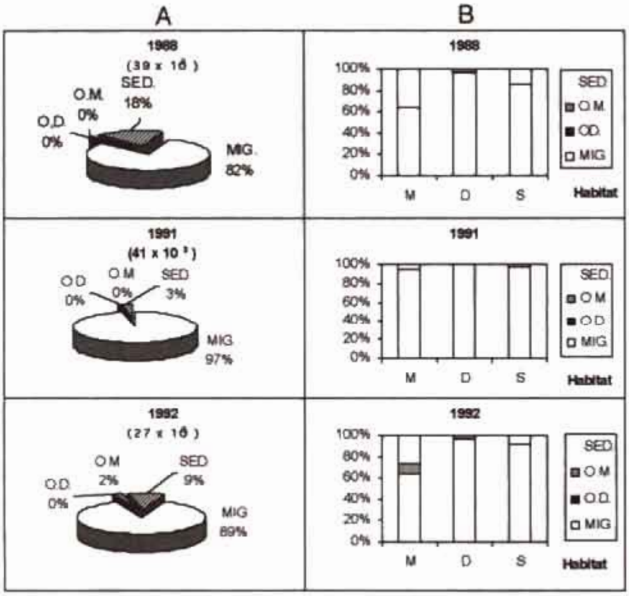

Fig. 13. Variation of abundance (%) of each community group: sedentary (SED.), occasional marine (O.M.), occasional freshwater (O.D.) and marine migrant (MIG.). A - in the estuary; B - in each habitat: marine (M), freshwater (D), and brackish (S).

Space-temporal variation of fish communities with the status

To detect annual differences between the community components of fish fauna from the three habitats, its proportions were analysed by year, zone, and month and for the system as a whole.

The fish fauna of Mondego estuary is dominated by the migrants status species which represent a percentage of 37% – 47% of species number, 82% – 97% of individuals and 97% – 99% of biomass (Fig. 10 – 13), occurring lowest abundance in autumn, winter and spring.

Sedentary presented a number of species similar from year to year and its importance in number of individuals or in biomass was greater in marine region, occupying the second place after migrants.

Occasional freshwater species were present mainly in periods of greater freshwater discharges and their species numbers were higher in the brackish and freshwater habitats.

Occasional marine visitors were mainly represented in marine zone. In 1992, considering the three areas as a whole, their species numbers were greater than that observed for migrants and, like the freshwater group, had little number of individuals and biomass.

The occurrence and importance of these groups in marine, brackish, and freshwater zones seem be related with seasonal evolution of parameters and migrants behaviour. Thus, the lowest values of migrants abundance in autumn, winter, and beginning of spring, (Fig. 11) can be determined by migration impulses (Fig. 7) in connection with decreases of salinity and temperature as well as trophic needs of individuals above certain size. In 1992 the more regular presence of occasional marine visitors from April till September is certainly in relation with the dry climate that characterised this year.

Space-temporal variations of fish communities diversity

The structure of a community is one of its essential characteristics and can be represented by the species number or by the abundance or biomass of each species and may be, in more or less degree, influenced by environmental changes. A diversity index is a way to express the community structure that is closely related with the diverse solutions adopted by the different community groups when they colonise a ecosystem (Vieira da Silva 1979). The evenness indicates if a community is near or far from the steady state, which is reached when evenness is maximum, equal to 1. At this point there is an adjustment of the species in a progressive way to the environmental constraints (Amanieu and Lasserre 1982).

The evolution of specific richness, the diversity index of Shannon-Winner and evenness, based on biomass, were determined by month and habitat studied, to point out their space-temporal variations. The time variability of all indexes is lower in marine habitat then in freshwater and brackish habitat (Fig. 14). The specific richness was higher in marine habitat (Fig. 15) and lower in the freshwater one. The most important values were observed, in general, in summer and the lowest in winter or at the end of autumn. The diversity index and evenness had a parallel evolution in all zones, with bigger values in Gala/Porto Comercial region. In all habitats studied the maxima values occurred in general from April until the end of summer and the smallest took place in winter or at the end of autumn. In spite of the different methodologies used in the community indexes determination, the results of Mondego estuary have shown a trend similar to those recorded for other fish nursery areas in portuguese coast (Costa 1986 in Tejo estuary, Rebelo 1993 in Ria de Aveiro and Monteiro 1989 in Ria Formosa): the highest values in spring or summer and the lowest in autumn/winter. However, exceptions to these general trends were sometimes found in Mondego estuary, related with the instability that characterises estuaries: high diversity or evenness indexes at the end of autumn or winter when biomass were equi-distributed by the species with more resilience (in freshwater habitat in December of 1988; in marine and freshwater habitats on January 1991 and in brackish one in March of 1991; in January and December of 1992 in freshwater zone); low values of those indices in summer when a species is strongly dominant (brackish zone in August of 1991), what may happen when the salinity drops due to a freshwater discharge, abundant rain or a sluice opening (brackish zone in August of 1992).

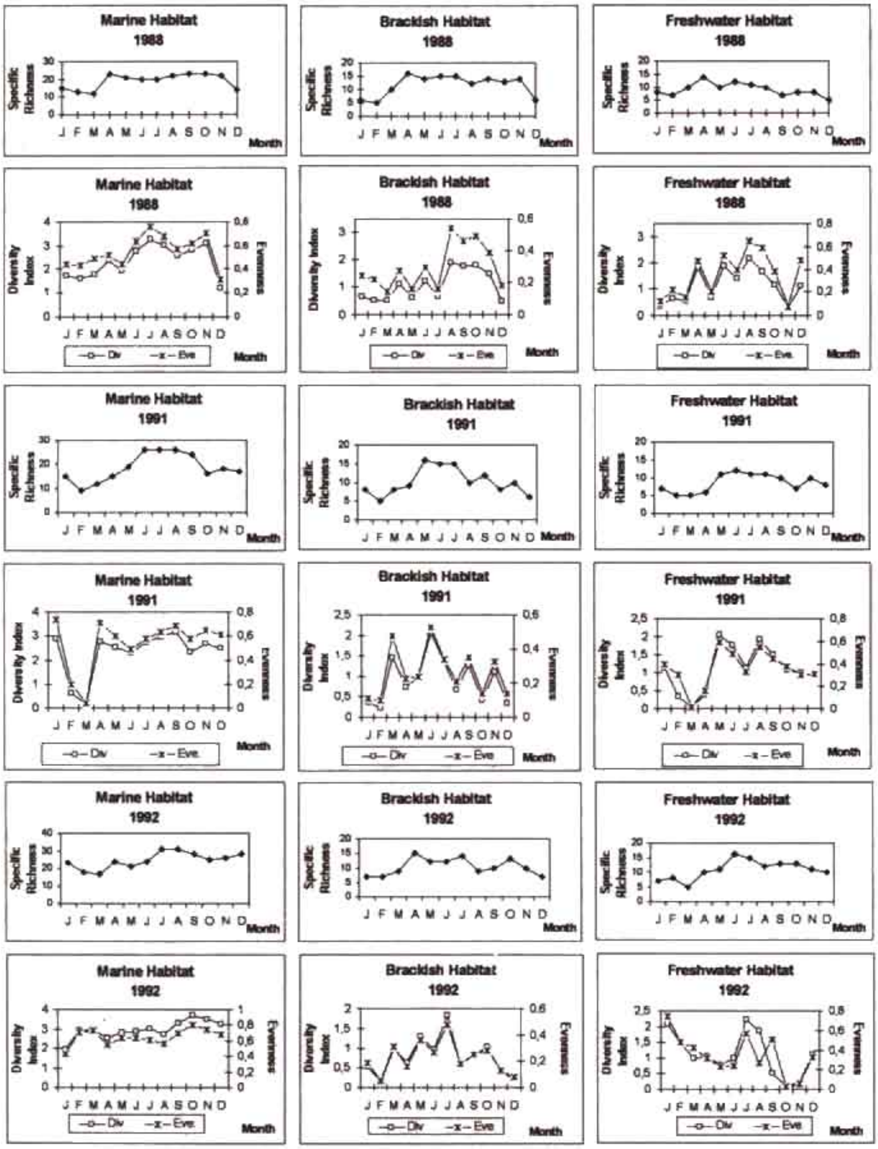

Fig.14. Monthly evolution in each habitat and year of community indexes: specific richness, diversity and evenness.

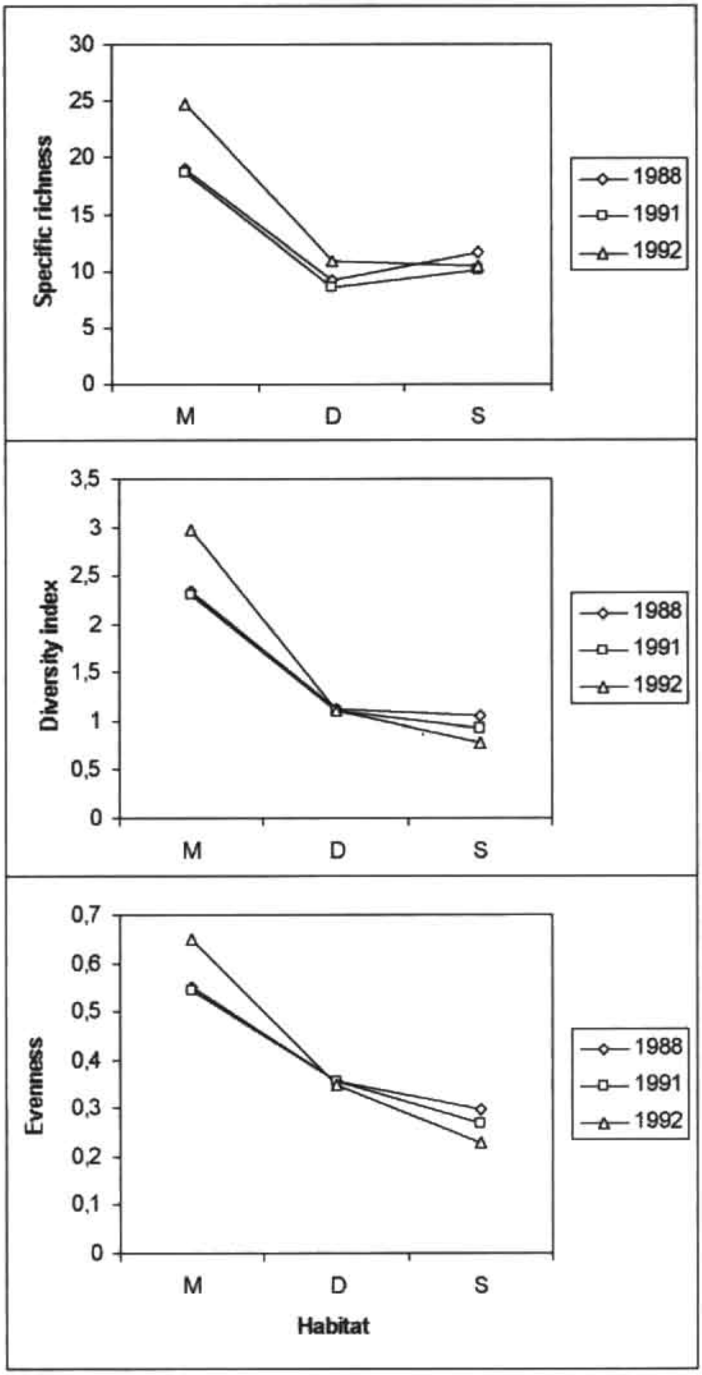

Fig. 15. Yearly values of community indexes by habitat

Multidimensional analysis of fish communities assemblages

The results of correspondence factorial analysis applied to fish fauna biomass matrix are represented in Fig. 16-18. The graphics show the projections of species and sampling habitats on the plan of two first axes that explain for 1988, 1991 and 1992 respectively, 44%, 40% and 42% of variance in the total data set.

In 1988 (Fig. 16) there are three groups relating species and stations: one concerning marine sector in summer/autumn with stenohaline marine migrants – *Trigla lucerna* (68), *Mullus surmuletus* (34), *Diplodus sargus* (35) and occasional marine species – *Symphodus bailloni* (43); other with Pranto station in summer/autumn and the migrant species *Engraulis encrasicolus* (6) and *Diplodus vulgaris* (36); another in spring with Pranto and Vila Verde stations, associated to eurialine species *Liza ramada* (64) and *Dicentrarchus labrax* (32).

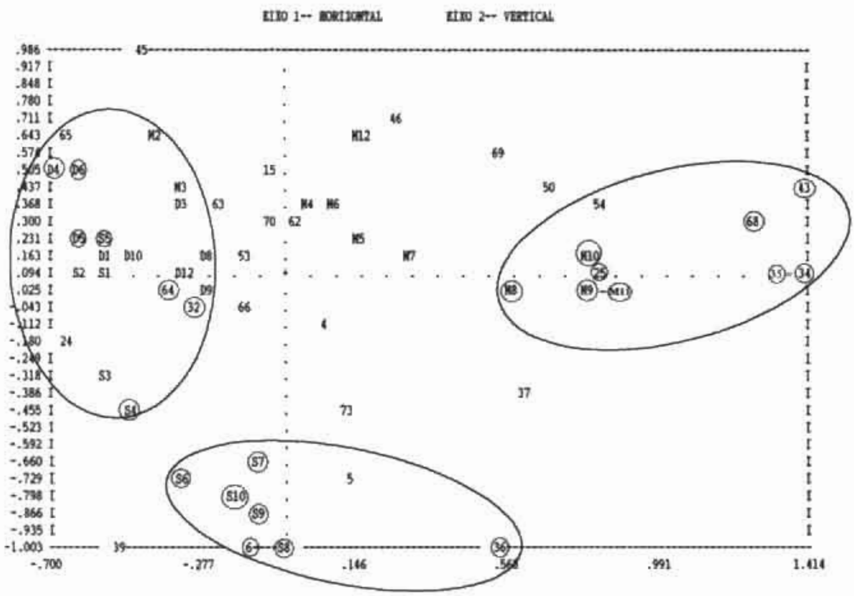

Fig 16. Correspondence factor analysis of biomass matrix from 1988.

In 1991 (Fig. 17) there is one group corresponding to a temporal association of the three habitats in winter, including the freshwater region during spring and December. The remainder two groups comprise the marine and the brackish habitats. The first habitat corresponds to Gala/Porto Comercial station in summer/autumn, with marine migrants – *Trigla lucerna* (68) and *Scophthalmus rhombus* (69), the sedentary *Gobius niger* (50) and the marine occasional *Callionymus lyra* (57). The second group comprising Pranto station in summer is related with *Sardina pilchardus* (5), *Engraulis encrasicolus* (6) *Diplodus vulgaris* (36) and *Sparus aurata* (37).

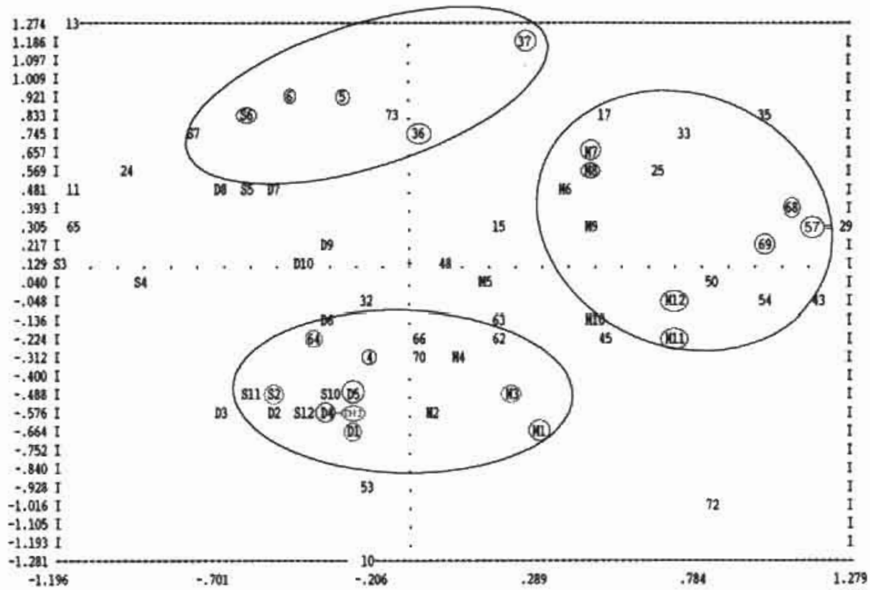

Fig. 17. Correspondence factor analysis of biomass matrix from 1991.

In 1992 (Fig. 18) were identified four groups: one with marine habitat in summer/autumn associated to migrants species – *Trigla lucerna* (68), *Scophthalmus rhombus* (69), *Diplodus vulgaris* (36) – occasional marine species – *Ciliata mustela* (29), *Callionymus lyra* (57) and *Symphodus bailloni* (43) – and sedentary species like *Gobius niger* (50) and *Pomatoschistus minutus* (54). Other group concerning brackish habitat in summer is associated with *Engraulis encrasicolus* (6) and *Sparus aurata* (37). The remainder two groups correspond to the freshwater sector in winter associated with *Platichtys flesus* (70) and the brackish area in spring/autumn related with *Liza ramada* (64) and *Dicentrarchus labrax* (32).

Conclusion and perspectives

The space-temporal variability of abiotic factors allowed us to characterise three habitats: marine, brackish and freshwater.

Each year two space temporal units were systematically found: (i) one concerning marine stations (M) in summer/autumn with an assemblage of fish species composed by stenohaline migrants (*Trigla lucerna, Scophthalmus rhombus, Mullus surmuletus, Diplodus sargus*), occasional marine species (*Ciliata mustela, Callionymus lyra, Symphodus bailloni*) and sedentary species (*Gobius niger* and *Pomatoschistus minutus*); (ii) other with brackish habitat in summer (or summer/autumn in 1988), in connection with *Engraulis encrasicolus, Sardina pilchardus, Sparus aurata* and *Diplodus vulgaris*. Less consistent in time of occurrence were found temporal units related with low salinity due to stronger

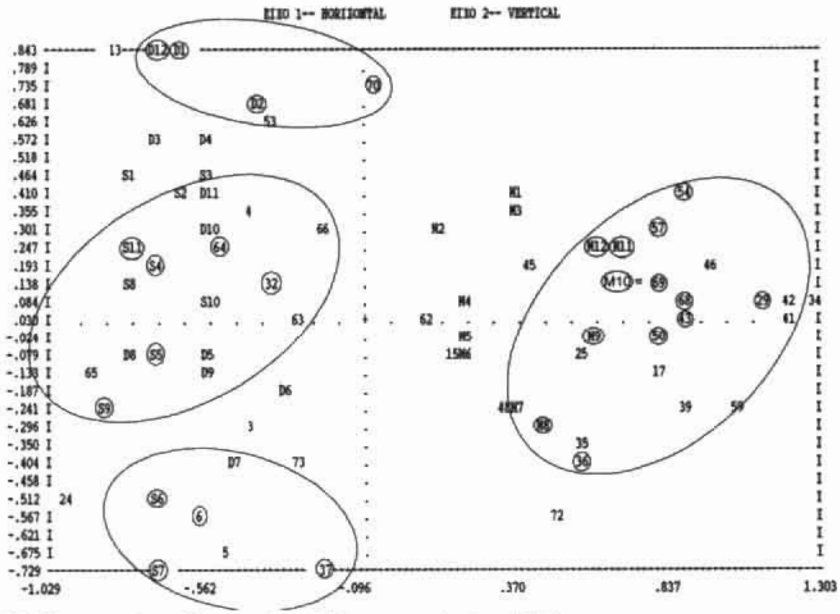

Fig. 18. Correspondence factor analysis of biomass matrix from 1992.

freshwater discharges associated with the presence of eurialine species assemblages (*Liza ramada, Dicentrarchus labrax, Platichtys flesus* and *Alosa spp.*).

The marine habitat, Gala/Porto Comercial, is a zone submitted to a daily marine influence where there are the lowest yearly amplitudes of temperature and salinity and consequently, with a greater capacity for receive stenohaline species and those sedentary which prefer the places where the abiotic parameters are more stable.

The freshwater habitat Vila Verde located in upstream of north arm is the station most exposed to the freshwater discharge of Coimbra bridge-dam.

The brackish habitat of Pranto station is plenty influenced by the tide currents when the dam of Bizorreiro is closed. In summer the sunstroke is frequently strong and can induce to higher temperature and salinity. These conditions in calm waters leads some migrants like *Engraulis encrasicolus, S. pilchardus, Sparus aurata* and *Diplodus vulgaris* to frequent this habitat, despite temporary disturbances caused by the overture of Pranto sluice. The result is a very high variability of community indexes like diversity with its lowest level.

Besides the spatial and seasonal variations of assemblages there are interannual fluctuations, and as an estuary is a dynamic system, it functioning can change due to natural causes or impacts of human activities, that can interfere for example in the volume or quality of freshwater flow. If marine influence will decrease we can assist to a diminution of salinity and the assemblages that characterised the previous marine and brackish habitats will be replaced by associations with species more euryhaline or freshwater species because the capacity to receive the first will decrease. *Liza ramada, Plathichthys flesus, Dicentrarchus labrax* are good indicators of this situation.

On the contrary, if marine influence increases due to a deficit of pluviosity, or artificial reduction of freshwater discharges in dams, the assemblages of species evolve towards to a marinization and some of the preceding occasional species may behave migrants because the capacity of the system to receive the marine species will increase. In a small scale it was what happened in the 1992 dry year, when the number of marine occasional species enhanced in estuary, staying some of them (*Ciliata mustela, Belone belone, Symphodus bailloni, Labrus merula, Callionymus lyra* and *Ammodytes tobianus*) during more time.

The perspectives are according to the principle of biological indicator to the functioning and ecological classification of ecosystem:

1. select the most indicative migrant species of each habitat;
2. select the date of their disponibility to the estuary;
3. quantify their exact tolerance to the environment factors (salinity, temperature, oxygen, chemical pollution...).

The objective is monitoring the estuarine ecosystem quality in relation to its traditional socio economic activity and with agriculture and industrial activity in river basin.

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2002