ICES CM 2004/Q: 23. "Not to be cited without prior reference to the author".

Abnormal domination of gilt sardine (*Sardinella aurita*) in the middle shelf ichthyoplankton community of Gulf of Cádiz (SW Iberian Peninsula) in summer: related changes in the hydrologic structure and implications in the larval fish and mesozooplankton assemblages finded.

J. P. Rubín[1] and P. Mafalda Jr.[2]

[1] Centro Oceanográfico de Málaga–Fuengirola
Instituto Español de Oceanografía (IEO)
Muelle Pesquero s/n. Apdo. 285.
E-29.640 Fuengirola, Málaga (Spain). [jprubin@ma.ieo.es]

[2] Laboratório de Plâncton, Instituto de Biologia
Universidade Federal da Bahia
40.210-020 Salvador, Bahia (Brazil).
(Grant *CAPES* – IEO)

ABSTRACT

During the yearly '*Ictio.Alborán-Cádiz*' (1994–1997) multidisciplinary oceanographic surveys, the eggs and larvae of anchovy (*Engraulis encrasicolus*) are generally the dominant in the middle shelf ichthyoplankton community of the Gulf of Cádiz in summer. In the 1995 survey a notorius change have detected: the maximum localized abundance for ichthyoplanktonic components of gilt sardine (*Sardinella aurita*) have multiplied x 10 (eggs) and x 20 (larvae) the anchovy's components. In this paper we discuss the observed changes in the hydrologic structure and in the larval fish and mesozooplankton assemblages (cluster analysis).

Keywords: ichthyoplankton, mesozooplankton, ecological assemblages, *Sardinella aurita*, *Engraulis encrasicolus*, hydrologic structure, Gulf of Cádiz.

INTRODUCTION

The '*Ictio.Alborán-Cádiz*' summer multidisciplinary surveys have been carried out by the Instituto Español de Oceanografía (IEO) during four years (1994–97) in the Gulf of Cádiz−NW Alborán Sea area. Preliminary results for each surveyare published for the global area (Rubín *et al*., 1997, 1999, 2003; Prieto *et al*., 1999; García *et al*., 2002). The interannual changes are only studied for some neritic sectors of the Gulf of Cádiz (Salmerón & Rubín, 1997a,b,c; Vargas-Yañez *et al*., 2002).

The environmental conditions of the two oceanographic surveys studied in this paper are described in Rubín *et al* (1997, 1999), and only a brief summary is presented here. During both years the hydrology of the Gulf of Cádiz was characterised by typical summer conditions. The water column was generally well stratified and the thermocline was located at a mean depth of 20 m. Due to mesoescale variability, the termocline depth varied, having a tendency to move downward in anticyclonic area in the slope and continental shelf, off Cádiz Bay. The horizontal distribution of surface temperature showed a consistent pattern in the two years. Warmer temperatures were observed at the inshore sites of the Cádiz Bay and Huelva, at the area north. The area south, in front off Cape of Trafalgar, was generally cooler than the rest of surveyed area. Yet, at the offshore sites, the north area is cooler than the south area. The horizontal distribution of surface salinity showed interannual changes in both years. In 1994, higher salinities were observed at the north area and offshore, though in July 1995, major values were observed around Cadiz bay. The upper water column was generally cooler and less saline in 1994 than in 1995. Surface salinity ranged from 36.2–36.4 ups, in 1994 and from 36.1–36.5 ups in 1995. Surface temperature ranged from 20.4–23 °C, en 1994 and ranged from 20 – 22.5 °C, in 1995. The mean zooplankton displacement volume are similar in both years: ranged from 2–62 ml/m^3 (average = 19) in 1994, and from 4–50 ml/m^3 (average = 17.7) in 1995. The zooplankton density was major in 1994 (504−24,734 org/m^3, average= 6,633), than 1995 (1,215−1,5083 org/m^3 (average= 3,552). Some indications of south-eastwardly drift of eggs and larvae have been reported, as well as an increased in the average age of eggs offshore. This has been interpreted as a passive displacement of surface water from their northern inshore spawning areas (Rubin *et al*., 1999).

MATERIAL AND METHODS

During the cruises 'Ictio.Alborán−Cádiz 0794' (8 – 15 July 1994) and 'Ictio.Alborán−Cádiz 0795' (10 – 17 July 1995), on R/V *Francisco de Paula Navarro* (IEO), 34–33 stations were occupied in the Gulf of Cádiz (Figure 1). Each station consisted of a "SBE−25" CTD cast, from 0-200 m depth and mesozooplankton sampling. This one consist in double-oblique trawls, from 0−100 m depth, with a "Bongo 40" net, equipped with two independent flowmeters and depth meter gauge). The planktonic samples obtained (mesh size of 250 μm for mesozooplankton and 335 μm for ichthyoplankton), were preserved in 5 % buffered formalin. The taxononic identification of mesozooplankton only for 10 selected stations (nº ind./m^3). The number of fish larvae collected was standardized to 10 m^2 (Smith & Richardson, 1979) and were classified to the lowest possible taxonomic level and grouped into three ecological categories, "demersal", "epipelagic" and "mesopelagic". The interannual differences in the abundance of mesozooplankton and ichthyoplankton were tested using the non-parametric Wilcoxon Test (Siegel, 1982). Similarity among sampling sites and taxa were measured using Manhattan distances and were grouped by the Ward's method (Pielou, 1984) to produce dendrograms. Prior to analysis, ln (x+1) transformation of the larval abundance data was performed to homogenize variances (Taylor, 1961). The most frequent and abundant taxa were used as larvae assemblages descriptors (Pianka, 1974).

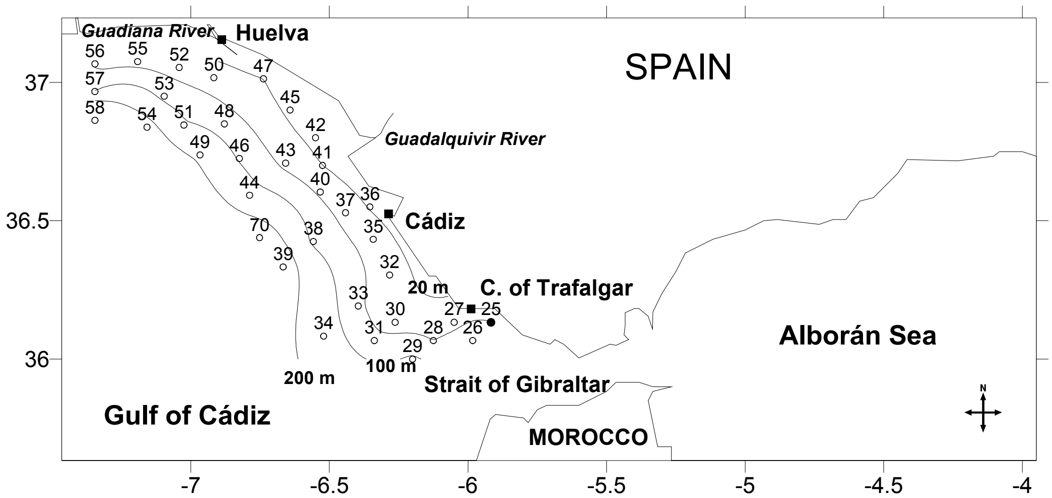


Figura 1. Study area in the Gulf of Cádiz showing the sampling stations and isobaths.

RESULTS

1. Ichthyoplankton

1.1 Taxonomic composition and abundance

A total of 13 / 16 taxa were identified (1994 / 1995) and the interannual differences weren´t significant ($p > 0.05$). Eleven taxa were more abundant and frequent in both year collections, and were used to ecological classification (Table I).

Table I.– The eleven more abundant (A %) and frequent (F %) fish larvae taxa, its 'origin' (adults habitat: D = demersal, EP = epipelagic, MP = mesopelagic) and their codes in the Cluster analysis.

		1994	1994	1994		1995	1995	1995
Taxa	Origin	Order	A%	F%	Code	Order	A%	F%
GOBIIDAE	D	1°	19.0	88.6	GOB	2°	9.6	94.1
LABRIDAE	D	2°	14.8	91.4	LAB	3°	7.0	79.4
Engraulis encrasicolus	EP	3°	14.2	68.6	ENG	7°	3.9	82.4
SPARIDAE	D	4°	11.9	80.0	SPA	4°	6.2	88.2
CALLIONYMIDAE	D	5°	8.0	74.3	CAL	6°	4.0	82.4
Serranus spp	D	6°	5.8	71.4	SER	5°	4.4	61.8
Sardinella aurita	EP	7°	4.9	45.7	SAR	1°	33.7	58.8
Cepola rubescens	D	8°	3.1	42.9	CEP	8°	3.7	67.6
BOTHIDAE	D	9°	2.3	60.0	BOT	9°	2.6	64.7
Trachurus spp	EP	10°	1.1	31.4	TRA	10°	1.6	44.1
Capros aper	MP	11°	0.6	22.9	CAP	11°	1.6	50.0

Mean larvae density was major ($p < 0.01$) in 1995 (66–12,610 larvae/10 m^2, average = 1962) than 1994 (0-1,920 larvae/10 m^2 , average = 768.5). The abundance of demersals taxa (Gobiidae, Labridae, Sparidae, Callionymidae, Serranus spp, *Cepola rubescens* and Bothidae) was similar between the two years ($p > 0.05$). Gobiidae was the dominant demersal taxa in both years.

Larvae of pelagic species (i.e. *Sardinella aurita, Trachurus spp. and Capros aper*) were more abundant in the 1995 collections ($p > 0.05$), but anchovy (*Engraulis encrasicolus*) was more abundant in 1994 (Table I). In 1994 the eggs and larvae of anchovy (*Engraulis encrasicolus*) are dominant in the pelagic ichthyoplankton community. But, in 1995 ichthyoplanktonic components of gilt sardine *Sardinella aurita* was multiplied x 10 (eggs) and x 20 (larvae) the anchovy's components.

1.2 Changes at the spatial distribution of anchovy and gilt sardine larvae

The anchovy larvae (Fig. 2a) and gilt sardine larvae (Fig. 2b) showed interannual differences ($p < 0.05$) in their abundance and horizontal distribution. During 1994 the higher larval abundances for both species are the same (> 400 larvae/10 m^2) but the spatial location opposite. Gilt sardine larvae have appeared in a neritic station at the north sector (surface temperature = 22.5° C). Whereas, the maximum abundances of larvae of anchovy have been located at the south of Cadiz, in the warmer waters (> 23º C). On the other hand, in 1995 the greater abundance and spatial concentration of both species are very different (gilt sardine: 4,000–6,000 l./10 m^2, more concentrated; anchovy 200–300 l./10 m^2, more dispersed), but in spatial coincidence (middle shelf off Cádiz, 22º C).

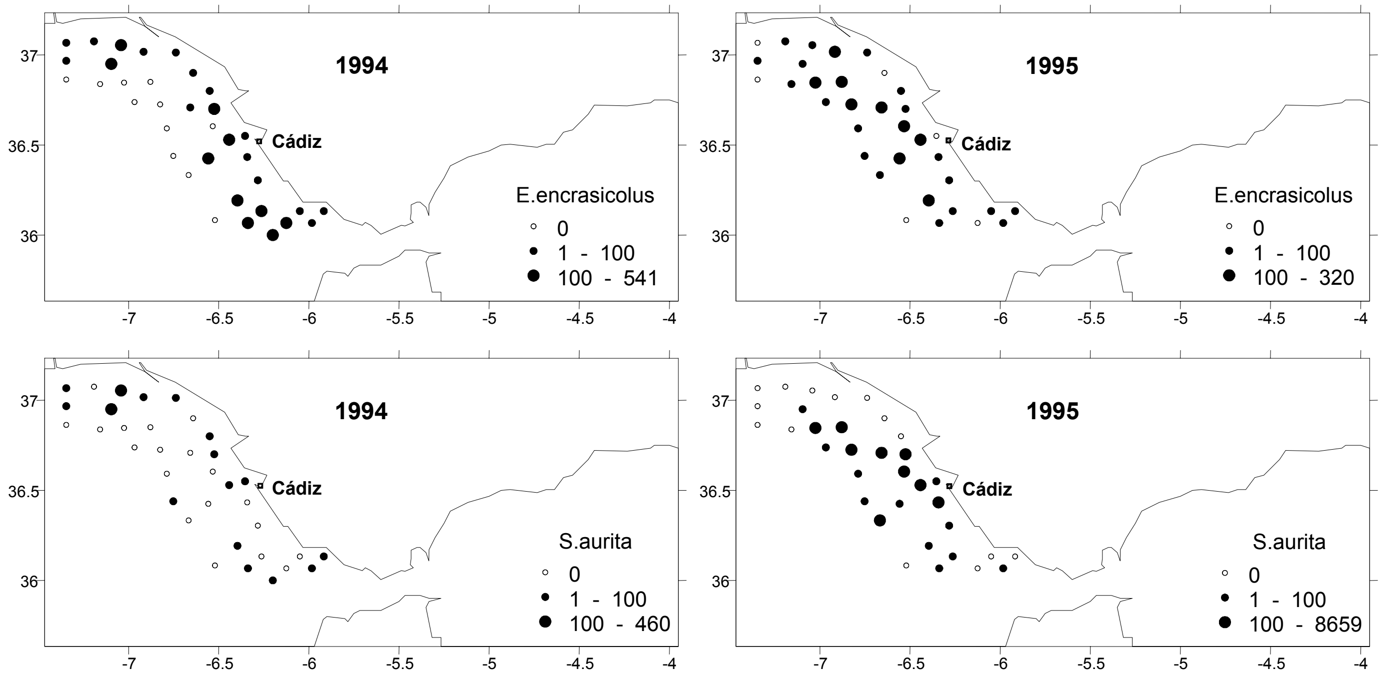


Figure 2. Distribution and abundance (nº larvae/10 m^2) of anchovy larvae (*E. encrasicolus*; Fig. 2a) and gilt sardine (*S. aurita*; Fig. 2b).

1.3 Sampling stations and fish larvae assemblages

Cluster analysis of stations produced the same three groups for 1994 and 1995: 'Inshore', 'Intermediate-shelf' and 'External-shelf' (Fig. 3).

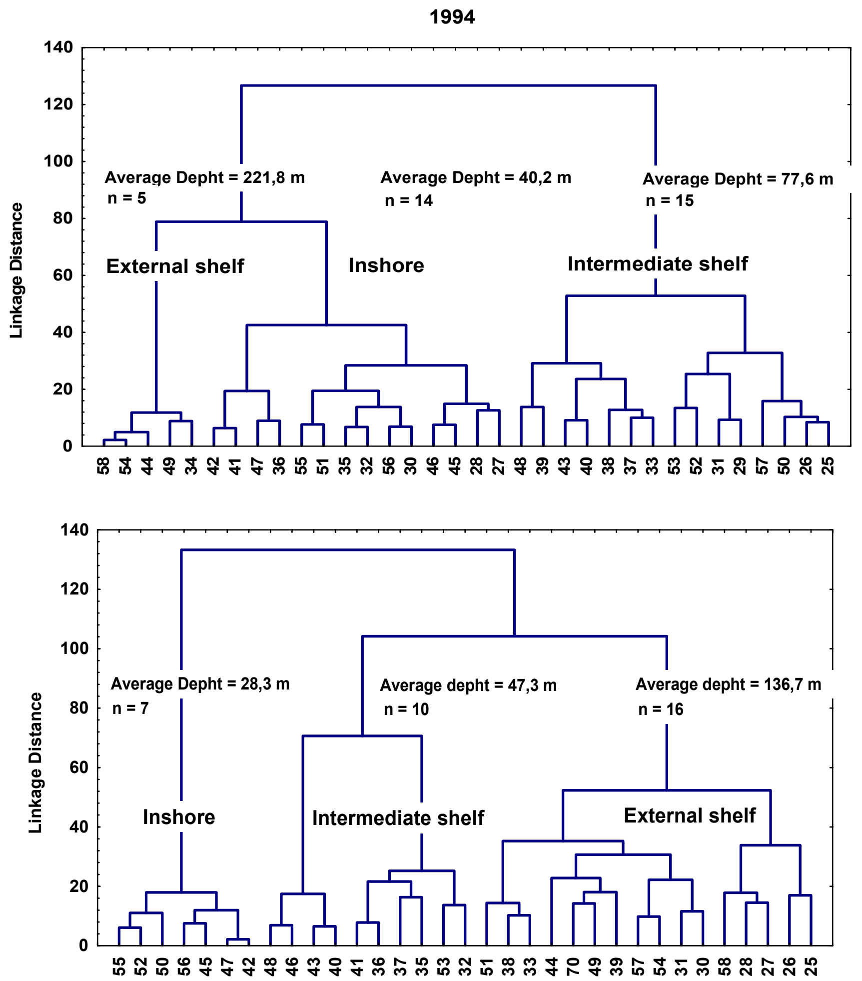


Figure 3. Dendrogram representing groups of stations according their ichthyoplankton composition.

The larval assemblages (Fig. 4) correspond to the mentioned station groups. The interannual variability in the fish larvae abundance and groups spatial distribution are presented in Fig. 5

<u>INSHORE ASSEMBLAGE</u>: influenced by riverine inputs, occupied mainly the shallow stations. The sector occupied by this assemblage varied throughout the years. In 1994, it comprised the south zone area from Guadiana river to the Cape of Trafalgar (< 40 m depth). In 1995 this assemblage was smaller and northerly, from Guadiana river to Cádiz city (< 28 m depth), and the less larvae density have presented (Fig. 5). The taxa characterizing this assemblage (Fig. 4) included demersals (Gobiidae, Labridae, Sparidae and Callionymidae) and pelagic (*Engraulis encrasicolus*). In 1994 Labridae was the dominant taxa but, in 1995, the most abundant was Callionymidae. The between-year differences too involved a "movie" of Serranus spp larvae from coastal to neritic assemblage, in 1995.

<u>CONTINENTAL SHELF ASSEMBLAGE</u>: this assemblage had two subgroups (intermediate-shelf and external-shelf), in depths upper than 100 m and in variable extension along the years. They were orientation from the coast to the ocean, and were designated as inner shelf assemblage and mid-shelf assemblage. The <u>intermediate shelf</u> assemblage was characterized by epipelagic species (*Sardinella aurita* and *Trachurus spp*). In 1995 it presented the more larvae density (Fig. 5). In both years the gilt sardine (*Sardinella aurita*) was the dominant specie and show a conspicuous peak of abundance in 1995 (Figure 2). In 1995 your area occupied was smaller than 1994. The <u>external shelf</u> was formed by <u>demersal</u> taxa such as Bothidae, *Cepola rubescens* and *Serranus* spp (this taxa only in 1995). The mesopelagic *Capros aper* was presented but always at low densities. In 1994 this assemblage presented the less larvae density (Fig. 5).

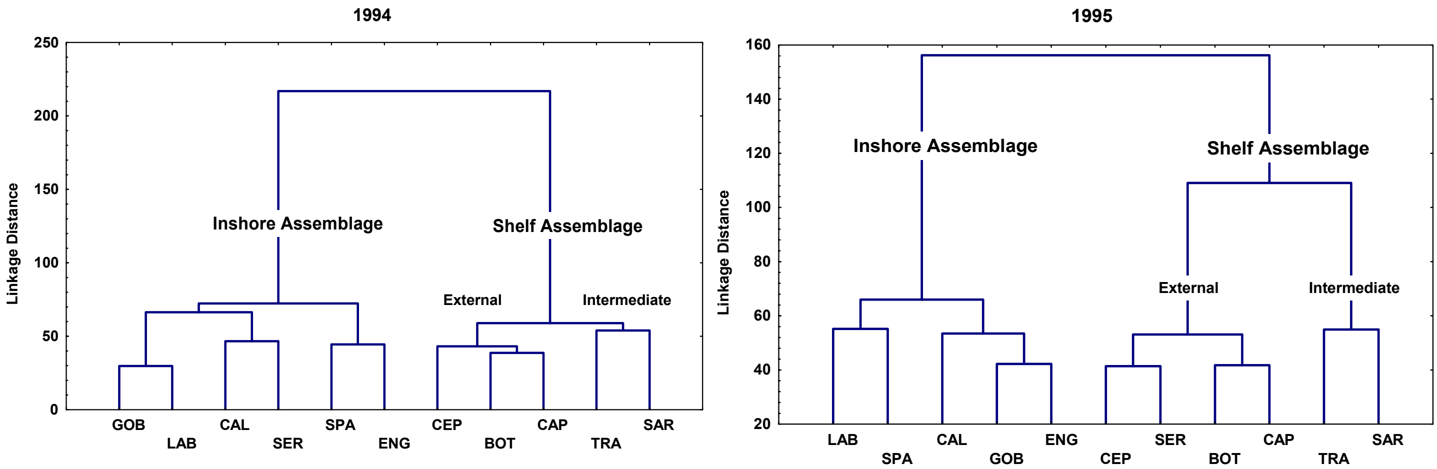


Figure 4. Dendrograms representing fish larvae assemblages in both years.

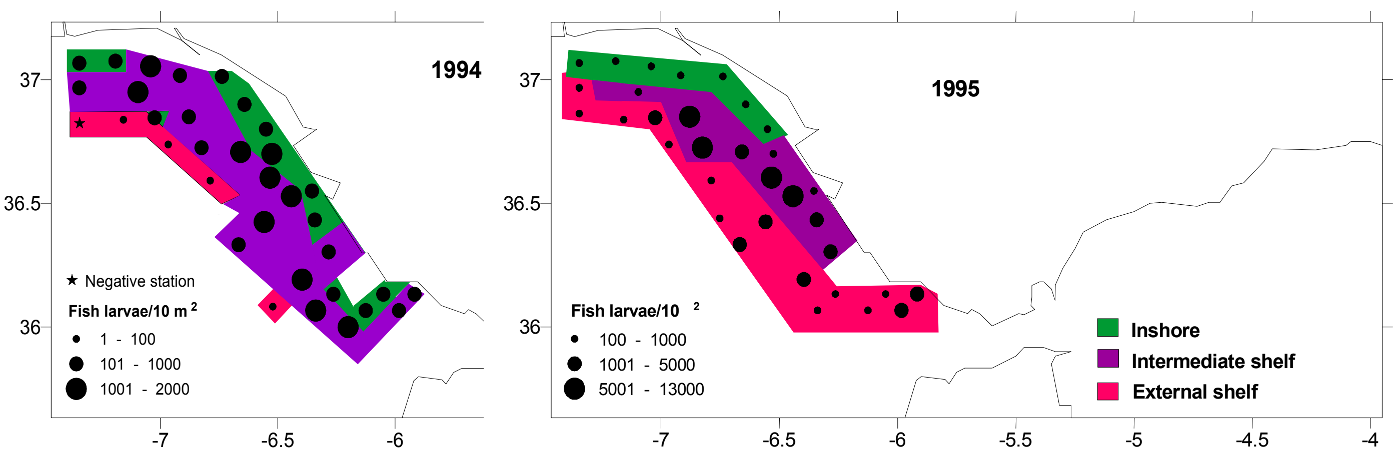


Figure 5. Interannual variation for each zone and fish larvae abundance.

2. Mesozooplankton

2.1 Taxonomic composition and abundance

A total of 15 taxa were identified in the two years (Table II), thus the interannual differences weren´t significant ($p > 0.05$). The most abundant and frequent taxa were Cladocera (more abundant in 1994; $p < 0.05$) and Copepoda (similar abundance in both years; $p > 0.05$).

Table II –Mesozooplankton taxa: relative abundance (A%), frecuency of occurrence (F%), and their code in the Cluster analysis (* = taxa excluded in the Cluster analysis).

	1994	1994	1994		1995	1995	1995
Taxa	Order	A%	F%	Code	Order	A%	F%
Cladocera	1°	86.90	100	CLA	1°	65.0	100
Copepoda	2°	7.90	100	*	2°	25.4	100
Apendicularia	3°	1.80	100	APE	3°	3.5	100
Cirripedia	4°	0.78	90	LCI	15°	0.00	0
Chaetognata	5°	0.70	90	QUE	9	0.51	90
Crustacea	6°	0.58	100	LCR	5°	0.85	100
Equinodermata	7°	0.54	100	LEQ	8	0.59	90
Euphausiacea	8°	0.54	50	EUF	10°	0.40	90
Siphonophora	9°	0.26	100	SIF	7	0.65	100
Doliolidae	10°	0.21	80	DOL	4°	2.0	100
Mollusca	11°	0.10	90	LMO	12°	0.10	50
Foraminiferida	12°	0.10	80	FOR	6°	0.75	100
Polychaeta	13°	0.03	60	LPO	13°	0.06	60
Hydromedusas	14°	0.02	70	HID	11°	0.21	90
Ostracoda	15°	0.00	00	OST	14°	0.02	30

2.2 Sampling stations and mesozooplankton assemblages

Cluster analysis for the 10 selected stations produced the same three groups for 1994 and 1995: inshore, north shelf and south shelf (Fig. 6).

The mesozooplankton assemblages (Fig. 7) correspond to the mentioned station groups. In both years Copepoda are abundant and had a wide spatial distribution (for this reason are excluded of the cluster analysis. The inshore assemblage, occupied mainly the shallow stations (average depth = 24.5 m). In 1994, this zone are more reduced. In 1995 the area was extending from Guadalquivir river mouth to Cape of Trafalgar. Cladocera was the dominant taxa in the two years. The interannual differences involved a "shift" of Apendicularia and Dolilidae from inshore to continental shelf assemblages.

The interannual variability in the mesozooplankton abundance and groups spatial distribution are presented in Fig. 8. In both years it presented the most mesoozooplankton density and less taxon´s number.

The neritic population occupied continental shelf stations (depths 30−100 m). It had two subgroups, variable in extension along the years: north shelf population and south shelf population. The south shelf population was characterized by the dominance of Euphuasiacea larvae, in 1994 and by Decapoda Crustacea larvae, in 1995. In 1995 your area occupied was bigger than 1994. The north shelf population (Group 3) was characterized by the dominance of Apendincularia, in1994 and by Mollusca larvae, in 1995. In both years this populations presented the less mesoozooplakton density (Figure 8) and most taxon´s number.

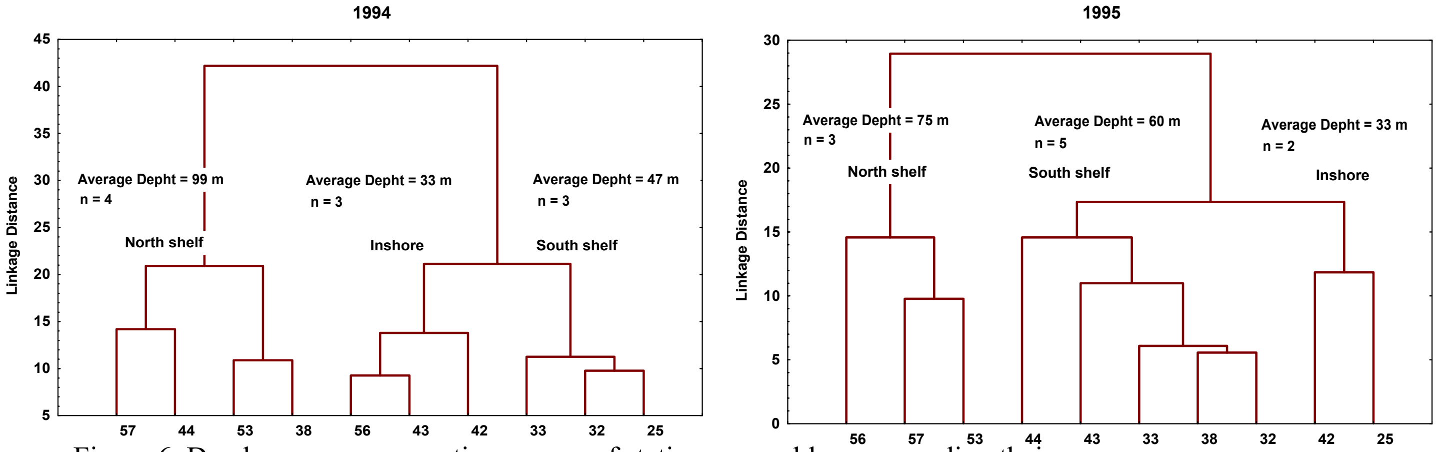


Figure 6. Dendrograms representing groups of stations assemblages according their mesozooplankton composition.

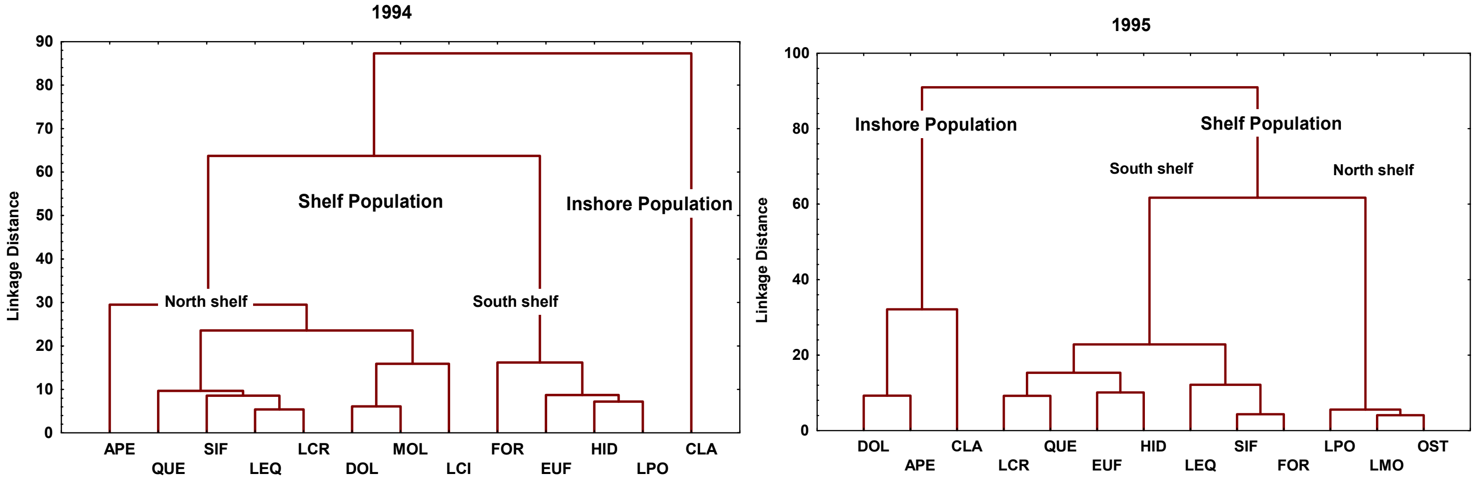
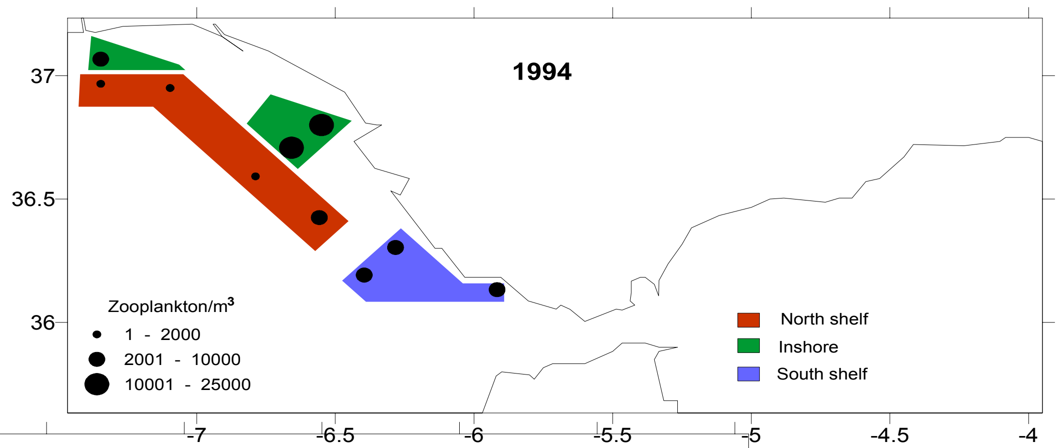
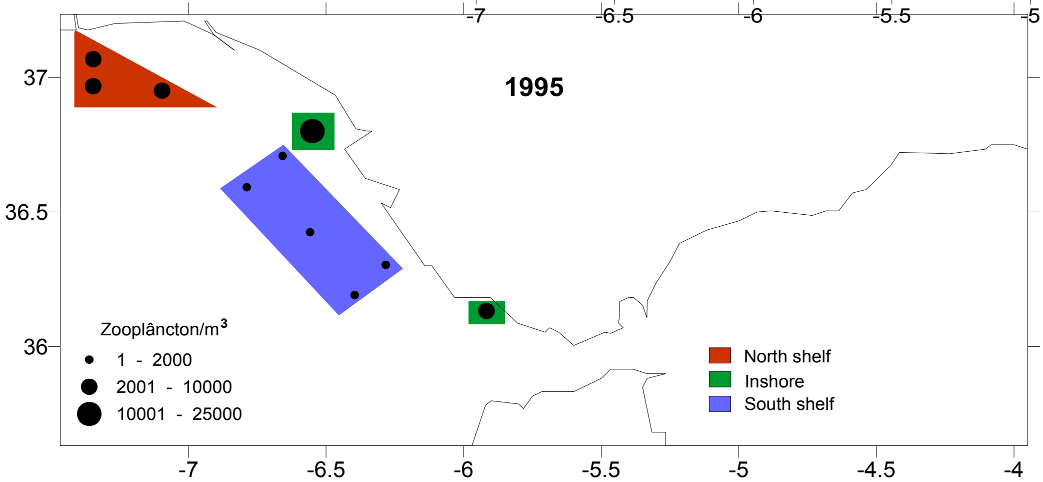


Figure 7. Dendrograms representing mesozooplankton assemblages.

Figure 8. Interannual variation for each zone and mesozzoplankton abundance.





CONCLUSIONS

Substantial interannual differences were found. In 1994, the upper water column was generally cooler, fresher and richer in zooplankton, which indicated a delay in the spring-to-summer transition during this year. In 1995 the maximum localized abundance for ichthyoplanktonic components of gilt sardine (*Sardinella aurita*) have multiplied x 10 (eggs) and x 20 (larvae) the anchovy's components. Similar substitution are detected in this year in Alborán Sea, where the adult biomass of the pelagic species *E. encrasicolus* & *Sardina pilchardus* coming down and *S. aurita*, *Trachurus mediterraneus* and *Boops boops* (Serranidae) are increased (A. Giráldez, personal communication).

During 1994 and 1995, two larval fish assemblages and two mesozooplankton populations were distinguished: '*Inshore*' (the shallower zones and closely related to the estuarine system) and '*Continental Shelf*' (occupied the remainder area), corresponding to the depth of the area and reflecting adult spawning bathymetry. The characteristics taxa comprising mainly *E. encrasicolus* / Gobiidae / Cladocera ('*Inshore assemblage*') and *Sardinella aurita*, *Trachurus* spp, Euphausiacea and Decapoda larvae ('*Continental Shelf assemblage*').

Variations in composition and extension of the mesozooplankton and fish larvae subgroups, between years, can be attributed to main circulation patterns, continental waters discharges, and spawning areas.

ACKNOWLEDGEMENTS

The authors would like to thank the crew of R/V *Francisco de Paula Navarro* and many scientists who assisted in collecting samples at the sea and sorted the ichthyoplankton. This study RV *Francisco de Paula Navarro.* This study was partly supported by CAPES (Ministry of Education, Brazil) as part of the post doctoral grant (CCE 0007/2003).

REFERENCES

García, C. M., L. Prieto, M. Vargas, F. Echevarría, J. García-Lafuente, J. Ruiz, J. P. Rubín. 2002. Hydrodynamics and the spatial distribution of plankton and TEP in the Gulf of Cádiz (SW Iberian Peninsula). *Journal of Plankton Research*, 24 (8): 817-833.

Pianka, E.R. 1974. Evolutionary Ecology. New York: Harper and Row Publisher. 356 p.

Pielou, E. C. 1984. The Interpretation of Ecological Data: a Primer on Classification and Ordination. New York: Wiley. 263 p.

Prieto, L., C. M. García, A. Corzo, J. Ruiz Segura, F. Echevarría. 1999. Phytoplankton, bacterioplankton and nitrate reductase activity distribution in relation to physical structure in the northern Alborán Sea and Gulf of Cádiz (southern Iberian Peninsula). *Bol. Inst. Esp. Oceanogr.* 15 (1-4): 401-411.

Rubín, J. P., N. Cano, P. Arrate, J. García, J. Escánez, M. Vargas, F. Hernández. 1997. El ictioplancton, el mesozooplancton y el medio marino en el golfo de Cádiz, estrecho de Gibraltar y sector noroeste del mar de Alborán, en julio de 1994. *Inf. Téc. Inst. Esp. Oceanogr.*, 167. 48 pp.

Rubín, J. P., N. Cano, L. Prieto, C. García, J. Ruiz, F. Echevarría, A. Corzo, J. A. Gálvez, F. Lozano, J. C. Alonso-Santos, J. Escánez, A. Juárez, L. Zabala, F. Hernández, J. García Lafuente, M. Vargas. 1999. La estructura del ecosistema pelágico en relación con las condiciones oceanográficas y topográficas en el golfo de Cádiz, estrecho de Gibraltar y mar de Alborán (sector noroeste), en julio de 1995. *Inf. Téc. Inst. Esp. Oceanogr*. 175. 73 pp.

Rubín, J. P. & M. Vargas-Yañez. 2003. Oceanographic zonation of the Gulf of Cádiz Area (SW Iberian Peninsula), inferred from hydrological, topographic and ichthyoplanktonical data. In: *The role of zooplankton in global ecosystem dynamics: Comparative studies from the world oceans*. III International Zooplankton Production Symposium (Gijón, Spain. May 20-23, 2003) [S1-P64: 82].

Salmerón, F., J. P. Rubín. 1997a. Cambios interanuales en la composición del ictioplancton nerítico estival en el golfo de Huelva (1994−1996). *2º Simposio sobre el Márgen Continental Ibérico Atlántico (Cádiz, 17-20 septiembre 1997)*: 259-260.

Salmerón, F., J. P. Rubín. 1997b. Fluctuaciones en el desove del boquerón y la alacha en la zona costera del golfo de Huelva (1994−1996). *2º Simposio sobre el Márgen Continental Ibérico Atlántico (Cádiz, 17-20 septiembre 1997)*: 261-262.

Salmerón, F., J. P. Rubín. 1997c. Estudio comparado de la distribución espacio-temporal de las larvas de boquerón y alacha en el litoral onubense (1994−1996). *2º Simposio sobre el Márgen Continental Ibérico Atlántico (Cádiz, 17-20 septiembre 1997)*: 263-264.

Siegel, S. 1982. Estadística no paramétrica. México. Editorial Trillas. 344 p.

Smith, P. E. & Richardson, S. L. 1979. Técnicas modelo para prospecciones de huevos y larvas de peces pelágicos. *FAO. Doc. Téc. Pesca*, 175. 107 pp.

Taylor, L.R. 1961. Aggregation, variance and the mean. Nature, 189, p .732-735.

Vargas-Yañez, M., T. Sarhan, F. Plaza, J. P. Rubín, M. C. García-Martínez. 2002. The influence of tide-topography interaction on low-frequency heat and nutrient fluxes. Application to Cape Trafalgar. *Continental Shelf Research.* 22: 115-139.