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THE EUROPEAN ANCHOVY AND ITS ENVIRONMENT, *I. PALOMERA and P. RUBIÉS (eds.)*

Anchovy early life history and its relation to its surrounding environment in the Western Mediterranean basin

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SUMMARY: This paper is a review on the anchovy early life history in the western Mediterranean. There is evidence of latitudinal differences in the duration of the spawning period associated with regional temperature variations. The main spawning areas of the anchovy are located in the Gulf of Lyons and at the shelf surrounding the Ebro river delta. The extensions of spawning grounds seem to be linked to the size of the shelf and to the degree of hydrographic enriching-processes. Punctual studies on egg and larval ecology have been made mainly in the areas of the main spawning grounds, reporting preliminary results on growth, feeding, condition and mortality estimates. Biomass estimation by the Daily Egg Production Method (DEPM) has also been applied at the northern region.

Key words: Anchovy, *Engraulis encrasicolus,* eggs and larvae, reproduction, Western Mediterranean.

RESUMEN: PRIMEROS ESTADIOS DE DESARROLLO DE LA ANCHOA Y SU RELACIÓN CON EL AMBIENTE EN EL MEDITERRÁNEO OCCIDENTAL. – Este trabajo es una revisión de los estudios realizados sobre las primeras fases de desarrollo de la anchoa del Mediterráneo occidental. Existen diferencias latitudinales en la duración del periodo de puesta relacionadas con las variaciones regionales de temperatura. Las principales áreas de puesta se encuentran en el Golfo de León y sobre la plataforma asociada a la desembocadura del río Ebro. La extensión de las áreas de puesta depende de la anchura de la plataforma y de los procesos hidrográficos de enriquecimiento. Se han realizado estudios puntuales sobre aspectos de la ecología de huevos y larvas de anchoa, principalmente en las áreas de máxima puesta, que aportan resultados preliminares básicos sobre crecimiento, alimentación, condición y estimas de mortalidad. En la región norte se ha evaluado la biomasa del estock en puesta en el periodo 1990-94 por medio del DEPM.

Palabras clave: Anchoa, *Engraulis encrasicolus,* huevos y larvas, reproducción, Mediterráneo occidental.

INTRODUCTION

The most abundant clupeoids off the coasts of W Mediterranean are sardine, *Sardina pilchardus*, and anchovy, *Engraulis encrasicolus*, which are the base for the small-pelagic fishery in the region. Although sardine makes up the larger share, fishing pressure is heavier on anchovy because of the higher prices brought by this species.

With regards to anchovy, its distribution along the European coasts off the western Mediterranean shows greater concentrations in certain areas, followed by discontinuities which can define different population units. In a W-E direction, starting at the Strait of Gibraltar, the following areas of anchovy concentration can be defined: 1) Alboran Sea, 2) Spanish Levantine region, 3) Catalan Sea,

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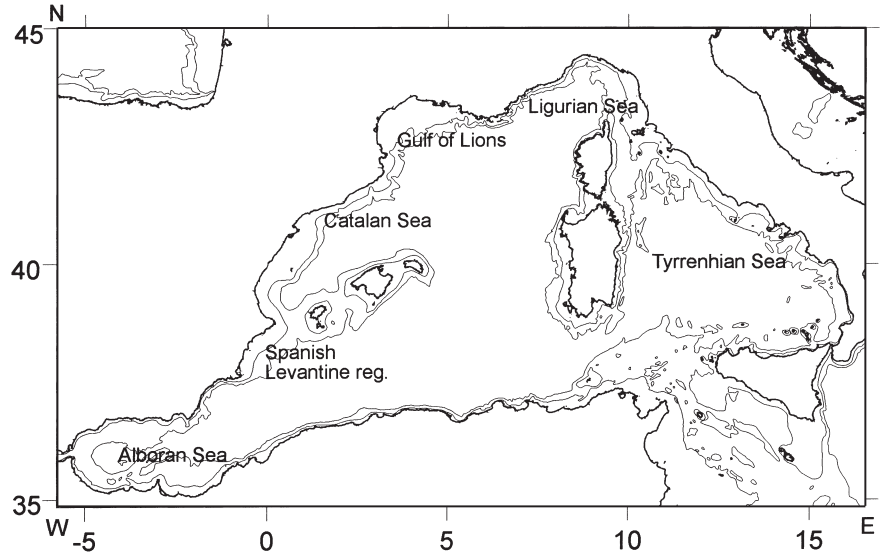

FIG. 1. – Main areas of anchovy concentration and fishing of anchovy in the European coasts of the Western Mediterranean.

4) Gulf of Lions, 5) Ligurian and Tyrrhenian Seas (Fig. 1).

The relative economic importance of this resource and the need for its assesment has greately influenced the degree of research carried out within each region. There are very exceptional fish egg and larval surveys extending along several of the aforementioned regions such as the "Thor" and "Dana" historical expeditions (Fage, 1920). These surveys already highlighted the importance of the Catalano-Balearic System within the Western Mediterranean basin.

SEASONALITY

There have been a number of earlier studies of the spawning season of anchovy in the Western Mediterranean (D'Ancona, 1931; Fage, 1937; Demir, 1965). It appears that the species basically spawns from April to September off the coast of Spain (Andréu and Rodríguez Roda, 1951; Planas and Vives, 1951; Palomera and Rubiés, 1979; Palomera, 1992). In the eastern part of the Gulf of Lions, Chavance (1980) found anchovy eggs from May to September. There is evidence of latitudinal differences in the duration of the spawning period of the western Mediterranean associated with regional temperature fluctuations. The spawning period is more constricted at northern latitudes (five months) than at the southern ones (seven months). The mean abundance of anchovy eggs (Palomera, 1992) showed the increasing duration of the spawning season from north to south along the Catalan coast. In this area the peak spawning is always centered on two months (Palomera, op. cit.). In the northern part of the region, anchovy seems to spawn at the time of year when water temperature is high and the outflow from the Rhône River is still substantial, creating, in terms of stability and productivity, an environment favourable to spawning. In the Gulf of Lions and Catalan Sea, the most favourable environmental conditions for spawning are encountered from June to August with sea surface temperatures between 15°C and 22 °C (Fig. 2).

In the Alborán Sea, the spawning period has been reported from March-April to September-October with the peak in June-July (Giráldez and Abad,

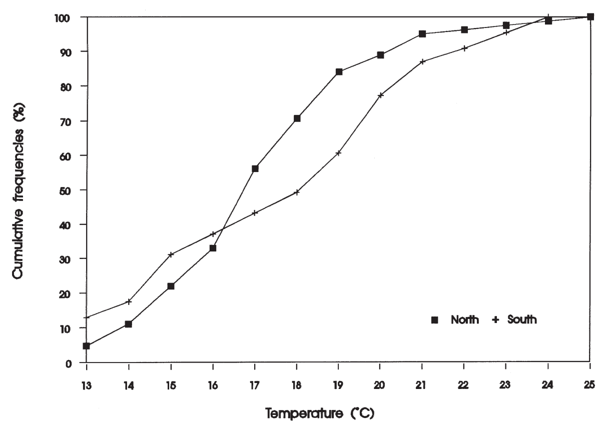

FIG. 2. – Cumulative frequencies of anchovy eggs by temperature found during the spawning periods of 1983, 1984 and 1985 off the Catalan Sea, by northern (close to Gulf of Lions) and southern (river Ebro delta) areas.

1995). Anchovy eggs may be found from May to November (Rodríguez and Rubín, 1986; Rodriguez, 1990), though the peak spawning usually occurs during the month of August with surface temperatures between 19°C and 23°C. In the Ligurian-North Tyrrhenian regions, Albertelli *et al.* (1988) have observed anchovy spawning seasonality extending from May to September, with peaks in July.

From the point of view of interaction with other clupeiform species its interesting to note that at northern region anchovy and sardine do not have coincident spawning period, whereas the sardine spawns from October to March (Larrañeta, 1960), the anchovy spawns from April to October, as said before. Among other small pelagic fish present in the area, the gilt sardine (*Sardinella aurita*) has a spawning period in summer thus coinciding with anchovy peak spawning; nevertheless Palomera and Sabatés (1990) found different distributional patterns of egg and larvae of both species indicating some degree of spatial segregation.

SPATIAL PATTERNS

Alboran Sea

In the Spanish coast of the Alboran Sea the traditional coastal anchovy fishery has been targeting the 0-age class fraction. Its neritic distribution inshore led to the development of artisanal gears, such as, beach seines and specific seines for the exploitation of this resource (Bellón, 1950; García *et al.*, 1981 and Reina-Hervás and Serrano, 1987). This fishery motivated research in the early life history aspects of this species, mainly focused on its distribution along the coasts (García and Rubín, 1985) and seasonality (Rodríguez and Rubín, 1986; Rodríguez, 1990).

Most of the fishing effort applied to the 0-age class was localized in the Bay of Málaga. García *et al.* (1981) defined this zone as an anchovy-sardine nursery ground. Although this zone did not register the highest egg concentrations the existence of nursery grounds was attributed to local wind induced larval transport from adjacent spawning grounds. The concentration of water masses in the Bay described by Arévalo and García (1983) could be the cause of retention in this area favourable to growth and feeding.

In the northwestern sector of the Alborán Sea, near Gibraltar, divergence areas exist between the Atlantic water inflow and the northern coasts. The upwelling of deep waters in the coast near Gibraltar provokes the enrichment of the surface layers. High phytoplankton productivity is associated with this region (Cortés *et al.*, 1985), and in its immediate western borders with higher zooplankton biomass (García and Camiñas, 1985; Camiñas, 1983). Data from egg and larval surveys during 1975, 1982 and 1984 have shown that the upwelling margins nearshore are favourable to sardine and anchovy spawning. However, this coastal area is under the direct influence of the Atlantic jet current which after hitting the coastline on east-north-east direc-

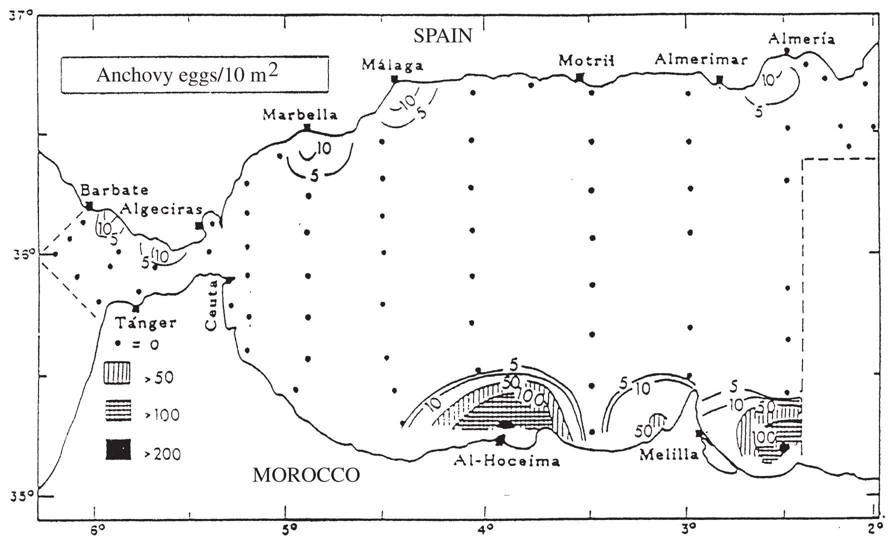

FIG. 3. – Anchovy egg distributions in the Alboran Sea during July 1993 (from Rubín, 1996).

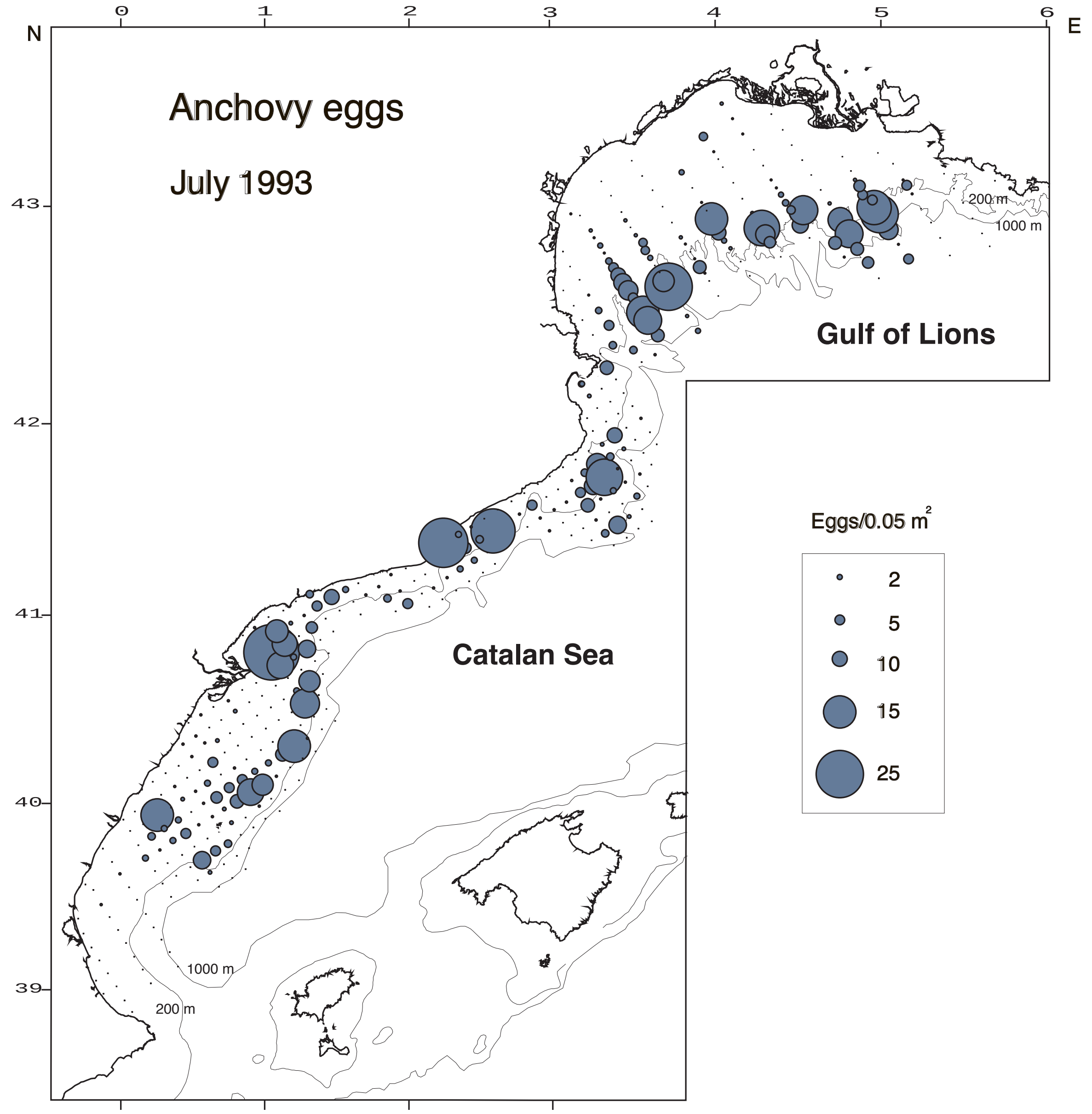

FIG. 4. – Anchovy egg distribution in the northwestern Mediterranean Sea during July 1993.

tion, may carry eggs and larvae seaward. Recent research by Rubín (1996) showed that the Atlantic inflow can be a mechanism of egg and larval transport from the inmediate Atlantic spawning ground located at the Gulf of Cadiz to the Mediterranean.

Little information on anchovy spawning off the northern African coasts is available. Results from Suau and Lamboeuf (1975) and Rubín (1996) reveal rather important spawning areas off the Alhucemas Bay and near the Chafarinas island, adjacent to the Moroccan coastal waters (Fig. 3). Ktari-Chakroun (1979) found nearshore concentrations of anchovy eggs north of Tunisian coasts.

Spanish Levantine region

Information on the distribution of anchovy spawning grounds in this region is practically nil. The traditionally low catch quantities of anchovy in this region (Abad and Giráldez, 1990) contributed to the scarcity of information from this sector. However, Suau (1974) found the highest anchovy egg and larval abundances off the Gulf of Alicante in a fish egg and larval survey that covered the western Alborán Sea, the Gulfs of Vera and Alicante. Coincident results were encountered by Lago de Lanzós and Solá (1986).

Catalan Sea and Gulf of Lions

These two areas have the most important spawning grownds in the western Mediterranean. Anchovy spawning distribution has been studied by Aldebert and Tournier (1971) off the Gulf of Lions, by Palomera (1992) in the Catalan sea and by Palomera *et al*. (1995) in both areas. Main concentrations of eggs and larvae were generally recorded from 10 to 50 miles offshore, which in this region spans a very broad range of bottom depths, from 50 to 1000 m (Fig. 4). It is common to observe mass concentrations of anchovy eggs and larvae in the borders of submarine canyons such as those of the northern Catalan Sea or the Gulf of Lions. The presence of the shelf-slope front, which, subject to certain fluctuations in intensity, runs along the entire shelf (Font *et al*., 1988), suggests that anchovy may take advantage of the productivity associated with the front, particularly bearing in mind the substantial enrichment associated with the front during the peak spawning period (summer) (Estrada and Margalef, 1988). Spawning is also clearly associated with the areas under the influence of the inflows of two large rivers (Aldebert and Tournier, 1971; Palomera, 1992), i.e., the Rhône and the Ebro Rivers. A similar association has also been reported for anchovy in the Bay of Biscay in the vicinity of the mouth of the Loire River (Arbault and Lacroix-Boutin, 1977). The effect of the influx of inland waters from the Gulf of Lions in the northern part of Catalan coast became apparent when highest levels of anchovy eggs and larvae were recorded in the area covered by a surface plume of fresh water (Castellón *et al*., 1985), whereas the larvae of most other fish species were located at the outer edges of the said plume (Sabatés, 1990). In the vicinity of the Ebro River delta the highest concentrations of anchovy eggs were recorded in the permanent upwelling zone described by Font *et al*. (1986-1987), caused by the intrusion of slope waters onto the continental shelf. Recent studies on anchovy egg distribution (Maynou and Palomera, 1995) in this area showed the importance of mesoscale mechanisms (eddies, filaments) in egg concentration and transport. Results from the studies that include the entire area from the Levantine area to the Thyrrenian Sea (Palomera *et al*., 1995) show that these distributional patterns in the Catalan Sea and Gulf of Lions are persistent in each spawning period.

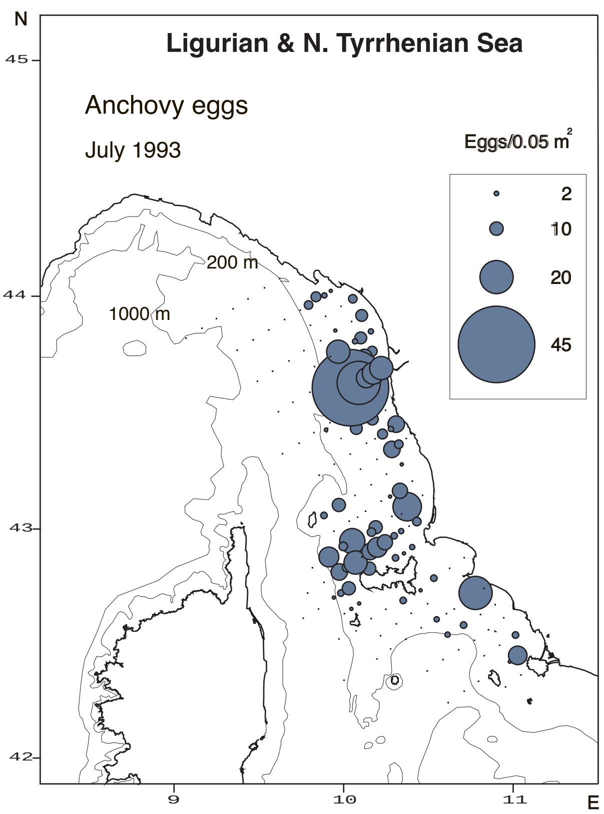

FIG. 5. – Anchovy egg distribution in the Ligurian Sea and North Tyrrhenian Sea during July 1993

Ligurian and Tyrrhenian Seas

From egg surveys carried out in the Ligurian Sea from 1988-1991 (Giovanardi, 1991) the main spawning grounds were found in the area where the shelf is wider, mainly around the island of Elba. Similar results were obtained in the peak spawning of 1992 and 1993 (Palomera *et al*., 1995) (Fig. 5) showing concentrations of eggs in the Tuscan region with higher abundances opposite river outflows.

EARLY LIFE HISTORY BIOLOGY

Daily spawning time

Based on data from various anchovy egg and larval surveys, Palomera (1989) analysed the presence of eggs at stage I and II in relation to time of day. Daily peak spawning occurred during a time span from 20:00-4:00 GMT. Maximum of initial stages were found at 24:00 GMT, which is in agreement with the results of Motos (1996) for the Bay of Biscay anchovy.

TABLE 1.- Larval growth rates from different *Engraulis* species around the world.

Species	Area	Authors	Medium	Growth model	Growth rate (mm/day)	Temperature °C
Engraulis capensis	South Atlantic	Thomas, 1986	Sea	Linear	**0.7	22
E. japonicus	East Pacific	Fukuhara and Takao,1988	Laboratory	Linear	0.4-0.6	20-27
		Mitani, 1988	Sea	Linear	0.4-0,69	-
E. mordax	North Pacific	Kramer and Zewifel, 1970	Laboratory	Exponential	*0.4	15
		Methot and Kramer, 1979	Sea	Gompertz	*0.37	15
E. encrasicolus	Adriatic	Regner, 1980	Laboratory	Gompertz	*1.15	21.3
	North Atlantic	Ré, 1987	Estuaries	Linear	0.4	16-19
	NW Mediterranean	Palomera *et al.*, 1988	Sea	Gompertz	*0.9	20
		García *et al.*, 1995a	Sea	Exponential	0.56	18

* Growth rate at 8 mm length
** Estimated from author's data

The data gathered in 1993 from adult catches made between 6:00 and 23:00 and in 1994-1995 with catches covering the 24 h cycle off the nort-western Mediterranean indicated the presence of maximum hydrated stages were found between 19:00 and 22:30 GMT (García *et al.*, 1994; Ochoa-Báez, com. pers.). These data sustain the previous observations about the spawning time of the day.

Vertical distribution

Maximum abundance levels for both eggs and larvae are always located above the thermocline (Palomera, 1991). When a strong thermocline is present, the eggs are distributed above it. On the other hand, when stratification is less pronounced, eggs tend to sink deeper towards the bottom. In view of the egg abundance levels recorded spawning would appear to take place primarily in the upper 10 m, with the thermocline acting as a barrier. Larvae are more abundant in the upper 10 m, although mean abundance levels between the surface and 30 m are also relatively high. Small larvae (2-4 mm) were located in the same water as the eggs. These results confirm that in the Mediterranean anchovy larvae larger than 10 mm carry out vertical migrations from the surface at night to nearly 30 m during the day. The distribution of larvae in the surface layers can be attributed to the types of organisms that occur in those layers and the main components of the diet of anchovy larvae (Tudela and Palomera, 1995). According to Estrada *et al.* (1985), 78% of the copepod population is located between the surface and 50 m, the portion of the column richer in copepod eggs and nauplii essential to the diet of anchovy larvae. With regard to first feeding larvae and assuming a feeding behaviour similar to northern anchovy (Lasker and Zweifel, 1978) in which dinoflagellates are the main diet, the component of the phytoplankton above the thermocline in the stratified waters of the western Mediterranean are dinoflagelates (Margalef, 1985), while diatoms, which are not well-suited to the diet of anchovy larvae, predominate at the level of the deep chlorophyll maximum.

Larval growth

Larval growth of western Mediterranean anchovy was analyzed for the first time using growth rings in sagital otoliths and an age-length key from first-feeding to 23.7 mm length larvae was established (Palomera *et al.*, 1988). Growth rings were interpreted as daily; subdaily rings were observed from the third or forth increment. The results of otolith readings fit well to a Gompertz growth equation commonly employed in larval growth analysis (Zweifel and Lasker, 1976). This is suitable to represent the growth of this species at the length range analyzed; however extrapolation to greater lengths is not reliable. An instantaneous growth rate about 0.9 mm/day was calculated for 8 mm larvae at a temperature of 20°C. More recently, García *et al.* (1995a) analyzed the anchovy larvae growth, obtaining an instantaneous growth rate at 8 mm length lower than the previous estimate (0.56 mm/day). The larval growth rates reported for the western Mediterranean anchovy is higher than those reported for other *Engraulis* species and *Engraulis encrasicolus* from Mira estuary (Table 1), but close to Adriatic anchovy, that shows the highest growth rate. Temperature and food availability are the main causes of growth variability in field-captured larvae. Significant larval anchovy growth differences were observed by García *et al.* (1995a) between the larvae spawned off the Gulf of Lions and those originating

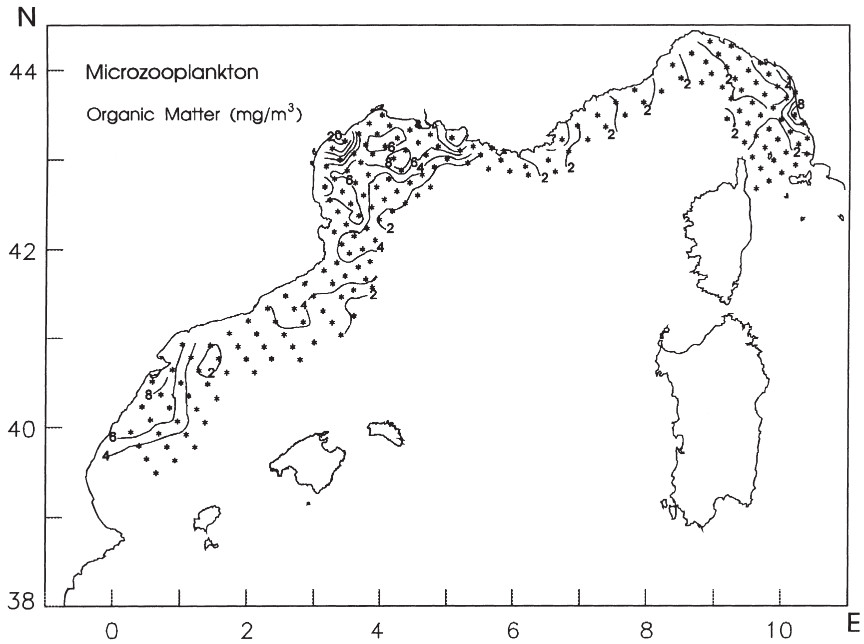

FIG. 6. – Microzooplankton biomass distribution off NW Mediterranean during MAD 92 cruise (July 1992).

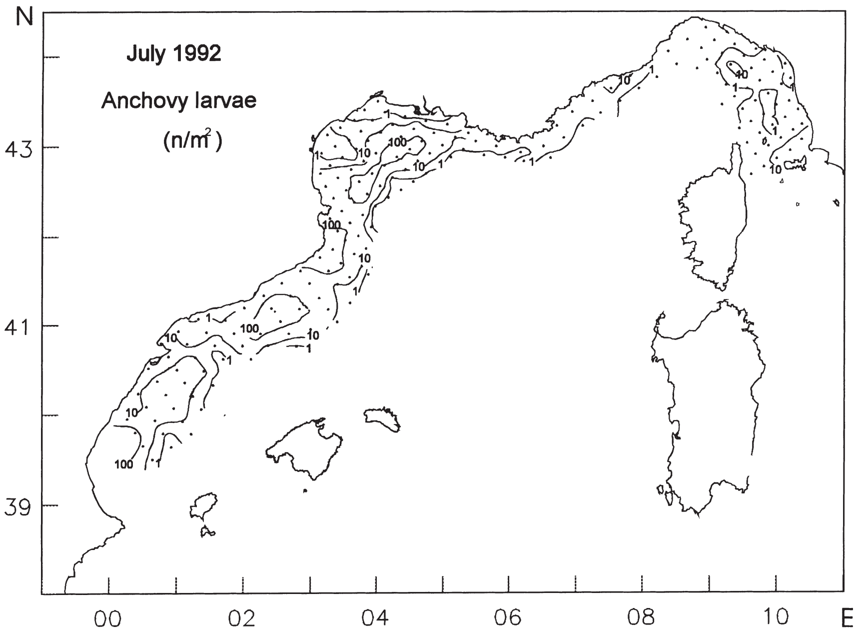

FIG. 7. – Anchovy larvae distribution off NW Mediterranean during MAD 92 cruise (July 1992).

off the more southern Catalonian coasts, which evidences rather distinct environmental characteristics.

Larval feeding

First anchovy larval feeding studies in the western Mediterranean were made by Tudela and Palomera (1995). Microzooplankton analysis was used as an index of food availability. Maximum concentrations of organic matter were found at Gulf of Lions, with a maximum around 20 mg/m^3 at a coastal area. Generaly the values over the Gulf were high with values in the central area of 11 mg/m^3 and near the mouth of the Rhone river. In the rest of the area the values were lower until the delta of the Ebro river with a maximum of 12 mg/m^3 and at a coastal area of the Ligurian Sea (11 mg/m^3) (Fig. 6). In fact, maximum values coincide with areas of lower salinities in the zones of outflow of rivers. Nevertheless maximum abundances of anchovy larvae at the same cruise were not found in areas where the values of microzooplankton were higher (Fig. 7). Nauplii and copepodites were the dominant components of microzooplankton, which also had abundant cladocerans.

Gut contents were analysed from 228 larvae captured in the Catalan coasts and the Gulf of Lions. The range of larvae analysed varied from 3.59-13.33 mm, although only larvae from 5.33-11.59 mm had gut contents. The mean number of feeding particles per larvae was 1.83. The main diet was composed of eggs, nauplii and the copepodite stages of copepods as found by Regner (1971) for the Adriatic Sea anchovy and Pavlovskaia (1961) for the Black Sea. Copepod eggs were the 29.5% of the prey, nauplius 27.2% and copepodites 31.8%. Other items in the diet were cladocerans, pollen of gymnosperms and other organic particles not identified. Cladocerans were the largest prey detected. Measures of the maximum width of preys showed that maximum prey size increased with larval size. Nevertheless the range of prey size also increased meaning that larger larvae fed on larger prey but continue to feed on small prey (Fig. 8). As stated by Regner (1996), for anchovy larvae from the Adriatic Sea, the percent of larvae with food in their guts is very low (only 10.5% of the larvae had gut contents).

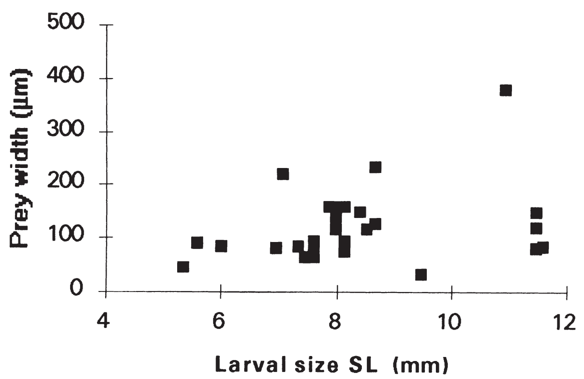

FIG. 8. – Relationship between anchovy larvae size and size of prey found in their guts.

Larval condition

The first estimates of larval condition using RNA/DNA ratios as a measure of the nutritional status of individual anchovy larvae were carried out by Cortés and Ramírez (1995), adapting the analytical technique described by Clemensen (1988). The size range of sampled larvae varied from 6-12 mm, and the RNA/DNA ratios varied from 1.9-7.8 (mean value of 4.49: SD = 1.28). Thes values were similar to those registered for herring larvae by Clemensen (1988, 1989) and for sardine larvae by Chícharo (1995).

A comparative study of larval growth and condition by García *et al.* (1995a) applied the log-linear regression of RNA vs DNA between the two larval populations sampled (Gulf of Lions and Catalan Sea). The study confirmed significant differences which were consistent with the differences observed in daily growth rates. As a consequence of this comparative analysis, it was shown that larvae from the Gulf of Lions have a higher nutritional condition than those caught along the Catalan Sea coast, as well as, higher growth rates.

These authors also analyzed the influence of certain environmental parameters on their condition estimates, such as, food availability (microzooplankton organic matter, relative fluorescence) and temperature. RNA/DNA ratios of larvae from the Catalan Sea showed positive correlation with fluorescence ($p<0.0001$) and microzooplankton organic matter ($p<0.0001$), while this trend was not observed with anchovy larvae from the Gulf of Lions ($p>0.5$). In reference to temperature, RNA/DNA ratios of Catalan Sea anchovy larvae showed a negative correlation ($p<0.05$), while larvae from the Gulf of Lions showed a positive correlation ($p<0.005$). However, when the whole larval population was analysed, highest RNA/DNA ratios, were located within the 17.5-18.0°C temperature interval. Out with this temperature range, RNA/DNA ratios were notably lower. Also, diurnal cycle observations on variations of RNA showed maximum RNA values during the nocturnal period, probably due the to larval diel rythm of feeding.

Larval mortality

Instantaneous mortality rates calculated from the decline in abundance through successive age-class in June of 1983 to 1985 along the Catalan coast ranged between 0.17 and 0.58, and were lower in the northern area, close to the Gulf of Lions than in the southern area (Palomera and Lleonart, 1989). These mortality rates fall within the ranges reported for other *Engraulis* species (*E. mordax,* Hewitt, 1982; *E. anchoita,* Sánchez, 1986). In the Adriatic Sea, Regner (1985) reported mortalities over 0.30 for the same species. By comparing temperature, salinity, chlorophyll and observed egg production against mortality rates (Palomera and Lleonart, 1989) only a relationship with the latter could be detected, which indicates high mortality values associated with high egg production. As said before, mortality was lower in the northern spawning area than in the southern one, especially in 1983. That year phytoplankton production (chlorophyll-a) was higher in the northern area due to an intrusion of continental water from the Rhône river (Castellón *et al.*, 1985) and could be responsible for an increase in food availability for anchovy larvae hence favouring survival in this area. Higher growth rates produce better survival rates in larval populations because the time exposure to potential predation is shortened (Folkvord and Hunter, 1986). As said before, recent analysis and comparisons between the two areas by García *et al.* (1995a) coincides in the differences between both areas showing higher growth rates and higher condition indices in the northern population than in the southern one.

ICHTHYOPLANKTON BASED METHODS OF SPAWNING STOCK ESTIMATES

The first application of the Daily Egg Production Method (Lasker, 1985) in the Mediterranean was focused on the spawning stock of the anchovy from the Ebro river (Palomera and Pertierra, 1993). Prior to this, Chavance (1980) attempted the first ichthyoplankton based method of sardine and anchovy spawning biomass in the north-western Mediterranean basin off the Gulf of Lions during 1978-1979, using an annual fecundity method (Saville, 1964), assuming that these species were determinate spawners. In 1993, a joint evaluation on a simultaneous temporal and spatial scale using both DEPM and acoustic echo-integration was carried out to estimate anchovy spawning biomass off the Catalan coast, the Gulf of Lions and the Ligurian-north Tyrrhenian (García *et al.* 1995b). The area covered encompassed the totality of the northwestern Mediterranean anchovy spawning grounds. In 1994 a DEPM evaluation was centered on the main spawning ground off this region (Catalan Sea and Gulf of Lions) (Palomera, 1995) making possible a first comparison between years (1993 and 1994). The values of biomass estimates range from 30,849 tons to 52,557 tons (Table 2).

The batch fecundity estimates obtained in 1990 are quite different from the rest. The estimate of this parameter was calculated by counting the largest size oocyte group found in ripe gonads because it was not able to collect hydrated females. This may account for the difference in this batch fecundity of the other years which had an ample range of sizes of anchovies which were found in the hydrated stages. Differences in the same parameter for the other years is easily explained taking into account the high female weight obtained in 1994.

The application of DEPM to north-western Mediterranean anchovy has produced good results mainly because of the well defined spawning area

TABLE 2 . – Parameters obtained for the application of the DEPM biomass model in the north-western Mediterranean. A: Total area covered; N: number of stations; A(1): Spawning area; P: Daily egg production; z: Instantaneous egg mortality rate; W: Average female weight; R: Sex ratio; F: Batch fecundity; F/W: Specific batch fecundity; S: Spawning fraction; D: Daily specific fecundity.

PARAMETERS	1990*		1993 west		1993 east		1994 west	
	mean	cv	mean	cv	mean	cv	mean	cv
A (km^2)	17,081		44,554		15,424		42,085	
N	126		430		172		334	
A(1) (km^2)	8,095		33,012		8,221		31,692	
P (eggs/day)*e^{12}	0.46	0.33	2.12	0.17	0.41	0.32	1.95	0.21
z	0.56	0.441	1.09	0.26	0.86	0.34	0.47	0.26
W (gr)	14.25	0.041	14.31	0.07	14.17	0.068	22.92	0.06
R (% weight)	54	0.086	64	0.05	63	0.05	59	0.19
F (eggs/batch)	8,006	0.018	4,958	0.11	4,894	0.10	7,039	0.02
F/W	561.82		346.47		345.38		307.11	
S	0.36	0.095	0.31	0.13	0.32	0.11	0.21	0.2
D (eggs/gr per day)	109.2		68.7		69.6		38.1	
BIOMASS (tons)	4,239	0.35	30,849	0.30	5,829	0.36	52,557	0.36

*Southwest Region only

that doesn't have substantial interannual variations assuring an accurate estimation of egg production. Egg mortality and spawning fraction were smaller in 1994. Those differences can be explained because the estimate was made earlier (May-June) in 1994 than in 1993 (July) implying environmental differences that can affect mortality and also differences in the amount of spawners in the population.

CONCLUSIONS

Although the western Mediterranean basin encompasses different environmental settings, some common features stand out in relation to the localisation of anchovy spawning grounds. The extensions of spawning grounds seem to be linked to the size of the shelf and the degree of hydrographic enriching processes. River outflows, which at local scales may produce frontal systems, play an important role in the distribution patterns of anchovy eggs and larvae. Also in regions with low river outputs, such as in the Ligurian Sea or in the northern and southern coasts of the Alboran Sea, anchovy spawn in its proximity. Bottom topography can play another important role since it can affect water mass circulation, causing upwelling deep waters as in the case of submarine canyons such as those of the northern Catalan Sea or the Gulf of Lions.

Until now the ichthyoplankton studies in western Mediterranean have allowed an overview of the spawning grounds over the area, particularly the northern area. Emphasis must be made in the future on the Alboran Sea, and areas with very special hydrographic features, cyclonic gyres, inflow of Atlantic waters, and frontal areas, that can play an important role in the egg and larval transport and retention mechanism. Moreover, although the importance of small pelagic resources is rather well known off the North African coasts, there are few studies which analyze environmental influence on these resources.

Some previous studies have attempted to link some of the environmental characteristics prevalent in the area, such currents, fronts, upwelling, eddies, etc. with certain early life biological aspects of the species. But for the time being only direct relations with certain environmental parameters have been made: influence of temperature and salinity on egg and larval distribution (Aldebert et Tournier, 1971; Palomera, 1992; Rubín, 1996), growth and condition or mortality (Palomera *et al*., 1988; Palomera and Lleonart, 1989; García *et al*., 1995a) and a first approach to larval feeding in relation to dietary components (Tudela and Palomera, 1995).

Nevertheless, the environmental impact on the variability of the anchovy resources in the western Mediterranean basin has not been specifically assessed to the present date, although emphasis on the implementation of multi-disciplinary approaches with the principal aim of linking environment and variability has been made (Alheit and Bakun, 1989).

There are large gaps in our knowledge concerning the effects of environment on biological traits. It is important to discriminate the relevant environmental features. That may constitute an arduous task since from all the described spawning areas, there are convergent features which may mask the main forces influencing recruitment. Also the climatic component is one the most overlooked matters in relation to the variability of the resource in the Mediterranean, a region which is characterised by its climatic contrasts.

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