

Summer fish larval assemblages and station groups in the northern Aegean Sea

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*Fish larvae were collected in two surveys, carried out at the beginning of July 2002 and 2003 in Kavala Gulf (northern Aegean Sea) aimed at studying ichthyoplankton species assemblages and station groupings. The similarity dendrograms revealed the existence of four species assemblages associated with three station groups in 2002 and five species assemblages associated with four station groups in 2003. These groupings were confirmed by non-metric multidimensional scaling (NMDS) analysis. Analysis of similarity showed that the station groups were significantly different for 2002 (global $R=0.748$; $P<0.001$) and 2003 (global $R=0.931$; $P<0.001$). High dissimilarity between species assemblages as obtained from dendrograms and NMDS analyses was also recorded for 2002 (global $R=0.834$; $P<0.001$) and 2003 (global $R=0.767$; $P<0.001$). The assemblage structure was mainly determined by the most abundant and frequently occurring larvae, especially the European anchovy (*Engraulis encrasicolus*), and was largely influenced by the reproductive traits and spatial distribution of adult fish. Differences among station groupings were also determined by the spatial occurrence and abundance of each taxon.*

Key words: ichthyoplankton, assemblages, Aegean Sea, Mediterranean Sea

INTRODUCTION

Various processes related to adult spawning, oceanographic features and larval life histories determine the composition and distribution of larval fish communities (BOEHLER & MUNDY, 1993), as well as the adult population biomass (SINCLAIR, 1988). Besides similar parental spawning strategies, larval assemblages may arise from exposure to similar hydrological and physical oceanographic processes (FRANK

& LEGGETT, 1983; SMITH & SUTHERS, 1999), or response to prey fluctuations (CUSHING, 1975; MOSER & SMITH, 1993) or even to habitat characteristics (LA MESA *et al.*, 2006). The groupings of co-occurring larval fish species often exhibit temporal and spatial variability reflecting behavioral adaptations, variable survival rates and response to external stimuli such as interactions between hydrodynamic processes (BAKUN, 2006).

The study of the summer community structure of Mediterranean marine fish is important

because most of them spawn during the spring/summer months (TSIKLIRAS *et al.*, 2010). The northern Aegean Sea is an important spawning ground for several spring/summer spawning fish (TSIKLIRAS *et al.*, 2009) and is the main fishing ground of Greek waters (TSIKLIRAS & STERGIOU 2007). So far, the summer ichthyoplankton assemblages have been extensively studied in the western Mediterranean Sea (for a review see SABATÉS *et al.*, 2007a) and to a lesser extent at the eastern part of the area (e.g. ISARI *et al.*, 2008).

The aims of the present study were (a) to describe the summer ichthyoplankton species assemblages and station groupings, (b) to examine their inter-annual changes, and (c) to assess the factors that are most likely to cause these changes.

MATERIAL AND METHODS

Larval fish were collected in Kavala Gulf across a fine-scale grid of 17 stations in two surveys, carried out in the beginning of July 2002 and 2003 (Fig. 1). The Kavala Gulf ($24^{\circ} 25' 00''$ E, $40^{\circ} 52' 50''$ N) is a shallow gulf located on the continental shelf of the northern Aegean Sea (for a full description of Kavala Gulf see TSIKLIRAS *et al.*, 2009). Two hydrographic features were examined: depth and distance from shore. Based on their depth, the 17 stations were divided into those not exceeding 30 m in depth (stations 6, 7, 8, 9, 10, 11, 12, 13) and those that were deeper than 30 m (stations 1, 2, 3, 4, 5, 14, 15, 16, 17), while based on their distance from shore, they were divided into near shore (those located close to shore: stations 1, 2, 6, 7, 8, 9, 10) and offshore (those located away from shore: stations 3, 4, 5, 11, 12, 13, 14, 15, 16, 17). For convenience, the shallower stations are referred to as shallow and the deeper ones as deep.

A paired bongo net sampler was used for the collection of plankton eggs and larvae. This sampler design has two 60 cm diameter frames fitted with 250 μ m mesh conical nets. A flow meter was centrally fitted at the opening of each frame to estimate the volume of water (m^3) flowing through the net. The sampler was deployed in a double oblique tow from the sur-

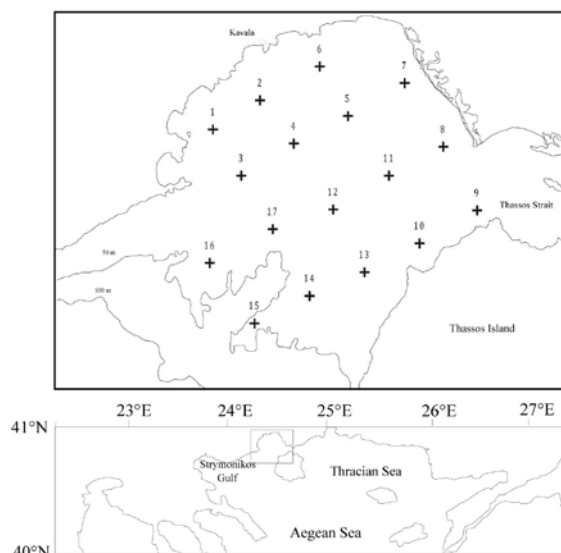


Fig. 1. Map of the study area (Kavala Gulf, northern Aegean Sea, Greece) showing the grid of 17 sampling stations (+)

face to within 1-2 m of the bottom. Retrieval speed was kept at the same rate (20 m/min) for all samplings, which were all carried out in daylight. Upon recovery of the sampler, the plankton was washed into a jar and fixed with 4% buffered formaldehyde solution. Fish larvae were removed from plankton samples, identified to the lowest possible taxonomic level and enumerated. Plankton data were standardized as the number of larvae beneath a unit sea surface area ($10 m^2$). Larval abundance data from each tow were transformed to $\log_{10}(\text{number} + 1)$ to ensure comparability with previously published literature.

The pattern of changes in the structure of the overall larval community was explored by multivariate analyses. The approach of LANKSBURY *et al.* (2005) was followed for the determination of species assemblages and station groups. To identify groups, the cluster analysis (dendrogram) and the non-metric multidimensional scaling (NMDS) ordination, which have been commonly applied in studying fish communities (e.g. KOUTRAKIS *et al.*, 2004), were used according to the procedure outlined by CLARKE & WARWICK (1994). The Bray-Curtis similarity measure was chosen as the similarity coefficient and similarity matrices coupled with group linkage were generated. Following cluster analysis,

the datasets were subjected to NMDS ordination which was used to graphically display a two-dimensional ordination plot of the interrelationships among species or stations. The similarity matrices and the ordination plots were based on spatial occurrence and abundance of each taxonomic group. Species in the plot that were close together were most similar and the extent to which the plot displayed these relationships among species (goodness of fit) was determined by a 'stress coefficient'. Stress coefficients lower than 0.15 indicate good ordination of data with no real prospect of misleading interpretation (CLARKE & WARWICK, 1994). Species recorded in less than 6% of samples (i.e. those caught only at one station) were excluded from the assemblage structure analyses (four species in 2002 and three species in 2003). Only groupings based on agreement between the results of cluster and NMDS analyses were accepted (FIELD *et al.*, 1982).

Analysis of similarities (ANOSIM) was performed to test the significance of differences in groupings separated in the NMDS ordinations. The values of the R statistic are an absolute measure of how well separated the groups are, ranging between 0 (indistinguishable) and 1 (well separated) (CLARKE & GORLEY, 2001). The nature of groupings identified in the NMDS ordinations was explored further by applying the similarity percentages (SIMPER) to determine the species' contribution to the average dissimilarity among samples. All multivariate analyses were performed using the PRIMER v. 5 software package (CLARKE & GORLEY, 2001).

RESULTS

Species assemblages

The NMDS analysis performed on the species collection revealed the existence of four species assemblages (A, B, C and D) in 2002 and five (E, F, G, H and I) in 2003 (Table 1). The cluster analysis, performed on the matrix derived from the Bray–Curtis similarity, supported the NMDS analysis. The ANOSIM analysis showed high dissimilarity between species assemblages obtained from cluster and NMDS

analyses for 2002 (Global R=0.834; P<0.001) and 2003 (Global R=0.767; P<0.001).

In 2002 (Table 1), the main assemblage (C) was composed of eight taxa that had the highest occurrence among stations and were the most abundant (e.g. *Engraulis encrasicolus*, *Sardinella aurita*, *Serranus hepatus* and *Gobius* sp.). The second (A) and third (B) assemblages included four (*Ceratoscopelus maderensis*, Labridae, Centranchthidae and *Trachinus draco*) and three (*Arnoglossus* sp., *Coris julis* and *Trachurus mediterraneus*) taxa, respectively, that were abundant though their overall occurrence was low. Finally, *Buglossidium luteum* and *Lesueurigobius friesii*, which were the least abundant taxa and had the lowest occurrence, formed the fourth assemblage (D). Three taxa (*Diplodus annularis*, *Scomber japonicus* and *Serranus cabrilla*) were excluded from the 2002 assemblage structure analysis because they were recorded in less than 6% of the samples (marked with + in Table 1). One outlier, not included in any assemblage, was also recorded (*Crystalllogobius linearis*).

In 2003 (Table 1), the main assemblage (G) was composed of six taxa that were abundant though their occurrence was low (e.g. *Arnoglossus thori*, *S. japonicus* and *S. cabrilla*). The second assemblage (F) was composed of five species that were frequent but not very abundant (e.g. *Chromis chromis*, *Arnoglossus* sp. and *Callionymus* sp.) and the third one (H) of the four most frequent occurring and abundant species (e.g. *E. encrasicolus*, *S. hepatus* and *S. aurita*). The final two assemblages (E and I) were composed of the least abundant and frequent species. Five taxa (*B. luteum*, *C. julis*, Labridae, Myctophidae and *Scorpaena* sp.) were excluded from the 2003 assemblage structure analysis because they were recorded in less than 6% of the samples (marked with + in Table 1), while two outliers, not included in any assemblage, were recorded (*Arnoglossus laterna* and *C. linearis*).

The frequent and abundant species of 2002 assemblage C formed the core of the 2003 assemblage H and the remaining species of 2002 assemblage C formed 2003 assemblage F. No other patterns emerged between the two surveys.

Table 1. Species assemblages (A to I) and station groups (I to VI as indicated in Figs. 2-4) resulted from non-metric multidimensional scaling (NMDS) and cluster analyses. Numbers are mean abundance (no. of larvae per 10 m²) of taxon in each station grouping, (+) denotes the presence at one station only and (-) denotes absence. Numbers in parentheses indicate total number of stations in each group and letters in parentheses represent outliers that lay close to a species group. Species taxonomic authorities are according to FishBase (Froese & Pauly 2009).

Taxon	species assemblages		2002 station groups					2003 station groups				
	2002	2003	I (9)	II (3)	III (2)	Outliers (3)	IV (5)	V (3)	VI (6)	VII (3)		
1 <i>Arnoglossus latera</i> (Walbaum, 1792)	-	outlier	-	-	-	-	-	-	127.27	-		
2 <i>Arnoglossus thori</i> Kyle, 1913	-	G	-	-	-	-	-	-	218.11	-		
3 <i>Arnoglossus</i> sp.	B	F	-	-	251.62	-	199.74	-	102.23	-		
4 <i>Biglossidium luteum</i> (Risso, 1810)	D	+	55.35	-	-	-	-	-	-	114.00		
5 <i>Callionymus</i> sp.	C	F	420.81	-	-	538.00	115.94	130.65	179.59	298.77		
6 <i>Cepola macrophthalmia</i> (Linnaeus, 1758)	C	(I)	134.12	330.57	-	-	-	-	216.76	-		
7 <i>Ceratoscopelus maderensis</i>	A	G	-	215.00	-	-	-	-	532.06	-		
8 <i>Chromis chromis</i> (Linnaeus, 1758)	C	F	111.08	-	-	-	132.16	-	66.62	-		
9 <i>Coris julis</i> (Linnaeus, 1758)	B	+	-	412.51	-	-	290.00	-	-	-		
10 <i>Symphodus (Crenilabrus)</i> sp.	-	F	-	-	-	-	-	89.50	218.58	111.25		
11 <i>Crystalllogobius linearis</i> (Döben, 1845)	Outlier	outlier	-	-	-	131.97	322.00	145.00	-	114.00		
12 <i>Diplodus annularis</i> (Linnaeus, 1758)	+	-	-	-	-	559.00	-	-	-	-		
13 <i>Engraulis encrasicolus</i> (Linnaeus, 1758)	C	H	1057.29	1285.04	1070.51	-	1685.69	1410.77	6545.38	-		
14 <i>Hygophum benoitii</i> (Cocco, 1838)	-	G	-	-	-	-	-	-	137.83	-		
15 <i>Gobius</i> sp.	C	F	477.77	827.83	-	1810.00	370.76	-	687.88	-		
16 Labridae	A	+	-	-	-	515.00	274.00	-	-	-		
17 <i>Lesueurigobius friesii</i> (Malm, 1874)	D	-	230.00	-	-	806.00	-	-	-	-		
18 Myctophidae	-	+	-	-	-	-	-	-	454.00	-		
19 <i>Pagrus pagrus</i> (Linnaeus, 1758)	-	I	-	-	-	-	145.00	-	214.00	-		
20 <i>Sardinella aurita</i> Valenciennes, 1847	C	H	92.87	-	-	-	-	-	1988.23	-		
21 <i>Scomber japonicus</i> Houttuyn, 1780	+	G	-	-	284.00	-	-	-	184.74	-		
22 <i>Scorpaena</i> sp.	-	+	-	-	-	-	-	-	173.00	-		
23 <i>Serranus cabrilla</i> (Linnaeus, 1758)	+	G	-	215.00	-	-	-	-	661.21	-		
24 <i>Serranus hepatus</i> (Linnaeus, 1766)	C	H	518.63	2720.01	-	-	-	-	1505.16	-		
25 Soleidae	-	E	-	-	-	-	516.00	-	-	170.00		
26 Sparidae	C	G	193.41	160.17	-	-	-	-	674.55	-		
27 Centracanthidae	A	-	231.00	215.00	-	258.00	-	-	-	-		
28 <i>Trachinus draco</i> Linnaeus, 1758	A	-	-	153.64	-	-	-	-	-	-		
29 <i>Trachurus mediterraneus</i> (Steindachner, 1863)	B	I	-	337.09	251.62	-	145.00	123.00	641.00	-		
30 Unidentified sp. 1	-	E	-	-	-	-	458.53	-	-	208.57		
31 Unidentified sp. 2	-	H	-	-	-	-	-	376.66	2266.74	-		
32 Unidentified sp. 3	+	-	-	265.00	-	-	-	-	-	-		
Mean ichthyoplankton abundance			320.21	594.74	464.44	659.71	387.90	379.26	847.38	169.43		

Station groups

The multivariate analyses separated three station groups (I, II and III) and three outliers in 2002 (Table 1, Fig. 2 and 3) and four station groups (IV, V, VI and VII) in 2003 (Table 1, Figs. 2 and 4). ANOSIM showed that the station groups obtained from cluster and NMDS analyses were significantly different within 2002 (Global $R=0.748$; $P<0.001$) and 2003 (Global $R=0.931$; $P<0.001$).

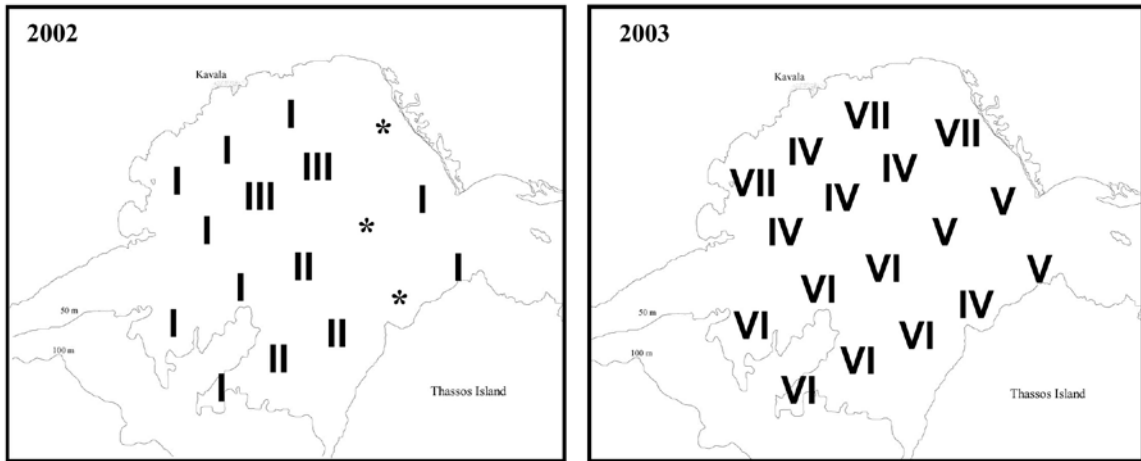


Fig. 2. Station groups for 2002 and 2003 survey years (Kavala Gulf, northern Aegean Sea). Numbers according to station groups as presented in Table 1. The asterisk represents outliers, i.e. stations not belonging to any group

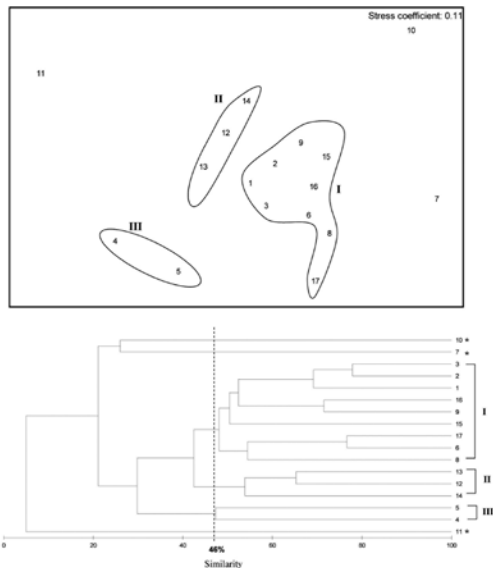


Fig. 3. Non-metric multidimensional scaling plot and dendrogram of the cluster analysis showing the station groups for 2002 (Kavala Gulf, northern Aegean Sea). Numbers according to station groups as presented in Table 1 and Fig. 2.

In 2002, the three outlying stations were characterised by low taxa and the absence of *E. encrasicolus* larvae. Station group I consisted of seven stations located at the N, W and SW part of the gulf and two located close to Thassos strait (Fig. 1), and was characterized by the high spatial occurrence and abundance of *Callionymus* sp. and *Gobius* sp. that were present at almost all stations. The stations of group I were characterized as deep/nearshore. Group II (three stations) included stations with the high-

est abundances of *S. hepatus* and *E. encrasicolus*, and group III consisted of two stations with a low number of taxa and low larval abundance. The stations of groups II and III were characterized as shallow/offshore and deep/offshore, respectively. For 2002, SIMPER revealed that *Callionymus* sp. made the highest contribution (25%) to the similarity within station group I, *S. hepatus* (28%) within station group II and *E. encrasicolus* (41%) within station group III.

In 2003, station group IV (five stations) was characterized by intermediate abundances of *E. encrasicolus* and the presence of *Gobius* sp., whereas group V (three stations) was formed by the stations (8, 9 and 11) influenced by water inflow through the Thassos strait. The stations of group IV were characterised as deep/offshore, while those of group V were shallow/nearshore. Station group VI (six stations) included the open sea stations located at the SW part of the gulf and group VII the three stations with the absence

of *E. encrasicolus* and low total and mean larval abundance. The stations of group VI were characterised as deep/offshore, while those of group VII were shallow/nearshore. Group V was characterised by the maximum percentage of *E. encrasicolus* compared to the total larval abundance and group VI by the maximum total larval abundances. For 2003, SIMPER revealed that the highest contributions to the similarity within station groups were made by *E. encrasicolus* (63%) and *Gobius* sp. (18%) for station group IV, *E. encrasicolus* (82%) for station group V, *E. encrasicolus* (49%) and unidentified 2 (18%) for station group VI, and finally, *Callionymus* sp. (78%) for station group VII. *E. encrasicolus* also made the largest contribution to the dissimilarity among station groups for 2003.

DISCUSSION

The species composition of Kavala Gulf consisted of inshore species with pelagic and demersal eggs, as well as of larvae of species that are distributed offshore as adults. Thus, it can be classified as a neritic assemblage based on the categories described by BOEHLER & MUNDY (1993). The general pattern of ichthyoplankton assemblages of the area seems to be closely related to the adult fish assemblage and the spawning locations of adult populations. Clupeids (*S. aurita*, *Sardina pilchardus*), sparids (*Diplodus* spp., *Dentex* spp., *Boops boops*, *Pagrus pagrus*, *Pagellus* spp.), scombrids (*Scomber* spp.), serranids (*Serranus* spp., *Epinephelus* spp.) and one engraulid species (*E. encrasicolus*) constitute the main target species of the northern Aegean bottom-trawl and purse-seine fisheries (TSIKLIRAS & STERGIU, 2007). The larvae of most of the aforementioned species that spawn in late spring/early summer (TSIKLIRAS *et al.*, 2010) were abundant in the dataset. Members of the Bothidae and Gobiidae families are also abundant in commercial catches but are usually discarded because of their low or non-commercial value.

The coincidence of adult and larval fish is related to the spawning behavior of the adult stocks (FRANCO-GORDO *et al.*, 2001) which may

have spawned close to the regions that offer the most favorable conditions for the growth and survival of their offspring. In the case of Kavala Gulf, the spawning areas are concentrated at the western coast of Thassos island (SW part of the gulf) where a frontal structure is formed between an anticyclonic eddy and the general cyclonic circulation (KOURAFALOU & TSIARAS, 2007; TSIKLIRAS *et al.*, 2009). This is particularly true for anchovy *E. encrasicolus* and round sardinella *S. aurita* that were grouped together and, at least for 2003, both their larval abundances were high on the SW coast of Thassos island (ISARI *et al.*, 2008). Anchovy eggs are mainly found in warm waters but anchovy may spawn in a wide salinity range, often in waters of continental origin (PALOMERA *et al.*, 2007; SABATÉS *et al.*, 2007b). The common parental spawning strategies among species that have evolved to benefit from the coincidence of spawning act with phytoplankton and zooplankton blooms and hydrology patterns (ILES & SINCLAIR, 1982; WINEMILLER & ROSE, 1992) may determine larval assemblages but it may also result in competition for resources. It has been shown that, in order to avoid competition, larvae of closely related and sympatric species may be spatially and/or temporally segregated (PALOMERA & SABATÉS, 1990; WANG & TZENG, 1997). This asynchrony may result in new assemblages that diversify from the seemingly favourable habitat and occupy less favorable conditions.

The adult habitat preferences and their spawning characteristics (i.e. pelagic or demersal eggs, parental care) are also important in shaping larval assemblages. The habitat preferences of the species did not contribute to the structure of the larval community as, in both years, the main groupings (the core group C in 2002, F and H in 2003) constituted of pelagic, demersal and reef-associated species. This could be due to the limited spatial scale of the survey and consequently the short distance among stations and the minimal topography inside Kavala Gulf (TSIKLIRAS *et al.*, 2009). However, the two clupeoids *E. encrasicolus* and *S. aurita* were grouped together in both surveys as were *Callionymus* sp., *C. chromis* and *Gobius* sp. The

consistency in the grouping of those groups of species indicates that the adult spawning behaviour and the larval characteristics may be similar. The two clupeoids have pelagic eggs and larvae (SABATÉS *et al.*, 2008) and their adult stocks inhabit the epipelagic zone in the Aegean Sea, often forming mixed schools. However, the bathymetric distribution may be segregated with the *E. encrasicolus* larvae inhabiting deeper waters (SABATÉS *et al.*, 2008). The parental stocks of the remaining three species are demersal (*Callionymus* sp. and *Gobius* sp.) with pelagic or demersal eggs, for most species of these genera likely to occur in the area (TSIKLIRAS *et al.*, 2009), and reef-associated (*C. chromis*) with nested eggs and larvae associated with the substrate (FROESE & PAULY, 2009). Moreover, *Callionymus* sp. and *Gobius* sp. are reported to show preference for low dissolved oxygen values (TSIKLIRAS *et al.*, 2009).

The occasional presence of some species (*B. luteum* and *L. friessi* in 2002, and *C. linearis*, *P. pagrus* and Soleidae in 2003) and the incidental presence of others (*C. linearis* and *S. cabrilla* in 2002, *B. luteum* and *C. julis* in 2003) determined the peripheral species assemblages that consisted of low number of species (assemblages D, E, I) and the outliers. With the exception of *P. pagrus*, which is a well studied commercial species, little is known about the spawning habits of the remaining taxa in the area (TSIKLIRAS *et al.*, 2010).

The outlying stations in 2002 (stations 7, 10, 11) were those with the least recorded species and with an absence of the most abundant ones (*E. encrasicolus*, *S. hepatus* and *S. aurita*). The extremely high abundance of *Gobius* sp. that was recorded at station 10 could also be the reason for the non-grouping of that station. The absence of the most abundant species and the low number of species characterised station group VII in 2003. In contrast, the high diversity and high abundance of contributing species grouped stations 12-17 together in group VI. These stations were all deep, located offshore in the SW part of the gulf and are very close to the frontal structure which is rich in zooplankton (MICHALOUDI *et al.*, 2006) and concentrates adults

to feed and spawn and thus there is a high abundance and diversity of larvae. Finally, despite their hydrographic differences, groups IV (deep/offshore) and V (shallow/nearshore) were very similar (Fig. 4) and could have formed a single group at a lower similarity level (38% instead of 44% similarity). Their common features were the high *E. encrasicolus* abundance and the low mean ichthyoplankton abundance (Table 1).

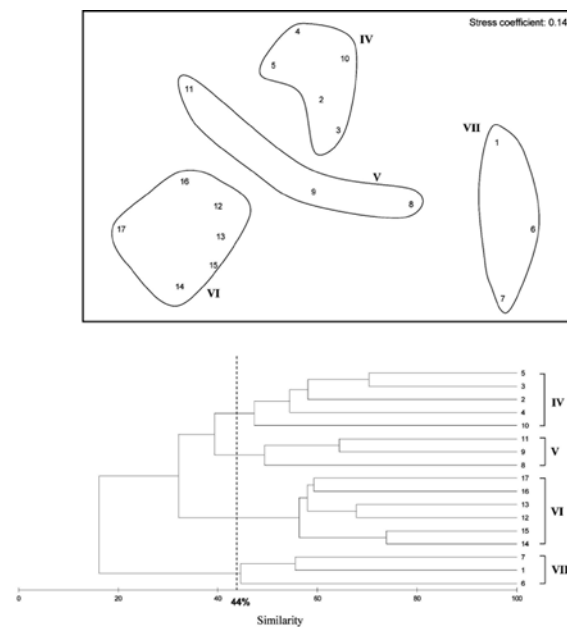


Fig. 4. Non-metric multidimensional scaling plot and dendrogram of the cluster analysis showing the station groups for 2003 (Kavala Gulf, northern Aegean Sea). Numbers according to station groups as presented in Table 1 and Fig. 2.

The variability in the station groupings between the two survey years is probably due to the different oceanographic and hydrological conditions prevailing (TSIKLIRAS *et al.*, 2009) and to a lesser extent due to the species composition. Indeed, the second survey year (2003) was characterised by a shallower thermocline, and cooler, less saline waters compared to the first year (TSIKLIRAS *et al.*, 2009). However, it is clear that stations with common hydrographic/oceanographic characteristics were grouped together, especially in 2003 (station groups V and VI). The stations that formed group V (near Thassos strait) were shallow, located nearshore and affected by the water flowing westwards into the gulf through the Thassos strait, while the sta-

tions that formed group VI (in the SW part of the gulf) were deep, located offshore and affected by the frontal structure described by KOURA-FALOU & TSIARAS (2007). The latter (group VI) was characterised by the maximum total larval abundances, which are commonly observed in high productivity areas, including fronts (TSIKLIRAS *et al.*, 2009). The common hydrographic/oceanographic characteristics may concentrate larvae with similar requirements in terms of food, temperature and water circulation (BOEHLER & MUNDY, 1993). Thus, it seems that species composition, while shaping the spatial group structure within a year, may not be able to fully explain the inter-annual differences between station groupings, and longer time series of ichthyoplankton surveys are required to establish the consistency of these groupings.

CONCLUSIONS

In conclusion, the species assemblages identified in the analysis are largely explained by the spatial occurrence and abundance of each taxon and the adult spawning habits, provided that adult spawning distributions and behaviour have been studied in detail. Indeed, the importance of taxa's occurrence and abundance in structuring an assemblage structure has been pointed out by KOUTRAKIS *et al.* (2005) in a similar dataset. The results of the present study may be proven important for future fisheries management which in Greece currently relies on spatial (trawling is prohibited within 2 nautical miles from shore) and temporal (trawling operates between October and May inclusive; purse-seining operates between March and mid-December) fisheries closures, as well as on minimum landings sizes (KAPANTAGAKIS, 2007). Ecosystem based management, which incorporates habitat and resource protection should account for the protection of preferred areas and spatial differences in community structure.

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Sastav sakupljenih ličinki riba i njihova prostorna grupiranost tijekom ljetnog razdoblja u sjevernom Egejskom moru

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SAŽETAK

Riblje ličinke su prikupljene tijekom dvaju istraživanja koja su provedena početkom srpnja 2002. i 2003. godine u zaljevu Kavala (sjeverni dio Egejskog mora) s ciljem utvrđivanja strukture ribljih vrsta i postojanih populacija. Sličnost dendograma otkrila je postojanje četiri populacije povezane s tri skupine u 2002. godini i pet populacija povezanih s četiri stalne skupine u 2003. godini.

Te skupine su potvrđene pomoću ne-metričke analize višedimenzionalnih skala (NMDS). Analiza je pokazala da su grupe stalnih populacija bile značajno različite za 2002. godinu (globalno $R = 0,748$; $P < 0,001$) i 2003 (globalno $R = 0,931$; $P < 0,001$). Visoki stupanj različitosti između grupacija dobivenih od dendograma i NMDS analize također je zabilježena za 2002. godinu (globalno, $R = 0,834$; $P < 0,001$) i 2003 (globalno, $R = 0,767$; $P < 0,001$). Skupna struktura uglavnom je bila određena prema najrasprostranjenijim i učestalim ličinkama, posebice brgljuna (*Engraulis encrasicolus*), te je uvelike bila pod utjecajem reprodukcijjskih obilježja i prostornom raspodjelom odraslih riba. Razlike između utvrđenih grupacija također su određene s obzirom na prostorno pojavljivanje i brojnost svake svojte.

Ključne riječi: ihtioplankton, populacija, Egejsko more, Sredozemlje