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Research Article

The Ichthyoplankton of İzmir Bay: A One-Year Study of Fish Eggs and Larvae

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Abstract: This study was carried out in order to determine the species diversity, abundance, and distribution and seasonal frequency occurrence times of the eggs and larvae of Teleost fish in Izmir Bay during 1989-1990. A total of 32140 eggs and 6582 larvae were collected from plankton samples and 69 species belonging to 27 families were identified. The most abundant families included Sparidae 23.79%, Clupeidae 24.63%, Mullidae 12.22%, Serranidae 8.72% and Mugilidae 8.04% of total eggs, and Gobiidae 67.38%, Sparidae 9.43% and Blennidae 9.31% of total larvae. In this study, with regard to eggs, because some species preferred to release their eggs in clean water, stations in the outer bay showed similarities, while stations in the middle bay formed various groups amongst themselves. From the point of view of larvae, apart from station 2, which was near the lagoon area in the middle bay, the other stations were similar. The reason for this is the abundance of species of the Gobiidae family specific to that area. In areas with a low diversity index in respect of eggs, the presence of dominant species was detected. The highest diversity index and frequency of occurrence of fish eggs and larvae were determined in spring, the reason for this being that the spawning period of many fish species in Izmir Bay begins at the end of spring. In the middle and outer bay, where the stations in this study were situated, the pollution in Izmir Bay was found generally not to influence the species diversity of fish eggs and larvae.

Key Words: Fish eggs and larvae, diversity, abundance and distribution, İzmir Bay

İzmir Körfezi İhtiyoplanktonu: Balık Yumurta ve Larvalarının Bir Yıllık İncelenmesi

Özet: Bu araştırma, İzmir Körfezi'nin 1989-1990 yılındaki kemikli balık yumurta ve larvalarının tür çeşitliliği, bolluğu, dağılımı ve bunlara rastlanma zamanlarının saptanması için yapılmıştır. Plankton örneklemelerinden toplam 32140 yumurta ve 6582 larva toplanmış olup 27 familyaya ait 69 tür tayin edilmiştir. Toplam yumurtanın % 23.79'u Sparidae, % 24.63'ü Clupeidae, % 12.22'si Mullidae, % 8.72'si Serranidae ve % 8.04'lük kısmını da Mugilidae familyası üyelerine ait yumurtalar oluşturmaktadır. Toplam larvanın % 67.38'i Gobiidae,% 9.43'ü Sparidae ve % 9.31'ini Blenniidae familyası üyelerine aittir. Bu araştırmada yumurtalar açısından bazı türlerin yumurta bırakmak için temiz suları tercih etmesi nedeniyle dış körfeze ait istasyonlar kendi aralarında benzerlik gösterirken, orta körfeze ait istasyonlar kendi aralarında farklı gruplar meydana getirmektedir. Larvalar açısından orta körfezdeki lagünel bölgeye yakın olan 2. istasyonun dışındaki diğer istasyonlar benzerlik göstermektedir.Bunun nedeni o bölgeye has Gobiidae familyasına ait türlerin bolluğudur. Düşük çeşitlilik indeksine sahip bölgelerde baskın türlerin varlığı saptanmıştır. En yüksek çeşitlilik indeksi ve balık yumurta ve larvalarının bulunma sıklığı ilkbaharda saptanmış olup bunun nedeni İzmir Körfezi'ndeki pek çok balık türünün üreme periyodunun ilkbahar sonu başlamasıdır. İzmir Körfezi'ndeki kirlenmenin, bu araştırmadaki istasyonları kapsayan orta ve dış körfezde, genelde balık yumurta ve larvalarının tür çeşitliliğini etkilemediği saptanmıştır.

Anahtar Sözcükler: Balık yumurta ve larvası, çeşitlilik, bolluk ve dağılım, İzmir Körfezi

Introduction

Izmir Bay is one of the largest bays on the western part of the Aegean Sea coast of Turkey. It is strongly affected by pollution due to the discharge of small rivers and the inflow of sewers. Izmir Bay is generally divided into 3 areas, which are the inner bay, middle bay and outer bay (Figure 1). Previous studies indicated that the inner bay was heavily polluted and eutrophication had started, that the middle bay was an area of transition under increasing threat, and that the outer bay was not significantly polluted (1,2). Later, with the support of the World Bank a waste water management project was implemented and, as one part of it has only just been put into action, it is hoped that when completed it will contribute to the cleaning up of the bay.

Izmir Bay is of great importance since it is preferred by many species of fish as a spawning ground for their eggs. In Izmir Bay so far, a number of studies have been conducted concerning fish eggs and larvae (3-9). In research carried out on the inner bay, fish eggs and larvae have been reported to be very poor with regard to quality and quantity because of pollution (10).

This study was realized by means of the determination of ichthyoplankton material investigated in Izmir Bay in 1989-1990. As the eggs and larvae in the inner bay were poor in quality and quantity, only stations situated in the middle and outer bay were investigated. The aim of this study was to determine the diversity, abundance and distribution of Teleost fish eggs and larvae in Izmir Bay and consequently to establish the spawning times of mature stock. In addition, it is believed that in the event of the bay having been cleaned in the years to come this study will constitute a valuable data basis for comparison with studies undertaken in the future.

Materials and Methods

Sampling was done over a one-year period at monthly intervals from 5 stations from January 1989 to January 1990. In this study, stations 1 and 2 were situated in the middle bay, which is a transition zone with respect to pollution, and stations 3, 4 and 5 were in the outer bay, which is a clean zone (Figure 1).

Ichthyoplankton samples were collected using a 57 cm mouth diameter and 500 μm mesh size. The sampling was carried out horizontally for 15 min at 2 mil/h. Each sample was fixed in a 4% formaldehyde solution. Prior to calculation, the abundance and distribution of all taxa was expressed as the number of eggs and larvae per 10 m^3.

At the stations, temperature, salinity, pH and dissolved oxygen values were determined over one year at monthly intervals and variance analysis (ANOVA) was performed to establish the statistical significance of the difference between the stations. The species frequency coefficients (% F) of the fish eggs and larvae determined seasonally in the taxonomic lists for the sampling period were calculated by using the formula F = (Na/ N) x 100, where *Na* is the number of samples containing species A and *N* is the total number of samples. The results obtained were examined in 4 groups, these being rarely found species (1-15%), relatively frequently found species (16-40%), commonly found species (41-60%) and very common species (61-100%).

In order to express the species diversity of the stations the Shannon-Wiener species diversity index was used (11). The formula was;

$$\text{species diversity: } H' = -\sum_{i=1}^{f} (P_i \ln P_i) \qquad P_i = N_i / N$$

where *H'* is the species diversity, *Pi* is the proportion of the *i* th species, *f* is the total number of species at the station, *N* is number of the *i* th species and *N* is the total number of specimens.

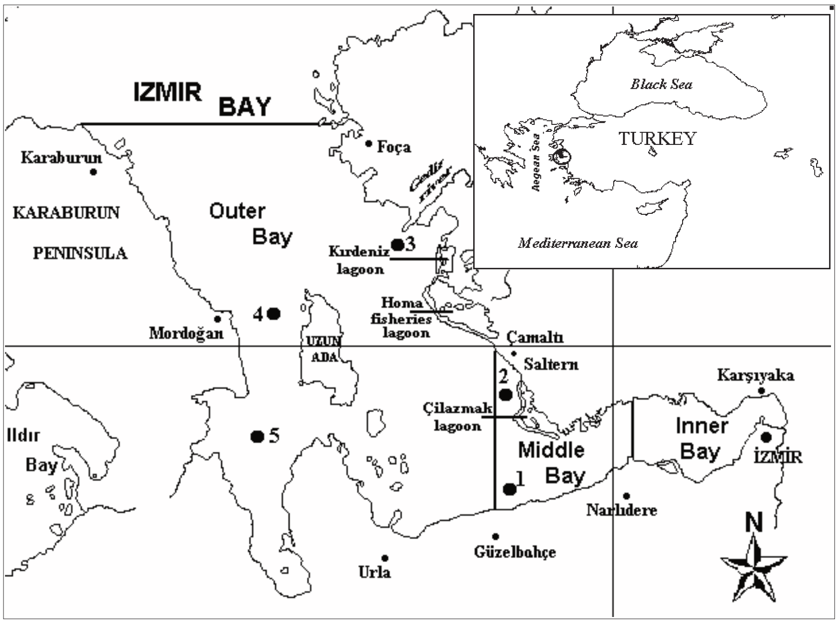

Figure 1. Sampling stations.

The Pielou evenness index used for the Shannon-Wiener diversity index was applied. The evenness rate varies between 0 and 1 and the nearer this value is to 0 the more abundant a species is shown to be (11,12). The evenness rate (J) was calculated for stations by the using the formula J= H' / $\log_2 S$ or H'/ H max, where H' is the largest value of H' (H'max= lnS) and S is the number of species in the sample.

Similarities and dissimilarities of the dispersal of species through stations over the annual period were measured using the Bray-Curtis similarity index (13) with the single linkage method and a distance matrix computed via the Biodiversity professional programmer. Non-parametric multidimensional scaling analysis (MDS) was applied in 5 stations using the Statistica 4.3 program.

Results

Hydrographical conditions

The mean annual surface water temperature was 18.75 ± 4.7ºC, the minimum being found to be 12.3ºC in January and the maximum was 24.3ºC in September (Figure 2a). No significant difference was found between the stations ($p>0.05$).

The mean annual salinity was 37.35 ± 0.82%, the minimum being 36.15% in December and the maximum 38.61% in August. During the study it was observed that salinity increased parallel to the increase in temperature and decreased due to rainfall in the winter (Figure 2b). No significant difference was found between the stations ($p>0.05$).

The mean annual pH value was found to be 7.93 ± 0.31, the minimum pH value being 7.2 in November and December and the maximum 8.25 in August (Figure 2c). No significant difference was found between the stations ($p>0.05$).

The mean annual dissolved oxygen value was 7.69 ± 0.61 mg.l^{-1}, and with increasing temperature from May onwards the oxygen level begin to fall, the minimum being found to be 6.8 mg.l^{-1} in August and the maximum was 8.6 mg.l^{-1} in March (Figure 2d). A significant difference was found between the stations ($p<0.05$).

Species diversity, abundance and distribution of fish eggs

As a result of monthly sampling carried out over the course of a year in the 1989 to 1990 period in Izmir Bay, a total of 32140 fish eggs were determined and

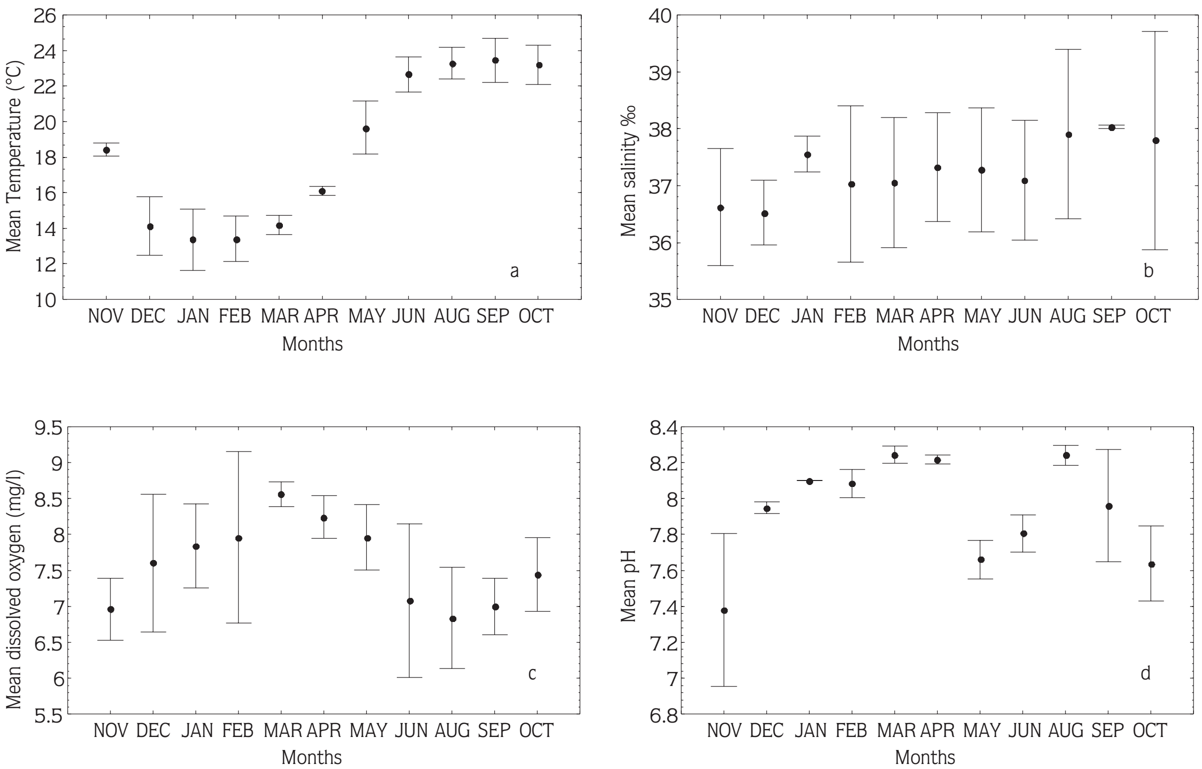

Figure 2. a: Mean temperature (ºC), b: salinity (‰), c: dissolved oxygen (mg.l^{-1}) and d: pH values of surface water during the sampling periods.

identified. Maximum abundance occurred in June and minimum abundance in January.

When variations in the species diversity index were examined, a distinct increase in species diversity was seen in the winter period in the southern areas of the bay (stations 1 and 5). The maximum diversity index value for this period was found to be 2.50 at station 1, situated in the transition zone, and the minimum value was 0.96 at station 2 (Table 1). This fall at station 2 was due to the occurrence of the species *Arnoglossus* sp. in an abundance of 25.81 number of eggs/10 m^3. It was found that the species diversity index values rose in the spring and that the highest value among all the periods was encountered at this time. In general, the highest diversity index value was found to be 3.20 at station 1 and the minimum value was 1.49 at station 4 (Table 1). This fall was due to the occurrence of the species *Diplodus annularis* L. in an abundance of 85.23 number of eggs/10 m^3. In the summer period the maximum diversity value was found to be 3.11 at station 1 and the minimum value was 1.33 at station 3 (Table 1). The reason for the fall at station 3 was the occurrence of the species *D. annularis* in an abundance of 44.86 number of eggs/10 m^3. While in this period there generally occurred a fall in index values at all stations, exactly the opposite was observed at station 4. In the autumn period it was seen that species diversity index values fell distinctly. The maximum value was found to be 2.21 at station 4 and the minimum was 0.33 at station 2 (Table 1). The reason for the fall at station 2 was the occurrence of the species *Sardinella aurita* V. in an abundance of 238.85 number of eggs/10 m^3.

On examining the overall species composition with respect to the fish eggs determined as a result of monthly sampling carried out in the study area during the 1989 to 1990 period, in both the spring and autumn period 27 species, in the summer period 26 species, and in the winter 14 species were found. Among these species it was seen that the species *Arnoglossus* sp. and *Buglossidium luteum* R. leave eggs all year round (Table 2). Regarding the seasonal frequency of the occurrence of fish eggs, in the winter period the number of very common species is 7 (61-100%) and of these the species *Sardina pilchardus* W., *Engraulis encrasicolus* L., *Arnoglossus* sp. and *Solea solea* L. are found with a 100% frequency rate. In the spring 14 species were very commonly found. Of these the species *S. pilchardus*, *E. encrasicolus*, *Serranus hepatus* L., *Serranus caprilla* L., *Mullus barbatus* L., *D. annularis*, *Callionymus festivus* L., *Arnoglossus* sp. and *B. luteum* were found with 100% frequency. In the summer period the number of very common species was 8 and the species *S. aurita*, *S. hepatus*, *D. annularis*, *Coris julis* L., *Mugil cephalus* L., *Liza saliens* R. and *Arnoglossus* sp. were those found with 100% frequency. In the autumn period the number of very common species fell to 4 and no species were found with 100% frequency (Table 2).

In the Bray-Curtis similarity index analysis carried out with regard to pelagic fish eggs throughout the sampling period stations 3, 4 and 5 were seen to form a group according to a 50% similarity rate (Figure 3). According to the MDS analysis results, stress was determined to be 0.025% and this finding supports the above grouping.

Regarding the distribution abundance of fish eggs in the research area, the families that appear most abundantly are Sparidae with 24.63%, Clupeidae 23.79%, Mullidae 12.22%, Serranidae 8.72% and Mugilidae 8.04%. *D. annularis* species represent 96.2% of the Sparidae family, *S. aurita* is 80.67% of the Clupeidae family, *M. barbatus* is 90.2% of the Mullidae family, and *Serranus scriba* L. is 44.8% of the Serranidae family (Figure 4). *D. annularis* was found abundantly at station 4, *S. aurita* at station 2, and *M. barbatus* and S.

Table 1. Seasonal species diversity (H´) and evenness rates (J) in fish eggs among the stations (S, number of species).

Stations	Winter			Spring			Summer			Autumn		
	S	H´	J	S	H´	J	S	H´	J	S	H´	J
1	10	2.50	0.75	20	3.20	0.74	15	3.11	0.80	11	1.12	0.32
2	6	0.96	0.37	19	2.02	0.48	16	2.98	0.74	16	0.33	0.08
3	11	1.71	0.49	15	2.76	0.70	10	1.33	0.4	5	1.44	0.62
4	9	1.77	0.56	21	1.49	0.34	19	2.28	0.54	13	2.21	0.60
5	9	2.03	0.64	14	2.25	0.59	16	1.81	0.45	8	1.59	0.53

Table 2. Pelagic fish eggs composition and abundance in Izmir Bay (Abundances expressed as eggs 10 m^{-3}; X, Mean abundance; STD, standard deviation;% F, percentage of occurrence).

Taxa of fish eggs	WINTER			SPRING			SUMMER			AUTUMN		
	X	STD	%F	X	STD	%F	X	STD	%F	X	STD	%F
Sardina pilchardus W.	5.95	7.99	100	2.07	2.76	100				4.31	6.46	80
Sardinella aurita V.							0.14	0.14	100	52.08	104.8	80
Engraulis encrasicolus L.				3.55	6.01	100	0.42	0.53	60	0.34	0.57	40
Gadus sp.	0.67	0.47	100	0.01	0.02	20				0.01	0.02	20
Serranus cabrilla L.				1.63	3.33	80		0.19	0.42	20		
Serranus hepatus L.				2.37	3.11	100	7.23	6.71	100	0.20	0.44	20
Serranus scriba L.				6.36	8.81	100	7.32	13.52	60			
Dicentrarchus labrax L.	0.09	0.09	80	0.04	0.09	20						
Trachurus trachurus L.				0.36	0.57	40	0.17	0.31	40	0.42	0.93	20
Trachurus mediterraneus L.				0.44	0.96	40	0.36	0.45	40			
Mullus barbatus L.				3.57	5.26	100	25.66	53.34	80	0.76	1.17	40
Mullus surmuletus L.				1.4	2.46	80	0.45	0.45	60	0.20	0.45	20
Mullus sp.				0.75	1.68	40	0.65	0.66	60			
Sparus aurata L.	0.42	0.42	60							0.20	0.29	60
Dentex gibbosus L.				0.03	0.05	40	0.10	0.14	40	0.03	0.04	40
Dentex sp.										2.01	4.46	40
Diplodus annularis L.				39.3	33.7	100	25.18	22.88	100			
Spicara maena L.										0.18	0.37	40
Spicara sp.							0.01	0.02	20			
Coris julis L.				1.57	1.48	100	1.11	1.67	100	0.04	0.04	60
Thallosoma pavo L.							0.01	0.02	20			
Trachinus vipera Cuv.	0.01	0.02	20	0.01	0.02	20				0.01	0.02	20
Trachinus draco L.							0.20	0.30	40			
Uranoscopus scaber L.							0.03	0.06	20	0.03	0.06	20
Scomber scombrus L.				0.02	0.04	20						
Scomber japonicus Hout.							0.11	0.25	20			
Scomber sp.				1.14	2.13	80	0.13	0.22	60	0.03	0.06	40
Sarda sarda Bloch							0.2	0.44	20			
Callionymus festivus L.				0.8	0.34	100	0.13	0.22	60	0.23	0.51	20
Callionymus sp.	1.13	1.46	80							0.01	0.02	20
Sphyraena sphyraena L.				0.01	0.02	20						
Mugil cephalus L.							9.13	7.06	100	1.02	0.92	80
Mugil sp.	0.02	0.04	20							0.14	0.18	60
Liza saliens R.				3.72	4.74	80	7.86	9.33	100			
Scorpaena sp.				0.04	0.04	40	0.05	0.09	40	0.08	0.17	20
Trigla sp1.	0.14	0.15	60							0.15	0.32	40
Trigla sp2.										0.60	1.33	20
Lepidotrigla sp.				0.08	0.13	40						
Arnoglossus sp.	5.16	2.36	100	5.8	3.36	100	2.33	2.00	100	0.72	0.69	80
Pleuronectes sp.	0.05	0.11	20	0.04	0.07	40				0.03	0.06	20
Solea solea L.	0.99	0.56	100	0.03	0.06	40						
Solea sp.	0.03	0.06	20							0.06	0.10	40
Pegusa lascaris R.	0.14	0.17	80									
Buglossidium luteum R.	0.22	0.43	40	0.62	0.62	100	0.04	0.04	60	0.01	0.02	20

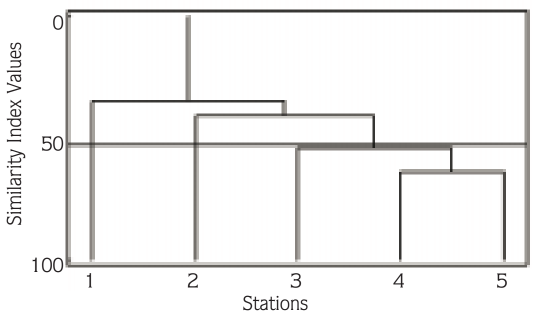

Figure 3. Dendrogram of the stations defined using the Bray-Curtis similarity index and Single Linkage method for fish eggs compositions.

scriba at station 5. Throughout the research period more eggs were found at stations 2 (450 number of eggs/10 m^3) and 5 (402 number of eggs/10 m^3).

Species diversity, abundance and distribution of larvae

As a result of monthly samples taken during the research period, 6542 larva specimens were determined and 43 species belonging to 19 families were identified. No larvae were found in November, December, January or February. For this reason, the species diversity index was calculated for the spring, summer and autumn periods. It can be seen from the species diversity index

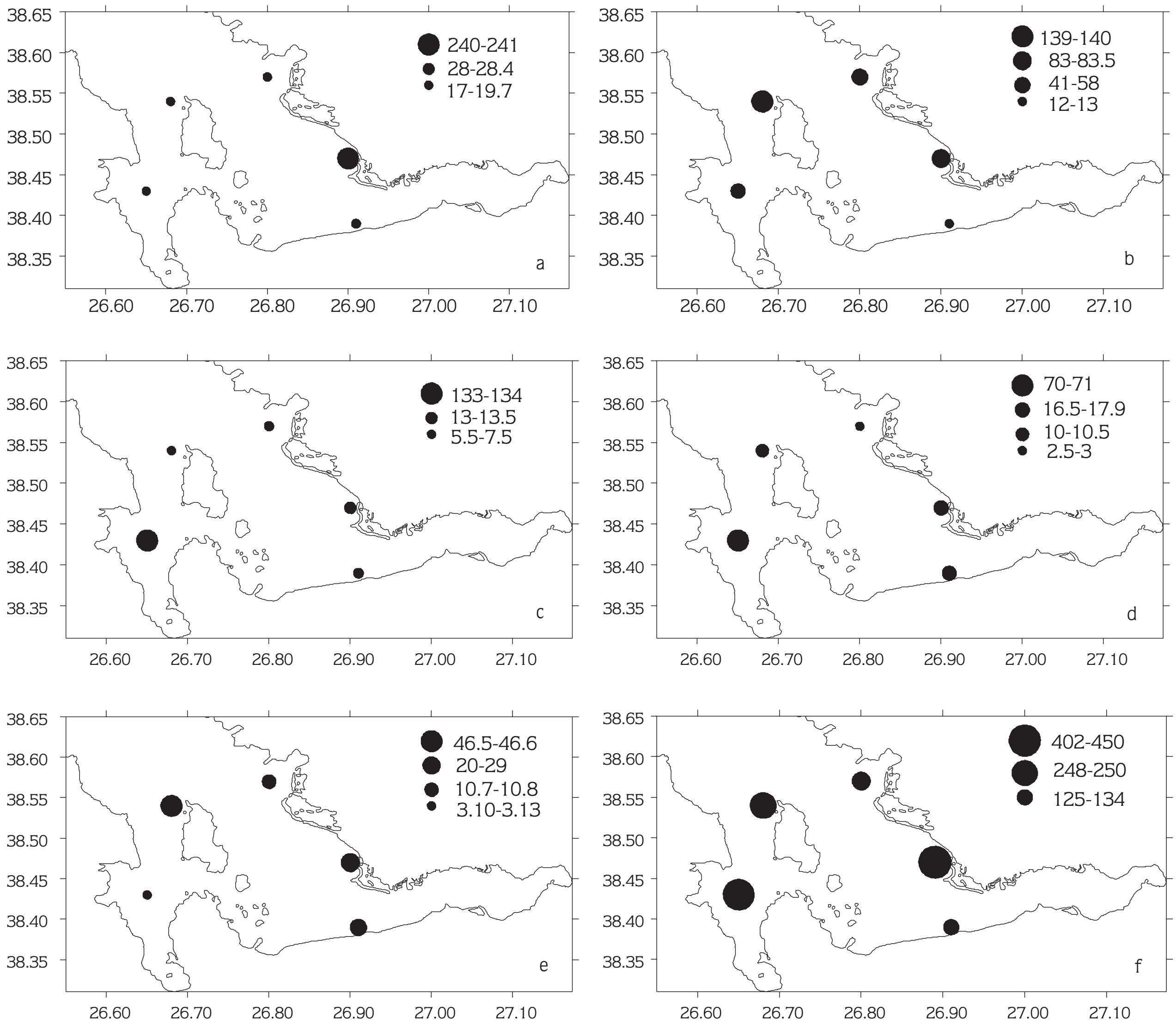

Figure 4. Abundance and distribution of Clupeidae (a), Sparidae (b), Mullidae (c),Serranidae (d), Mugilidae (e) and the total eggs (f) between stations (Number of eggs x 10 m^{-3}).

values for the spring period that the maximum value was found at stations 3 and 4 to be 3.10 and 3.09, respectively, and the minimum value at station 5 was 1.75. A distinct fall was observed in the species diversity index values at stations 3 and 4 in the summer period, the maximum value being found to be 2.71 at station 3 and the minimum value was 1.96 at station 5. In the autumn period the highest diversity index value was 3.29 at station 2; however, a distinct fall was seen at the other stations and the minimum value was found at station 4 to be 1.32 (Table 3).

Regarding the seasonal frequency of occurrence of fish larvae, in the spring period the number of very commonly found species was 8 and of these the species *D. annularis*, *Crenilabrus* sp., and *Parablennius gattorugine* B. were found with 100% frequency. In the summer period the number of very common species was 4 and of these only the species *E. encrasicholus* was found with 100% frequency. In the autumn the number of very common species was 2, but no species were found with 100% frequency. No larvae were found during the research done in the winter months (Table 4).

According to the Bray-Curtis similarity index analysis carried out with regard to pelagic fish larvae throughout the sampling period, it was seen that according to a 50% similarity rate stations 1, 3, 4 and 5 displayed some differences (Figure 5). According to the MDS analysis results, the stress factor was below 0.01% and supported these distinct groups.

Regarding the distribution abundance of fish larvae, Gobiidae made up 67.4%, Sparidae 9.43%, and Blennidae 9.31% of total larvae (Figure 6). The Gobiidae and Blennidae families were found most abundantly at station 2, the Sparidae family at station 5. In general, it is notable that station 2 was more abundant in larvae than the other areas.

Discussion

In this study, except for dissolved oxygen, no statistically significant difference was found between stations in water temperature, salinity and pH values ($p>0.05$). Although there is a difference in dissolved oxygen, in general the mean monthly oxygen level of the stations shows a fluctuation in accordance with temperature (Figure 2c.)

As a result of this study (1989-1990) in Izmir Bay the eggs and larvae of a total of 69 species belonging to 27 families were found, while this value was reported as being 43 to 46 species in sampling carried out between the years 1974 and 1979 by Mater (4,5). The observation of a great increase in species diversity compared with 15 years earlier is due to the fact that from a systematic viewpoint more detailed investigations were made. According to the report (14) on the “Izmir Bay research project” carried out between 1994 and 1997 the number of species determined was similar to our results. The wealth of species diversity demonstrates

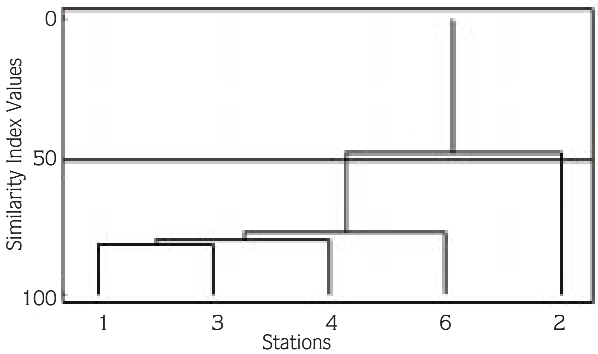

Figure 5. Dendrogram of the stations defined using the Bray-Curtis similarity index and Single Linkage method for fish larvae compositions.

Stations	S	H´	J	S	H´	J	S	H´	J
		Winter		Spring		Summer		Autumn	
1	11	2.12	0.61	8	2.37	0.79	6	1.94	0.75
2	19	2.38	0.56	11	2.47	0.71	11	3.29	0.95
3	14	3.10	0.81	10	2.71	0.82	7	2.13	0.76
4	14	3.09	0.82	6	2.36	0.91	6	1.32	0.51
5	11	1.75	0.51	5	1.96	0.85	3	1.53	0.97

Table 3. Seasonal species diversity (H´) and evenness rates (J) in fish larvae among the stations (S, number of species).

Table 4. Pelagic fish larvae composition and abundance in Izmir Bay (Abundances expressed as eggs 10 m^{-3}; X, Mean abundance; STD, standard deviation;% F, percentage of occurrence).

Taxa of fish larvae	SPRING			SUMMER			AUTUMN		
	X	STD	%F	X	STD	%F	X	STD	%F
Sardina pilchardus W.	0.03	0.06	20						
Sardinella aurita V.							2.28	3.79	80
Engraulis encrasicolus L.	0.54	1.19	40	1.68	2.1	100	0.29	0.3	60
Syngnathus acus L.							0.02	0.04	20
Hippocampus guttulatus L.							0.01	0.02	20
Cepola rubenscens L.							0.01	0.02	20
Trachurus trachurus L.				0.01	0.02	20			
Umbrina sp.				0.01	0.02	20			
Mullus barbatus L.				0.01	0.02	20			
Diplodus annularis L.	1.34	1.2	100						
Diplodus sargus L.	0.02	0.02	40	0.01	0.02	20			
Diplodus sp.	3.81	4.01	80						
Pagellus erythrinus L.	0.01	0.02	20				0.01	0.02	20
Pagellus bogaraveo L.							0.04	0.07	40
Pagrus pagrus L.				0.01	0.02	20	0.01	0.02	20
Crenilabrus melops L.	0.07	0.1	40	0.01	0.02	20			
Crenilabrus sp.	2.23	2.03	100						
Trachinus draco L.				0.01	0.02	20			
Scomber scombrus L.	0.01	0.02	20						
Scomber japonicus Hout.							0.02	0.02	40
Gobius niger L.	14.7	29.5	80	0.54	0.79	80	0.33	0.67	40
Gobius paganellus L.	0.63	0.97	60	0.69	1.08	80	0.41	0.81	80
Gobius sp.	0.49	0.85	60	0.23	0.44	60			
Pomatoschistus minutus L.	8.01	15.9	100	0.22	0.45	40	1.05	2.23	60
Aphia minuta L.	10	18.7	80	0.04	0.07	40	0.13	0.28	20
Callionymus sp.	0.03	0.06	20						
Aidablennius sphyx Val.	0.02	0.04	20						
Blennius ocellaris L.	0.08	0.06	80						
Blennius sp1.	0.14	0.3	20	0.14	0.21	40	0.02	0.04	20
Blennius sp2.	0.03	0.08	20						
Lipophyrs pavo L.	1.18	2.44	60	0.82	1.61	40			
Parablennius gattorugine B.	0.95	0.66	100	0.19	0.21	80	0.06	0.09	40
Parablennius tentacularis B.	1.18	2.61	40	0.34	0.33	60			
Parablennius sanguinolentus P.	0.16	0.18	60						
Sphyraena sphyraena L.							0.01	0.02	20
Mugil cephalus L.				0.02	0.04	20			
Mugil aurata R.							0.05	0.08	40
Liza saliens R.				0.01	0.02	20			
Atherina boyeri R.	0.04	0.05	60						
Arnoglossus laterna W.	0.01	0.02	20						
Arnoglossus sp.	0.01	0.02	20						
Pegusa lascaris R.	0.01	0.02	20						
Buglossidium luteum L.							0.01	0.02	20

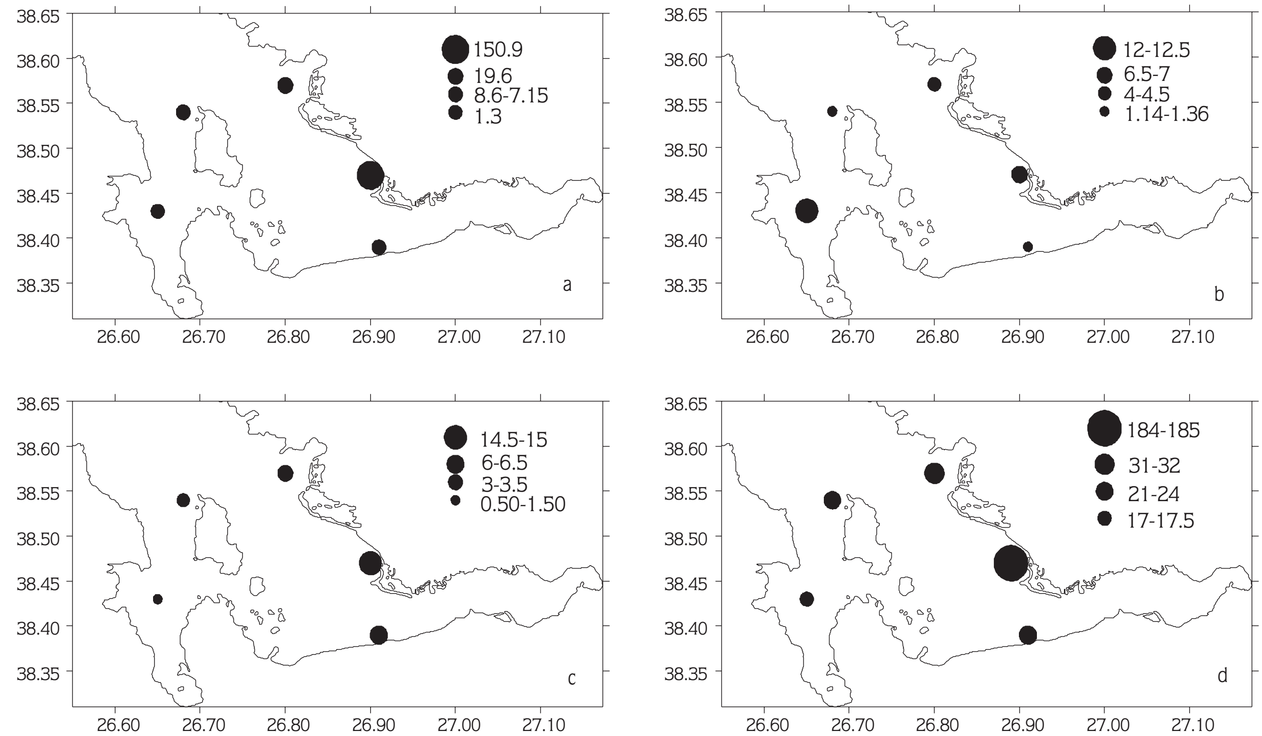

Figure 6. Abundance and distribution of Gobiidae (a), Sparidae (b), Blenniidae (c) and total larvae (d) between stations (Number of larvae x 10 m^{-3}).

that the middle and outer bay have not yet been affected by pollution.

Generally, when variations in the species diversity index are examined with regard to fish eggs, it is notable that at the stations with a low diversity index the evenness rates are low, that is, dominant species are present. For example, in the winter period at station 2 *Arnoglossus* sp., in the spring at station 4 *D. annularis*, and in the autumn at station 2 *S. aurita* are the dominant species. The highest diversity index value and occurrence frequencies of fish eggs were found in the spring, the reason for this being that in Izmir Bay the spawning period of many fish species begins at the end of spring (Tables 1,2). In respect of larvae, it is notable that in all periods the highest diversity values were seen at stations 2 and 3. The reason for this is that because these two stations are near to the lagoon areas, species of the Gobiidae and Blennidae families, whose eggs are demersal, prefer to spawn in these areas. Mature fish of the Gobiidae species spend their lives in estuary and lagoon areas and local currents resulted in the larvae of this species being carry to these areas (15).

According to similarity analyses carried out between stations with regard to eggs, the fact that there were similarities between the stations in the outer bay demonstrates that some species prefer clean areas entirely removed from the influence of the inner bay for spawning. However, the two stations in the middle bay are different from each other (Figure 3) and form separate groups, because station two is nearly in the lagoon area. In the MDS analysis done in order to demonstrate the difference between the stations, the fact that a stress factor was found to be 0.025% indicates that goodness of fit is "perfect" between variables. It means that there is a perfect monotone relationship between similarity and dissimilarity (16). In respect to larvae according to the similarity analyses between stations, all stations apart from station 2 form a group. The difference at station 2 was due to the abundance of species of the Gobiidae family specific to that area. In the MDS analysis done to demonstrate the difference between stations, the fact that a stress factor was found to be a value below 0.01% indicates that goodness of fit is perfect and the analysis results also support the grouping among stations.

Because most studies in Izmir Bay have been based mainly on the inner bay, where pollution is most intensive, and as a result of differences in methods, such as the stations being chosen from different areas, the hauls being vertical or horizontal, the irregularity of sampling period, or the analyses used by us not having been used before, it was not possible to compare this study sufficiently with other publications.

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