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The Ichthyoplankton of Izmir Bay (Central Aegean Sea of Turkey): 2008-2010 Years Study

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Abstract.- In this survey, we searched about the abundance, distribution and mortality rates of eggs and larvae belonging to the teleostei living in Izmir Bay between the years 2008 and 2010. For this purpose, we seasonally obtained the ichthyoplankton samples from 8 stations identified in the inner, middle and outer parts of the bay aboard the R.V.K. Piri Reis research vessel. We obtained 11612 eggs/m², 19 prelarvae/m², and 5277 larvae/m² throughout the survey and identified 24 species belonging to 17 families. The eggs and larvae of the species *Engraulis encrasicolus* (Linnaeus, 1758) were found to be dominant in station 2 (outer bay), in contrast eggs of Gadidae and larvae of Melucciidae, Myctophidae and Syngnathidae were found to be at least in Izmir Bay.

Keywords: Ichthyoplankton, *Engraulis encrasicolus*, Anchovy, Izmir Bay, Aegean Sea.

INTRODUCTION

Izmir Bay, which is one of the most significant fishing grounds in the Aegean, is located between 38” 20’ N - 38”40’N latitudes and 26”30’E – 27”10’E longitudes. Ege University Faculty of Fisheries and the Institute of Marine Science and Technology of Dokuz Eylul University have for years carried out a joint project for the determination of the biological diversity of Izmir Bay. As the pollution in the bay which came to the agenda in the 1960’s started to increase in the 1990’s, some measures were taken. Streams were improved, industrial activities were put under control, the treatment plant in the center of the bay was realized, and Ragippasa fishery believed to have hindered the flow of water to the bay was demolished in order to reduce the burdens of domestic and industrial pollution. The abundance and distribution of eggs and larvae, and the changes in species to a great extent reflect the quality of water of the environment (Fuiman and Werner, 2002). Therefore, samples of ichthyoplankton are also included in the monitoring of the bay.

The ichthyoplankton studies which were first started in the 18^{th} century by Cunningham (1889) in the world were initiated in Turkey by the studies of Arim (1957) especially in the Sea of Marmara and Black Sea. The first comprehensive study in Izmir Bay constituting the field of study was carried out by Mater (1977). He also studied the distributions and morphologies of some teleost fish habiting in Izmir Bay and searched the effects of the pollution on the eggs and larvae (Mater, 1981). Amongst the several other studies in Izmir Bay included those of Hossucu (1991) who studied the distribution, abundance, embrionic development of the eggs and larvae of Solenette (*Solea solea* L., 1758) and their possibilities of admission to the aquaculture. Hossucu and Mater (1995) studied the eggs and larvae of allis shad (*Sardinella aurita*, Valenciennes, 1847). Cihangir (1995) studied the spawning period of sardinella and the abundance and distribution of its eggs. Coker (1996) studied the distribution, abundance, morphology and bio-ecology of the species belonging to Blennidae family. Hossucu and Ak (2002) studied the distribution and abundance of the eggs and larvae of some teleost fish. Coker (2003) studied the morphology and ecology of pelagic egg and larvae of the teleost fish. Cakir *et al*. (2005) studied the ichthyoplankton composition of Izmir Inner Bay; and Taylan and Hossucu (2008) studied the abundance and distribution of the post-larvae of teleost fish in the bay. Consequently sufficient information is available on spawning periods and spawning grounds, embryonic and larval developments, mortality rates, state of pollution and fish populations of many fish species. Izmir Bay is an important spawning and nutrition ground for fish as it has water circulations formed by water currents and wind circulations and a high

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water circulation capacity. The ichthyoplankton studies in Izmir Bay have been gaining more importance as the bay constitutes a spawning ground for many species including the pelagic species which can migrate long distances, demersal fish species which live in deep waters but prefer more shallow waters to spawn or which live in coastal environments, and the species which migrate for short-term nutrition. For this purpose, we examined the eggs and larvae of teleost fish in Izmir Bay belonging to the period 2008-2010 and provided information about their abundance and distribution. We also made comparisons to the other studies made on similar subjects in the bay from past to present.

MATERIALS AND METHODS

Izmir Bay, the area of research, is a closed bay connected to the Aegean Sea which lies on the Anatolian coast. The bay, which is totally 666 km^2, is divided into three areas based on its physical properties: inner, middle and outer bay. Outer Bay, located between the Karaburun Peninsula and the Gediz Delta, is about 70 m in depth and at its end lies the more shallow Gulbahce Bay on the south. The Middle Bay, which is a passageway between the Inner and Outer Bay, extends from Yenikale Lighthouses and Urla to the northwest of Tuzla. With its 43-m average depth, the Middle Bay extends to Gulbahce Bay. The Inner Bay, which has relatively more contaminated waters, lies along the coasts of Izmir and its average depth is 7m. In our study, we identified 8 stations in the inner, middle and outer parts of the bay. The station 1 lies between Karaburun and Foca, station 2 lies around Uzunada, and station 3 and 4 lie in Gulbahce in the Outer Bay; station 5 and station 7 around Guzelbahce are in Middle Bay; and stations 6 and 8 lie in Inner Bay (Fig. 1). The coordinates of the mentioned stations are given in Table I.

The ichthyoplankton samples in this study where we examined the abundance and distribution of eggs and larvae of teleostei in Izmir Bay were seasonally collected by R.V.K. Piri Reis Research Vessel within the scope of the project for the determination of biological diversity in Izmir Bay (Project No: DBTE-098) between 2008-2010. In the study, the planktons were shot vertically with a UNESCO WP-2 model zooplankton net which has a 200 µm mesh-opening and is 57cm in diameter. The collected material was analyzed in 4% formalin solution. After the eggs and larvae were separated from the zooplankton material, their species were determined with a stereoscopic binocular with a 10x4 magnification rate. The abundance and distribution of eggs and larvae were determined as the amounts per square and were shown on the map using the Surfer 8 program.

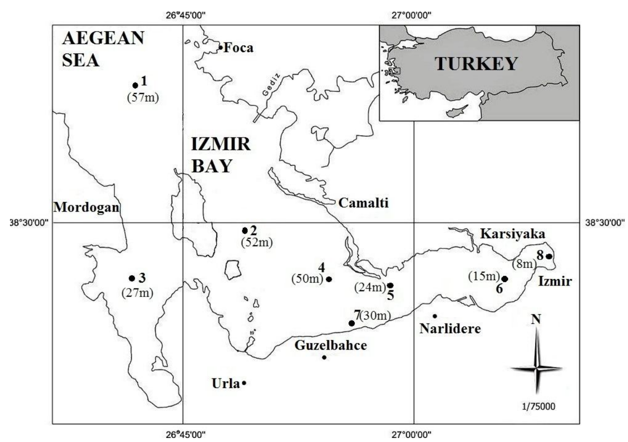

Fig. 1. The sampling stations in Izmir Bay and their depth.

Table I.- The coordinates of the sampling stations and their depth.

Station no.	Latitude	Longitude	Depth (m)
1	38º38'0.10''N	26º39'0.00''E	57
2	38º29'0.03''N	26º46'0.90''E	52
3	38º25'0.90''N	26º39'0.00''E	27
4	38º25'0.90''N	26º50'0.39''E	50
5	38º25'0.30''N	26º58'0.60''E	24
6	38º26'0.22''N	27º6'10.00''E	15
7	38º23'0.50''N	26º55'0.00''E	30
8	38º27'0.22''N	27º9'0.65''E	8

In order to examine similarities among the stations in terms of the types of species in the sampling period, "Hierarchical Cluster Analysis" was carried out using "Biodiversity Professional" program (Bray-Curtis, 1957).

RESULTS

In this study which was carried out between 2008-2010, we found totally 11612 eggs/m^2, 19 prelarvae/m^2, and 5277 larvae/m^2 belonging to teleostei. We identified 24 species belonging to 17 families in the end. The eggs and larvae of the seasonally identified species are given in Table II.

Regarding distribution of the sampled eggs per family, Engraulidae (89%) family is the dominant family and is followed by Clupeidae (8%), Labridae (1%) followed by other families which are less than 1% (Gadidae, Serranidae, Carangidae, Sparidae, Callionymidae, Mugilidae, Bothidae and Soleidae) (Fig. 2).

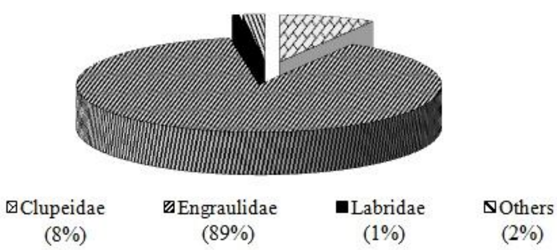

Fig. 2. Distribution (%) of the eggs determined in the sampling according to families.

The distributions of the first three families in the bay are like that: the *E. encrasicolus* species of Engraulidae family was found to be distributed in all stations, with the maximum distribution in the station 4 (4477 individuals/m^2), and the minimum distribution in the station 8 (65 individuals/m^2). While *S. pilchardus*, *Sardinella aurita and Sprattus sprattus* (Linnaeus, 1758) species of Clupeidae family are encountered in all the stations outside of the inner bay, they were found most in the station 2 (285 individuals/m^2) and least in station 5 (23 individuals/m^2). The only identified species of the Labridae family in the third row is *Coris julis* (Linnaeus, 1758). The eggs of this species were most encountered in the stations 4 and 7 (23 individuals/m^2) and least in the stations 1 and 3 (4 individuals/m^2) (Fig. 3).

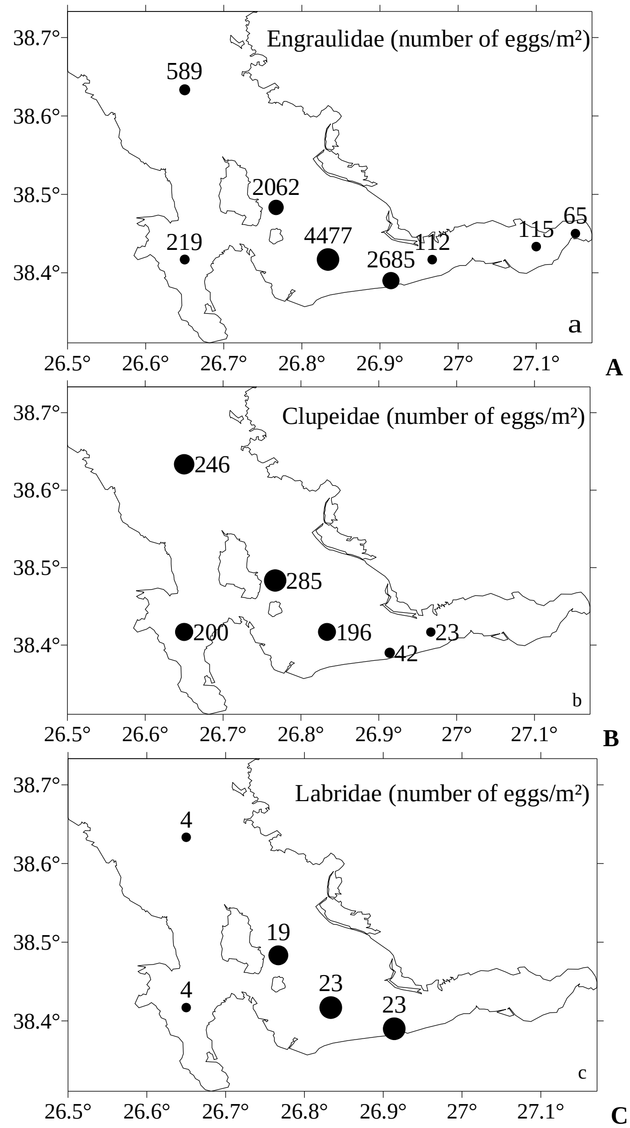

Fig. 3. The abundance and distribution of the eggs of Engraulidae (A), Clupeidae (B) and Labridae (C) according to stations (individuals/m^2)

Maximum species diversity was encountered in the station 2 (11 species) and it was followed by station 1 (9 species) and station 7 (7 species) respectively. Minimum species diversity was encountered in station 8 (1 species) (Fig. 4).

When the seasonal distribution of eggs is evaluated in terms of species diversity, we see that while rates of diversity (4 species) show similarities during the autumn and winter periods.

Table II.- Seasonal availability of the eggs and larvae determined between the years 2008-2010.

Species of fish eggs and larvae	Autumn		Winter		Spring		Summer	
	Egg	larvae	Egg	larvae	Egg	larvae	Egg	larvae
Sardina pilchardus	+	+	+	+	+	+	-	-
Sardinella aurita	-	-	-	-	-	-	+	-
Sprattus sprattus	-	-	-	-	+	-	-	-
Engraulis encrasicolus	+	-	-	-	+	-	+	+
Hygophum sp.	-	+	-	-	-	-	-	-
Hippocampus hippocampus	-	-	-	-	-	-	-	+
Merluccius merluccius	-	+	-	-	-	-	-	-
Trisopterus minutus capelanus	-	-	+	-	-	-	-	-
Serranus scriba	-	-	-	-	-	-	+	-
Cepola rubescens	-	-	-	-	-	-	-	+
Trachurus mediterraneus	-	-	-	-	-	-	+	-
Trachurus trachurus	-	-	-	+	-	-	-	+
Diplodus annularis	-	-	-	-	+	+	-	+
Sparus aurata	+	-	-	+	-	-	-	-
Coris julis	-	-	-	-	+	-	+	-
Gobius niger	-	+	-	-	-	+	-	+
Gobius paganellus	-	+	-	+	-	+	-	+
Callionymus lyra	-	-	-	+	-	-	-	-
Callionymus festivus	-	-	+	-	+	-	+	+
Lipophrys pavo	-	-	-	-	-	-	-	+
Liza saliens	-	+	-	-	-	-	+	+
Arnoglossus laterna	-	+	-	+	-	+	-	+
Arnoglossus sp.	-	-	+	-	-	+	+	+
Buglossidium luteum	-	+	-	-	+	-	+	+

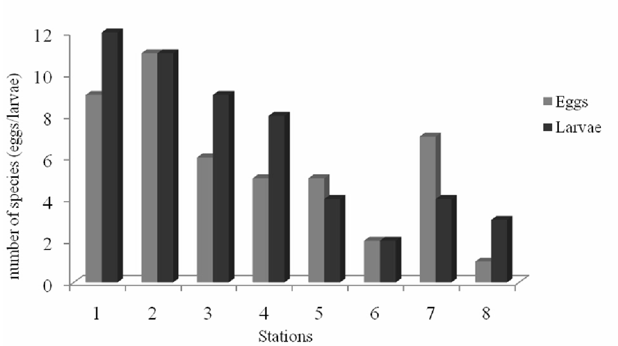

Fig. 4. Number of species determined eggs and larvae according to the stations

Results of Bray-Curtis analysis, winter and autumn seasons were found similar by species richness (66.67%). The rates gradually rise during spring and summer periods in parallel with the increase in temperatures. 7 species were identified in spring, and 9 species in summer. By the Bray-Curtis analysis spring and summer were found similar (66.67%).

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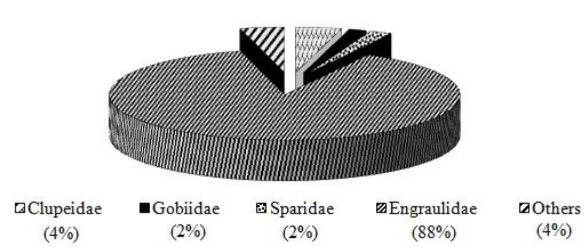

Fig. 5: Distribution (%) of the larvae determined in the sampling according to families.

When the larvae were evaluated, the family Engraulidae was the dominant family (88%) just like in the eggs, and was followed by Clupeidae (4%), Gobiidae (2%), Sparidae (2%) family and other families which were found less than 1% (Myctophidae, Syngnathidae, Merlucciidae, Cepolidae, Carangidae, Callionymidae, Blenniidae, Mugilidae, Bothidae and Soleidae) (Fig. 5).

When the abundance and distribution of the larvae were examined according to stations, the abundance and distribution of the first two families in the bay showed similarities to the eggs. The larvae of *E. encrasicolus* was encountered most in station 4 (2146 individuals/m^2), and least in station 6 (4 individuals/m^2); and the larva of *S. pilchardus* identified in the Clupeidae family were encountered most in station 1 (115 individuals/m^2), and least in stations 5 and 7. Unlike the eggs, two species, *Gobius niger* (Linnaeus, 1758) and *Gobius paganellus* (Linnaeus, 1758) of the family Gobiidae in the third row were identified and their larvae were encountered most in station 2 (31 individuals/m^2) and least in station 3 (4 individuals/m^2). The larvae of the two species, *Diplodus annularis* (Linnaeus, 1758) and *Sparus aurata* (Linnaeus, 1758), of the family Sparidae were only encountered in the Outer Bay and were found most in station 2 (62 individuals/m^2) and least in station 3 (4 individuals/m^2) (Fig. 6).

When the species diversity of the larvae according to the stations was examined, maximum species were in station 1 (12 species) and it was followed by station 2 (11 species), station 3 (9 species) and station 4 (8 species), respectively. The minimum species diversity was in station 6 (2 species) (Fig. 4).

When the seasonal distribution of the larvae was examined, it was found that the species diversity reached the highest level in the summer (13 species). Minimum species diversity (6 species) was seen in the winter period. Results of Bray-Curtis Analysis, autumn and summer seasons were found similar by species richness (73.91%). By the Bray-Curtis analysis autumn and winter were found similar (68.97%).

19 individuals/m^2 prelarvae belonging to the *S. pilchardus* species were identified during the study. 277 individuals/m^2 dead eggs were identified due to a damage which occurred during the shootings or a damage arising from fixation.

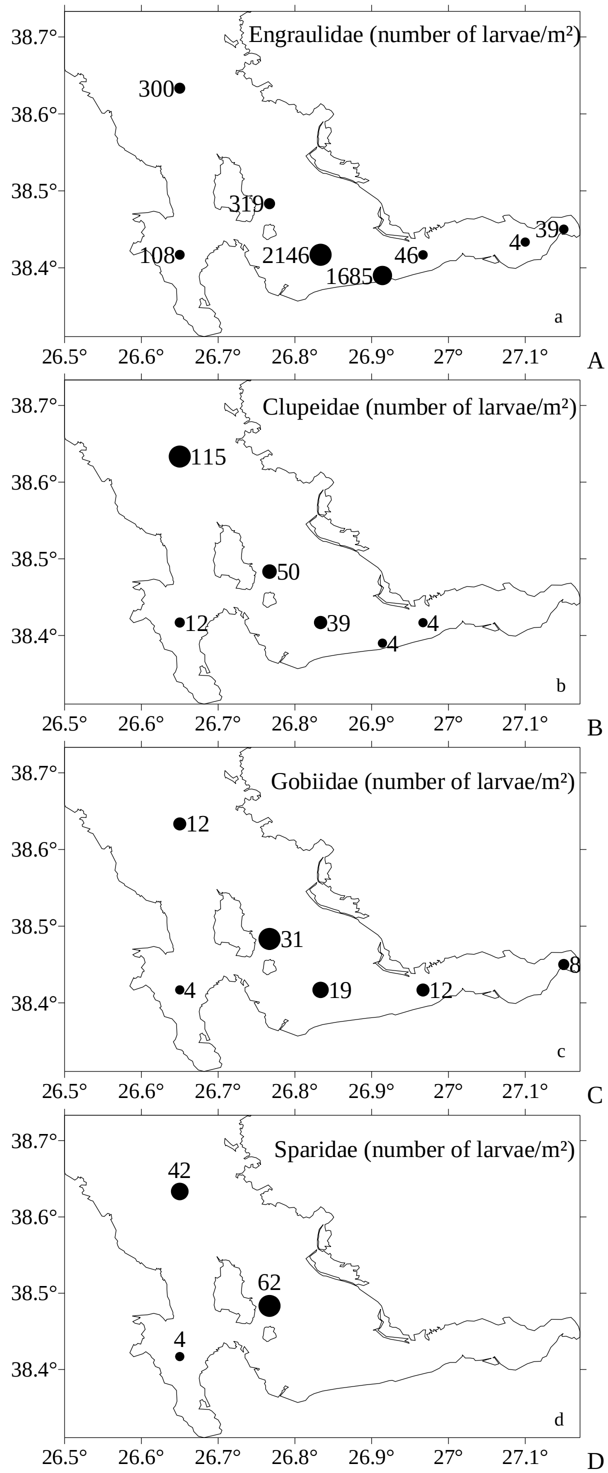

Fig. 6. The abundance and distribution of the larvae of Engraulidae (A), Clupeidae (B), Gobiidae (C) and Sparidae (D) according to stations (individuals/m^2)

According to do similarity results by the stations, two groups were formed. Stations 5, 6 and 8 formed the first group and stations 1,2,3,4, and 7 formed the second. Station 5 of the first group, and station 3 of the second group were found to be differed slightly from the other stations (Fig. 7).

The eggs and larvae in the study were found to be in maximum density in the Outer Bay (11980 individuals/m^2). It was followed by the Middle Bay (4680 individuals/m^2) and the Inner Bay (248 individuals/m^2), respectively.

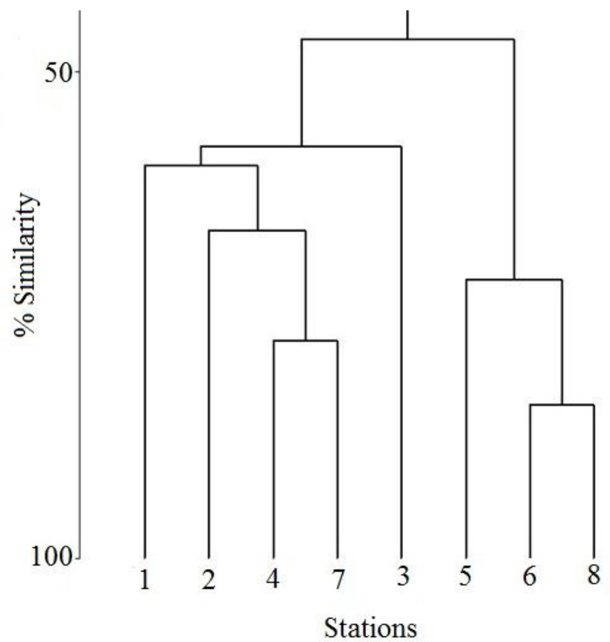

Fig. 7. The similarity of eggs and larvae obtained during the sampling period according to stations (Bray-Curtis).

DISCUSSION

In this study identified 24 species belonging to 17 families, and when we examined the eggs and larvae of the fish species, we determined 11612 eggs/m^2, 19 prelarvae/m^2, and 5277 larvae/m^2 in total. The family Engraulidae was found to be the dominant (89%) family in terms of both eggs and larvae in the bay and was followed by the family Clupeidae (7%). This indicates that especially pelagic species are dominant in the bay. When we examined the 8 stations selected from the inner, middle and outer parts of the bay, the Outer Bay was seen to be dominant in terms of species diversity, the main reason of which is thought to be the water body of the Aegean Sea flowing into the bay in high rates between Foca and Karaburun (Sayın, 2003). In the second row in terms of species diversity came the middle bay. This part of the bay constitutes a transition zone between the outer bay whose waters are relatively cleaner and the inner bay the waters of which are more polluted. The poorest area in terms of eggs and larvae (189 eggs/m^2 of two species, 58 larvae/m^2 of 4 species) was the inner bay because of the presence of polluted waters of domestic and industrial origin, the lack of currents and the low level of oxygen (Sayın, 2003). Moreover, the pollution in the bay was shown to cause deformation in the species *Liza ramada* (Bayhan *et al.*, 2010).

When we analyzed the seasonal distribution of the species, we observed an increase in species diversity in the spring and summer periods as the waters start to warm compared to the autumn and winter periods. This result proves that the spawning periods of many fish species in the bay are in spring and summer (Mater, 1981).

According to the results of the Hierarchical Cluster Analysis used in the evaluation of similarity among the stations in terms of species diversity, 2 groups occurred in terms of species diversity. The first group was formed by stations 5, 6, and 8, and the second group by stations 1, 2, 3, 4 and 7. However, station 5 in the first group was found to different from the other groups in itself. This is probably because of fact that it constitutes a transition zone between the Outer Bay whose waters are clean and the Inner Bay whose waters are relatively more polluted. The station 3 of the second group was found to be different from the others in itself. This may be because the station 3 is situated in Gulbahce bay, making it more protected against the winds and currents.

The first detailed study about the eggs and larvae of teleost fish of Izmir Bay was carried out by Mater (1981). The researcher evaluated the material he obtained by taking horizontal shots from the 10 stations between the periods 1974 – 1977, and found eggs and larvae belonging to 61 species in the bay. To author, mostly found the eggs of the species *E.*

encrasicolus and the larva of the species *G. niger* in the port (the station 8 in our study) where the amount of dissolved oxygen varied due to pollution. The same researcher indicated in his study that the eggs of the species *E. encrasicolus* were pollution-tolerant and the species *G. niger* was a pollution indicator, so these results support our study. In our study, the eggs of the anchovy were found more than the larvae of the species in the bay. The reason that the larvae were found less than the eggs is thought to stem from the fact that while the eggs of the anchovy are more pollution-tolerant, the high mortality rates due to pollution restrict the number of the larvae.

Hossucu and Ak (2002) examined the distribution and abundance of the eggs and larvae of the teleost fish in the bay, and identified 69 species of 27 families as a result of their horizontal samplings from 5 stations. The species the researcher identified from the areas of study of Uzunada, Gulbahce and Guzelbahce are in parallel with our study. Coker (2003) determined 113 species belonging to 42 families by vertical shootings in 28 stations in his study in Izmir Bay between the years 1994 – 1997. He stated that the family Engraulidae was dominant in the bay, followed by the family Clupeidae. Maximum species diversity was observed in summer in the Outer Bay. Cakir *et al*. (2005) examined the ichthyoplankton composition of Izmir Inner Bay, took shots of planktons in the three stations vertically in 15-day periods and as a result determined 10 species of 8 families in total. By the Cakir *et al*. (2005), the families Engraulidae, Gobiidae and Callionymidae had high numbers of eggs and larvae and that the species *E. encrasicolus* was the dominant species. In our study, we determined 5 species belonging to 4 families. We identified the families Gobiidae, Callionymidae, Blenniidae and especially the family Engraulidae in the Inner Bay. Taylan and Hossucu (2008) determined 22 species of totally 12 families in their study where they analyzed the abundance and distribution of the postlarvae of the teleost fish of Izmir Bay. They took horizontal shots from the 8 stations in the bay, and found maximum species diversity in the outer bay, especially in the spring and summer periods. When the obtained postlarvae were analyzed, the family Engraulidae was found to be dominant. The species determined in these studies carried out in Izmir Bay during the previous years matches the results of our study.

As a result, in the study performed within the scope of the project carried out jointly by the Institute of Marine Science and Technology of Dokuz Eylul University and Ege University Faculty of Fisheries, we found less species than in the other studies. While the vertical and seasonal sampling in our study is not in parallel with the other studies, the other studies differ among themselves. Thus, species diversity show fluctuations in our study just like in the other studies. In conclusion, it is of great importance for the ichthyoplankton samplings to be carried out in parallel with the other studies to monitor the diversity and abundance of species.

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