



Ichthyoplankton of Inner Part of Izmir Bay, Aegean Sea (2000-2005)

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Abstract

Inner Bay of Izmir was an important "point of pollution" in terms of domestic and industrial pollution of Mediterranean region at the end of 1990s. From the beginning of 2000s, however, positive effects on all of the groups of living organisms in the marine ecosystem has begun to be seen as a consequence of avoidance of the pollutants. As a result of evaluation on seasonal surface plankton samplings between 2000 and 2005, present study related to the species abundance, distribution evaluated with the abiotic environmental variables such as temperature, salinity and dissolved oxygen. Spawning situation has been demonstrated and compared with the previous studies in the Inner Izmir Bay fishes. During the study period, a total of 8727 eggs and 273 larvae were examined. 7 species of eggs and 13 species of larvae were determined. Availability rate of the species tended to increase from the spring to the summer seasons. The dominant species in the Inner Bay is *Engraulis encrasicolus* (Linnaeus, 1758), being responsible for 98% the eggs and 51% of the larvae. 6.59% of the obtained eggs, however, were found be dead. Being one of the other small pelagic species, *Sardina pilchardus* (Walbaum, 1792) continues to lay eggs at very low levels. *Parablennius gattorugine* (Linnaeus, 1758) larvae (12%), *Gobius niger* Linnaeus, 1758 (11%), and *Salaria pavo* (Risso, 1810) (9%) are other important species in the region. At the lowest level of dissolved oxygen *E. encrasicolus*, *Callionymus pusillus* Delaroche, 1809, *Buglossidium luteum* (Risso, 1810) eggs and larvae of *G. niger*, *Blennius ocellaris* Linnaeus, 1758, *Parablennius tentacularis* (Brünnich, 1768) 1.68 mg/L were found. The fact that Blenniidae larvae were detected again at high level in the Inner Bay was found to be related to increased rate of light transparency. Part of the Inner Bay of Izmir that is richest in eggs-larvae is south of the middle part (offshore of Çakalburnu Lagoon) and the part that is richest in larvae is Yenikale Lighthouse located on outer part of the Bay. The weak currents which start from Yenikale Lighthouse doesn't much effect to eggs and larval drift.

Keywords: Izmir Inner Bay, eggs, larvae, ichthyoplankton, fish larval diversity.

Introduction

Izmir Bay became a receiver area for domestic and industrial wastes due to unplanned growth and industrialization following rapidly increasing population at the end of 1960s and is now one of the most polluted areas of the Mediterranean region. For this reason, monitoring the effects of pollution in the Inner part of Izmir Bay has come into prominence in scientific studies since the 1970s (Anonymous, 2002; 2004a). These studies reported that pollutants in the Inner Bay originated from hydrocarbons, metals and pathogenic organisms from domestic and industrial waters (50%), with other sources including grainfall (15%), brooks and streams (10%), agricultural (10%) and marine transportation activities (4%), and others (11%) Uslu, Cihangir, Saner and Sayın (1999).

The condition of the ecosystem of Inner Bay

over the last 30 years may be classified into three stages as (1) beginning of pollution; Geldiay (1979) reported on the pollution levels of Inner Bay at the end of the 1970s by dividing the area in 5 different zones based upon benthic organisms (2) most polluted periods. In studies conducted between 1994 and 1998, pollution in Inner Bay was found to be at 'excessive levels' and to the point of threatening the Middle part of Izmir Bay Uslu *et al.* (1999), Cihangir *et al.* (2001) and (3) period during which sources of pollution ended.

Pollutants were contained to a large extent after the opening of the "Great Channel Project, Waste Water Treatment Plant" by the Izmir Metropolitan Municipality in 2000, and two important transitional periods for water quality and habitat have since occurred. Küçüksezgin, Konaş, Altay, Uluturhan and Darılmaz (2004) noted that eutrophication in the Inner

Bay decreased to a large extent and physical light transparency increased by 20%. Positive changes were also observed in water quality Anonymous (2002) as well as benthos and pelagos with return clean water species (Anonymous, 2003; 2004a).

Species composition, qualitative and quantitative levels and mortality rates of organisms varied during these periods. From 2001, a positive effects began to be observed in several groups of organisms (i.e. phytoplankton, zooplankton, macrobenthos, and fish) as a consequence of avoidance of pollutants, although several studies reported that most species were still predominant in the environment Çolak and Koray (2001), Sever and Mavili (2002), Aker and Özel (2006).

Eggs and larvae move passively in the direction of stream flow and some of them are considered to be pollution indicators (Özel, 1992), including ichthyoplankton. Additionally, the number of eggs and larvae especially of pelagic species such as sardine and anchovy are good indicators of population size (Fuiman and Werner, 2002).

In the Inner Bay of Izmir, ichthyoplankton studies have been carried out involving the evaluation of horizontal samples (Mater, 1979; 1981), (Alper, 1980), (Çoker, 1996). To update existing data, in the present study horizontal samples of ichthyoplankton were evaluated seasonally from 2000 to 2005 with special emphasis on abundance, distribution, ratio of living/dead eggs, percentage of egg/larvae as well as species' oxygen and temperature tolerance. The current findings will provide an insight of situation of fish eggs and larvae in the pelagic region of Inner Bay during the 'recovery period'.

Materials and Methods

Inner Bay subsection is surrounded by the residential, industrial areas, fishing shelters, marina, ship yard of Izmir, which is the third largest city in Turkey, and different industrial factory defined as the

eastern part of Ragıp Pasa Lagoon and Yeni Kale Cape (from north to south shore) line (Anonymous, 2011). It has a 58.9 km² surface area and 562,93 million m³ volume (Anonymous, 2015a). Mean depth is around 7.2 m. This subsection is heavily polluted by anthropogenic land-based pollutant and it is defined as Izmir Bay Inner Water (IBIW) (Sayın, Pazi, & Eronat, 2006). The water exchange between the Inner Bay and Middle Bay is restricted due to the weak currents in the Inner Bay (Beşiktepe, Sayın, İlhan, & Tokat, 2011). Inner Bay currents has been showing as an estuary characteristic. The more dense water flow from bottom to Inner Bay and less dense water goes out from the surface layer. The surface currents speed as 5-7 cm/s depending on the wind forces (Anonymous, 2011).

Sampling studies were performed on five stations located on the inner (Station 1:), middle (Stations 2, 3, and 4) and outer (Station 5) shore parts of Inner Bay with R/V K. Piri Reis between 2000 and 2005 (Figure 1). Table 1 summarized about station names, depths, coordinates of stations, bottom structure and flow characteristics at the area. Sampling was performed horizontally from the surface for 10 minutes at a speed of 3 knots with a WP-2 type plankton net (57 cm diameter, 250 µm mesh size). Sampling duration included different seasonal periods in 2000 (January), 2001 (January, April, August, December), 2002 (August), 2004 (March, August, November), and 2005 (April and February). Notably, no sampling was made in the months of June, September and October. Because of the other combined works (fisheries, and oceanographic studies) had to be carried out at the same time.

Ichthyoplankton was stored in 4% buffered formaldehyde solution, with sorting and detection procedures and measurement was performed and under a (4*10X) stereoscopic microscope (SZ-60 type). Stages for eggs in global shape were determined based on Smith and Richardson (1977)

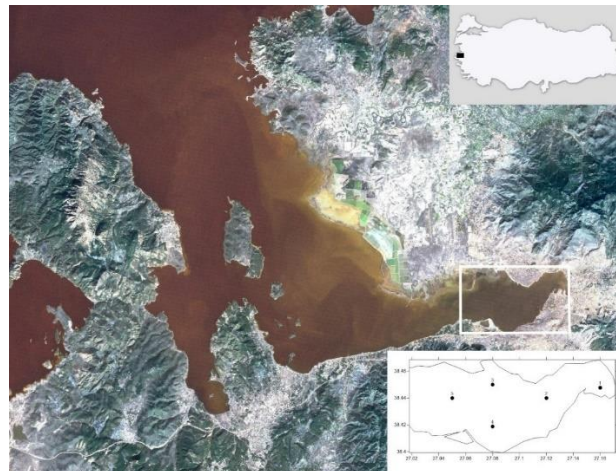


Figure 1. Location of Sampling Stations in the Inner Bay of Izmir.

Table 1. Station names, depths, coordinates of stations, bottom structure and flow characteristics of Inner Bay in 2000-2005.

Sections of the Inner Bay	Stations	Sampling site	Depth (m)	Coordinates	Bottom Structure	Currents
Inner Section	Station 1	Harbor	8	380 27' 20'' N, 270 08' 51'' E	Sediment (mud) color is brown, less smell, more shell in 6-meter water depth Sediment (mud) color is black, bad smell (due to the H ₂ S), less shell in 8-9 meters (Anonymous, 2004)	Almost no current inside of the harbor. (Mater,1981)
Middle Section	Station 2	(Between Karşıyaka-Konak)	15	380 25' 88'' N, 270 06' 95'' E		
	Station 3	Ragıpapaşa Lagoon	17	380 24' 67'' N, 270 06' 03'' E		
	Station 4	Çakalburnu Lagoon	16	380 26' 01'' N, 270 06' 11'' E	Sediment (mud), unsmell, with (Anonymous, 2004)	
Outer Section	Station 5	Yenikale Lighthouse	10	380 25' 38'' N, 270 02' 80'' E		The currents at 10 m water depth flows toward to the inside of the bay through the Yenikale front than goes out from the northern (Tuzla) coast (Besiktepe <i>et al.</i> 2011).

and for anchovy eggs after (Ahlstrom & Moser, 1980). Species identification was after (Padoa, 1956), (Russell, 1976), (Dekhnik, 1973), Mater (1981). Species systematic was after (Bilecenoglu, Kaya, Cihangir and Çiçek, 2014). The number of ichthyoplankton individuals per 100 m³ was calculated as follows (Postel, Fock, & Hagen, 2000): $V = t * v * M$ (m³/individuals = hour * mph * m²) where V = sampling volume, t = sampling time, v = sampling velocity, and M = surface area of mesh opening ($=\pi.r^2$).

Abundance of the detected species was estimated as:

$$\text{Abundance} = N/V \text{ (individuals/m}^3\text{)}$$

where N = number of samples from each station. The estimated result was then multiplied by 100 and expressed as number of individuals per 100 m³.

Physicochemical measurements were performed with SBE 911 plus CTD. pH was not recorded due to pH probe unfunctioning.

To evaluate the relationship between number of fish eggs and larvae with temperature, salinity, oxygen and transparency, Principal Component Analysis (PCA) was used and implemented in Statistica v10 Rabbania *et al.* (2013).

Results

Minimum and maximum temperatures in the Bay were between 9.7°C (January) and 26.6°C (August). Changes in salinity values by month and across stations were minimal. The lowest salinity was measured as 38.37 ‰ and the highest as 39.44 ‰. Mean oxygen levels were usually found to be lower in Yenikale Lighthouse, whereas the lowest oxygen

level was measured as 2.7 mg/l and the highest as 7.3 mg/l (Table 2).

(Table 3) summarizes species diversity by eggs and larvae, percentages of the eggs and larvae, rate of availability of the species and families by the stations, and species diversity by the stations.

Eggs (98%) and larvae (51%) of the Engraulidae family were most frequently represented ones in the inner bay. Larvae of the families Blenniidae (28%), Gobiidae (14%), and Callionymidae (5%) were found at substantial levels in the inner bay. Other species, all representing the remaining 2% of the eggs. In regard to larval distribution, *P.gattorugine* (12%) ranked number two. Other species showing significant distribution were *G. niger* (11%) and *S. pavo* (9%).

Of the individuals investigated at all stations, 98% was egg and 2% was larvae. 86% of all eggs and 78% of all larvae in the Inner Bay were from the Station 4 (Figure 2).

Spawning increased from spring to summer in autumn and winter, larval presence incidence was low (3%) and eggs remained below the incidence of 1% (Figure 3)

The months in which the vitality rate was the highest were July 2000, November 2000 (100%), August 2004 (76.2%), November 2004 (50%), April 2005 (39.8%), and April 2001 (39.1%). The months in which the mortality rate of the eggs were January 2001, May 2000, and December 2001 (Figure 4).

Overall, in Inner Bay 59% of anchovy eggs and 53% of *C. pusillus* were found dead. Whereas, all eggs from *Arnoglossus* spp. were alive at Stations 2, 3 and 5, and 67% of *S. pilchardus* and all eggs of *Solea* spp. were alive at Station 5. Of *C. pusillus* eggs, 30% were alive at Station 2, all of them at Station 4, and

Table 2. Temperature (a), salinity (b) and dissolved oxygen (c) values in the Stations 2 and 5 in 2000 – 2005

	WINTER			SPRING			
	DECEMBER 2001	JANUARY 2001	FEBRUARY 2005	MARCH 2004	APRIL 2001	APRIL 2005	MAY 2000
TEMPERATURE (°C)							
(S.5)	9.74	15.14	12.27	13.42	16.18	15.87	19.11
(S.2)	13.35	15.57	12.08	13.29	16.10	14.16	19.89
SALINITY(0‰)							
(S.5)	39.43	38.58	38.97	38.91	38.76	38.73	38.66
(S.2)	39.15	38.83	39.01	38.99	38.93	38.90	38.61
OXYGEN (mg/L)							
(S.5)	3.79	4.5	4.96	7.54	3.68	4.66	7.32
(S.2)	8.61	6.81	5.29	9.28	3.65	1.68	7.44
TRANSPARENCY (%)							
(S.5)		79.44	78.92	78.97		78.92	72.66
(S.2)			81.48	80.78		79.00	66.77
		SUMMER			AUTUMN		
	AUGUST	AUGUST	AUGUST	NOVEMBER	NOVEMBER		
	2001	2002	2004	2000	2004		
TEMPERATURE (°C)							
(S.5)	26.34	26.65	25.55	18.08		20.25	
(S.2)	-	26.63	25.68	17.62		20.25	
SALINITY (0‰)							
(S.5)	39.43	39.40	38.23	38.81		39.31	
(S.2)	-	39.32	39.44	38.37		39.31	
OXYGEN (mg/L)							
(S.5)	3.79	2.9	2.78	4.13		3.99	
(S.2)	-	5.67	3.45	3.21		4.73	
TRANSPARENCY (%)							
(S.5)		62.28	70.27			79.28	
(S.2)		62.17	73.57			82.03	

63% at Station 5. At Station 1, only eggs of *E. encrasicolus* (vitality rate: 86%) were found. The mortality rate of anchovy eggs was high at all stations from the shore to the west (50–88%). Dead eggs were predominant at Station 2 (Karsiyaka –Konak: 88%) and 5 (Yenikale Lighthouse: 74%) (Figure 5).

Abundance and distribution maps of the species with the highest number of individuals in the Inner Bay were prepared. During all seasons, the highest numbers of larvae were observed at the Stations 2, 4, and 5; and the highest number of the eggs were observed in the Stations 4, 2, and 3. Diversity of both eggs and larvae was observed in an east-to-west direction towards the outlet of Inner Bay, and it was low in the harbor and at the station located offshore of Çakalburnu Lagoon (Figure 6).

In regard to the distribution of eggs and tolerance to dissolved oxygen, minimal and maximal levels were 1.68 - 9.28 mg/l, and 1.68 - 4.73 mg/l, respectively. At the lowest level of dissolved oxygen, larvae of *E. encrasicolus*, *C. pusillus*, *B. luteum* and *G. niger*, *B. ocellaris*, *P. tentacularis* were found. Larvae of *S. pilchardus*, *T.minutus*, and *Arnoglossus spp.* were found at the dissolved oxygen level of 3.79 mg/l whereas those of *P. minutus* and *C. pusillus* were found at minimal level of 2.78 mg/l and those of *S. pilchardus* and *Z. ophiocephalus* were found at minimal dissolved oxygen level of 3.68 mg/l. Eggs of *C. pusillus* made 1.55% of all distribution range.

The larvae were 2.5 to 7.6 mm in size in the early post-larval period. Prelarva was observed only

in *C. pusillus* species. The biggest larva was that of *Callionymus lyra* Linnaeus, 1758 in the late post-larval period (10.5 mm). The minimal temperatures at which the eggs and larvae were detected were 9.74°C and 14.16°C, respectively, and the maximal temperature was 26.34°C (Table 4).

The first 2 factors of PCA calculates for surface showed a cumulative variance of 89.56%. Specifically, the factor 1 explained the highest overall variability 68.20 % whereas the factor 2 explained only the 21.36 %. By the correlation coefficients values of the parameters with factors salinity, eggs, larvae and transparency resulted inversed correlated with factor 1 whereas temperature showed a positive correlation with factor 1 and significant positive correlation of oxygen with factor 2 (Figure 7).

Discussion

As a result of the present seasonal investigations of plankton samples based on horizontal sampling from the five stations located in the inner part of Izmir Bay, eggs were detected from 7 species belonging to 6 families and larvae of 14 species, for a total of 18 species in 9 families. Mater (1979) recorded eggs from 23 species in 19 families by investigating the effects of pollution between the Harbor and Yenikale Lighthouse, and later, Mater (1981) reported eggs and larvae from 20 species in 15 families in the same area. Specifically, Mater (1979, 1981) detected eggs of *E. encrasicolus* and *D. annularis* and larvae of *G. niger*

Table 3. Species of which eggs and larvae were detected in the Inner Bay of Izmir between 2000 and 2005 and their distribution rates (by eggs, larvae, and stations) (E: Eggs, L: Larvae)

	%		Inner %		Central %				Outer %			
	Eggs	Larvae	S.1		S.2		S.3		S.4		S.5	
			E	L	E	L	E	L	E	L	E	L
CLUPEIDAE	0,03											
<i>Sardina pilchardus</i>	0,03										1,53	
ENGRAULIDAE	98	51										
<i>Engraulis encrasicolus</i>	98,19	51,11	100		92,80		96,27		99,95	61,74	43,07	
GADIDAE	0,02											
<i>Trisopterus minutus</i>	0,02										1,02	
SPARIDAE		0,55										
<i>Diplodus annularis</i>		0,55										0,03
GOBIIDAE		14										
<i>Gobius niger</i>		11,11				40				4,69		66,66
<i>Pomatoschistus microps</i>		1										6,66
<i>Zosterizessor ophiocephalus</i>		2,22										13,33
CALLIONYMIDAE	1,48	5										
<i>Callionymus lyra</i>		1,66									1,34	
<i>Callionymus pusillus</i>	1,48	3,33			6,63				0,32	2,01	34,87	6,66
BLENNIIDAE		28										
<i>Blennius ocellaris</i>		1,11				20						
<i>Salaria pavo</i>		9,44								11,40		
<i>Parablennius gattorugine</i>		12,22								14,76		
<i>Parablennius sanguinolentus</i>		1,66				30						
<i>Parablennius tentacularis</i>		2,22								2,68		3,33
<i>Blennius</i> spp.		1,82						100		1,34		
BOTHIDAE	0,19											
<i>Arnoglossus</i> spp.	0,19				0,22		3,72				18,97	
SOLEIDAE	0,06	0,55										
<i>Solea</i> spp. (<i>Microchirus ocellatus</i>)	0,03				0,11						0,51	
<i>Buglossidium luteum</i>	0,03	0,55			0,11	10			0,01			
Species Counts			1	-	5	4	2	1	3	8	7	6
General			1		9		2		9		9	

and *S. pilchardus* between 1974 and 1978. According to the latest (2015-2016) work, four species eggs and larvae were determined in Inner Bay. These are: *C. pusillus* (3 individual/m²), *E. encrasicolus* (3 individual/m²) and *G.niger* (3 individual/m²) larvae, and *S. pilchardus* (3 individual/m²) eggs (Anonymous, 2015b; 2016). In recent work, Çoker and Cihangir (2015) has been found anchovy eggs as 342 individual/m² in summer and 24 individual/m² in autumn in Inner Bay. In previous studies of the ichthyoplankton of Inner Bay indicated that eggs of *Sphyraena sphyraena* (Linnaeus, 1758) and larvae of *Atherina hepsetus* Linnaeus, 1758, *Symphodus melops* (Linnaeus, 1758), *Sygnathus* spp. and *Paraliparis* spp.

were not detected. *Paraliparis* spp. is a species not present in Turkish waters and must have been carried accidentally into Izmir Bay by boats coming from Alsancak Harbor.

In the present study, 83% of the adults of the ichthyoplankton species were demersal, 11% pelagic and 6% epipelagic. These data indicate that demersal species use habitat continuously, pelagic ones temporarily, and epipelagic species migrate depending on environmental conditions. *S. solea*, *Chelon labrosus* (Risso, 1827), *G.niger*, *D. annularis*, *Atherina boyeri* Risso, 1810, *Spicara smarvis* (Linnaeus, 1758), *B. luteum*, *Mullus barbatus* Linnaeus, 1758, *Callionymus maculatus* Rafnesque,

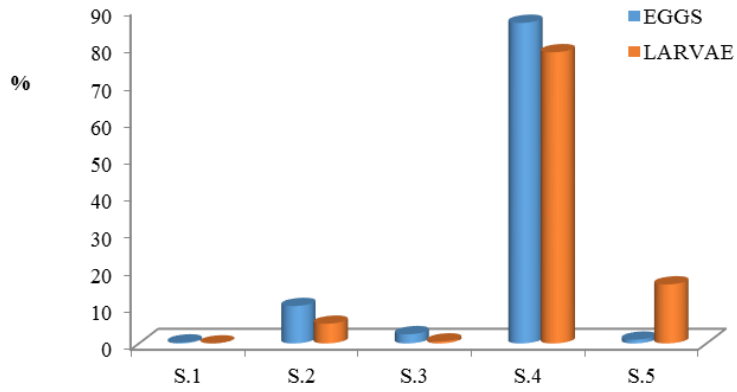


Figure 2. Total incidence of eggs and larvae by stations in the Inner Bay.

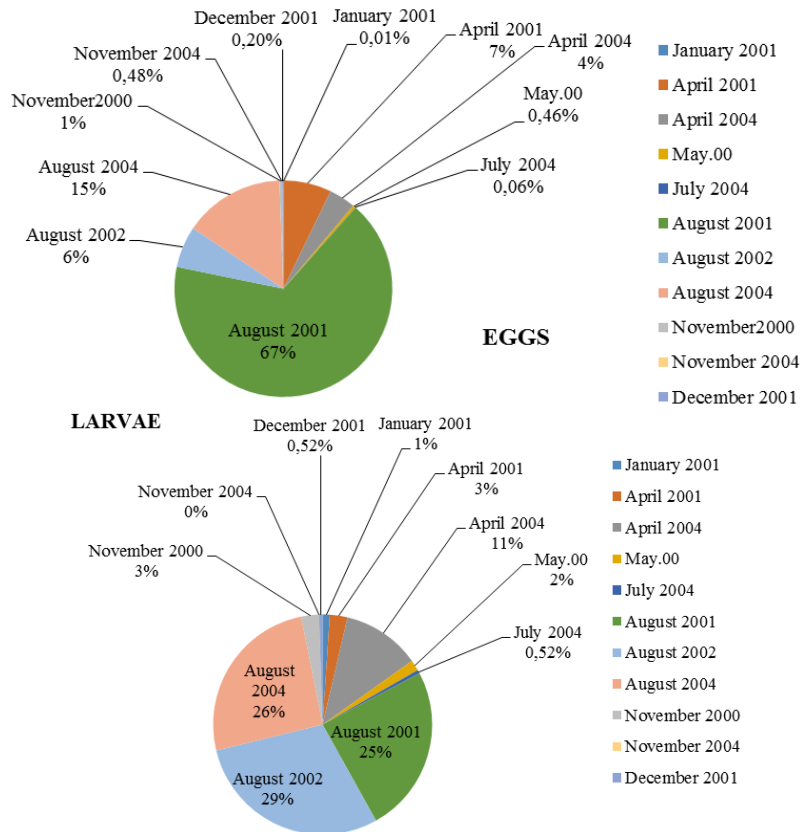


Figure 3. Monthly incidence of the eggs and larvae by years.

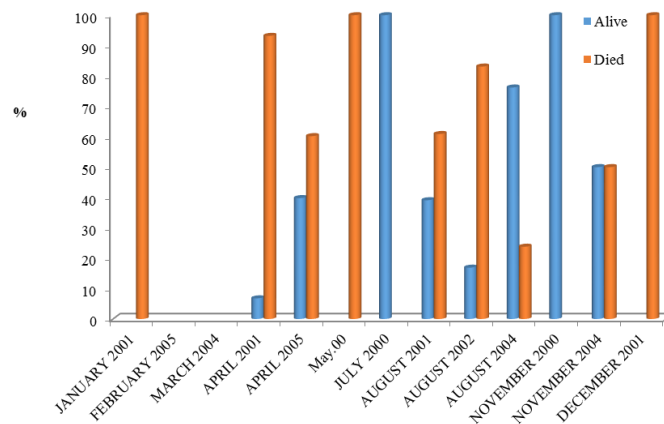


Figure 4. Incidence of dead-living eggs by the years

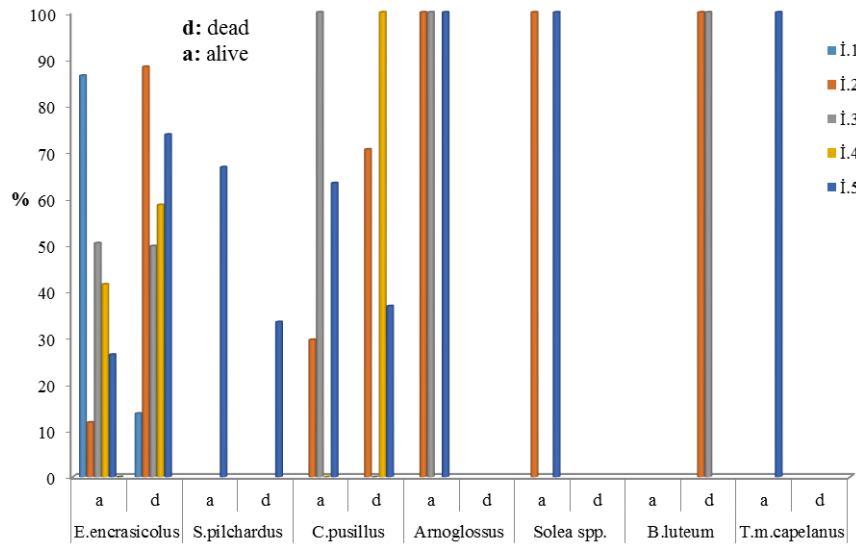


Figure 5. Mortality incidence of the eggs in the Inner Bay.

1810, *Callionymus risso* Le Sueur, 1814 adult species are typically detected in bim trial and grab samplings from Inner Part of Izmir Bay at the same years (Anonymous,2002; 2004b)

Egg diversity was low at the harbor and at the station located offshore of Çakalburnu Lagoon. Larval diversity increased in general at other station from the middle part of the Inner Bay. Eggs of highest number of the species were found at outlet of the Inner Bay (Station 5). The Station with the highest level of larval diversity was located offshore of Çakalburnu Lagoon (Station 4). No larva was found on the areas close to the harbor.

The highest rate of distribution of the eggs and larvae was found in April and August, reflecting the reproductive period of anchovy. The mean temperature in Inner Bay was 26.34°C in August 2001, during which anchovy eggs were at maximal levels. In this respect, Demir (1968) reports that anchovy starts to lay eggs at 13°C and to show reproductive activity at temperatures between 13°C and 26°C.

Mater (1981) reported that mortality rate of anchovy eggs were the highest at Stages II and III, and increased especially in the summer months when oxygen levels decreased. During the sampling period, the mean oxygen level was found to be at 5.5 mg/l for the whole year in Inner Bay between Karsiyaka and Konak (Station 2), and no minimum was observed except for April 2005 (1.68 mg/l). However, 59% of the anchovy eggs sampled were found to be dead and it was noticed that mortality rates increased from the inner to the outer stations of Izmir Bay. Pollution and winds from north-east may have been influential in causing mortality during the spawning period of anchovy. Koray and Cihangir (2002) reported that photosynthetic organisms maybe a cause of fish

mortality due to either anoxia (causing decomposition) or hyperoxia resulting from excessive amounts of oxygen during the daylight.

Anchovy larvae showed their highest distribution in Inner Bay with a rate of 51%. Mater (1979) noted that the area close to the harbor provided for a good environment for anchovy to spawn and for its eggs and larvae to grow in spite of the high rate of mortality observed in the region as supported by the current studies.

Mater (1983b) reported that presence of eggs of *Callionymus* spp. in the zone might be considered acceptable for pollution. Mater (1983a) also emphasized that the most important factor affecting availability of eggs of *S. pilchardus* was oxygen and noted that the lowest level was 6.5 mg/l. In the present study, sardine was seen to continue spawning at very low oxygen levels, indicating that Inner Bay is used for nutritional and (partly) for reproductive purposes because of its eutrophic environments. However, the fact that no larvae were found indicates that these probably did not have chance to survive. It was also observed that small pelagic fish such as *E. encrasicolus*, *S. pilchardus* and *S. aurita* grew in number in Inner Bay due availability of the nutrients, especially during eutrophic periods. Eutrophication Anonymous (2002); Küçüksegin *et al.* (2004) highlighted and reported that Nitrogen in the N:P ratio made the limiting step in Izmir Bay and phosphorus made source of pollution due to excessive productivity. Finally, Koray and Cihangir (2002) noted nutrients in Inner Bay caused rapid proliferation of microalgae and excessive plankton production was found to increase abundance and distribution of fish.

G. niger was the species of larva encountered in Inner Bay during almost all sampling periods. Larvae of this species with demersal eggs are considered in

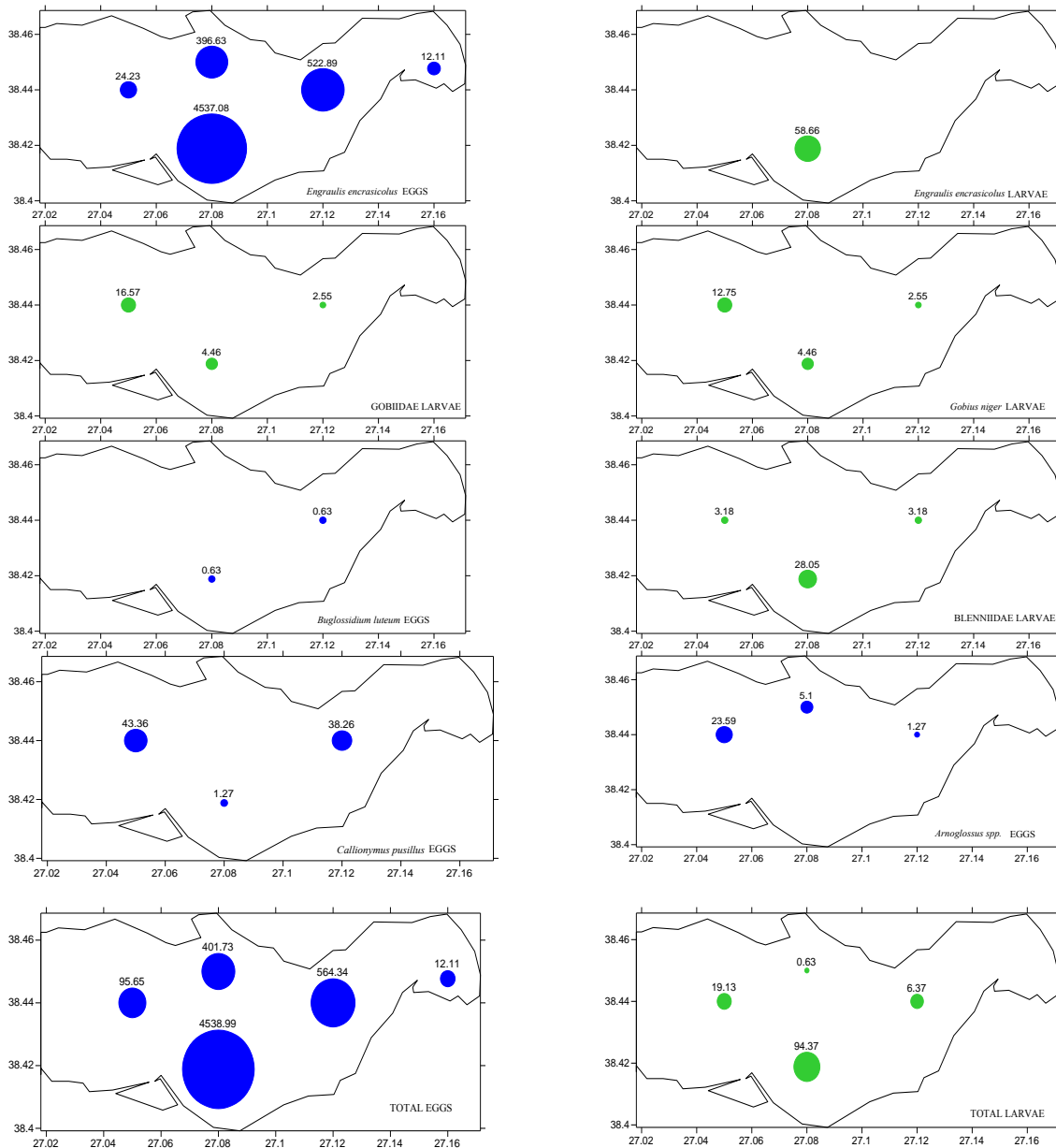


Figure 6. General Areas of Distribution and Total densities (individuals per 100 m³) of the eggs and larvae predominating in the Inner Bay

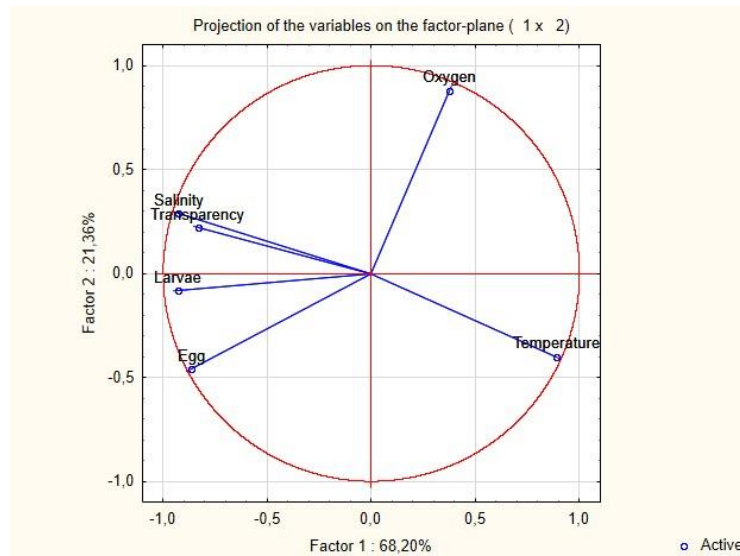
the literature as a pollution indicator because of their high tolerance. In the present study, *G. niger* was found mainly between Karsiyaka and Konak, and in high numbers offshore of Çakalburnu Lagoon. Antunes and Lopes Da Cunha (2002) also viewed *G. niger* as an indicator species for pollution and Çoker (2003) reported the presence of all 3 species of the Gobiidae family (i.e. *G. paganellus*, *P. minutus* and *Z. ophiocephalus*) in addition to *G. niger* between 1994 and 2002, during which pollution in Inner Bay was at the highest levels. In the present study, *P. microps* and *Z. ophiocephalus* were found at Yenikale Lighthouse, and it is believed that members of the Gobiidae family can continue to spawn in Inner Bay by taking advantage of very weak currents and that all

of them except for *G. niger* can tolerate pollution. Adults of the species of *G. niger*, *Pomatoschistus marmoratus* (Risso, 1810), *Z. ophiocephalus* and *P. microps* have also been recorded in Inner Bay at Alsancak Harbor (Anonymous, 2004b).

In the present study, the finding of a high number and rate of species in the Blenniidae family is remarkable. Species of *L. pavo*, *P. gattorugine*, *P. tentacularis* and *Blennius* spp. were found at relatively high levels off Çakalburnu-Lagoon, and oxygen levels during this period was 2.5–5.0 mg/l for *L. pavo* and 2.1–7.4 mg/l for *P. gattorugine*. In a study evaluating samples from 1989, Çoker (1996) reported Blenniidae of the species *P.gattorugine*, *L. pavo* and *P. tentacularis* from shores of RagıpPasa

Table 4. Temperature and oxygen tolerance, egg diameter, egg stages, and larval length of the species in the Inner Bay

	EGGS			LARVAE		
	EGG DIAMETER/OIL GLOBULE DIAMETER (mm)	TEMPERATURE (°C)	OXYGEN (mg/l)	LARVAE LENGTH (mm)	TEMPERATURE (°C)	OXYGEN (mg/l)
<i>S. pilchardus</i>	1.47-1.49 (0.13-0.21)	9.74	3.79			
<i>E. encrasicolus</i>	0.99-1.47 x 0.47-0.60	9.74-26.34	1.68-7.44	2.5-5.7	26.34	3.79
<i>T. minutus</i>	0.92	9.74	3.79			
<i>D. annularis</i>				3.3		
<i>G. niger</i>				1.5-4.9	14.16-25.52	1.68-4.73
<i>P. microps</i>				2.5	16.18	
<i>P. minutus</i>					15.87-25.55	2.78-4.66
<i>Z. ophiocephalus</i>				3.7-4.1	16.18	3.68
<i>B. ocellariss</i>				4.0	14.16	1.68
<i>P. tentacularis</i>				2.0-7.6	14.16	1.68
<i>C. pusillus</i>	0.44-0.60	14.16-19.11	1.68-7.32	0.8-1.5	25.55	2.78
<i>C. lyra</i>				10.5		
<i>Amoglossus</i> spp.	0.55-0.63 (0.10-0.15)	9.74-13.29	3.79-9.28			
<i>Solea</i> spp. (<i>M. ocellatus</i>)	0.89-0.99 (about 40 oil drops)	19.11	7.32			
<i>B. luteum</i>	0.76	9.74-16.10	1.68-3.79	3.0		
<i>S. pavo</i>				2.5-5.0		
<i>P. gattorugine</i>				2.1-7.4		
<i>P.</i>				4.9		
<i>sanguinolentus</i>						
<i>Blennius</i> spp.				2.1-2.5		

**Figure 7.** Principal Component Analysis between eggs and larvae and temperature, salinity, oxygen, transparency.

Lagoon and of *B. ocellaris* from off Çakalburnu Lagoon. Mater (1981) reported that *P. gattorugine* was the predominant species on the shores of both fisheries as well as offshore of Halkapınar Brook, where he also reported the presence of larvae of *L. pavo*. Adults of *L. pavo* have been reported from Inner Bay Geldiay (1969), Anonymous (2004b) and those of *P. sanguinolentus* from around the harbor. Adults of the Blenniidae species living in the coastal waters are one of the most important fish species of Inner Bay. The fact that larvae of Blenniidae were found at high levels again in the waters of Inner Bay may be associated with the clarity of the waters. In

Izmir Bay, these were at maximal level in August during which Blenniidae species made for 85% of the catch in 2001 and 84% in 2002. Members of the family are considered to tolerate low oxygen levels, although their embryonic stages do not to enter Inner Bay during the eutrophic period. Blenniidae larvae are also known for selective nutrition Dekhnik (1973), with their eyes starting to form in the early stages of development, so that a negative effect of turbidity may have accounted for the observed quantitative declines.

In this regard, the species that still continuing spawning in Inner Bay are *E. encrasicolus*,

Arnoglossus spp., *C. pusillus*, *B. luteum* and *Solea* spp. and the species whose larvae are always present are *E. encrasicolus* and *G. niger*.

Pollution effects in Inner Bay on coastal species with demersal eggs using the benthic zone as a spawning environment (i.e. Labridae, Atherinidae, Belonidae, and Centranchidae) will not be persist. Aksu, Yaşar and Uslu (1998) found Inner Bay to be polluted in terms of superficial sediments, heavy metals and organic matters in samples collected in 1994, and there is no treatment or recycling facilities in the Bay. Dölgen *et al.* (2001) mentioned that mud deposits rich in organic and inorganic matters were widespread in Inner Bay and contained low levels of oxygen leading to anaerobic conditions and production of malodorous H₂S. In these anoxic conditions, egg development is known to stop before the gastrulation stage with H₂S also impairing spawning.

In conclusion, it can be argued based that eggs of *E. encrasicolus*, *C. pusillus* and *Arnoglossus* and larvae of *E. encrasicolus* and *G. niger* can survive in polluted waters and that eggs of *Solea* spp. and *B. luteum* and larvae of *D. annularis*, *C. pusillus*, *B. luteum*, *P. microps* and *Z. ophiocephalus* may tolerate pollution to some extent. Mater (1979) viewed *E. encrasicolus* as the species most tolerant to pollution and indicated that *Callionymus* spp. might adapt to pollution conditions. Also, it is understood that adults of *T. minutus* spawn in the Inner Bay of Izmir, where they come for feeding similar to *S. pilchardus*, even though offspring cannot reach the larval stage. It has been noticed that the presence of adult species, being appropriate of the temperature and especially levels of dissolved oxygen, appropriateness of the habitat for spawning of the demersal species, and the currents had impacts on spawning of the species in the Inner Bay; and that visibility, dissolved oxygen, several pollution factors (biological, chemical) were influential along with structure of currents on availability of the larvae.

The main composition of the eggs and larvae in the Inner Bay are still seen to be consisting of those species in favor of and tolerating pollution despite improvement in water quality in 2000s. The photosynthetic organisms have occasionally observed to cause death of eggs by leading to excessive amount of oxygen in the spring season. The result of PCA with analyses was showed positive correlation between egg-larvae and primarily transparency, salinity and negative correlation between oxygen. The weak currents from Yenikale Lighthouse doesn't much effect to eggs and larval drift. Almost no current inside of the harbor Mater (1981). Qualitative and quantitative proliferation of the Blenniid larvae is a positive indication based on clarity of the water during this period in parallel to improvements in habitat of the Inner Bay and in other groups of organisms.

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