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Distribution and abundance of ichthyoplankton in natural al artificial reefs in Edremit Bay, Northern Aegean Sea, Türkiye

Distribución y abundancia del ictioplancton en arrecifes naturales y artificiales en la Bahía de Edremit, Mar Egeo septentrional, Turquía

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ABSTRACT

Edremit Bay is one of the important areas for small–scale fishing in the North Aegean Sea. For this reason, more detailed ichthyoplankton studies should be continued to evaluate the fish stock status of the region, calculate the adult fish biomass, and determine the spawning period, place, and time of fish species. In addition, from 2011 to 2013, artificial reefs were constructed in Edremit Bay. Regular investigation of fish eggs and larvae in the region influenced by the Edremit Bay artificial reef would provide better knowledge of the structure and function of the local ecosystem and provide a basis for monitoring the marine ecosystem in the area. The current research examined the species abundance and distribution of surface plankton samples collected in 2015 and 2016. The evaluation also included the influence of abiotic environmental factors such as temperature, pH, chlorophyll a (chl–a), salinity, depth, and dissolved oxygen. Throughout the research, 3345 eggs and 176 larvae were analyzed. 57 species of eggs and larvae were identified. Eggs were not found in the natural reef (S3) in the summer and winter of 2015, while the highest egg abundance (212.83·100 m^{-3}) was recorded in the natural reef (S1) in the summer of 2016. Larvae were not found in the natural reefs (S2 and S3) in the summer, autumn and winter of 2015 and in the artificial reefs (S4 and S5) in the summer and autumn in 2015 while the highest larvae abundance (8.12·100 m^{-3}) on the artificial reef (S1) in summer 2016. Although the natural reefs had the highest number of species (30 species), the artificial reefs showed the lowest species diversity (17 species).

Key words: Eggs; larvae; composition; biodiversity

RESUMEN

La Bahía de Edremit es una de las zonas importantes para la pesca a pequeña escala en el mar Egeo septentrional. Por esta razón, se deben continuar estudios más detallados del ictioplancton para evaluar el estado de las poblaciones de peces de la región, calcular la biomasa de peces adultos y determinar el período, lugar y tiempo de desove de las distintas especies de peces. Además cabe destacar que de 2011 a 2013 se construyeron arrecifes artificiales en esta bahía. La investigación periódica de huevos y larvas de peces en la región influenciada por el arrecife artificial de esta bahía, ofrecería un mejor conocimiento de la estructura y función del ecosistema local y proporcionaría una base para el seguimiento del ecosistema marino en la zona. La investigación actual examinó la abundancia de especies y la distribución de muestras de plancton de superficie recolectadas del año 2015 al 2016. La evaluación también incluyó la influencia de los factores ambientales abióticos como la temperatura, el pH, la clorofila a (chl–a), la salinidad, la profundidad y el oxígeno disuelto. A lo largo de la investigación se analizaron 3345 huevos y 176 larvas. Se identificaron 57 especies de huevos y larvas. No se encontraron huevos en el arrecife natural (S3) en el verano e invierno de 2015, mientras que la mayor abundancia de huevos (212,83·100 m^{-3}) se registraron en el arrecife natural (S1) en el verano de 2016. Además, no se encontraron larvas en los arrecifes naturales (S2 y S3) en el verano, otoño e invierno de 2015 y en los arrecifes artificiales (S4 y S5) en el verano y otoño de 2015, mientras que la mayor abundancia de larvas (8,12·100 m^{-3}) se encontró en el arrecife artificial (S1) en el verano de 2016. Los arrecifes naturales tuvieron el mayor número de especies (30 especies), y los arrecifes artificiales mostraron la diversidad de especies más baja (17 especies).

Palabras clave: Huevos; larvas; composición; biodiversidad

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INTRODUCTION

The studies on ichthyoplankton are important in the life cycle of fish species and stock management. Quantitative studies have found this important, explaining how fish species reproduce and recruit in the aquatic ecosystem [1]. Additionally, water quality and environmental conditions may affect the initial phases of the life cycle of fish species [2]. Larval fishes exhibit a high degree of fragility and are particularly vulnerable to fluctuations in environmental conditions and water quality. Due to the fragility and sensitivity of larval fish to ambient and water quality fluctuations, any environmental impact on these populations could be catastrophic [3]. The investigation of ichthyoplankton in Edremit Bay has been limited and the main studies so far being those by Türker–Çakır [2].

Edremit Bay is one of the important areas for small–scale fishing in the North Aegean Sea. For this reason, Türker–Çakır [2], suggests that more detailed ichthyoplankton studies should be continued to evaluate the fish stock status of the region, calculate the adult fish biomass, and determine the spawning period, place, and time of fish species. In addition, from 2011 to 2013 artificial reefs were constructed in Edremit Bay. This artificial reef in Edremit Bay is one of the largest artificial reef areas in the Levantine basin. Regular research of fish eggs and larvae in the region influenced by Edremit Bay Artificial Reef would offer a better knowledge of the structure and function of the local ecosystem, as well as provide a basis for marine ecosystem monitoring in the area. The first comprehensive ichthyoplankton study in the world was carried out by Cunningham [4] on the coasts of England, while the first ichthyoplankton study in Turkey was carried out by Arım [5] and included the descriptive characteristics of 8 species sampled from Marmara and Black Sea. In many ichthyoplankton studies after this date, species–specific early stages were investigated, while the number of studies investigating habitats in terms of a time series, (*e.g.*, Mater [6], Çoker [7], Çoker and Mater [8]) as in the Gulf of İzmir is limited. In addition, no ichthyoplankton monitoring study has been carried out for artificial habitats until this study. Ichthyoplankton surveys are one of the most useful and reliable methods to observe changes in fish communities [9, 10, 11, 12]. As a result, the current study intends to report on the regional and temporal fluctuations in the particular composition and abundance of ichthyoplankton via a comparative analysis of the data set. For this aim, samplings were carried out in 2013 (winter 2013), in 2014 (spring 2014; summer 2014; autumn 2014; winter 2014), in 2015 (spring 2015; summer 2015; autumn 2015; winter 2015), and in 2016 (spring 2016; summer 2016; autumn 2016; winter 2016) in Edremit Bay near the artificial reef. However, in this study, only data from 2015 and 2016 were evaluated.

MATERIAL AND METHODS

Edremit Bay is one of the greatest gulfs in the North Aegean Sea, with a narrowest point of 34 kilometers and a widest point of 45 kilometers. Edremit Bay is topographically separated into two bays: inner and outer bays. The inner bay is generated to the east of the line formed by the underwater valley that generates the depth differences between Bozburun and Altınoluk, while the outer bay is formed to the west [13]. Edremit Bay is located in the mixing zone of waters of Mediterranean and Black Sea origin. As a result of the mixing of these water masses with two different salinity and temperature, upwelling occurs with the effect of current systems. This situation causes an explosion of phytoplankton and zooplankton in the region and creates suitable habitats especially for pelagic fish [14, 15]. In addition to these features, Edremit Bay was preferred for artificial reef application due to its suitable bottom structure. More than 6000 cylindrical artificial reefs made of C3 type concrete have been laid in the area close to the coast from Narlı shores of Edremit Bay to Akçay shores. Samples were collected from stations determined within this area (FIGURE 1).

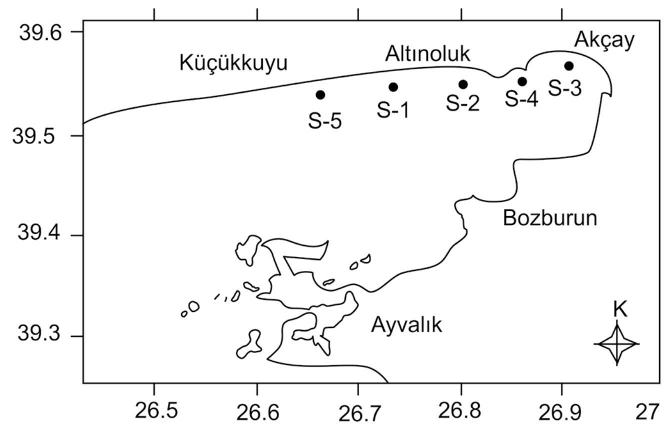

FIGURE 1. Location of sampling stations in Edremit Bay (Natural Reefs: S–1: Station 1, S–2: Station 2 and S–3: Station 3; Artificial Reefs: S–4: Station 4 and S–5: Station 5)

A WP–2 type plankton net (57 cm diameter, 250 µm mesh size) was used to collect data horizontally from the surface for 10 min at a speed of 2 knots. Eggs, larvae and fish samples, physico–chemical parameters and chlorophyll–a values were obtained from stations belonging to two different habitats: natural reef and artificial reef in Edremit Bay in 2013 (winter 2013), in 2014 (spring 2014; summer 2014; autumn 2014; winter 2014), in 2015 (spring 2015; summer 2015; autumn 2015; winter 2015), and in 2016 (spring 2016; summer 2016; autumn 2016; winter 2016). However, in this study, only data from 2015 and 2016 were evaluated. Physico–chemical environment parameters (depth, temperature, pH, salinity, dissolved oxygen) and chlorophyll–a (chl–a) values were measured seasonally and in the field at all stations with a WTW Multi 340i model (made in Germany) portable parameter measuring device. Station names, depths, temperature, salinity, dissolved oxygen levels, and chl–a values were presented in TABLE I.

Ichthyoplankton were preserved in 4% buffered formaldehyde solution. they were then separated and classified, with the help of the stereoscopic microscope (4×10X) (Olympus SZ–60 type, Japan). Eggs and larvae were identified following Mater [6], Çoker [7], Fahay [16], Leis and Rennis [17], Leis and Trnski [18], and Moser [19]. The number of ichthyoplankton individuals per 100 m^3 was computed using the methods described by Postel *et al.* [20] and Çoker and Cihangir [3]:

$V = t \times v \times M$ (m^3/individuals = hour × mph × m^2) where V = sampling volume, t = sampling time, v = sampling velocity, and M = area of the net mouth ($M = \pi \times r^2$). The abundance of the observed species was calculated as follows:

Abundance = N/V (individuals/m^3) where N = number of samples from each station. The calculated result was then multiplied by 100 and reported as number of individuals per 100 m^3 [3]. The chi–square test was applied to determine whether there is a difference between stations and seasons in terms of the abundance of fish eggs and larvae.

RESULTS AND DISCUSSION

The Bay had a range of temperatures, with the lowest recorded temperature being 13.5 °C from the natural reef (S2) in 2015 (winter) and the highest recorded temperature being 26.5 °C from the natural reef (S2) in 2015 (summer). The minimum salinity of 29.910 ppt was recorded at the artificial reef (S5) in 2013 (autumn), while the maximum of 40.660 ppt was recorded at the artificial reef (S5) in 2015 (summer). The minimum dissolved oxygen level of 3.83 mg·L^{-1} was recorded at the artificial reef (S4) in 2016 (spring), while the maximum dissolved oxygen level of 9.12 mg·L^{-1} was recorded at the artificial reef (S5) in 2016 (spring). The minimum pH of 7.51 was recorded at the natural reef (S3) in 2016 (autumn), while the maximum pH of 8.41 was recorded at the natural reef (S3) in 2013 (autumn). The minimum chl–a of 0.0037 mg·L^{-1} was recorded at the artificial reef (S4) in 2015 (summer), while the maximum chl–a of 1.8514 mg·L^{-1} was recorded at the artificial reef (S4) in 2016 (spring). The data associated with the years 2013 to 2016 is shown in TABLE I. In addition, FIGURE 2 presents the data for the years 2015 and 2016.

TABLE I

Station names, depths (m), temperature (°C), salinity (ppt), pH, dissolved oxygen levels (mg·L^{-1}), and chl–a (mg·L^{-1}) values in Stations 1 and 5 in 2013 to 2016 (Sp: Spring, Su: Summer, A: Autumn, W: Winter; Natural Reefs: S1: Station 1, S2: Station 2 and S3: Station 3; Artificial Reefs: S4: Station 4 and S5: Station 5)

Stations	Parameters Physico–chemical and Chl–a	2013				2014				2015				2016			
		Sp.	Su.	A	W	Sp.	Su.	A	W	Sp.	Su.	A	W	Sp.	Su.	A	W
Station 1	Depth (m)	–	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	Temperature (°C)	–	23.9	16.9	15.9	23.1	25.2	19.2	16.1	21.9	25.1	19.1	14	14.4	23	21.3	15.4
	Salinity (ppt)	–	39.4	29.99	38.07	39.69	40.54	39.77	38.52	40.43	40.22	39.72	39.28	37.73	39.64	39.67	38.06
	pH	–	8.14	8.36	8.24	8.13	8.01	7.85	7.68	8.18	8.03	7.84	7.83	7.9	7.9	7.84	8.13
	Oxygen (mg·L^{-1})	–	6.46	7.77	7.37	6.2	5.33	4.08	7.1	6.83	5.57	5.97	7.52	8.62	7.03	7.49	7.28
	Chl–a (mg·L^{-1})	–	0.201	0.698	0.278	0.517	0.027	0.267	0.456	0.297	0.023	0.234	0.405	0.416	0.131	0.094	0.465
Station 2	Depth (m)	–	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	Temperature (°C)	–	23.9	17.1	16.1	23.5	26.5	19.3	16.4	21.9	26.4	19.2	13.5	15.2	23.6	21	15.9
	Salinity (ppt)	–	37.4	30	38.14	39.49	40.55	39.76	38.99	40.1	40.33	39.75	38.05	39.15	39.63	39.63	37.99
	pH	–	8.14	8.36	8.26	8.1	7.98	8.01	8.06	8.02	8.01	8	7.71	7.77	7.88	7.79	8.14
	Oxygen (mg·L^{-1})	–	6.43	7.58	7.61	6.37	5.96	5.94	6.82	6.87	6.01	5.99	7.54	6.79	7.15	7.39	7.13
	Chl–a (mg·L^{-1})	–	0.113	0.368	0.296	0.633	0.178	0.318	0.242	0.664	0.184	0.284	0.505	0.308	0.117	0.107	0.481
Station 3	Depth (m)	–	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Temperature (°C)	–	23.6	17.2	16.2	24.3	25.2	19.3	17	22.2	25.3	19.2	13.8	15.6	24	20.7	15.4
	Salinity (ppt)	–	39.36	30.48	38.09	39.32	40.52	39.33	39.46	40.26	40.49	39.46	38.75	36.24	39.38	39,62	38.08
	pH	–	8.13	8.41	8.26	8.14	8.1	8	8.1	8.25	8.1	8	7.98	8.01	7.69	7.51	7.82
	Oxygen (mg·L^{-1})	–	6.5	7.82	7.56	7.03	6.36	6.03	6.74	7.34	6.42	6.14	8.03	4.34	7.97	6.9	7.55
	Chl–a (mg·L^{-1})	–	0.111	0.199	0.216	0.933	0.057	0.212	0.149	0.763	0.025	0.232	0.782	1.822	0.501	0.989	0.263
Station 4	Depth (m)	–	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	Temperature (°C)	–	24	16.9	15.9	23.3	24.1	19.5	16.4	22.3	25.2	19.2	13.8	15.7	23.2	20.7	15.2
	Salinity (ppt)	–	38.97	30.37	38.15	39.57	40.54	39.37	38.88	40.42	40.46	39.51	39.15	37.25	39.53	39.66	37.78
	pH	–	8.13	8.37	8.24	8.14	7.92	8.04	8.15	8.18	7.94	8.07	7.89	7.94	7.83	7.85	8.17
	Oxygen (mg·L^{-1})	–	6.59	7.66	7.7	6.57	5.04	6.01	7.07	7.02	6.11	6.17	8.01	3.83	7.25	7.14	7.45
	Chl–a (mg·L^{-1})	–	0.276	0.367	0.479	0.556	0.115	0.239	0.138	0.192	0.175	0.237	0.492	1.851	0.122	0.457	0.254
Station 5	Depth (m)	–	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
	Temperature (°C)	–	23.9	17.1	16.1	24.1	26.7	19.4	16.2	22.4	25.9	19.4	13.7	15.9	23.2	20.7	15.6
	Salinity (ppt)	–	37.18	29.91	38.03	39.35	40.78	39.27	38.58	40.6	40.66	39.25	39.7	37.75	39.57	39.61	38.06
	pH	–	8.1	8.36	8.25	8.16	8.07	7.97	8.07	8.16	8.03	8.06	7.91	7.6	7.93	7.95	8.14
	Oxygen (mg·L^{-1})	–	6.55	7.59	7.36	6.63	5.69	5.37	7.05	6.85	6.01	5.49	7.94	9.12	7.09	7.17	7.15
	Chl–a (mg·L^{-1})	–	0.328	0.298	0.285	0.607	0.004	0.320	0.205	0.103	0.003	0.296	0.312	0.970	0.108	0.646	0.357

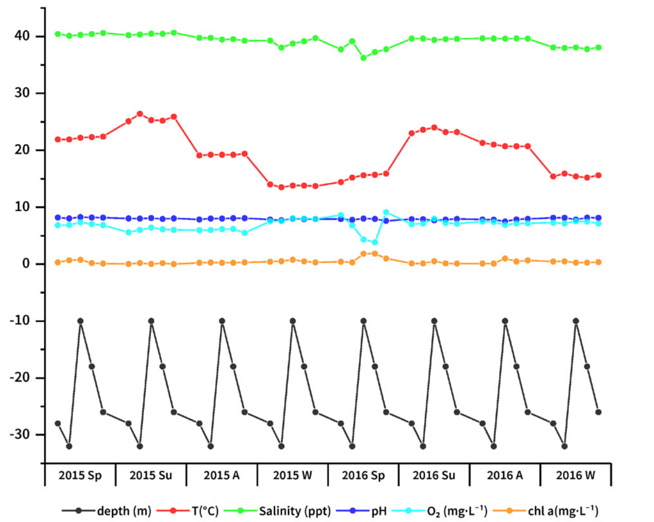

FIGURE 2. Depth (m), T: temperature (°C), salinity (ppt), pH, O2: dissolved oxygen levels (mg·L⁻¹), and chlorophyll–a: chl–a (mg·L⁻¹) values in Stations 1 and 5 in 2015–2016 (Sp: Spring, Su: Summer, A: Autumn, W: Winter)

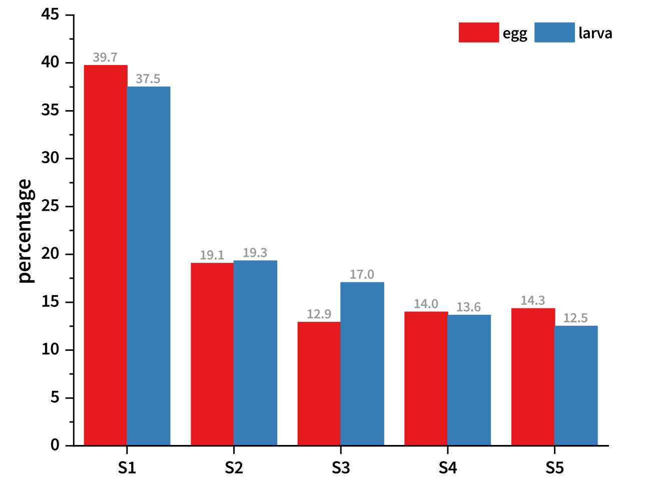

FIGURE 3. The total incidence of eggs and larvae by stations in the Edremit Bay (Natural Reefs: S1: Station 1, S2: Station 2 and S3: Station 3; Artificial Reefs: S4: Station 4 and S5: Station 5)

TABLE II provides information on the abundance of eggs and larvae for the different seasons. Eggs were not found in the natural reef (S3) in the summer and winter of 2015, while the highest egg abundance (212.83·100 m⁻³) was recorded in the natural reef (S1) in the summer of 2016. Larvae were not found in the natural reefs (S2 and S3) in the summer, autumn, and winter of 2015 and in the artificial reefs (S4 and S5) in the summer and autumn of 2015, while the highest larvae abundance (8.12·100 m⁻³) in the artificial reef (S1) in summer 2016. Upon analysis of the 3345 eggs collected during the study, it was found that Station–1 had the highest density while Station–3 had the lowest. Similarly, analysis of the 176 larvae revealed that Station–1 had the highest density while Station–5 had the lowest (FIGURE 3). A statistical difference was observed between the stations in terms of eggs and larvae abundance (P<0.05). During the study period, a total of 3345 eggs were collected, with 60% being sampled in the summer of 2016 and 1% in the spring of 2015. Additionally, a total of 176 larvae were collected, with 52% being sampled in the summer of 2016 and 1% in the autumn of 2015. (FIGURES 4-5). A statistical difference was observed in the abundance of eggs and larvae between the years (P<0.05).

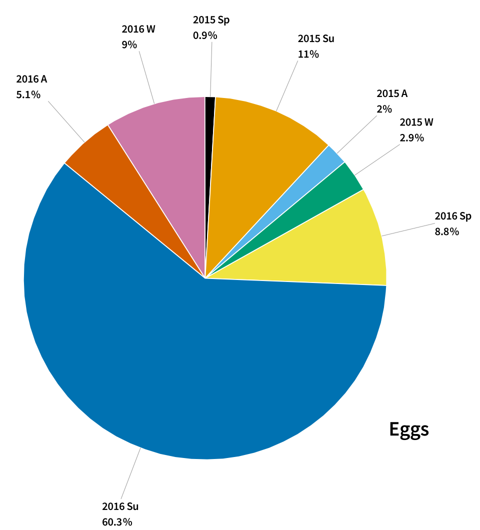

FIGURE 4. Seasonal incidence of eggs by year.

TABLE II

General areas of distribution and total abundance (individuals per 100 m³) of the eggs and larvae in Edremit Bay between 2015 and 2016 (Natural Reefs: S1: Station 1, S2: Station 2 and S3: Station 3; Artificial Reefs: S4: Station 4 and S5: Station 5)

Stations	2015								2016							
	Spring		Summer		Autumn		Winter		Spring		Summer		Autumn		Winter	
	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
Station 1	53.55	3.82	63.27	0.52	2.09	0.52	14.12	2.61	13.33	1.57	212.83	8.12	11.24	2.61	26.93	1.04
Station 2	19.12	3.82	8.37	0.52	2.35	0	1.31	0	17.52	1.05	104.32	4.44	10.19	1.57	21.43	1.04
Station 3	11.47	3.82	0	0	2.35	0	0	0	19.35	1.05	71.12	4.44	7.58	1.57	11.76	0.52
Station 4	22.95	3.82	15.95	0	1.05	0	6.01	1.05	10.46	0.26	68.5	3.39	7.84	1.05	10.71	0.26
Station 5	11.47	3.82	8.63	0.26	9.93	0	4.18	0.26	15.95	0.52	70.33	3.39	7.58	1.05	7.84	0.26

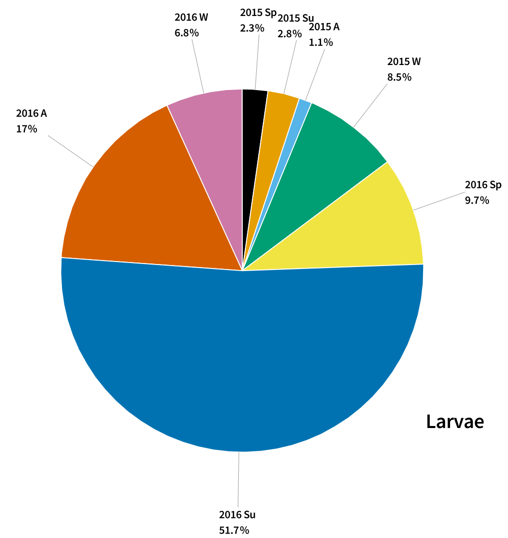

FIGURE 5. Seasonal incidence of larvae by year.

TABLE III provides information on the variety of species of eggs and larvae based on different stations. Natural reefs showed the highest number of species (30 species), while artificial reefs showed lower species diversity (17 species). *D. annularis*, *S. pilchardus* and *E. encrasicolus* were found in all stations. The eggs or larvae of seven species (*A. thori*, *M. variegatus*, *P. minutus*, *S. colias*, *S. porcus*, *S. sphyraena* and *L. cavillone*) were exclusively found at any of the artificial reefs (S4 and S5). The eggs or larvae of six species (*L. mormyrus*, *P. saltatrix*, *S. sarda*, *S. solea*, *S. melops*, and *T. mediterraneus*) were exclusively found at any of the natural reefs (S1, S2 and S3). In this study, it is seen that some fish species choose different habitats, such as natural or artificial reefs for reproduction.

There are limited number of ichthyoplankton studies in Edremit Bay. Among the existing ichthyoplankton studies, Türker–Çakır [2] can be considered as the most detailed study. The present research aims to determine the effect of artificial reefs on ichthyoplankton species diversity in Edremit Bay, which is significantly affected by anthropogenic factors, especially temperature fluctuations caused by the climate crisis. To provide a basis for comparison, the present investigation was compared with Türker–Çakır's [2], which is

TABLE III

Availability of eggs and larvae of the species at the station by year (* first record in this study for Edremit Bay); Natural Reefs: S1: Station 1, S2: Station 2 and S3: Station 3; Artificial Reefs: S4: Station 4 and S5: Station 5)

Species (Eggs and Larvae)	2015					2016				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
* *Arnoglossus kessleri* Schmidt, 1915	–	+	+	+	+	–	–	–	–	–
Arnoglossus laterna (Walbaum, 1792)	+	+	+	+	–	–	+	–	–	–
Arnoglossus thori Kyle, 1913	–	–	–	–	+	–	–	–	–	–
Arnoglossus sp.	–	–	+	+	–	–	–	–	–	–
Atherina boyeri Risso, 1810	–	+	+	–	–	+	–	+	+	+
* *Boops boops* (Linnaeus, 1758)	+	+	–	–	–	+	+	+	–	+
Buglossidium luteum (Risso, 1810)	+	+	+	+	+	+	+	–	–	+
Callionymus pusillus Delaroche, 1809	+	+	+	+	+	–	–	–	–	–
Chelon saliens (Risso, 1810)	–	+	–	–	+	+	+	+	+	+
* *Chelidonichthys lucerna* (Linnaeus, 1758)	+	+	+	–	–	–	–	–	–	–
Chromis chromis (Linnaeus, 1758)	–	–	–	–	+	+	+	+	–	–
Coris julis (Linnaeus, 1758)	+	+	–	+	+	+	+	+	+	–
Ctenolabrus rupestris (Linnaeus, 1758)	+	+	+	+	+	–	–	–	–	–
* *Dicentrarchus labrax* (Linnaeus, 1758)	–	–	–	–	–	+	+	–	+	+
Diplodus annularis (Linnaeus, 1758)	+	+	+	+	+	+	+	+	+	+
Diplodus sargus (Linnaeus, 1758)	–	+	+	+	–	–	+	–	–	–
* *Diplodus vulgaris* (Geoffroy Saint–Hilaire, 1817)	+	–	–	–	–	+	–	–	+	+
* *Echiichthys vipera* (Cuvier, 1829)	–	+	+	+	–	–	–	–	–	–
Engraulis encrasicolus (Linnaeus, 1758)	+	+	+	+	+	+	+	+	+	+
Gaidropsarus mediterraneus (Linnaeus, 1758)	+	+	–	–	–	+	+	+	–	–
Gobius niger Linnaeus, 1758	+	–	+	+	–	+	+	+	+	+
* *Lepidotrigla cavillone* (Lacepède, 1801)	–	–	–	+	–	–	–	–	–	–
* *Lithognathus mormyrus* (Linnaeus, 1758)	+	–	–	–	–	–	–	–	–	–
* *Merlangius merlangus* (Linnaeus, 1758)	–	–	–	–	–	+	+	+	–	+
* *Merluccius merluccius* (Linnaeus, 1758)	+	–	+	+	–	+	+	+	+	–

TABLE III cont...
Availability of eggs and larvae of the species at the station by year (* first record in this study for Edremit Bay); Natural Reefs: S1: Station 1, S2: Station 2 and S3: Station 3; Artificial Reefs: S4: Station 4 and S5: Station 5)

Microchirus variegatus (Donovan, 1808)	–	–	–	+	–	–	–	–	–	–
* *Mugil cephalus* Linnaeus, 1758	+	–	–	–	–	–	–	–	–	–
Mullus barbatus Linnaeus, 1758	+	+	–	+	+	+	+	+	+	+
* *Mullus surmuletus* Linnaeus, 1758	+	–	–	+	+	+	–	+	+	+
* *Pagellus erythrinus* (Linnaeus, 1758)	–	–	–	–	–	+	+	+	+	+
* *Pomatomus saltatrix* (Linnaeus, 1766)	+	–	–	–	–	–	–	–	–	–
* *Pomatoschistus minutus* (Pallas, 1770)	–	–	–	+	–	–	–	–	–	–
Phycis blennoides (Brünnich, 1768)	–	+	+	+	–	–	–	–	–	–
* *Sarda sarda* (Bloch, 1793)	–	–	–	–	–	+	–	–	–	–
Sardina pilchardus (Walbaum, 1792)	+	+	+	+	+	+	+	+	+	+
Sardinella aurita Valenciennes, 1847	+	–	–	+	+	–	–	–	–	–
* *Sciaena umbra* Linnaeus, 1758	+	–	–	–	–	+	+	+	–	–
* *Scomber colias* Gmelin, 1789	–	–	–	+	–	–	–	–	–	–
* *Scomber scombrus* Linnaeus, 1758	–	–	–	–	–	+	+	+	+	+
Scorpaena porcus Linnaeus, 1758	–	–	–	–	–	–	–	–	–	+
* *Scorpaena scrofa* Linnaeus, 1758	+	–	–	–	–	+	+	+	+	+
* *Seriola dumerili* (Risso, 1810)	–	–	–	–	–	+	+	+	–	–
Serranus cabrilla (Linnaeus, 1758)	+	+	–	+	+	–	–	–	–	–
Serranus hepatus (Linnaeus, 1758)	+	+	+	+	+	–	–	–	–	–
Serranus scriba (Linnaeus, 1758)	+	–	–	+	+	–	–	–	–	–
* *Serranus* sp.	+	+	–	–	–	–	–	–	–	–
* *Solea solea* (Linnaeus, 1758)	–	–	–	–	–	+	–	–	–	–
Specimen of the Sparidae family.	–	–	+	–	–	–	–	–	–	–
* *Sparus aurata* Linnaeus, 1758	+	–	+	–	–	–	+	–	–	–
* *Sphyraena sphyraena* (Linnaeus, 1758)	–	–	–	–	+	–	–	–	–	–
* *Spicara smaris* (Linnaeus, 1758)	+	+	–	+	+	–	+	–	+	+
* *Symphodus melops* (Linnaeus, 1758)	–	+	–	–	–	–	–	–	–	–
Symphodus ocellatus (Linnaeus, 1758)	+	+	+	+	–	+	+	–	–	–
Trachinus draco Linnaeus, 1758	+	+	+	–	+	–	–	–	–	–
Trachurus mediterraneus (Steindachner, 1868)	–	+	–	–	–	–	–		–	–
Trachurus trachurus (Linnaeus, 1758)	–	–	–	+	+	+	+	+	+	+
* *Uranoscopus scaber* Linnaeus, 1758	–	+	–	–	–	+	+	–	–	–

considered the most exhaustive research of Edremit Bay so far. It was found that the physicochemical characteristics differed between the two investigations. Over 15 years, the highest recorded temperature has risen by 3.5°C. Furthermore, a decline in the level of dissolved oxygen was observed (TABLE IV). However, different measurement methods for some physicochemical parameters may have caused different results in both studies.

TABLE IV
Comparison of physicochemical parameters and chl–a ($mg \cdot L^{-1}$) value

Studies	Study Years	T (°C)		Salinity (ppt)		pH		Dissolved O_2 ($mg \cdot L^{-1}$)		chl–a ($mg \cdot L^{-1}$)	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Türker–Çakır, 2004	1999–2000	14	23	35.3	39	7.2	8.3	6.9	12.8	–	–
This study	2015–2016	13.5	26.5	29.91	40.66	7.51	8.41	3.83	9.12	0.0037	1.8514

This might have had an impact on the variety of species present. Türker–Çakır [2] found a total of 62 species, while the present research found 57 species. In this investigation, a total of 29 species' eggs or larvae were identified as new reports, as shown in TABLE III. Due to variations in the locations of the stations, general evaluations were regarding the prevalence of eggs and larvae. In the research of Türker–Çakır [2], the abundance of eggs and larvae according to stations were determined as Station–1 5.33·100 m^{-3}, Station–2 5.49·100 m^{-3}, Station–3 9.90·100 m^{-3}, Station–4 38.69·100 m^{-3}, Station–5 14.11·100 m^{-3}, Station–6 6.32·100 m^{-3}, Station–7 45.64·100 m^{-3}, Station–8 5.09·100 m^{-3}, Station–9 7.18·100 m^{-3} and Station–10 34.17·100 m^{-3}. These values vary according to the results of the current study.

CONCLUSION

As can be seen in TABLE VI, eggs or larvae of some species were found for the first time in this study, while the species given by Türker–Çakır were not found in this study. This research shows that in addition to variations in physicochemical parameters, the presence or absence of anthropogenic influences, such as the construction of artificial reefs in the bay, has a substantial impact on biodiversity. The chi-square test for egg and larval abundance also shows that there is a difference both temporally and locally. Regular monthly or seasonal monitoring of ichthyological research can greatly enhance resource management for small-scale fisheries in Edremit Bay.

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Conflicts of interest

The authors declare no conflict of interest.

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