Journal of Anatolian Environmental and Animal Sciences
(*Anadolu Çevre ve Hayvancılık Bilimleri Dergisi*)
https://doi.org/10.35229/jaes.1870337

JAES
Year: 11, 2026 (1-8)
AÇEH
Yıl: 11, 2026 (1-8)

ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Biodiversity of Summer Ichthyoplankton Associated with Coastal *Posidonia oceanica* Beds at Gümüldür (Aegean Sea)

Orçin UYGUN *
Sinop University, Fisheries Faculty, Department of Hydrobiology, Sinop, Türkiye

Received: *23.01.2026* ***Accepted:*** *09.04.2026*

How to cite: **Uygun, O. (2026).** Biodiversity of Summer Ichthyoplankton Associated with Coastal *Posidonia oceanica* Beds at Gümüldür (Aegean Sea). *J. Anatolian Envion. Anim. Sci.*, ***11***, 1-8. https://doi.org/10.35229/jaes.1870337

Atıf yapmak için: **Uygun, O. (2026).** Gümüldür (Ege Denizi) Kıyılarındaki *Posidonia oceanica* Yatakları ile İlişkili Yaz İhtiyoplanktonunun Biyoçeşitliliği. *Anadolu Çev. Hay. Bil. Derg.*, ***11***, 1-8. https://doi.org/10.35229/jaes.1870337

***Corresponding author's:**
Orçin UYGUN
Sinop University, Fisheries Faculty,
Department of Hydrobiology, Sinop, Türkiye
✉: onuygun@gmail.com

Abstract: This study was conducted to determine species diversity, abundance dynamics, and variation in the summer ichthyoplankton assemblage along the Gümüldür coast (İzmir), a significant coastal habitat of the Aegean Sea. Sampling was conducted at five stations in a shallow coastal area characterized by *Posidonia oceanica* seagrass meadows during July and August 2024. As a result of the study, 27 taxa belonging to 18 families were identified. Among the identified taxa, 22 were represented as eggs and 9 as larvae. The taxa dominant in the plankton community were identified as Labridae (70.7%), Engraulidae (7.8%) and Sparidae (5.3%), respectively. The mean abundance was calculated as 7189 ind·1000 m^{-3} for fish eggs and 351 ind·1000 m^{-3} for larvae throughout the study period. The highest mean abundance was recorded for *Coris julis* eggs with 2544 ind·1000 m^{-3} larvae with 78 ind·1000 m^{-3}. *Engraulis encrasicolus* eggs with 558 ind·1000 m^{-3} and larvae with 13 ind·1000 m^{-3}. Among the sampling periods, species diversity reached its peak in the first half of July (S_{max}=13, J'_{max}= 0.96, H'_{max}=2.39). In contrast, during the first half of August, species diversity decreased as the Labridae species became increasingly dominant, even as total abundance peaked. A decline in spawning activity was observed in the second half of August. As the first ichthyoplankton study conducted in Gümüldür, this research emphasizes the importance of the regional seagrass meadows, particularly for ecologically significant demersal fish taxa.

Keywords: Aegean sea, ichthyoplankton, izmir, *Posidonia oceanica*, species diversity.

Gümüldür (Ege Denizi) Kıyılarındaki *Posidonia oceanica* Yatakları ile İlişkili Yaz İhtiyoplanktonunun Biyoçeşitliliği

***Sorumlu yazar:**
Orçin UYGUN
Sinop Üniversitesi, Su Ürünleri Fakültesi,
Hidrobiyoloji Bölümü, Sinop, Türkiye
✉: onuygun@gmail.com

Öz: Bu çalışma, Ege Denizi'nin önemli bir kıyısal habitatı olan Gümüldür kıyıları (İzmir) boyunca yaz dönemi ihtiyoplankton topluluğunun tür çeşitliliğini, bolluk dinamiklerini ve kısa dönemli zamansal değişimini belirlemek amacıyla yürütülmüştür. Örnekleme, Temmuz ve Ağustos 2024 döneminde *Posidonia oceanica* deniz çayırı yatakları ile karakterize edilen sığ kıyısal alandaki beş istasyonda gerçekleştirilmiştir. Çalışma sonucunda, 18 familyaya ait 27 takson tanımlanmıştır. Tanımlanan taksonların 22'si yumurta, 9'u ise larva olarak temsil edilmiştir. İhtiyoplankton topluluğuna baskın olan taksonlar sırasıyla Labridae (%70,7), Engraulidae (%7,8) ve Sparidae (%5,3) olarak tespit edilmiştir. Çalışma dönemi boyunca ortalama bolluk, balık yumurtaları için 7189 yumurta·1000 m^{-3}, larvalar için ise 351 larva·1000 m^{-3} olarak hesaplanmıştır. En yüksek ortalama bolluk değerleri; *Coris julis* yumurtalarında 2544 birey·1000 m^{-3} ve larvalarında 78 birey·1000 m^{-3}; *Engraulis encrasicolus* yumurtalarında 558 birey·1000 m^{-3} ve larvalarında 13 birey·1000 m^{-3} olarak kaydedilmiştir. Zamansal olarak, tür çeşitliliği Temmuz ayının ilk yarısında zirveye ulaşmıştır (Smax=13, J'max= 0,96, H'max=2,39). Buna karşın, Ağustos ayının ilk yarısında toplam bolluk zirve yapmasına rağmen, Labridae türlerinin giderek baskın hale gelmesiyle biyoçeşitlilik azalmıştır. Ağustos ayının ikinci yarısında yumurtlama aktivitesinde bir düşüş gözlenmiştir. Bu çalışma, Gümüldür'de gerçekleştirilen ilk ihtiyoplankton araştırması olup; bölgedeki deniz çayırlarının, özellikle ekolojik açıdan önemli demersal balık taksonları üzerindeki önemini vurgulamaktadır.

Anahtar Kelimeler: Ege denizi, ihtiyoplankton, izmir, *Posidonia oceanica*, tür çeşitliliği.

INTRODUCTION

Coastal marine ecosystems are the foundation of the marine food web because of their high biodiversity and productivity. Within these ecosystems, seagrass meadows (*Posidonia oceanica*) are recognized as important nursery grounds for the early life stages of many fish species. They provide structure, food availability, and protection from predators (Vizzini et al., 2002; Heck et al., 2003; Duffy, 2006). Monitoring ichthyoplankton assemblages in these sensitive habitats serves as an effective method for assessing ecosystem health and understanding fish population dynamics. By providing fishery-independent data, these surveys offer critical insights into adult fish biomass and play a pivotal role in estimating future recruitment success (Ahlstrom, 1965; Govoni, 2005; Cuttitta et al., 2011). In Mediterranean and Aegean Sea ecosystems, fish reproductive strategies are tightly coupled to seasonal environmental cycles. The summer season, in particular, is the most productive period, when spawning activity peaks in many teleost fish species due to rising water temperatures (Tsikliras et al., 2010). Previous studies conducted in different regions of the Aegean Sea (e.g., Izmir Bay, Sığacık Bay) have also documented that ichthyoplankton biodiversity or abundance peaks during the summer period and varies depending on the coastal habitat structure (Ak & Hoşsucu, 2001; Çakır et al., 2005; Uygun & Hoşsucu, 2024).

The study area, the Gümüldür coast (Central Aegean Sea), is a coastal ecosystem rich in biodiversity, characterized by dense *P. oceanica* meadows (Dural et al., 2012) and artificial reefs (Lök et al., 2008). Previous research in the region has documented dense populations of species in the Pomacentridae, Sparidae, and Labridae families, particularly around these artificial reef sites (Ulaş et al., 2007; Lök et al., 2008). The region is also a critical habitat for the early life stages of rare species; for instance, the first record of *Hirundichthys rondeletii* eggs along the Turkish coast was reported from this area (Uygun & Hoşsucu, 2018). These ecological features indicate that the region has significant potential as spawning and nursery grounds for both resident and transient species. Despite this potential, there is no comprehensive study of ichthyoplankton diversity in the region. Due to the limited available literature, the area represents a significant research gap. To address this, we hypothesized that summer ichthyoplankton assemblages over *Posidonia* beds would be dominated by resident demersal taxa rather than pelagic species.

The primary objective of this study is to elucidate the species composition, abundance distribution, and short-term dynamics (in approximately 15-day intervals) of the ichthyoplankton assemblage in the Gümüldür coastal area during the summer season. The data obtained constitute the first baseline dataset documenting the region's importance in fisheries biology.

MATERIAL AND METHOD

Study Area: This study was conducted in the coastal waters of Gümüldür (Central Aegean Sea), between latitudes 38.05°-38.07° N and longitudes 26.99°-27.02° E, located approximately 60 km south of İzmir, in the Kuşadası Bay. The sampling area exhibits distinct benthic habitat characteristics depending on the depth gradient from the shore. While the shallow zone (0-15 m) of the coastline generally has a sandy bottom (Lök et al., 2008), this area is known to be covered by *P. oceanica* meadows, which are critical to the Mediterranean ecosystem (Dural et al., 2012). Visual observations via skin diving in the shallow zones indicated that the seabed is predominantly composed of dense *P. oceanica* meadows, while *Cymodocea nodosa* was present only as occasional patches in the shallow coastal sections of the study area.

Another element enhancing the region's habitat diversity is the artificial reef areas, positioned parallel to the coastline at depths of approximately 18-21 m. There are numerous artificial reef blocks in the region consisting of concrete modules, which are known to provide significant shelter for demersal fish communities (Ulaş et al., 2007; Lök et al., 2008). Previous studies conducted in the area have recorded dense populations of species belonging to the Pomacentridae, Sparidae, and Labridae families around these artificial reef sites (Lök et al., 2008). Although the Gümüldür coast is not under heavy fishing or aquaculture pressure, it is exposed to tourism activities, particularly during the summer months. Nevertheless, it has been reported as one of the productive regions of the Aegean Sea in terms of seagrass productivity (Dural et al., 2012).

Ichthyoplankton surveys were conducted in four distinct periods during the summer of 2024: July (July 17 and 28) and August (August 17 and 25). Sampling was conducted at five stations with depths ranging from 7 to 13 m (Figure 1). Among the sampling sites, Station 1 represents the deepest point (~13 m) along the transect and is situated directly offshore of the Gümüldür Stream (Azmak) outlet, potentially subjecting it to freshwater inputs. In contrast, Station 5 constitutes the shallowest site (~7 m) and is located offshore of the local fishery harbor. The intermediate stations (St 2, St 3, and St 4) characterize the central part of the transect, which is subject to intensive tourism and recreational activities, particularly during the summer season. To facilitate clear temporal tracking in figures and tables without confusion with calendar dates, the sampling events were coded based on their occurrence within the month: Early July (JulE; July 17), Late July (JulL; July 28), Early August (AugE; August 17), and Late August (AugL; August 25). In the text and figures, station numbers are appended directly to these period codes (e.g., JulE1 indicates Station 1 sampled during the early July period).

Sampling and Laboratory Procedures: In the ichthyoplankton survey, a standard plankton net with a mouth diameter of 25 cm and a 500 µm mesh size was used. A total of 20 samples were collected (4 periods × 5 stations). Horizontal surface tows were conducted in a circular path just below the surface (~0.5 m depth) during daytime, at a vessel speed of ~2 knots for a duration of about 10 minutes (Smith & Richardson, 1977). A flowmeter (Hydrobios) was mounted at the center of the net mouth to calculate the volume of filtered water. The collected samples were fixed in a 4% borax-buffered formalin-seawater solution.

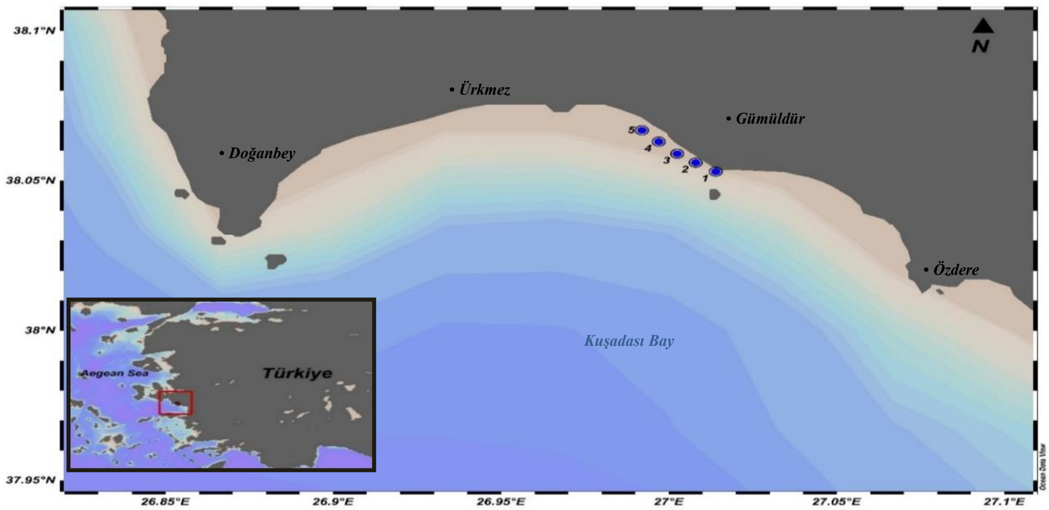

Figure 1. Study area.

In the laboratory, fish eggs and larvae were sorted from other zooplankton groups under a stereomicroscope (Nikon SMZ745T) and identified to the lowest possible taxonomic level. Species identification was performed using keys and descriptions with D'Ancona, (1931-1956), Dekhnik (1973), Russell (1976), Mater and Çoker (2004), Ré and Meneses (2008), and Rodríguez (2017). The taxonomic validity and current scientific nomenclature of the identified fish species were verified according to Eschmeyer's Catalog of Fishes (Fricke et al., 2026).

Data Analyses: The abundance data of the identified species were standardized as the number of individuals per unit volume (ind·1000 m^{-3}) (Smith & Richardson, 1977). To determine species representation within the assemblage, Frequency of Occurrence (FO%) and Dominance (D%) values were calculated for each species. The FO% value was determined by the ratio of the number of samples in which the species was present to the total number of samples, while the D% value was based on the numerical proportion of the species within the assemblage (Bellan-Santini, 1981). Ichthyoplankton diversity was calculated using the Shannon-Weaver (1949) diversity index and Pielou's Evenness Index (1969). To test for differences in assemblage structure between periods and stations, PERMANOVA (Anderson et al., 2008; Clarke & Gorley, 2015) was applied at the significance level $p<0.05$. All analyses were performed using PRIMER v7 software. Spatial distribution maps of ichthyoplankton abundance were generated using Ocean Data View v5.8 (Schlitzer, 2023).

RESULTS AND DISCUSSION

Species Composition: In this study conducted in the Gümüldür coastal area, the species composition of the summer ichthyoplankton assemblage was analyzed, yielding a total of 30 taxonomic categories (Table 1). These included 27 identified taxa belonging to 18 families (22 represented by eggs and 9 by larvae), as well as three unidentified morphotypes (two egg types and one larval form). The mean abundance was calculated as 7189 ind·1000 m^{-3} for fish eggs and 351 ind·1000 m^{-3} for larvae.

Regarding the overall assemblage structure (Figure 2), fish eggs were dominated by the Labridae (70.7%), followed by Engraulidae (7.8%) and Sparidae (5.3%). In contrast, the larval fraction was dominated by Gobiidae (28.5%), Labridae (22.4%), and Sparidae (8.5%). In terms of species richness, Labridae and Sparidae were the most diverse families, each represented by 4 species. At the species level, *Coris julis* was the most frequently encountered species, dominating both egg (35.4%; 2544 ind·1000 m^{-3}) and larval (22.4%; 78 ind·1000 m^{-3}) assemblages. Among the larvae, following *C. julis*, the Gobiidae family, particularly *Pomatoschistus* spp. (21%; 78 ind·1000 m^{-3}), showed high dominance.

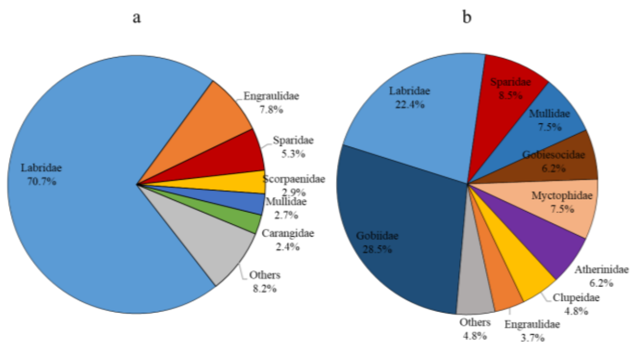

Figure 2. Proportional (%) distribution of families in the assemblage: (a) fish eggs, (b) larvae.

The species composition identified in this study consists entirely of resident taxa typical of the region and shows similarities with previous research conducted in İzmir Bay (Çoker & Mater, 2006; Bayhan & Aydın Uncumusaoğlu, 2022). However, notable differences in dominance patterns are observed when compared to the adjacent Sığacık Bay. According to Uygun and Hoşsucu

(2024), the summer ichthyoplankton in Sığacık Bay is primarily dominated by Sparidae (27%) and Engraulidae (17%) eggs, whereas Labridae represents a smaller fraction (15%). In our study, the clear dominance of Labridae (70.7%) can be attributed to the specific sampling habitat, which is directly situated over shallow *P. oceanica* meadows. While *Engraulis encrasicolus* and *Sardinella aurita* were present in our samples, their abundance was considerably lower than in other regional studies in summer (Ak & Hoşsucu, 2001; Çakır et al., 2005; Uygun & Hoşsucu, 2024). This is expected, as the main spawning grounds of *E. encrasicolus* are known to be concentrated in deeper continental shelf waters rather than the immediate coastal zone (Palomera, 1991; Somarakis et al., 2004; Palomera et al., 2007). Therefore, it is well documented that *P. oceanica* meadows are characteristically dominated by Labridae species (Guidetti, 2000; Kalogirou et al., 2010). Accordingly, the assemblage structure in Gümüldür reflects this habitat-driven pattern, supporting resident demersal groups rather than transient pelagic stocks, which directly confirms our initial hypothesis.

Table 1. List of ichthyoplankton taxa identified in the study area, including mean abundance (ind·1000 m^{-3}), frequency of occurrence (FO%), and dominance (D%).

Family	Species	Code	Frequency of Occurrence (%)		Dominance (%)		Mean abundance (ind·1000m^{-3})	
			Egg	Larvae	Egg	Larvae	Egg	Larvae
Atherinidae	*Atherina boyeri*		0	20	0.0	6.2	0	22
Bothidae	*Arnoglossus* sp.		20	0	0.4	0.0	29	0
Callionymidae	*Callionymus* sp.	Calspp	40	0	2.0	0.0	141	0
Carangidae	*Trachurus mediterraneus*		40	0	0.6	0.0	45	0
	Carangidae	Carsp	60	0	1.8	0.0	130	0
Clupeidae	*Sardinella aurita*	Saraur	40	20	0.8	4.8	56	17
Engraulidae	*Engraulis encrasicolus*	Engenc	80	0	7.8	3.7	558	13
Gobiesocidae	*Diplecogaster bimaculata*		0	20	0.0	6.2	0	22
Gobiidae	*Gobius paganellus*		0	20	0.0	7.5	0	26
	Pomatoschistus sp.	Pomspp	0	60	0.0	21.0	0	74
Labridae	*Coris julis*	Corjul	100	20	35.4	22.4	2544	78
	Symphodus spp.	Symspp	100	0	5.1	0.0	259	0
	Thalassoma pavo	Thapav	80	0	3.3	0.0	236	0
	Labridae spp.	Labspp	100	0	26.9	0.0	1933	0
Mugilidae	*Chelon saliens*		40	0	0.7	0.0	49	0
Mullidae	*Mullus barbatus*	Mulbar	60	20	2.7	7.5	192	26
Myctophidae	*Ceratoscopelus maderensis*		0	20	0	7.5	0	26
Scorpaenidae	*Scorpaena porcus*	Scopor	60	0	2.1	0.0	153	0
	Scorpaena scrofa		60	0	0.8	0.0	58	0
Serranidae	*Serranus* sp.	Serspp	60	0	1.0	0.0	74	0
Soleidae	*Pegusa lascaris*		20	0	0.4	0.0	29	0
Sparidae	*Diplodus annularis*	Dipann	60	40	3.3	8.5	237	30
	Diplodus sp.	Dipspp	40	0	1.1	0.0	76	0
	Sparidae sp.1		40	0	0.7	0.0	54	0
	Spicara sp.		20	0	0.2	0.0	17	0
Synodontidae	*Synodus saurus*		40	0	0.9	0.0	68	0
Trachinidae	*Trachinus draco*		60	0	0.8	0.0	59	0
Unknown	MorphotypeE1		20	0	0.4	0.0	30	0
	MorphotypeE2		60	0	0.8	0.0	54	0
	MorphotypeL1		0	20	0.0	4.8	0	17

Variations in Biodiversity Structure: Analysis of ecological indices revealed significant short-term changes in assemblage structure within the summer period (Figure 3a). Statistical analysis confirmed significant differences between sampling periods (PERMANOVA, Pseudo-F=2.83; df= 3, 14; p= 0.003). The highest biodiversity values were recorded during the first period of July. Specifically, station JulE3 exhibited the highest diversity (H'=2.39) and evenness (J'=0.96), while the highest species richness (S=13) was observed at station JulE1. During this early-summer phase, the assemblage was balanced, with many species and no single dominant group. However, as the season moved into August, the assemblage dynamics changed. Although the highest abundance values were seen in the first period of August (especially at stations AugE4 with 5325 ind·1000 m^{-3} and AugE5 with 5141 ind·1000 m^{-3}), these stations had much lower evenness values (J'=0.50 and 0.65). This difference shows that the sharp increase in abundance was caused by the rapid growth of a single species, not a general increase in productivity. By the end of the season (AugL), both abundance and diversity dropped to minimum levels at almost all stations.

The change in dominant species over time explains these fluctuations (Figure 3b). The high diversity observed in early July (JulE) was supported by pelagic species such as *E. encrasicolus*, which were absent later. As the season progressed, the Labridae family became the dominant group. The shade plot and relative abundance analysis (Figure 4) clearly show that *C. julis* and *Labridae* spp. became very dominant in August, reducing the presence of other species. Importantly, different Labrid species (*C. julis*, *Thalassoma pavo*, and *Symphodus* spp.) dominated at different stations and sampling dates. This pattern suggests a degree of short-term temporal partitioning during the study period. This implies that related species may separate their spawning peaks within the summer season to minimize competition for resources (García-Rubies & Macpherson, 1995; Tsikliras et al., 2010).

a

Sample	S	N	J'	H'
JulE1	13	3532	0.902	2.314
JulE2	9	4560	0.6134	1.348
JulE3	12	1051	0.9631	2.393
JulE4	3	435	0.75	0.824
JulE5	3	443	1	1.099
JulL1	6	2687	0.846	1.516
JulL2	6	2616	0.6691	1.199
JulL3	5	2392	0.4086	0.6576
JulL4	8	3611	0.7203	1.498
JulL5	3	739	0.9464	1.04
AugE1	3	1803	0.5463	0.6002
AugE2	7	844	1	1.946
AugE3	9	1421	0.807	1.773
AugE4	5	5325	0.5058	0.814
AugE5	5	5141	0.6534	1.052
AugL1	1	150	0	0
AugL2	1	83	0	0
AugL3	2	320	0.971	0.673
AugL4	1	118	0	0
AugL5	3	428	1	1.099

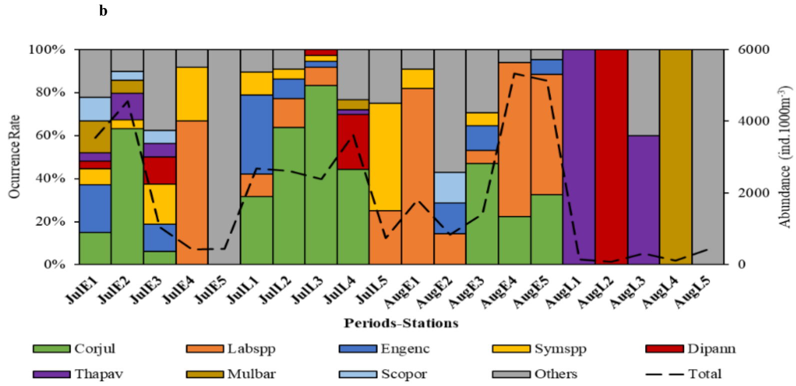

Figure 3. (a) Biodiversity indices in the Gümüldür during the summer period (S: Species richness, N: Abundance [ind·1000 m^{-3}], J': Pielou's evenness, H': Shannon-Wiener diversity), (b) The dominant taxa and the intra-seasonal variation in their relative abundance ratios and total abundance values (dashed line) across stations are shown (Abbreviations: Jul: July, Aug: August, E: Early period, L: Late period of the month, Labels follow the format [Month][Period][Station]; e.g., JulE1 denotes Station 1 sampled during the early July period).

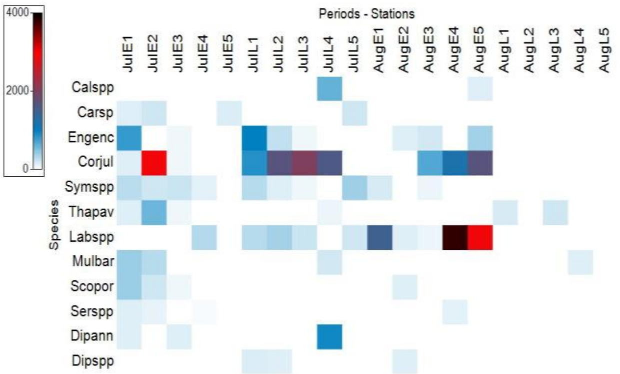

Figure 4. Shade plot showing the variation of dominant ichthyoplankton species across sampling periods. The color scale represents abundance values (ind·1000 m^{-3}) (Abbreviations: Jul: July, Aug: August, E: Early period, L: Late period of the month, Labels follow the format [Month][Period][Station]; e.g., JulE1 denotes Station 1 sampled during the early July period).

Spatial distribution analysis revealed variations in ichthyoplankton density across the sampling stations (Figure 5). Mean abundance values ranged from 1189 to 2318 ind·1000 m^{-3} for eggs and from 30 to 196 ind·1000 m^{-3} for larvae. Although no statistically significant difference in total abundance was found between stations (PERMANOVA, Pseudo-F= 0.87; *df*= 4, 13; *p*= 0.618), a notable spatial pattern in distribution was observed. Specifically, Station 1 exhibited the highest larval abundance (196 ind·1000 m^{-3}). This station is located offshore of the mouth of the Gümüldür Stream (Azmak). River plumes and estuarine fronts are known to be highly productive zones that provide nutrient enrichment, increased prey availability, and retention mechanisms, thereby creating favorable nursery conditions for fish larvae (Grimes & Kingsford, 1996). The higher concentration of larvae at this station suggests that the hydrographic features associated with the stream discharge may support larval survival and aggregation.

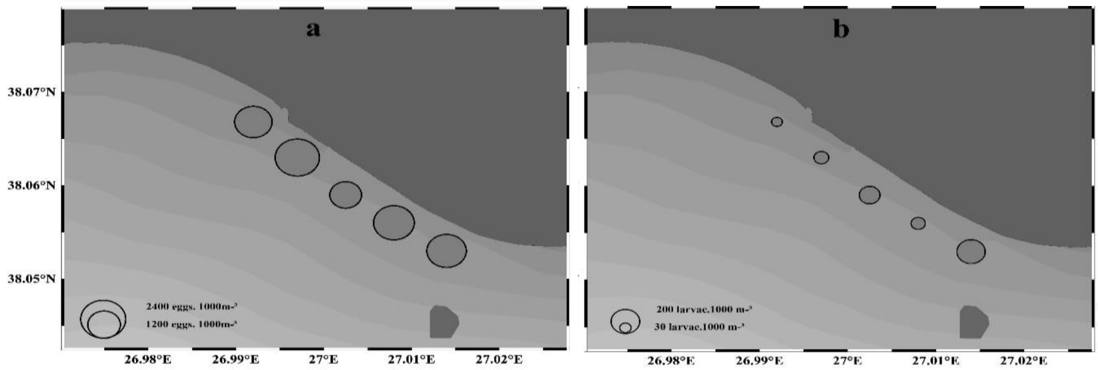

Figure 5. Spatial distribution of mean ichthyoplankton abundance at sampling stations in Gümüldür coast. (a) Fish eggs, (b) Fish larvae. Bubble sizes are proportional to abundance values (ind·1000 m^{-3}).

Habitat Effect: Habitat structure is considered the primary determinant shaping the biodiversity indices and species composition in the study area. Guidetti (2000) emphasized that variations in fish species richness and abundance are primarily related to habitat structure, demonstrating that recruits of species such as *C. julis*, *Symphodus* spp., and *Diplodus annularis* (which were also dominant in our study) prefer *P. oceanica* meadows over bare sandy bottoms (García-Rubies & Macpherson, 1995; Guidetti, 2000; Kalogirou et al., 2010). The dense seagrass meadows in the region provide a sheltered nursery ground that reduces predator pressure for early life stages, thanks to their complex leaf canopy and three-dimensional structure (Heck et al., 2003; Kalogirou et al., 2010).

Furthermore, beyond providing physical shelter, these meadows play a crucial role in enhancing food availability. The epiphytic community and organic matter retention within the *Posidonia* canopy support high densities of small invertebrates, particularly copepods, which constitute the primary prey for developing fish larvae (Vizzini et al., 2002). On the other hand, the protective capacity of this rich habitat should be evaluated within the context of predator-prey dynamics. The same structural complexity that offers refuge also attracts predators such as *Scorpaena* spp. and *Serranus* spp., which were also identified in the present study. This co-occurrence may counteract the sheltering effect by increasing predation pressure on larval and early post-settlement stages (Hindell et al., 2000; Houde, 2008; Başçınar & Sağlam, 2009; Lokovšek et al., 2022).

In addition to this natural seagrass habitat in the shallow zone, artificial reef groups positioned just offshore (18–21 m) enhance the region's habitat diversity (Lök et al., 2008). Artificial reefs are known to create significant shelter, feeding, and spawning grounds, particularly for demersal fish species such as Sparidae and Labridae (Ulaş et al., 2007; Lök et al., 2008). Although sampling in the current study was conducted over shallow *Posidonia* beds, the high density of larvae belonging to these families suggests a probable strong ecological connectivity between the natural seagrass meadows and the adjacent artificial reef systems. In this context, artificial reefs are thought to support not only resident adult stocks but also to expand spawning grounds, thereby facilitating egg and larval transport to adjacent natural habitats and supporting the successful settlement of new generations (Sánchez-Caballero et al., 2024).

Another notable finding of the study is the detection of larvae of *Ceratoscopelus maderensis*, a typical mesopelagic species, despite the shallow coastal character of the sampling site (Table 1). The presence of these deep-water forms in the shallow coastal zone can be explained by the shoreward intrusion of open sea waters and hydrodynamic processes transporting larvae to the coast (Sabatés & Masó, 1990; Uygun & Hoşsucu, 2024). Indeed, the previous report of oceanic *Hirundichthys rondeletii* eggs in the same region (Uygun & Hoşsucu, 2018) supports the existence of open sea-coastal interactions and this hydrodynamic transport hypothesis.

CONCLUSION

This study represents the first research to reveal the summer ichthyoplankton composition of the Gümüldür coast, which is one of the important coastal habitats of the Aegean Sea. The findings suggest that the region possesses significant potential as a spawning and nursery ground, particularly for demersal fish species such as Labridae, Gobiidae, and Sparidae, thanks to the dense *P. oceanica* meadows and adjacent artificial reef systems. Additionally, the presence of commercially important pelagic species, such as anchovy, indicates that the region should also be considered in coastal fisheries management.

In conclusion, the ichthyoplankton assemblage in Gümüldür exhibited a high-diversity and ecologically balanced structure at the beginning of the season (July). However, as the season progressed into August, the assemblage shifted under the dominance of *C. julis* and other Labridae species that utilize the *Posidonia* habitat. Although this study does not reflect the full annual cycle due to its limited focus on the summer period and the shallow coastal zone, it is considered scientifically significant for demonstrating that notable changes in assemblage structure within seagrass meadows occur even over short intervals.

In future studies, extending the sampling period to cover the entire year and simultaneously monitoring biological data alongside physicochemical parameters is critical. This approach is essential for understanding how this fragile coastal ecosystem responds to environmental factors, especially under the increasing pressure of climate change. Furthermore, integrating molecular techniques, such as DNA barcoding, with classical morphological methods is recommended to address identification challenges and ensure taxonomic accuracy in early life stages. As the findings of the current study also indicate, the Gümüldür coastline is a highly significant habitat due to its *Posidonia* beds and its role as a spawning and nursery area for demersal fish communities of high ecological value. For this reason, it is recommended that the region be included in “marine spatial planning” (MSP) processes. This would enable the integrity of the marine ecosystem to be preserved whilst supporting sustainable fishing activities.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Hüseyin Uygun for his support in the fieldwork.

STATEMENTS AND DECLARATIONS

Author Contribution Statement: Orçin UYGUN: Writing-original draft, Investigation, Methodology, Conceptualization, Writing -review and editing, Data Curation, Formal Analysis, Visualization, Supervision; The author has read and agreed to the published version of the manuscript.

Conflicts of interest: The author declares no conflict of interest.

Declaration of AI use: During the preparation of this work, the author used Google Gemini to improve

language and readability, and for translation assistance. This usage falls under the category of linguistic refinement and editing. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the article's content.

REFERENCES

Ahlstrom, E.H. (1965). Kinds and abundance of fishes in the California Current region based on egg and larval surveys. CALCOFI Rep., 10: 31-37 pp.

Ak, Y., & Hoşsucu, B. (2001). İzmir Körfezi Kemikli Balıklarına Ait Pelajik Yumurta ve Larvaların Tür Çeşitliliği, Dağılımı ve Bolluğu. *Ege Journal of Fisheries and Aquatic Sciences*, ***18***(1). https://izlik.org/JA72SW49DR

Anderson, M.J., Gorley, R., & Clarke, K.R. (2008). *PERMANOVA+ for PRIMER: Guide to software and statistical methods*. Primer-E: Plymouth, UK

Başçınar, N.S., & Sağlam, H. (2009). Feeding habits of black scorpionfish *Scorpaena porcus*, in the South-Eastern Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences,* ***9***(1), 99-103. https://izlik.org/JA78WG63AZ

Bayhan, B. & Aydın Uncumusaoğlu, A. (2022). Length-Weight and Length-Length Relationships of the Main Commercial Fish Species in Izmir Bay (Aegean Sea Coast of Turkey) / 2020-2021 Fishing Season. *J. Anatolian Env. and Anim. Sciences*, *7*(3), 380-384. https://doi.org/10.35229/jaes.1115364

Bellan-Santini, D. (1981). Influence des pollutions sur le peuplement des amphipodes dans la biocénose des algues photophiles. *Tethys*, ***10***, 185–194.

Clarke, K.R., & Gorley, R.N. (2015). *PRIMER v7: User Manual/Tutorial.* PRIMER-E.

Cuttitta, A., Zgozi, S., Bonanno, A., Basilone, G., Turki, A., Patti, B., Gmati, H., Buscaino, G., Hamza, M., Caruana, L., Patti, C., Mazzola, S., Tirelli, V., Borme, D., Amato, M., & Borghi, M., (2011). *Identification sheets of early life stages of bony fish (Western Libya, Summer 2006)*. MedSudMed Technical Documents. Rome. ***18***, 251.

Çakır, D.T., Örek, Y.A., Hoşsucu, B., Sever, T.M., & Sunlu, U. (2005). İzmir İç Körfezi İhtiyoplankton Kompozisyonu. *Ege Journal of Fisheries and Aquatic Sciences*, ***22***(3), 317-323. https://izlik.org/JA44JZ43WP

Çoker, T., & Mater, S. (2006). İzmir Körfezi İhtiyoplanktonu (1974-2005) Türleri. *Ege Journal of Fisheries and Aquatic Sciences,* ***23***(3), 463-472. https://izlik.org/JA29LZ73WJ

D'Ancona, U. (1931-1956). *Clupeoidei, in Uova, larve e stadi giovanili di Teleostei, Fauna Flora Golfo di Napoli. Pub. Stazione Zoologica Di Napoli*. Monographia 38. part I-Ü-İİİ 1064 p. Napoli.

Dekhnik, T.V. (1973). *Ichthyoplankton of the Black Sea*. Cernova Moria Haukova.

Duffy, J.E. (2006). Biodiversity and the functioning of seagrass ecosystems. *Marine Ecology Progress Series*, ***311***, 233-250. https://doi.org/10.3354/meps311233

Dural, B., Aysel, V., Demir, N., & Erduğan, H. (2012). The status of sensitive ecosystems along the Aegean coast of Turkey: *Posidonia oceanica* (L.) Delile meadows. *Journal of Black Sea/Mediterranean Environment*, ***18***(3), 360-379. https://izlik.org/JA74YP97GN

Fricke, R., Eschmeyer, W.N., & Van der Laan, R. (eds) (2026). Eschmeyer's Catalog of Fishes: Genera, Species, References. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Electronic version accessed 18 Mar 2026.

García-Rubies, A., & Macpherson, E. (1995). Substrate use and temporal pattern of recruitment in juvenile fishes of the Mediterranean littoral. *Marine Biology*, ***124***(1), 35-42. https://doi.org/10.1007/BF00349144

Govoni, J.J. (2005). Fisheries oceanography and the ecology of early life histories of fishes: a perspective over fifty years. *Scientia Marina*, ***69***(S1), 125-137. https://doi.org/10.3989/scimar.2005.69s1125

Grimes, C.B., & Kingsford, M.J. (1996). How do riverine plumes of different sizes influence fish larvae: do they enhance recruitment? *Marine and Freshwater Research*, ***47***(2), 191-208. https://doi.org/10.1071/MF9960191

Guidetti, P. (2000). Differences among fish assemblages associated with nearshore Posidonia oceanica seagrass beds, rocky–algal reefs and unvegetated sand habitats in the Adriatic Sea. *Estuarine, Coastal and Shelf Science*, ***50***(4), 515-529. https://doi.org/10.1006/ecss.1999.0584

Heck Jr, K.L., Hays, G., & Orth, R.J. (2003). Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series,* ***253***, 123-136. https://doi.org/10.3354/meps253123

Hindell, J.S., Jenkins, G.P., & Keough, M.J. (2000). Evaluating the impact of predation by fish on the assemblage structure of fishes associated with seagrass (*Heterozostera tasmanica*)(Martens ex Ascherson) den Hartog, and unvegetated sand habitats. *Journal of Experimental Marine Biology and Ecology*, ***255***(2), 153-174. https://doi.org/10.1016/S0022-0981(00)00289-6

Houde, E.D. (2008). Emerging from Hjort's Shadow. *Journal of Northwest Atlantic Fishery Science,* ***41***, 53-70. https://doi.org/10.2960/J.v41.m634

Kalogirou, S., Corsini-Foka, M., Sioulas, A., Wennhage, H., & Pihl, L. (2010). Diversity, structure and function of fish assemblages associated with *Posidonia oceanica* beds in an area of the eastern Mediterranean Sea and the role of non-indigenous species. *Journal of Fish Biology*, *77*(10), 2338-2357. https://doi.org/10.1111/j.1095-8649.2010.02817.x

Lokovšek, A., Orlando-Bonaca, M., Trkov, D., & Lipej, L. (2022). An insight into the feeding ecology of *Serranus scriba*, a shallow water mesopredator in the northern Adriatic Sea, with a non-destructive method. *Fishes*, *7*(4), 210. https://doi.org/10.3390/fishes7040210

Lök, A., Gül, B., Ulaş, A., Düzbastılar, F. O., & Metin, C. (2008). Diel variations on the fish assemblages at artificial reefs in two different environments of the Aegean Sea (Western Coast of Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, ***8***(1), 79-085. https://izlik.org/JA38EL73XE

Mater, S., & Çoker, T. (2004). *Türkiye denizleri ihtiyoplankton atlası*. Bornova, İzmir, Turkey, Ege Üniversitesi Basımevi (in Turkish).

Palomera, I. (1991). Spawning of anchovy *Engraulis encrasicolus* in the Northwestern Mediterranean relative to hydrographic features in the region. *Marine Ecology Progress Series*, ***79***, 215-223. https://doi.org/10.1016/j.pocean.2007.04.012

Palomera, I., Olivar, M. P., Salat, J., Sabatés, A., Coll, M., García, A., & Morales-Nin, B. (2007). Small pelagic fish in the NW Mediterranean Sea: an ecological review. *Progress in Oceanography, 74*(2-3), 377-396. https://doi.org/10.1016/j.pocean.2007.04.012

Pielou, E.C., 1969. *An introduction to mathematical ecology*, Wiley, Interscience, NewYork.

Ré, P., & Meneses, I., (2008). *Early Stages Of Marine Fishes Occurring in The Iberian Peninsula*. IPIMAR/IMAR: 282 p. ISBN-978-972-9372-34-6

Rodríguez, J.M., Alemany, F., & Garcia, A. (2017). *A guide to the eggs and larvae of 100 common Western Mediterranean Sea bony fish species*. FAO. Rome, Italy. pp 256.

Russell, F.S. (1976). *The Eggs And Planktonic Stages Of British Marine Fishes*, Academic Press, London, 524 pp.

Sabatés, A., & Masó, M. (1990). Effect of a shelf-slope front on the spatial distribution of mesopelagic fish larvae in the western Mediterranean. *Deep Sea Research Part A. Oceanographic Research Papers*, *37*(7), 1085-1098. https://doi.org/10.1016/0198-0149(90)90052-W

Sánchez-Caballero, C.A., Borges-Souza, J.M., Saldierna-Martínez, R.J., & Abelson, A. (2024). Assessing the Conservation Value of Artificial and Natural Reefs via Ichthyoplankton Spatio-Temporal Dynamics. *Fishes, 9*(5), 166. https://doi.org/10.3390/fishes9050166

Schlitzer, R. (2023). Ocean Data View, https://odv.awi.de

Shannon, C.E., & Weaver, V. (1949). *A mathematical theory of communication*. University Press.

Smith, P.E., & Richardson, S. (1977). *Standard techniques for pelagic fish egg and larva surveys* (FAO Fisheries Technical Paper No. 175). Food and Agriculture Organization of the United Nations.

Somarakis, S., Palomera, I., Garcia, A., Quintanilla, L., Koutsikopoulos, C., Uriarte, A., & Motos, L. (2004). Daily egg production of anchovy in European waters. *ICES Journal of Marine Science.* ***61***(6), 944-958. https://doi.org/10.1016/j.icesjms.2004.07.018

Tsikliras, A.C., Antonopoulou, E., & Stergiou, K.I. (2010). Spawning period of Mediterranean marine fishes. *Reviews in Fish Biology and Fisheries,* ***20***(4), 499-538. https://doi.org/10.1007/s11160-010-9158-6

Ulaş, A., Düzbastılar, F.O., Lök, A., & Metin, C. (2007). Yapay Resiflerde Balık Örnekleme Yöntemlerinin Etkinliğinin Belirlenmesi Üzerine Bir Ön Çalışma. *Ege Journal of Fisheries and Aquatic Sciences*, ***24***(3), 287-293. https://izlik.org/JA82NA55PH

Uygun, O., & Hoşsucu, B. (2018). The first record of the eggs of black wing flyingfish *Hirundichthys rondeletii* (Valenciennes, 1846) in the Turkish nearshores of the Aegean Sea (Gümüldür). *Turkish Journal of Zoology,* ***42***(1), 121-125. https://doi.org/10.3906/zoo-1707-10

Uygun, O., & Hoşsucu, B. (2024). Temporal dynamics of the ichthyoplankton assemblages in the central Aegean Sea during one year and the effects of ecological factors. *Regional Studies in Marine Science*, ***72***, 103439. https://doi.org/10.1016/j.rsma.2024.103439

Vizzini, S., Sara, G., Michener, R.H., & Mazzola, A.J.A.O. (2002). The role and contribution of the seagrass *Posidonia oceanica* (L.) Delile organic matter for secondary consumers as revealed by carbon and nitrogen stable isotope analysis. *Acta Oecologica*, *23*(4), 277-285. https://doi.org/10.1016/S1146-609X(02)01156-6