



Fish Diversity and Abundance in the Seyhan River Estuary, Mediterranean Sea Basin, Turkey

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Abstract: The aim of the present study was to explore the seasonal changes in the fish assemblage composition in relation to density and species number in a shallow Mediterranean estuary of Anatolia. Fishes were sampled seasonally at three sites located in the main channel of the Seyhan River Estuary from December 2014 to June 2017 (11 sampling events). In total, 6950 individuals of 30 species were captured. The family Mugilidae was represented by six species of three genera. *Liza aurata*, *L. saliens* and *Gambusia holbrooki* were the dominant species and comprised over 60% of the total abundance. The fish fauna comprised 20 marine, six freshwater, two migrant and two brackish species. Fish community structure estimated by the ecological diversity indices showed variations between stations and seasons. This study also provided information about abiotic parameters of the estuarine ecosystem.

Key words: fish assemblage, salinity, estuary, Seyhan, Mediterranean

Introduction

The fish fauna in river ecosystems in the Mediterranean Region is diverse (DE FIGUEROA et al. 2013). The status and ecology of fish species in these systems have been characterised in various recent studies (BIANCO 1995, APARICIO et al. 2000, SMITH & DARWALL 2006, FRICKE et al. 2007, HERMOSO & CLAVERO 2011, ALMODÓVAR et al. 2012). In the Mediterranean part of Turkey, there are many river systems with different physical and chemical properties (AKBULUT et al. 2009). Data on fish species composition were available for river systems in Antalya (KÜÇÜK & IKIZ 2004), Göksu River (KÜÇÜK et al. 2007), Seyhan and Ceyhan River basins (ERK'AKAN & ÖZDEMİR 2011), Büyük Menderes River (GÜÇLÜ et al. 2013), Gediz River (GÜÇLÜ & KÜÇÜK 2015). Although there are many studies related to fish fauna of freshwater zones of river systems in Turkey, there are limited studies about estuarine zones.

The Seyhan River is one of the longest rivers in Turkey. The fish fauna of the Seyhan River is characterised by a high level of endemism. ERK'AKAN & ÖZDEMİR (2011) reported 29 fish species and one subspecies from this river basin. Eight of these species are endemic. The available information on the freshwater fishes of Seyhan is mostly on systematics and distribution (ERK'AKAN & ÖZDEMİR 2011, ERGÜDEN & GÖKSU 2012, TURAN et al. 2013, KÜÇÜK et al. 2017, ÇEVİK et al. 2018).

The ecology of the Seyhan River Basin has considerably changed in the last decade due to human activities, which have resulted in decreased water quality and quantity (personal communication of the local authorities). Limited data are available in the literature on the distributions of estuarine fish fauna from the Mediterranean Estuaries in Turkey. *Equulites klunzingeri* and *Hemigrammocapoeta culiciphaga* have been recorded from the Seyhan River Estuary (INNAL et al. 2015, 2016). No detailed and comprehensive findings are available on diversity of

fishes and their abundance in this estuary. The present study aimed to describe the status of estuarine fish assemblages across seasons.

Materials and Methods

Sampling sites and data collection

The Seyhan River is the longest river in Turkey that flows into the Mediterranean Sea. The river is 560 km long, flowing south-west from its headwaters in the Tahtalı Mountains (in Sivas and Kayseri Provinces) in the Anti-Taurus Mountains to the Mediterranean Sea via a broad delta. Totally, 6950 fish specimens were caught throughout the study. Fish were collected seasonally between December 2014 and June 2017 (11 sampling events) with gill nets of various mesh sizes (310 m total long; 10, 17, 23, 30 mm stretch mesh sizes), fish traps and fyke nets. Three sampling stations were selected in different parts of the estuary (Fig. 1): Site 1 – lower zones (36°43'53.07 N, 34°54'55.05 E); Site 2 – middle zone (36°44'25.87N, 34°56'13.20 E); Site 3 – upper zone (36°44'57.15 N, 34°57'26.89 E). These sites represented different distances from the Mediterranean Sea. They had similar geophysical and flow characteristics. Mean depth varied from 1.2 to 9.6 m depending upon the estuary location. The Seyhan River Estuary is characterised by sand-mud and mud sediments.

Water quality parameters (Table 1) were measured at each survey site. Temperature (C), salinity, pH and oxygen concentration were determined using WTW 340*i*. Transparency was estimated by a Secchi disk. Captured fishes were anaesthetised, then fixed in 4% formalin in the field. Morphological and morphometrical features of the specimens were used for species identification following

AKSIRAY (1987) and GELDIAY & BALIK (1988). Classification of the systematic position of fish species in the Seyhan River was according the Catalog of Fishes (Eschmeyer's Catalog of Fishes). Fish species were categorised in terms of salinity preference and migratory behaviour into marine, migratory, estuarine and freshwater (ARAUJO et al. 1999). Exotic and native taxa were classified following INNAL & ERK'AKAN (2006). Information on the conservation status of the taxa was retrieved from the International Union for Conservation of Nature (IUCN) accessed on 8–10 March 2019.

Data analysis

The frequency and the abundance of fish species was ascertained according to SISLI (1996): Abundance % = $[\text{Ni}/\text{Nt}] \times 100$, where Ni was the number of specimens of the species and Nt was the total number of specimens; Frequency % = $[\text{Nx}/\text{N}] \times 100$, where Nx was the number of samples of the species and N was the total number of samples. The fish community structure was characterised using either the species richness S (total number of species obtained at each sampling) or the Shannon-Wiener Diversity Index H' . Distribution of individuals was measured by the uniformity or "Evenness Index, J" (MAGURAN 1988). Water quality parameters were analysed using ANOVA to measure the significant difference among sampling sites.

Results

Environmental parameters

Water temperature of the Seyhan Estuary was in the range 9.8–32.2°C and did not differ significantly between sites (Table 1). Values of Secchi depth did not show a strong seasonal pattern; the

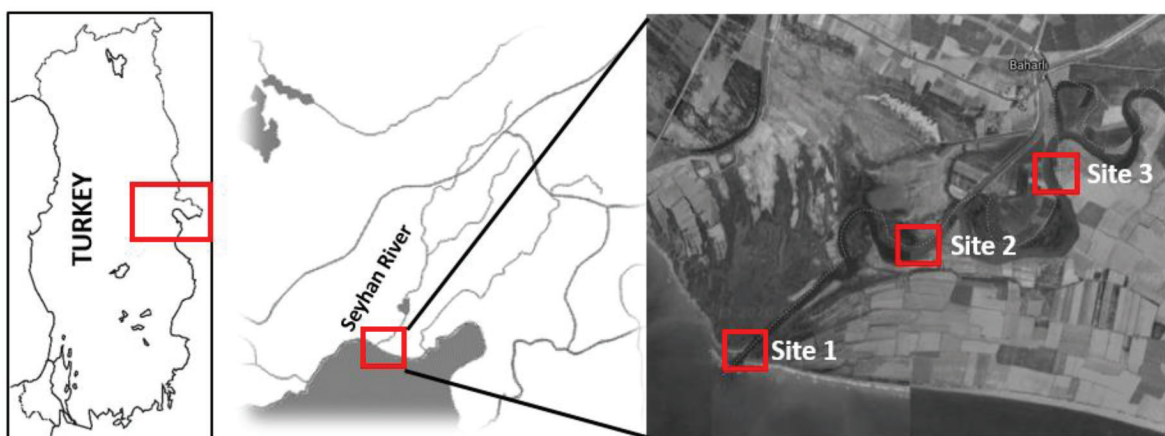


Fig. 1. Map of Turkey showing the sampling locality (Seyhan River) and the sampling sites.

Table 1. Water quality parameters of the Seyhan Estuary, December 2014 – June 2017.

Date	Temperature (°C)			pH			Dissolved oxygen (mg/l)			Salinity (ppt)			Secchi (m)		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Dec 14	19.5	18.5	17	6.8	6.7	6.3	4.5	2	0.5	29.5	27	15.9	0.5	0.5	0.5
Feb 15	12	12.3	10.9	6.4	6.8	7.1	8.3	8.6	9	0.3	0.3	0.2	0.5	0.6	0.6
May 15	23	24.4	23.1	7.2	7.5	7.5	4.4	5.3	6.8	27	2	0.2	0.5	0.5	0.6
Aug 15	31.1	30.8	31	6.6	6.4	6.2	0.2	2.1	2	25.7	22.5	20.2	0.5	0.5	0.6
Dec 15	18.3	18.9	18.2	8.3	8.1	10	3.3	2.4	0.6	28.9	20.8	18.2	0.6	0.5	0.4
Feb 16	10	9.9	9.8	7.8	7.8	7.9	6.7	6.8	5.5	0.2	0.2	0.2	0.3	0.3	0.3
May 16	22.3	22.5	22.6	8	8	7.9	1.7	2.2	0.8	17.9	17.4	15	0.4	0.4	0.4
Aug 16	31.6	30.8	32.2	8.4	8.4	8.5	3.9	1.2	2.5	28	1.1	2.8	0.5	0.5	0.5
Dec 16	15.2	10.1	10	7.3	7.2	7.3	8.5	9.7	7.5	29.7	0.5	0.8	0.5	0.4	0.4
Apr 17	15.1	14.4	14	7.3	7.4	7.4	7.5	4.2	5.7	0.3	0.4	0.3	0.6	0.5	0.6
Jun 17	27.8	24.9	24.9	7.2	7.4	7.3	2	1.3	1.3	35.6	0.4	0.4	0.4	0.5	0.5
Min	10	9.9	9.8	6.4	6.4	6.2	0.2	1.2	0.5	0.2	0.2	0.2	0.3	0.3	0.3
Max	31.6	30.8	32.2	8.4	8.4	10	8.5	9.7	9	35.6	27	20.2	0.6	0.6	0.6
Mean	20.5	19.8	19.4	7.4	7.4	7.6	4.6	4.2	3.8	20.3	8.4	6.7	0.5	0.5	0.5

mean values varied from a minimum of 0.3 m to a maximum of 0.6 m and were not significantly different between sites. Salinity values ranged from 0.2 to 35.6. Salinity showed a spatial gradient along the length of the estuary, decreasing progressively from the river mouths (Site 1) to the upstream sites. This decrease was statistically significant ($p < 0.05$). Mean monthly pH values did not show a strong seasonal pattern and were not significantly different between sites. Concentrations of dissolved oxygen varied from a minimum of $0.2 \text{ mg} \cdot \text{l}^{-1}$ to a maximum of $9.7 \text{ mg} \cdot \text{l}^{-1}$ and were not significantly different between sites.

Fish community composition

Thirty fish species of 18 families were recorded in the Seyhan Estuary (Table 2). The family Mugilidae was the most species-rich family represented by six species. It was followed by the family Cyprinidae (four species) as well as four families each represented by two species (Clupeidae, Gobiidae, Sciaenidae and Sparidae). Each of the remaining families (Anguillidae, Atherinidae, Carangidae, Cichlidae, Cyprinodontidae, Engraulidae, Leiognathidae, Moronidae, Poeciliidae, Soleidae, Syngnathidae and Trachinidae) was represented by one species.

Species of the family Mugilidae were among the most abundant (Table 3), accounting for 69.08% of the total catch. The golden grey mullet *Liza aurata* was the dominant species (25.99%), followed by *L. saliens* (20.14%), *L. ramada* (11.54%) and *Mugil*

cephalus (8.12%). *Liza saliens* and *M. cephalus* were present throughout the whole sampling period.

The marine species of the Seyhan Estuary, with 20 species (66.7%), had the highest abundance (71.77%). The freshwater species, with six species (20%), accounted for 20.16% of the abundance. Two migrant species represented 0.37% of the total abundance. Two estuarine-dependent species represented 7.7% of the total abundance.

In the Seyhan River, 10% of fish species were threatened. Among them, 3.33% were critically endangered and 6.7% were vulnerable.

Five introduced species (*Carassius gibelio*, *Oreochromis niloticus*, *Gambusia holbrooki*, *Equulites klunzingeri* and *Liza carinata*) comprised 21.48% of the catches in terms of number of specimens.

Spatial and temporal variation in fish abundance and species richness

The values of the diversity index exhibited a strong spatial (Fig. 2) and temporal (Fig. 3) variation throughout the study. The number of species varied from six (December 2016) to 19 (May 2015) at the stations of the Seyhan Estuary. The number of specimens varied from 150 (April 2017) to 1558 (August 2015). The highest H' value was found at Site 1. Based on the Shannon-Wiener's diversity index, the highest ecological diversity was recorded in May 2015 (2.30) and the lowest in December 2016 (1.29).

Table 2. List of fish taxa in the Seyhan Estuary, December 2014 – June 2017.

No	Species	Family	Order	Origin	Habitat	Threat status
1	<i>Acanthobrama orontis</i>	Cyprinidae	Cypriniformes	Native	Freshwater	Not evaluated
2	<i>Alosa fallax</i>	Clupeidae	Clupeiformes	Native	Migrant	Least concern
3	<i>Anguilla anguilla</i>	Anguillidae	Anguilliformes	Native	Migrant	Critically endangered
4	<i>Aphanius fasciatus</i>	Cyprinodontidae	Cyprinodontiformes	Native	Estuarine dependent	Least concern
5	<i>Argyrosomus regius</i>	Sciaenidae	Perciformes	Native	Marine	Least concern
6	<i>Atherina boyeri</i>	Atherinidae	Atheriniformes	Native	Marine	Least concern
7	<i>Carassius gibelio</i>	Cyprinidae	Cypriniformes	Alien	Freshwater	Not evaluated
8	<i>Chelon labrasus</i>	Mugilidae	Mugiliformes	Native	Marine	Least concern
9	<i>Cyprinus carpio</i>	Cyprinidae	Cypriniformes	Native	Freshwater	Vulnerable
10	<i>Dicentrarchus labrax</i>	Moronidae	Perciformes	Native	Marine	Least concern
11	<i>Engraulis encrasicolus</i>	Engraulidae	Clupeiformes	Native	Marine	Least concern
12	<i>Equulites klunzingeri</i>	Leiognathidae	Perciformes	Alien	Marine	Not evaluated
13	<i>Gambusia holbrooki</i>	Poeciliidae	Cyprinodontiformes	Alien	Freshwater	Least concern
14	<i>Gobius niger</i>	Gobiidae	Perciformes	Native	Marine	Least concern
15	<i>Garra culiciphaga</i>	Cyprinidae	Cypriniformes	Native	Freshwater	Least concern
16	<i>Lithognathus mormyrus</i>	Sparidae	Perciformes	Native	Marine	Least concern
17	<i>Liza aurata</i>	Mugilidae	Mugiliformes	Native	Marine	Least concern
18	<i>Liza carinata</i>	Mugilidae	Mugiliformes	Alien	Marine	Not evaluated
19	<i>Liza ramada</i>	Mugilidae	Mugiliformes	Native	Marine	Least concern
20	<i>Liza saliens</i>	Mugilidae	Mugiliformes	Native	Marine	Least concern
21	<i>Mugil cephalus</i>	Mugilidae	Mugiliformes	Native	Marine	Least concern
22	<i>Oreochromis niloticus</i>	Cichlidae	Perciformes	Alien	Freshwater	Not evaluated
23	<i>Pomatoschistus anatoliae</i>	Gobiidae	Perciformes	Native	Estuarine dependent	Not evaluated
24	<i>Sardinella madarensis</i>	Clupeidae	Clupeiformes	Native	Marine	Vulnerable
25	<i>Solea solea</i>	Soleidae	Pleuronectiformes	Native	Marine	Data Deficient
26	<i>Sparus aurata</i>	Sparidae	Perciformes	Native	Marine	Least concern
27	<i>Syngnathus acus</i>	Syngnathidae	Syngnathiformes	Native	Marine	Least concern
28	<i>Trachinotus ovatus</i>	Carangidae	Perciformes	Native	Marine	Least concern
29	<i>Trachinus araneus</i>	Trachinidae	Perciformes	Native	Marine	Least concern
30	<i>Umbrina cirrosa</i>	Sciaenidae	Perciformes	Native	Marine	Not evaluated

Discussion

The present study is the first attempt to analyse the ichthyofaunal composition of the Seyhan River Estuary. According to this study, 30 species permanently or temporarily occupy the study area. The number of fish species recorded here was lower than those reported for the Köyceğiz Lagoon Estuary system (Turkey, Aegean Sea, see AKIN et al. 2005), Richmond River Estuary (Australia, Coral Sea, 64 species) and Clarence River Estuary (Australia, Coral Sea, 66 species) (WEST & WALFORD 2000) and Strymon River Estuary (Greece, Aegean Sea, 43 species) (KOUTRAKIS et al. 2000). On the other hand, it was higher than that observed for

the Kakanui River Estuary (New Zealand, Pacific Ocean, 20 species) (JELLYMAN et al. 1997), Solway Estuary (England, 22 species) (ELLIOTT & DEWAILLY 1995), Waitaki River Estuary (New Zealand, Pacific Ocean, 16 species), Clutha River Estuary (New Zealand, Pacific Ocean, 14 species), Waiau River Estuary (New Zealand, Pacific Ocean, 14 species) and Mohaka River Estuary (New Zealand, Pacific Ocean, 13 species) (JELLYMAN et al. 1997), Kundu Creek Estuary (Turkey, Mediterranean Sea) (INNAL & Özdemir 2012), Köprüçay River Estuary (Turkey, Mediterranean Sea) (INNAL 2012) and Aksu River Estuary (Turkey, Mediterranean Sea) (INNAL 2016). Comparisons of species number between different estuaries are difficult because

Table 3. Total abundance of fishes caught in the Seyhan Estuary in December 2014 – June 2017. Life stages: 1 – juvenile + adult individuals, 2 – only adult individuals, 3 – only juveniles.

Species	Life stages	N	% N	Frequency (%)
<i>Acanthobrama orontis</i>	2	10	0.14	27.27
<i>Anguilla anguilla</i>	1	15	0.22	54.55
<i>Aphanius fasciatus</i>	1	5	0.07	18.18
<i>Atherina boyeri</i>	1	6	0.09	27.27
<i>Carassius gibelio</i>	1	244	3.51	54.55
<i>Chelon labrasus</i>	1	133	1.91	81.82
<i>Dicentrarchus labrax</i>	1	59	0.85	72.73
<i>Gambusia holbrooki</i>	1	1023	14.72	63.64
<i>Garra culiciphaga</i>	1	17	0.24	18.18
<i>Liza aurata</i>	1	1806	25.99	90.91
<i>Liza ramada</i>	1	802	11.54	90.91
<i>Liza saliens</i>	1	1400	20.14	100
<i>Mugil cephalus</i>	1	564	8.12	100
<i>Pomatoschistus anatoliae</i>	1	530	7.63	72.73
<i>Solea solea</i>	1	33	0.47	45.45
<i>Syngnathus acus</i>	1	2	0.03	9.09
<i>Alosa fallax</i>	2	11	0.16	27.27
<i>Argyrosomus regius</i>	2	11	0.16	36.36
<i>Cyprinus carpio</i>	2	12	0.17	27.27
<i>Engraulis encrasicolus</i>	2	8	0.12	27.27
<i>Gobius niger</i>	2	1	0.01	9.09
<i>Lithognathus mormyrus</i>	2	6	0.09	9.09
<i>Liza carinata</i>	2	96	1.38	54.55
<i>Oreochromis niloticus</i>	2	95	1.37	63.64
<i>Sardinella madarensis</i>	2	1	0.01	9.09
<i>Trachinotus ovatus</i>	2	2	0.03	18.18
<i>Trachinus araneus</i>	2	1	0.01	9.09
<i>Umbrina cirrosa</i>	2	20	0.29	27.27
<i>Equulites klunzingeri</i>	3	35	0.5	18.18
<i>Sparus aurata</i>	3	2	0.03	9.09

sampling sites and sampling methods vary. Occurrence, distribution and movement of fishes in estuary systems are certainly determined by a complex combination of both biotic and abiotic factors (MARTINO & ABLE 2003, JAUREGUIZAR et al. 2006, SOSA-LO'PEZ et al. 2007).

Of the 30 species recorded in the Seyhan Estuary, 20 are marine, six are freshwater, two are estuarine species and two are migrating in and off the river during their life cycle. The fish fauna of the Seyhan Estuary was mainly composed of marine species in terms of number of species. Similar re-

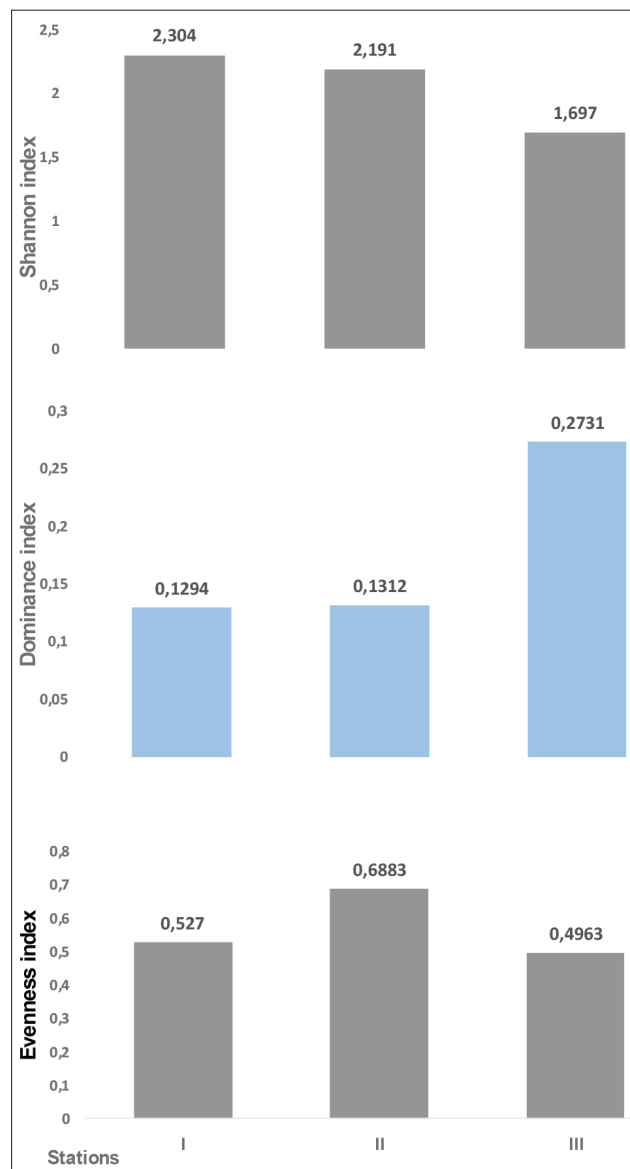


Fig. 2. Spatial variation of the diversity indices across stations in the Seyhan Estuary, December 2014 – June 2017.

sults were reported for other estuaries (THIEL & POTTER 2001, AKIN et al. 2005).

Based on the orders, the percentage analysis identifies the highest occurrence of the Mugiliformes and the Perciformes. The species composition shows that the Mugilidae (20%) and Cyprinidae (13.3%) constitute the dominant fish families. The dominance of the families Mugilidae and Cyprinidae in terms of species number has been reported from other Mediterranean rivers, which is compatible with the results of this study (INNAL & OZDEMIR 2012, INNAL 2012, 2016).

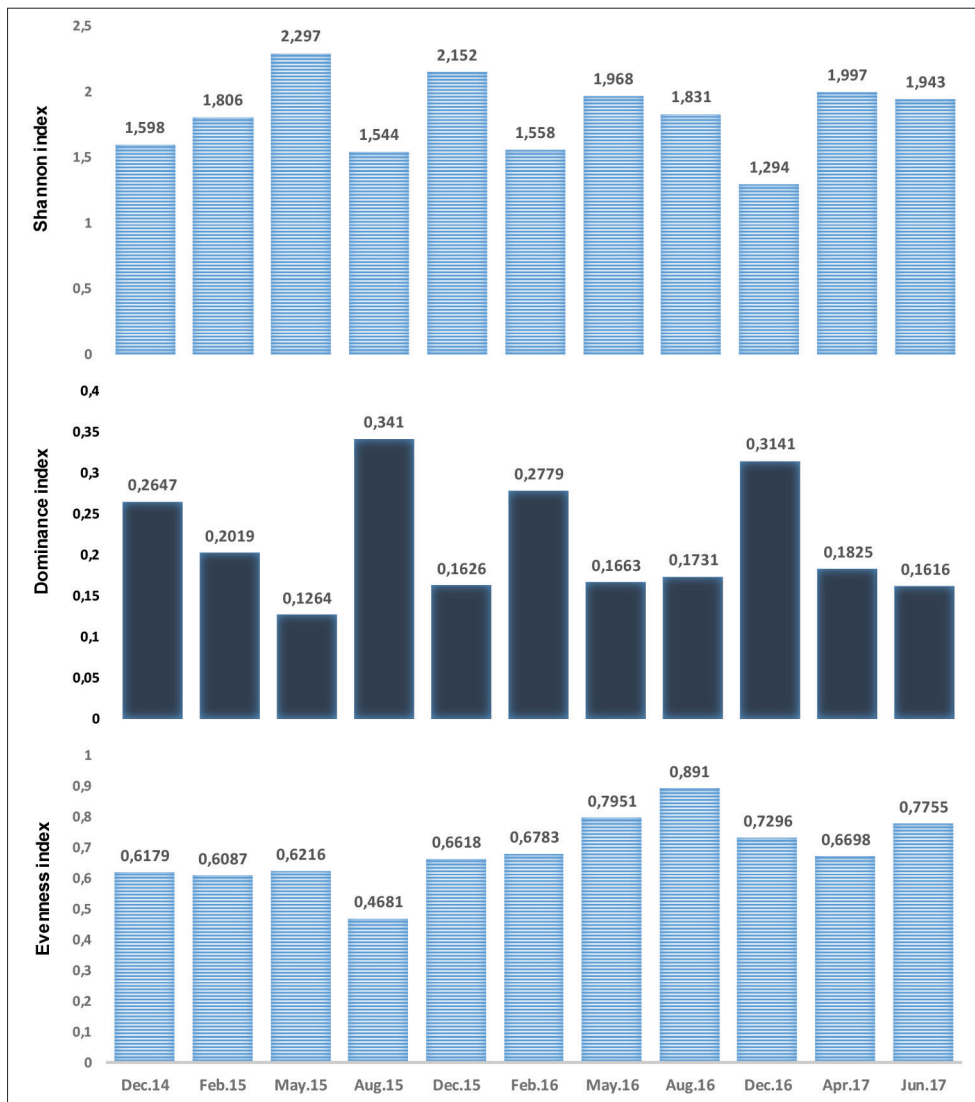


Fig. 3. Temporal variations of diversity indices (December 2014 – June 2017) in the Seyhan Estuary.

Members of the family Mugilidae represent the highest biomass (69.08%) in the Seyhan Estuary. Of the six mugilid species captured during this study, *L. aurata* and *L. saliens* were the most common. The dominance of mugulids in the Seyhan Estuary is typical of many estuaries worldwide (KOUTRAKIS et al. 2000, TZENG et al. 2002). The dominance of various species of Mugilidae, especially juveniles, suggests that this family is able to exploit the studied habitat successfully. A total of five alien species (*C. gibelio*, *E. klunzingeri*, *G. holbrooki*, *L. carinata* and *O. niloticus*) have been recorded during the present study. Overall, *G. holbrooki* comprised approximately 15% of the abundance of the collected fish.

Juveniles of *Anguilla anguilla*, *Aphanius fasciatus*, *Atherina boyeri*, *C. gibelio*, *Chelon labrasus*, *Dicentrarchus labrax*, *G. holbrooki*, *Garra culiciphaga*, *L. aurata*, *L. ramada*, *L. saliens*, *Mugil cephalus*, *Pomatoschistus anatoliae*, *Solea solea*, *Syng-*

nathus acus, *E. klunzingeri* and *Sparus aurata* have been recorded in the Seyhan Estuary. These results suggest that the Seyhan Estuary is utilised by marine species as a nursery area. Estuaries enhance growth and survival of juvenile fish because they provide high food availability, low predation risk, high water temperatures and protection from adverse weather conditions (ABOOKIRE et al. 2000).

The number of species and values of the diversity index exhibited a strong spatial and temporal variation throughout the study. Seasonal variations in fish assemblages are a common feature of estuarine ecosystems. The wide range of Shannon-Wiener Diversity Index suggests that a large number of species use the estuarine on a seasonal basis. Seasonal changes in the species diversity were also observed in other studies of fish populations (SELLESLAGH & AMARA 2007, SHERVETTE et al. 2007, BARREIROS et al. 2009).

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References

- ABOOKIRE A.A., PIATT J.F. & ROBARDS M.D. 2000. Nearshore fish distributions in an Alaskan estuary in relation to stratification, temperature and salinity. *Estuarine, Coastal and Shelf Science* 51: 45–59.
- AKBULUT N., BAYARI S., AKBULUT A. & Şahin Y. 2009. Rivers of Turkey. *Rivers of Europe*. London: Academic Press, pp. 643–672.
- AKIN S., BUHAN E., WINEMILLER K.O. & YILMAZ H. 2005. Fish assemblage structure of Koycegiz Lagoone Estuary, Turkey: Spatial and temporal distribution patterns in relation to environmental variation. *Estuarine, Coastal and Shelf Science* 64: 671–684.
- AKSIRAY F. 1987. Türkiye deniz balıkları ve tayin anahtarı. **İstanbul: İstanbul Üniversitesi Rektörlüğü Yayınları**, No: 3490. 811 p.
- ALMODÓVAR A., NICOLA G.G., AYLLÓN D. & ELVIRA B. 2012. Global warming threatens the persistence of Mediterranean brown trout. *Global Change Biology* 18: 1549–1560.
- APARICIO E., VARGAS M.J., OLMO J.M. & DE SOSTOA A. 2000. Decline of native freshwater fishes in a Mediterranean watershed on the Iberian Peninsula. *Environmental Biology of Fishes* 59 (1): 11–19.
- ARAUJO F.G., BAILEY R.G. & WILLIAMS W.P. 1999. Spatial and temporal variations in fish populations in the upper Thames estuary. *Journal of Fish Biology* 55: 836–853.
- BARREIROS J.P., BRANCO J.O., JU'NIOR F.F., MACHADO L., HOSTIM-SILVA M. & VERANI J.R. 2009. Space–time distribution of the ichthyofauna from Saco da Fazenda Estuary, Itajai, Santa Catarina, Brazil. *Journal of Coastal Research* 25 (5): 1114–1121.
- BIANCO P.G. 1995. A revision of the Italian *Barbus* species (Cypriniformes: Cyprinidae). *Ichthyological Exploration of Freshwater* 6 (4): 305–324.
- Çevik C., GÜNDOĞDU S. & ERGÜDEN S.A. 2018. New Record of the Big-Scale Sand Smelt *Atherina boyeri* Risso, 1810 (Atherinidae) in the Seyhan Dam Reservoir (Seyhan River basin, Turkey). *Natural and Engineering Sciences* 3 (2): 133–140.
- DE FIGUEROA J.M.T., LÓPEZ-RODRÍGUEZ M.J., FENOGLIO S., SÁNCHEZ-CASTILLO P. & FOCHETTI R. 2013. Freshwater biodiversity in the rivers of the Mediterranean Basin. *Hydrobiologia* 719 (1): 137–186.
- ELLIOTT M. & DEWAILLY F. 1995. The structure and components of European estuarine fish assemblages. *Netherlands Journal of Aquatic Ecology* 29: 397–417.
- ERGÜDEN S.A. & GÖKSU M.Z.L. 2012. The fish fauna of the Seyhan dam lake (Adana). *Journal of Fisheries Sciences* 6(1): 39–52.
- ERK'AKAN F. & ÖZDEMİR F. 2011. Revision of the fish fauna of the Seyhan and Ceyhan River basins in Turkey. *Research Journal of Biological Sciences* 6(1): 1–8.
- FRICKE R., BİLECENOĞLU M. & SARI H. M. 2007. Annotated checklist of fish and lamprey species of Turkey, including a Red List of threatened and declining species. *Stuttgarter Beiträge zur Naturkunde Serie A (Biologie)* 706: 1–169.
- GELDİAY R. & BALIK S. 1988. Türkiye tatlısu balıkları. *Bornova-Izmir: Ege Üniversitesi Fen Fakültesi Kitaplar Serisi* 97: 1–519.
- GÜÇLÜ S.S. & KÜÇÜK F. 2015. The Ichthyofauna of Gediz River (Turkey): Taxonomic and zoogeographic features. *Annual Research and Review in Biology* 6(3): 202–214.
- GÜÇLÜ S.S., KÜÇÜK F., ERTAN Ö.O. & GÜÇLÜ Z. 2013. The fish fauna of the Büyük Menderes River (Turkey): taxonomic and zoogeographic features. *Turkish Journal of Fisheries and Aquatic Sciences* 13(4): 685–698.
- HERMOSO V. & CLAVERO M. 2011. Threatening processes and conservation management of endemic freshwater fish in the Mediterranean basin: a review. *Marine and Freshwater Research* 62: 244–254.
- INNAL D. & ERK'AKAN F. 2006. Effects of exotic and translocated fish species in the inland waters of Turkey. *Reviews in Fish Biology and Fisheries* 16: 39–50.
- INNAL D. 2012. Fish assemblage structure of the Köprüçay River-Estuary (Antalya–Turkey). *Journal of Natural Sciences Research* 2(8): 20–30.
- INNAL D. 2016. Fish diversity and distribution in the Aksu River Estuary (Antalya–Turkey) in relation to environmental variables. *Ecologica Montenegrina* 5: 90–98.
- INNAL D. & ÖZDEMİR F. 2012. Species composition of fish community in Kundu Estuary (Antalya–Turkey) and their length-weight relationships. *Asian Journal of Animal and Veterinary Advances* 7(11): 1191–1197.
- INNAL D., AKDOĞANBULUT D., AKSU M. & MAVRUK S. 2015. Occurrence of Lessepsian *Equulites klunzingeri* (Actinopterygii: Leiognathidae) and its length-weight relationship in the Seyhan River Estuary (Mersin–Turkey). *Review of Hydrobiology* 8(2): 67–76.
- INNAL D., AKDOĞANBULUT D. & MAVRUK S. 2016. Occurrence of *Hemigrammocapoeta culiciphaga* (Cyprinidae) and its morphometry in the Seyhan River Estuary (Mersin–Turkey). *Review of Hydrobiology* 9(1): 37–45.
- JAUREGUIZAR A.J., MENNI R., LASTA C. & GUERRERO R. 2006. Fish assemblages of the Northern Argentine Coastal System: spatial patterns and their temporal variations. *Fisheries Oceanography* 15(4): 326–344.
- JELLYMAN D.J., GLOVA G.J., SAGAR P.M. & SYKES J.R.E. 1997. Spatio-temporal distribution of fish in the Kakanui River Estuary, South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 31: 103–118.
- KOUTRAKIS E.T., KOKKINAKIS A.K., ELEFThERİADIS E.A. & ARGYROPOULOU M.D. 2000. Seasonal changes in distribution and abundance of the fish fauna in the two estuarine systems of Strymonikos Gulf (Macedonia, Greece). *Belgian Journal of Zoology* 130 (Suppl. 1): 41–48.
- KÜÇÜK F. & İKİZ R. 2004. Fish fauna of streams discharging to Antalya Bay. *Ege Journal of Fisheries and Aquatic Sciences* 21(3): 287–294.
- KÜÇÜK F., GÜMÜŞ E., GÜLLE İ. & GÜÇLÜ S.S. 2007. The fish fauna of the Göksu River (Türkiye): taxonomic and zoogeographic features. *Turkish Journal of Fisheries and Aquatic Sciences* 7(1): 53–63.
- KÜÇÜK F., TURAN D., GÜÇLÜ S.S., MUTLU A.G. & ÇİFTİ Y. 2017. Two new species of *Chondrostoma* Agassiz, 1832 (Teleostei: Cyprinidae) from the Ceyhan, Seyhan and Göksu rivers in the East Mediterranean region of Turkey. *Turkish*

- Journal of Fisheries and Aquatic Sciences 17(4): 795–803.
- MAGURRAN A.E. 1988. Ecological diversity and its measurement. New Jersey: Princeton University Press. 179 p.
- MARTINO E.J. & ABLE K.A. 2003. Fish assemblages across the marine to low salinity transition zone of a temperate estuary. Estuarine, Coastal and Shelf Science 56: 969–987.
- SELLESLAGH J. & AMARA R. 2007. Temporal variations in abundance and species composition of fish and epibenthic crustaceans of an intertidal zone: Environmental factor influence. Cybium 31(2): 155-162.
- SHERVETTE V.R., AGUIRRE W.E., BLACIO E., CEVALLOS R., GONZALES M., POZO F. & GELWICK F. 2007. Fish communities of a disturbed mangrove wetland and adjacent tidal river in Palmar, Ecuador. Estuarine, Coastal and Shelf Science 72: 115–128.
- SISLI N. 1996. Çevre Bilim – Ekoloji. Ankara: Yeni Fersa Matbaacılık, 492 p.
- SMITH K.G. & DARWALL W.R.T. 2006. The status and distribution of freshwater fish endemic to the Mediterranean Basin. The World Conservation Union (IUCN), Gland, Switzerland and Cambridge, UK. 44 p.
- SOSA-LO´PEZ A., MOUILLOT D., RAMOS-MIRVEA J., FLORES-HERNVEEZ D. & DO CHI T. 2007. Fish species richness decreases with salinity in Tropical Coastal Lagoons. Journal of Biogeography 34(1): 52–61.
- THIEL R. & POTTER I.C. 2001. The ichthyofaunal composition of the Elbe Estuary: an analysis in space and time. Marine Biology 138(3): 603–616.
- TURAN D., KOTTELAT M. & BAYÇELEBI E. 2013. Two new species of *Squalius*, *S. adanaensis* and *S. seyhanensis* (Teleostei: Cyprinidae), from the Seyhan River in Turkey. Zootaxa 3637(3): 308–324.
- TZENG W.N., WANG Y.T. & CHANG C.W. 2002. Spatial and temporal variations of the estuarine larval fish community on the west coast of Taiwan. Marine and Freshwater Research 53: 419–430.