www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 413-423 (2011) DOI: 10.4194/trjfas.2011.0311

Distribution of the Demersal Fishes on the Continental Shelves of the Levantine and North Aegean Seas (Eastern Mediterranean)

Çetin Keskin[1,*], Cemal Turan[2], Deniz Ergüden[2]

[1] Istanbul University, Faculty of Fisheries, Marine Biology Department, Ordu St. No: 200, 34470 Istanbul, Turkey.
[2] Mustafa Kemal University, Faculty of Fisheries, Fisheries Genetics Laboratory, 31220, Iskenderun, Hatay, Turkey.

* Corresponding Author: Tel.: +90. 212 4555700/16414; Fax: +90. 212 5140379;
E-mail: seahorse@istanbul.edu.tr

Received 10 December 2010
Accepted 28 February 2011

Abstract

The aim of this study was to investigate the distribution patterns of demersal fishes on the continental shelves of the north-eastern Levantine and north-eastern Aegean seas. Fish samples were collected by bottom trawl. A total of 29 hauls were carried out, 15 hauls between 43 to 121 m depth in the north-eastern Levantine Sea and 14 hauls between 65 to 100 m depth in the north-eastern Aegean Sea. The total trawled area for both region was 1.87 km^2. Cluster analysis and non-metric multidimensional scaling were applied to identify hauls grouping. Among 114 fish species found, 84 were recorded in the north-eastern Levantine Sea and 64 in the north-eastern Aegean Sea. Fifty species were found exclusively from the north-eastern Levantine Sea, 30 species exclusively from the north-eastern Aegean Sea and 34 species were shared by the two areas. The Lessepsian migrants, *Upeneus moluccensis, Equulites klunzingeri, Saurida undosquamis*, and the indigenous species *Pagellus erythrinus* were the most common species of fish assemblage in the north-eastern Levantine Sea. The most common species in the north-eastern Aegean Sea were *Serranus hepatus, Mullus barbatus, Citharus linguatula, Merluccius merluccius* and *Lepidotrigla cavillone*. Faunal composition in the north-eastern Levantine Sea was influenced by the oligotrophic, temperate and high saline water, while in the north-eastern Aegean Sea it was mainly affected by the outflow of cold, less saline and highly productive waters from the Black Sea.

Keywords: Demersal fish, distribution, diversity, Eastern Mediterranean.

Levant Denizi ve Kuzey Ege Denizi (Doğu Akdeniz) Kıta Sahanlıklarındaki Demersal Balıkların Dağılımı

Özet

Çalışma Levant Denizi'nin kuzeydoğusu ve Ege Denizi'nin kuzeydoğusunda kıta sahanlıkları üzerinde bulunan demersal balıkların dağılımlarını araştırmak amacıyla yapılmıştır. Balık örnekleri dip trolü kullanılarak toplanmıştır. Levant Denizi'nde 43-121 m derinlikler arasında 15 ve Kuzey Ege Denizi'nde 14 olmak üzere toplam 29 trol çekimi yapılmıştır. Her iki bölgede trol çekimi yapılan toplam alan 1,87 km^2'dir. Trol çekimlerinin gruplandırılmasında "Kümeleme" ve "metrik-olmayan Çok Boyutlu Ölçekleme" analizleri kullanılmıştır. 84 tür Levant Denizi'nden ve 64 tür Kuzey Ege Denizi'nden olmak üzere toplam 114 tür elde edilmiştir. 50 tür sadece Levant Denizi'nden, 30 tür sadece Kuzey Ege Denizi'nden, 34 tür ise her iki bölgeden de yakalanmıştır. Lessepsian türlerden *Upeneus moluccensis, Equulites klunzingeri*, *Saurida undosquamis* ve yerli türlerden *Pagellus erythrinus* Levant Denizi'ndeki balık topluluğu içinde en yaygın türlerdir. Kuzey Ege Denizi'nde ise en yaygın türler; *Serranus hepatus, Mullus barbatus, Citharus linguatula, Merluccius merluccius* ve *Lepidotrigla cavillone*'dir. Tür komposizyonu, Kuzey Ege Denizi'nde Karadeniz'den gelen soğuk, az tuzlu ve yüksek verimlilikteki suların etkisindeyken, Levant Denizi'nde sıcak ve yüksek tuzluluktaki oligotrofik suların etkisi altındadır.

Anahtar Kelimeler: Demersal balıklar, dağılım, çeşitlilik, Doğu Akdeniz.

Introduction

The Mediterranean Sea is a unique ecosystem comprising semi-enclosed water bodies (Fredj *et al*., 1992; Quignard and Tomasini, 2000; Bianchi and Morri, 2000) and Mediterranean fish biodiversity includes nearly 4% of marine fish species worldwide (Coll *et al*., 2010). Fish biodiversity decreases from west to east due to the effect of straits (Gibraltar, Sicily, Dardanelles, and Bosphorus), different current systems, salinity level and temperature regime throughout the Mediterranean-Black Sea system (Bianchi, 2007).

Since the opening of the Gibraltar Strait 5.33

million years ago, after the extinction of the Tethyan biota during the "Salinity crisis" of the Messinian Stage, the Mediterranean Sea was repopulated by species originating from the Atlantic Ocean. In total, 650 fish species are known today in the Mediterranean Sea (Coll *et al.*, 2010). This number has recently risen due to alien species that came from the Atlantic Ocean through the Gibraltar Strait and the Indian Ocean across the Red Sea after the Suez Canal was opened in 1869 (Quignard and Tomasini, 2000; Ben Rais Lasram and Mouillot, 2009).

Climate change and human impacts, such as the opening of the Suez Canal, have been recognized factors affecting the distribution patterns of biodiversity and the species composition in the Mediterranean Sea. In the last decades, abundance and distribution of subtropical and tropical alien species in the warm-temperate Mediterranean water increased, due to the combined effect of climate change and anthropogenic actions (Bianchi, 2007). The Mediterranean Sea is the major recipient of alien species, with an average of one species introduced every 4 weeks over the past 5 years (Streftaris *et al.*, 2005). In the eastern Mediterranean, sixty percent of alien species were introduced via the Suez Canal, 25% by shipping, 5% via the Gilbraltar, 4% aquaculture and 3% via Dardanelles (Pancucci-Papadopoulou *et al.*, 2005). In the whole Mediterranean, there are nearly four times as many alien species along the Levantine coast as in the westernmost Mediterranean, and the majority of aliens in the easternmost Mediterranean entered through the Suez Canal (81%) and mostly originate Indo-Pacific (Galil, 2009). Overall, 65 out of 116 alien fish species in the Mediterranean Sea derive from the Indo-Pacific region, having migrated through the Suez Canal (CIESM, 2010). This phenomenon is the main reason for increasing faunal divergence between the western and eastern Mediterranean Sea (Golani and Ben-Tuvia, 1995; Quignard and Tomasini, 2000; Golani *et al.*, 2002).

The high heterogeneity of the Mediterranean Sea biota and characterization of the biogeographic areas (Bianchi, 2007) were also documented in terms of fisheries resources (Garibaldi and Caddy, 1998). In these areas a statistically similar resident fauna and flora occurs, usually at a similar depth and bottom type, including fairly very well defined group of commercial species (Caddy, 1998). These classifications may provide some management units under a common framework on species assemblages, which are roughly equivalent to the poorly-defined concept of 'multi-species stock' in the fish community (Caddy, 1998). The information on such assemblages is scarce in the eastern Mediterranean, although there are some studies in terms of demersal fish assemblages in the Aegean Sea relating geomorphological, oceanographic and fishing impact (Stergiou and Pollard, 1994; Kallianiotis *et al.*, 2004; Labropoulou and Papaconstantinou, 2004; Keskin *et al.*, 2011). In the north-eastern Levantine Sea, the distribution and occurrence of Red Sea fishes and species assemblage on the continental shelf investigated by Gucu *et al.* (1994) and Gucu and Bingel (1994).

The Levantine and North Aegean seas are two important areas of the eastern Mediterranean (Garibaldi and Caddy, 1998; Bianchi, 2007). Faunal composition is closely related to the oligotrophic, temperate and high saline water in the Levantine Sea, while in the North Aegean Sea it is mainly affected by the outflow of cold, less saline and highly productive waters from the Black Sea.

The aim of this study is to compare the distribution patterns of demersal fishes on the continental shelves of the north-eastern Levantine and north-eastern Aegean seas.

Materials and Methods

Study Areas

The Levantine Sea is the easternmost part of the Mediterranean Sea, east of the line connecting Rhodes and the coast of Cyrenaica (Figure 1). The Levantine Sea is connected to the Aegean Sea through the Cretan Arc Straits between the islands of Crete and Karpathos, the islands of Karpathos and Rhodes, and Rhodes and Turkey. It is characterized by extreme oligotrophic conditions, high temperature (16-29.3°C) and high salinity (37-39.5 psu) (Avsar, 1999; Mavruk and Avsar, 2008). The water mass is characterized by the Levantine Surface Water, the Modified Atlantic Water, the Levantine Intermediate Water and the Eastern Mediterranean Deep Water (Küçüksezgin and Pazi, 2006 and references therein). Concerning the thermohaline circulation of the eastern Mediterranean, the Rhodes gyre area in the north-western Levantine Basin appears a formation site of waters denser than the Levantine Intermediate Water and distinctly warmer and more saline characteristics than the Eastern Mediterranean Deep Water (Eastern Mediterranean Transient, EMT) (Theocharis *et al.*, 2002; Bergamasco and Malanotte-Rizzoli, 2010).

The North Aegean Sea is located in the north-eastern Mediterranean and is separated from the South Aegean Sea by the Cyclades islands. The Black Sea waters out-flow from the Dardanelles affects the uppermost (20-30 m) layer of the North Aegean Sea (Teocharis and Georgopoulos, 1993). This current is modified moving westward and southward by lateral and diapycnal mixing with the Levantine Intermediate Water, warm and highly saline water originating from the South Aegean to the Levantine basins, extending down to 350-400 m depth (Theocharis and Georgopoulos, 1993; Pazi, 2008). Below there are very dense North Aegean Deep Waters (13.3°C and 39 psu). The North Aegean Sea is influenced by the

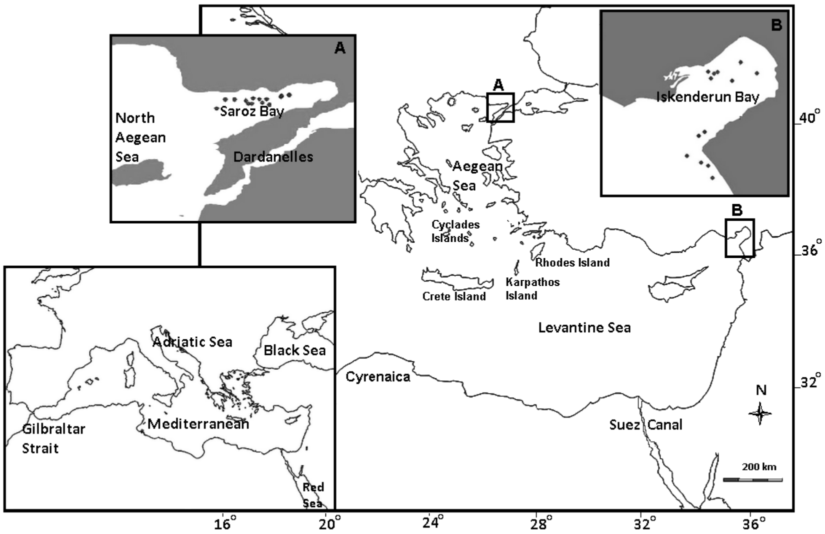

Figure 1. Sampling areas on the continental shelf in the North Aegean Sea (A) and the Levantine Sea (B).

cold (8.8-25°C), less saline (31.8-38.3 psu) and highly productive waters of the Black Sea (Beşiktepe *et al*., 1994), while the South Aegean is filled with warmer (14.6-24.7°C) and more saline (38.7-39.4 psu) oligotrophic water characteristic of the eastern Mediterranean Sea (Ignatiades, 1998).

The samples were mainly collected in Iskenderun Bay (36°30′N, 35°40′E) in the north-eastern Levantine Sea and in Saroz Bay (40°33′N, 26°27′E) in the north-eastern Aegean Sea. Iskenderun Bay has mean 55 m depth and 90 m depth further more depth (maximum depth 99 m) and its width 34 km and its length 70 km. Silty and muddy materials take place on 40-70 meters depth in sea bottom, mud and muddy materials cover between 50 and 70 meters depth, mud was observed more than 70 meter depth (Eryılmaz and Yücesoy-Eryılmaz, 2003). Saroz Bay is roughly "V" shaped; its length is about 61 km, and the width is about 36 km long, reaching a depth of 700 m. In the Bay, biogenic and terrigenous sandy bottoms are dominant on the shelf (Sarı and Çağatay, 2001). During the study, the value of surface temperature ranged from 10.8 to 28°C in the north-eastern Aegean Sea and from 18 to 31.7°C in the north-eastern Levantine Sea, salinity from 30.1 to 38.9 psu in the north-eastern Aegean Sea and 38.4 to 39 psu in the north-eastern Levantine Sea.

Sampling

The samples were collected during four periods (July 2006, October 2006, March 2007, and June 2007) in the north-eastern Aegean Sea, and three periods (November 2007, January 2008 and August 2008) in the north-eastern Levantine Sea. Fish sampling was carried out using bottom trawl nets with16 mm cod-end mesh size in the north-eastern Aegean Sea and 22 mm cod-end mesh size in the north-eastern Levantine Sea. Overall, 15 hauls were carried out (between 43 and 121 m depth) in the north-eastern Levantine Sea and 14 hauls (between 65 and 100 m depth) in the north-eastern Aegean Sea. The total trawled area was 1.87 km^2 (Table 1).

Fish samples were sorted and species identified. The taxonomic order was performed according to Nelson (2006) and species were named according to Eschmeyer and Fricke (2010).

Data Analysis

Cluster analysis and non-metric multidimensional scaling (MDS) were applied to identify biogeographical patterns in fish assemblage composition. These analyses were carried out on presence/absence data, due to differences in sampling methodology between areas, using the Bray Curtis similarity index. SIMPER analysis was applied to determine the contribution of each species to the overall similarity within areas and the dissimilarity between areas. Before the statistical analysis, pelagic species (Table 2) were removed from the data matrix. All analyses were carried out using the PRIMER v5 statistical package (Clarke and Warwick, 2001). The frequency of species was expressed as % of occurrence of each species in the hauls.

Results

A total of 114 fish species belonging to 56 families were collected from the north-eastern Levantine Sea and the north-eastern Aegean Sea (Table 2). Overall, 84 species were found in the north-eastern Levantine Sea, and 64 species were found in the north-eastern Aegean Sea. Fifty species were recorded exclusively in the north-eastern Levantine Sea, 30 species exclusively in the north-eastern

Table 1. Sampling stations and haul characteristics during the surveys in the north-eastern Aegean Sea (AS) and the north-eastern Levantine Sea (LS)

Area	Surveys	Latitude (N)	Longitude (E)	Swept area (km^2)	Minimum depth (m)	Maximum depth (m)	Mean depth (m)
AS	July 2006	40°34'606	26°33'204	0.01	65	70	68
AS	July 2006	40°32'418	26°23'958	0.02	88	90	89
AS	July 2006	40°33'909	26°28'282	0.01	72	77	75
AS	October 2006	40°35'258	26°35'482	0.01	75	78	77
AS	October 2006	40°32'424	26°23'007	0.02	90	98	94
AS	October 2006	40°32'685	26°27'042	0.02	76	82	79
AS	October 2006	40°34'113	26°26'355	0.01	70	72	71
AS	March 2007	40°33'909	26°26'215	0.02	75	80	78
AS	March 2007	40°32'072	26°29'108	0.02	100		100
AS	March 2007	40°29'578	26°10'000	0.03	75	80	78
AS	June 2007	40°33'340	26°22'250	0.02	80	95	88
AS	June 2007	40°33'807	26°18'879	0.02	77	79	78
AS	June 2007	40°34'153	26°33'083	0.02	63	73	68
AS	June 2007	40°32'705	26°16'089	0.02	70	73	72
LS	November 2007	36°44'284	35° 49' 385	0.17	56	74	65
LS	November 2007	36°33'655	35° 45' 661	0.13	53	74	64
LS	November 2007	36°42'157	35° 50' 310	0.10	53	55	54
LS	November 2007	36°33'792	35° 38' 005	0.18	52	55	54
LS	November 2007	36°44'234	35° 52' 560	0.09	51	54	53
LS	November 2007	36°41'274	35° 57' 476	0.13	55	99	77
LS	November 2007	36°43'869	35° 05' 805	0.08	55	59	57
LS	November 2007	36°33'792	36° 47' 005	0.13	55	61	58
LS	November 2007	36°47'465	36° 00' 425	0.16	45	51	48
LS	January 2008	36°22'983	35° 46' 206	0.16	73	121	98
LS	January 2008	36°16'279	35° 42' 177	0.08	96	121	109
LS	January 2008	36°14'114	35° 48' 943	0.04	50	58	54
LS	August 2008	36°12'972	35° 49' 319	0.04	47	56	52
LS	August 2008	36°12'966	35°49'394	0.06	43	85	63
LS	August 2008	36°44'979	35°50'875	0.04	45	68	57

Aegean Sea and 34 species were shared by the two areas. The most common species (frequency degree > 80%) were *Upeneus moluccensis, Saurida undosquamis, Equulitis klunzingeri* and *Pagellus erythrinus* in the north-eastern Levantine Sea, while *Serranus hepatus, Citharus linguatula, Lophius budegassa*, *Merluccius merluccius* and *Mullus barbatus* were in the north-eastern Aegean Sea (Table 2).

Considering the different zoogeographical affinity of fishes, 85 species (75%) were Atlanto-Mediterranean, 19 species (17%) were Indo-Pacific, 6 species (5%) were cosmopolitan and 4 species (4%) were Mediterranean endemics (Table 3). Indo-Pacific species were collected only in the north-eastern Levantine Sea, while the proportion of Atlanto-Mediterranean species was higher in the north-eastern Aegean Sea.

Cluster analysis clearly distinguished the fish assemblages of the north-eastern Aegean Sea from those of the north-eastern Levantine Sea, with a similarity level of 15% (Figure 2). Samples separation in the MDS (2D stress=0.12) plot corresponded to the pattern revealed by cluster analysis. SIMPER results were shown in Table 4. The main contributing species within groups with 50% similarity were *U. moluccensis, E. kluzingeri, S. undosquamis* and *P. erytrinus* in the north-eastern Levantine Sea, while *S. hepatus, M. barbatus, C. linguatula* and *M. merluccius* were in the north-eastern Aegean Sea. Most of the highly contributing species are of commercial importance (Table 4).

Discussion

In the present study, 114 species were recorded, corresponding to 24% of the fish species (n=470) reported by Golani *et al.* (2006) for the eastern Mediterranean Sea.

There were clear differences in fish assemblage composition between the north-eastern Levantine Sea and the north-eastern Aegean Sea. Several species very common in the north-eastern Levantine Sea were absent or very scarce in the north-eastern Aegean Sea. The high contribution of Lessepsian fishes, *U. moluccensis, S. undosquamis* and *E. kluzingeri,* to the within-group similarity of the fish assemblage in the north-eastern Levantine Sea supported the influence

Table 2. Fish species collected on the continental shelf in the north-eastern Levantine Sea (LS) and the north-eastern Aegean Sea (AS). D: Depth range, FO: frequency of occurrence of each species (%).

			LS		AS	
Families	Species	Origin	D	FO	D	FO
SCYLIORHINIDAE	*Scyliorhinus canicula* (Linnaeus, 1758)*	A-M			68-94	67
TRIAKIDAE	*Mustelus mustelus* (Linnaeus, 1758)	A-M	64	7		
SQUALIDAE	*Squalus acanthias* Linnaeus, 1758*	C			68-78	20
	Squalus blainville (Risso, 1827)*	C			68-88	20
DALATIIDAE	*Oxynotus centrina* (Linnaeus 1758)	A-M			78	7
TORPEDINIDAE	*Torpedo marmorata* Risso, 1810	A-M	65	7	78	13
RHINOBATIDAE	*Rhinobatos cemiculus* Geoffroy St. Hilaire, 1817	A-M	63-65	14		
RAJIDAE	*Dipturus oxyrinchus* (Linnaeus, 1758)	A-M			68	7
	Raja asterias Delaroche, 1809*	M			78	7
	Raja clavata Linnaeus, 1758*	C			68-100	60
	Raja miraletus Linnaeus, 1758*	C	57-98	14	68-79	40
	Raja montagui Fowler, 1910*	A-M	57	7		
	Leucoraja naevus (Müller & Henle, 1841)	A-M	63	7		
	Raja radula Delaroche, 1809	M	57	7	78	7
DASYATIDAE	*Dasyatis pastinaca* (Linnaeus, 1758)*	A-M	63-65	14	68	7
GYMNURIDAE	*Gymnura altavela* (Linnaeus, 1758)	A-M	57-63	14		
MYLIOBATIDAE	*Myliobatis aquila* (Linnaeus, 1758)	A-M			78-94	13
OPHICHTHIDAE	*Echelus myrus* (Linnaeus, 1758)	A-M	53-65	21		
CONGRIDAE	*Conger conger* (Linnaeus, 1758)	A-M	54-77	21	77-78	13
ENGRAULIDAE	*Engraulis encrasicolus* (Linnaeus, 1758)* [p]	A-M	54-65	14	75-88	20
CLUPEIDAE	*Sardinella maderensis* (Lowe, 1838)* [p]	A-M	52	7		
	Dussumieria elopsoides Bleeker, 1849 [p]	IP	53-65	36		
	Etrumeus teres (DeKay, 1842) [p]	IP	48-64	36		
ARGENTINIDAE	*Argentina sphyraena* Linnaeus, 1758	A-M			89	7
SYNODONTIDAE	*Saurida undosquamis* (Richardson, 1848)*	IP	43-121	86		
	Synodus saurus (Linnaeus, 1758)*	A-M	57-63	14		
MERLUCCIDAE	*Merluccius merluccius* (Linnaeus, 1758)*	A-M	53-98	50	68-100	80
GADIDAE	*Merlangius merlangus* (Linnaeus, 1758)*	M			68-88	13
	Phycis blennoides (Brünnich, 1768)*	A-M			100	7
	Trisopterus minutus (Linnaeus, 1758)*	M			68-100	53
OPHIIDAE	*Ophidion barbatum* Linnaeus, 1758	A-M			94	7
LOPHIIDAE	*Lophius budegassa* Spinola, 1807*	A-M			68-100	80
ZEIIDAE	*Zeus faber* Linnaeus, 1758*	C	48-64	29	68-100	33
FISTULARIIDAE	*Fistularia commersonii* (Rüppell, 1835)	IP	54-65	21		
DACTYLOPTERIDAE	*Dactylopterus volitans* (Linnaeus, 1758)	A-M	77	7		
SCORPAENIDAE	*Scorpaena porcus* Linnaeus, 1758*	A-M	53-65	21		
	Helicolenus dactylopterus (Delaroche, 1809)	A-M			94	7
	Scorpaena notata Rafinesque, 1810	A-M	52-57	14	75-94	53
TRIGLIDAE	*Eutrigla gurnardus* (Linnaeus, 1758)*	A-M			68-89	67
	Trigloporus lastoviza (Bonnaterre, 1788)*	A-M	48-121	43	68-94	53
	Chelidonichthys lucernus (Linnaeus, 1758)*	A-M	48-121	50	68-94	53
	Trigla lyra Linnaeus, 1758*	A-M			68-94	53
	Chelidonichthys cuculus (Linnaeus, 1758)	A-M	54-121	43	78-88	20
	Lepidotrigla cavillone (Lacepède, 1801)	A-M	57-77	14	68-100	67
SERRANIDAE	*Ephinephelus haifensis* Ben-Tuvia, 1953*	A-M	54	7		
	Epinephelus aeneus (Geoffroy Saint-Hilarie, 1817)*	A-M	48-121	57		
	Epinephelus costae (Steindachner, 1878)*	A-M	54	7		
	Anthias anthias (Linnaeus, 1758)	A-M	98	7		
	Serranus cabrilla (Linnaeus, 1758)	A-M	54-98	21	75-94	67
	Serranus hepatus (Linnaeus, 1758)	A-M	48-77	57	68-100	93
	Serranus scriba (Linnaeus, 1758)	A-M			88	7
APOGONIDAE	*Apogon pharaonis* Bellotti, 1874	IP	48-121	29		
	Apogon queketti Gilchrist, 1903	IP	53-57	29		
SILLAGINIDAE	*Sillago sihama* (Forsskål, 1775)	IP	54-64	14		
POMATOMIDAE	*Pomatomus saltatrix* (Linnaeus, 1766)* [p]	A-M	54	7		
CARANGIDAE	*Trachurus mediterraneus* (Steindachner, 1868)* [p]	A-M	57-98	21		
	Trachurus trachurus (Linnaeus, 1758)* [p]	A-M	48-121	64	68-100	67
	Alectis alexandrinus (Geoffroy St. Hilaire, 1817)	A-M	63	7		
LEIOGNATHIDAE	*Equulites klunzingeri* (Steindachner, 1898)	IP	48-77	79		
HAEMULIDAE	*Pomadasys incisus* (Bowdich, 1825)	A-M	52	7		
NEMIPTERIDAE	*Nemipterus randalli* Russell, 1986	IP	48-58	29		
SPARIDAE	*Boops boops* (Linnaeus, 1758)*	A-M	53-98	57	68-100	40
	Dentex dentex (Linnaeus, 1758)*	A-M	63-77	14	78	7
	Dentex macrophthalmus (Bloch, 1791)*	A-M			78-88	13

A-M: Atlanto-Mediterranean, IP: Indo-Pacific, C: Cosmopolitan, M: Mediterranean endemic.
* Economically important species, [p] Pelagic species

Table 2. (Continued)

			LS		AS	
Families	Species	Origin	D	FO	D	FO
SPARIDAE	*Dentex maroccanus* Valenciennes, 1830*	A-M	57-63	14	78-94	27
	Diplodus annularis (Linnaeus, 1758)*	A-M	48-63	36		
	Diplodus sargus (Linnaeus, 1758)*	A-M	48-54	21		
	Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)*	A-M	54-64	21		
	Lithognathus mormyrus (Linnaeus, 1758)*	A-M	48-77	43		
	Pagellus acarne (Risso, 1826)*	A-M	52-98	29	68-94	40
	Pagellus bogaraveo (Brünnich, 1768)*	A-M			78-100	20
	Pagellus erythrinus (Linnaeus, 1758)*	A-M	52-121	86	75-94	40
	Pagrus auriga Valenciennes, 1843*	A-M	57	7		
	Pagrus coeruleostictus (Valenciennes, 1830)*	A-M	57-77	21		
	Pagrus pagrus (Linnaeus, 1758)*	A-M			78-94	27
	Sparus aurata Linnaeus, 1758*	A-M	48-63	43		
	Spondyliosoma cantharus (Linnaeus, 1758)*	A-M	52	7		
CENTRACANTHIDAE	*Centracanthus cirrus* Rafinesque 1810*	A-M			88	7
	Spicara maena (Linnaeus, 1758)*	A-M	57-63	14	68-100	27
	Spicara smaris (Linnaeus, 1758)*	A-M	48-98	29	68	7
SCIAENIDAE	*Umbrina cirrosa* (Linnaeus, 1758)*	A-M	64	7		
MULLIDAE	*Mullus barbatus* Linnaeus, 1758*	A-M	52	7	68-100	80
	Mullus surmuletus Linnaeus, 1758*	A-M	52-64	29	78	27
	Upeneus moluccensis (Bleeker, 1855)*	IP	52-121	93		
	Upeneus pori Ben-Tuvia & Golani, 1989*	IP	53-121	36		
CEPOLIDAE	*Cepola macrophthalma* (Linnaeus, 1758)	A-M	54-121	43	72-100	27
TRACHINIDAE	*Echiichthys vipera* (Cuvier, 1829)	A-M			68-78	13
	Trachinus draco Linnaeus, 1758	A-M	57-98	29	68-100	60
URONOSCOPIDAE	*Uranoscopus scaber* Linnaeus, 1758	A-M	48-98	43	68-79	20
BLENNIDAE	*Blennius ocellaris* Linnaeus, 1758	A-M	57-98	36	68-100	53
CALLIONYMIDAE	*Callionymus filamentosus* Valenciennes, 1837	IP	54-121	21		
	Callionymus lyra Linnaeus, 1758	A-M			68	7
	Callionymus pusillus Delaroche, 1809	A-M			77	7
GOBIIDAE	*Gobius niger* Linnaeus, 1758	A-M	48-64	57	88	7
	Deltentosteus quadrimaculatus (Valenciennes, 1837)	A-M			68-88	20
	Oxyurichthys papuensis (Valenciennes, 1837)	IP	48-65	36		
SIGANIDAE	*Siganus rivulatus* Forsskål, 1775*	IP	48-77	36		
TRICHIURIDAE	*Trichiurus lepturus* Linnaeus, 1758	C	58-77	21		
SCOMBERIDAE	*Scomber scombrus* Linnaeus, 1758* p	A-M	54	7	100	7
CAPROIDAE	*Capros aper* (Linnaeus, 1758)	A-M			100	7
CITHARIDAE	*Citharus linguatula* (Linnaeus, 1758)*	A-M	48-121	43	68-100	80
SCOPHTHALMIDAE	*Lepidorhombus whiffiagonis* (Walbaum, 1792)*	A-M	52-54	14		
BOTHIDAE	*Arnoglossus laterna* (Walbaum, 1792)	A-M	52-98	14	68-100	67
	Arnoglossus thori Kyle, 1913	A-M			75-79	20
BOTHIDAE	*Bothus podas* (Delaroche, 1809)	A-M	54-121	43		
SOLEIDAE	*Solea solea* (Linnaeus, 1758)*	A-M	52-121	57	68-78	33
	Microchirus variegatus (Donovan, 1808)	A-M			68-78	20
CYNOGLOSSIDAE	*Cynoglossus sinusarabici* (Chabanaud, 1931)	IP	53-65	43		
	Symphurus nigrescens Rafinesque, 1810	A-M			68-89	13
BALISTIDAE	*Balistes capriscus,* Gmelin 1789	A-M	53-64	21		
MONACANTHIDAE	*Stephanolepis diaspros* Fraser & Brunner, 1940	IP	54-57	14		
TETRAODONTIDAE	*Lagocephalus sceleratus* (Gmelin, 1789)	IP	63	7		
	Lagocephalus spadiceus (Richardson, 1845)	IP	54-64	50		
	Lagocephalus suezensis Clark and Gohar, 1953	IP	57-65	36		

A-M: Atlanto-Mediterranean, IP: Indo-Pacific, C: Cosmopolitan, M: Mediterranean endemic.
* Economically important species, p Pelagic species

Table 3. Number (N) and percentages (N%) of species by zoogeographical origin in the north-eastern Levantine Sea (LS) and the north-eastern Aegean Sea (AS).

Origin of species	LS		AS		for both area	
	N	N%	N	N%	N	N%
A-M	61	72.6	55	86	85	75
IP	19	22.6		-	19	17
C	3	3.6	5	8	6	5
M	1	1.2	4	6	4	4
Total number of species	84		64		114	

A-M: Atlanto-Mediterranean, IP: Indo-Pacific, C: Cosmopolitan, M: Mediterranean endemic

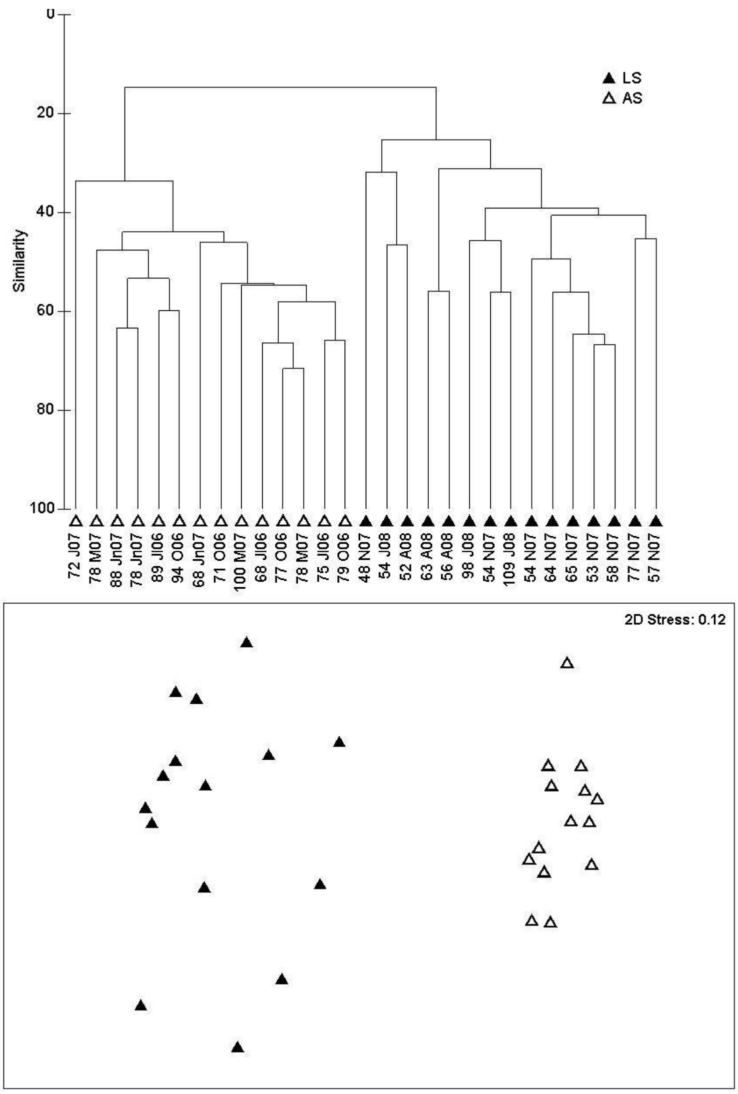

Figure 2. Dendrogram (a) and two-dimensional MDS ordination (b) based on presence/absence data from samples collected in the north-eastern Levantine Sea (LS) and the north-eastern Aegean Sea (AS). Labels show the mean depths (meter) and sampling period (JL06: July 06, O06: October 06, M07: March 07, J07: June 07, A07: August 07, N07: November 07, J07: January 08, A08: August 08) for each haul.

of Indo-Pacific fishes on fish community structure in this area (Gucu *et al*., 1994; Gucu and Bingel, 1994). These species have adapted to the subtropical environmental conditions of the Levantine Sea, which is characterised by oligotrophic waters with an annual mean isotherm of 20°C and surface isohaline of 39 psu, and established mainly because of the existence of free ecological niches (Kosswig, 1956; Mavruk and Avsar, 2008 and references therein). Up to now, 41 Indo-Pasific fishes have been recorded from the north-eastern Levantine coasts in Turkey (Bilecenoglu, 2010). *U. moluccensis* and *S. undosquamis* were firstly recorded in the Mediterranean Sea in 1947 and 1953, and their populations increased in the Levantine Sea after the exceptionally warm winter of 1954-1955 (Goren and Galil, 2005 and references therein). Native species, *Mullus barbatus* and *Merluccius merluccius*, have been forced to migrate to deeper waters by non indigenous species, *U. moluccensis* and *S. undosquamis*, respectively (Galil and Zenetos, 2002). Similar results were obtained in our study where lower frequency for *M. barbatus* as compared to *U. moluccensis* and *M. merluccius* as compared to *S. undosquamis* at depths of 40 to 121 m in the north-easternmost part of the Levantine Sea. Although there is no documented evidence on direct competition between Lessepsian and indigenous species (Goren and Galil, 2005), this type of interaction is one explanation for this kind of replacement.

It is general assumed that Lessepsian migrants are mostly distributed in the shallow waters of the Levantine Sea due to the restricting effect of low temperate in waters deeper than 70 m (Por, 1978; Golani, 1993; Galil and Zenetos, 2002). However, last studies reported that Indo-Pacific fishes were distributed up to 190 m depth in the Levantine Sea (Gucu *et al*., 1994; Bilecenoglu and Taskavak, 2002; Erguden *et al*., 2008). In this study, Indo-Pacific fishes were caught deeper than 40 m, and some of

Table 4. Species mostly contributing to within-group (the north-eastern Levantine Sea, LS and the north-eastern Aegean Sea, AS) average similarity (cut-off: 80% of similarity level) and among groups dissimilarity Av.SIM: Average similarity, Cont.%: Percentage contribution of each species, Cum.%: Cumulative contribution to similarity.

Group LS Av. SIM= 35.15			Group AS Av. SIM= 46.93			Group LS & AS Av. DISSIM= 85.26		
Species	Cont.%	Cum.%	Species	Cont.%	Cum.%	Species	Cont.%	Cum.%
U.moluccensis (IP)*	18.44	18.44	_S. hepatus_	19.24	19.24	_U.moluccensis_ (IP)*	6.11	6.11
E. klunzingeri (IP)*	15.43	33.87	_M. barbatus_*	13.53	32.77	_M. barbatus_*	6.06	12.18
S. undosquamis	14.93	48.8	_C. linguatula_*	12.85	45.62	_E. klunzingeri_ (IP)	5.89	18.07
_P. erythrinus_*	11.35	60.16	_M. merluccius_*	11.91	57.52	_S. hepatus_	5.38	23.45
_M. merluccius_*	4.09	64.25	_L. cavillone_	9.15	66.67	_S. undosquamis_	5.35	28.8
_B. boops_*	3.13	67.38	_E. gurnardus_*	4.2	70.88	_L. cavillone_	4.88	33.68
L. spadiceus (IP)	2.51	69.89	_S. canicula_	3.69	74.56	_M. merluccius_*	3.85	37.53
_C. linguatula_*	2.08	71.97	_S. cabrilla_	3.29	77.85	_C. linguatula_*	3.81	41.34
_C. cuculus_*	1.97	73.94	_L. budegassa_*	2.88	80.74	_P. erythrinus_*	3.59	44.92
_C. lucernus_*	1.92	75.86				_E. gurnardus_*	2.58	47.5
S. hepatus	1.76	77.62				_P. acarne_*	2.03	49.53
_E. aeneus_*	1.66	79.28				_S. canicula_	1.83	51.36
_S. solea_*	1.62	80.9				_T. lastoviza_*	1.83	53.19
						S. cabrilla	1.77	54.96
						_B. boops_*	1.76	56.72
						L. spadiceus (IP)	1.66	58.38
						U. pori (IP)*	1.49	59.87
						_C. cuculus_*	1.49	61.36
						O. papuensis (IP)	1.47	62.82
						A. laterna	1.4	64.22
						_D. maroccanus_*	1.37	65.59
						_P. bogaraveo_*	1.37	66.96
						_C. lucernus_*	1.31	68.27
						_L. budegassa_*	1.21	69.47
						A. queketti (IP)	1.16	70.64
						_L. mormyrus_*	1.11	71.75
						_S. aurata_*	1.07	72.82
						S. rivulatus (IP)*	1	73.82
						T. draco	0.97	74.79
						C. macrophthalma	0.96	75.75
						S. solea	0.96	76.72
						_T. lyra_*	0.95	77.66
						_M. surmuletus_*	0.94	78.6
						G. niger	0.94	79.54
						_E. aeneus_*	0.87	80.41

IP: Indo-Pacific species. Av.DISSIM: Average dissimilarity. * Economically important species

them such as *U. moluccensis, S. undosquamis, Upeneus pori, Callionymus filamentosus* and *Apogon pharaonis* were observed depth up to 121 m. This result supports the hypothesis that certain Indo-Pacific fishes can adapt and colonise the low-temperature deeper water in the Levantine Sea and that their distribution range is larger than reported in the past.

The high frequency of Atlanto-Mediterranean species observed in the North Aegean Sea supports the biogeographical distinction from the Levantine Sea. The North Aegean Sea is characterised by highly productive waters fed by nutrient inputs from cold and less saline Black Sea water that flows through the Dardanelles. Species composition changes from warm-temperate and subtropical in the South Aegean to more arcto-boreal tendency in the North Aegean (Stergiou and Pollard, 1994). Considering the surface isotherm of 14-15 °C for February in Mediterranean, the North Aegean Sea biota is more similar to that of western Mediterranean than to that of the Levantine Sea (Bianchi, 2007). Also, *Merlangius merlangus* was found in the North Aegean, indicating the affinity to the Adriatic and Black Seas (Papaconstantinou, 1988).

Our results confirm that Indo-Pacific fishes did not establish in the north-eastern Aegean Sea up to date, even if some new records of Indo-Pacific fish species have been reported, namely *Lagocephalus sceleratus* and *Etrumeus teres* (Türker-Çakır *et al*., 2009; Yarmaz *et al*., 2010). These species may have the potential to adapt successfully to the changing environmental conditions in the North Aegean Sea (Corsini-Foka, 2010; Bilecenoglu, 2010). Thermophilous fish fauna in the Mediterranean Sea is mainly distributed in warm waters along the African and Asian coasts in the south, while it is restricted by cold waters along the North Adriatic, North Aegean, Black Sea coasts in the north (Corsini-Foka and Economidis, 2007). The number of Indo-Pacific species has decreased from the north-eastern

Levantine towards the west, and then this decreasing trend continuous in the Aegean Sea from south to north (Gucu *et al*., 1994 and references therein; Golani and Appelbaum-Golani, 2010). High seasonal differences of temperature and salinity in the North Aegean Sea represent hydrological barriers for the establishment and spread of Indo-Pacific species from south to north (Papaconstantinou, 1990; Corsini-Foka, 2010). Especially, the low winter temperature is the main factor limiting the ability of the Red Sea species to establish in the new environment in the Mediterranean Sea (Ben-Tuvia and Golani, 1995; Golani and Appelbaum-Golani, 2010).

The geographic distribution of Indo-Pacific fishes in the Aegean Sea clearly reflects the main hydrological characteristics of particular subareas. With the increasing temperature trend after the mid-1980s, the difference of faunal composition in the Aegean Sea has increased from south to north by Indo-Pacific species (Por 1990; Bianchi 2007). The warm and saline waters of the South Aegean Sea offer suitable environmental conditions for the establishment of a thermophilous fish fauna, and consequently they represent a favored path for colonization by tropical or sub-tropical Indo-Pacific fish species (Corsini *et al*., 2005). Also, the evolution of the Eastern Mediterranean Transient (EMT) and vacant niches provide favourable conditions for the maintenance and spread of Indo-Pacific fishes (Corsini-Foka, 2010 and references therein). Until now, 31 species of Indo-Pacific fishes have been observed in the South Aegean Sea (Corsini-Foka, 2010) and some of them, such as *U. moluccensis* and *S. rivulatus,* have successfully colonised the area (CIESM, 2010).

Overall, 34 species were of commercial interest in demersal fish assemblage in the north-eastern Aegean Sea, and *M. barbatus* and *M. merluccius* of them are among the most common species. The North Aegean Sea, is one of most important areas for the demersal fishery in Turkey (Benli *et al*., 1999), and separates from the south part and also from the Sea of Marmara in terms of demersal resources (Stergiou and Pollard, 1994; Keskin *et al*., 2011). Forty-one species in the north-eastern Levantine Sea had commercial importance and four of them, namely *S. undosquamis, U. moluccensis, U. pori* and *S. rivulatus* were Lessepsian migrants. *P. erythrinus, M. merluccius* and non-indogenous, *U. moluccensis* composed of a great part trawl catch in the north-eastern Levantine Sea (Iskenderun Bay) from 1950 to 1955 (Goren and Galil, 2005). Trawl catch composition was changed in 1980-1984, and *S. undosquamis* and *U. molluccensis* were the most abundant commercial species found in nearly every haul in this area (Gucu *et al*., 1994; Gucu and Bingel, 1994). In this study*, U. moluccensis, S. undosquamis* and indogenious, *P. erythrinus* the most common exploited species in the fish assemblages in the north-eastern Levantine Sea. These results may suggest that the fish composition in trawl fisheries in the Levantine Sea has changed significantly over recent decades. However, impact of the Lessepsian fishes to the local fisheries need to be further investigated.

The present results describe the diversity, distribution pattern and characteristic species of fishes on two area of the continental shelves in the eastern Mediterranean, and supports to the faunal heterogeneity in this areas. The results can be useful for the monitoring of the northward extension of non indigenous fish species. In addition to, our findings contribute to better regional fishery policy implementation for sustainable fishery such as multi-species management plan in a unit area.

Acknowledgements

A part of this study was funded by TÜBİTAK (The Scientific and Technological Research Council of Turkey) project number 105Y039. We thank the project team for their helpful cooperation and assistance with fieldwork. We thank Dr. Daniel Golani and Dr. B. Öztürk for their pre-review of the manuscript and valuable contributions.

References

Avsar, D. 1999. Physico-chemical characteristics of the Eastern Mediterranean in relation to distribution of the new Scyphomedusae (*Rhopilema nomadica*). Journal of Zoology, 23(2): 605-616 (in Turkish).

Ben Rais Lasram, F. and Mouillot, D. 2009. Increasing southern invasion enhances congruence between endemic and exotic Mediterranean fish fauna. Biological Invasions, 11: 697-711. doi: 10.1007/s10530-008-9284-4

Benli, H.A., Cihangir, B. and Bizsel, K.C. 1999. Investigation on demersal fishery resources in the Aegean Sea. Istanbul University, Fisheries Faculty, Journal of Aquatic Products (Special Print): 301-370.

Ben-Tuvia, A. and Golani, D. 1995. Temperature as the main factor influencing the Lessepsian migration. J.P. Quignard *et al*. (Eds.) Proceedings of International Colloqium Maison Environment Montpellier: 159-162.

Bergamasco, A. and Malanotte-Rizzoli, P. 2010. The circulation of the Mediterranean Sea: a historical review of experimental investigations. Advances in Oceanography and Limnology, 1(1): 9-22. doi: 10.1080/19475721.2010.491656

Beşiktepe, S.T., Sur, H.I., Ozsoy, E., Latif, M.A., Oguz, T. and Unluata, U. 1994. The circulation and hidrography of the Marmara Sea. Progress in Oceanography, 34: 285-334.

Bianchi, C.N. 2007. Biodiversity issues for the forthcoming tropical Mediterranean Sea. Hydrobiologia, 580: 7-21. doi: 10.1007/s10750-006-0469-5

Bianchi, C.N. and Morri, C. 2000. Marine biodiversity in the Mediterranean Sea: Situations, problems and prospects for future research. Marine Pollution Bulletin, 40: 367-376. doi: 10.1016/S0025-326X(00)00027-8

Bilecenoglu, M. and Taskavak, E. 2002. Characterization of lessepsian migrant fish at Turkish seas. In: B. Öztürk, N. Başusta (Eds.) Workshop on Lessepsian Migration. 20-21 July 2002, Gökçeada-Turkey, Turkish Marine Research Foundation 9: 87-91.

Bilecenoglu, M. 2010. Alien marine fishes of Turkey - an updated review. Fish Invasions of the Mediterranean Sea. In:: D. Golani and B. Appelbaum-Golani (Eds.) Change and Renewal, Pensoft Publishers, Sofia-Moscow: 189-217.

Caddy, J.F. 1998. Zoogeographical Categories Relevant to Fisheries Management in the Mediterranean. In: J.F. Caddy (Ed.) Mediterranean Fisheries Management: Geographical Units and Effort Control. Studies and Reviews. General Fisheries Council for the Mediterranean. No. 70. FAO. Rome, 56 pp.

CIESM, 2010. Atlas of exotic fishes in the Mediterranean. http://www.ciesm.org/atlas/appendix1.html (Accessed January 27, 2010).

Clarke, K.R. and Warwick, R.M. 2001. Change in Marine Communities: An approach to statistical analysis and interpretation. 2nd Edition. PRIMER-E: Plymouth, UK, 172 pp.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., *et al.* 2010. The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. PLoS ONE, 5(8): e11842. doi:10.1371/journal.pone. 0011842

Corsini, M., Margies, P., Kondilatos, G., Economidis, P.S. 2005. Lessepsian migration in Aegean Sea: *Tylerius spinosissimus* (Pisces, Tetraodontidae) new for the Mediterranean, and six more fish records from Rhodes. Cybium, 29 (4): 347-354.

Corsini-Foka, M. and Economidis, P.S. 2007. Allochthonous and vagrant ichthyofauna in Hellenic marine and estuarine waters. Mediterranean Marine Science, 8(1): 67-89.

Corsini-Foka, M. 2010. Current status of alien fishes in Greek seas. D. Golani and B. Appelbaum-Golani (Eds.) Fish invasions of the Mediterranean Sea: change and renewal, Sofia-Moscow, Pensoft Publishers: 219-253.

Erguden, D., Turan, C. and Gurlek, M. 2008. Weight-length relationships for 20 Lessepsian fish species caught by bottom trawl on the coast of Iskenderun Bay (NE Mediterranean Sea, Turkey). Journal of Applied Ichthyology, 25: 133-135. doi: 10.1111/j.1439-0426. 2008.01198.x.

Eryılmaz, M. and Yücesoy-Eryılmaz, F. 2003. İskenderun Körfezi'nin güncel çökel dağılım haritası. 56. Türkiye Jeoloji Kurultayı Bildiri özleri kitabı. 14-20 Nisan 2003, Ankara: 286-287 (in Turkish).

Eschmeyer, W.N. and Fricke, R. (Eds) 2010. Catalog of Fishes electronic version http://research.calacademy. org/ichthyology/catalog/fishcatmain.asp. Accessed 15 January 2010.

Fredj, G., Bellan-Santini, D. and Menardi, M. 1992. État des connaissances sur la faune marine méditerranéenne. Bulletin de l'Institut Océanographique de Monaco, no. Spécial, 9: 133-145.

Galil, B.S. 2009. Taking stock: inventory of alien species in the Mediterranean Sea. Biological Invasions. 11(2): 359-372. doi: 10.1007/s10530-008-9253-y

Galil, B. and Zenetos, A. 2002. A sea change – exotics in the Eastern Mediterranean Sea. In: E. Leppäkoski *et al*. (Eds.), Invasive Aquatic Species in Europe. Distribution, Impacts and Management. Kluwer Academic Publishers: 325-336.

Garibaldi, L. and Caddy, J.F. 1998. Biogeographic characterization of Mediterranean and Black Sea faunal provinces using GIS procedures. Ocean and Coastal Management, 39: 211-227.

Golani, D. 1993. The sandy shore of Red Sea-launching pad for Lessepsian (Suez Canal) migrant fish colonizers of the eastern Mediterranean. Journal of Biogeography, 20: 579-585.

Golani, D. and Ben-Tuvia, A. 1995. Lessepsian migration and the Mediterranean fisheries of Israel. In: N.B. Armantrout (Ed.), Conditions of the World's Aquatic Habits. Proc. World Fish. Congr. Theme I. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi: 279-289.

Golani, D., Orsi-Relini, L., Massuti, E. and Quignard, J.P. 2002. CIESM Atlas of Exotic Species in the Mediterranean. In: F. Briand (ed) Fishes, CIESM Publisher. Monaco, 254 pp.

Golani, D., Öztürk, B. and Başusta, N. 2006. Fishes of the Eastern Mediterranean. Turkish Marine Research Foundation, Pub. Number: 24, Istanbul, Turkey, 260 pp.

Golani, D. and Appelbaum Golani, B. (Eds.) 2010. Fish Invasions of the Mediterranean Sea – Change and Renewal. Sofia: Pensoft, 332 pp.

Goren, M. and Galil, B.S. 2005. A review of changes in the fish assemblages of Levantine inland and marine ecosystems following the introduction of non-native fishes. Journal of Applied Ichthyology, 21: 364-370. doi: 10.1111/j.1439-0426.2005.00674.x

Gucu, A.C., Bingel, F., Avsar, D. and Uysal, N. 1994. Distribution and occurrence of Red Sea fish at the Turkish Mediterranean coast-northern Cilician basin. Acta Adriatica, 34(1/2): 103-113.

Gucu, A.C. and Bingel, F. 1994. Trawlable species assemblages on the continental shelf of the Northeastern Levant Sea (Mediterranen) with an emphasis on lessepsian migration. Acta Adriatica, 35(1/2): 83-100.

Ignatiades, L. 1998. The productive and optical status of the oligotrophic waters of the Southern Aegean Sea (Cretan Sea), Eastern Mediterranean. Journal of Plankton Research, 20(5): 985-995.

Kallianiotis, A., Vidoris, P. and Sylaios, G. 2004. Fish species assemblages and geographical sub-areas in the North Aegean Sea, Greece. Fisheries Research, 68: 171-187. doi:10.1016/j.fishres.2003.12.007.

Keskin, C., Ordines, F., Guijarro, B. and Massutí, E. 2011. Comparison of fish assemblages between the Sea of Marmara and the Aegean Sea (north-eastern Mediterranean). Journal of the Marine Biological Association, 1-12. DIO:10.1017/S002531541000 2213.

Kosswig, C. 1956. Facts and problems offered by the Erythrean invaders into the Mediterranean. (Istanbul) Balık ve Balıkcılık, 4 (9): 31-37.

Küçüksezgin, F. and Pazi, I. 2006. Circulation, hydrographic and nutrient characteristics of the Cilician Basin, Northeastern Mediterranean Sea. Journal of Marine Systems, 59: 189-200. doi: 10.1016/j.jmarsys.2005.10.003.

Labropoulou, A. and Papaconstantinou, C. 2004. Community structure and diversity of demersal fish assemblages: the role of fishery. Scientia Marina, 68(1): 215-226.

Mavruk, S. and Avsar, D. 2008. Non-native fishes in the Mediterranean from the Red Sea, by way of the Suez Canal. Reviews in Fish Biology and Fisheries, 18:

251-262. doi: 10.1007/s11160-007-9073-7.

Nelson, J.S. 2006. Fishes of the World, 4th ed., John Wiley & Sons, New York, 601 pp.

Pancucci-Papadopoulou, M., Zenetos, A., Corsini-Foka, M., Politou, Ch. 2005. Update of marine alien species in Hellenic waters. Mediterranean Marine Science, 6: 147-158.

Papaconstantinou, C. 1988. Faunae Graeciae. Check-List of Marine Fishes of Greece. National Centre for Marine Research and Hellenic Zoological Society, 257 pp.

Papaconstantinou, C. 1990. The spreading of Lessepsian fish migrants into the Aegean Sea (Greece). Scienta Marina, 54: 313–316.

Pazi, I. 2008. Water mass properties and chemical characteristics in the Saros Gulf, Northeast Aegean Sea (Eastern Mediterranean). Journal of Marine Systems, 74: 698-710. doi:10.1016/j.jmarsys.2008.07.002.

Por, F.D. 1978. The Influx of Red Sea Biota into the Mediterranean by way of the Suez Canal, vol. 23. Spinger, Berlin, 228 pp.

Por, F.D. 1990. Lessepsian migration: An appraisal and new data. Bulletin de l'Institute Oceanographique, Monaco, Special No 7: 1-10.

Quignard, J.P. and Tomasini, J.A. 2000. Mediterranean fish biodiversity. Biologia Marina Mediterranea, 7(3): 1-66.

Sarı, E. and Çağatay, M.N. 2001. Distributions of heavy metals in the surface sediments of the Gulf of Saros, NE Aegean Sea. Environment International, 26:169-173.

Stergiou, K.I. and Pollard, D. 1994. A spatial analysis of the commercial fisheries catches from the Hellenic Aegean Sea. Fisheries Research, 20: 109-135.

Streftaris, N., Zenetos, A. and Papathanassiou, E. 2005. Globalisation in marine ecosystems: The story of non-Indigenous marine species across European Seas. Oceanography and Marine Biology- an Annual Review, 43: 419-453.

Theocharis, A. and Georgopoulos, D. 1993. Dense water formation over the Samothraki and Limnos plateaux in the North Aegean Sea (eastern Mediterranean Sea). Continental Shelf Research, 13(8/9): 919-939.

Theocharis, A., Klein, B., Nittis, K. and Roether, W. 2002. Evolution and status of the eastern Meditarranean Transient (1997-1999). Journal of Marine Systems, 33-34: 91-116. doi: 10.1016/S0924-7963(02)00054-4.

Türker-Çakır, D., Yarmaz, A. and Balaban, C. 2009. A new record of *Lagocephalus sceleratus* (Gmelin 1789) confirming a further range extension into the northern Aegean Sea. Journal of Applied Ichthyology, 25(5): 606-607. doi: 10.1111/j.1439-0426.2009.01276.x.

Yarmaz, A., Balaban, C., Türkakın, M. and Türker-Çakır, D. 2010. A new record of Lessepsian migrant *Etrumeus teres* (DeKay, 1842) (Osteichthyes: Clupeidae) from the northern Aegean Sea. Journal of Applied Ichthyology, 26: 134-136. doi: 10.1111/j.1439-0426.2009.01365.x.