Turkish Journal of Zoology

http://journals.tubitak.gov.tr/zoology/

Research Article

Turk J Zool
(2016) 40: 522-533
© TÜBİTAK
doi:10.3906/zoo-1505-35

Catch composition of trawl fisheries in Mersin Bay with emphasis on catch biodiversity

Gökhan GÖKÇE[1,*], İsmet SAYGU[1], Ahmet Raif ERYAŞAR[2]
[1]Faculty of Fisheries, Çukurova University, Adana, Turkey
[2]Faculty of Fisheries, Recep Tayyıp Erdoğan University, Rize, Turkey

Received: 21.05.2015 • **Accepted/Published Online:** 02.03.2016 • **Final Version:** 09.06.2016

Abstract: This study presents the catch composition and biodiversity of Mersin Bay, northeastern Mediterranean, which is an important fishing ground for demersal trawls. A total of 182 hauls were performed on board a commercial trawler on the commercial fishing grounds between 15 September 2009 and 15 April 2013. The monthly changes in species composition were analyzed by conducting cluster analysis based on catch per unit effort (CPUE), nonmetric multidimensional scaling (nMDS), and correlation vectors, which were used to evaluate the discrete groups. Shannon–Wiener index (H'), its evenness (J') component, and the Pielou evenness index were calculated to clarify temporal monthly changes. One hundred and thirty-five species belonging to 10 classes, 26 orders, and 71 families were identified. CPUE values were 1558 (individual/h) and 23.96 (kg/h), respectively. While the most abundant species were *Mullus barbatus* in terms of IRI and CPUE (kg/h), *Equulites klunzingeri* had the highest CPUE (N/h). Four clear clusters of the months were observed. The highest diversity was observed in November, with H' = 3.28 and J' = 0.74 index values. The results highlighted the differences of catch composition between fishing months.

Key words: Bottom trawl fisheries, species composition, catch per unit effort, index of relative importance

1. Introduction

Bottom trawl fisheries are one of the main anthropogenic factors leading to the degradation of coastal areas of the Mediterranean Sea due to the multispecies nature of trawl fisheries (Jackson et al., 2001; Coll et al., 2010).

The Food and Agriculture Organization (FAO) reported in 2012 that in 2009, 33% of the Mediterranean and Black Sea fish stocks were fully exploited, 50% were overexploited, and only 17% were not fully exploited. In the Mediterranean Sea, the main stocks of sole, most sea breams, and all hake and red mullet are overexploited. Moreover, the increasing introduction of the Lessepsian species (i.e. migration from the Red Sea to the Mediterranean via the Suez Canal), which compete with the native species, is an important threat, especially in the eastern Mediterranean. According to Golani (1998), the construction of the Suez Canal and the Aswan High Dam in the eastern Mediterranean has caused the greatest human-made effect on a marine ecosystem. Thus, fishing and invasive species are the two main factors that have heavily degraded the Levantine marine ecosystem. Lessepsian species have come to constitute an important part of the catch (Gücü et al., 2010; Türkstat, 2012).

Even though the continental shelf is narrow in most areas of the northeastern Mediterranean, Mersin Bay is relatively wide. The bay is very productive in terms of demersal fish and crustacean species due to its large continental shelf, bottom type, and river discharge (Gücü and Bingel, 1994; Gökçe, 2012). Thus, bottom trawl fisheries are dominant in the region. Discard is one of the major problems (Gücü, 2012; Özbilgin et al., 2013), and fisheries management is very complicated, similar to other ecosystems of the Mediterranean.

Bottom trawls, which are the most efficient fishing method for demersal fisheries in the area, are regulated by the Ministry of Agriculture and Rural Affairs with certain restrictions, including closed zones, seasons, distance, and the shape and size of the codend (Kaykaç et al., 2012). Fishing is prohibited from 1 April to 1 September for purse seine and until 15 September for bottom trawlers (Turkish Fisheries Regulations No 3/1, 2012). Currently, traditional bottom trawl nets have 600, 700, 860, or 900 meshes around the mouth, with a 44-mm mesh size hand-woven slack knotted codend (Özbilgin et al., 2010; Özbilgin et al., 2013), which have poor selectivity and a high discard ratio (Özbilgin et al., 2013; Eryaşar et al., 2014).

Although many scientific studies have been carried out on the discard composition and selectivity of commercial species in Mersin Bay, relatively little is known about the catch composition, including target and nontarget species or catch biodiversity.

* Correspondence: gokceg@cu.edu.tr

Understanding the catch composition and biodiversity of bottom trawl fisheries is important for evaluating the effects of trawl fisheries on the spectrum of biodiversity. Generally, species richness and evenness represent biodiversity (Jennings and Reynolds, 2000).

This paper will discuss the catch composition and biodiversity of the commercial bottom trawl fisheries in Mersin Bay, northeastern Mediterranean, and will identify the catch per unit effort (CPUE) and discard status for each species. This information will provide the necessary knowledge and baseline data to help fill a main gap in the region with regard to fisheries management and ecological framework, the latter of which is currently disputed.

2. Materials and methods

Sea trials were carried out in the commercial fishing grounds of Mersin Bay, eastern Mediterranean, at depths ranging from 14.7 to 141.1 m, between 15 September 2009 and 15 April 2013 (Figure 1). Sea trials were only conducted during the legal fishing season. A total of 182 valid hauls were performed on board 7 different commercial trawlers with tow durations ranging from 91 to 360 min. The tow speed ranged from 2.3 to 3.1 knots. Detailed monthly information on the hauls is presented in Table 1. The commercial codend (CD44) was hand-woven from multimonofilament (∅ 0.35 mm × 15) polyethylene (PE) twine material, 4 m in stretched length, 300 meshes in circumference, and 44 mm in nominal mesh size.

When the catch was on board, it was selected as retained or discarded by the crew, and then sorted into species and measured by the researchers. According to the time and sea conditions, the number (*N*) and weight (*W*) of each retained and discarded species were measured by applying subsample.

CPUE (Sparre and Venema, 1992) for each species was calculated and standardized in number and kg per hour for each haul:

$$\text{CPUE} = \frac{\Sigma\, C_i / N_ç}{\Sigma\, t / N_ç},$$

where 'C$_i$' is the catch amount in *N* or *W* (kg) for species i; 'N$_ç$', is the number of hauls, and 't' is haul duration in hours 'h'.

Index of relative importance (*IRI*) was calculated using the following formula (Pinkas et al., 1970):

IRI= Fi (Ni+Wi),

where 'N' is the percentage of CPUE (N/h) for species i; 'W', is the percentage of CPUE (kg/h) for species i; 'F', and is the total observed haul frequency for species 'i'.

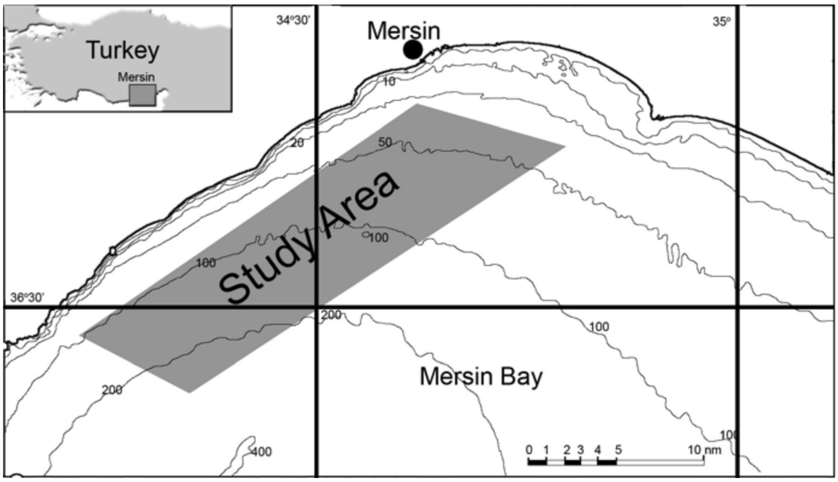

Figure 1. Study area.

Table 1. Haul summary.

	Fishing months								
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	All
Haul number	36	26	17	27	17	21	20	18	182
Total haul duration (h)	106.9	69.8	43.9	65.4	54.7	64.4	56.5	58.2	519.7
Mean haul depth (m)	35.6 ± 15.5	30.7 ± 15.1	41.6 ± 21.3	34.0 ± 14.1	36.4 ± 19.6	51.5 ± 25.5	48.5 ± 12.7	79.5 ± 55.3	42.9 ± 27.4

Species richness (S), Shannon–Wiener diversity (H′), and Pielou's evenness (J′) indices were calculated. Species richness is the number of species, Shannon–Wiener diversity index ($\log_2$base) (Kindt, 2005):

$$H' = -\sum_{i=1}^{n} P_i \ln P_i,$$

where is the proportion of the total number of individuals in the population of species , and evenness (Kindt, 2005):

$$J' = (H')/\log S$$

Rank curves, ranking species in descending order according to CPUE% (N/h), and CPUE% (kg/h) of the species were used to demonstrate the indication of evenness. The indices and calculations were performed monthly during each fishing month (from September to April).

Cluster analyses were performed to understand the differences between catch compositions in different fishing months. Bray–Curtis dissimilarity matrix and average method (Kindt, 2005; Mutlu and Ergev, 2008, 2012) were used for the cluster analysis and applied to standardized data CPUE (N/h) and CPUE (kg/h), transformed using $\mathrm{Log}_{10}(X + 1)$. Nonmetric multidimensional scaling (nMDS) and correlation vectors were used to evaluate the discrete groups described by cluster analysis (Kindt, 2005; Mutlu and Ergev, 2008). The analyses were performed using the Fathom Toolbox for MATLAB (Jones, 2014).

3. Results

3.1. Catch composition and biodiversity indices

During the study period, a total of 135 species belonging to 10 classes, 26 orders, and 71 families encountered the gear (Table 2). It was estimated that bottom trawl fishermen caught 1558 individuals and 23.96 kg/h during the fishing season. The highest CPUE was found in September as 47.82 kg/h and 2989 N/h, and the lowest values were observed as 13.90 kg/h in January and 843 N/h in February (Table 3). The results highlight a dramatic decline in CPUE after September, which is the beginning of the fishing season (Figure 2). Whilst the 27 species described retained (landed), discarded species were 57 and 48.

The catch mainly consisted of 40.43% commercial fish, 13.79% commercial invertebrates, 6.23% Lessepsian commercial fish, 7.88% Lessepsian commercial invertebrates, 7.70% discarded fish, 4.56% discarded invertebrates, 4.98% Lessepsian discarded fish, 9.32% Lessepsian discarded invertebrates, 5.11% Elasmobranchs in terms of CPUE (kg/h), and 23.40%, 13.29%, 3.86%, 6.64%, 15.93%, 1.99%, 20.45%, 14.36%, and 0.09 in terms of CPUE (N/h), respectively. The distribution of the catch by months is given in Figure 3.

Table 2. Taxonomic composition of the landed and discarded catches. CPUE, catch per unit effort; N, number; h, hour; IRI, index of relative importance; %IRI, percentage of IRI; D, discarded; L, landed; B, both; *, Lessepsian species.

Class order	Family	Species	CPUE (N/h)	CPUE (kg/h)	Total catch (N)	Total catch (kg)	F	%IRI	Status
Actinopterygii Anguilliformes	Congridae	*Conger conger*	3	0.1815	1976	109.47	63	0.27	B
	Muraenidae	*Muraena*	0	0.0016	1	1.00	1	0.00	D
	Ophichthidae	*Echelus myrus*	0	0.0003	4	0.14	2	0.00	B
	Atherinidae	*Atherina hepsetus*	25	0.0645	13829	35.08	8	0.07	D
		Atherinomorus lacunosus	0	0.0036	152	2.60	4	0.00	D
Aulopiformes	Synodontidae	*Saurida undosquamis**	19	0.8310	9500	427.28	156	3.23	B
		Synodus saurus	0	0.0006	5	0.30	5	0.00	L
Clupeiformes	Clupeidae	*Alosa fallax nilotica*	0	0.0059	9	3.30	3	0.00	L
		Sardina pilchardus	1	0.0086	403	4.01	11	0.00	D
		Sardinella aurita	14	0.0967	7496	54.32	54	0.30	B
	Dussumieriidae	*Dussumieria elopsoides**	6	0.0923	3181	49.62	32	0.11	B
		*Etrumeus teres**	5	0.0651	2664	34.64	8	0.02	D
	Engraulidae	*Engraulis encrasicolus*	35	0.1804	18666	100.00	56	0.74	D
Cyprinodontiformes	Cyprinodontidae	*Aphanius fasciatus*	0	0.0024	160	1.28	6	0.00	D
Gadiformes	Merlucciidae	*Merluccius merluccius*	5	0.3749	2898	214.71	81	0.68	B
	Phycidae	*Phycis blennoides*	0	0.0019	10	1.06	5	0.00	L
Lophiiformes	Lophiidae	*Lophius budegassa*	0	0.0295	13	17.53	8	0.00	L
Mugiliformes	Mugilidae	*Chelon labrosus*	0	0.0031	15	1.44	3	0.00	L
		Liza aurata	0	0.0178	148	9.75	10	0.00	L
		*Liza carinata**	0	0.0063	58	2.98	8	0.00	L
		Liza ramada	0	0.0154	63	5.86	10	0.00	B
		Mugil cephalus	0	0.0020	5	1.30	2	0.00	L
Perciformes	Apogonidae	*Apogonichthyoides nigripinnis*	3	0.0544	1958	32.45	49	0.10	D
	Blenniidae	*Blennius ocellaris*	1	0.0098	394	5.27	34	0.01	D

Table 2. (Continued).

	Callionymidae	*Callionymus lyra*	3	0.0128	1674	7.01	18	0.02	D
	Carangidae	*Caranx crysos*	0	0.0041	68	2.29	8	0.00	B
		Caranx hippos	0	0.0003	3	0.18	1	0.00	L
		Caranx rhonchus	0	0.0020	16	0.98	3	0.00	L
		Lichia amia	0	0.0002	1	0.10	1	0.00	L
		Pseudocaranx dentex	0	0.0005	5	0.23	2	0.00	L
		Trachurus mediterraneus	0	0.0023	94	1.17	2	0.00	B
		Trachurus picturatus	1	0.0403	244	18.52	5	0.00	L
		Trachurus trachurus	34	0.9228	17905	498.21	155	4.15	B
	Centracanthidae	*Spicara maena*	0	0.0013	14	0.70	4	0.00	L
		Spicara smaris	10	0.2299	5706	128.07	104	0.74	B
	Cepolidae	*Cepola macrophthalma*	0	0.0029	127	1.72	9	0.00	D
	Champsodontidae	*Champsodon nudivittis*	2	0.0139	840	6.81	28	0.02	D
	Echeneidae	*Echeneis naucrates*	0	0.0065	74	3.59	6	0.00	D
		Remora remora	0	0.0223	19	12.18	6	0.00	D
	Gobiidae	*Deltentosteus quadrimaculatus*	17	0.0668	8453	34.02	68	0.41	D
		Gobius geniporus	28	0.1793	14890	99.89	84	0.94	D
		Oxyurichthys papuensis	9	0.1452	5116	79.15	50	0.27	D
	Haemulidae	*Pomadasys incisus*	0	0.0003	2	0.20	2	0.00	L
	Leiognathidae	*Equulites klunzingeri*	309	0.8183	162457	435.37	117	12.02	D
	Mullidae	*Mullus barbatus*	187	4.1795	98048	2194.86	180	23.47	B
		Mullus surmuletus	1	0.0297	578	16.45	22	0.02	L
		*Upeneus moluccensis**	23	0.2202	11577	113.30	94	0.98	B
		*Upeneus pori**	1	0.0045	264	2.32	12	0.00	B
	Nemipteridae	*Nemipterus randalli**	12	0.2880	6887	152.76	96	0.84	B
	Pomatomidae	*Pomatomus saltatrix*	0	0.0112	54	5.86	13	0.00	L
	Sciaenidae	*Argyrosomus regius*	0	0.0564	112	30.24	20	0.02	L
		Umbrina cirrosa	0	0.0031	10	1.50	5	0.00	L
	Scombridae	*Scomber japonicus*	2	0.0578	1282	32.62	59	0.10	B
	Serranidae	*Anthias anthias*	0	0.0001	3	0.04	1	0.00	D
		Epinephelus aeneus	0	0.0422	17	22.64	15	0.01	B
		Epinephelus costae	0	0.0016	2	0.62	2	0.00	L
		Epinephelus marginatus	0	0.0013	2	0.70	2	0.00	L
		Serranus cabrilla	2	0.0224	923	12.30	39	0.04	B
		Serranus hepatus	21	0.1783	11593	97.18	117	1.09	D
	Siganidae	*Siganus luridus**	0	0.0004	24	0.24	1	0.00	D
	Sparidae	*Boops boops*	25	0.7372	13323	396.56	164	3.38	B
		Dentex gibbosus	0	0.0002	5	0.12	2	0.00	L
		Dentex macrophthalmus	0	0.0020	82	1.09	5	0.00	B
		Diplodus annularis	0	0.0099	257	5.26	20	0.01	B
		Diplodus sargus	0	0.0004	6	0.20	1	0.00	L
		Diplodus vulgaris	0	0.0019	18	1.03	6	0.00	L
		Lithognathus mormyrus	0	0.0023	35	1.19	3	0.00	B
		Pagellus acarne	34	0.6589	17724	338.28	111	2.42	B
		Pagellus bogaraveo	0	0.0033	88	1.96	6	0.00	B
		Pagellus erythrinus	26	0.7047	13591	370.88	147	2.98	B
		Sparus aurata	0	0.0404	213	19.69	58	0.05	L
	Sphyraenidae	*Sphyraena chrysotaenia**	0	0.0007	4	0.24	3	0.00	L
		Sphyraena sphyraena	2	0.1559	1226	99.53	35	0.12	B
	Terapontidae	*Pelates quadrilineatus**	0	0.0000	1	0.02	1	0.00	L
	Trachinidae	*Trachinus draco*	0	0.0052	40	2.53	4	0.00	D
	Trichiuridae	*Lepidopus caudatus*	1	0.0234	381	12.68	14	0.01	B
		Trichiurus lepturus	2	0.1223	1104	67.47	45	0.13	B
	Uranoscopidae	*Uranoscopus scaber*	1	0.0356	427	20.94	43	0.04	D
Pleuronectiformes	Bothidae	*Arnoglossus kessleri*	17	0.0918	9609	51.93	91	0.59	D
		Bothus podas	0	0.0014	178	0.73	8	0.00	D
	Citharidae	*Citharus linguatula*	35	0.3358	20498	193.08	131	2.12	D
	Cynoglossidae	*Symphurus nigrescens*	1	0.0051	313	2.96	16	0.00	D
	Soleidae	*Microchirus ocellatus*	0	0.0137	215	8.57	13	0.00	B

Table 2. (Continued).

		Solea solea	3	0.1674	1649	95.56	111	0.44	B
Scorpaeniformes	Dactylopteridae	*Dactylopterus volitans*	0	0.0002	12	0.12	1	0.00	D
	Scorpaenidae	*Scorpaena maderensis*	6	0.0570	3286	30.01	4	0.01	D
		Scorpaena notata	0	0.0030	85	1.73	8	0.00	D
	Triglidae	*Chelidonichthys lucerna*	9	0.2734	4663	145.23	122	0.92	B
		Lepidotrigla dieuzeidei	31	0.2087	17990	117.82	101	1.28	D
		Trigla lyra	0	0.0017	13	0.94	2	0.00	B
		Trigloporus lastoviza	0	0.0163	254	9.89	18	0.01	B
Syngnathiformes	Centriscidae	*Macroramphosus scolopax*	8	0.0257	6020	18.19	14	0.04	D
Tetraodontiformes	Balistidae	*Balistes capriscus*	0	0.0073	77	3.79	10	0.00	B
	Monacanthidae	*Stephanolepis diaspros**	0	0.0000	2	0.02	1	0.00	D
	Tetraodontidae	*Lagocephalus sceleratus**	0	0.0529	169	26.72	15	0.02	D
		*Lagocephalus spadiceus**	3	0.2153	1591	113.50	57	0.27	D
		*Lagocephalus suezensis**	5	0.0477	2569	25.79	44	0.10	D
		*Torquigener flavimaculosus**	0	0.0000	1	0.01	1	0.00	D
Zeiformes	Zeidae	*Zeus faber*	1	0.0346	353	18.18	21	0.02	B
Cephalopoda Myopsida	Loliginidae	*Loligo vulgaris*	5	0.1901	2463	96.86	106	0.51	B
Octopoda	Octopodidae	*Eledone moschata*	1	0.1094	675	60.69	35	0.08	B
		Octopus vulgaris	0	0.1227	282	67.00	40	0.10	B
Oegopsida	Ommastrephidae	*Illex coindetii*	0	0.0147	168	8.21	24	0.01	B
Sepiida	Sepiidae	*Sepia officinalis*	15	1.3348	8408	707.65	151	4.38	B
Demospongiae			0	0.4888	138	274.59	46	0.42	D
Echinoidea			1	0.0388	944	25.92	5	0.01	D
Elasmobranchii Carcharhiniformes	Carcharhinidae	*Carcharhinus plumbeus*	0	0.0071	1	4.50	1	0.00	D
	Scyliorhinidae	*Scyliorhinus stellaris*	0	0.0199	112	13.68	7	0.00	D
	Triakidae	*Mustelus mustelus*	0	0.0275	16	14.04	4	0.00	D
Rajiformes	Dasyatidae	*Dasyatis pastinaca*	0	0.5302	92	278.64	27	0.27	D
		Dasyatis tortonesei	0	0.0417	5	20.10	3	0.00	D
	Gymnuridae	*Gymnura altavela*	0	0.1694	25	90.64	10	0.03	D
	Rajidae	*Raja clavata*	0	0.2010	181	139.75	17	0.06	D
		Raja miraletus	0	0.0146	27	8.30	6	0.00	D
	Rhinobatidae	*Rhinobatos rhinobatos*	0	0.0841	160	42.79	7	0.01	B
Squaliformes	Oxynotidae	*Oxynotus centrina*	0	0.0016	1	1.20	1	0.00	D
Torpediniformes	Torpedinidae	*Torpedo marmorata*	0	0.0196	37	10.10	4	0.00	D
		Torpedo nobiliana	0	0.0629	179	31.40	12	0.02	D
Gastropoda Neogastropoda	Muricidae	*Bolinus brandaris*	0	0.0016	151	1.07	3	0.00	D
Holothuroidea			0	0.0006	2	0.41	2	0.00	D
Malacostraca Decapoda	Goneplacidae	*Goneplax rhomboides*	1	0.0042	744	2.32	2	0.00	D
	Leucosiidae	*Ixa monodi*	1	0.0207	802	14.97	13	0.01	D
	Majidae	*Maja goltziana*	1	0.0061	479	3.88	19	0.01	D
	Penaeidae	*Metapenaeus monoceros**	50	0.4437	27683	247.86	79	1.77	B
		Parapenaeus longirostris	150	0.3500	97394	223.67	120	5.88	B
		*Penaeus japonicus**	15	0.1047	8729	60.15	69	0.43	B
		Penaeus kerathurus	32	0.6419	17751	359.45	123	2.58	B
		*Penaeus semisulcatus**	38	1.2687	21185	704.10	98	3.36	B
	Portunidae	*Callinectes sapidus**	0	0.0623	235	32.04	9	0.01	B
		*Charybdis longicollis**	224	2.1494	124455	1196.52	121	12.49	D
		*Portunus segnis**	3	0.3537	1382	185.07	22	0.16	B
Stomatopoda	Squillidae	*Eurosquilla massavensis*	24	0.4506	13804	255.05	95	1.45	D
		Squilla mantis	1	0.0409	776	22.28	13	0.02	D
Reptilia Testudines	Cheloniidae	*Caretta caretta*	0	0.3226	5	172.50	5	0.03	D
Scyphozoa Rhizostomeae	Rhizostomatidae	*Rhopilema nomadica**	1	0.5803	402			0.25	D

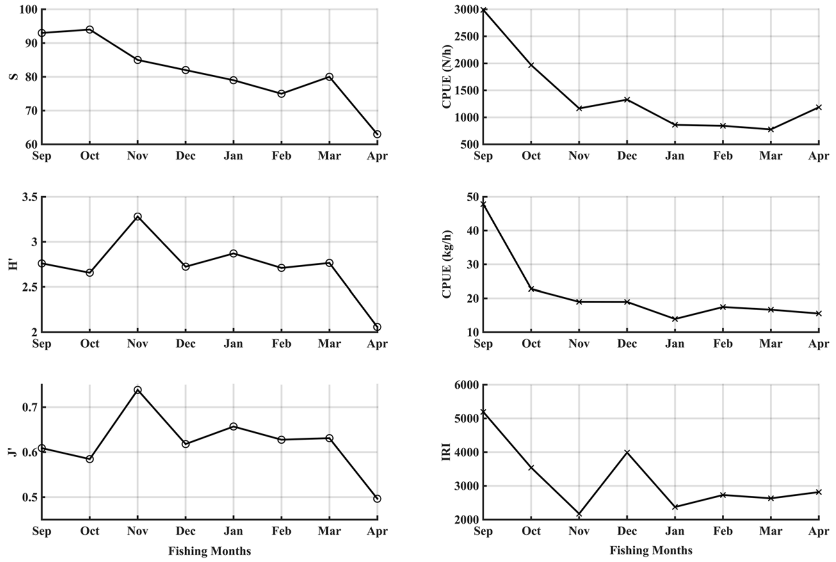

Figure 2. Monthly changes in catch per unit effort (CPUE), index of relative importance (IRI), and biodiversity indices (S, species richness; H', Shannon–Wiener diversity; and J´, Pielou's evenness).

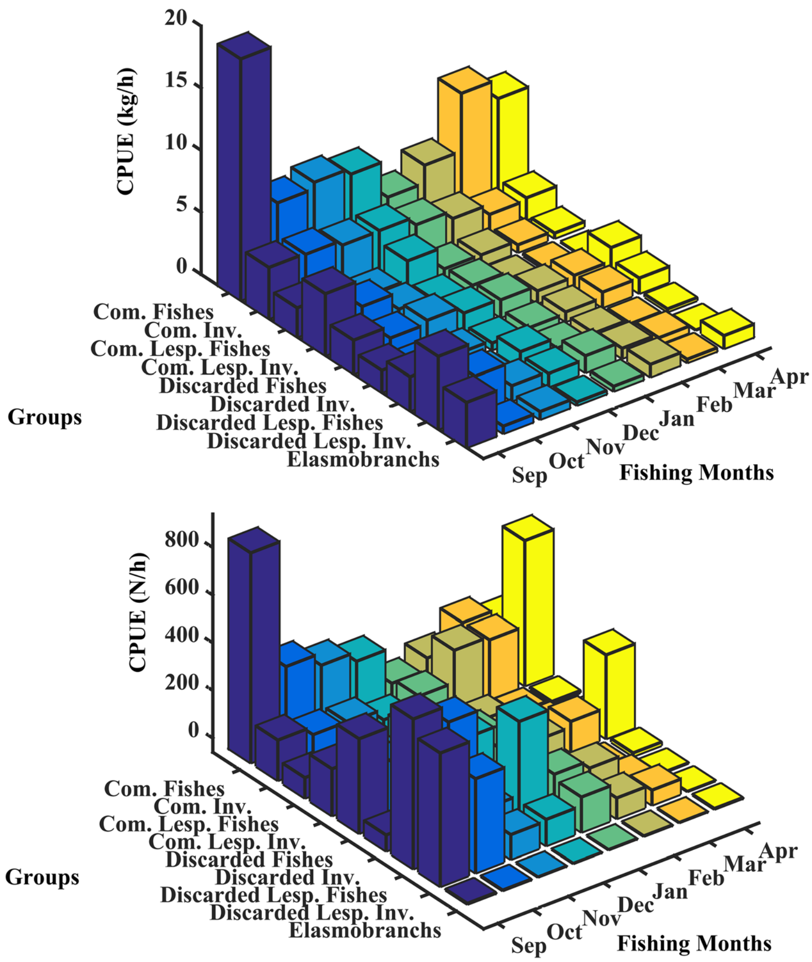

Figure 3. Monthly distribution of the catch.

While the most dominant species was *M. barbatus* in terms of IRI (5304.83) and CPUE (4.18 kg/h), *E. klunzingeri* showed the highest CPUE (309 N/h). Table 2 provides detailed CPUE, catch, IRI (%), and discard status for each species in taxonomic order. The species dominating the catch in terms of CPUE (kg/h and N/h) are demonstrated by months using rank–abundance curves. The curve helps to follow the trend of dominant species during the fishing months (Figures 4 and 5).

Four distinct groups were described from the cluster analysis based on CPUE (kg/h). The groups are September, October–January, February, and March–April, as illustrated in Figure 6. nMDS ordination and correlation vectors clearly highlight similar results (Figure 7). Four main groups based on CPUE (N/h) (September, November–January, February–March, and April) were clearly clustered (Figure 8), and the same pattern was observed for the months in the ordination and correlation vectors (Figure 9).

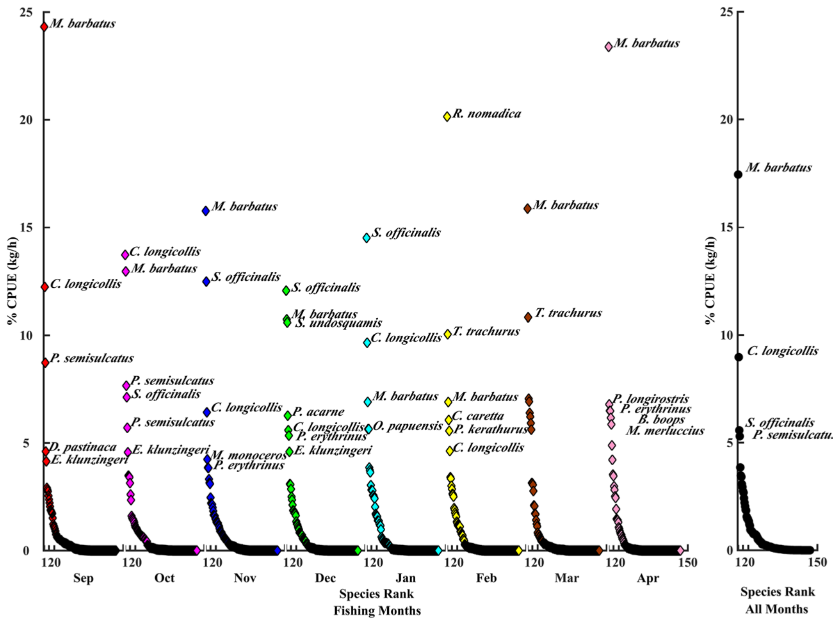

Figure 4. Rank–abundance curves by month in terms of CPUE% (kg/h).

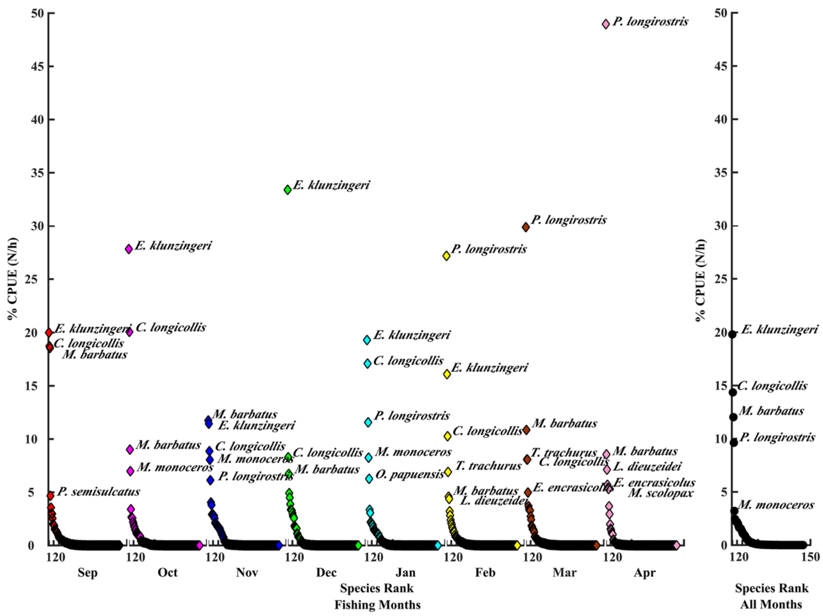

Figure 5. Rank–abundance curves by month in terms of CPUE% (N/h).

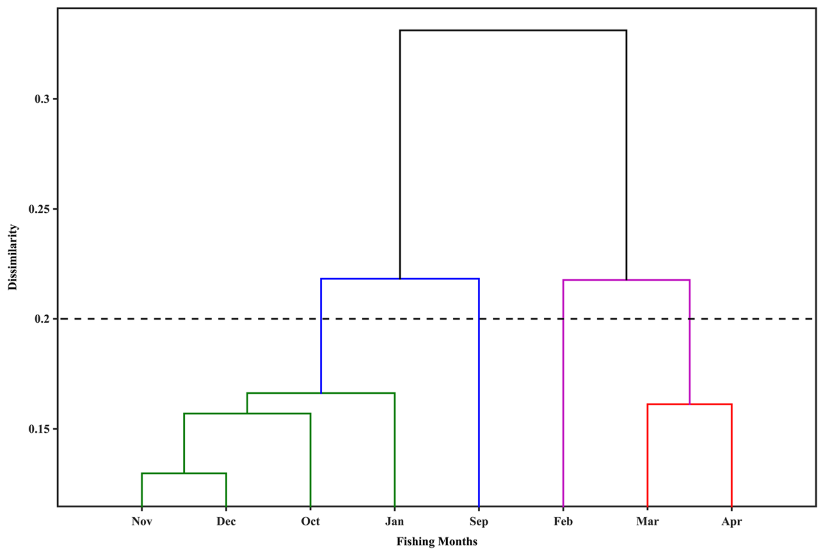

Figure 6. Cluster analysis based on CPUE (kg/h) and the distance (Bray–Curtis, UPGMA) of the catch during the fishing months.

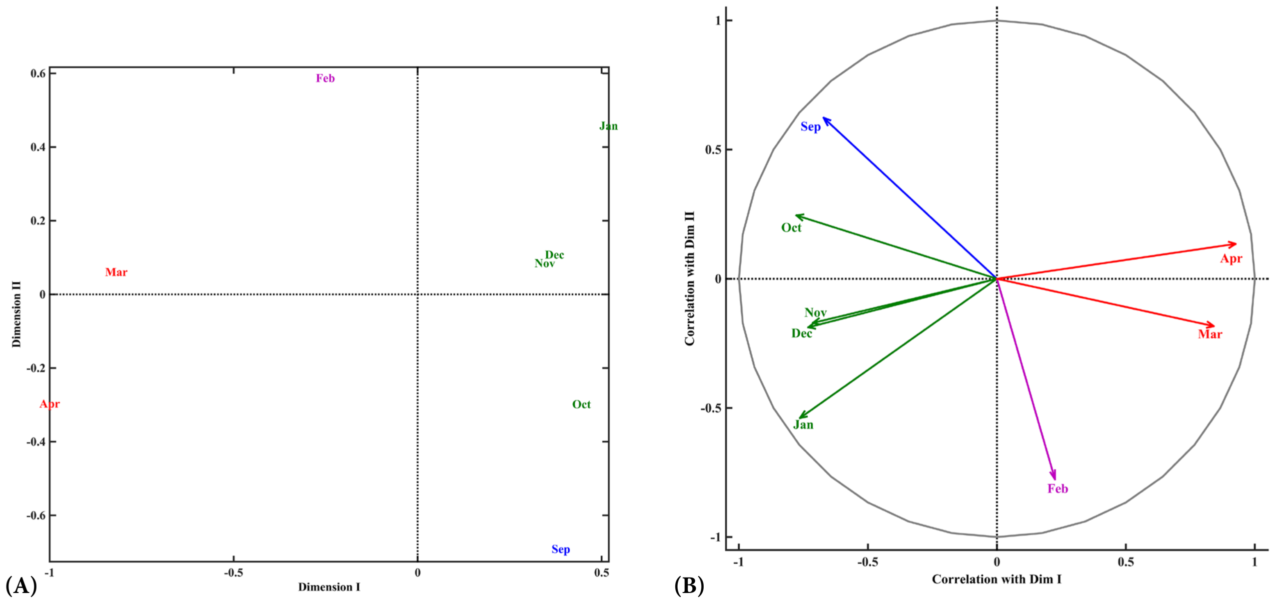

Figure 7. nMDS (A) and correlation vectors (B) applied to standardized data CPUE (kg/h), transformed using $Log_{10}(X + 1)$.

The biodiversity indices of the catch were estimated for all hauls, and were *S* = 135, *H'* = 3.02, and *J'* = 0.62. The highest evenness value (0.74) was detected in November, and the lowest one was in April (0.50) (Table 3). Monthly changes in biodiversity indices are given in Figure 2.

4. Discussion

Çiçek (2006) reported that a total of 110 species were found. Mean CPUE (kg/h) was 26.3 kg/h, and the highest CPUE value was obtained in September as 66.8 kg/h. This value had a tendency to reduce towards the end of the fishing season, with the lowest value recorded in March (12.5 kg/h) in the eastern Mediterranean. There is an intensive fishing pressure in the region and, consequently, very sharp declines in CPUE. Reductions in the lengths of commercial species were reported by Gücü (2000). This trend is broadly similar to our results. *M. barbatus* (19.48%), *C. longicollis* (15.98%), and *S. undosquamis* (15.56%) were determined as dominant species in the catch in terms of CPUE (kg/h) (Çiçek, 2006). Gücü et

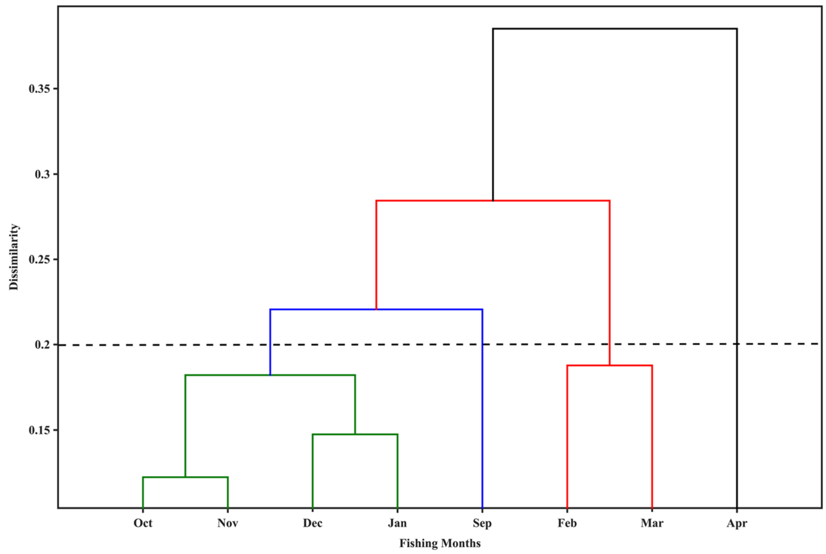

Figure 8. Cluster analysis based on CPUE (N/h) and the distance (Bray–Curtis, UPGMA) of the catch during the fishing months.

al. (2010) also reported the main dominant species in the trawl catch as *S. undosquamis* (24.0%), *D.s pastinaca* (12.5%), *E. klunzingeri* (11.5%), and *M. barbatus* (9.5%) in 1980–1982, and *M. barbatus* (19.8%) and *E. klunzingeri* (15.7%) in 2007–2010. Moreover, *E. klunzingeri* was found to be the main contributor to the discard (Gücü, 2012). In our study, *M. barbatus* (17.41%), *C. longicollis* (8.97%), *S. officinalis* (5.57%), *P. semisulcatus* (5.29%), and *T. trachurus* (3.85%) were dominant species in the catch in terms of weight. The dominant species were *E. klunzingeri* (19.81%), *C. longicollis* (14.35%), *M. barbatus* (12.03%), *P. longirostris* (9.62%), and *M. monoceros* (3.21%); and *M. barbatus* (23.47%), *C. longicollis* (12.49%), *E. klunzingeri* (12.02%), *P. longirostris* (5.88%), and *S. officinalis* (4.38%) in terms of CPUE (N/h) and IRI, respectively.

At the beginning of the fishing season, the commercial species catch was 30.85 kg/h, and the dominant species was *M. barbatus* with 11.63 kg/h (Figures 3 and 4). A dramatic decline of 14.68 kg/h occurred in the commercial species catch (Figures 2 and 3). The discarded catch showed a similar trend. Moreover, the dominance of the species changed. As a notable example, the percentage of *S. officinalis* in the catch rose from 2.83% in September to 15.76% in November (Figure 4). From February to April, the increasing dominance of *P. longirostris* should be considered as a sign of deeper waters used by fishermen (Figure 5; Table 1). Seasonally altered fishing pressure (Özbilgin et al., 2013) in the region can be explained by the changing CPUE and catch composition. Therefore, the local knowledge of fishermen, which is an important source of information in fisheries science, can be used as a descriptor (Anuchiracheeva et al., 2003).

There are similarities among studies on discard composition and rate in the Levant basin. The factors affecting discard composition and rate have been described as sea temperature, daylight (Özbilgin et al., 2013), haul duration (Machias et al., 2001), and depth (Machias et al., 2001; Sanchez et al., 2004; Çiçek, 2006; Gücü, 2012). Time was depicted as an important factor in the study by Özbilgin et al. (2013), but Gücü (2012) did not identify it as an important factor. Although the comparison may be unfitting due to different survey years and periods (Özbilgin et al., 2013), we may consider that the same factors affect catch composition and biodiversity. Our results highlight the differences in catch composition during the fishing months of 2009–2013.

E. klunzingeri and *C. longicollis* are Lessepsian immigrant populations, besides being dominant species in the catch. Therefore, a better understanding of how the catch biodiversity regarding the introduction of Lessepsian species will impact the ecosystem functioning and food web structure may be necessary. It is estimated that 26.69% of the total catch is Lessepsian. Gücü et al. (2010) stated that this ratio was 42.00% in 1980–1982, and 27% in 2007–2010. The proportion of the alien fish species has reached 55% in the continental shelves of Levantine (Edelist et al., 2013; Katsanevakis et al., 2014). Twenty-two of 135 species were Lessepsian species and constituted 28.41% and 45.30% of the total catch in terms of weight and numbers, respectively (Figure 3).

Diversity does not depend on density or total abundance, but is affected by the species dominating the catch (Kindt, 2005). The species that are dominant in the catch and, therefore, affect biodiversity are demonstrated in detail in Figure 5 for the fishing season.

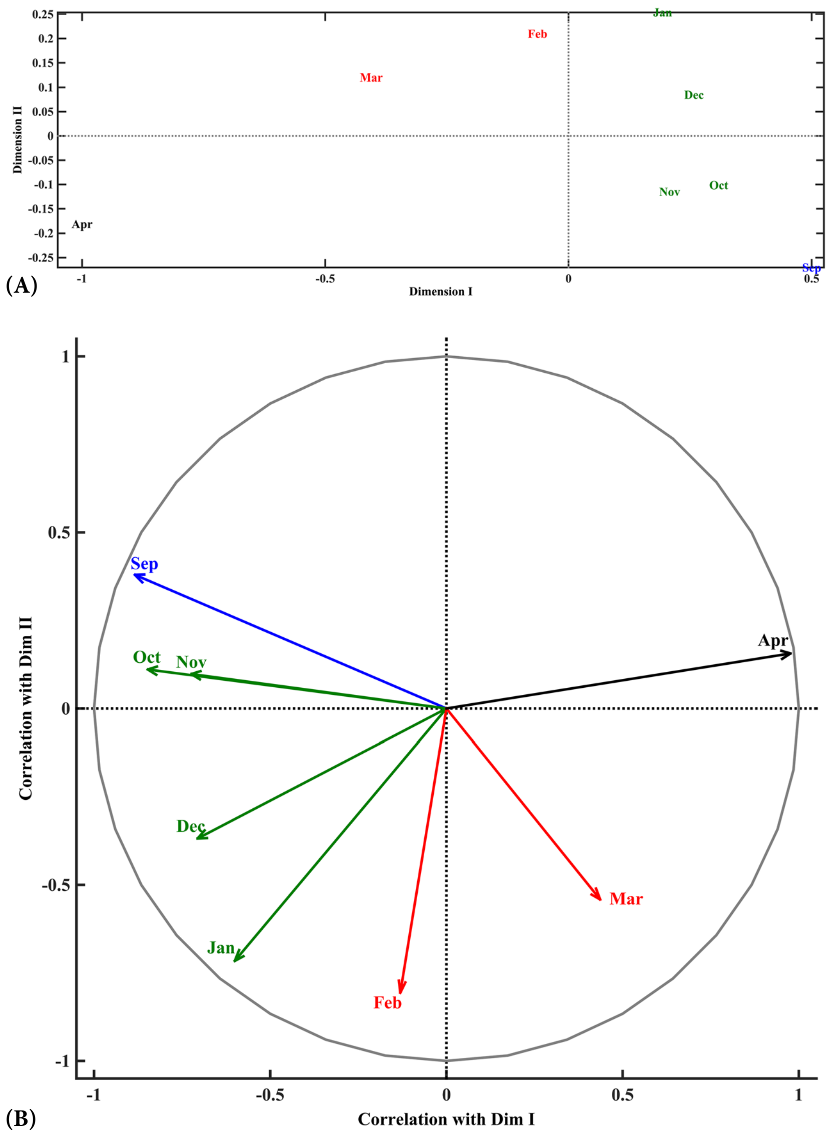

Figure 9. nMDS (A) and correlation vectors (B) applied to standardized data CPUE (N/h), transformed using $Log_{10}(X + 1)$.

Table 3. Catch per unit effort (CPUE), index of relative importance (IRI), and biodiversity indices by months. S, species richness; H', Shannon–Wiener diversity; and J´, Pielou's evenness.

	Fishing months								
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	All
CPUE (N/h)	2989	1966	1166	1328	862	843	777	1186	1558
CPUE (kg/h)	47.82	22.73	18.97	18.95	13.90	17.44	16.65	15.51	23.96
IRI	5192.43	3539.68	2174.22	3988.91	2374.82	2730.15	2631.96	2816.77	22,600.50
S	93	94	85	82	79	75	80	63	135
H'	2.76	2.66	3.28	2.72	2.87	2.71	2.77	2.06	3.02
J'	0.61	0.58	0.74	0.62	0.66	0.63	0.63	0.50	0.62

An important approach to the management of the complex ecosystem in the northeastern Mediterranean is ecosystem-based fishery management (EBFM), which considers the impact of fishing on the ecosystem in terms of target and nontarget species, trophic interactions, and environmental factors (Botsford, 1997; Duda and Sherman, 2002; Coll et al., 2008; Coll and Libralato, 2012). In this context, while making an effort to reduce discard ratios, quantifying changes in catch biodiversity may be an important ecosystem approach to fisheries.

Consequently, in the commercial fishing grounds and seasons of Mersin Bay between 2009 and 2013, demersal trawl fisheries were characterized by multispecies catches and low CPUEs. During the fishing months, the results highlighted that the differences in the composition of the catch and CPUEs change monthly, which might have reflected on the fisheries' behavior and pressure. Understanding the differences besides catch and discard dynamics may ensure a new perspective for policy-makers to examine the consequences of different management actions for ecological framework and balanced harvest, which is currently disputed.

Acknowledgments

We would like to thank the captain and crew of the commercial trawler "Azim". Thanks are also extended to Dr H Özbilgin, Y Özbilgin, Dr AS Bozaoğlu, E Kalecik, and the students of the Fisheries Faculty, Mersin University for their help during the sea trials. We are also grateful to S Mavruk for the helpful revision of the manuscript. This study was financed by the Scientific and Technological Research Council of Turkey (TÜBİTAK, Grant No. 1090684).

References

Anuchiracheeva S, Demaine H, Shivakoti GP, Ruddle K (2003). Systematizing local knowledge using GIS: fisheries management in Bang Saphan Bay, Thailand. Ocean Coast Manag 46: 1049-1068.

Botsford LW (1997). The management of fisheries and marine ecosystems. Science 80: 509-515.

Coll M, Bahamon N, Sardà F, Palomera I, Tudela S, Suuronen P (2008). Improved trawl selectivity: effects on the ecosystem in the South Catalan Sea (NW Mediterranean). Mar Ecol Prog Ser 355: 131-147.

Coll M, Libralato S (2012). Contributions of food web modelling to the ecosystem approach to marine resource management in the Mediterranean Sea. Fish Fish 13: 60-88.

Coll M, Piroddi C, Steenbeek J, Kaschner K, Ben Rais Lasram F, Aguzzi J, Ballesteros E, Bianchi CN, Corbera J, Dailianis T, et al. (2010). The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PLoS One 5: 1-36.

Çiçek E (2006). Study on the potentially economical important species trawled from Karataş (Adana) coasts. PhD, Çukurova University, Adana, Turkey.

Duda AM, Sherman K (2002). A new imperative for improving management of large marine ecosystems. Ocean Coast Manag 45: 797-833.

Edelist D, Rilov G, Golani D, Carlton JT, Spanier E (2013). Restructuring the sea: profound shifts in the world's most invaded marine ecosystem. Divers Distrib 19: 69-77.

Eryaşar AR, Özbilgin H, Gökçe G, Özbilgin YD, Saygu I, Bozaoğlu AS, Kalecik E (2014). The effect of codend circumference on selectivity of hand-woven slack knotted codend in the North Eastern Mediterranean demersal trawl fishery. Turk J Fish Aquat Sci 470: 463-470.

FAO (2012). The State of World Fisheries and Aquaculture. Rome, Italy: Food and Agriculture Organization.

Golani D (1998). Impact of Red Sea fish migrants through the Suez Canal on the aquatic environment of the Eastern Mediterranean. Yale F&ES Bull 103: 375-387.

Gökçe G (2012). Fisheries of the Mediterranean part of Turkey. In: Tokaç A, Gücü AC, Öztürk B, editors. The State of Turkish Fisheries. Ankara, Turkey: Turkish Marine Research Foundation, pp. 242-250.

Gücü AC (2000). Kuzeydoğu Akdeniz balık stokları—20 yıllık zaman serisi. In: Uysal Z, Salihoğlu I, editors. Proceedings of the 1st National Marine Science Conference; 30 May–2 June 2000; Ankara, Turkey. pp. 160-164 (in Turkish).

Gücü AC (2012). Impact of depth and season on the demersal trawl discard. Turk J Fish Aquat Sci 12: 817-830.

Gücü AC, Bingel F (1994). State of the fisheries along the Turkish Mediterranean Coast. Turk J Zool 18: 251-258.

Gücü A, Ok M, Sakinan S (2010). Past and present of fish fauna in the NE Levant Sea and factors facilitating the colonization by Lessepsian fishery. In: Report of the Technical Meeting on the Lessepsian Migration and its Impact on Eastern Mediterranean Fishery. Rome, Italy: Food and Agriculture Organization, pp. 88-108.

Jackson JB, Kirby MX, Berger WH, Bjorndal KA, Botsford LW, Bourque BJ, Bradbury RH, Cooke R, Erlandson J, Estes JA et al. (2001). Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629-637.

Jennings S, Reynolds JD (2000). Impacts of fishing on diversity: from pattern to process. In: Kaiser MJ, de Groot SJ, editors. Effects of Fishing on Non-Target Species and Habitats: Biological, Conservation and Socio-Economic Issues. Oxford, UK: Blackwell, pp. 235-250.

Jones DL (2014). The Fathom Toolbox for Matlab: Multivariate Ecological and Oceanographic Data Analysis. St Petersburg, FL, USA: University of South Florida.

Katsanevakis S, Coll M, Piroddi C, Steenbeek J, Ben Rais Lasram F, Zenetos A, Cardoso AC (2014). Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. Front Mar Sci 1: 1-11.

Kaykaç MH, Tosunoğlu Z, Tokaç A (2012). Trawl fisheries. In: In: Tokaç A, Gücü AC, Öztürk B, editors. The State of the Turkish Fisheries. Ankara, Turkey: Turkish Marine Research Foundation, pp. 316-327.

Kindt R (2005). Tree Diversity Analysis: a Manual and Software for Common Statistical Methods for Ecological and Biodiversity Studies. Nairobi, Kenya: World Agroforestry Centre.

Machias A, Vassilopoulou V, Vatsos D, Bekas P, Kallianiotis A, Papaconstantinou C, Tsimenides N (2001). Bottom trawl discards in the northeastern Mediterranean Sea. Fish Res 53: 181-195.

Mutlu E, Ergev MB (2008). Spatio-temporal distribution of soft-bottom epibenthic fauna on the Cilician shelf (Turkey), Mediterranean Sea. Rev Biol Trop 56: 1919-1946.

Mutlu E, Ergev MB (2012). Distribution of soft-bottom mollusks (Mollusca) in Mersin Bay (eastern Mediterranean Sea). Turk J Zool 36: 430-446.

Özbilgin Y, Gökçe G, Özbilgin G, Çelik O, Göçer M, Ünal V, Güncüoğlu, H, Tokaç A (2010). Kuzeydoğu Akdeniz'de Balıkçılık. Mersin, Turkey: Mersin Deniz Ticaret Odası (in Turkish).

Özbilgin H, Gökçe G, Özbilgin Y, Eryaşar AR, Kalacik E, Bozaoğlu AS (2013). Investigations to improve species and size selectivity in Mersin Bay trawl fisheries. Ankara, Turkey: TÜBİTAK (in Turkish).

Pinkas L, Oliphant MS, Iverson ILK, (1970). Food habits of Albacore, bluefin tuna, and Bonito in California waters. Fish Bull Calif 152: 1-105.

Sanches P, Demestre M, Martin P (2004). Characterisation of the discards generated by bottom trawling in the northwestern Mediterranean. Fish Res 67: 71-80.

Sparre P, Venema SC (1992). Introduction to Tropical Fish Stock Assessment. In: Part 1. Manual. FAO Technical Paper, 306/1. Rome, Italy: Food and Agriculture Organization.

Turkish Fisheries Regulations No 3/1 (2012). The Commercial Fish-Catching Regulations in Seas and Inland Waters in the 2012-2016 Fishing Period: Circular No. 2012/68. Ankara, Turkey: Ministry of Agriculture and Rural Affairs (in Turkish).

Türkstat (2012). Fishery Statistics. Ankara, Turkey: Türkstat.