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RESEARCH ARTICLE

Some observations on the ichthyofauna of the Finike (Anaximander) Seamounts, the eastern Mediterranean

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Abstract

Deep sea ecosystems are home to many unique habitats. Considering the Mediterranean Sea, extreme environments are clustered mainly in the eastern basin such as the Nile Deep Sea Fan, Finike (Anaximander) and Eratosthenes Seamounts, Olimpi mud volcano field, Calabrian Arc and Marmara deep fault systems. This study was conducted in the Finike Seamounts, to assess the ichthyofauna of the area with a depth of down to 2200 m. Samples of larval, juvenile and adult phases indicated the presence of 20 fish species belonging to 13 families in and around the Finike Seamounts area. The collected individuals consisted of 422 adults, 6 juveniles and 31 larvae. Most of the individuals belonged to *Cyclothone braueri*, all of them being adults.

Keywords: Eastern Mediterranean, deep sea, seamount, fish, larvae

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Introduction

Waters deeper than 1000m cover approximately 60% of our planet. Considering their exclusive features and low turn-over rates, deep sea ecosystems are highly vulnerable. They host many unique ecosystems such as hydrothermal vents, cold seeps, brine pools or seamounts (Cartes *et al.* 2004). The Mediterranean Sea, from shallow marine to bathyal depths, encompasses both cold seeps and hydrothermal vents. Cold seeps comprise mud volcanoes, brine pools and active pockmark

fields, which are mostly exploited by chemosynthesis-based communities, including bivalves and siboglinid polychaetes (Taviani 2014). It is also known that cold seeps enhance meiofauna biodiversity (Zeppilli *et al.* 2011) and act as deep-sea nurseries for elasmobranchs (Treude *et al*. 2011). Important cold seep areas were first described in the Atlantic (Paull *et al.* 1984) and in the eastern and western Pacific Ocean (Kennicut *et al.* 1985; Suess *et al*. 1985; Juniper and Sibuet 1987). In the Mediterranean, while occurring in the Strait of Sicily, Adriatic, Tyrrhenian and Alboran Seas, these extreme environments are clustered mostly in the eastern Mediterranean Sea, such as Nile Deep Sea Fan, Anaximander mud volcano field, Olimpi mud volcano field, Eratosthenes Seamount, Calabrian Arc, and Marmara deep fault systems (Taviani 2014). This difference can be related to their important geological and biological features: the western Mediterranean is relatively featureless, while the eastern Mediterranean is more biologically and geologically active.

Over the last three decades, three major areas have been the focus of multidisciplinary cruises: the Olimpi mud volcano field on the Mediterranean Ridge south of Crete, the Finike Seamounts off southern Türkiye and the seafloor of the Nile Deep Sea Fan (Vanreusel *et al*. 2009). The discovery of the two regions, the Olimpi mud field and the Finike Seamounts, was a part of the Dutch ANAXIPROBE project in 1995-1996, and seven large mud volcanoes were sampled during the project (Woodside 1996; Woodside *et al*. 1998). Later in 1998, investigations in the Anaximander Mountains continued with the French research submersible Nautile during the joint French-Dutch MEDINAUT programme. In 2003, a new project was proposed to sample the gas hydrates in the Finike Seamounts (Lykousis *et al*. 2004). Between the years 2005-2009, this was followed by the HERMES project (Vanreusel *et al*. 2009). In these projects, gas hydrates from different mud volcanoes were collected and studied, and two new mud volcanoes named Athina and Thessaloniki were discovered and studied (Heeschen *et al*. 2006; Lykousis *et al*. 2009; Perissoratis *et al*. 2006, 2011). Besides, both living specimens and shells of newly described deep-sea species were discovered from the Anaximender volcanoes (Salas and Woodside 2002). In 2010, the E/V Nautilus surveyed the summits and flanks of three different mud volcanoes between 1300m and 2000m depth, and two volcanic seamounts chain (Anaximenes and Anaxagoras). First data on Mediterranean cold-seep communities were collected (Salas and Woodside 2002; Olu-Le Roy *et al*. 2004; Werne *et al*. 2004; Duperron *et al*. 2009; Brissac *et al*. 2011). Siboglinid polychaetes belonging to the clades Obturata (*Lamellibrachia anaximandri*, Southward *et al*. 2011) and Frenulata (*Siboglinum* sp.) have also been observed. Later in 2012, a new Spionid polychaete was discovered in deep-sea sediments of the Amsterdam mud volcano site by the E/V Nautilus in the same area (Blake and Ramey-Balci 2020).

Knowledge of fish taxonomy and biodiversity of the Mediterranean Sea has increased in recent years (Kovačic *et al*. 2021). The deep demersal fishery in the

western and central Mediterranean is carried out up to depths of 800 to 1000m, while bottom trawling in the eastern basin is operated to depths of 400m (Ibrahim *et al*. 2011; Farrag 2016). Therefore, most of the deep-sea ichthyofauna of the eastern basin remains unknown.

The early life stages of fish species are strongly related to biotic and abiotic factors of the environment (Peck *et al*. 2012). Depending on the spawning cycles and reproductive strategies of the adults, fish eggs and larvae indicate a pronounced variability in both density and species composition (Sabates *et al*. 2007). Hence, ichthyoplanktonic studies are considered as important tools for determining fish diversity or ecologic interactions with the physicochemical factors in marine ecosystems, providing important information on ecologically important processes for marine food webs (Tortonese 1970; Moser and Smith 1993). The aim of this study was to assess the ichthyofauna of the Finike Seamount, located in the eastern Mediterranean.

Materials and Methods

Larval, juvenile and adult fish specimens were collected on 11-25 May and 25 September-1 October 2021 from the Finike Seamount, northern Levantine Sea (Figure 1). Surveys were carried out with the research vessel "R/V Yunus S" (32m length) to a depth of 2200m. Beam trawl (7 mm mesh size), pelagic net (3m in diameter and 7mm mesh size) and plankton net were used as sampling gears (Table 1). The towing duration of the beam trawl was 1 hour and the towing speed varied between 2.2 and 2.5knots.

All samples were preserved in 4% formalin or 70% ethanol solution and deposited in the collection of Faculty of Aquatic Sciences, Istanbul University. The current scientific names of the fishes were checked following Eschmeyer *et al*. (2022). Besides, the taxonomic classification is in accordance with Nelson *et al*. (2016).

Table 1. Stations, date, coordinates and gear type for sampling the specimens

Stations	Date	Gear Type	Latitude	Longitude
PKI-1	14.05.2021	Plankton net	35°42'17.34"N	30°5'30.36"E
PKI-2	14.05.2021	Plankton net	35°45'27.06"N	30°12'24.96"E
PKI-3	14.05.2021	Plankton net	36°2'6.90"N	30°26'35.04"E
PKI-4	15.05.2021	Plankton net	36°14'18.84"N	30°13'14.46"E
PKI-5	16.05.2021	Plankton net	36°11'22.14"N	30°24'23.04"E
PKI-6	19.05.2021	Plankton net	35°32'32.40"N	30°34'8.40"E
PKI-7	19.05.2021	Plankton net	35°22'8.40"N	30°47'9.72"E
PKI-8	20.05.2021	Plankton net	35°46'14.40"N	30°15'12.60"E
PKI-9	24.05.2021	Plankton net	35°33'37.08"N	30°2'3.42"E
PKI-10	25.05.2021	Plankton net	35°34'32.04"N	29°3'33.39"E
BT-2	19.05.2021	Beam trawl	35°46'8.52"N	30°15'12.72"E
BT-3	19.05.2021	Beam trawl	35°45'47.59"N	30°11'38.58"E

Table 1. Continued

FKI-1	11.05.2021	Pelagic net	36°21'14.40"N	29°2'23.88"E
FKI-2	12.05.2021	Pelagic net	36°10'39.78"N	30°13'23.04"E
FKI-4	15.05.2021	Pelagic net	35°36'11.58"N	29°32'28.50"E
FKI-3	15.05.2021	Pelagic net	36°13'11.64"N	30°14'43.02"E
PKII-2	18.09.2021	Plankton net	35°34'47.39"N	29°7'22.43"E
PKII-3	25.09.2021	Plankton net	35°10'19.98"N	29°19'15.60"E
PKII-4	25.09.2021	Plankton net	35°41'37.40"N	29°31'30.21"E
PKII-5	26.09.2021	Plankton net	35°9'45.06"N	29°48'27.12"E
PKII-6	27.09.2021	Plankton net	36°1'37.08"N	30°27'21.78"E
BT-1	30.09.2021	Beam trawl	35°51'13.08"N	30°10'55.26"E
FKII-1	18.09.2021	Pelagic net	35°34'55.14"N	29°7'16.23"E
FKII-2	25.09.2012	Pelagic net	35°46'22.38"N	29°35'42.06"E
FKII-3	28.09.2021	Pelagic net	36°11'20.40"N	30°14'20.10"E
FKII-4	01.10.2021	Pelagic net	36°22'49.56"N	29°0'46.26"E

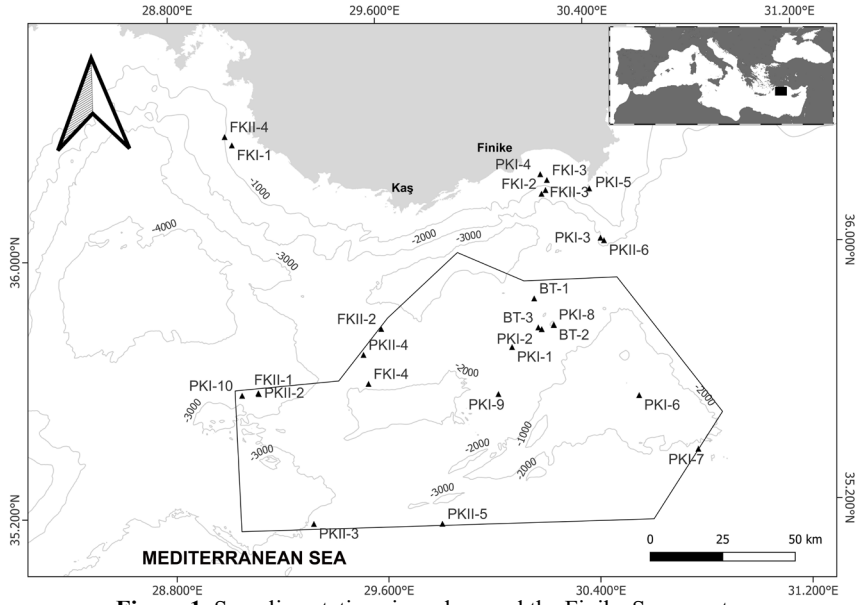

Figure 1. Sampling stations in and around the Finike Seamounts.
The polygon shows the border of Finike Special Environmental Protection Area.

Results and Discussion

In total 20 species belonging to 13 families were identified in the samples collected in and around the Finike Seamount during the surveys (Table 2). Samples consisted of 422 adults, 6 juveniles, 18 larvae and 13 postlarvae. Three of the samples could not be identified at the species level, thus identified at the family level. The highest number of individuals (419) belonged to a species *Cyclothone braueri*, all of which were adults.

The highest number of obtained species was achieved with the beam trawl (8) followed by plankton net (7) and ring net (5). Considering the life stages, larvae were obtained with all methods used, while juveniles were caught with beam trawl and ring net, and adults were caught only with beam trawl.

The highest number of species belongs to bathypelagic fishes (*A. hemigymnus*, *B. glaciale*, *C. maderensis*, *C. braueri*, *D. rafinesquii*, *H. benoiti*, *L. crocodilus*, *M. muelleri*, *V. attenuata, S. boa*). Besides, demersal, pelagic-oceanic, pelagic-neritic and reef-associated species were also collected.

The species *A. hemigymnus* can be found at depths down to 2400m (Froese and Pauly 2020). Kaya (1993) firstly reported *A. hemigymnus* in the Turkish waters of the Aegean Sea. Afterwards, Türetken (2009) and Dalyan *et al.* (2021) gave further records of the species. The larval occurrence of the species has also been reported in the North Aegean Sea (Daban and İşmen 2020) and in the North Levant Sea (Ak-Örek and Mavruk 2016).

The family Gonostomatidae has three species belonging to two genera in the Mediterranean Sea and three of them (*C. braueri, C. pygmaea* and *Gonostoma denudatum*) are found in the Turkish waters (Bilecenoğlu *et al*. 2014). In this study, *C. braueri* was determined as the most dominant species among the samples.

In the Mediterranean, the genus *Hygophum* is represented by two species; *H. benoiti* and *H. hygomii*. *Hygophum benoiti* distributed in the Mediterranean Sea and Atlantic Ocean (Hulley 1986) down to depths of 700m. There are larval records of the species (Ak-Örek and Mavruk 2016; Daban and İşmen 2020) as well as a few adult records (Papaconstantinou 2014). The documented record of *H. benoiti* in the Turkish waters was reported by Türetken (2009) and Dalyan *et al.* (2021).

The distribution of *B. glaciale* extends vertically from the surface to a depth of 1407m (Coad and Reist 2004). The species exists in the northern hemisphere up to 81°N (Froese and Pauly 2020). The first record of *B. glaciale* was given by Tåning (1918) from the Sea of Marmara, later its occurrence was confirmed by Demir (1958). The occurrence of the species was reported by Kaya (1993), Türetken (2009) and Dalyan *et al*. (2021), from the Aegean Sea.

Table 2. List of the fish species identified in the Finike Seamounts.
(Nr: Number of the samples; La: Larvae, Le: Leptocephalus, J: Juvenile, A: Adult; M: May, S: September)

Family	Species	Life Phase	Nr	Habitat	Month	Equipment/Station
Congridae	*Ariosoma balearicum* (Delaroche, 1809)	Le	1	Reef-associated	S	FKII-2
	Gnathophis mystax (Delaroche, 1809)	Le	1	Demersal	S	FKII-2
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	La	4	Pelagic-neritic	S	PKII-5
		La	9	Pelagic-neritic	S	FKII-2
Gobiidae	Gobiidae sp1.	La	1	--	S	PKII-6
	Gobiidae sp2.	La	1	--	S	FKII-2
Gonostomatidae	*Cyclothone braueri* Jespersen & Tåning, 1926	A	42	Bathypelagic	S	BT-1
		A	4	Bathypelagic	S	PKI-6
		A	127	Bathypelagic	S	FKI-4
		A	246	Bathypelagic	S	FKII-2
Macrouridae	Macrouridae sp.	La	1	--	S	FKII-2
Mugilidae	*Chelon labrosus* (Risso, 1827)	La	1	Demersal	S	PKII-6
Mullidae	*Mullus barbatus* Linnaeus, 1758	La	3	Demersal	M	PKI-3
Myctophidae	*Benthosema glaciale* (Reinhardt, 1837)	A	1	Pelagic-oceanic	S	BT-1
	Ceratoscopelus maderensis (Lowe, 1839)	J	1	Bathypelagic	S	BT-1
		La	2	Bathypelagic	S	PKII-5
	Diaphus rafinesquii (Cocco, 1838)	A	1	Bathypelagic	M	BT-1
		La	1	Bathypelagic	S	FKII-2
	Lampanyctus crocodilus (Risso, 1810)	J	1	Bathypelagic	S	BT-1
		La	1	Bathypelagic	S	FKII-2
Ophichthidae	*Dalophis imberbis* (Delaroche, 1809)	Le	1	Demersal	M	BT-3
Phosichthyidae	*Vinciguerria attenuata* (Cocco, 1838)	La J	1	Bathypelagic	S	FKII-2
Scombridae	*Thunnus alalunga* (Bonnaterre, 1788)	La	1	Pelagic-oceanic	S	PKII-5
Sternoptychinae	*Argyropelecus hemigymnus* Cocco, 1829	J	1	Bathypelagic	M	BT-2
		A	1	Bathypelagic	S	FKI–4
	Hygophum benoiti (Cocco, 1838)	J	1	Bathypelagic	S	FKI–4
	Maurolicus muelleri (Gmelin, 1789)	J	1	Bathypelagic	S	FKI–4
Stomiidae	*Stomias boa* (Risso, 1810)	La	1	Bathypelagic	S	FKII-2

Additionally, Daban and İşmen (2020) collected larvae of the species from the coasts of the Gökçeada Island. Ak-Örek and Mavruk (2016) documents larvae of the species from the Turkish part of the Mediterranean.

Ceratoscopelus maderensis shows distribution in the northern hemisphere (Froese and Pauly 2020). The species occurs at depths from 51 to 1480m. The first record of *C. maderensis* from Turkish waters was given by Tåning (1918). Later, Türetken (2009) and Dalyan *et al*. (2021) confirmed the occurrence of the species. Larvae of species was also observed in several ichthyoplankton surveys performed throughout the Turkish part of the Mediterranean Sea (Ak-Örek and Mavruk 2016).

The Mediterranean population of the jewel lanternfish, *L. crocodilus*, exhibits diurnal migrations; between the depths of 100 to 1000m (Froese and Pauly 2020). The occurrence of the species in Turkish waters was first mentioned by Taning (1918) and subsequently by Kaya (1993), Ak-Örek and Mavruk (2016), Daban and İşmen (2020), Bayhan *et al*. (2020) and Dalyan *et al*. (2021).

Vinciguerria attenuata prefers depths down to 2000m and is found between 48°N and 57°S. Whitehead *et al*. (1984-1986) and Mouneimne (1977) mentioned the presence of the species in the Levantine Sea. Accordingly, its larval and juvenile stages were observed in several ichthyoplankton surveys, details of which were given in Ak-Örek and Mavruk (2016). The species was collected as larvae, juvenile and adult phases and documented in this study.

The ichthyoplankton assemblages of the eastern Mediterranean show seasonal variations mostly depending on the variations of spawning activities of fish populations (Mavruk *et al*. 2018). Regarding the eastern Mediterranean, bathypelagic and mesopelajic fish larvae are dominant in the open waters, while the wide continental shelf constitutes the main spawning area of economically important fish species (Ak-Örek and Mavruk 2016). All the species mentioned in this study were encountered in previous ichthyoplankton studies (Ak-Örek and Mavruk 2016; Mavruk *et al*. 2018, 2020).

Among the obtained species *E. encrasicolus, C. labrosus, M. barbatus* and *T. alalunga* were commercial fish species. Along with mesopelagic species, postflexion-stage larvae of several coastal species such as *Mullus barbatus* and *Chelon labrosus* were also detected in offshore waters within the Finike Special Environmental Protection Area (SEPA). Depth within the SEPA is higher than 600m at the shallowest summits (GEBCO 2022) and these depths are unsuitable for adults of such coastal species (Froese and Pauly 2020). Therefore, these propagules should have been produced in continental shelf areas and drifted with currents. The adjacent continental shelf of Finike SEPA also includes very important marine areas such as Kaş-Kekove SEPA, where Mavruk *et al*. (2020) have reported that the density of *Mullus barbatus* eggs in the no-take zones

reaches 71 individuals per m^2, doubling the maximum egg density reported in the Levant Basin for this species. The dynamics of cross-shelf transport of these species, the role of the Finike Seamounts in their recruitment, the dispersal connectivity between seamounts and continental shelf are unknown and should be investigated in further studies.

Besides, among the plankton samples, a postflex stage postlarval albacore, *Thunnus alalunga*, was discovered. Albacore is an economically important species for Turkish fisheries, total catch of which was recorded as 58 tons in 2021 (TUIK 2021). It is also included in the shared stock list of General Fisheries Commission for the Mediterranean (GFCM 2006). Knowledge of tuna larval abundance is important as it is used to calculate the larval index, which is the indicator of spawning stock biomass in stock management of the flag spices *Thunnus thynnus* (Ingram *et al*. 2017) and some other economically important tuna fishes such as *Katsuwonus pelamis* and *Euthynnus alleteratus* (Alvarez-Berastegui *et al.* 2017 and references therein). Alvarez-Berastegui *et al*. (2017) calculated larval index for albacore in the western Mediterranean and showed that the index can provide important information on albacore dynamics in the area.

In this study, larvae of three species are considered leptocephali. However, there is no comprehensive study regarding these species (*G. mystax*, *A. balearicum* and *D. imberbis*) (Bilecenoğlu *et al*. 2014). Leptocephali is the larval form of the superorder Elopomorpha, which predominantly consists of marine teleost fishes (Anibaldi *et al*. 2016). The number of studies is even limited in the Mediterranean Sea. *A. balearicum*, *G. mystax* and *D. imberbis*, which are considered to be rare species for the eastern Mediterranean Sea, were three leptocephali species obtained from this study (Figure 2).

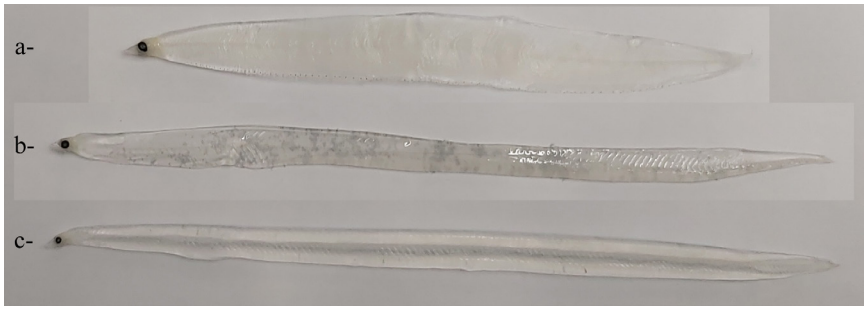

Figure 2. **a**- *Gnathophis mystax* (TL: 10.9cm), **b**- *Ariosoma balearicum* (13.5cm) and **c**- *Dalophis imberbis* (12.9cm) were caught in and around the Finike Seamounts area.

Important geological and biological features of the eastern Mediterranean result in the formation of extreme environments such as the Finike Seamounts which was declared as a Special Environmental Protection Area on 16 August 2013 (Anonymous 2013). Regarding the pelagic ichthyofauna, the Finike Seamounts

area is a major spawning ground and it has previously been suggested as a protected area by Öztürk *et al.* (2010). Nevertheless, further investigations are necessary in order to understand this unique habitat and the biodiversity that it harbours.

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Doğu Akdeniz'de bulunan Finike (Anaximander) Denizaltı Dağları'nın ihtiyofaunası üzerine bazı gözlemler

Öz

Derin denizler birçok eşsiz ekosisteme ev sahipliği yapmaktadır. Akdeniz'in derin deniz ekosistemine bakıldığında "Nile Deep Sea Fan", Finike (Anaximander) ve Eratosthenes Denizaltı Dağları, Olimpi çamur volkanı sahası, Calabria Yayı ve Marmara derin fay sistemleri gibi ekstrem ortamların ağırlıklı olarak doğu havzasında kümelendiği görülmektedir. Bu çalışma Finike Deniz Dağları'nda derinliği 2200 m'ye kadar ulaşan bölgenin ihtiyofaunasının değerlendirilmesi amacıyla yapılmıştır. 13 familyaya ait 20 balık türüne ait larva, juvenil ve ergin dönem örnekleri Finike Denizaltı dağları ve çevresinde tespit edilmiştir. Toplanan bireyler 422 ergin, 6 genç ve 31 larvadan oluşmaktadır. Bireylerin çoğu, hepsi yetişkin olan *Cyclothone braueri* türüne aittir.

Anahtar kelimeler: Doğu Akdeniz, derin deniz, denizaltı dağları, balık, larva

References

Ak-Örek, Y., Mavruk, S. (2016) Ichthyoplankton of the Mediterranean Sea. In: The Turkish Part of the Mediterranean Sea, Marine Biodiversity, Fisheries, Conservation and Governance (eds., Turan, C., Salihoglu, B., Ozbek Ozgur, E., Ozturk, B.), Turkish Marine Research Foundation, Publication No: 43, Istanbul, Turkey, pp. 226-247.

Alvarez-Berastegui, D., Ingram, G.W., Reglero, P., Macías-López, D., Alemany, F. (2017) Albacore (*Thunnus alalunga*) larval index in the western Mediterranean. *ICCAT Collective Volume of Scientific Papers* 74: 687-707.

Anibaldi, A., Benassi-Franciosi, C., Massari, F., Tinti, F., Piccinetti, C., Riccioni, G. (2016) Morphology and species composition of Southern Adriatic Sea leptocephali evaluated using DNABarcoding. *PLoS One* 11(11): e0166137.

Anonymous (2013) Decision of the Council of Ministers. Official Newspaper Date: 16.08.2013, Issue: 28737. Available at: https://www.resmigazete.gov.tr (accessed 11 Jul 2022) (in Turkish).

Bayhan, Y.K., Alagoz,-Erguden, S., Erguden, D. (2020) Length-weight relationships for three deep sea fish species in North Eastern Mediterranean, Turkey. *Aquatic Sciences and Engineering* 35(3): 89-93.

Bilecenoglu, M., Kaya, M., Cihangir, B., Çiçek, E. (2014) An updated checklist of the marine fishes of Turkey. *Turkish Journal of Zoology* 38(6): 901-929.

Blake, J.A., Ramey-Balci, P.A. (2020) New genus and species of spionid polychaete (Annelida, Spionidae) from a deepwater cold seep site in the Eastern Mediterranean Sea off Turkey. *Zoosymposia* 19: 121-134.

Brissac, T., Rodrigues, C.F., Gros, O., Duperron, S. (2011) Characterization of bacterial symbioses in *Myrtea* sp. (Bivalvia: Lucinidae) and *Thyasira* sp. (Bivalvia: Thyasiridae) froma cold seep in the Eastern Mediterranean. *Marine Ecology* 32: 198-210.

Cartes, J.E., Maynou, F., Sardà, F., Company, J.B., Lloris D., Tudela, S. (2004) The Mediterranean Deep-sea Ecosystems: An Overview of Their Diversity, Structure, Functioning and Anthropogenic Impacts. In: The Mediterranean Deep-sea Ecosystems: An Overview of Their Diversity, Structure, Functioning and Anthropogenic Impacts, with a Proposal for Conservation. IUCN, Málaga and WWF, Rome, pp. 9-38.

Coad, B.W., Reist, J.D. (2004) Annotated List of the Arctic Marine Fishes of Canada. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2674. 112 pp.

Daban, İ.B., İşmen, A. (2020) Fish larvae assemblages of Gökçeada Island, North Aegean Sea: effect of weekly sampling interval on their incidences. *Turkish Journal of Zoology* 44: 165-172.

Dalyan, C., Gönülal, O., Kesici, N.B., Eryılmaz, L., Tunçer, S., Öztekin, A. (2021) New and confirmed records and rare occurrences of some deep sea fishes in the Turkish waters of the northern Aegean Sea (Mediterranean Sea). *Fishtaxa-Journal of Fish Taxonomy* 21: 1-18.

Demir, M. (1958) Three deep sea fishes from the Sea of Marmara and northerneastern of the Aegean Sea. *Hidrobiologi Mecmuası* 4: 134-151.

Duperron, S., Lorion, J., Samadi, S., Gros, O., Gaill, F. (2009) Symbioses between deep-sea mussels (Mytilidae: Bathymodiolinae) and chemosynthetic

bacteria: diversity, function and evolution. *Comptes Rendus Biologies* 332: 298-310.

Eschmeyer, W.N., Fricke, R., Van der Laan, R. (2022) Catalog of Fishes. Available from: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp/. (accessed 11 Jul 2022)

Farrag, M.M. (2016) Deep-sea ichthyofauna from Eastern Mediterranean Sea, Egypt: Update and new records. *The Egyptian Journal of Aquatic Research* 42(4): 479-489.

Froese, R., Pauly, D. (2020) Fishbase. www.fishbase.org (accessed 1 Sep 2020).

GEBCO (2022) General Bathymetric Chart of the Oceans. Girded Bathymetry Data for Global Ocean. Available at: https://www.gebco.net/data_and_products/gridded_bathymetry_data/ (accessed 14 Jun 2022).

GFCM (2006) Report of the Ninth Session of the Scientific Advisory Committee of the GFCM, Rome, Italy.

Heeschen, K., Dahlmann, A., Hohnberg, H.-J. (2006) Pressurized near-surface sediment cores of Anaximander mud volcanoes. In: Eastern Mediterranean, EGU General Assembly, vol. 8 of Geophysical Research Abstracts, Vienna, Austria, 07005. SRef-ID: 1607-7962/gra/EGU06-A-07005

Hulley, P.A. (1986) Myctophidae. In: Fishes of the North-eastern Atlantic and the Mediterranean, (eds., Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonese, E.). Vol. 1. UNESCO, Paris. 429-483.

Ibrahim, M.A., Hasan, M.W.A., El-Far, A.M.M., Farrag, E.F.E, Farrag, M.M.S. (2011) Deep sea shrimp resources in the South eastern Mediterranean waters of Egypt. *Egyptian Journal of Aquatic Research* 37(2): 131-137.

Ingram, G.W., Alvarez-Berastegui, D., Reglero, P., Balbín, R., García, A., Alemany, F. (2017) Incorporation of habitat information in the development of indices of larval bluefin tuna (*Thunnus thynnus*) in the Western Mediterranean Sea (2001-2005 and 2012-2013). *Deep Sea Research Part II: Topical Studies in Oceanography* 140: 203-211.

Juniper, S.K., Sibuet, M. (1987) Cold seep benthic communities in Japan subduction zones-spatial-organization, trophic strategies and evidence for temporal evolution. *Marine Ecology Progress Series* 40(1-2): 115-126.

Kaya, M. (1993) A study on deep sea fish of the Aegean Sea. *Turkish Journal of Zoology* 17(3): 411-426 (in Turkish).

Kennicut, M.C., Brooks, J.M., Bidigare, R.R., Fay, R.R., Wade, T.L., McDonald, T.J. (1985) Vent type taxa in a hydrocarbon seep region on the Louisiana Slope. *Nature* 317: 351-353.

Kovačic, M., Lipej, L., Dulčic, J., Iglesias, S.P., Goren, M. (2021) Evidence-based checklist of the Mediterranean Sea fishes. *Zootaxa* 4998: 1-115.

Lykousis, V., Alexandri, S., Woodside, de Lange, G., Dahlmann, Perissoratis, C., Heeschen K., Ioakim, Chr., Sakellariou D., Nomikou, P., Rousakis, G., Casas, D., Ballas, D., Ercilla, G. (2009) Mud volcanoes and gas hydrates in the Anaximander Mountains (Eastern Mediterranean Sea). *Marine and Petroleum Geology* 26: 854-872.

Lykousis, V., Alexandri, S., Woodside, J., Nomikou, P., Perissoratis, C., Sakellariou, D., de Lange, G., Dahlmann, A., Casas, D., Rousakis, G., Ballas, D., Ioakim, Chr. (2004) New evidence of extensive active mud volcanism in the Anaximander Mountains (Eastern Mediterranean): The ‘‘ATHINA’’ mud volcano. *Environmental Geology* 46: 1030-1037.

Mavruk, S., Bengil, F., Yüksek, A., Özyurt, C. E., Kiyaga, V. B., Avşar, D. (2018) Intra-annual patterns of coastal larval fish assemblages along environmental gradients in the northeastern Mediterranean. *Fisheries Oceanography 27*: 232-245.

Mavruk, S., Özbek, E.Ö., Muhling, Ş.M.K. (2020) Preliminary results of the diversity and abundance of ichthyoplankton for winter and spring seasons in the northwestern Levant coast, the eastern Mediterranean. *Journal of Black Sea/Mediterranean Environment* 26: 203-222.

Moser, H.G., Smith, P.E. (1993) Larval fish assemblages and oceanic boundaries. *Bulletin of Marine Science* 53: 283-289.

Mouneimne, N. (1977) Liste des poissons de la cote du Liban (Méditerranée orientale). *Cybium* 1: 37-66.

Nelson, J.S., Grande, T.C., Wilson, M.V.H. (2016) Fishes of the World, 5th ed. John Wiley and Sons, New York.

Olu-Le Roy, K., Sibueta, M., Fiala-Medioni, A., Gofas, S. Salas, C., Mariotti, A., Fouchere, J.P., Woodside, J. (2004) Cold seep communities in the deep eastern Mediterranean Sea: composition, symbiosis and spatial distribution on mud volcanoes. *Deep-Sea Research I* 51: 1915-1936.

Öztürk, B., Topcu, E. N., Topaloglu, B. (2010) A preliminary study on two seamounts in the eastern Mediterranean Sea. *Rapports et process-verbaux des*

reunions Commission internationale pour l'exploration scientifique de la Mer Mediterranee 39: 620.

Papaconstantinou, C. (2014) Fauna Graeciae: An Updated Checklist of the Fishes in the Hellenic Seas, Monographs on Marine Sciences Vol. 7, Athens, HCMR. 340 p.

Paull, C.K., Hecker, B., Commeau, R., Freeman-Lynde, R.P., Neumann, C., Corso, W.P., Golubic, S., Hook, J.E., Sikes, E., Curray, J. (1984) Biological communities at the Florida Escarpment resemble hydrothermal vent taxa. *Science* 226: 965-967.

Peck, M., Huebert, K., Llopiz, J. (2012) Intrinsic and extrinsic factors driving match-mismatch dynamics during the early life history of marine fishes. *Advances in Ecological Research* 47: 177-302.

Perissoratis, C., Ioakim, Chr., Alexandri, S., Woodside, J., Nomikou, P., Dählmann, A.D., Casas, D., Heeschen, K., Amman, H., Rousakis, G., Lykousis V. (2011) Thessaloniki mud volcano, the shallowest gas hydrate-bearing mud volcano in the Anaximander Mountains, Eastern Mediterranean. *Journal of Geological Research Article* 247983: 1-11.

Perissoratis, C., Ioakim, Chr., Lykousis, V. (2006) Characteristics of the Thessaloniki mud volcano, a recently discovered gas hydrate bearing area in the Anaximander Mountains. In: Eastern Mediterranean, EGU General Assembly, vol. 8 of Geophysical Research Abstracts, Vienna, Austria, April 2006, 03874, SRef-ID: 1607-7962/gra/EGU06-A-03874.

Sabates, A., Olivar, M.P., Salat, J., Palomera, I., Alemany, F. (2007) Physical and biological processes controlling the distribution of fish larvae in the NW Mediterranean. *Progress in Oceanography* 74(2-3): 355-376.

Salas, C., Woodside, J. (2002) *Lucinoma kazani* n.sp. (Mollusca: Bivalvia): evidence of a living benthic community associated with a cold seep in the Eastern Mediterranean Sea. *Deep-Sea Research Part I* 49: 991-1005.

Southward, E.C., Andersen, A.C., Hourdez, A. (2011) *Lamellibrachia anaximandri* n.sp., a new vestimentiferan tubeworm (Annelida) from the Mediterranean, with notes on frenulate tubeworms from the same habitat. *Zoosystema* 33: 245-279.

Suess, E., Carson, B., Ritger, S.D., Moore, J.C., Jones, M.L., Kulm, L.D., Cochrane, G.R. (1985) Biological communities at vent sites along the subduction zone off Oregon. *Bulletin of the Biological Society of Washington* 6: 475-484.

Taning, A.V. (1918) Report on the Danish Oceanographical Expeditions 1908-1910 to the Mediterranean and Adjacent Seas. Copenhagen.

Taviani, M. (2014) Chemosynthesis in the Mediterranean Sea. In: The Mediterranean Sea: Its History and Present Challenges, (eds., Goffredo, S., Dubinsky, Z.), Springer, Dordrecht, pp. 69-83.

Tortonese, E. (1970) Osteichthyes (Pesci ossei). Parte prima: Fauna D'italia, Vol. 10. Edizioni Calderini, Bologna, pp. 1-565.

Treude, T., Kiel, S., Linke, P., Peckmann, J., Goedert, J.L. (2011) Elasmobranch egg capsules associated with modern and ancient cold seeps: a nursery for marine deep-water predators. *Marine Ecology Progress Series* 437: 175-181.

TUIK (2021) Fishery Production Statistics of Tukey. Available at: www.tuik.gov.tr.

Türetken, K.F. (2009) Quantitive-qualitive analysis of deep sea fishes around Gökçeada Island (Northern Aegean Sea). MScThesis, Istanbul University. (in Turkish).

Vanreusel, A., Andersen, A.C., Boetius, A., Connelly, D., Cunha, M.R., Decker, C., Hilario, A., Kormas, K.A., Maignien, L., Olu, K., Pachiadaki, M., Ritt, B., Rodrigues, C., Sarrazin, J., Tyler, P., Van Gaever, S., Vanneste, H. (2009) Biodiversity of cold seep ecosystems along the European margins. *Oceanography* 22: 110-127.

Werne, J.P., Haese, R.R., Zitter, T., Aloisi, G., Bouloubassi, I., Heijfs, S., Fiala-Médioni, A., Pancost, R.D., Sinninghe Damsté, J.S., de Lange, G., Forney, L.J., Gottschal, J.C., Foucher, J.P., Mascle, J., Woodside, J. (2004) Life at cold seeps: a synthesis of biogeochemical and ecological data from Kazan mud volcano, eastern Mediterranean Sea. *Chemical Geology* 205: 367-390.

Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonese, E. (eds.) (1984-1986). Fishes of the North-eastern Atlantic and the Mediterranean. UNESCO, Paris.

Woodside, J. (1996) Neotectonic deformation of the Anaximander Mountains observed from EM12D Multibeam Data. In: Sedimentary Basins of the Mediterranean and Black Seas, TTR, Fourth Post-cruise Meeting, UNESCO Report, pp.11-12.

Woodside, J., Ivanov, M.K., Limonov, A.F. (1998) Shallow gas and gas hydrates in the Anaximander Mountains region, Eastern Mediterranean Sea. In: Gas Hydrates: Relevance to World Margin Stability and Climate Change. (eds.,

Henriet, J.P., Mienert, J.) Geological Society of London, Special Publication 137, pp. 177-193.

Zeppilli, D., Canals, M., Danovaro, R. (2011) Pockmarks enhance deep-sea benthic biodiversity: a case study in the western Mediterranean Sea. *Diversity and Distributions* 18: 832-846.