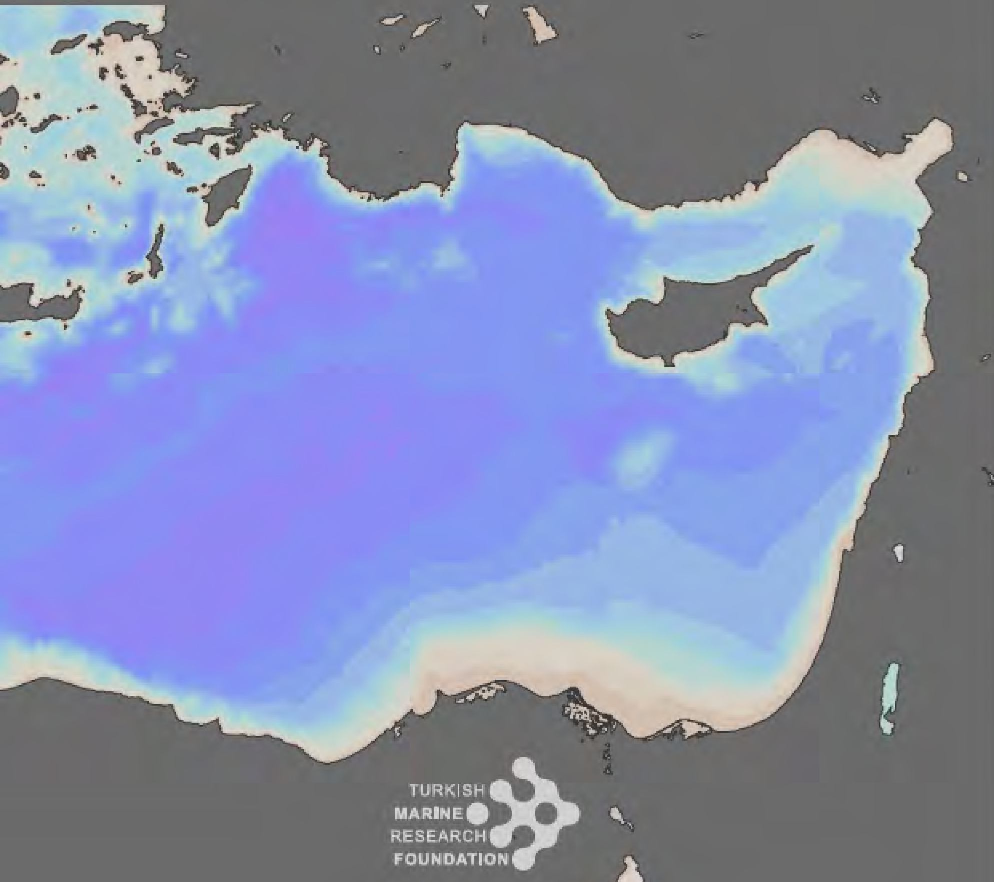
THE TURKISH PART OF THE MEDITERRANEAN SEA
MARINE BIODIVERSITY, FISHERIES, CONSERVATION AND GOVERNANCE

EDITORS :
CEMAL TURAN, BARIŞ SALİHOĞLU, ELİF ÖZGÜR ÖZBEK, BAYRAM ÖZTÜRK



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Edited by

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PREFACE

This book aims to compile all types of information starting from its biodiversity, fisheries, pollution, conservation and governance on the Turkish part of the Mediterranean Sea. Needless to say, this confirms how important for Turkish people the Mediterranean Sea is in many ways, tourism, fisheries, alien species, climate change, coastal development and to protection of the biodiversity for future generations. We know that recently the eastern Mediterrnean Sea has become a so-called an alien species sea, thus regional and national monitoring is needed.

"The Mediterranean Sea Biodiveristy, Fisheries, Conservation and Governance" which is a part of the series of Turkish Marine Reseaerch Foundation (TÜDAV), reflects some current topics covered in 38 articles, 4 chapters by 73 authors from various institutions, universities and disciplines.

The publication of this book was decided by the editors at the begining of 2016 and the book has been completed in the same year. We hereby thank all of the authors and editors for their full support and valuable contribution to this book. We are also thankful to Ms. Tuğçe Gül for her assistance in editing this volume.

Finally, we believe that this work is unique in many ways due to its content based on a wide range of information and with original outputs of many surveys for the Turkish part of the Mediterranean Sea. We are pleased to present this publication to the scientific community, decision makers, fishermen and all stakeholders who are interested in saving the Mediterranean Sea for future generations in a sustainable way.

Prof. Dr. Bayram ÖZTÜRK

Director, Turkish Marine Research Foundation (TÜDAV)

December 2016

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CONTENTS

IV. CONSERVATION AND GOVERNANCE

PHYSICAL OCEANOGRAPHY OF THE EASTERN MEDITERRANEAN SEA

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1. Introduction

The Mediterranean basin-scale circulation can be described in terms of a surface inflow of Atlantic Water from the Atlantic Ocean entering through the Strait of Gibraltar and flowing eastward at the surface towards the eastern basin, and a return flow of intermediate water originating in the Levantine Basin at subsurface, proceeding towards Gibraltar and finally exiting into the Atlantic (Malanotte-Rizzoli *et al.* 2014). However, the circulation of Atlantic Water in the eastern basin of the Mediterranean Sea is still debated (Hamad *et al.* 2005).

The Turkish part of the Mediterranean Sea is located in the Eastern Mediterranean Sea and the Levantine Basin in one of the two major basins of the Eastern Mediterranean. Recent advances in both observations and modeling have allowed better understanding of the factors that influence the circulation in the Eastern Mediterranean and its impacts on physics and ecosystem over a range of spatial and temporal scales. This study is a review of the present understanding of the Eastern Mediterranean in terms of flow and water mass characteristics.

In the following sections, after reviewing basic geographical features and atmospheric setting of the Eastern Mediterranean relevant to its physical oceanography, we present the current knowledge on the circulation, water masse structure and climatic changes occurring in this basin.

2. Geographic Setting and Bathymetry

The Levantine Basin is the easternmost part of the Mediterranean. The Levantine Basin is bounded by the Cretan Archipelago and Asia Minor to the north, the Middle East to the east, and north-eastern Africa to the south occupying a total volume of $7.5x10^5$ km^3 with a maximum depth of ~4300m (Figure 1). It has three sub-basins in the north: the Latakia (1000–1500 m depth), Cilician (1000 m depth) and Antalya (2000 - 3000 m depth) sub-basins.

With a generally narrow continental shelf (except for the Gulf of İskenderun, Bay of Mersin and the Nile Fan), the Levantine Basin displays various bathymetric features including seamounts: Anaximander (1500m) and Eratosthenes Seamounts (1000m) and troughs: Rhodes (~4000m), Latakia (1000-1500m), Cilicia (1000m), Antalya (2000-2500m), Hellenic Trench (3000-3500m) and Herodotus Abyssal Plain (3000m). The Mediterranean Ridge (2500m) is another important bathymetric feature separating the Hellenic Trench and the Herodotus Abyssal Plain (Özsoy *et al.* 1989). The Cilician basin and Latakia basin are two shallow basins of the Levantine, which are connected via a narrow channel of 700m depth (Özsoy *et al.*1989; Özsoy *et al.* 1993).

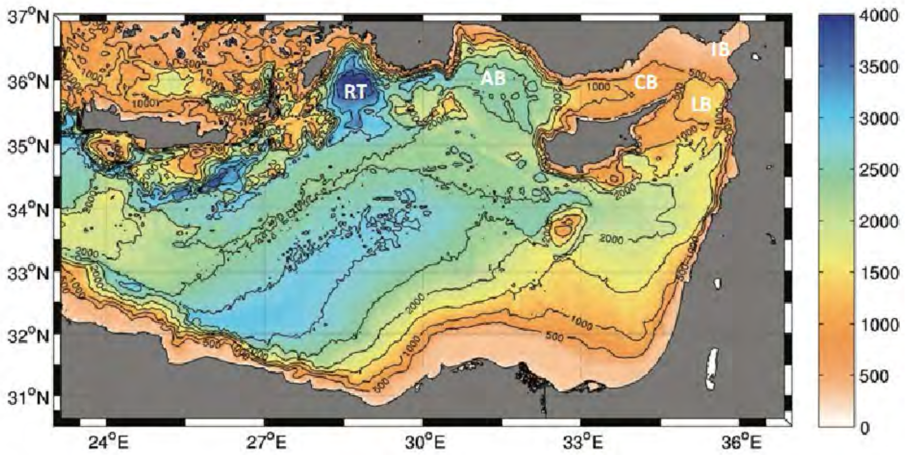

Figure 1. Bathymetry of the Levantine basin. Data obtained from (http://www.gebco.net). Abbreviations: RT-Rhodes Trough, AB-Antalya Basin, CB-Cilician Basin, LB- Latakia Basin, IB-Iskenderun Bay.

3. Atmospheric Conditions

The meteorological conditions of the region are highly variable as a result of different atmospheric systems and topographic features interacting. The regional Mediterranean climate is composed of hot, humid summers and mild winters. Surrounding the Eastern Mediterranean are the Taurus mountains and Amanos mountains that have only narrow coastal plains, except for the river deltas of the Seyhan and Ceyhan rivers. The steep mountain ranges influence the atmospheric conditions considerably. In summer and autumn, Etesian and Westerlies are the common wind systems, which interact over the southern Aegean Sea, resulting in west-northwesterly winds over the Levantine Basin (Figure 2) whereas winter and spring are dominated by Poyraz and Sirocco winds (Özsoy 1981; Özsoy *et al.* 1989) resulting in a modified climatic wind regime (Figure 3). In winter, cyclones intensifying in the Northern Levantine are followed by cold and dry Poyraz winds pumped through river valleys and gaps in Taurus mountains (Özsoy 1981; Özsoy *et al.* 1989; Özsoy *et al.* 1993). These cold and dry outbreaks were suggested to be the source of extensive heat and buoyancy losses leading to the formation of the Levantine Intermediate water (Wüst 1961), which has been verified in various studies (Özsoy and Ünlüata 1983; Özsoy *et al.* 1989; Onken and Yüce 2000).

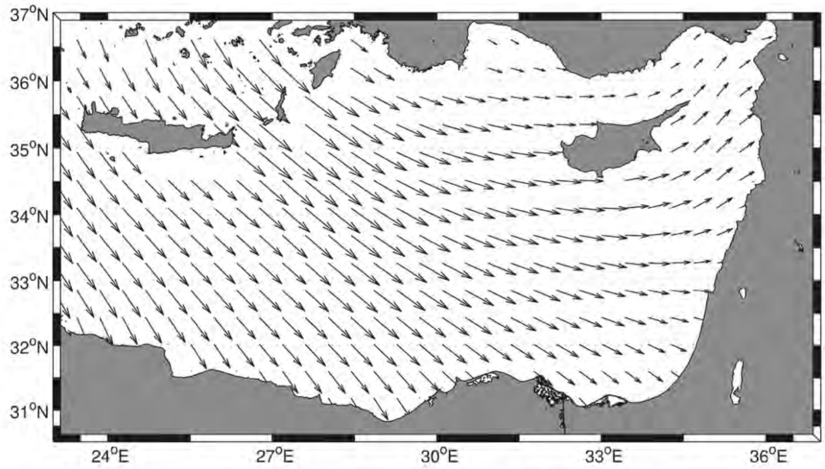

Figure 2. Summer (JJA) climatological wind pattern in the Levantine basin. Climatology represents 1988-2011 mean obtained from Cross-Calibrated Multi-Platform Ocean Surface Wind VectorL3.0 First-Look Analyses dataset (CCMP).

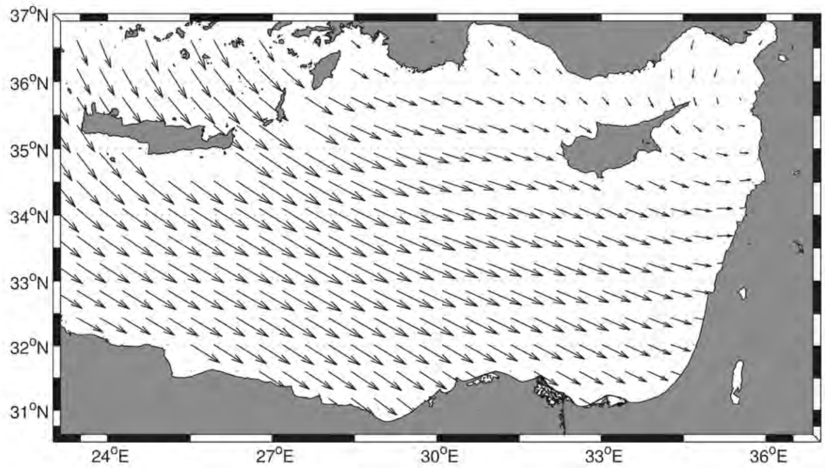

Figure 3. Winter (JFM) climatological wind pattern in the Levantine basin. Climatology represents 1988-2011 mean obtained from Cross-Calibrated Multi-Platform Ocean Surface Wind VectorL3.0 First-Look Analyses dataset (CCMP).

4. Water Masses

Water in the Eastern Mediterranean basin is connected to the North Atlantic Ocean through the Western Mediterranean and Ionian Basin as well as to the Black Sea through the Turkish Strait System and Aegean Sea. There is continuous water exchange between these basins as a result of thermohaline processes and mass and salt conservation. Four major water masses are found in the Eastern Mediterranean Sea, namely the Levantine

Surface Water (LSW), Modified Atlantic Water (MAW), Levantine Intermediate Water (LIW), and Eastern Mediterranean Deep Water (EMDW).

The Mediterranean Sea is a concentration basin, that is evaporation exceeds precipitation and river runoff. To conserve mass and salt, there is a continuous low salinity water inflow from North Atlantic Ocean that continues through the basin and returns as high salinity Mediterranean water outflow (Figure 4). Even though Eastern Mediterranean is not directly connected to the North Atlantic Ocean, its hydrographic features are highly affected by fresh Atlantic Water Mass. Atlantic Water enters the Mediterranean the upper 150m of the Strait of Gibraltar with salinity of about 36.15 and temperature ~15 °C first penetrating the Western Mediterranean. As it flows eastward it becomes saltier and denser (Wüst 1961; Malanotte- Rizzoli and Hecht 1988; Malanotte-Rizzoli and Bergamasco 1989; Pinardi and Masetti 2000), enters the Eastern Basin and is named as Modified Atlantic Water (MAW). Since it travels just below the Levantine Surface Water, it is protected from the atmospheric exposure and its properties are conserved to some degree. It can be observed as far as the eastern boundary of the Levantine Basin with a salinity minimum of around 38.6 near the 50 – 150m depth (Özsoy *et al.* 1981). Together with highly saline (>39 psu) and temperate (~28^{O}C) LSW, it is known to play a crucial role in the formation of Levantine Intermediate Water.

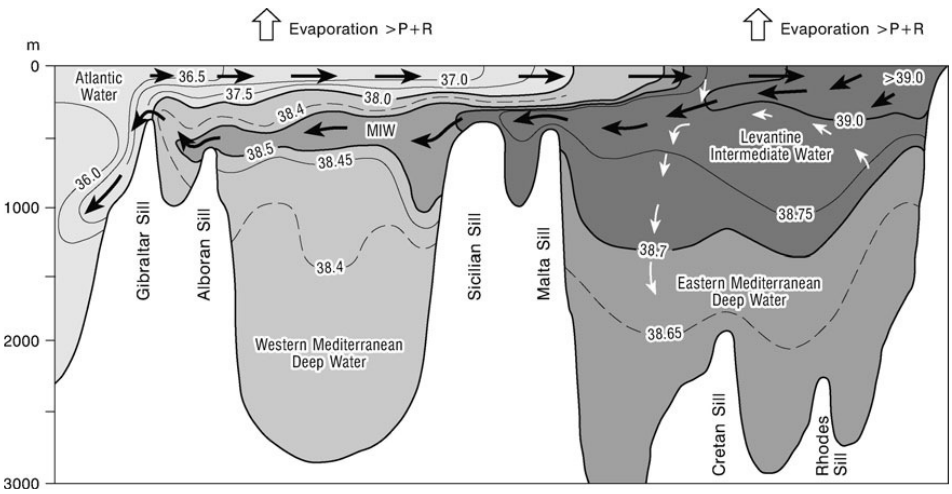

Figure 4. Longitudinal cross-section through the Mediterranean Sea showing water mass circulation during the present-day winter (reproduced from Rohling *et al.* 2009). Isolines indicate salinity values and arrows the direction of water circulation.

Information on the formation region and dispersal of LIW in the Eastern Mediterranean was limited in the past years and the processes still are yet to be fully understood. The main formation site of the LIW is widely accepted as Rhodes Cyclonic

Gyre. High salinity surface waters of the Levantine Basin are exposed to winter cooling, become denser than the MAW which are upwelled in the core of the gyre. As a result, the surface water sinks to the periphery of the gyre following the isopycnals, is trapped at depths around 150 - 200m and is found to accumulate in the core of anti-cyclonic eddies near the vicinity of the Rhodes area (Özsoy *et al.* 1989). Özsoy and Ünlüata (1983) observed that LIW formation intervals in this area coincide with Poyraz events. LIW formation can also occur in the cyclonic circulation that takes place in southern coasts of Turkey, around Asian Minor Current and during extreme cooling events, by deepening of the local mixed layer. (Sur *et al.* 1993)

Table 1. Water mass characteristics of Levantine Intermediate Water from Lascaratos *et al.* (1993a)

	Temperature (°C)	**Salinity**	**σ ±**
Wüst (1961)	15.5	39.10	29.05
Lacombe and Tchernia (1972)	15.7	39.10	28.98
Ozturgut (1976)	16.2 - 16.4	39.12 - 39.15	28.85 - 28.87
Ovchinikov (1984)	14.7 - 14.9	39.03 - 39.06	29.12 - 29.15
Palkhin and Smirnow (1984)	14.5	38.85	29.06
Hecht (1986)	15.5 ± 0.4	39.02 ± 0.05	28.91 - 29.01
Hecht *et al.* (1988)	15.5 ± 0.5	38.98 ± 0.06	28.86 - 28.99

LIW is located below MAW with a salinity maximum (~39.1) in the entire Mediterranean Sea between 200m to 600m depth (Table 1), comprising approximately 26% of the net water volume of the Mediterranean Sea (Ovchinnikov 1984). The renewal time of the LIW is 25 years, meaning only 4% of its total volume is renewed annually (Ovchinnikov 1984). After flowing westward into the Ionian Basin and Western Mediterranean, it finally exits from the Strait of Gibraltar (Wu and Haines 1996). It is generally identified by a scorpion-tail form in the T-S diagram (Figure 5). Millot (2013) however, claims that this form could be biased since there are other known water masses that display this form. She also states that the water masses that flow out from the Strait of Gibraltar may be deep waters of Western Mediterranean instead of LIW.

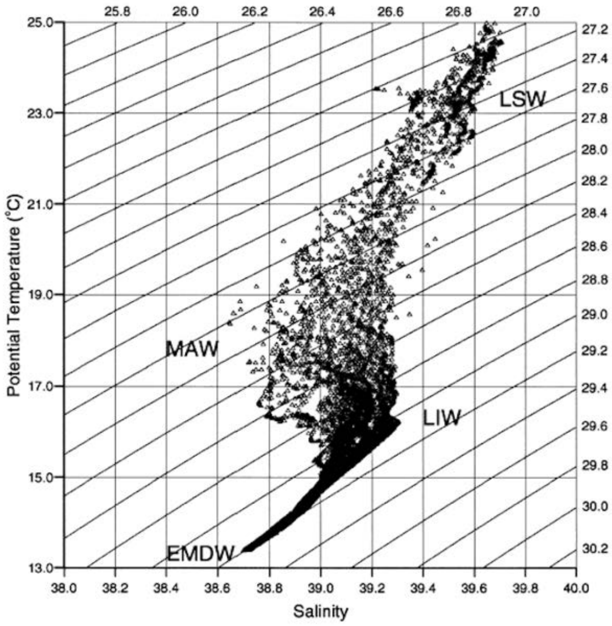

Figure 5. Potential temperature – salinity relationships in the Northern Levantine Basin. (reproduced from Malanotte-Rizzoli 1999)

Eastern Mediterranean Deep Water is found at ~800m depth and below. It originates in the southern Adriatic Sea during the dense water formation processes which occur at several sites in the north of the Mediterranean Sea through convective mixing in the shelf waters (Wüst 1961; Klein *et al.* 1999). After its formation, these water masses flow eastwards through the Ionian Basin and enter the Eastern Mediterranean Sea (Pollak 1951; Lascaratos *et al.* 1993b). This path is also observed by the study of Roether *et al.* (1994), where tritium and $_3$He tracers are used to follow the dispersal of the Adriatic dense waters. Nielsen (1912) suggested that EMDW is also produced in the southern part of the Aegean Sea. During the late 80's and early 90's massive dense water formation occurred in the Aegean Sea due to extended dry periods and extreme winter cooling events. This dense deep water mass named Eastern Mediterranean Transient Water (EMTW) flowed eastwards from the south of Crete, entering the Levantine Basin and effectively blocking the intrusion of the Adriatic water into the Eastern Mediterranean (Klein *et al.* 1999; Lascaratos *et al.* 1999; Sayin and Besiktepe 2010; Sayin *et al.* 2011). The effect of this water mass on hydrographic structure (i.e. changes in thermohaline circulation) of the Eastern Mediterranean as well as its occurrence interval is still unknown.

5. Circulation

The general circulation of the Eastern Mediterranean Sea is a complex system including basin scale, sub-basin scale and mesoscale variabilities. It consists of permanent and recurrent eddies, gyres and jets, arising from different driving forces like topography, seasonal changes, and internal dynamical processes. Prominent features of the general surface circulation are the mid-basin jet and the Asia-Minor current along the Turkish coast, along with quasi-permanent anticyclonic eddies in the Eastern Mediterranean (Wüst 1961; The POEM Group 1992; Özsoy *et al.* 1993).

The basin-wide surface circulation is mainly driven by the intrusion of AW into the basin and the Coriolis effect. The entrance and transport of Atlantic waters into the Levantine basin was a controversial issue over historical and recent studies. First studies were describing counterclockwise circulation over the basin entering from southern Eastern Mediterranean. Flowing parallel to the Egyptian coasts, it is deflected northwards following the eastern boundary of the Levantine basin then joins in Latakia basin and Asia Minor Current (AMC) parallel to the south coast of Turkey (Nielsen 1912). Later on, in light of the coarse data collected in POEM (Physical Oceanography of the Eastern Mediterranean) cruises, Robinson (1991) came up with a new picture of the direction of the AW into the EMED. He proposed Atlantic water was entering the basin in offshore/middle of the basin as Mid-Mediterranean Jet. Flowing through the basin eastwards, it bifurcates in south of the Rhodes Island and one branch flows to the north, joining Rhodes cyclonic gyre, and another one to the south to the Mersa-Matruh anti-cyclonic gyre. The remaining part of the jet flows through the Israel coasts, and splits to 2 parts with directions north and south. Northern branch enters the Latakia Basin, joins the Cilician Current and then AMC whereas southern branch joins Shikmona eddies (see Robinson and Golnaraghi 1994).

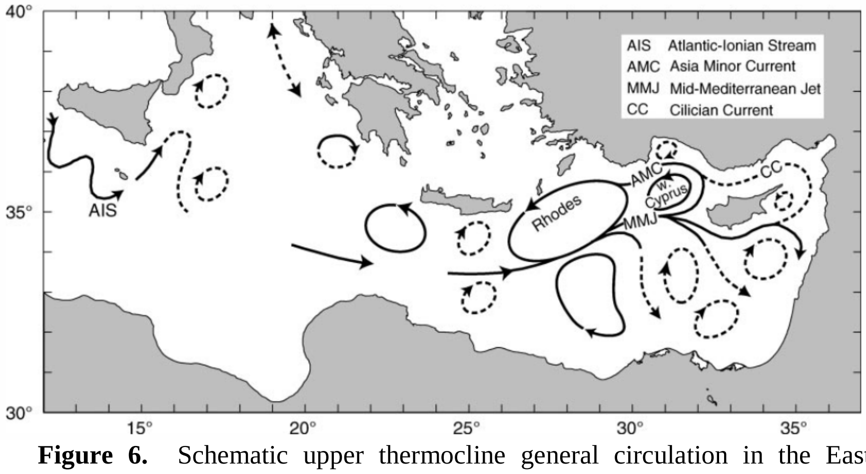

Figure 6. Schematic upper thermocline general circulation in the Eastern Mediterranean Sea after Robinson *et al.* 1991 (redrawn from Onken and Yuce 2000).

In 2005, Hamad hypothesized that the Atlantic originated waters enter the basin through southern part, further moving cyclonically following the south coasts, then curl northwards until they join the AMC. Comparing available CTD data with relevant satellite SST images, he confirmed the POEM results for the area where the data availability is enough to explain in the northern and middle part of the basin. However, he states that POEM cruise data were not sufficient to resolve the circulation in the southern part of the basin, where vast amount of Atlantic Water is found. He also questions the existence of Rhodes, Mersa Matruh and Shikmona eddies. Also, Millot and Gerin (2010) suggested that the Mid-Mediterranean Jet (MMJ) is a data analysis artefact.

However, Menna *et al.* (2012) used drifters and satellite altimetry data to show that the MMJ exists; Rhodes Gyre persists steadily; Mersa-Matruh eddies are generated recurrently and the Shikmona eddy has a periodic nature displaying higher intensities during cold months providing an updated schematic of the circulation scheme (Figure 7).

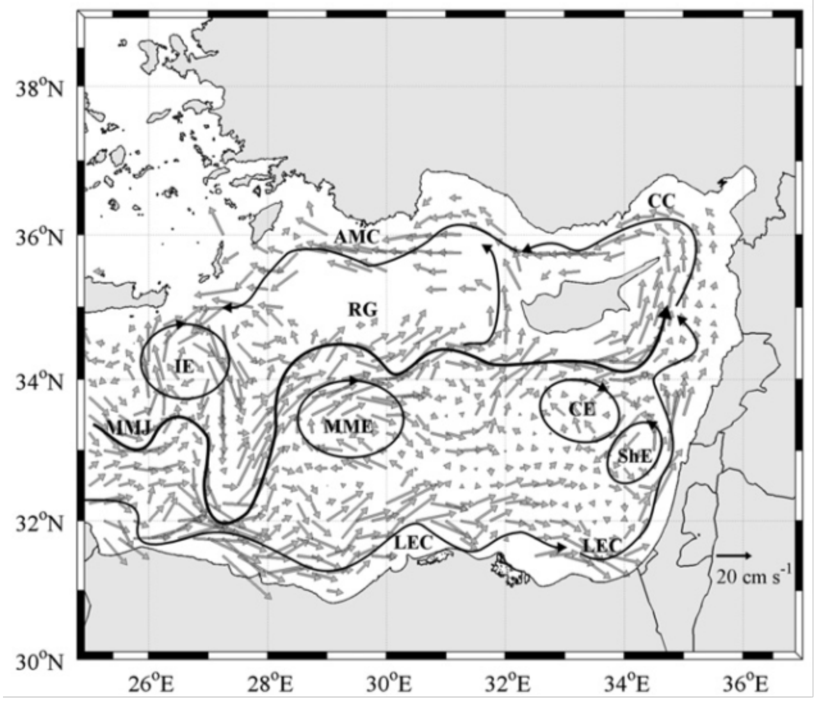

Figure 7. Mean absolute geostrophic velocities (1992-2010). Black lines represent the main currents and sub-basin eddies (redrawn from Menna *et al.* 2012). Abbreviations: IE-Iera Petra, RG-Rhodes Gyre, CE- Cyprus Eddy, LEC-Libyo-Egyptian Current, AMC- Asian Minor Current, MME-Mersa Matruh Eddy, CC-Cilician Current, ShE-Shikmona Eddy, MMJ-Mid Mediterranean Jet.

Flow in the Cilician Basin as derived from satellite data (Figure 8) shows the southern branch of the Mid Mediterranean Jet flowing along the southern coast of Cyprus and further northward along the Lebanese-Syrian coasts. The current is then turning westwards towards Mersin Bay. Due to the protruding coastline topography the current does not penetrate the inshore waters of the Mersin Bay and only few fluctuating weak eddies are found there (Ünlüata *et al.* 1983). Owing also to the coastline topography freshwater input into the bay by rivers are trapped in the inshore waters of the bay. The circulation of Iskenderun Bay cannot be resolved by satellite sea surface height data alone, but a previous study by Collins and Banner (1979) combined the satellite imagery and secchi depths data and hydrographic observations and found a cyclonic and an anticyclonic eddy occurring in İskenderun Bay.

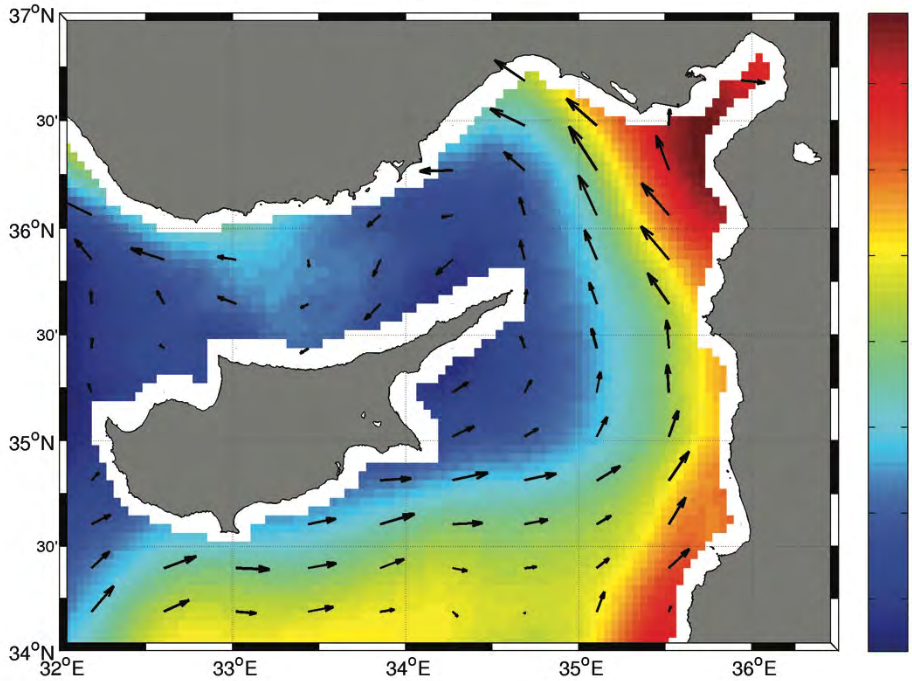

Figure 8. Map of climatological absolute dynamic topography (ADT) in the Cilician basin and derived geostrophic flow pattern indicated with black arrows. Climatology represents 1993-2014 mean calculated from sea surface height data obtained from AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic data) absolute dynamic topography regional product for the Mediterranean Sea (http://www.aviso.altimetry.fr/index.php?id=1275).

Further downstream from Mersin Bay the Asia Minor Current flows westward, meandering and joining some permanent and quasi-permanent gyres and eddies on the southern coast of Turkey. Significant ones are the persistent anticyclonic Anaximander Anticyclone (AxAC) located between the Anaximander Seamounts and Anatolian coast, the Antalya Anticyclone (AyAC) and West Cyprus Cyclone (WCC) located in the western part of the Cilician Basin and West Cyprus cyclonic eddy located in the west of the Cyprus Island (Özsoy *et al.* 1993). Onken and Yuce (2000) also claim that there are seasonal variations in the occurrence of these currents that are strongly dependent on the flow of the AMC (Figure 9). They present evidence that if the AyAC is present, the AMC is confined to a path about 100 km offshore, while if the AyAC is not present, the AMC flows immediately offshore. AMC then joins the permanent cyclonic Rhodes Gyre and eventually flows westwards along the southwest Anatolian coast.

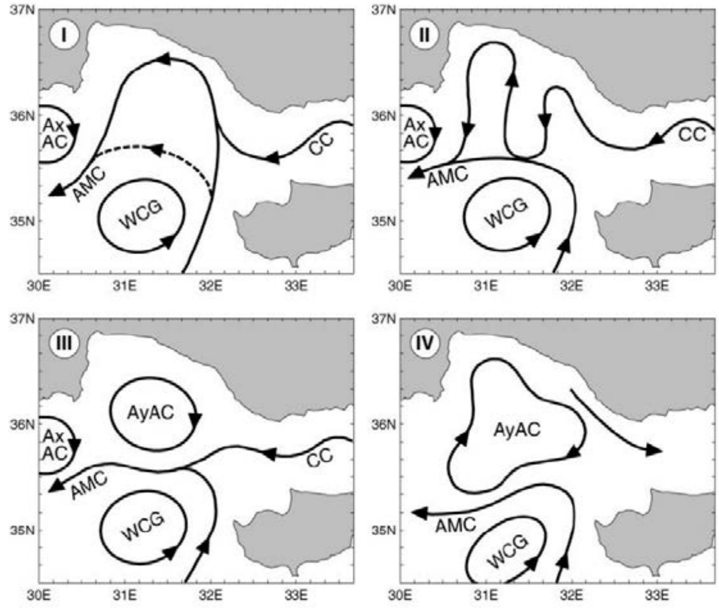

Figure 9. Near-surface circulation patterns of the Antalya Basin redrawn from Onken and Yuce (2000).

6. Effect of climatic variability

The main parameter in quantifying climatic variability and warming in the oceans is the sea surface temperature (SST), considering it is the longest measured parameter and has a wide spatial coverage, especially in the satellite era (1980's till today). SST changes of the Mediterranean have been subject to various studies and the Mediterranean Sea has been denoted to be a climate change hotspot (IPCC 2007). Marullo (1999) and Marullo *et al.* (2011) investigated the seasonal and interannual variability of the Eastern Mediterranean and found a positive trend 0.15^{o}C/year. Criado-Aldeanueva *et al.* (2008) investigated the steric contribution to sea level in the Mediterranean and found a positive SST trend of 0.061 ^{o}C/year for 1992-2005. Nykjaer (2009) has found warming trend 0.03^{o}C/year and 0.05 ^{o}C/year for 1985-2006 in the Western and Eastern Mediterranean respectively. Skliris *et al.* (2012) has calculated warming trends as 0.037 ^{o}C/year for the whole Mediterranean and 0.042 ^{o}C/year for the Eastern Mediterranean for 1985-2008. Shaltout *et al.* (2014) investigated the trends in the whole Mediterranean Sea and sub-regions and found a similar trend 0.042 ^{o}C/year for the Levantine sub-basin for 1982-2012. Increased temperatures contribute to steric component of the sea level, which corresponds to 55% of total sea level trend (Criado-Aldeanueva *et al.* 2008), resulting in alterations of the circulations field. Sea surface height however is not only influenced by thermal expansion. Through modelling (Fukumori *et al.* 2007), zonal wind stress over the Strait of Gibraltar and Atlantic Ocean was suggested to be the reason for non-seasonal sea level fluctuations in the Mediterranean Sea. Extreme sea level anomalies during winter of 2009/2010 and 2010/2011 were shown to be correlated with the wind stress anomalies (Landerer and Volkov 2013), practically proving the previous theoretical model study.

The circulation patter in the Mediterranean Sea is regulated by the salinity differences between the inflowing Atlantic Water and the return flow of Eastern Mediterranean waters (mainly Levantine Intermediate Water). This salinity difference is preserved even through evaporation far exceeds precipitation (Malanotte-Rizzoli *et al.* 2014). Deep closed circulation cells are directly linked to the dense water formation, which is regulated by air-sea heat fluxes and the intensity of the preconditioning phase (Malanotte-Rizzoli *et al.* 2014). Thus variability of the circulation cells is strongly dependent on the air-sea heat fluxes. Considering the general warming scheme presented above, changes in dense water formation are to be expected, resulting in alterations in circulation.

The circulation of the Eastern Mediterranean has been studied by the POEM (Physical Oceanography of the Eastern Mediterranean) group via both in-situ and modelling studies (Özsoy *et al.* 1989, 1991, 1993). The POEM derived scheme of circulation for the Eastern Mediterranean is generally accepted by scientists today, however there is still on-going debate on the main pathway of the Atlantic water through the Mediterranean and the basin-scale surface current (Hamad *et al.* 2005; Amitai *et al.* 2010; Ciappa 2014). Steric effects (mainly of thermal origin) on sea level trends in the basin will most likely alter the surface circulation (Criado-Aldeanueva *et al.* 2008) and aggrandize the debate on the issue. Recently, Volpe *et al.* (2012) showed a reduction in the cyclonic circulation of both the Ionian and the Levantine basin between 2003 and 2006.

SST variability directly influences the dense water formation and the steric sea-level rise, which modify the circulation. Variability in the Mediterranean SST and its links with teleconnection patterns have been subject to various studies as detailed above. Variability in the Mediterranean SST was found to be modulated by the Atlantic Multidecadal Oscillation (AMO). Marullo *et al.* (2011) has shown that AMO and Mediterranean SST have similar oscillations and it was suggested that AMO variability is transferred to the Mediterranean through atmospheric processes (Mariotti and Dell'Aquila 2011). Another study suggested that AMO is responsible for more than half of total warming in the Mediterranean (Macias *et al.* 2013). Skrilis *et al.* (2012) has shown that the North Atlantic Oscillation (NAO) displays fairly low correlations with Mediterranean SST, displaying lowest correlations in the Northern Levantine.

7. Conclusions

In this chapter the water mass formation, circulation and the possible impact of climatic variability on the physical dynamics of the Eastern Mediterranean Sea has been reviewed. The general characteristics of physical dynamics is well documented, the general circulation and water mass characteristics have been identified, however their temporal and spatial variability, especially in the southern Eastern Mediterranean is not yet well understood and still debated. In addition, the variability of the Asia Minor Current, as well as in the Levantine Intermediate Water formation are still poorly known.

It is of importance to realize that the Eastern Mediterranean is especially vulnerable to climatic variability, not only over long time scales due to global warming, but also abrupt, short-term changes in water mass formation and properties such as the Eastern Mediterranean Transient observed in the Aegean Sea. It is therefore an ideal environment to study these processes with important implications for the global ocean.

Long-term warming trends are likely going to influence surface circulation patterns and already abrupt changes in surface circulation and water mass have been recognized that already results in modifications in the hydrology and dynamics of the entire Eastern Mediterranean. In addition, the effect of dense deep Eastern Mediterranean Transient Water entering the Levantine Basin and blocking the intrusion of the Adriatic water into the Eastern Mediterranean, on hydrographic structure (i.e. changes in thermohaline circulation) of the Eastern Mediterranean as well as its occurrence interval is still unknown.

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CHEMICAL OCEANOGRAPHY OF NORTH EASTERN MEDITERRANEAN

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1. Introduction

The salty eastern Mediterranean open sea (Figure 1) is one of the well known basins of low productivity among the world's seas due to limited nutrient supply to its euphotic zone (EZ) layer from external (rivers and precipitation) and internal sources (Dugdale and Wilkerson 1988; Markaki *et al.* 2003). Its hydro-dynamical and bio-chemical properties exhibit spatial and temporal variability, extending from the near surface layer down to at least 1000-1500 m depth (Yılmaz and Tuğrul 1998; Kress *et al.* 2003; Garcia *et al.* 2006). A cyclonic circulation in the eastern Mediterranean dominates the mean current system (Wüst 1961). Accordingly, along-shore currents with the associated bio-chemical properties follow the coast of Israel, Lebanon and Syria and turns west to flow along the southern Turkish coast, by showing regional eddies and meandering features (Özsoy *et al.* 1993).

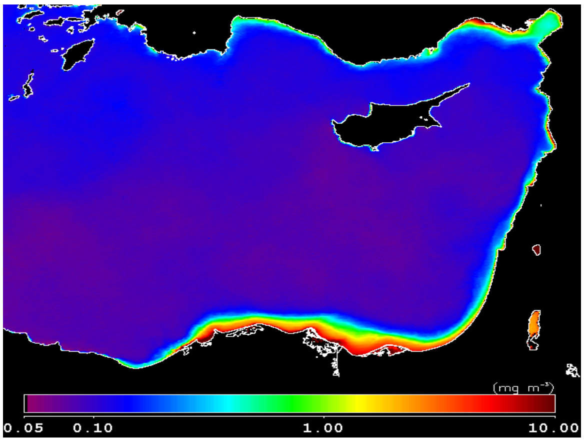

Figure 1. Annual average surface chlorophyll distribution in the eastern Mediterranean based on the MODIS satellite data for the year 2009.

The upper layer of the oligotrophic eastern Mediterranean is renewed by the less saline Atlantic surface water with the modified physical and bio-chemical properties during its flow through the western basin (Robinson *et al.* 1991; Malanotte-Rizzoli *et al.* 1999). The surface water salinity of the eastern Mediterranean increases markedly from 39.0-39.1 in winter to 39.5 - 40 levels in late summer due to excessive evaporation and limited freshwater input to the eastern basin. On the other hand, Levantine Intermediate Water (LIW) evolved in the NE Mediterranean and with slightly enriched nutrient concentrations (Yılmaz and Tuğrul 1998), flows at intermediate depths (200-500 m) western basin through the Cretan (Özsoy *et al.* 1993). The Levantine deep water is isolated from the western basin by the shallow sill depth of the Sicily Straits.

The NE Mediterranean shelf zone is relatively wide in the Cilician Basin (Figure 2) and receives large volumes of nutrient-laden river inflows (about 27 km^3/yr). Nutrient inputs by the Göksu, Lamas, Tarsus, Seyhan, Ceyhan and Asi rivers markedly enhance primary productivity (Figure 1-2) and thus fisheries in the Cilician basin shelf waters. In addition, large amounts of chemicals of different origins (domestic, agricultural, industrial) are introduced by point and diffusive discharges to the Mersin and Iskenderun Bay coastal waters having limited exchanges with the open sea (Figure 2). Therefore, the inner bay waters become more polluted and highly productive, leading to the formation of sharp contrasts between the bio-chemical properties of inner bay waters and the oligotrophic open sea (Figure 1). In such semi-enclosed marine environments, interactions between coastal and open sea systems determine the spatial variations in the bio-chemical properties of bay/coastal ecosystems. However, the atmospheric inputs of nutrients and essential trace metals have important roles for the Cilician open sea ecosystem during the spring-autumn period when the internal supply from deeper water layers remains at minimal levels in the Eastern Mediterranean (Kocak *et al.* 2010). They estimated that atmospheric deposition of reactive phosphate in the Cilician basin could reasonably account for a significant fraction of the new production (up to 38%) in the summer- autumn period.

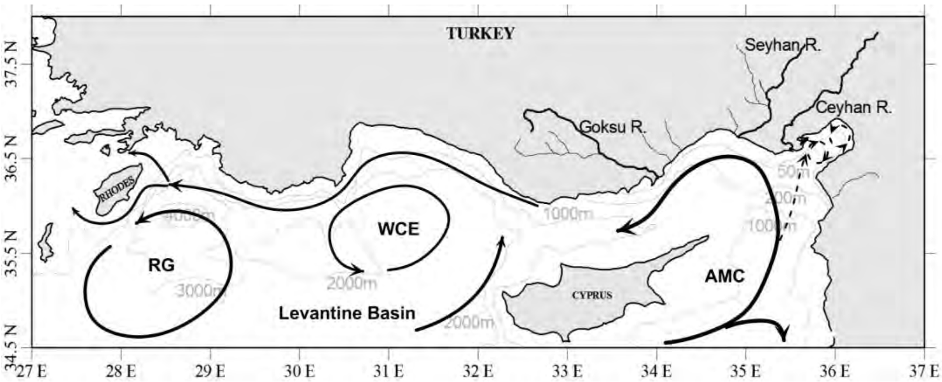

Figure 2. Bathymetry, rivers and main currents (AMC-Asia Minor Current, WCE-West Cyprus Eddy, RG-Rhodes Gyre) of the north eastern Mediterranean (modified from Ozsoy *et al.* 1993).

2. Dissolved Oxygen and Nutrients Distributions

Though the physical evolution of water masses and the upper layer current systems have been studied extensively, the spatio-temporal changes in the concentrations of dissolved oxygen and in dissolved inorganic nutrients (nitrate, phosphate, silicate) across the eastern Mediterranean were less described in the literature (Schlitzer *et al.* 1991; Roether *et al.* 1996; Klein *et al.* 1999; Klein *et al.* 2003; Kress *et al.* 2003). Typical transect profiles in Figure 3 clearly show that nutrient concentrations are very low in the surface layer of 150-200 m in the Eastern Mediterranean; it is separated from the nutrient-enriched the deep layer (nitrate: 5-6 µM nitrate, phosphate: 0.2-0.3 µM and silicate: 11-12 µM) by a permanent nutricline situated at greater depths the anticyclonic eddies. The deep water nutrient values are much less than the associated chemical properties of Atlantic Ocean deep waters near Gibraltar (about 20, 1.4 and 23 µM for nitrate, phosphate and silicate, respectively).

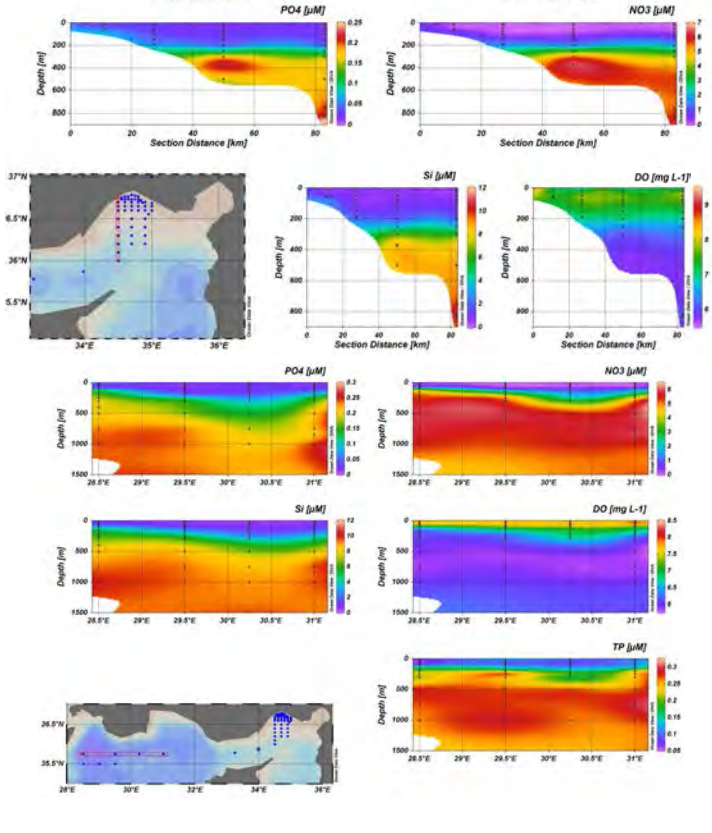

Figure 3. Vertical distributions of phosphate, nitrate, silicic acid, dissolved oxygen and total phosphorus along a north-south and west-east cross section of the eastern Mediterranean in 2012-2013.

In general, the vertical distributions of dissolved oxygen and nutrients in the upper layers (0-150 m) are quite homogeneous across the eastern Mediterranean (Kress *et al.* 2003). Dissolved oxygen concentrations are nearly at saturation levels and the nutrient concentrations are very low in the euphotic zone (EZ), except severe winter conditions within the Rhodes cyclonic gyre (Yılmaz and Tuğrul 1998). As shown in Figure 3, the largest changes in the concentrations of nutrients and oxygen appear in the permanent density gradient zone formed in the upper intermediate water layers having different physical (salinity, temperature and thus density) properties (Roether *et al.* 1996; Klein *et al.* 1999; Manca *et al.* 2002; Roether *et al.* 2007). The oxygen and nutrient concentrations below the main chemocline display spatial and temporal variability at 500-1500 m depth range (Klein *et al.* 1999; Lascaratos *et al.* 1999), depending on the intrusion rate of younger dense water masses from the upper layer in winters with low nutrients but saturated values of oxygen (Klein *et al.* 2003; Kress *et al.* 2003). Concentrations of dissolved oxygen and nutrient concentrations in deep basin water masses are determined by the rates of both organic matter inputs from the euphotic zone and its residence time at a given depth of the deep basin; principally younger water masses have higher values of oxygen but low nutrient concentrations.

The hydrochemistry of Levantine Basin in the NE Mediterranean display three regions of distinct features; namely, the cyclonic Rhodes basin (CYC), the anticyclonic Cilician basin (ACYC) and the transitional area (periphery and frontal regions). Therefore, different vertical distributions of nutrient and oxygen concentrations are observed in the hydro-dynamically different regions of the NE Mediterranean (Figure 4) (Ozsoy *et al.* 1993; Yılmaz and Tuğrul 1998; Kress *et al.* 2003). The nutricline, closely correlated with the main pycnocline, is situated at much shallower depths (50-125 m) in the Rhodes cyclone as compared to its position (300-600 m) in the Cilician basin (Figure 4), showing a close relationship with its hydro-dynamical properties.

Reactive phosphate concentrations are consistently very low (<0.02-0.04 μM) in the euphotic zone (EZ) waters of the eastern Mediterranean during the year (Table 1, Figure 5). However, the surface inorganic nitrogen values increases in the river-fed coastal waters about 1.5-3.03 μM during winter-spring periods (Table 2). On the other hand, in the open sea, the surface nitrate exhibits remarkable increases in the Rhodes cyclonic gyre in winter when the nutrient-replete deep waters ascend up to the euphotic zone via deep convective mixing processes (Figure 4) (Yılmaz and Tuğrul 1998). Below the EZ, the position and thickness of the nutricline are highly variable with season and location (Figure 4) due to apparent changes in the position of the main pycnocline (density gradient zone). The deepening of the nutricline in the anticyclonic regions highly limits nutrient inputs to the EZ waters. In the Levantine deep water, the nitrate concentrations reach the maximal levels of 4.5-6 μM, below the nutricline (Figure 3-4). The concentrations of reactive phosphate (0.15-0.25 μM) in the Levantine deep waters are much lower than the nitrate values (5-6 μM), leading to much higher N/P molar ratio (25-28) in the Levantine deep water than the classical Redfield ratio of 16 for the oceans system (Krom *et al.* 1991; Yılmaz and Tuğrul 1998).

Table 1. The average concentrations of dissolved nutrients and N/P molar ratios for the Euphotic Zone of Rhodes Cylonic Gyre, Antalya and Cilician Basins, NE Mediterranean (from Ediger *et al.* 2005)

Sampling Date	Region	PO_4 (μM)	NO_x(μM)	N/P
October, 1991	Rhodes Basin	0.03±0.004	0.28±0.27	9.3
	Antalya Basin	0.02±0.0	0.11±0.0	5.5
	Cilician Basin	0.02±0.0	0.15±0.02	7.5
March, 1992	Rhodes Basin	0.16±0.02	4.66±0.41	29
	Antalya Basin	0.06±0.02	1.70±0.88	28.3
	Cilician Basin	0.03±0.01	0.76±0.26	25.3
July, 1993	Rhodes Basin	0.03±0.0	0.15±0.01	5
	Antalya Basin	0.02±0.0	0.18±0.0	9
	Cilician Basin	0.02±0.0	0.13±0.02	6.5
March, 1994	Rhodes Basin	0.02±0.0	0.25±0.19	12.5
	Antalya Basin	0.02±0.0	0.36±0.13	18
	Cilician Basin	0.02±0.0	0.16±0.13	8

Table 2. The average concentrations of dissolved nutrients and N/P molar ratios for the 0-10 meters and surface concentrations ranges in the Mersin Bay (from Kaptan 2013; Erdoğan 2014; Akçay 2015)

Sampling Date	Region /Layer	PO_4 (μM)	DIN (μM)	N/P
April, 2009	Inner Bay (0-10 m)	0.06±0.01	1.67±1.57	25.5±20
August, 2009	Inner Bay (0-10 m)	0.110±0.04	2.09±0.25	20.0±5.5
October, 2009	Inner Bay (0-10 m)	0.070±0.01	1.78±0.06	25.9±4.4
February, 2010	Inner Bay (0-10 m)	0.050±0.01	13.5±0.07	282±78
April, 2009	Central Bay (0-10 m)	0.045±0.00	0.27±0.12	6.18±3.6
August, 2009	Central Bay (0-10 m)	0.045±0.00	0.60±0.07	13.6±3.7
October, 2009	Central Bay (0-10 m)	0.045±0.00	0.38±0.06	8.65±2.6
February, 2010	Central Bay (0-10 m)	0.030±0.00	3.93±1.62	131±54
April, 2009	Offshore (0-10 m)	0.033±0.0	0.34±0.02	10.4±1.3
August, 2009	Offshore (0-10 m)	0.030±0.0	0.24±0.08	8.11±2.5
October, 2009	Offshore (0-10 m)	0.030±0.0	0.28±0.05	9.33±1.8
February, 2010	Offshore (0-10 m)	0.030±0.0	0.19±0.03	6.22±0.8
		PO_4 (μM)*	DIN (μM)*	N/P*
Sep, 2008-Feb 2011	Inner Bay (Surface)	0.02-0.49 (0.10)	0.27-44.06 (4.83)	4.2-528.0 (56.1)
Sep, 2008-Feb 2011	Central Bay (Surface)	0.02-0.19 (0.05)	0.17-10.60 (1.73)	4.63-519.0 (43.4)
Apr, 2014- Feb 2015	Inner Bay (Surface)	0.05-0.34 (0.15)	0.27-125.94 (2.91)	3.9-370.4 (21.1)
Apr, 2014- Feb 2015	Central Bay (Surface)	0.02-0.06 (0.03)	0.13-3.10 (0.79)	2.1-103.3 (18.2)

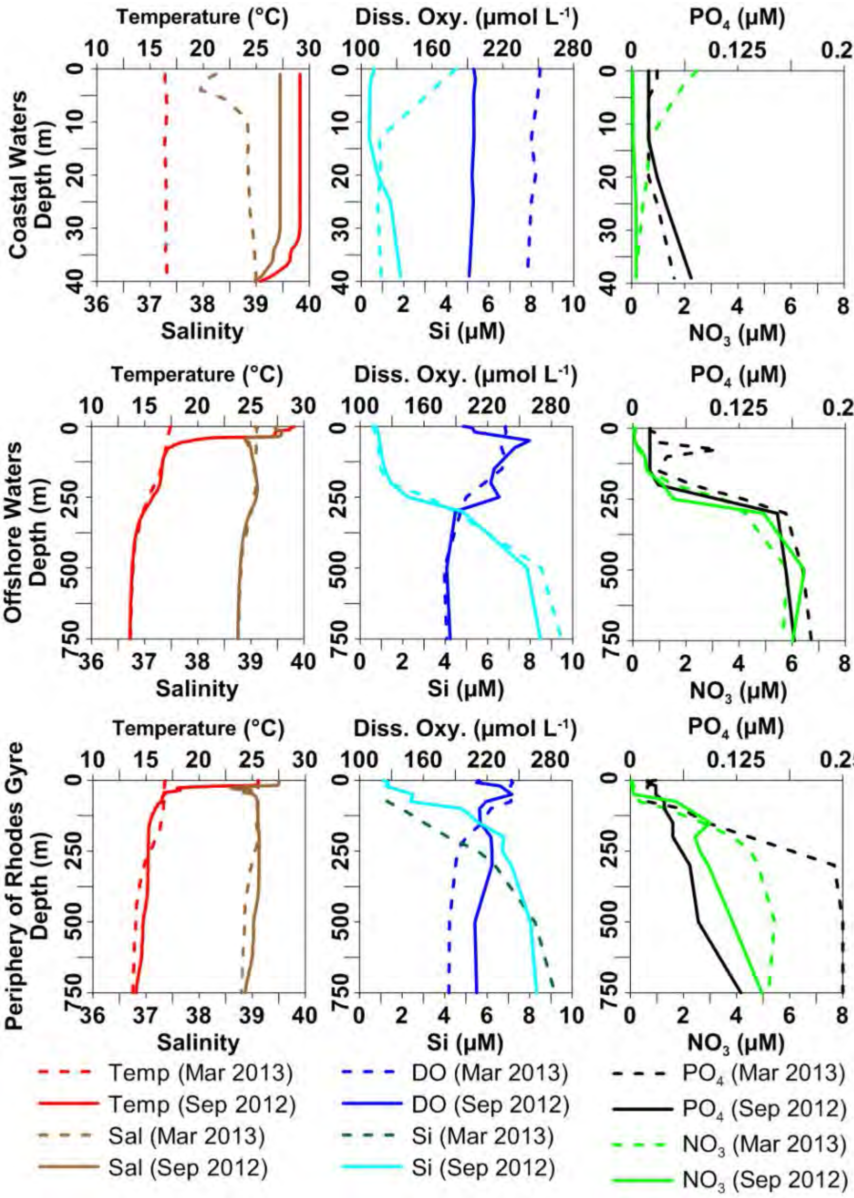

Figure 4. Typical depth of profiles of nitrate, phosphate and silicate concentrations, and N/P ratios in the coastal waters, offshore waters and periphery of Rhodes Gyre in NE Mediterranean in 2012-2013.

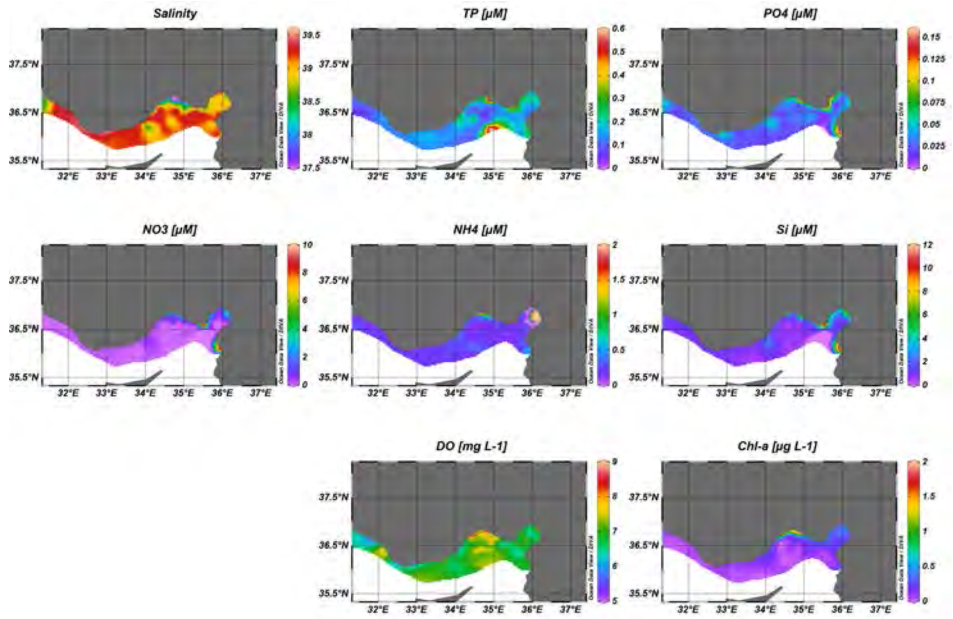

Figure 5. Surface distributions of the seasonal average salinity, nutrients, dissolved oxygen and chlorophyll-a for the period of 2014-2016 in the Cilician basin of NE Mediterranean (data from METU-IMS data center, provided through the national monitoring and different TUBITAK projects).

The coastal ecosystem of Cilician wide shelf, however, have been significantly altered by large inputs of organic and inorganic nutrients by rivers and wastewater discharges as a result of rapid industrial growth, excess uses of fertilizers and population explosion in the Çukurova plain region within the recent decades (Figures 1-2). Monitoring studies in Mersin Bay in recent years clearly show sharp contrasts in the surface distributions of nutrients and chlorophyll-*a* (biomass indicator) concentrations in the inner and outer bay (Figure 5). The limited interactions between the bay waters shelf area and the open sea help the inner bay bottom waters flush by the more oxygenated waters of Cilician Basin via circulations. Moreover, the strong local wind in Iskenderun region is also effective on the oxygenation of the water column through vertical turbulent mixing; it is limited to more saline and warmer upper layer in summer-autumn period.

3. Spatio-Temporal Variations of Particulate Organic Matter (POM), Algal Biomass (Chorophyll-*a*) and Primary Productivity in NE Mediterranean

Particulate matter in the oceans consists of living organisms and detrital material such as organic fragments, clays and carbonates, on which organic substances, colloids and metals may be fixed or absorbed.

The abundance and chemical composition of bulk POM (composed of living and nonliving organic matter) in the upper layer of Eastern Mediterranean displays remarkable spatial and temporal variations. POM concentration decreases by at least 10-fold from river-fed coastal zone to less productive open sea. POC concentrations exceeded 60 µM in river-fed coastal surface waters where elemental composition (C/N) of the bulk POM are very similar to Redfield Ratio (Table 3). In the deep basin, the lowest POM values are observed in the less productive anticyclonic regions (Abdel-Moati 1990; Rabitti *et al.* 1994; Ediger *et al.* 1999, 2005; Socal *et al.* 1999; Çoban-Yıldız *et al.* 2000; Doğan-Saglamtimur and Tuğrul 2004). Spatial distributions of bulk POM and chlorophyll-*a* (biomass indicator) generally display similar vertical features during more productive seasons, winter-spring months.

Table 3. The average concentrations of particulate organic carbon (POC), particulate organic nitrogen (PON), total particulate phosphorus (TPP) and C/N and N/P molar ratios in the surface and their ranges in the euphotic zone of NE Mediterranean Regions

Region	POC (µM)	PON (µM)	TPP (µM)	C/N	N/P
Mersin Bay coastal surface waters(1)	14.47-107.03	1.82-12.89	0.078-0.470	5.96-10.7	11.1-37.2
Mersin Bay central basin surface waters	3.44-15.68	0.56-2.48	0.025-0.115	6.14-9.7	12.3-55.6
Mersin Bay coastal surface waters(2)	22.6-63.3	3.37-7.72	0.2-0.4	6.68-8.45	
Mersin Bay offshore surface waters	2.33-5.24	0.29-0.59	0.02-.0.04	7.09-10.1	10-50
Mediterranean Sea surface waters-Dec 2001-2003(3)	1.9-114	0.11-10	0.029-0.191	4.7-19.6	8.9-56.2
Anticyclonic Cilician Basin-Oct 1991 (average)(4)	2.7±1.61	0.20±0.03		14±8.0	
Anticyclonic Cilician Basin-Mar 1992 (average)	1.8±0.61	0.25±0.08		7.0±1.2	
Rhodes Cyclonic Region-Oct 1991 (average)	2.1±0.8	0.21±0.06	0.02±0.01	10.3±3.0	15±5
Rhodes Cyclonic Region-Mar 1992 (average)	2.0±1.30	0.22±0.06	0.02±0.002	8.5±0.95	11.8±1.6

(1) Akçay, 2015; (2) Erdoğan, 2014; (3) Doğan-Sağlamtimur, 2007; (4) Ediger *et al.* 2005

The eastern Mediterranean open waters posses oligotrophic properties; high water transparency (SDD: 25-35m), low primary productivity (45-50 mg C m^{-2} d^{-1}) and algal biomass (Chl-*a* is <0.5µg L^{-1}) in the anticyclonic eddies and its peripheries. Algal production is mainly limited by reactive phosphorus ions (Ediger and Yılmaz 1996; Robarts *et al.* 1996; Tüfekçi *et al.* 2013) due to high N/P ratios in deep waters and external inputs (river and rain waters, Koçak *et al.* 2010).

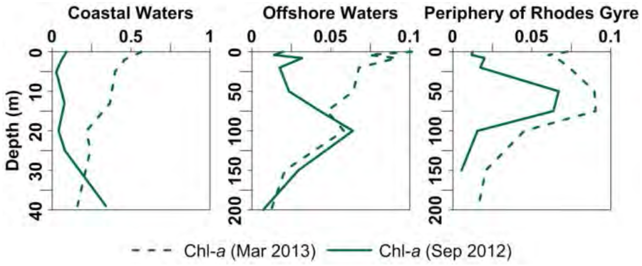

Figure 6. Typical depth of profiles of chlorophyll *a* concentrations (µg l^{-1}) in the coastal waters, offshore waters and periphery of Rhodes Gyre in NE Mediterranean in 2012-2013.

A deep chlorophyll maximum (DCM) is a characteristic feature of Levantine basin (Figure 6); it is principally formed at depths near the base of the euphotic zone during spring-autumn period (Yılmaz *et al.* 1994; Yacobi *et al.* 1995; Ediger and Yılmaz 1996; Ediger *et al.* 2005). In anticyclonic regions, the DCM is located at the base of the euphotic zone (EZ) and much above the nutricline. However, the nutricline is located at the base of the EZ in the Rhodes cyclonic region (Ediger *et al.* 2005).

In the Cilician shelf waters, POC/Chl-*a* ratio by regression analyses range from 25 in productive regions and season to over 1000 in the offshore waters for dry summer-autumn period, indicating phytoplankton dominated POM changes in the river-fed shelf waters (Yılmaz 2006). The C/N and C/P ratios of bulk POM derived from regression analysis are variable; higher POC/PON (10-20) and POC/PP (140-240) ratios obtained in the near shore waters of Mersin Bay indicate land-based input of organic matter to POM pool in coastal waters (Doğan-Saglamtimur and Tuğrul 2004; Erdoğan 2014). In the open sea, the elemental composition of bulk POM data (Ediger *et al.* 2005) obtained in the NE Mediterranean open sea are comparable with the Redfield ratio of C/N/P:106/16/1. Higher N/P ratios of nitrate/phosphate and bulk POM across the Cilician shelf zone strongly suggest P-controlled organic matter production in the river-fed coastal waters as suggested for the open sea.

Primary productivity and concentrations of chlorophyll in the oligotrophic NE Mediterranean are very low and lower than in the western Mediterranean (Krom *et al.* 1991; Ediger and Yılmaz 1996; Eker-Develi 2004; Siokou-Frangou *et al.* 2010; Yucel 2008; 2013). nnual primary production was estimated 65.4 - 110 g C m^{-2} y^{-1} for the nutrient-depleted open sea (Yılmaz 2006; Yucel 2013) and 151 g C m^{-2} y^{-1} for the coastal regions fed by the big rivers (Seyhan, Ceyhan, Göksu, Tarsus Rivers) (Yucel 2013) (Table 4). Similar spatio-temporal variability appears in chlorophyll concentrations, ranging from <0.5 mg m^{-3} in offshore waters to 6.5 mg m^{-3} in high productive areas (Ediger and Yılmaz 1996; Yılmaz 2006; Tuğrul *et al.* 2010; Yucel 2008, 2013; Uysal *et al.* 2014). Phytoplankton blooms were observed in winter and spring periods (Eker and Kıdeys 2000; Ediger *et al.* 2005). Phytoplankton biomass is dominated by diatom in the more productive coastal waters, while picoplankton was reported to form the most abundant group in the open sea (Eker and Kıdeys 2000; Polat *et al.* 2000; Eker *et al.* 2003; Uysal *et al.* 2004; Uysal 2006; Uysal *et al.* 2008; Yucel 2013).

The depth integrated primary production was preported to vary between 2.05 – 121 mg C m^{-2} h^{-1} in coastal waters and 0.31 – 3.36 mg C m^{-2} h^{-1} in offshore waters (Yucel 2013). The contribution of picoplankton to total primary production increased from coastal waters to offshore (41% to 71%). Primary production was measured high in late winter-early spring and summer season (July and August). There was a competition between larger cells and picoplankton in coastal waters. However, higher bloom was generally achieved by larger cells in coastal waters. Phosphate (P), nitrogen (N) and N+P controlled seasonally the productivity in the northeastern Mediterranean (Yucel 2013).

Table 4. Primary Production measurements in the northeastern Mediterranean

References	Primary Production (PP)	Location	Period
Yucel *et al.* (Unpublished data)	21.54 – 348.85 mg C m^{-2} h^{-1}	Transect from Mersin Bay to Rhodes Gyre	Jul and Sep 2012, Mar and May 2013
Yucel 2013	5.24-72.2 mg C m^{-2} h^{-1} Coastal 2.05-40.4 mg C m^{-2} h^{-1} Offshore	East side of the Cilician Basin	Sep 2008 - Oct 2011 (seasonal)
Yucel 2013	2.45-120.8 mg C m^{-2} h^{-1} Coastal 3.29-46.54 mg C m^{-2} h^{-1} Offshore 18.9 – 1126 mg C m^{-2} d^{-1} Coastal 32.7 - 478.5 mg C m^{-2} d^{-1} Offshore 151.2 g C m^{-2} y^{-1} Coastal 65.4 g C m^{-2} y^{-1} Offshore	NE Mediterranean	May 2010 - Oct 2011 (monthly)
Yılmaz 2006	1.5 - 9.5 mg C m^{-3} d^{-1} Coastal Surface 14 - 425 mg C m^{-3} d^{-1} Offshore Surface	NE Mediterranean	May, Jul, Nov and Dec 2002 and Mar 2003
Yayla 1999	153 mg C m^{-3} d^{-1} 236 mg C m^{-3} d^{-1}	Finike Trough Rhodes Gyre	May, Nov 1996, Sep, 1997
Ediger *et al.* 2005	38.5 - 457 mg C m^{-3} d^{-1} 250 mg C m^{-3} d^{-1}	Rhodes Gyre Cilician Basin	Oct 1991, Mar 1992

Recent data obtained in NE Mediterranean in July, September 2012, March and May 2013) (Figure 7) mean rates of primary production varied regionally and seasonally between 3.70 – 8.43 mg C m^{-3} h^{-1} in the Cilician coastal region, 0.09 – 0.90 mg C m^{-3} h^{-1} in the offshore, and 0.04 – 0.70 mg C m^{-3} h^{-1} within the periphery of

Rhodes Gyre (Figure 7). Expectedly, the rate of primary production decreased markedly at 1 % light depth which is reached at 150 meters in the open sea. Larger cells (35.8%) were observed to dominate algal productivity in the upper 20 meters of the coastal region fed by river inflows, whilst picoplankton constituted about 38% of the total depth-integrated primary productivity in the euphotic zone. Moreover, contribution of picoplankton to total primary productivity reached 67 % level in the offshore waters and 75% in the periphery of Rhodes Gyre.

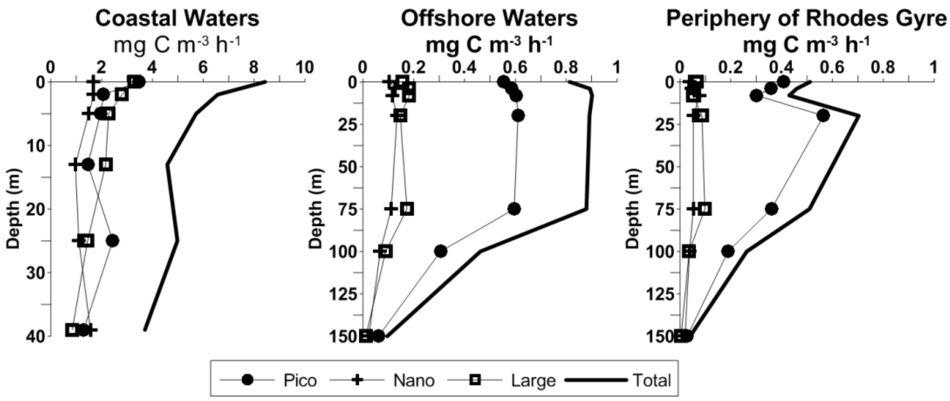

Figure 7. Vertical distribution of size fractionated and total primary production at northeastern Mediterranean (Pico:Picoplankton (0.2-2.0 µM), Nano: Nanoplankton (2.0-5.0 µM), Large:Larger cells (5.0 µM <) (modified from Yucel *et al.* unpublished data).

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ATMOSPHERIC INPUT OF INORGANIC MACRO-NUTRIENTS IN THE EASTERN MEDITERRANEAN: RAMIFICATIONS REGARDING MARINE PRODUCTIVITY

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1. Introduction

The Mediterranean Sea has been foci of oceanographers and atmospheric chemists since 1990's. It is known by its oligotrophic (deficit in macro nutrients) surface waters and low primary productivity, in other words it can be described as low nutrient and low chlorophyll (LNLC) region. The oligotrophy of Mediterranean is not only attributed to its anti-estuarine circulation but also limited fresh water input through rivers. Before the construction of the Aswan High Dam in 1965, the Nile had the largest drainage in basin and water load to the Mediterranean. Construction of the Dam had a significant influence on the water discharge with a decrease greater than 90 % (Pouslos and Drakopoulos 2001) and has left the Turkish rivers Seyhan and Ceyhan as the two largest riverine sources of material to the Eastern Mediterranean Basin. As these few rivers are the only source of particulate matter to the Eastern Mediterranean the atmospheric input to the basin will influence more the marine biogeochemical cycles.

The primary productivity in the basin decreases from west to east along with increasing nutrient deficiency (Krom *et al.* 2004; Pitta *et al.* 2005). For instance, primary and bacterial production rates were found to be two to three times lower in the Eastern Mediterranean than those observed for the Western Mediterranean (Turley *et al.* 2000). Similarly to productivity, the molar N/P ratio in the Eastern Mediterranean (25-28) is higher than that of Western Mediterranean (22) and the normal oceanic Redfield ratio of 16. Considering aforementioned features, the inadequate primary productivity in the Eastern Mediterranean is attributed to macro nutrient phosphorous (Yılmaz and Tuğrul 1998). In 2004, Krom *et al.* (2004) budgeted fluxes of N and P for the Eastern Mediterranean and concluded that the high N/P ratio is due primarily to the high biologically available N/P ratio in all the input sources but for those particularly from the atmosphere (117:1). Another study (Ludwig *et al.* 2009) suggested that decreases in the dissolved Silica concentrations were due to a substantial reduction in the fresh water discharges. They hypnotized that Si may not necessarily reduce the productivity in the Mediterranean however it can provoke a switch from diatom dominated communities to non-siliceous populations.

The scientific research about airborne macro nutrients in the Eastern Mediterranean can be traced back to late 1990s. For example, Herut and his colleagues (1999) investigated levels of dissolved inorganic nitrogen and phosphorus in aerosol and rain. Results revealed atmospheric input as an important external source of macro-nutrients. The number of studies about atmospheric nutrient fluxes has been increased since then (Kouvarakis *et al.* 2001; Herut *et al.* 2002; Markaki *et al.* 2003, 2010; Koçak *et al.* 2010, 2015). Nonetheless, only few studies have attempted to appraise nutrient fluxes both from rivers and atmosphere in the Eastern Mediterranean (Koçak *et al.* 2010). Equivalently, there are few publications focusing on the solubility of macro-nutrients in the region (Markaki *et al.* 2003; Chen *et al.* 2006; Koçak 2015).

2. Estimation of Atmospheric and Riverine Inputs

The wet and dry atmospheric fluxes of nutrients can be calculated according to the procedure explained in Herut *et al.* (1999, 2002). The wet atmospheric deposition fluxes (F_w) can be obtained from the annual amount of precipitation (P) and the volume weighted mean concentration (C_w) of the substance of interest (Eqn.1).

$$F_w = C_w x P \qquad [1]$$

The dry deposition (F_d) of nutrients can be estimated as the product of atmospheric mean nutrient concentrations (C_d) and their settling velocities (V_d), where F_d is given in units of μmol m^{-2} yr^{-1}, C_d in units of μmol m^{-3} and V_d in units of m yr^{-1}.

$$F_d = C_d x V_d \qquad [2]$$

Riverine fluxes of nutrients can be calculated from a discharge weighted mean concentration (C_{dw}). For a study period, the discharge weighted mean concentration (C_{dw}, eq. 3) is determined on the basis of n samples of instantaneous concentrations (C_i, C_{i+1}) and discharge values (Q_i, Q_{i+1}). Consequently, annual riverine fluxes (F_r, Eqn. 4) can be estimated by the product of C_{dw} and Q_{annual} (Karakatsoulis and Ludwig 2004).

$$C_{dw} = \frac{\sum_{i=1}^{n} C_i x Q_i}{\sum_{i=1}^{n} Q_i} \qquad [3]$$

$$F_r = C_{dw} x Q_{annual} \qquad [4]$$

3. Nutrient Concentrations in Aerosol and Rainwater over the Eastern Mediterranean

Comparison of the sampling sites will be useful to evaluate spatial trends in the Eastern Mediterranean even though the values from in the literature cover different collection periods (and might have different sampling and analytical methodologies).

Table 1 shows the soluble nutrient concentrations in aerosol and rainwater samples obtained from different sites located around the Mediterranean.

Table 1. Comparison of nutrient concentrations in aerosol (nmol m^{-3}) and rainwater (µmol L^{-1}) samples for different sites of the Mediterranean.

Location	NO_3^-	NH_4^+		Reference
		Aerosol (nmol m^{-3})		
Erdemli, Turkey	65±34	121±64	Jan.99-Dec.09 (1525)	**Koçak *et al.* (2010)**
Erdemli, Turkey	58	118	Jan.99-Jan.00 (194)	**Markaki *et al.* (2003)**
Finokalia, Crete	27±13	53±21	Oct.96-Sep.99 (496)	**Kouvarakis *et al.* (2001)**
Finokalia, Crete	16	24	Sep.99-Sep.00 (85)	**Markaki *et al.* (2003)**
Tel Shikmona, Israel	93±29[a]	117±88[a]	Apr.96-Jan.99 (41)	**Herut *et al.* (2002)**
Eliat, Israel	39±19	25±14	Aug.03-Sep.05 (137)	**Chen *et al.* (2007)**
Cap Ferrat, France	63	150	May-June.92	**Loye-Pilot *et al.*(1993)**
		Rainwater (µmol L^{-1})		
Erdemli, Turkey	37	41	Jan.99-Dec.07 (237)	**Koçak *et al.* (2010)**
Erdemli, Turkey	46	-	Feb.99-Dec.99 (16)	**Markaki *et al.* (2003)**
Heraklion, Crete	18	21	Sep.99-Sep.00 (41)	**Markaki *et al.* (2003)**
Tel Shikmona, Israel	41	25	Jan.92-Mar.98 (187)	**Herut *et al.* (1999)**
Ashod, Israel	**57**	**45**	**Nov.95-Mar.98 (67)**	**Herut *et al.* (1999)**

Location	Si_{diss}	PO_4^{3-}		Reference
		Aerosol (nmol m^{-3})		
Erdemli, Turkey	1.1±1.5	0.5±0.4	Jan.99-Dec.09 (1525)	**Koçak *et al.* (2010)**
Erdemli, Turkey	-	0.3	Jan.99-Jan.00 (194)	**Markaki *et al.* (2003)**
Finokalia, Crete	-	0.1	Sep.99-Sep.00 (85)	**Markaki *et al.* (2003)**
Tel Shikmona, Israel	-	0.8[a]±0.5	Apr.96-Jan.99 (41)	**Herut *et al.* (2002)**
Eliat, Israel	-	0.4±0.2	Aug.03-Sep.05 (137)	**Chen *et al.* (2007)**
		Rainwater (µmol L^{-1})		
Erdemli, Turkey	1.9	0.5	Jan.99-Dec.07 (237)	**Koçak *et al.* (2010)**
Erdemli, Turkey	-		Feb.99-Dec.99 (16)	**Markaki *et al.* (2003)**
Heraklion, Crete	-	0.1	Sep.99-Sep.00 (41)	**Markaki *et al.* (2003)**
Tel Shikmona, Israel	-	0.6	Jan.92-Mar.98 (187)	**Herut *et al.* (1999)**
Ashod, Israel	**-**	**0.6**	**Nov.95-Mar.98 (67)**	**Herut *et al.* (1999)**

[a] Indicates sea-water solubility of nutrient species.

As can be deduced from the table, water soluble Si_{diss} in the aerosol and rain over the Eastern Mediterranean have been reported in one publication. Therefore, comparison for this macro-nutrient would not be possible. The mean aerosol phosphate concentration at Erdemli is comparable to levels reported for Eliat, Israel (Chen *et al.* 2007). Although phosphate concentrations are measured in seawater, highest levels over the Eastern Mediterranean is reported for Tel Shikmona and this might be attributed to the closer proximity of the sampling site to arid regions (Koçak *et al.* 2004a). Aerosol nitrate and ammonium concentrations are in agreement with the values reported for Erdemli (Koçak *et al.* 2004b). Mean aerosol nitrate and ammonium concentrations are two to four times higher than those reported for Finokalia, Crete (Kouvarakis *et al.* 2001; Markaki *et al.* 2003) and Eliat, Israel (Chen *et al.* 2007) whereas values are comparable levels reported for Tel Shikmona, Israel (Herut *et al.* 2002) and Cap Ferrat (Loÿe-Pilot *et al.* 1993). It should be highlighted that Erdemli and Tel Shikmona aerosol samples are collected on Whatman 41 cellulose fiber filters whilst Finokalia and Eliat aerosol are collected on Teflon and polycarbonate filters, respectively. It has been shown that positive nitrate and ammonium artifact can result the adsorption of gaseous HNO_3 and NH_3 on filter surfaces (mainly glass fiber and cellulose) or on already collected particles (Wieprecht *et al.* 2004 and references therein). Comparing nitrate and ammonium results from different substrates Koçak *et al.* (2010) has been shown that NO_3^- and NH_4^+ values for Whatman 41 were 42 % and 50 % higher than those concentrations observed for polycarbonate filters.

Rainwater volume weighted mean phosphate, nitrate and ammonium concentrations at Erdemli are comparable to values reported for Israeli coastal sites (Herut *et al.* 1999) whereas lowest values are observed at Finokalia (Markakie *et al.* 2003) since this site is categorized by natural background (distance from large pollution sources > 50 km) and its proximity to arid regions located at the Middle East/Arabian Peninsula.

4. Solubility of Nutrients in Eastern Mediterranean

As stated before, only few studies have attempted to evaluate nutrient solubilities by using sea-water and pure-water as extraction medium. Markaki *et al.* (2003) used samples from Finokalia, Central Mediterranean; Chen *et al.* (2006) applied aerosol filters collected at Eliat, Golf of Aqaba whilst Koçak (2015) utilized aerosol samples from Erdemli, Northeastern Mediterranean. These studies revealed that the difference between pure-water and sea-water extractions for nitrate and ammonium was estimated to be small. This similarity can be ascribed to highly soluble chemical forms such as NH_4NO_3, Ca $(NO_3)_2$, $NaNO_3$ $(NH_4)_2SO_4$ and NH_4HSO_4. However, comparison between sea-water and pure-water from three studies revealed contradictory results for phosphate solubility. Results of Markaki *et al.* (2003) did not demonstrate any statistical difference for the solubility of P in sea-water and pure-water (slope=0.99, R^2=0.80). On contrary, Chen *et al.* (2006) showed that the dissolution of PO_4^{3-} was 11 % lower in sea-water than that observed for pure-water. Recent study carried out in the Northeastern Mediterranean has shown that the solubility of the phosphate might be substantially lower than that reported for Eliat, Golf of Aqaba. This difference for phosphate has been attributed to pH and ionic strength of sea water, size distribution and association of phosphate particles with less soluble compounds such as calcium phosphate, kaolinite, and origin of the aerosol species. Therefore, the atmospheric phosphorus flux tends to be overestimated if one only considers phosphate concentration in pure water.

5. Atmospheric Nutrient Fluxes in the Eastern Mediterranean

Table 2 shows dry, wet and total atmospheric depositions of nutrients obtained from different sites located at the Eastern Mediterranean. Dry deposition for phosphate at Erdemli was comparable to value reported for Eilat, Israel, Israel (Chen *et al.* 2007) whereas (as expected) phosphate dry deposition at Erdemli was approximately two times lower than those calculated for Tel Shikmona and Israeli coast. NO_3^- dry depositions at Erdemli, Tel Shikmona, Israeli coast and Eilat were comperable, whereast the highest dry deposition for ammonium was estimated at Tel Shikmona (Herut *et al.* 2002) and Israeli coast (Carbo *et al.* 2005) due to applied settling velocity (0.6 cm s^{-1}). Wet depositions for phosphate and nitrate at Erdemli and Tel Shikmona were two to four times higher than those of reported for Crete, respectively. But, wet deposition of ammonium at Erdemli was two times higher than those calculated for Tel Shikmona. Considering the total atmospheric depositions, phosphate demonstrated decreasing fluxes in the order of Tel Shikmona > Erdemli > Crete while DIN showed declining fluxes in the order of Tel Shikmona ~ Erdemli > Crete. At Erdemli, the PO_4^{3}, Si_{diss} and NH_4^+ fluxes were found to be dominated by wet deposition (0.34, 0.92 and 23 mmol m^{-2} yr^{-1}) with dry deposition contributions amounting to 40 % (0.22 mmol m^{-2} yr^{-1}), 35 % (0.54 mmol m^{-2} yr^{-1}) and 18 % (3 mmol m^{-2} yr^{-1}) of their total deposition, respectively. However, dry and wet deposition of nitrate was comparable with a value of 22 mmol m^{-2} yr^{-1}. Furthermore, nitrate and ammonium fluxes via wet deposition were found to be similar whilst dry deposition flux of nitrate was an order of magnitude higher than those for ammonium owning to differences in their particle sizes and hence settling velocities.

6. Comparison between Atmospheric and Riverine Nutrient Fluxes

Atmospheric and the riverine nutrient fluxes for Eastern Mediterranean are illustrated in Table 3. As can be deduced from Table, reported atmospheric phosphorous and nitrogen fluxes are in good agreement for Eastern Mediterranean. In spite of different approaches during the estimation of the riverine nutrient fluxes in Northeastern Levantine Basin, the reported fluxes by Ludwig *et al.* (2009) and Koçak *et al.* (2010) were found in the same magnitude.

Table 2. Dry and wet deposition depositions of the analyzed nutrients calculated for the literature for different Eastern Mediterranean sites.

Location	Si_{diss}	PO_4^{3-}	NO_3^-	NH_4^+	DIN	Reference
			Dry Deposition (mmol m^{-2} yr^{-1})			
Erdemli, Turkey[a]	0.54	0.22	38 (22)	5 (3)	43 (25)	**Koçak *et al.* (2010)**
Erdemli, Turkey[a]	-	0.16	36 (21)	8 (4)	44 (25)	**Markaki *et al.* (2003)**
Finokalia, Crete[b]	-	0.08	10	2	12	**Markaki *et al.* (2003)**
Tel Shikmona, Israel[a]	-	0.51	35 (20)	22 (11)	57 (31)	**Herut *et al.* (2002)**
Israeli Coast[a]		0.45	40 (23)	26 (13)	66 (36)	**Carbo *et al.* (2005)**
Eilat, Israel[b]	-	0.25	-	-	38	**Chen *et al.* (2007)**
			Wet Deposition (mmol m^{-2} yr^{-1})			
Erdemli, Turkey	0.92	0.34	22	23	45	**Koçak *et al.* (2010)**
Erdemli, Turkey	-	-	16	-	-	**Markaki *et al.* (2003)**
Heraklion, Crete	-	0.07	9	11	20	**Markaki *et al.* (2003)**
Tel Shikmona, Israel		0.30	20	13	33	**Herut *et al.* (1999)**
			Atmospheric Deposition (mmol m^{-2} yr^{-1})			
Erdemli, Turkey	1.46	0.56	60 (44)	28 (26)	88 (70)	**Koçak *et al.* (2010)**
Crete	-	0.15	19	13	32	**Markaki *et al.* (2003)**
Tel Shikmona, Israel	**-**	**0.81**	**55 (40)**	**35 (26)**	**90 (76)**	**Herut *et al.* (1999; 2002)**

[*] denotes seasonal fluxes, a and b show Whatman 41 and Teflon filter. Values in parenthesis indicate alternative dry depositions of nitrate and ammonium for Whatman 41 filters after multiplying 0.58 and 0.50, respectively.

Table 3. Comparison of riverine and atmospheric nutrient inputs (10^9 mol km^{-2} yr^{-1}) to the Northeastern Levantine Basin of the Eastern Mediterranean and the literature for the Eastern Mediterranean region.

River	Si_{diss}	PO_4^{3-}	NO_3^-	NH_4^+	DIN	N/P	Si/N
NLB-R[a]	1.54	0.04	1	0.2	1.2	28	**1.3**
NLB-A[a]	0.16	0.06	7	3	10	233	**0.01**
Total[a]	1.70	0.10	8	3.2	11	145	**0.1**
EMED-A[a]	2.44	0.93	100	47	147	145	**0.1**
EMED-A[b]	-	0.95	-	-	111	117	**-**
NLB-R[c]	**2.77**	**0.12**	**-**	**-**	**5.5**	**46**	**0.5**

[*] [a] Koçak *et al.* 2010, [b] Krom *et al.* 2004, 2010, [c] Ludwig *et al.* 2009. NLB: Northeastern Levantine Basin, Total: Riverine + Atmospheric inputs, EMED: Eastern Mediterranean, A: Atmospheric flux and R: Riverine flux.

On the basis of annual atmospheric and riverine inputs the following general observation might be made:

a) Inorganic nitrogen species (DIN = NO_3^- + NH_4^+) fluxes to Northeastern Levantine Basin were dominated by the atmospheric pathway with a mean contribution being more than 90 %. Riverine phosphate flux (40 %) had a substantial contribution to the phosphate pool in the Northeastern Levantine Basin, whereas; the atmosphere was the chief source to the surface waters with a mean contribution of 60 %. The Northeastern Levantine Basin Si pool was almost exclusively dominated by riverine fluxes (90 %) and only 10 % of the Si was attributed to atmospheric source.

b) Riverine molar N/P ratios ranged from 18 to 279 with a mean value of 28 and in contrast the molar Si/N ratios were found to range from 0.8 to 1.7, with a mean value of 1.3. Obtained riverine N/P and Si/N ratios suggested that riverine sources in the region are deficient in phosphate compare to DIN and Si. Atmospheric molar mean N/P ratios were found to be order of magnitude higher than former ratio whereas riverine Si/N ratio was 100 times greater than those observed for atmospheric inputs. It is clear that both sources were deficient in phosphorus compared to nitrogen.

7. Conclusion and Recomendation

The Northeastern Levantine Basin of the Mediterranean Sea receives excessive amounts of DIN; higher than those required by autotrophic organisms. Taking into account N/P ratio it might be suggested that unbalanced phosphorus and nitrogen inputs may provoke even more phosphorus deficiency in Northeastern Levantine Basin. On the other hand, Si/N ratio suggests that Si deficiency relative to nitrogen might cause a switch from diatom dominated phytoplankton population to non-siliceous communities particularly at coastal areas in Northeastern Levantine Basin.

A great number of data on atmospheric nutrient fluxes in Eastern Mediterranean have been published (Herut *et al.* 1999; Kubilay *et al.* 2000; Kouvarakis *et al.* 2001; Markaki *et al.* 2003; Krom *et al.* 2004; Carbo *et al.* 2005; Koçak *et al.* 2010). Yet, only one study has focused on assessing possible impact of both atmospheric and riverine inputs onto Northeastern Levantine waters. Moreover, three publications have attempted to assess the solubility of macro-nutrients. Given the importance of atmospheric deposition in the Eastern Mediterranean, apart from the long-term continuation to examine for possible trends, there is a clear need to i) assess the importance of atmospheric and riverine inputs of macro nutrients nitrogen and phosphorous including their inorganic and organic forms and ii) determine the soluble fractions of macro nutrient phosphorus.

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SEA CAVES, FLANK MARGIN CAVES AND TUFA CAVES OBSERVED ON ANTALYA COASTAL CLIFFS

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1. Introduction

Gaps which are growing when rocks were formed or that had occurred after are called cave. Depending on the development time caves are formed, caves are divided into two subgroups; primary and secondary caves. The primary caves develop simultaneously with host rock (such as lava caves, glacier caves, travertine- tufa caves). The caves which developed after the bedrock had formed are secondary caves. Caves observed around the sea-level on the coasts are called coastal cave. Coastal caves can be divided into two main groups. The first group caves starts with reasons such as bio-erosion, wave erosion and salt erosion, expands with the roof collapse and are called "sea cave". Despite the second group caves takes place on the shore, differ from sea caves and are formed due to chemical dissolution in the rock and are called flank margin caves (Mylroi and Carew 1990). In both types of coastal caves, development is concentrated on the fault plane, bedding plane or lithological weakness. This is effective in the final morphology of caves.

On the Antalya coastal cliffs which are 13 km length (Figure 1) and 30 m height, tufa rocks are exposed under the sea down to 25 m depth. Below this depth the sea bottom is composed of sand and mud. Flank margin caves, sea caves and tufa caves are found in Quaternary Antalya tufa cliffs. All three cave types can be found in coastal exposures being cliffed by Holocene wave activity, but also inland behind the coastal cliffs. On rocky outcrops of the cliffs down to 5 m below present sea level, caves and notches were studied. Cavities which are too small to enter were out of the scope of the study.

On the coasts, in areas where the groundwater meet the sea, there exist a fresh groundwater lens and the thickness of this lens increases landward (Ghyb the-Herzberg model) (Figure 2). Below this freshwater lens there is salty groundwater (sea water) and above the vadose zone groundwater. Due to the difference in density in the upper limits of fresh groundwater lens consists of high solubility water (Bogle 1980; Back *et al.* 1986). Along the lower limit of the freshwater lens, as a result of mixing occurring throughout the holocline, "brackish" water occurs having high solubility (Plummer 1975). Seawater is not a solvent for calcite, due to its chemical properties. However, even for mixing zone having pH> 8 values, the water has a high solubility (Figure 3) (Plummer 1975). Because the area where the lens meet the sea has the highest solubility, dissolution is in maximum level in that region (Mylroi and Carew 1990) (Figure 4).

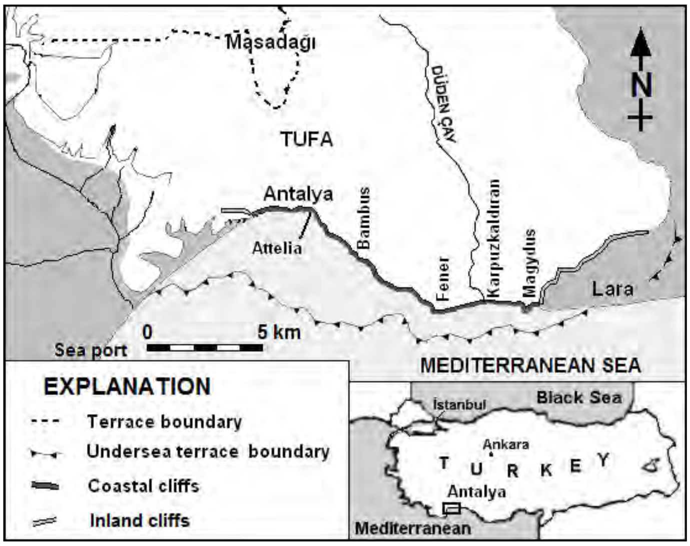


Figure 1. Location of Antalya coastal cliffs.

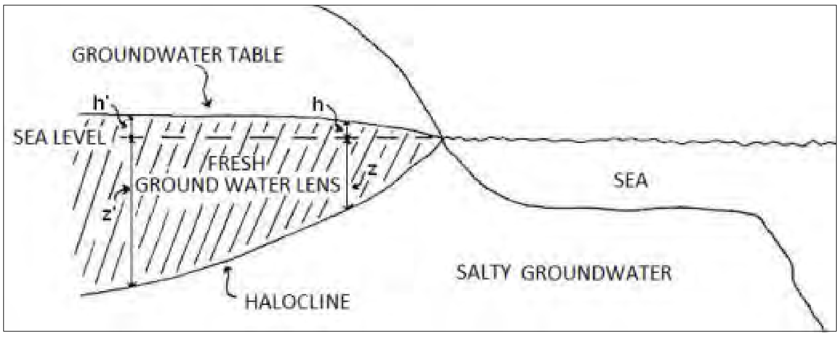


Figure 2. The Ghyben-Herzberg Model.

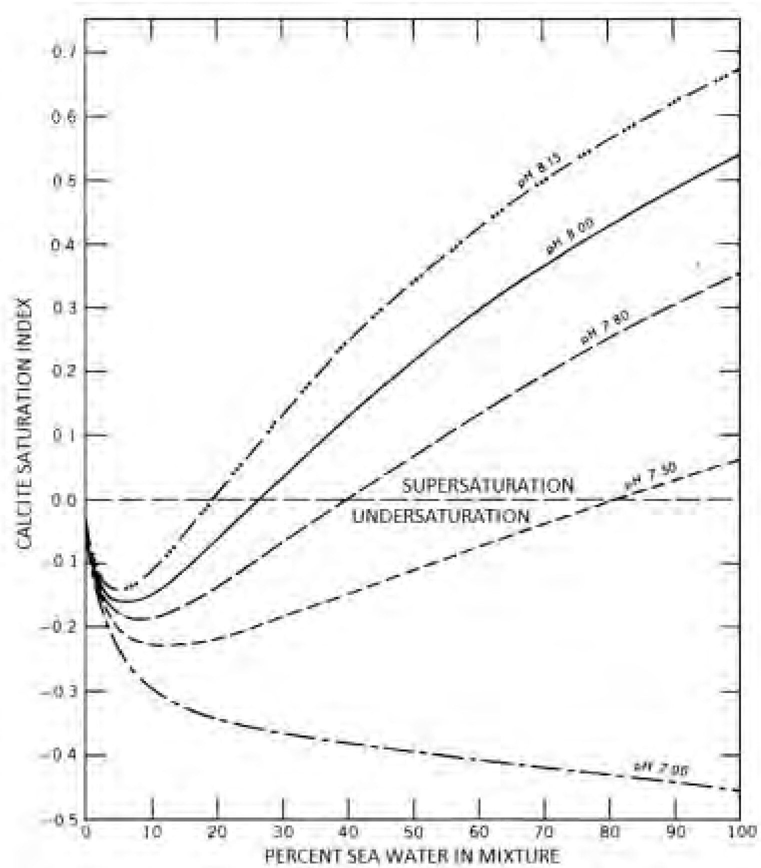


Figure 3. Changes in solubility as a result of variation in pH and concentration (Plummer 1975).

The mixing of saline sea water and fresh groundwaters in rocky coasts produces dissolutional features on both the surface (Folk *et al.* 1973; Taboroši *et al.* 2004) and in the subsurface (Back *et al.* 1986; Mylroie *and* Carew 1990) of carbonate rocks. The flank margin cave has been identified from coastal carbonates in the Bahamas by Mylroie *and* Carew (1990), Isla de Mona in Puerto Rico by Frank *et al.* (1998), Yucatan by Smart *et al.* (2006), and the Mariana Islands by Jenson *et al.* (2006). A common feature of all these caves is that they have developed in young and diagenetically immature carbonates. In a flank of a carbonate rocky coast with a fresh-water lens, the maximum dissolution occurs in the distal margin of the lens. The caves that form in this location are therefore called flank margin caves (Mylroie *and* Carew 1990).

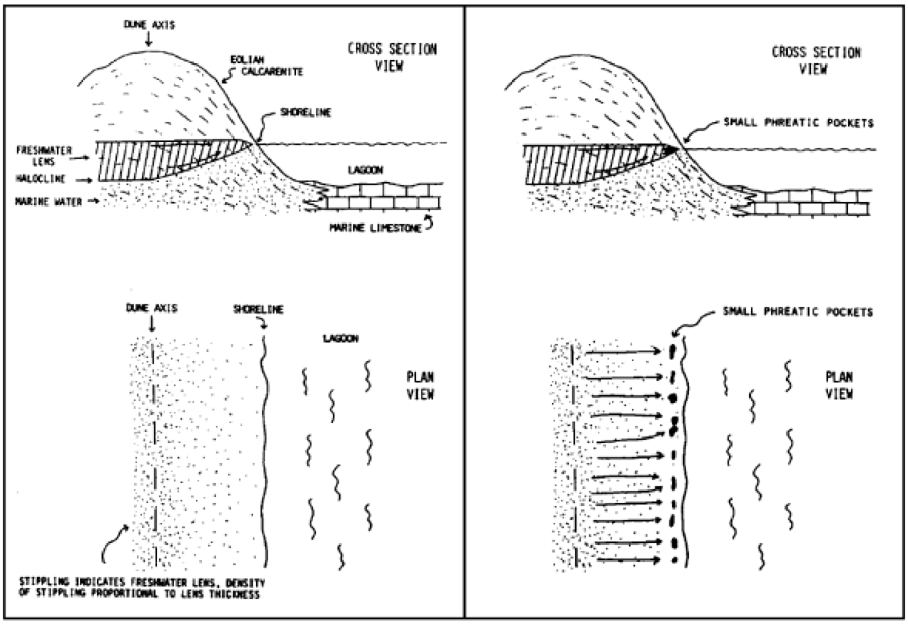


Figure 4. The flank margin model for dissolution cave development in carbonate platforms (Mylroi and Carew 1990)

Erosive processes on the Antalya tufa cliffs including the chemical action of mixing zone water, the mechanical action of waves, degradation via salt crystallization and biological degradation, play roles in the stability of the cliffs and their occurrence affects the present geomorphology. The caves on Antalya cliffs are three types; sea caves, tufa caves and flank margin caves. Sea caves are formed due to wave action on weak parts of the rock. Because the rocks of the Antalya cliffs are heterogeneous and strength varies in a wide range, weak parts of the cliffs are susceptible to erosion and therefore to cave formation. Tufa caves occurred as blind holes behind tufa curtains which deposited on tufa cascade environment of deposition. The obvious distinguishing features of tufa caves are primary sedimentary structures instead of corrosion morphologies. The flank margin caves occurred due to mixing corrosion at sea and groundwater interface.

Possible effects of bioconstruction and bioerosion on formation of the caves were also studied. Bioerosion was defined as erosion of calcareous substrates as a result of biological activities by Neumann (1966). Bioerosion erodes carbonate rocks by means of chemical and physical ways. Many carbonate costs were shaped by bioerosion. Relationship between ephilithic and endolithic organisms results in bio-erosion through (1) colonization of surfaces by epilithic organisms, (2) boring into rock surfaces by endolithic organisms, and (3) grazing of epi and endoliths. Bio-construction occurs as a result of biological activities of macro algae and some animal species which build-up calcium carbonates on their bodies (Cocito 2004). Bio-protection is a result of rock covering organisms, which are neither bioeroders nor bioconstructors: they simply protect the rock surface from erosion.

2. Methodology

Geology of the rocks was determined by making literature search and field surveys as well. All of the cliffs were searched at the sea level and below sea level by diving down to -5 meters. Entrances of some caves are below the sea level. Location of caves was determined using GPS (Global Positioning System). Distance from the cliff face to caves was measured with nylon tape. Locations of all caves were shown on a digital map. Classification of caves at each site was achieved in the field by observational identification of representative characteristic of tufa, sea cave or flank margin development.

Cave morphologies were determined by lazer scanning technique. Lazer scanning technique has been used for dimensioning of historical buldings, mining galleries and similar irregular surfaces in engineering works. Multi-beam lazer scanning method is easier, faster and more definite method, however being expensive. Alternatively, in this study a device was prepared to measure cave morphologies taking single beam measurements using standard lazermeter which can also measure inclination. To determine azimuth of the beam a turn table on a tripod was used (Figure 5). In this way length, inclination and azimuth of map projection of the beam is being recorded. Using a simple spread sheet, 3D coordinates (X-Y-Z) of end of all the measured beams can be calculated easily. These 3D coordinates was used to draw cross-section and plan view of the caves.

Sea water differs from fresh groundwater in chemical properties such as temperature, salinity and pH. Water chemistry measurements were done by an electronic device which measures electrical conductivity, pH and salinity. Chemical properties of water give some clues about location of groundwater discharge and origin of the caves. Calcite is not soluble in the sea water. However, in the mixing zone, even for pH > 8 mixed water is undersaturated for calcite (Plummer 1975). Therefore mixing ratios of every tested water samples were calculated.

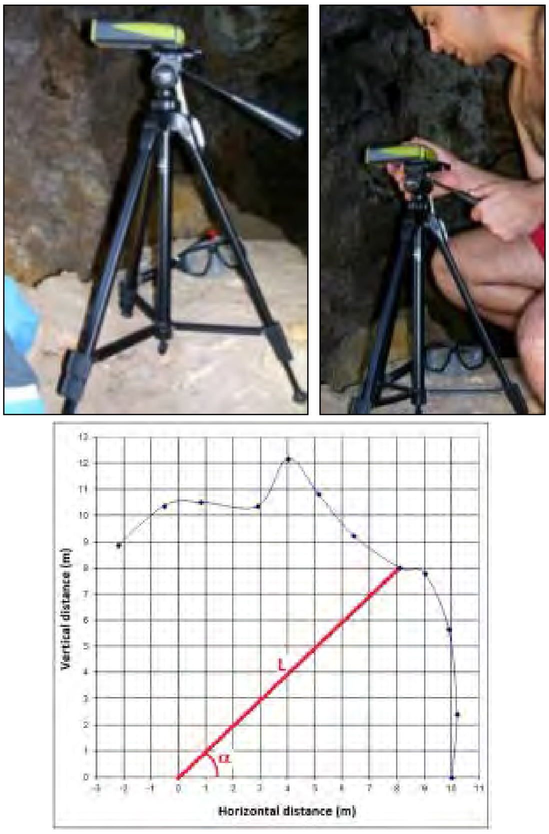


Figure 5. (a) The apparatus used in laser scanning of the caves, (b) The apparatus in use, (c) Finding coordinates using vector length (L) and inclination degree (α) (Dipova *et al.* 2009).

Biological sampling was carried out at depth of 0.2-5.0 meters below sea level with SCUBA and free diving. Members of flora and fauna were pictured. Samples were taken using 20*20 cm quadrant. Collected samples were kept in % 4-6 formaldehid solution in sea water. Identification and characterization of the species were done under stereo and optical microscope.

3. Geological origin of Antalya coastal cliffs

The coastal cliffs of Antalya are composed of tufa type rocks. Tufas are defined as the product of calcium carbonate precipitation under an ambient water temperature regime that typically contains the remains of microphytes and macrophytes, invertebrates and bacteria (Ford and Pedley 1996). The Antalya tufa, which is the largest known tufa deposit in the world (Pentecost 1995), covers an area of over 630 km^2 and obtains a thickness of up to 270 m. Antalya tufa is composed of terraces and gentle slopes decreasing in elevation towards the south-east. X-ray diffraction and SEM analysis have revealed the tufa deposits were made almost completely of calcite (Dipova and Doyuran 2006). The Antalya tufa deposits accumulated in the basin that opened as a result of the half-graben system during pre-glacial time after extensional faulting had largely ceased within the main Aksu Basin (Glover and Robertson 1998). The source of the carbonate for tufa deposition in this basin is the Kirkgoz springs. These springs drain from the Jurassic–Cretaceous karstic limestones (Beydaglari). Minor tufa deposition today occurs in highly supersaturated spring waters (i.e., at Kirkgoz) and in highly turbulent waterfalls (i.e., at Karpuzkaldiran).

On the Antalya tufa terraces five levels of tufa have been identified (Nossin 1989). Four of them lie on the continent and the fifth lies below sea level at a depth down to -90 m. The present geomorphology of the Antalya Tufa is the result of both erosional and depositional processes. Spur-like landforms combined with depressions at the top form as a result of sedimentation in pools hanging on a slope. In the mature stages these pools tend to join together and large planar areas appear, as at Masadagi. With the further enlargement of these sedimentary basins, a lacustrine environment forms. On planar areas streams flow in braided and meandering beds causing fluvial deposition. These streams also caused the formation of marshy areas resulting in paludal deposition in small pools. Fluvial and paludal environments are together the main sources of the planar appearance of tufa. Cascade deposition creates cliffs through vertical deposition; however, most of the coastal cliffs are the result of coastal erosion.

The rocks of Antalya's coastal cliffs occur in a wide range, from collapsible soil to hard rock. Sedimentary structures of frequently changing sedimentary environments, variation in lithology due to depositional and post-depositional changes and cavities of primary and karstic origin, result in differences in resistance to erosion.

4. Distribution of the caves

Distribution of the caves is shown in Figure 6. It is obvious that caves are concentrated at the east and the west part of the cliffs, while at the central parts of the cliffs are covered with rock blocks. One reason for this may be that cave forming mechanisms are more pronounced at the east and the west. Otherwise, because caves were detected by means of visual inspection and water chemistry measurements, caves may not be detected where the cliffs are covered with rock blocks.

Figure 6. Distribution of the caves on the Antalya cliffs.

5. Classification of the caves

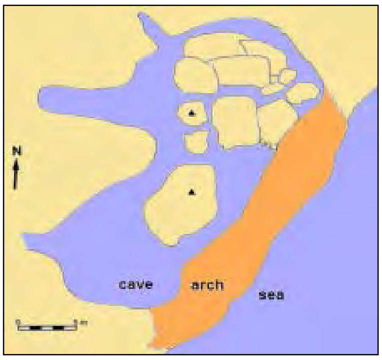
5.1. Sea Caves

Sea caves forms primarily by the wave action of the sea. In order to form a sea cave by erosion, the host rock must first contain a weak zones and a driving force (wave action) should be available. In Antalya cliffs most sea caves are small and consist of a single passage or chamber in relation to other cave types. The biggest sea cave in Antalya cliffs is shown in Figure 7. Structural and lithologic weaknesses caused upward propagation of the cave.

5.2. Tufa Caves

Tufa Caves are primary caves formed during the precipitation of the tufa itself. The formation of caves starts with rim of a cascade. Along the rim, the water of the pond falls down, as the water deposits tufa at the rim, the rim grows outward. When it is not stable enough to carry its own weight, it breaks down and forms rock falls in front of the rim. The cave is complete, when the extent of the rim touches to the ground (Figure 5). As the process continues, several parallel caves may be formed. Large cascades may cause to formation of large tufa caves (Figure 8-10).

A



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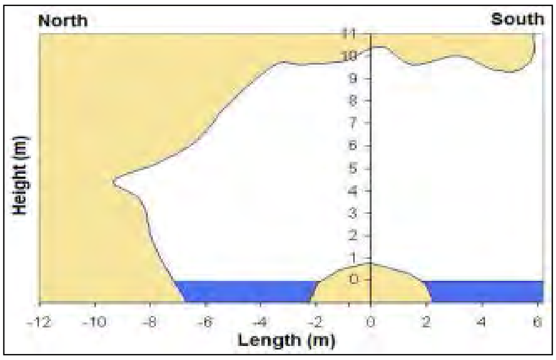

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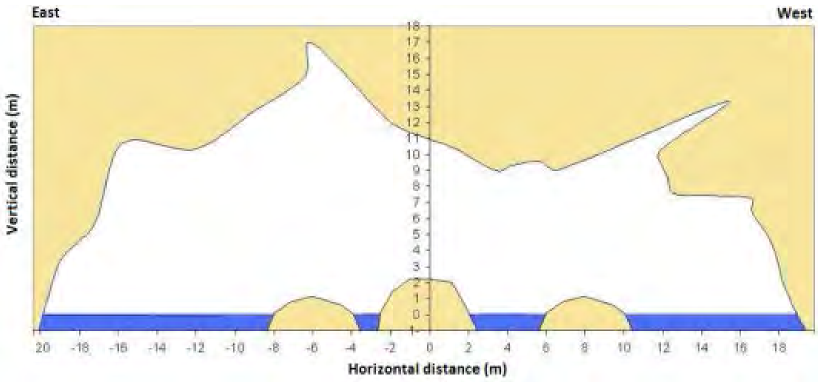
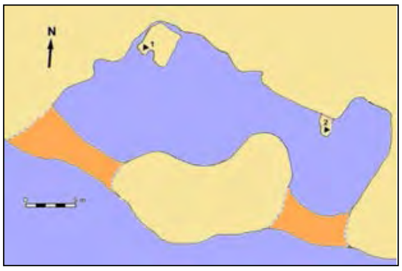


D

Figure 7. A sea cave which was formed due to wave effects and rock weakness; (A) panoramic view, (B) plan view, (C) cross-section (N-S), (D) cross-section (E-W).

Figure 8. A cave formed by tufa cascade.

A



B

C

Figure 9. A big tufa cave; (A) inside view, (B) plan view, (C) outside view.

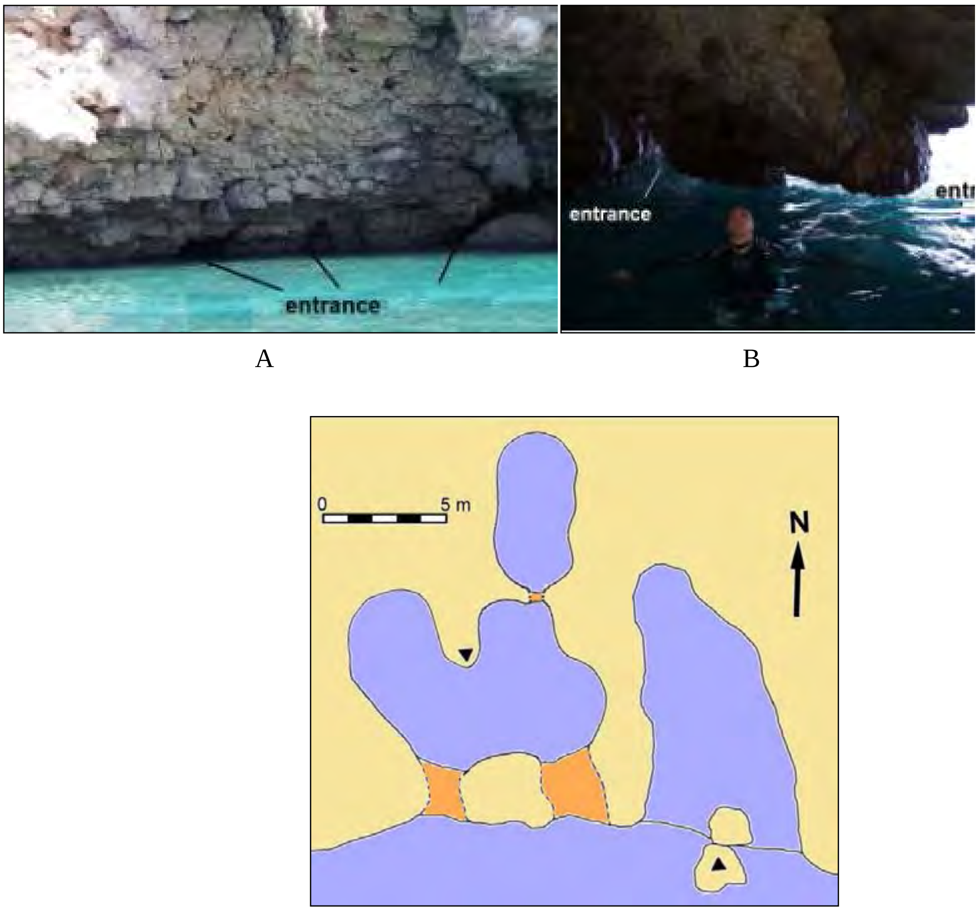


Figure 10. A cave network formed due to cascade tufa deposition; (A) three entrance of the cave, (B) view from inside, (C) plan view.

1.1. Flank Margin Caves

The horizontal and subhorizontal dissolution caves found in the Antalya cliffs are of interest to geologists and geomorphologists because they have developed in continental part of the cliff with small openings to the sea. If not collapsed due to low rock tensile strength, the ceilings of these caves are very close to the sea level, generally not more than 2 meters. Another common feature of Antalya flank margin caves is that the caves are connected to the sea with small openings (Figure 11 and 13). Inside the cave, the main chamber is large and reaches up to 40 meters. Height of the chambers can reach to 20 meters due to ceiling rock failures (Figure 11d and 12d). Similarly, fully submerged caves have big inner chambers with small entrances (Figure 14).

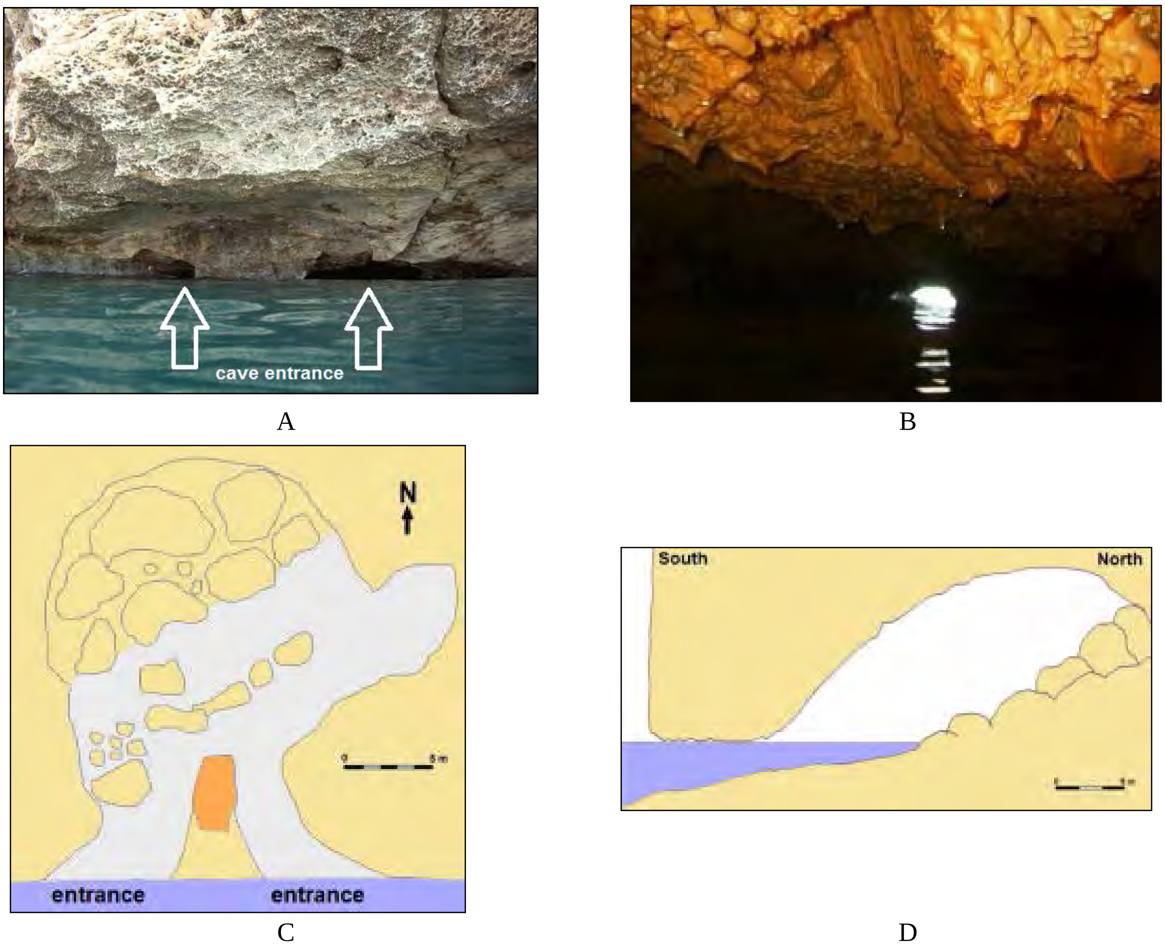


Figure 11. Entrance of a flank margin cave from the sea (A). View of entrance from inside (B). Plan view (C) and cross section (D) of the cave.

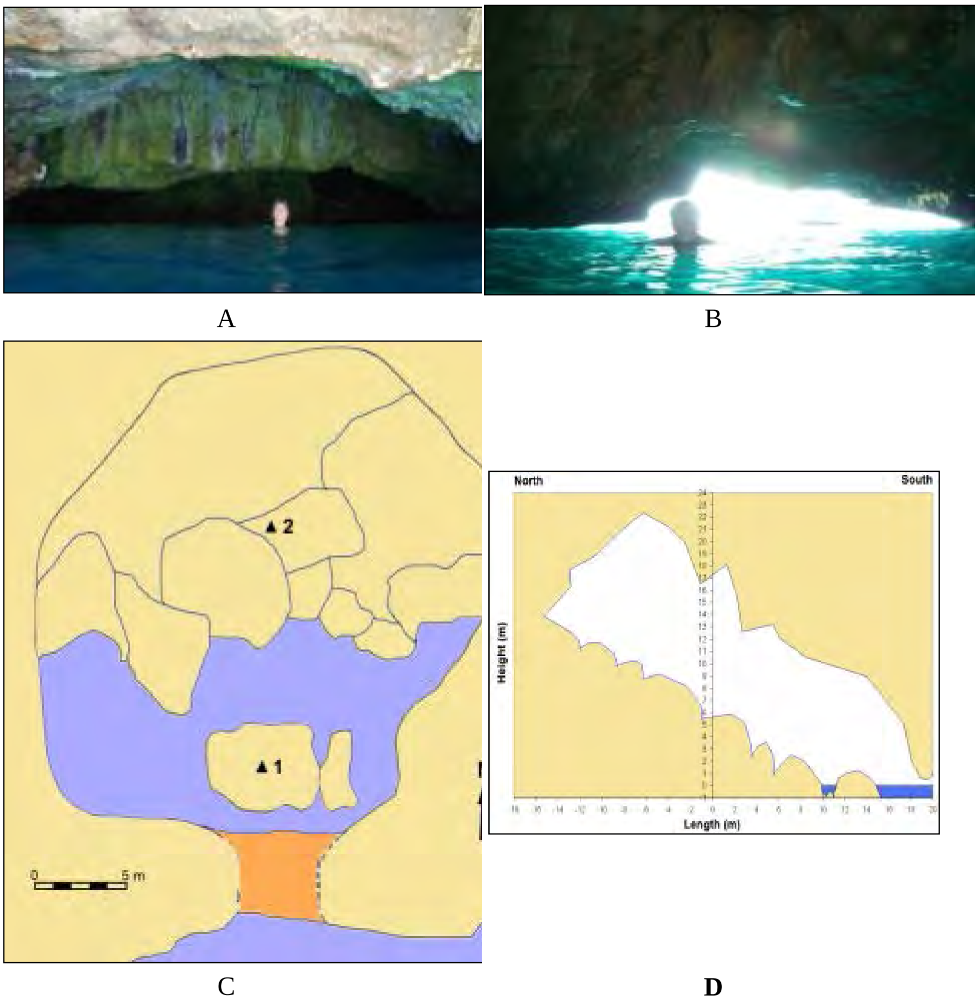


Figure 12. Entrance of a flank margin cave from the sea (A). View of entrance from inside (B). Plan view (C) and cross section (D) of the cave.

A

B

C

D

Figure 13. Small entrances of horizontal cave networks (A and C), inside view of horizontal caves (B and D).

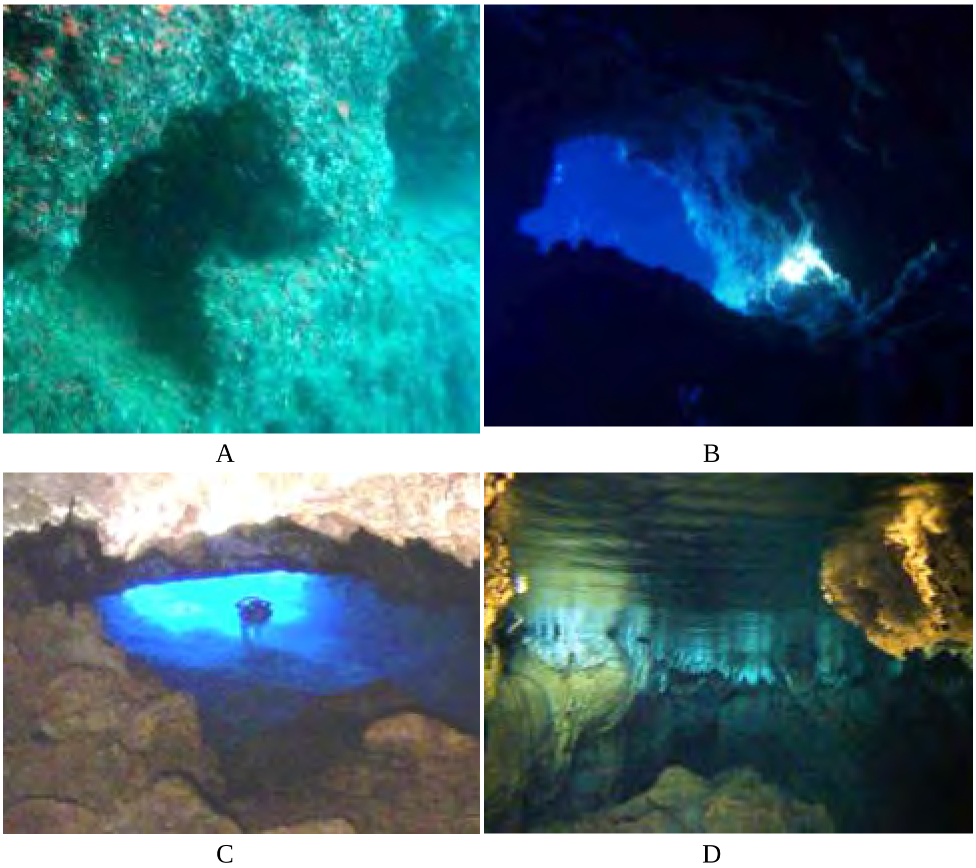


Figure 14. Entrance of a fully submerged caves (A-C), Undersea photograph of a cave (D)

Entrances of the caves are generally located between the sea level and 5 m below the sea level. In the caves which have entrance at the sea level, bottom of the caves are also around 5 m. Most of the cliffs plunge down to 5 meters depth, then topography turns into gentle slope. In the soil profile of Bogacay Plain, which is neighboring unit of the Antalya tufa at west, there exist a sandplain at 4-5 m below sea level, which imply that there was a eustatic highstand at that depth (Dipova 2010). This may mean that flank margin cave formation had started at that time.

Water chemistry measurements were carried out to decide the origin of a cave. On the flank margin caves where mixing corrosion is active, pH and salinity values are important clues. On the below Figure mixing process around 0.3-0.5 m is obvious. On the other hand, where mixing is not valid, water chemistry values are the same as the sea water (Figure 15).

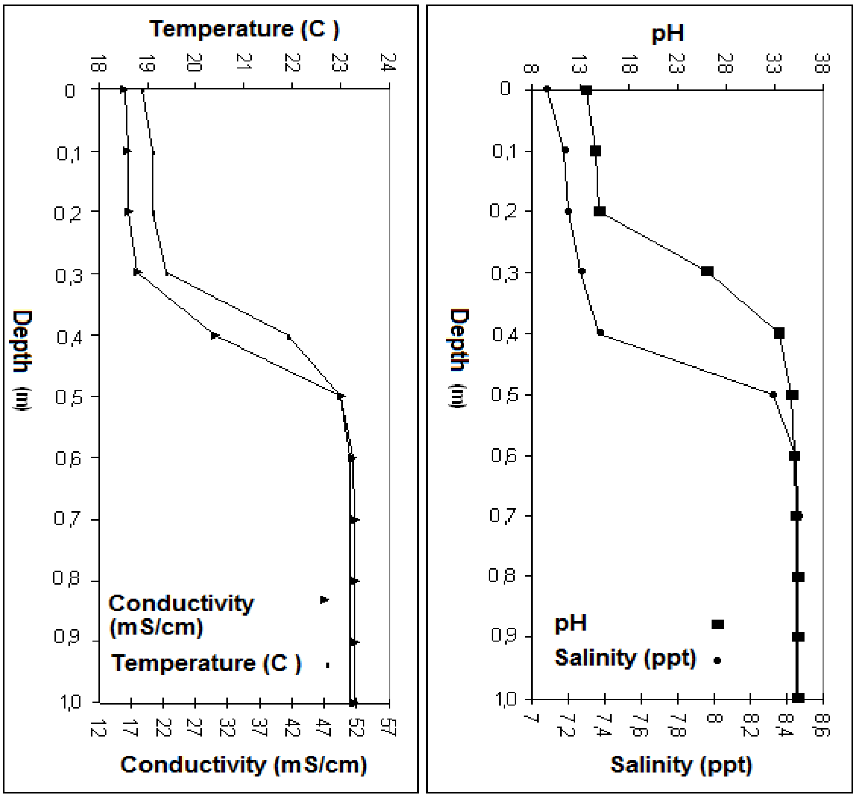


Figure 15. Water chemistry measurement at the entrance of a flank margin cave.

2. Conclusion

The caves observed on the Antalya cliffs are of three origin; 1) Sea caves which forms as a result of physical effects of waves and due to rock weaknesses, 2) Flank margin caves which forms due to mixing corrosion, 3) Tufa caves which are open spaces remained behind vertical tufa deposition. Tufa and flank margin caves may be enlarged due to physical erosion and roof failures. Similarly, sea caves or flank margin caves may be exposed to primary depositional processes such as flowstone and stalactite formation.

Sea caves form by erosional processes acting from the outside the cliffs. Sea cave development is effected by rock resistance and structural differences (e.g. faults and intrusions) in the host rock. Subaerial erosion and related cliff retreat progressively removes sea caves. Tufa Caves are formed during the vertical tufa precipitation. Along the rim of a cascade, as the water deposits tufa at the rim, the rim grows outward. When the extent of the rim touches to the ground, tufa caves are complete behind the tufa curtain. Occurrence of both sea caves and tufa caves are limited to cliff face, and these are very susceptible to extinction due to cliff retreat.

Flank margin caves are dissolutional features that form within the tufa by mixing corrosion, as horizontal sea level chambers. Mixing corrosion is a process which results in dissolution of calcium carbonate when groundwater and saline sea water mixes. Continuing corrosion may lead to enlargement and join of small chambers to form horizontal cavity network. Because the tufa has a weak and blocky rock mass, roof failures may result in formation of big caves.

Bioerosion and bioconstruction on tufa substrate has effects on cave and notch formation. However, these effects are not much as coral reefs to result in extensive rock formation and not as much as extensive notch formation alone. On Antalya tufa cliffs bioeroder and bioconstructer organisms are living, however their effects are negligible as compared to other mechanisms.

Biologically, caves and notches provide substrates to a variety of life forms of different characteristics. The composition of the environment defines the resident living creatures. Especially notches are the area that are most covered by life forms. The characteristic living creatures of the area that gets wet with the spattering water are *Patella* sp. individuals. They act as a rasp on the substrate and flattens the surface. The characteristic living creatures of the area that falls under the waves are Corallina sp. Jania sp. They cover the surface as a carpet and form a layer of CaCO3. This hard layer formed by Corallina sp. And Jania sp. protects the surface against the effects of waves. Among them there are Modius sp. that forms a tough shell on rocks and Balanus sp. individuals. They cause bio-erosion through the burrows that they make on the surface to hang on. As a result, biogenesis and bioerosion on this zone are the two process that are ongoing in parallel and at the same time. Corallina sp., Amphiroa sp., Hydrolithon sp., Galaxaura sp. and Jania sp. individuals are scattered through the first 2-3 meters from surface. Coverage percentage can reach up to 70-80% on some locations. Inside and on cave mouths Haliptilon sp., Lithophyllum sp., Mesophyllum sp. and palmophyllum sp. individuals are the dominant population. They cover the surface and form a thick layer. In and on the entrance of caves and on notches Lithopaga sp. individuals have been encountered frequently. With burrows of 6-7cm length to nest on the surface they are the most significant cause for the bioerosion. They can be found up to 100 in 1 square meter.

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ORIGIN AND MORPHOLOGICAL PROPERTIES OF ANTALYA (SW TURKEY) COASTAL CLIFFS

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1. Introduction

Antalya city is located on the Mediterranean coasts of SW Turkey. The coastal cliffs of Antalya are composed of tufa type rocks. Following the establishment of historical Attelia, during the Roman, Byzantine, Ottoman and early Republican periods, the areas close to the tufa cliffs in Antalya were used for the construction of defense buildings, lighthouses and residential buildings. After the 1980's as tourism activity has grown, these tufa cliffs have increasingly become the sites for houses and hotels, with the attendant risks.

Tufas are defined as the product of calcium carbonate precipitation under an ambient water temperature regime that typically contains the remains of microphtyes and macrophytes, invertebrates, and bacteria (Ford and Pedley 1996). The Antalya tufa which is the largest known tufa deposit in the world (Pentecost 1995), cover an area of over 630 km^2 and reach up to 270 m in thickness. Antalya tufa is composed of terraces and gentle slopes decreasing in elevation to east through the Aksu Valley and to the sea to the south. Although eight levels of tufa were identified by Burger (1990), it seems more appropriate to group them into five (Nossin 1989). Four of them, the Döşemealtı, Varsak, Düden, and Arapsuyu plateaus, are terrestrial; the fifth is submarine, and occurs at a depth of 90 m below sea level. Glover and Robertson (1998) relate the origin of the Antalya tufa to the Miocene-Pliocene evolution of the Aksu Basin. During the Late Miocene-Early Pliocene, the structure of the Aksu Basin was influenced by right-lateral strike-slip faults, which exploited pre-existing structural weaknesses. These weaknesses resulted from interaction between the uplifting and extruding Anatolian plateau and extensional western Turkey and the Aegean. The Pliocene sediments drape a block-faulted topography that opened to the south as an asymmetrical graben. During the Late Pliocene-Early Pleistocene, the Aksu Basin formed as a half-graben system in response to a combination of N-S and NE-SW (i.e., orthogonal) extensional faulting, while the adjacent Tauride Mountains were progressively uplifted. Antalya tufa deposits accumulated in the basin opened as a result of the half-graben system, during the pre-glacial period, after extensional faulting had largely ceased within the main Aksu Basin (Glover and Robertson 1998). The source of the carbonate for the tufa deposition in this basin is the Kırkgöz springs. These springs drain from Jurassic-Cretaceous karstic limestones (Beydağları).

The geomorphological units of the Antalya Tufa and its locations are shown on Figure 1. The earth processes which lead to the formation of the present geomorphology of the Antalya tufa including; terraces, gorges, caves, depressions, embayments and coastal cliffs have long been debated by earth scientists (Penck 1918; Planhol 1956;

Burger 1990; Darkot and Erinc 1951; Glover and Robertson 2003). In this paper, origin and morphological properties of Antalya tufa cliffs will be presented in three subsections: constructional processes, erosional processes and failure processes.

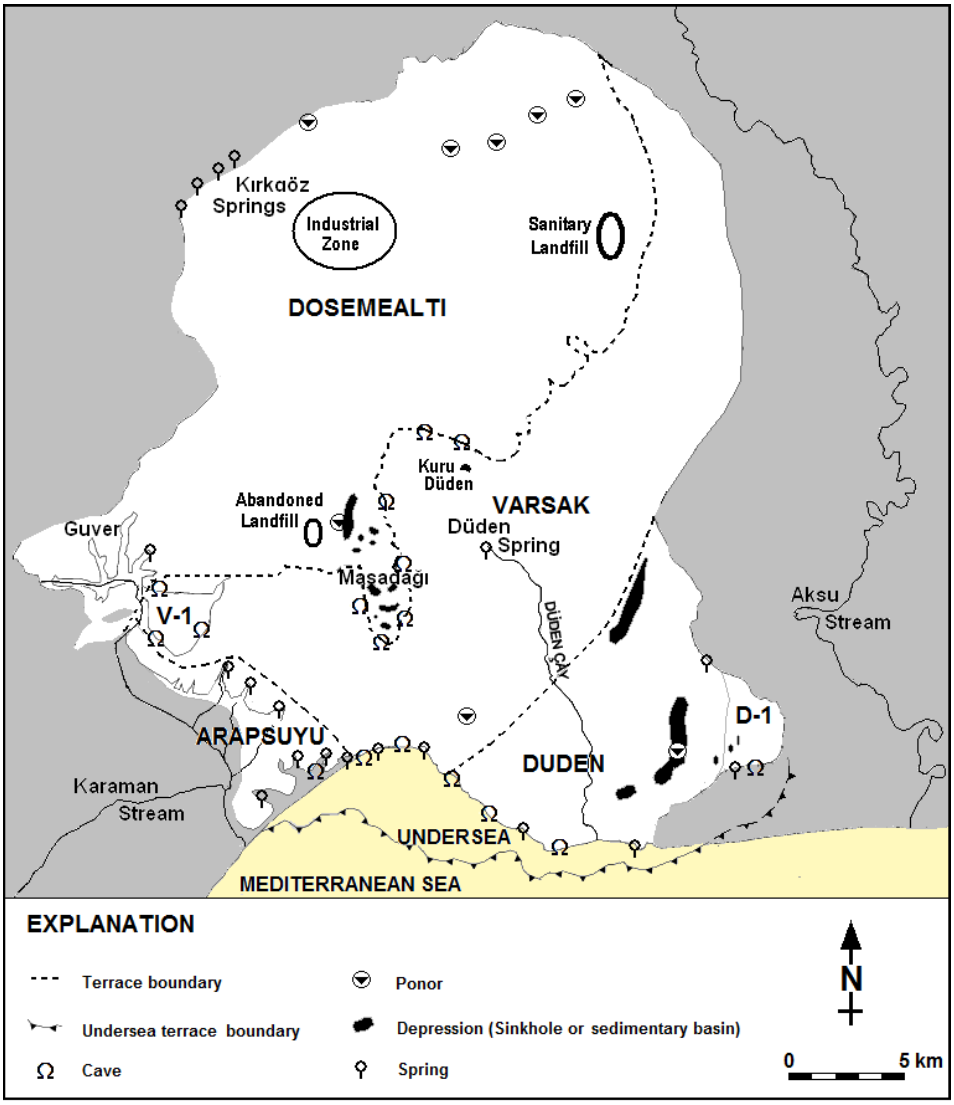
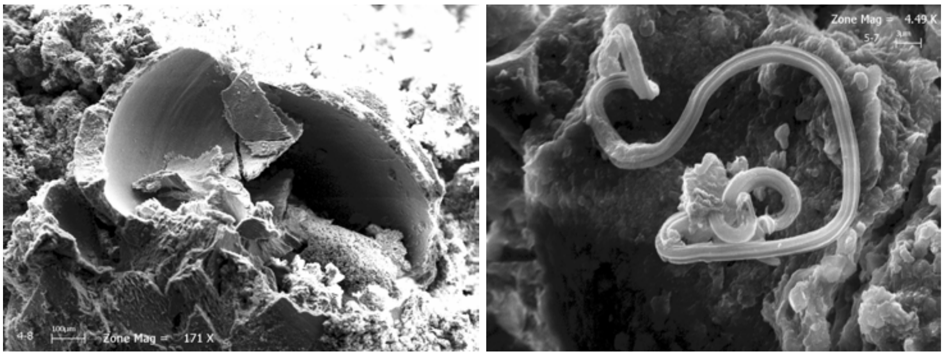


Figure 1. Geomorphological units map of the Antalya tufa area (The sources of material in this map are 1:25000 topographical map of 1934, Bathymetry map, aerial photographs of 1982, satellite images, Burger (1990) and the field work of the author).

2. Constructional Processess

In the Kirkgoz Springs and the Düden River, modern tufa precipitation is visible as overgrowths on/around mosses. The mosses thus appear to stimulate calcite precipitation by intake of carbon dioxide for photosynthesis. Calcite, which crystallizes around mosses, makes a mould of their form. This precipitation is a dynamic process wherein the lower part is progressively covered, while growth at the apex proceeds. Around Duden Stream, in small pools of paludal-environmental character, present-day calcite precipitation can be observed. Algae or bacteria are abundant in these pools. Daylight photosynthesis of blue-green algae results in net removal of CO_2 from the water during the day. In the most recent precipitates taken from the surface, traces of biogenic remains can be observed (Figure 2).



A B

Figure 2. SEM view of tufa samples showing the biological remains.

Most of the tufa in the Antalya basin consists of horizontally-bedded sediments. This fact implies that the dominant depositional environment was lacustrine. However, a perched springline system played an important role as a point of origin. The perched springline system itself includes paludal and lacustrine aspects. Generation of the terraced morphology was completed after the closure of the pools by sedimentation from the paludal/lacustrine systems. The fluvial systems are the final process to shape the extensive planar appearance. After reaching a higher elevation, a cascade system developed where the water flowed downward. In a braided-river environment, paludal/lacustrine environments also developed as secondary aspects. In the following account the depositional environments of Antalya Tufa are given in detail, based on Pedley (1990).

Perched springline and slope environments might be the initiating mechanism of the Antalya tufa. Calcium carbonate may precipitate immediately around the spring outlet, and this turns the spring into a raised, fan-shaped mound. The top of each mound is almost flat and contains paludal pools restricted by massive phytohermal rims. When waters pass over the rim, the water velocity and turbulence are high, resulting in thin layers of tufa which develop at a high rate. However, in the pools, slow precipitation – mostly of a biogenic origin – occur in a sluggish regime. Burger (1990) termed these pools “travertine basins”.

Cascade environment is a high-energy environment where water flows turbulently from cliffs. Curtains of moss build out from the fall rim and become covered by steeply inclined sheets of carbonate derived from carbonate-rich water that flows from the cliff (Pedley 1990). Tufa curtains develop as hanging bodies on the rim. Blind caves often develop behind the tufa curtain, and curtain-like stalactites may grow there. At the coastal cliffs of the Düden Plateau, cascade deposits and fallen blocks in the sea are visible along a length of 4 km.

Fluvial environment is characterized by thick, braided, cyanolith-dominated deposits (Pedley 1990). However, in the Antalya tufa, minor volumes of fluvial-system deposits are observed. These sediments – of a meandering-river origin – are observed as thin lenses; cross-bedding is widespread. Laterally extensive fluvial system deposits are observed on the Düden Plateau. On this plateau the upper 5-7 m thick weakly cemented tufa layer is partly paludal and partly fluvial. The clast types in fluvial deposits are dominantly lithoclasts, phytoclasts, and lumps of sparry and microcrystalline calcite (Figure 3a).

Lacustrine environment refers to large bodies of deep water, however, as a tufa depositional environment this term is used for elliptical open lakes that do not dry for long periods. As water flows over the barriers, stromatolites grow up on the barrage. Mammilated stromatolites reflect a nearshore, shallow, calm to wavy environment (Figure 3b). Pisoliths of the Antalya tufa formed in the open spaces among these stromatolites.

A B

Figure 3. (A) Intraclasts of fluvial environment, (B) Boundstone stromatolitic tufa.

Paludal environment is similar to the lacustrine model, but the pools generally are not open and water levels are low. Spring-fed waters seep sluggishly through the bryophyte carpet and between hummocks, leaving behind a surface tufa coating on all the vegetation (Pedley 1990). At present, paludal deposition is negligible because of land drainage and river-bed improvement for urban development. At the beginning of 20th century on the Düden Plateau, there were many living paludal environments. Today, along the Düden River, microdetrital-calcite precipitation closely related to living cyanobacteria can be observed in small pools. The bottle in Figure 4a is recent (a maximum of 5 years old). The carbonate crust on the surface of the bottle reach a thickness of 1.5 mm. The thickness of the crust is almost uniform all over the surface. Tufa formation on the inner surface of the bottle implies precipitation is related to the mosses attached all over the inner and outer surface (Figure 4b).

A B

Figure 4. (A) A section of tufa cover on the bottle, (B) Interior view of the bottle and the tufa layer covering the inner surface of the bottle.

1.1. Post-Depositional Modifications

As post depositional modification cementation and diagenesis are important factors for the final appearance of tufa deposits. After the precipitation or deposition of grains, meteoric cementation and diagenesis begins in the vadose zone. Recent sediment samples, taken from a depth of 4-6 m show only thin meniscus cements concentrated at grain contacts. In phreatic zone sediments or in sediments in which water seepage is available, sparry-calcite cement develops at grain contacts and possibly as void fillings. In figure 5, pictures taken from trenches in Antalya tufa, post depositional modifications through cementation and diagenesis are shown.

A B

Figure 5. Cementation and diagenesis. Cementation as patches (A) and Void fill between phytoherm tufa (B).

Considering the fact that the dominant depositional environments in Antalya are paludal and shallow lacustrine and sedimentation takes places in meteoric-vadose environments, the Bermuda Model (Land *et al.* 1967) was adapted to tufa. The model presented below is a modification of the Bermuda Model in respect to the meteoric-vadose cementation and diagenesis of Antalya tufa (Dipova and Doyuran 2006). The first stage is the initial sediment, consisting of allochthonous grains and grains of micritic or sparry calcite which are directly precipitated. The second stage involves the precipitation of low-Mg calcite on the surfaces of the grains. The cement is generally asymmetric, or located at grain contacts as meniscus cement. Bacteria and algae remain undisturbed between the cemented grains at this early stage. The third stage involves the loss of Mg from high-Mg calcite, leaving a sediment of low-Mg calcite. The fourth stage is the main diagenetic event of the dissolution of fine crystals and the reprecipitation of $CaCO_3$ as drusy sparry calcite. The main feature of this dissolution-reprecipitation process is a loss of the internal structure in the former grains. Reprecipitated sparry calcite is observed as patches in a fine micritic matrix. Aggrading neomorphism is typical in this stage as is calcitization and the replacement of skeletal grains or pseudospar formation. The last stage involves further precipitation of calcite to fill remaining voids. In some tufas of a limestone appearance, this final stage rarely produces a fully-cemented rock.

2. Erosional Processess

Erosional processes that shape Antalya tufa can be studied under the titles of surficial erosional processes, karstification, groundwater erosion and coastal erosion.

2.1. Surface Erosion

On the margins of tufa terraces some creeks and deep gorges develop. These are thought to develop due to stream bed erosion due to high surface gradient and a seasonal high hydraulic gradient of flowing water. On the coastal cliffs the deepest creek is Kadinyari Creek which is 14 m deep with a maximum width of 7 m. The gradient of 30 m hight cliffs and the high velocity of storm water superpose there. On the submarine continuation of the tufa, a deep creek was detected on the bathymetry map, which implies a similar mechanism occurred before the Holocene sea level rise. Guver gorge is the biggest on the Antalya tufa having a depth of 115 m. There are several other gorges neighboring to Guver. This area is effected y a high gradient drainage system. The Karaman stream and its two tributaries having a high hydraulic gradient has resulted in a large amount of stream bed erosion.

Land surface lowering as a result of surface dissolution processes is another erosion mechanism. The percolation of undersaturated water or acidic rain water through carbonate rock may cause dissolution. This kind of dissolution causes channels or furrows on massive carbonate rock surfaces. Termed karren, these channels vary in depth from a few millimeters to more than a meter and are separated by ridges. In Antalya tufa, karrens can be seen on massive rocks, however on the other kinds of tufa which bear primary structures, erosion is observed as thinning concentrated around the weak parts.

2.2. Karst Prosesses

The development of karstic features such as: sinkholes, caverns and burried channels, are the direct result of chemical dissolution with help of the erosive action of acidic water. Most ***caves***, excluding ones of primary origin, are formed through this chemical dissolution process, a result of groundwater circulation. On the phreatic zone, dissolution begins along fracture systems or weak zones of tufa. Widening of the dissolution chambers and its connection to other fractures from a cave, or cave system. In figure 6, one of the caves found during a foundation excavation is shown. Most caves are thought to form near the water table, related to mixing dissolution. Some collapse sinkhole development is also due to this mechanism, as in the Duden karst window.

Figure 6. Entrance of a cave in the city center.

The term ***sinkhole*** (doline is a synonym) indicates any depression in the topographical surface, is used for depressions which don't show polje property. To define a sinkhole in more detail, an adjective was added indicating a peculiar attribute and conforming to Ford and Williams (1989) classification. Some sinkholes in Antalya are thought to form when the roofs of caves collapsed and are termed "collapse sinkhole". However, some are formed at the surface through dissolving the rock beneath, termed a "dissolution sinkhole".

The largest of the ***Collapse sinkholes*** is the Kuru Duden (Figure 7) at Varsak (termed a "karst window"). Similar sinkholes can be seen on the coastal cliffs (these are explained in the coastal erosion section). These kinds of caves caused by sinkhole formation followed by roof collapse, are the result of mixing dissolution around the groundwater table. The aggressiveness of the new water formed after the mixing of vadose and phreatic waters rise and caves at the GW table are formed. This causes the formation of widespread caves which can join together. Further enlargement of caves results in roof collapse.

Dissolution sinkholes can grow on a primary depositional depression such as tufa pools. Glover and Robertson (2003) interpreted the depressions of Masadağı as karst-related sinkholes (Figure 7). These were previously defined by Burger (1990) as depositional pools termed "tufa basins". In this paper these depressions are thought to be dissolution sinkholes developed upon former depositional pools. The karstic features observed in the depressions are of secondary origin and the elongate appearance of these depressions is related to the interlinked pool system. The bedding in the pools is seen to dip inwards around the edge, however in cross-section the bedding planes are concave related to biogenic precipitation. Burger (1990) identified a large depression at an altitude of 40 m and east of the present airport area as ***polje***. The elevation difference between the bottom and the surroundings reach 15 m, the length is 2 km and the width 1 km. There are also several small depressions of 100-150 m width. Moreover another large depression near Duacı at 280 m altitude, which is 700 m long and filled today with 7 m of terra rossa, was also identified as a paleopolje. A third similar one is detected in this study at the south of the Duden-Varsak terrace boundary. All these depressions are thought to be formed as dissolution drawdown on a previous sedimentary basin.

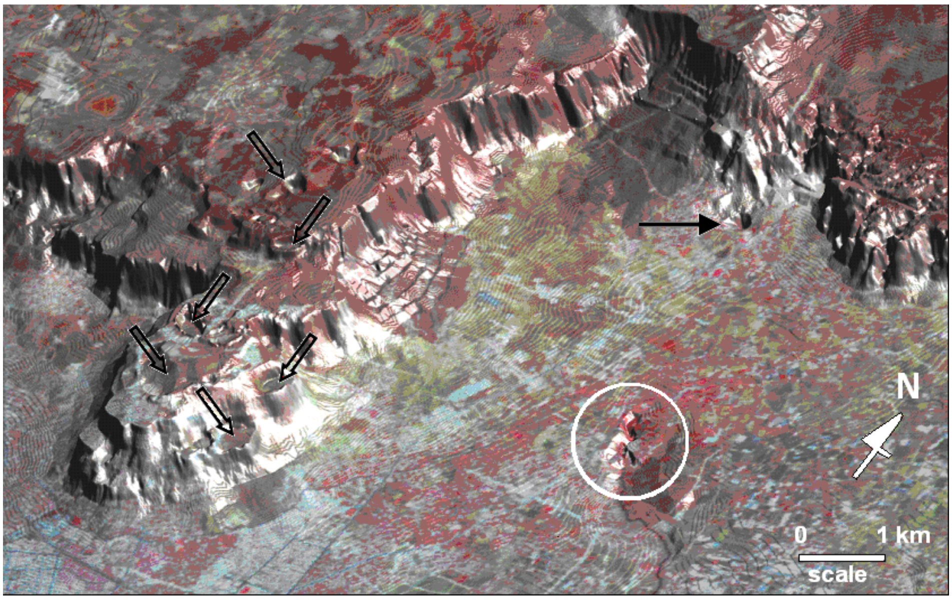


Figure 7. 3D elevation model covered by a satellite image showing; dissolution sinkholes developed on previous depositional basins (arrows), spring head erosion where the Duden stream emerges (white circle), and the Kuru Duden collapse sinkhole (solid black arrow).

2.3. Groundwater Erosion

Groundwater erosion can be realized through two processes. ***Seepage erosion*** occurs through the dragging induced by seeping water in granular materials and the enlargement of pores by applying shear stresses to their perimeters in cohesive materials and unsaturated granular soils. ***Groundwater sapping*** is another process in which rock is weathered and eroded when groundwater emerges from a porous medium. This leads to the erosion of the basal support and the failure of the overlying rock (Dunne 1990). Sapping processes produce step sided channels that migrate headward and results in theater-like heads that lack well-developed tributaries (Laity and Malin 1985). These two mechanisms was adopted to the Antalya tufa; seepage erosion can erode clastic, weakly cemented and soil-like units and, through groundwater sapping, hard and diagenetic rock tufa was eroded.

During groundwater sapping, karst processes contribute to erosion by means of dissolution. At the south-west margin of the Antalya tufa there are many embayments. These embayments are bordered by tufa cliffs and base of the embayments are around groundwater level. Burger (1990) called these embayments “karst marginal planes” and their formation was explained by the corrosive action of carbondioxide rich wet and vegetated soil. On the side walls of these embayments many small springs emerge (Figure 1). The discharge rate of these small springs was reported in Karaguzel *et al.* (1999) as between 0.19 to 2.50 m^3/sn. In Antalya Tufa the maximum discharge is 20.04 m^3/sn at the Duden spring, resulting in a spring cave and sapping erosion (Figure 7).

2.4. Coastal Erosion

On the carbonate rocky shores, erosive processes, including the chemical action mixing zone water, the mechanical action of waves, degradation via salt crystallization and biological degradation, all play roles. A long debate has raged about the relative contribution of the erosional processes (e.g. Trudgill 1976; Moses and Smith 1994). However it seems too detailed for this study. The final morphology of a cliff depends on rock properties (lithology, stratification, height etc.) and represents the relative contributions of the marine erosion mechanisms and also terrestrial erosion mechanisms. In the following section, the erosion mechanisms observed in Antalya tufa coasts are explained.

Wave erosion erodes coasts through both wave abrasion and through purely hydraulic wave action. However in Antalya almost no abrasion platform or beach is observed. Wave force may be sufficient to break up of fragments from weakly cemented layers or weak rocks. However for massive (sound) rock layers, waves serve secondary duty for other erosion mechanisms, rather than purely hydraulic action. Focke (1978) explain this role with amount of wave amplitude which causes turbulence. As turbulence increase organic accretions and salt water surf increases. These subjects will be explained in the following sections.

Salt erosion effects can be observed on the sides of concrete electricity pylons, on steel parapets as well as on tufa rocks. Coastal cliffs are subject to salt water inundation and exposed to a range of wetting and drying regimes. Antalya’s Mediterranean climate with long dry seasons and a high level of storms provide the ideal conditions for salt crystallization to occur. The transport of salt water into the pores is possible from the sea water spray of waves and capillary rise. Wind and sun serve as the agent for the drying and crystallization of the salt. One of the distinguishing features of salt erosion is salt pot, which is previously formed small pot later deepened by salt erosion. The other features, sharp piny leaching marks, are easily distinguished from marks left by boring micro-organisms.

Solution in mixing zones is another mechanism which results in erosion and thus in erosional landforms. Plummer (1975) demonstrated that the mixing of sea water with fresh calcium bicarbonate groundwater can result in calcite undersaturation in mixtures, even though both solutions may be saturated or supersaturated with calcite prior to mixing. Solution effects on carbonate rocks are prominent where fresh groundwater mixes with sea water on the shore. The mixing of phreatic and vadose zone groundwaters of differing chemical character can achieve a similar effect (Palmer 1990).

There are collapse sinkholes located 20-50 m behind the coastal cliffs. On old maps and aerial photos more sinkholes can be seen, however due to infilling and landscaping, today they are visible only in front of Lighthouse and in Ataturk Park where there are several sinkholes side by side. In addition to sinkholes there are many caves around sea level and behind the cliffs. Some coastal landforms are thought to be formed by this mechanism. Alagoz (1973) claimed that ancient harbor (today's yacht harbor) is a former collapse sinkhole which was opened to sea after marine erosion. There are many springs draining into the harbor which support this idea. On the cliffs behind the harbor some failures had occurred as toppling failure. Boreholes drilled during site investigation to explain these failures, showed there are voids around groundwater level, the porosity of rocks are increasing and the rocks tend to be more brittle (Ercan *et al.* 1985).

Bio-erosion plays roles through both physical and chemical processes. Scrapers (fish, echinoids and gastropods) range from the subtidal zone to high-water level, the endolithie algae (algae, bacteria and other microorganisms) on which they graze are limited to the intertidal and supratidal zones. The intertidal zone, where scrapers interact with algae, serve the most suitable part in the development of notches. Organisms that may be able to dissolve calcium carbonate by means of acidic body fluids include certain algae, bacteria, barnacles, fungi, pelecypods, and worms. Such erosion may be especially effective where intertidal browsers scrape the rock surface and drive the solutional borers deeper (Neumann I966; Hutchings 1986; Spencer 1992). Observations suggest that even though intertidal organisms make an important contribution to the development of notches, bio-erosion alone does not account for all coastal undercuts. Moreover encrusting organisms are also abundant on the cliffs at sea level (Figure 8).

1. Failure Processes

Recognition of the instability mechanism is essential in assessing the extent of the hazard. Failures of the tufa cliffs in Antalya commonly involve: rock fall, cavity collapse, raveling, the washout of weakly lithified tufa, shear failure (slide), secondary toppling and complex failures including more than one of these failure modes. The geo-mechanical properties of the tufa forming the cliffs may be a factor in controlling instabilities. The complexity of geology in the cliff face, the degree of weathering, the presence or absence of dissolution structures and the terra-rossa deposits on the cliff top are all factors which should be considered.

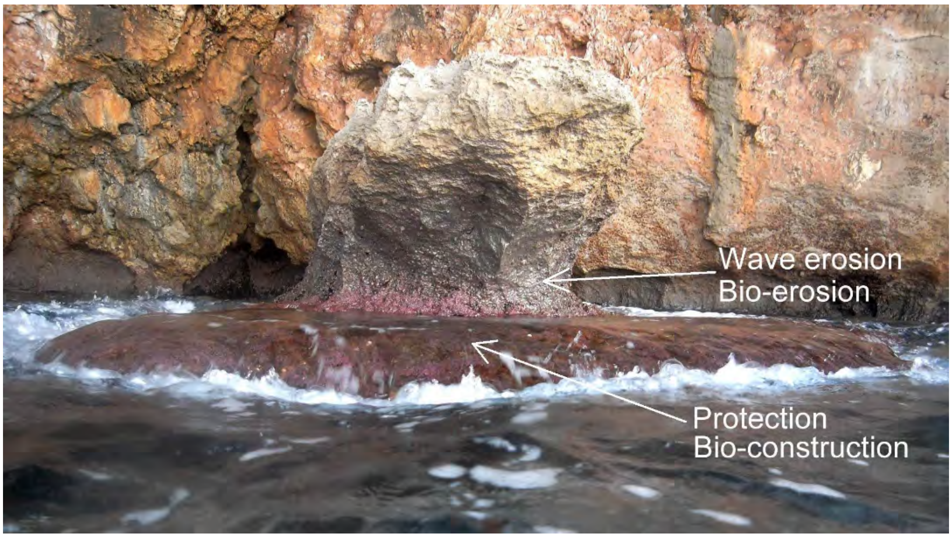
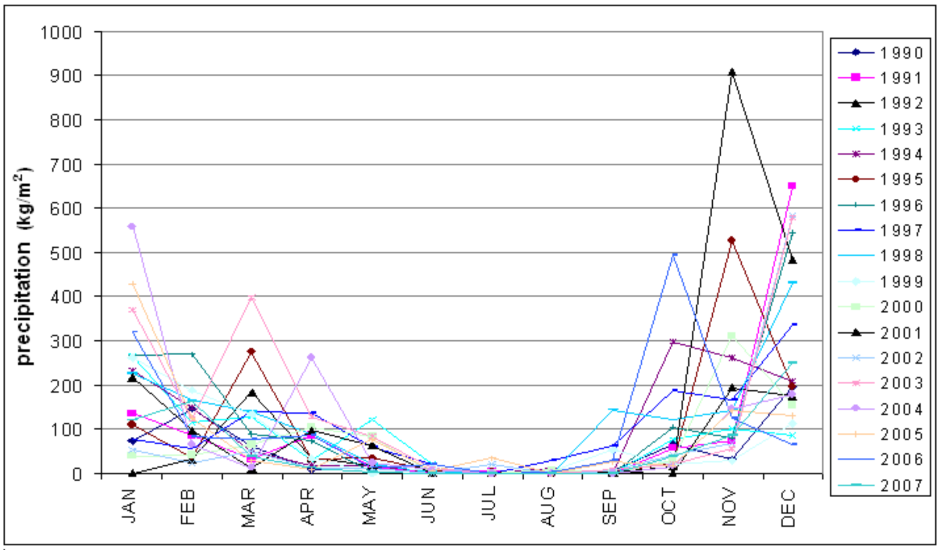


Figure 8. Bio-erosion and bio-construction.

Heavy rainfall may cause the saturation of pores, thereby increasing pore water pressures and total mass. Because an increase in water content reduces the strength of rocks, heavy rainfall is often the triggering mechanism in cliff failures. Antalya has a Mediterranean climate and after a dry summer a heavy rainfall comes during November and December (Figure 9A). The observation made during November-December 2001 highlights the role of the water content in the unsaturated zone on tufa cliff instability. This exceptionally wet winter illustrated the scale of failures that can occur, not only on the cliffs, but also on deep excavations in residential areas. During 2001 Antalya received 1892 kg/m^2 precipitation, which is the second highest amount recorded during the previous one hundred years, below the 1969 total of 1914 kg/m^2. Figure 9B shows the November, December and the annual precipitation data. 1390 kg/m^2 of precipitation, 74% of the annual total precipitation occurred during the months of November and December. In just the month of November 2001, there was 907 kg/m^2 of precipitation, the monthly peak value during the last hundred years. Major cliff collapses at Karpuzkaldiran and Bambus show a close relationship to rainfall data from Antalya. These failures occurred in the first week of December 2001, when the rocks reached maximum saturation.



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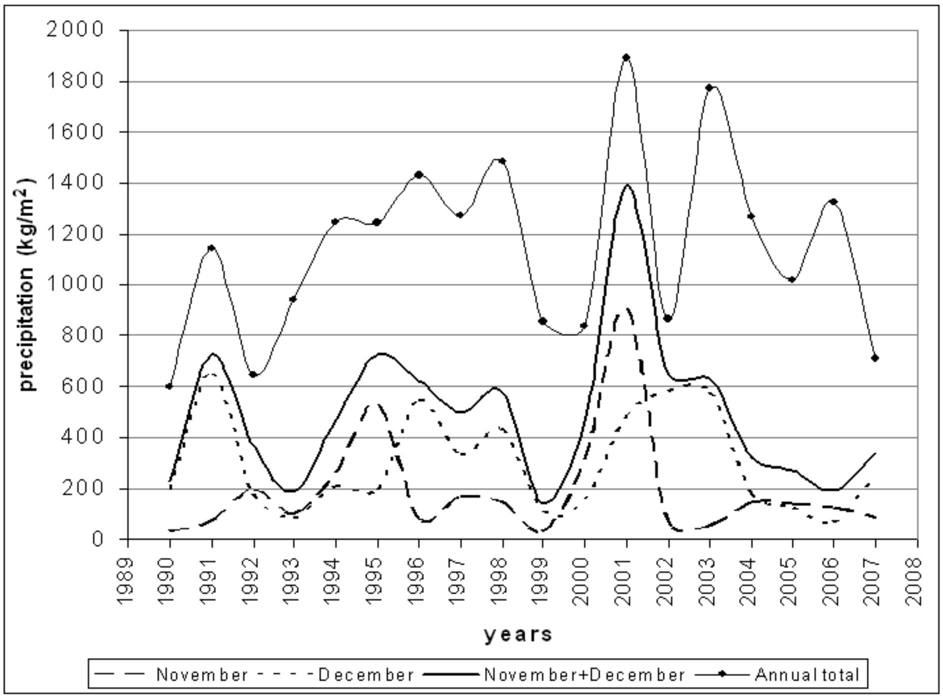


B

Figure 9. A) Antalya's monthly average precipitation data of 17 years between 1990 and 2007, B) Antalya's annual total and some wet seasons precipitation data.

The modes of instability observed in Antalya's cliffs are explained in the following sections.

1.1. Cave/Porosity Collapse

On the coastal cliffs of Antalya many caves and voids have been recorded. Most of these are described as flank margin caves because they are formed in the mixing zone. Although both phreatic and vadose groundwater are generally at or near to equilibrium in respect to $CaCO_3$, their mixture can become undersaturated (Bögli 1964). The dissolution potential may be further increased by descending acidic vadose water (Mylroie and Carew 1997). This results in the formation of voids at the top of the lens (Harris *et al.* 1995). With further upward growth, cave may collapse completely or can join to other karstic features such as solution pipes and caves (Figure 10). In figure 11 collapse sinkholes and caves, located 20-50 m from the cliffs, are shown. A small cove in front of the biggest collapse is thought to be a former cave collapse. Some caves are located below sea-level with a maximum depth of 2-3 meters. Along water level, chambers of different dimensions constitute a cave network. Some sea-level caves are connected to the surface through a cave network. Some of them find the opportunity to grow upwards along jointed or weak zones and reach the surface through a window (Figure 12). Recently no cave collapses have been recorded, however this mechanism presents a significant risk.

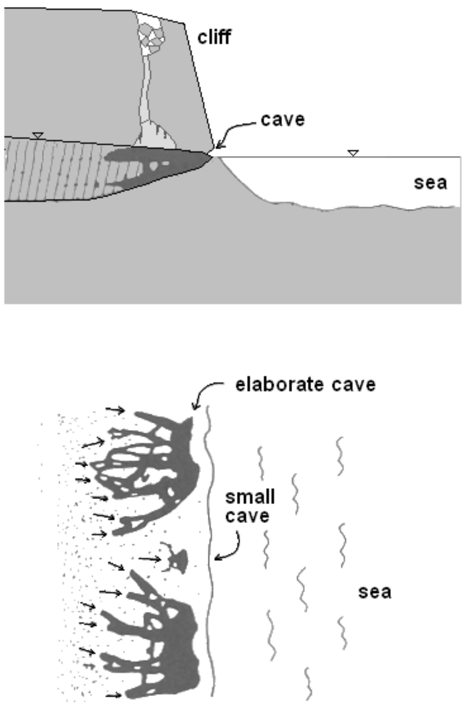


Figure 10. Porosity and cave development due to mixing dissolution, and collapse or join with other karstic features upon upward propagation (Adapted to Antalya tufa from Mylroie and Carew 1990)

Figure 11. Cave and cave collapse features of the tufa coastline.

Figure 12. Upward growth of a water level cave along jointed zone resulting in block fall into the cave and opening to the surface by a window.

1.2. Raveling

Raveling is defined as particle-by-particle or block-by-block gradual erosion, observed generally in poorly cemented conglomerates and breccias, in very highly fractured hard rocks and in thinly layered rock masses (Goodman and Kieffer 2000). Notch development is prevented in thin layered or weak tufa, because the retreat at the face is faster than at the base. A small amount of carving results in the forward movement of the thin layers and the fall of the blocks. Once the first blocks collapse from the lower layers, there is very little support for the layers above and, when gravitational force of the layers is higher than the indirect tensile strength of the layers, or the layer is jointed, the blocks can readily fall from the cliff face. This mechanism results in the retreat of the coastal cliff, without any evident notch development (Figure 13).

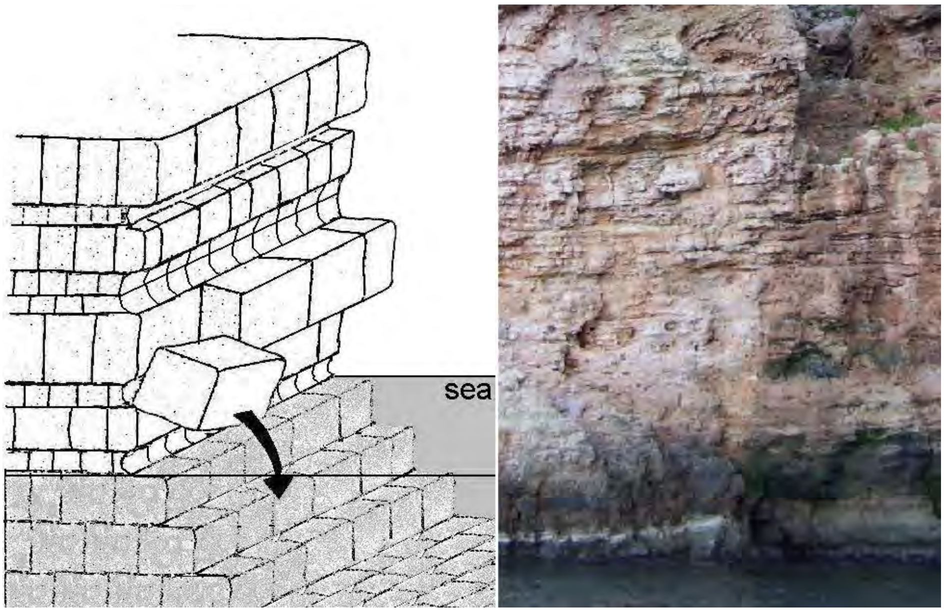


Figure 13. Raveling as particle-by-particle or block-by-block gradual erosion.

1.3. Washout Of Weakly Lithified Tufa

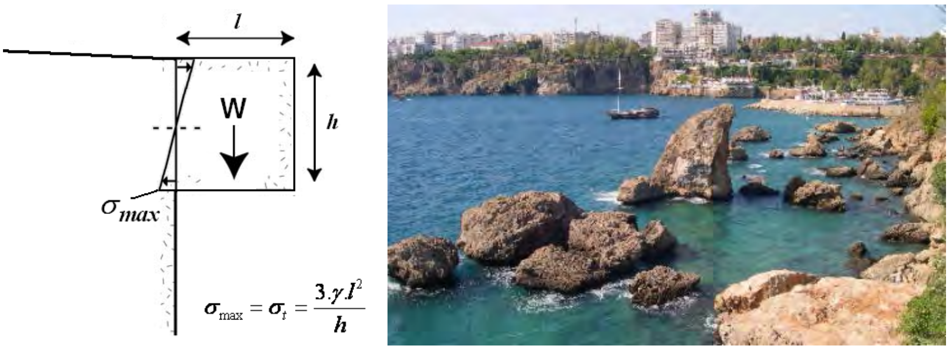
Washout of Weakly Lithified Tufa is the carrying away of granular material by rain water action. Tufas from paludal and fluvial depositional environments are weakly cemented. Upon saturation this weak cementation can be loosened and became sediment (Figure 14). After loosing cohesion, particles and blocks can easily be moved down through surface runoff and this may cause the undermining of stairs constructed on the cliff face or result in hard tufa cantilevers left on the cliff face. Analytical modeling of this kind of failure is almost impossible, especially for heterogeneous tufa.

A B

Figure 14. Wash out of weakly lithified tufa, B) Close up view of white rectangle shown in A).

1.4. Rock Fall

Rock Fall means here the natural downward motion of free blocks with free falling, bouncing, rolling, and sliding. Rock blocks may be freed due to structural discontinuities or other erosion or failure modes. Weathering, the ravelling of blocks, the wash-out of weak materials often undercut the base of rock blocks and form cantilever blocks hanging on the cliff face. Within progressive differential erosion, originally weak zones of overhanging rock bodies deepen and enlarge to form failure planes and when gravitational forces exceed the strength of the rock mass, the hanging rock body begins to freely fall. A solution to the block fall process can be achieved by modeling cliff protrusions as a simple cantilever (Kogure *et al.* 2006). A protruding two-dimensional cantilever block, illustrated in Figure 15A, may detach and fall from the cliff if the tensile stress at the top equals the tensile strength. The cantilever model is useful for conceptualizing the block-fall process, however structurally weak rock mass are hard to model. Fallen blocks can be seen below some sections of the cliffs (Figure 15B).



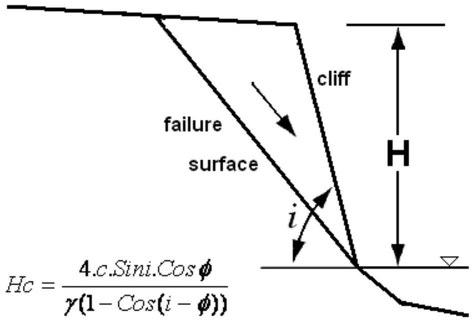
A B

Figure 15. Rock fall. A) Cantilever beam model, (h: Block height; l: Block length; σ_t : Tensile strength; σ_{max}: Maximum tensile stress; and γ: Unit weight.) B) Fallen blocks along the coast.

1.5. Shear Failure

Shear failure is experienced on weak and soft tufa units. A defining feature of weak rocks is the reduction of cohesion through increased water content. During high rainfall the water content of the rock increases. Rock masses, which are stable in the dry season, may fail under a high level of saturation. In figure 16A the clean back scar of the failure surface can be clearly seen. The occurrence of this kind of failure, that involves the entire cliff height, can be examined through the Culmann method (Figure 16B). Due to heterogeneity the failure surface may not be purely planar and failed block generally breaks into pieces after collapse. Another shear failure is seen, combined with notch or porosity collapse at the bottom (Figure 16C-D). This kind of failure is slow rather than collapse.

A



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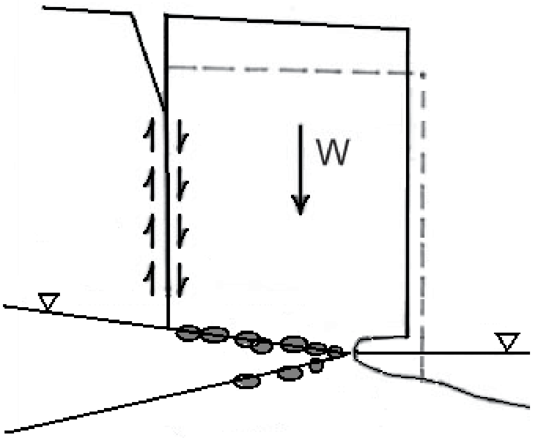

D

Figure 16. A-B) Cullman type shear failure, (Hc: Critical cliff height; C: Cohesion along the failure surface; i: Cliff inclination; ϕ: Internal friction angle; and γ: Unit weight.) C) Shear failure combined with cavity collapse, D) Voids forming in the margin of the fresh-water lens may promote collapse.

1.6. Secondary Toppling

Goodman and Bray (1976) have defined secondary toppling as a failure initiated by some undercutting, which occur due to erosion or weathering agents. A main primary failure (such as shear failure or crush) is essential before toppling of the rock blocks. Conforming to this definition topplings observed in Antalya tufa, were classified as secondary toppling. The undermining of, or cavity development at the cliff base and stress release, cause high stress at the top of the cliff. When this stress exceeds the tensile strength of the rock mass tensile cracks develop at the top of the cliff. In this way a prismatic rock block occurs between the crack and the sea. As erosion at the bottom of the cliff continues, the forces that cause the block to topple are increasing. As toppling proceeds, the rock block topples into the sea. In the rainy season, the reduced strength of the rock and high pore water pressure may contribute to the secondary toppling mechanism.

Along the cliff-line many previously toppled blocks can be seen (Figure 17A). Figure 17B-C show toppling of cliffs after heavy rainfall just after the failure (note that terra-rossa cover still remains on the tufa block). The surfaces at the back of failures are not iron stained and said not to be open to weathering agents down to the base of the rock. The contribution of rainfall should reduce the shear and tensile strength of the rock mass. Shear strain is greater around the toe of the cliff. Small shear displacements in the lower part of the slope generate tensile forces at the upper part increasing tensile stress. When tensile stress exceeds the tensile strength of the rock mass which is reduced due to saturation, tensile cracks begin to open. Tensile cracks propagate down to a depth where the cracks coincide with the potential failure line which corresponds to Rankine's active state (Figure 17D). Rock blocks topple through the sea instantaneously, after the failure.

Without the full toppling of the blocks, slow or instantaneous forward movement of the blocks can also cause instability (Figure 18A-B). During long stationary periods, apertures between the blocks can be filled with blocks and soil. In a long rainy season, water pressure behind the block causes it to tilt (Figure 18C). In December 2001, roads on the cliff tops around Lara, were cracked along three lines (Figure 18D). The maximum aperture was 40 cm and downward movement was around 15 cm. Local shear failures were observed on the cliff face. The cliff rocks moved towards the sea causing the deformation of structures constructed on the cliff face. The cliffs did not fail but some permanent residual tilt occurred.

1.7. Rate of Erosion and Retreat

The rate of erosion of the cliff rocks is controlled by the force of waves at the base of cliffs, the mechanical strength of the rock masses, the properties of discontinuities, the reduction in rock strength due to weathering, the reduction in rock strength due to saturation, rock mass removal and rock material fatigue caused by the cyclic loading of the wave impact. Regarding only the wave action Sunamura (1992) related the distance eroded in the rock to the wave force, to the rock mass resistance and to time. This approach is imprecise for several reasons, particularly because of the depositional character and the consequent variation of physical properties throughout the cliffs and differential weathering. Moreover, this approach doesn’t include bio-erosion, seepage and strength reduction due to saturation and weathering.

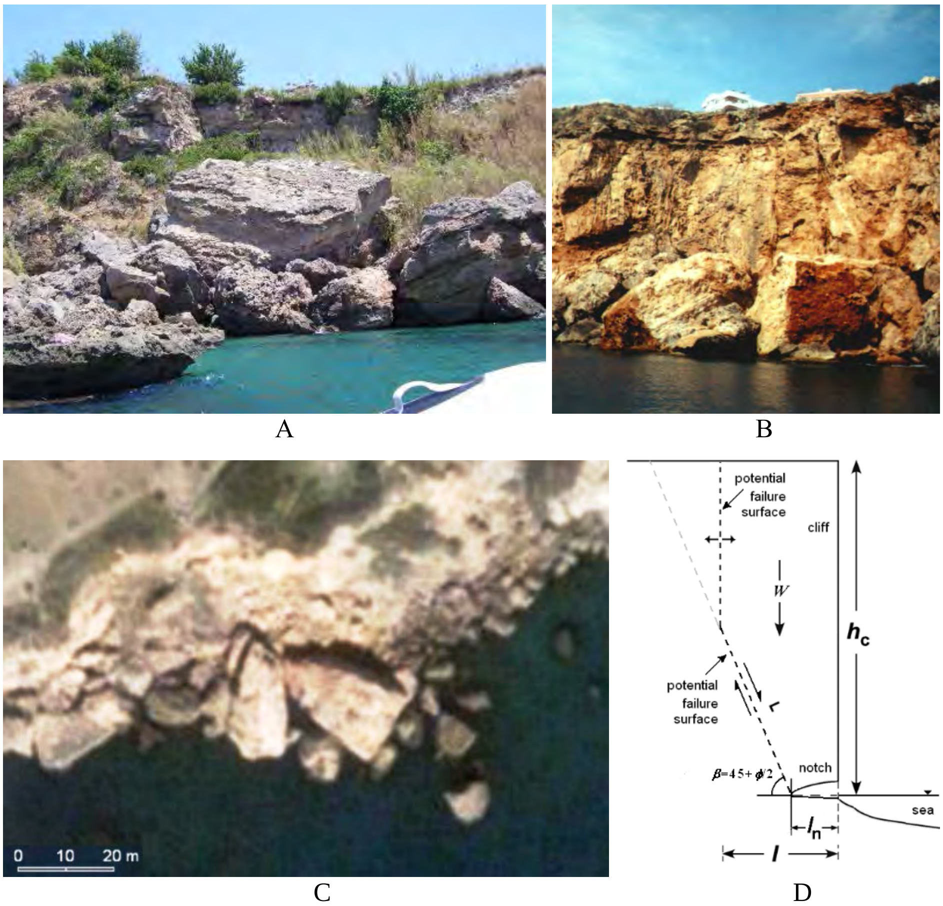

Figure 17. A) Old block toppling failure, B) Toppling of tufa blocks after heavy rain in December 2001, C) Block heights reach almost the full height of the cliffs, D) Analytical model for block toppling failure (hc: Cliff height; W: Weight of the block; l: Block length; ln: Notch length; L: Length of the failure surface; ϕ: Internal friction angle).

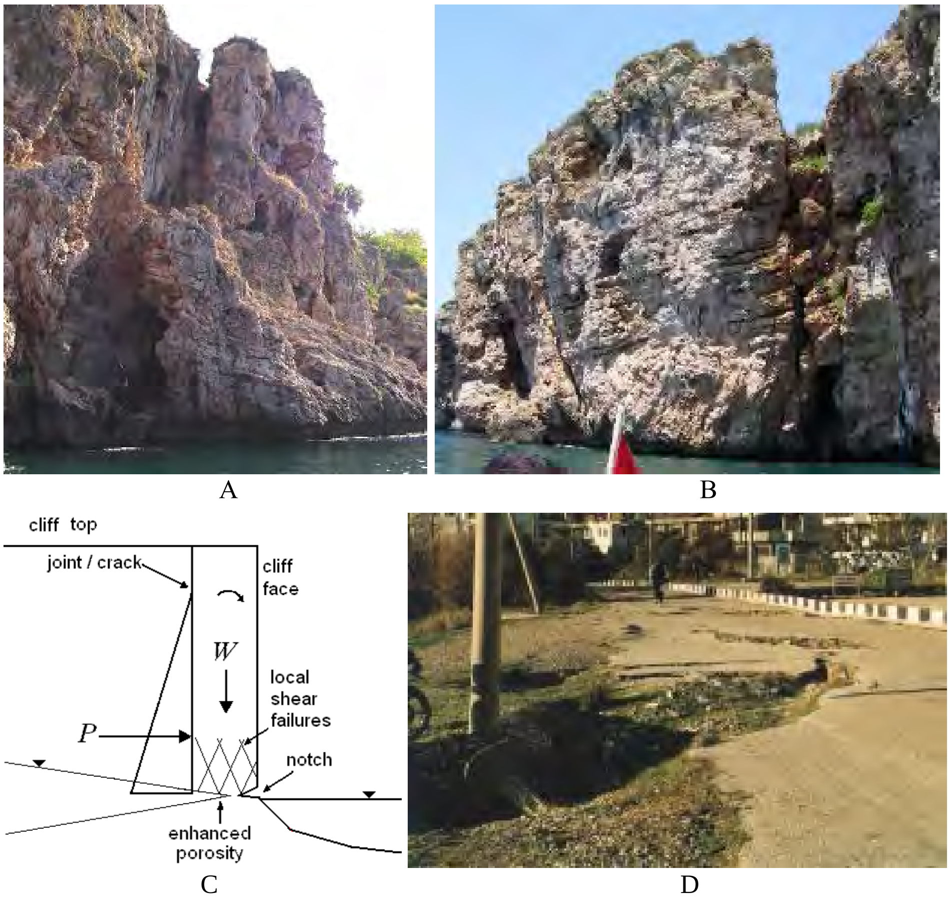

Figure 18. A-B) Tilted blocks on the cliff, C) Permanent residual tilt as a result of water pressure, D) Tilt of blocks and deformations on the cliff top after heavy and long duration rainfall.

Some other attempts have been made to determine the rate of coastal cliff retreat. Mean erosion rates for a long period of time may be determined using aerial photographs (Moore 2000). The more accurate measurement of the retreat rate may be obtained by terrestrial laser scan techniques (Rosser *et al.* 2005). These may be supported by measurements of the actual retreat around clearly dated historical structures.

Below the Antalya cliffs, except for two small pocket beaches of 40-50 m long, no beach exist and optical and terrestrial laser scanning is not possible. Comparison, between valid aerial photographs or photographic maps of different dates, doesn’t show considerable retreat. We know little about local cliff history. However, what we know is that there has been little or no retreat for 2000 years. Two historical harbors on tufa area: Attelia (150 B.C.) (Figure 19A-B) and Magydos (200 B.C.) (Figure 19C) have remained in their original positions. The Roman Hidirlik mausoleum has been in place on the cliff top for 1800 years (Figure 19D). The Roman defensive walls erected in front of the

Hidirlik mausoleum were stable before their demolition in the 1930's. So the erosion rate of Antalya tufa cliffs is said to be very slow. Retreat is valid on a geological timescale however, on an engineering timescale these cliffs are subjected to instabilities and to local failures causing local retreats.

A B C D

Figure 19. A) Historical Port of Attelia (today the marina), B) Seljuk-Ottoman walls and Hidirlik castle in 1930's, C) Port of Magydus, D) Hidirlik mausoleum (Roman) in 2000's.

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BACTERIOPLANKTON, CYANOBACTERIA, PHYTOPLANKTON

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The eastern Mediterranean is one of the well known basins of low productivity among the world's seas due to limited nutrient supply to its sunlit surface layer from external and internal sources. In the Levantine basin of the eastern Mediterranean, as well as in other areas of the Mediterranean shelf zones are often much limited in extent. The only locations with a wide shelf are the Cilician Basin in the northeast corner, and the coastal part of the Nile Cone in the south. Both areas are typical Regions of Freshwater Influence (ROFI) where riverine inputs combined with shallow topography create buoyancy currents that often spread along the shelf and lead to increased productivity. Perennial rivers Göksu, Lamas, Tarsus, Seyhan, Ceyhan and Asi plus some smaller rivers draining an area of 80,000 km^2 connected to the Cilician Basin account for a total fresh water flux of 27 km^3/yr (870 m^3/s), accounting for about half the river discharge along the Turkish Mediterranean - Aegean coasts, but much greater than the present discharge of the Nile in the eastern Mediterranean (estimated to be 540 m^3/s, Pinardi *et al.* 2005). In the nutrient poor eastern Mediterranean, these river inputs are extremely significant regional sources. Especially following the almost 90% reduction in the discharge of the River Nile in the 1960's, Turkish rivers concentrated in the Cilician Basin presently seem to be the main fresh water and nutrient sources for the entire Levantine Basin of the oligotrophic eastern Mediterranean. The concentrations of nutrients and primary production are relatively high in the northeastern shelf area as a result of land based sources. Although limited in amount, the supply of nutrients from various heterogenous sources, drainage outlets and fresh water from a few rivers partially meet the demand for phosphorus and support relatively high rates of primary production near the coast, in contrast with the deeper parts. Consequently, a sharp contrast develops between the coastal area supplied by land-based nutrient sources and the nutrient limited open sea. Niches of greatly varying properties occur along the coast as a result of this heterogenous distribution of sources. Coastal / open sea interactions and the interaction with the atmosphere determine the changes in this highly variable and sensitive coastal ecosystem, and its response to eutrophication processes. The prominent cyclonic circulation as well as accompanying diverse features like eddies, meanders etc., determine the fate and transport of dissolved and particulate substances in the eastern Mediterranean

The Cilician Basin coastal system is presently experiencing significant environmental stresses as a result of explosive increases in population, industrial, agricultural and tourism activities. Wastes from various industries (steel, paper, fertilizer etc.,) and untreated or primary-treated municipal wastes from major towns of Mersin, Adana, İskenderun and Antakya are potential sources of marine pollution. Civilian and military marine transport linked to the harbours of Mersin, İskenderun and Taşucu, oil storage and pipeline terminals at Yumurtalık, Ceyhan and Dörtyol (including the recently completed Baku-Tbilisi-Ceyhan pipeline transporting oil and gas from the Caspian Sea) are additional activities with potential impact on the environment. In addition, the coastal ecosystems of the easternmost part of the basin itself has suffered greatly from major changes in the drainage systems, such as the construction of the Aswan High Dam in the upper Nile. Following construction, terrestrial nutrient input to the receiving Mediterranean waters was reduced significantly and resulted in a relatively less fertile, more saline, oligotrophic water system. Shortage of nutrients first diminished phytoplankton productivity, and hence the zooplankton as the second step in the marine food chain. Similar threats were also observed from the northern Levantine basin. Dramatic increase in human population, intense marine traffic to/from Mersin and Iskenderun harbours, pollutants of industrial and domestic origin, and agricultural and atmospheric loads make the ecosystem of the region extremely vulnerable to the imposed environmental burdens. The most predominant anthropogenic impact is the elevated eutrophication phenomenon being experienced in Iskenderun and Mersin Bays in parallel to increase in human population at coastal and Çukurova plain area for more than 3-4 decades. Eutrophication is considered to play a key role in the ecosystem by leading to substantial alterations in the structure and function of marine flora and fauna both qualitatively and quantitatively. Recent studies have shown alarming expansion of eutrophication northwards toward offshore and westwards along the shelf. Compared to the Black Sea, the region may be regarded as one of the least studied extreme environments. Recent studies indicate that changes are occuring intensely in the northern Levantine basin at different trophic levels (Gücü *et al.* 1992, 1994; Uysal and Mutlu 1993; Gücü and Bingel 1995; Kideys and Gücü 1995). Introduction of extraneous species represents anthropogenic effects through Lessepsian migration from the Red Sea. The presence of new species being introduced into the Levantine basin points out that their invasion and acclimatisation in this region is intensive at present which requires further monitoring studies.

The picoplanktonic fraction of marine planktonic communities consists of both phototrophic and heterotrophic organisms. They generally dominate the 0.2 to 2.0 μm size class of marine plankton in terms of abundance and biomass. Heterotrophic bacteria are a large and active part of the marine ecosystem and are the main agents making some of the extensive dissolved organic carbon pool available to the rest of the food web via bacterivorous organisms, particularly flagellates. They are also important remineralizers and solubilizers of particulate matter (Pomeroy 1974; Azam and Hodson 1977; Sieburth *et al.* 1978; Smith *et al.* 1992; Azam 1998) and are, therefore, an important component of investigations of oceanic carbon and nitrogen flow. In oligotrophic waters bacteria often consumes up to half of the primary production via dissolved organic matter and in turn are consumed by grazers.

To date only few studies have been carried out on heterotrophic bacteria and coccoid cyanobacterium *Synechococcus* in Turkish seas. Monthly abundance and biomass distribution of heterotrophic bacteria was first described at three stations in Cilician basin shelf waters over a period of one year (Uysal *et al.* 2004). This then followed by a similar study conducted monthly at two stations in the same area (Bayındırlı 2007) and seasonally at a transect in highly eutrophic Mersin bay (Gazihan-Akoğlu 2011). Bacterial populations of Turkish coastal waters have been studied more extensively during the basinwide cruises of R/V Bilim-2 of IMS-METU to Levantine basin (Uysal *et al.* 2008; 2014) and to Turkish seas within the scope of EU funded integrated SESAME (Southern European Seas: Assessing and Modelling Ecosystem Changes) and PERSEUS (Policy-oriented marine Environmental Research in the Southern EUropean Seas) projects (Gazihan-Akoğlu *et al.* 2010).

Picoplankton (including heterotrophic bacteria and cyanobacteria) content and dynamics of the Cilician Basin shelf waters have been studied at three stations (nearshore, middle, offshore stations with total depths of 20, 110 and 210m, respectively) offshore Erdemli at monthly intervals (Figures 1-3) over a period of one year (Uysal *et al.* 2004).

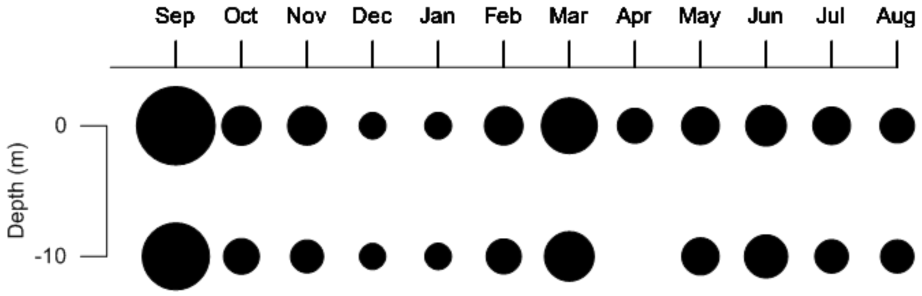

Figure 1. Monthly changes in heterotrophic bacterial abundances at nearshore station (min-max values at $5.85x10^5 – 4.06x10^6$ cells/ml).

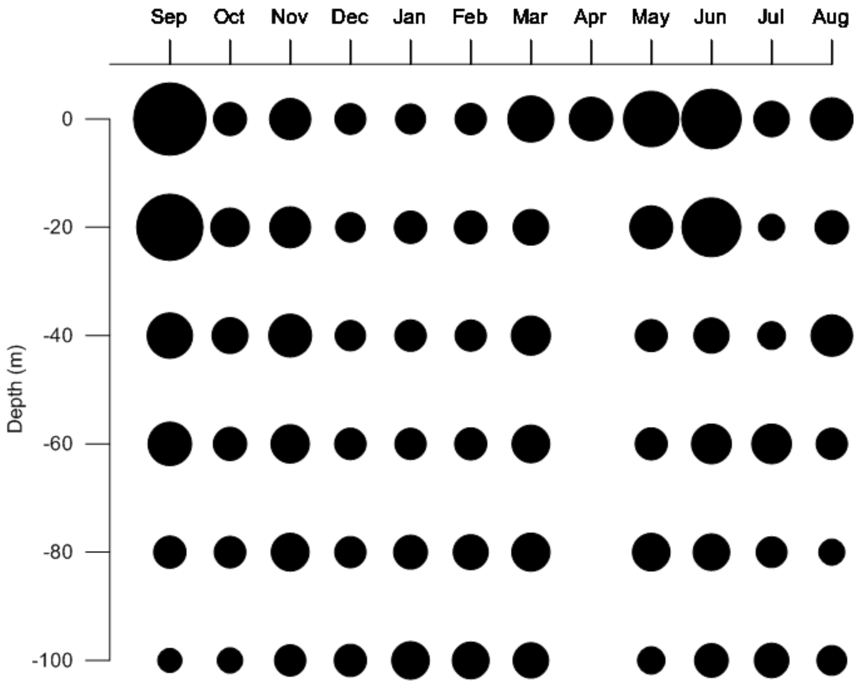

Figure 2. Monthly changes in heterotrophic bacterial abundances at middle station (min-max values at $4.3x10^5 – 1.78x10^6$ cells/ml).

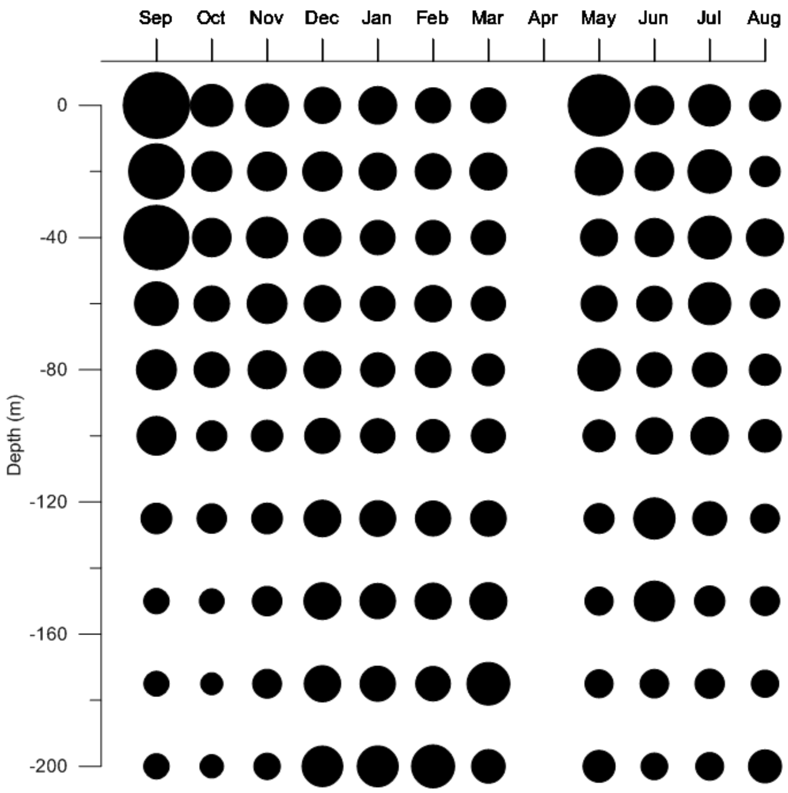

Figure 3. Monthly changes in heterotrophic bacterial abundances at offshore station (min-max values at 1.72×10^5 – 1.66×10^6 cells/ml).

In general, shelf waters displayed highly dynamic features and strong mixing during winter has effected greatly the concentration of nutrients as well as the distribution of bacterial populations in the water column. Winter bacterial population was low in abundance as well as in terms of biomass and distributed homogeneously in the water column due to convectional mixing (Figures 1-3). Based on water column mean abundances, nearshore station contained 1.9 and 2.3 times greater bacterial population than the middle and offshore stations. Almost similar ratios were calculated when water column mean biomasses were taken into account. Late winter – spring flowering of phytoplankton (dominated by diatoms) favoured bacterial growth during spring at both nearshore and middle stations. Bacterial abundance and biomass have reached peak levels during September due to elevated ambient temperatures and possibly due to accumulated dissolved organics. Timely changes in abundance and biomass at offshore station were insignificant. In contrast to chlorophyll no subsurface maxima is observed for bacteria at the offshore station. Except winter bacterial abundances decreased with increasing depth at middle and offshore stations. Population was found more abundant above thermocline at surface mixed layer during fall at both middle and offshore stations.

In offshore waters of the Levantine basin primary production is dominated by picophytoplankton populations and considerable amount of the primary production and chl.- *a* is based on these picophytoplankters (<3μ). The main components of this group are the cyanobacterium *Synechococcus* sp. and the *Prochlorococcus*. Picoplanktonic unicellular cyanobacterium *Synechococcus* are known to be major contributors of the total photosynthetic biomass in the oceans especially in the more oligotrophic regions such as the Mediterranean. In oligotrophic oceans this group contribute up to an estimated 25% of photosynthetic carbon fixation (Waterbury *et al.* 1986) and accounted for 64% of the total photosynthesis in the North Pacific Ocean (Iturriaga and Mitchell 1986). This dominance of picophytoplankton leads the expectation that most material and energy transfer is through the microbial loop. Preliminary studies from Turkish coastal waters dealt mainly with size, distribution, growth and pigment structure of *Synechococcus* clones obtained from the Black Sea (Uysal 2000, 2001). Studies concerning their dynamics with respect to ambient biophysicochemical properties were conducted in the Cilician shelf waters (Köksalan 2000; Uysal and Köksalan 2006, 2011, Bayındırlı 2007; Gazihan-Akoğlu 2011) and in highly contrasting Turkish coastal waters (Uysal 2006).

Cyanobacterium *Synechococcus* spp. was found more abundant at or near surface waters with elevated temperatures during summer and early fall in the Cilician basin shelf waters (Uysal *et al.* 2004). Changes in cell abundance with depth was insignificant during winter due to intense vertical mixing and remained at lowest levels compared to other seasons. (Figures 4-6). Based on water column mean abundances, nearshore station contained 2.7 and 5.7 times greater cyanobacterial population than the middle and offshore stations.

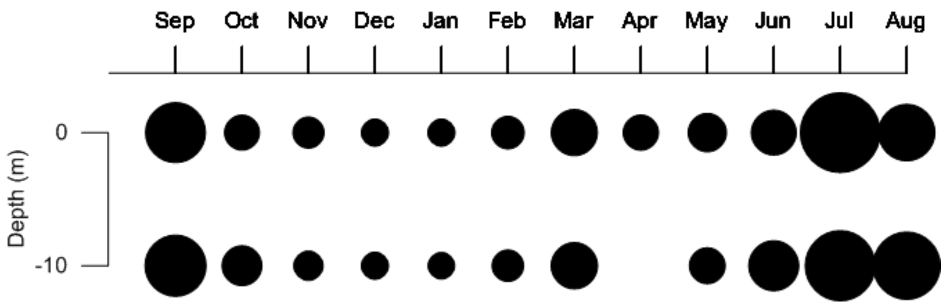

Figure 4. Monthly changes in *Synechococcus* spp. abundances at nearshore station (min-max values at $9.59x10^3 – 1.62x10^5$ cells/ml).

Similar to heterotrophic bacteria, almost similar ratios were calculated when water column mean biomasses were taken into account. Except winter all monthly abundance profiles displayed a decreasing trend from surface to bottom. Similar to heterotrophic bacteria no subsurface maxima is observed for *Synechococcus* at deep stations. Population was found more abundant nearsurface during summer and early fall. In general, heterotrophic bacterial biomass surpassed the cyanobacterial (*Synechococcus*.) biomass in the water column throughout the year (Figure 7).

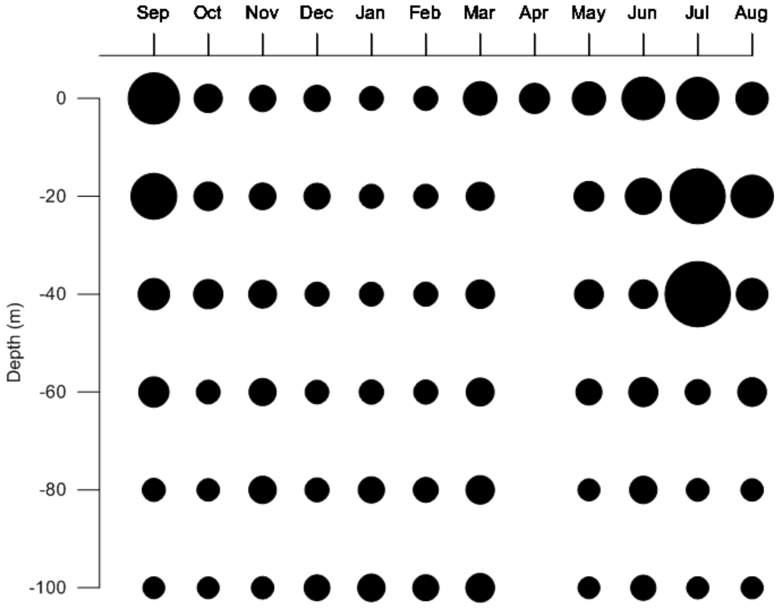

Figure 5. Monthly changes in *Synechococcus* spp. abundances at middle station (min-max values at $6.77 x 10^2 – 1.29 x 10^5$ cells/ml).

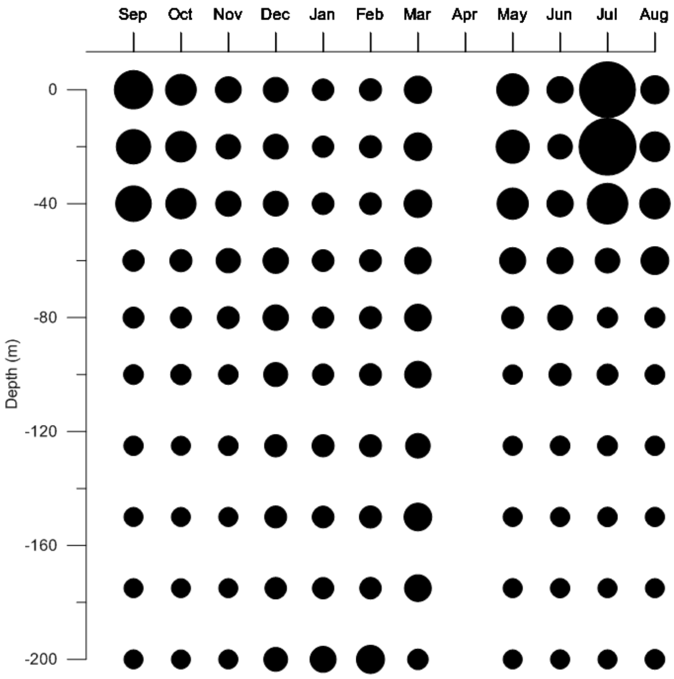

Figure 6. Monthly changes in *Synechococcus* spp. abundances at offshore station (max value at $7.51 x 10^4$ cells/ml).

Bacterial and cyanobacterial content of Turkish seas (Figure 8) have been studied extensively for comparison during spring and fall 2008 within the scope of EU funded integrated FP6 Project SESAME (Southern European Seas: Assessing and Modelling Ecosystem Changes). Among the contrasting water bodies maximum heterotrophic bacterial and cyanobacterial abundance and biomass were observed in the sea of Marmara during fall with values ranging between $2.6x10^6$ cells/ml and 14.4 µgC/l for heterotrophic bacteria and $2.1x10^5$ cells/ml and 25.3 µgC/l for cyanobacteria whereas the lowest figures were retained from the Levantine basin with values ranging between $4.1x10^4$ cells/ml and 0.24 µgC/l for heterotrophic bacteria and $2.5x10^1$ cells/ml and 0.02 µgC/l for cyanobacteria (Gazihan-Akoğlu *et al.* 2010). Relatively much higher values were observed in shallower shelf areas compared to offshore waters in the Cilician Basin. Both the surface bacterial and cyanobacterial abundance and biomass averages peaked in fall compared to spring in all regions except the apparent decrease in heterotrophic bacterial abundance and biomass values in the sea of Marmara.

Phytoplankton studies undertaken earlier in the area are few and have targeted only certain specific sub-areas (inner bays, coastal areas, harbours, etc.,) of the Cilician basin (Kıdeyş 1987; Kıdeyş *et al.* 1989; Avşar *et al.* 1998; Gücü *et al.* 1999; Gücü *et al.* 2000; Köksalan 2000; Eker and Kıdeyş 2000; Polat and Sarıhan 2000; Polat *et al.* 2000; Uysal *et al.* 2008; Gücü *et al.* 2001; Polat and Işık 2002; Uysal *et al.* 2003; Eker *et al.* 2003; Yılmaz *et al.* 2003; Uysal *et al.* 2004). Majority of these studies have covered large sized cells composed mainly of diatoms, dinoflagellates and a few of smaller sizes like coccolithophores. Phytoplankton data additionally contained pico and nano fractions of phytoplankton (heterotrophic bacteria, Cyanobacterium *Synechococcus* and small flagellates <15 micron) following the year 2000. Time series (weekly data off IMS-METU at three stations within the shelf) data is available only for the period April 1997 to November 1998. Observations are not regular and gaps do exist for this basin. Basinwide (mostly seasonal) as well as multibasin phytoplankton distributions are also available although they are very few. Disappearence of certain taxons with increasing anthropogenic loads from the Mersin bay area (for example *Coscinodiscus* species etc.,) is an interesting phenomenon worth to follow. Similar shifts from diatoms to dinoflagellates have been observed in the western Black Sea in the past. Intrusion of huge amounts of nutrients via waste discharges from domestic, industrial and agricultural sources had also boosted monospecific phytoplankton blooms in Mersin Bay (Uysal *et al.* 2003).

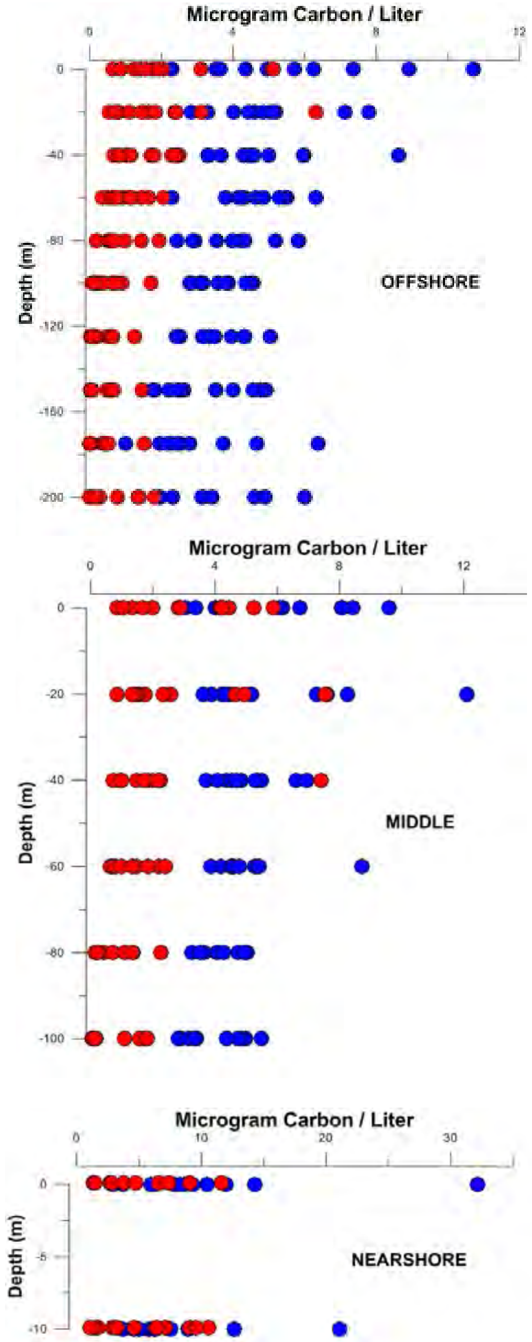

Figure 7. Annual biomass profiles of heterotrophic bacteria (green) and *Synechococcus* (red) of the Cilician shelf waters.

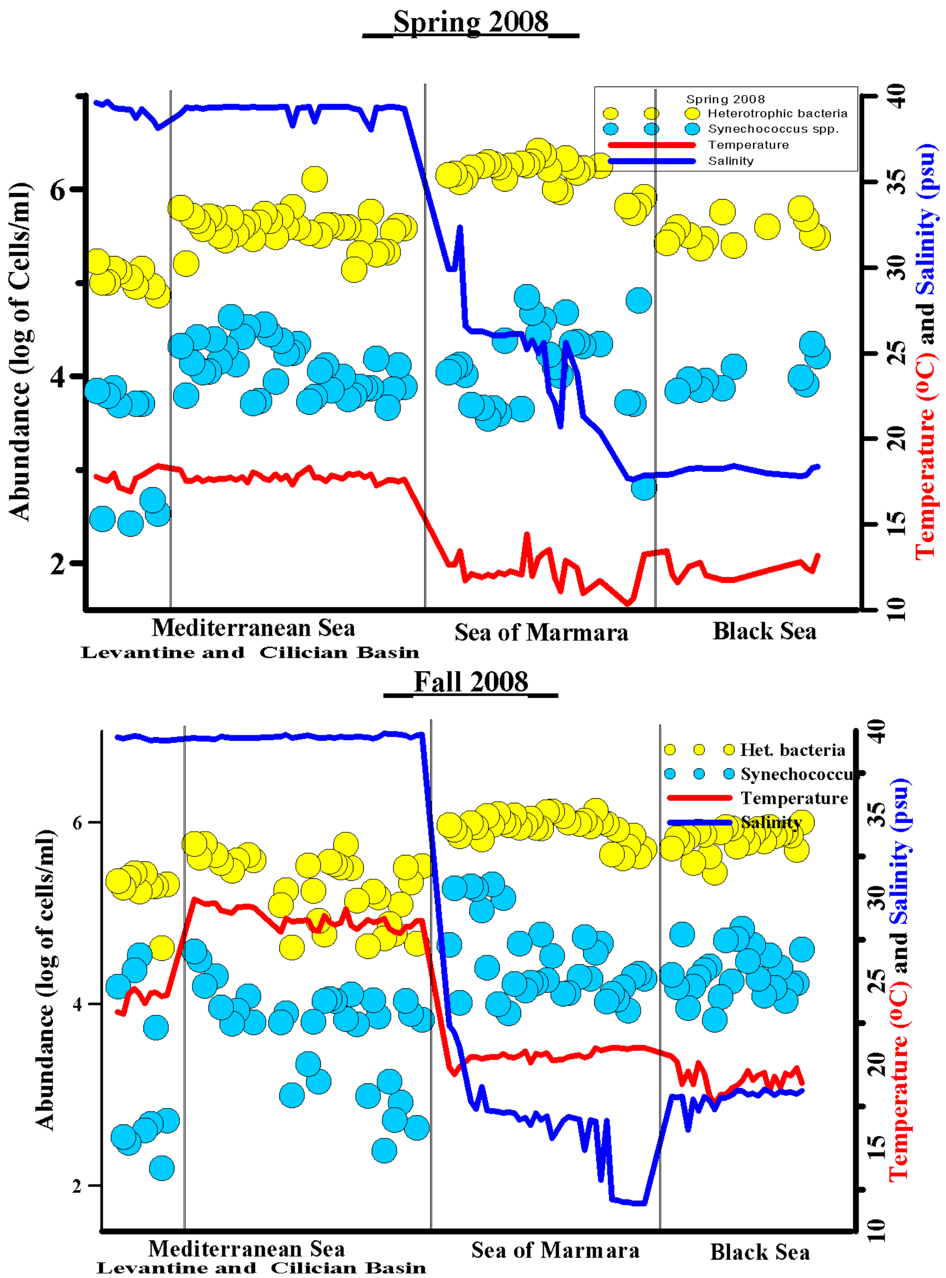

Figure 8. Surface abundance distribution of both groups in Turkish seas during spring and fall 2008.

In general phytoplankton has been found more abundant and diverse during late winter and spring in Cilician shelf waters. In a study conducted earlier in the shelf (Uysal *et al.* 2004) clearly pointed out the spring flowering of phytoplankton (Figures 9-10). Extension of phytoplankton enriched surface waters towards offshore was observed in late spring and early summer (May-June) due to increased run off from local perennial rivers to the basin as a result of melting snow in Taurus Mountains. Cell abundances varied in the range $2.5x10^4$ cells/l in December and $2.75x10^6$ cells/l in may at the nearshore station. Population was least abundant ($1.23x10^4$ cells/l) during September at the offshore station. During this period 71 diatom, 40 dinoflagellate and 21 chrysophycean species have been identified from the region. A decreasing trend in surface phytoplankton abundance as well as diversity towards offshore was prominent. Multivariate analysis performed over phytoplankton data indicate direct impact of temperature on seasonal clusters observed over the year. Weekly succession of phytoplankton for the period June 1997-May 1998 in the same area has also displayed similar results (Figure 11) where massive blooms took place in late winter and early spring. Diatoms' contribution in terms of biomass to the bulk was much higher than rest of the other groups at all three stations throughout the sampling period. Besides diatoms, dinoflagellates, coccolithophorids and small flagellates were the other important constituents of the phytoplankton in the shelf region. Dinoflagellates were much abundant in the nearshore station reaching 4.3×10^5 cells/l especially during summer. Major impact of terrestrial inputs via rivers to the highly oligotrophic Mediterranean coastal waters has been clearly identified recently in an approach to obtain Good Environmental Status (GES) of Turkish coastal waters. Coastal sectors receiving nutrient rich freshwater via rivers have contained much higher population densities (e.g. Mersin and İskenderun Bays) compared to others in close contact with oligotrophic offshore waters (Figure 12).

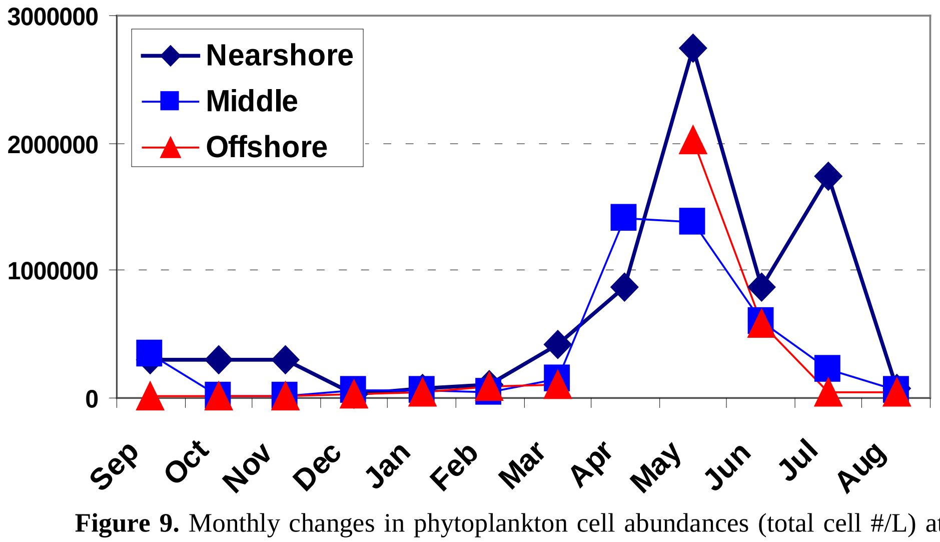

Figure 9. Monthly changes in phytoplankton cell abundances (total cell #/L) at Cilician shelf waters.

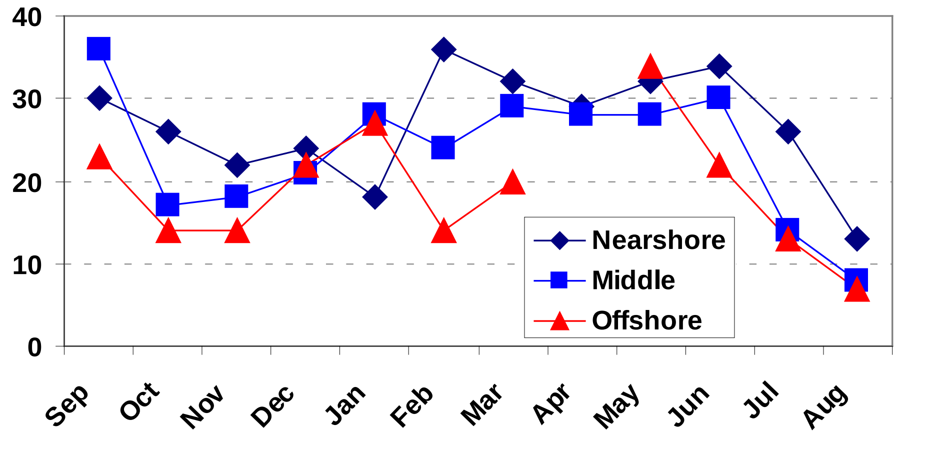

Figure 10. Monthly changes in total phytoplankton species observed in Cilician shelf waters.

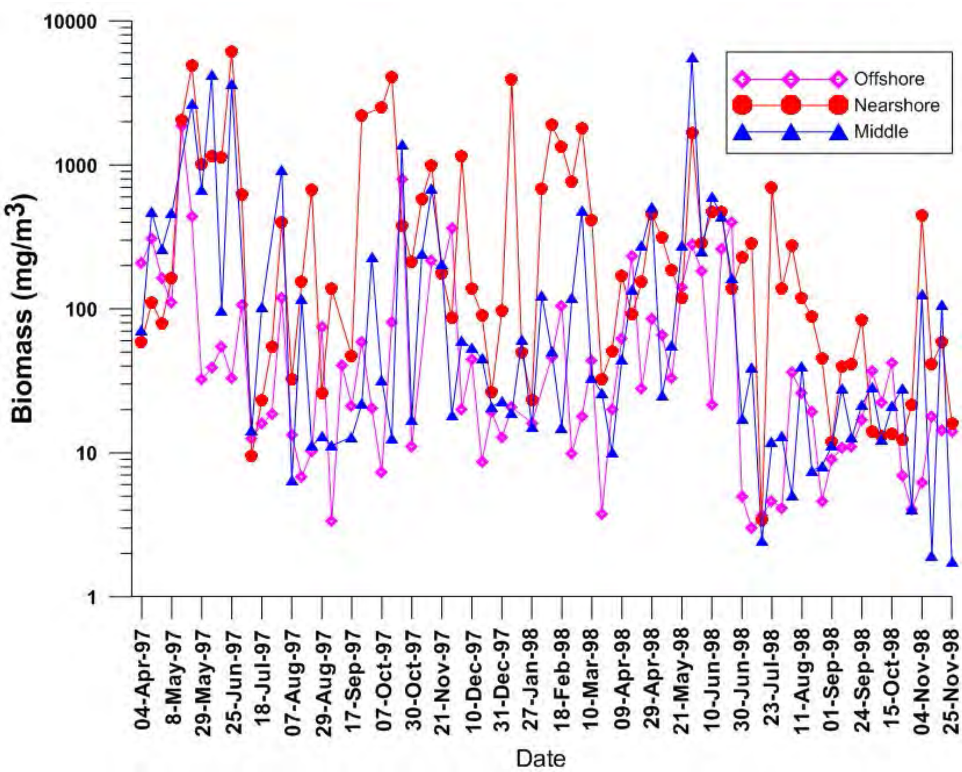

Figure 11. Weekly changes in phytoplankton biomass at Cilician shelf waters.

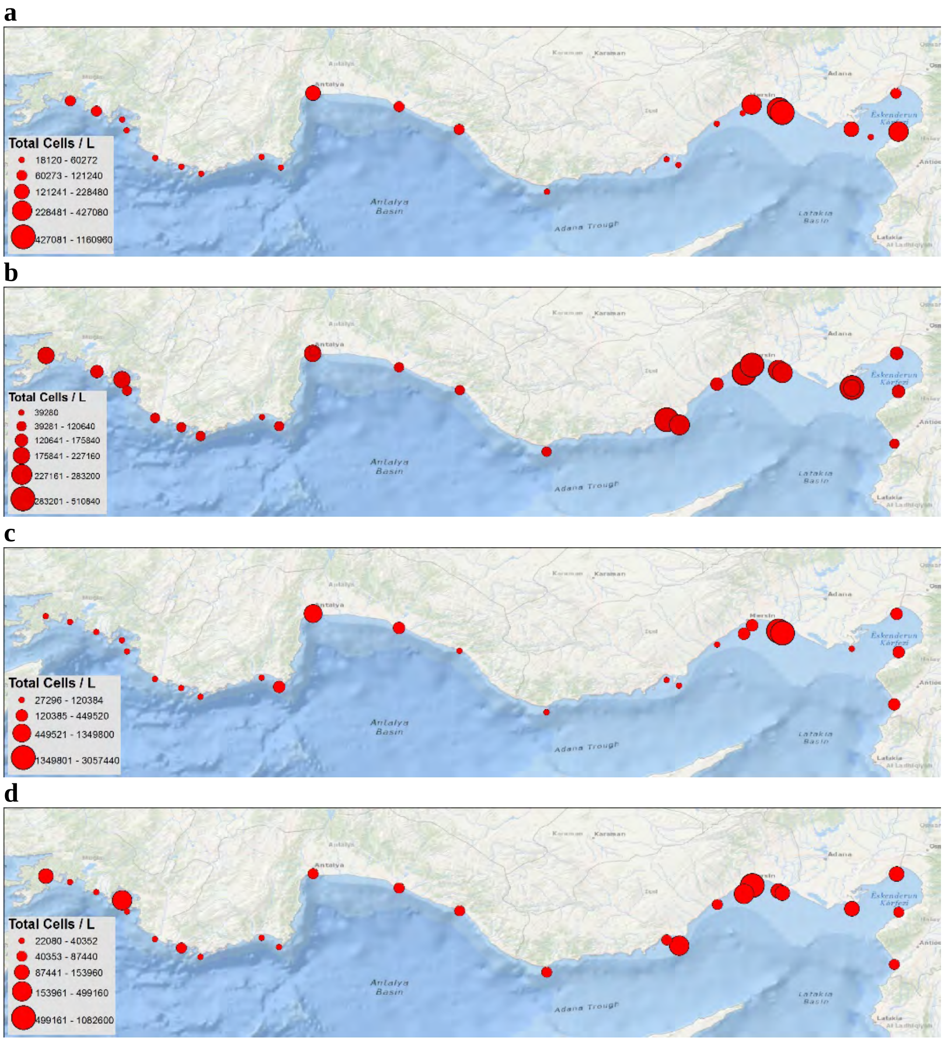

Figure 12. Phytoplankton abundances from the Turkish coastal waters of the Mediterranean, a: September 2014, b: February 2015, c: August 2015, d: February 2016)

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BACTERIOLOGICAL STUDIES
IN EASTERN MEDITERRANEAN SEA

Mine ÇARDAK

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1. Introduction

The Mediterranean Sea is connected to the Atlantic Ocean, surrounded by the Mediterranean region and almost completely enclosed by land: on the north by Anatolia and Europe, on the south by Africa, and on the east by the Levant. The sea is technically a part of the Atlantic Ocean although it is usually identified as a completely separate body of water. It covers an approximate area of 2.5 million km^2 (UNEP 1996; Bianchi and Morri 2000). The Mediterranean Sea is considered as one of the least productive seas of the world and geophysical and arid climatic conditions make the Eastern Mediterranean the most oligotrophic part (Azov 1991; Yılmaz and Tuğrul 1998; Ediger *et al.* 2005). Eastern Mediterranean is a good example for low nutrient low chlorophyll ecosystem (Ediger and Yılmaz 1996; Eker-Develi 2004; Koçak *et al.* 2010). Krom *et al.* (2005) reported that eastern Mediterranean surface waters have extremely low nutrient content. The nutricline is located at around 300-500 m in the anticyclonic regions (Yılmaz and Tuğrul 1998). However, despite its oligotrophic nature, the northeastern sector of the eastern Mediterranean receives substantial amounts of river waters which further enhance the nutrient content of the shallow shelf areas (Yücel 2008) Bacteria are considered an important component of primary productivity and the bacterial production by mainly phosphorus (Siokou-Frangou *et al.* 2010). Bacterial production was limited by phosphorus and nitrogen. To date only few studies dealt with the bacteriological in the northeastern Mediterranean (Zoppini *et al.* 2008; Amalfitano *et al.* 2009). Previous studies focused on the western Mediterranean, the Aegean Sea, and the Levantine Basin (Zohary and Robarts 1992; Robarts *et al.* 1996, Wambeke *et al.* 2002; Turley *et al.* 2000; Christaki *et al.* 2003;). In general, the rate of the bacterial production decreases from west to east exhibiting similar trends with primary production and chlorophyll in the Mediterranean (Siokou-Frangou *et al.* 2010).

Studies on marine bacterioplankton diversity have provided a comprehensive inventory of the major groups of bacteria frequently observed in the water column have indicated there and crucial role in the decomposition of organic matter and cycling of nutrients in marine environments (Hagstrom *et al.* 2002). However, it has been recognized that bacterial populations may be considerably modified by interactions with biotic factors (Martin and Bianchi 1980). Increased human pressure in the Eastern Mediterranean is responsible for major changes in the increased ecosystem (Duarte 2000).

This chapter summarizes bacteriological studies conducted in the Sea of Mediterranean in recently years.

2. Fecal Pollution

As a consequence of urban and rural development in areas of extraordinary geographical beauty, the tourist population visiting those places has not ceased to grow. This increase in population has had a profound impact on the quantity and quality of wastes produced. Quite often during the tourist season, municipal services in charge of the safe disposal of solid and liquid wastes are totally unable to cope with the additional waste-load that invariably reaches the coastal waters.

However, in spite of the importance of pollution loads originating directly from human agglomerations in coastal areas, they appeared to be of minor importance when compared to other forms of pollution originating inland and discharged into the sea by various means. Discharges from “inland” municipal, industrial and agricultural districts, which are only partially treated or even in untreated form, are still reaching the sea through the hydro- graphic river network of the Mediterranean Basin. Municipal sewage carries increased loads of nutrients such as nitrogen and phosphorus, and a heavy load of micro-organisms, including bacterial and viral pathogens.

In the Mediterranean Sea coastal urbanization has led to the release of enteric human pathogens into surface waters. Regulations regarding bathing water quality (Council Directive 2006/7/EC) have led to improvements in the microbiological quality of coastal waters and to a reduction in the incidence of waterborne diseases arising from contact with bathing waters. In these a study, we evaluated several microbiological parameters in an Italian coastal area of the Southern Adriatic Sea in order to assess the water quality. Several interesting issues can be inferred from these data (Stabili and Cavalo 2011). Along the examined coastal tract, the microbial pollution indicators were always below the tolerance limits for bathing waters defined by the CEE directive suggesting a good sanitary quality (Franco *et al.* 1982; Russo and Artegiani 1996). Another study was done by Skaraki (2006) assessed total and faecal coliforms were occasionally present, with the highest values of 278 MPN 100 ml^{-1} for total coliforms and 172 MPN 100 ml−1 for faecal coliforms observed in Italian Sea.. *P. aeruginosa* was not identified during the sampling period at any of the examined stations.

Sun and beach tourism is very important to the economy of Mediterranean coastal area, so the control of the quality of the environment on the beaches is essential. Therefore, the analysis and control of the quality of bathing water is necessary, which is defined by the European Directive 2006/7/EC as excellent, good or sufficient depending on the presence of microbiological contamination or other organisms or waste presenting a risk to bathers' health. For that, 1392 beaches of the Mediterranean Pennsiula and its islands were analysed, taking into account: fecal bacteria (*Escherichia coli* and Enterococcus), physical characteristics of sediment, level of urbanization, climatic and anthropogenic factors, and maritime climate. Thus, it was observed that urban sand beaches located in seas with fewer hours of sunshine and important tide have higher concentrations of *E. coli* and Enterococcus.

There are many studies focusing on indicator bacteria concentrations, bacterial pathogens and source tracking of fecal pollution from water in the Sea of Mediterranean. Altug *et al*. (2010) was investigated the levels of indicator bacteria with respect to the areas from which they were isolated were investigated and compared in the sea water samples taken from the coastal area of the Eastern Mediterranean (Turkey, Syria, Lebanon). While the highest levels of resistant bacteria were found in the samples taken from Syria, the lowest level of resistant bacteria was found in the samples taken from the offshore area. Faecal coliform, total coliform and HPC were found to be betweenc <1,0–1,0 log_{10} CFU/100 ml, <1,0–2,1 log_{10} CFU/100 ml, 5,4–7,1 log_{10} CFU/100 ml, during August 2007. Also in 2007, results of analyses conducted at 97 points between Cesme and Cevlik in the Eastern Mediterranean coastal area of Turkey were found to be between 1,7-4,7 log CFU/100 ml for faecal coliform, 1,8-6,9 log_{10} CFU/100 ml for total coliform, and 5,5-8,8 log_{10} CFU/100 ml for HPC. Again in 2008, results of analyses conducted at 90 points between Cesme and Cevlik in the Eastern Mediterranean coastal area of Turkey were found to be slightly lower than in 2007. In 2007, results of analyses conducted at 6 points along the coastal area of Syria were found to be between 2,5-3,7 log_{10} CFU/100 ml for faecal coliform, 3,1-4,5 log_{10} CFU/100 ml for total coliform, and 5,5-6,6 log_{10} CFU/100 ml for HPC. Once more in 2008, results of analyses conducted at 6 points along the coastal area of Syria were found to be slightly higher than in 2007 (2,7-3,8 log CFU/100 ml for faecal coliform, 2,9-4,1 log_{10} CFU/100 ml for total coliform, and 5,8-6,2 log_{10} CFU/100 ml for HPC). Also in the year 2008, results of analyses conducted at 5 points along the coastal area of Lebanon were found to be between 1,0 -3,2 log_{10} CFU/100 ml for faecal coliform, 1,9-5,2 log CFU/100 ml for total coliform, and 5,5-7,8 log_{10} CFU/100 ml for HPC.

Bathing water quality was monitored according to the Turkish Bathing Water Directive (76/160/EEC) in Göcek Bay had been polluted due to densely boat tourism by Can and Alp (2012), their measurements showed that fecal coliform concentrations in study area were ranging between $1.4x10^3$ and $1.8x10^3$ fecal coliforms $100ml^{-1}$. Kocasoy *et al.* 2008, investigated sea water quality at selected two beaches and a coastal village having summer resorts in Çeşme and found that the maximum total coliform value had been reduced from $10x10^4$ to $9.2x10^1$ coliform $100ml^{-1}$ after wastewater treatment plant. Fecal contamination in seawater of the beaches can stem from many point and non-point sources. For example, people and domesticated or wild animals using the beach, leaks from the sewer system or from waste storage tanks, illegal discharge from restaurants, cafes and businesses around, nearby agricultural fields and river inputs are but a few of the factors leading to contamination. (Kaçar and Kucuksezgin 2014)

3. Bacterial Diversity

There are many different environmental factors that regulate microorganism abundance, activities and ecto-enzyme profiles in marine environments. Furthermore, different bacteria degrade different fractions of organic matter in the sea (Fuhrman *et al*. 1993). In the water column, the presence of micro organisms usually decreases with increasing depth. While culture independent studies serve as common applications in detecting bacterial diversity, the studies showed that cultured strains of marine bacteria can represent significant fractions of the bacterial biomass in sea water (Pinhassi *et al*. 1997). There are several studies focusing on bacterial diversity of the Sea of Mediterrranean using both culture and molecular methods.

In a study by Altuğ *et al.* (2010a), the level of mesophilic aerobic heterotrophic bacteria and bacterial composition with respect to the areas from which they were isolated were investigated for the first time in the coastal areas of Lattakia (Syria) and Beirut (Lebanon) the Mediterranean. During the study period, six bacterial classes: Gamma Proteobacteria (58%), Beta Proteobacteria (%11), Alfa Proteobacteria (5%), Flavobacteria (12%), Actinobacteria (6%) and Bacilli (5%) were determined. Gamma Proteobacteria was the most common group in terms of species number in comparison to the other taxonomic groups in the coastal areas (Table 1).

The species belonging to *Enterobacteriaceae* family was the most common taxonomic group in the coastal areas of Syria and Lebanon. *Flavobacteriaceae* family was the second most common group. The presence of 16 bacteria species belonging to ten different families from the coastal areas of Syria and Lebanon were reported for the first time.

Among all the strains, percentage of the Gram - bacteria in the coastal areas of Syria and Lebanon and the offshore area were 90 % and 2%, respectively. Among Gram-negative bacteria, enteric bacteria were abundant and the predominant genus was Enterobacter at all sampling points in the coastal areas of Syria and Lebanon. This situation was evaluated to be a result of anthropological pollution input in the coastal areas. The bacteria classes found in this study include species that are able to secrete large quantities of ectoenzymes. This situation suggests that those particular species have potential importance in organic matter turnover in these areas.

Table 1. The aerobic heterotrophic culturable bacteria composition which were isolated from the coastal areas of Syria and Lebanon and offshore area of Northern Aegean Sea and Eastern Mediterranean (2007-2008 August).

Families	Species	Stations			Class
		Lebanon	Syria	Offshore	
ENTEROBACTERIACEAE	*Enterobacter cloacae* (Jordan 1890) Hormaeche and Edwards 1960	+	+	-	Gamma Proteobacteria
	Enterobacter sakazaki (Farmer et. al., 1980)	+	+	-	Gamma Proteobacteria
	Enterobacter aerogenes Hormaeche and Edwards 1960	+	+	-	Gamma Proteobacteria
	Enterococcus faecalis (Andrewes and Horder 1906) Schleifer and Kilpper-Balz 1984	+	+	-	Gamma Proteobacteria
	Escherichia coli (T. Escherich, 1885)	+	+	-	Gamma Proteobacteria
	Serratia fonticola Bizio 1823	+	+	-	Gamma Proteobacteria
	Serratia liqefaciens (Grimes and Hennerty 1931) Bascomb et al. 1971	+	+	-	Gamma Proteobacteria
PSEUDOMONADACEAE	*Pseudomonas luteola* (Kodama et al. 1985) Holmes et al. 1987	+	+	-	Gamma Proteobacteria
XANTHOMONADACEAE	*Stenotrophomonas maltophilia* Palleroni and Bradbury 1993	+	+	-	Gamma Proteobacteria
SHEWANELLACEAE	*Shewanella putrefaciens* (Lee et al. 1981) MacDonnell and Colwell 1986	+	+	+	Gamma Proteobacteria
CAULOBACTERACEAE	*Brevundimonas vesicularis* (Büsing et al. 1953) Segers *et al.* 1994	+	+	-	Alpha Proteobacteria
ALCALIGENACEAE	*Alcaligenes faecalis ssp faecalis* (King 1959) Kim et al. 2005	+	+	-	Beta Proteobacteria
NEISSERIACEAE	*Chromobacterium violaceum* Bergonzini 1880 (Approved Lists 1980)	+	+	-	Beta Proteobacteria
MICROCOCCACEAE	*Micrococcus luteus* Lehmann and Neumann 1896	-	-	+	Actinobacteria
STAPHYLOCOCCACEAE	*Staphylococcus hominis* Kloos and Schleifer 1975 emend. Kloos et al. 1998	+	+	+	Bacilli
FLAVOBACTERIACEAE	*Elizabetkingia meningoseptica* (King 1959) Kim *et al.* 2005	+	+	-	Flavobacteria
	Chryseobacterium indologenes Yabuuchi Et Al. 1983	+	+	-	Flavobacteria

Research conducted by Gärtner *et al.* (2011) in Mediterranean Sea revealed that most of the bacteria isolated and identified belong to the two phylogenetic groups Firmicutes and Actinobacteria. Gram-positive bacteria were clearly dominant among the strains isolated from the Eastern Mediterranean deep-sea sediment. This is in accordance to the frequent isolation of mainly Firmicutes and Actinobacteria from diverse marine habitats (Jensen *et al.* 2005; Gontang *et al.* 2007; PrietoDavo´ *et al.* 2008).

Another study by Çardak *et al.* 2015, a total of 3,005 colonies were isolated on Marine agar. Approximately 83 % of the isolates were identified to genus level. During the study period, 6 bacterial classes were recorded: Gammaproteobacteria (46.81 %), Bacilli (27.66 %), Betaproteobacteria (12.77 %), Alphaproteobacteria (6.38 %), Actinobacteria (4.26 %) and Flavobacteria (2.13 %). In this study, the presences of 48 culturable heterotrophic bacteria species belonging to 18 different families from the Gulf of Antalya were reported for the first time. Although these bacteria had not previously been reported from these areas, they may be ubiquitous in aquatic environments. Gamma Proteobacteria was the most common group in terms of species number in comparison to the other taxonomic groups in the coastal areas. The species belonging to Enterobacteriaceae family was the most common taxonomic group in the coastal areas of Gulf of Antalya. Bacilli family was the second most common group. The species belonging to the family Enterobacteriaceae were determined to have the highest count in these regions, implying that abundance of enteric bacteria is a part of the anthropological pollution input of the coastal areas. Furthermore, modeling studies conducted in the Gulf of Antalya and in the Mediterranean Sea indicate that under normal conditions, 11–15 % of the waste water discharged from various points of the Gulf of Antalya into the Eastern Mediterranean Sea (Atik *et al.* 2011).

In a study by Altuğ 2012, the presence of Salmonella spp. and indicator bacteria with respect to the areas from which they were isolated were investigated in the coastal areas of the Eastern Mediterranean. The occurrence of Salmonella spp. in the 14 units of seawater samples from the Eastern Mediterranean, Turkey were investigated during the months of August in 2007 and 2008. Due to the differences between coastal areas and offshore areas with respect to exposed pollution factors, the offshore areas can be accepted as reference stations for the studies which monitor bacterial contamination.

The frequency of Salmonella spp. according to their exposure to environmental factors in the areas from which they were isolated were different. For instance, higher indicator bacteria and Salmonella spp. abundance was found in the coastal stations compared to the offshore areas. The coastal areas which were under the influence of biological pollution with respect to heavy inland population displayed higher levels of Salmonella spp. than the offshore areas.

Aeromonas hydrophila in the aquatic environment may be related to the levels of pollution in the water. It has been reported by several authors including (Araujo *et al.* 1991; Stecchini and Domenis 1994) and that *A. caviae* predominates waters with a high degree of faecal pollution and dominant in water samples collected from polluted and unpolluted regions. In study reported, that isolated samples are associated with the direct discharges to the sea or via rivers and streams. *Burkholderia cepacia* was isolated from relatively unpolluted areas. *B. cepacia* is an important opportunistic human pathogen and in this study, it was isolated from the samples that were taken from both polluted and unpolluted areas. Future studies on the biotechnological use of isolated bacteria from the Mediterranean Sea should now focus on safe ways to harmness their great potential to improve agriculture and reduce global pollution.

4. Bacterial Heterotrophic Activity

Major biogeochemical processes in the water columns of marine environments are related mostly to the activities of heterotrophic bacteria (Azam *et al*. 1983; Martin *et al.* 2014). Bacterial activity is strongly limited in the eastern Mediterranean offshore waters by lacking necessary sources while the uptake and removal of such sources by bacteria are intense in eutrophic coastal areas (Ducklow 2000). In contrast, bacterial activity was found high in offhore waters above thermocline in the meantime due to accumulation of particles within the surface mixed layer.

In a study by Yücel, (2013) investigated heterotrophic bacterial abundance varied in the range 29686 and 1397129 cells ml^{-1} in the shelf and 11989 and 886253 cells ml^{-1} in the eutrophic shelf waters samples collected from offshore throughout Eastern Medditerranean. Mean abundances for the shelf and offshore were 443306 and 233028 cells ml^{-1}, respectively. Mean values were very low during July, August and November, December 2010 in coastal waters. Bacterial abundances were least during October 2011 in the shelf and during August 2010 and 2011 in the offshore. In addition, PP, chlorophyll and floral activity were also measured very low in October 2011 in the shelf. This eventually had a negative impact on the success of bacterial community. However, in a similar study conducted on the same site, bacterial abundance was found much higher at surface during October 2005 (Bayındırlı 2007).

Cardak *et al.* (2015) collected from 6 different locations in the Gulf of Antalya. The mean abundance of heteretrofic bacteria value was recorded as ranged between 8.15- 9 10^6 and 2.54- 9 10^8 CFU ml^{-1} throughout the year. Abundance of HB differed according to the variations of biotic and abiotic factors. The seasonal distribution of HB in the gulf seems to be similar to those from many other environments (Altug *et al*. 2011; Stabili and Cavallo 2011). HB abundance was low in winter, autumn and spring, but it was at its highest level in summer. Many similar studies indicated that high temperature stimulates HB abundance and its annual maximum coincide with the warmest period (Stabili and Cavallo 2011). However, although the temperature was remarkably high in autumn, abundance was found to be low in this study.

Uysal *et al.* (2004) declared that maximum HBAs were found in September and March in the in the surface waters in the Cilician basin (Northeastern Mediterranean). Low abundances were observed during winter convectional mixing HBA increased with increasing productivity and increase in amount of particulate matter in coastal waters. The mean abundance in shelf waters was 4.4 x 10^5 and in offshore was 2.3 x 10^5 cells ml^{-1}. Very low values were observed in shelf in October and in offshore in Augusts (2010 and 2011). Higher abundances were also observed above thermocline in offshore waters. HBA decreased with increasing depth in September. Abundance reached maximum numbers in deeper part (≈ 160 m). Bacterial abundance was maximal during summer 2011 in the shelf. Similarly, higher abundance was also met in summer 2010. On the other hand, to the peak abundance was met in winter (seasonal mean 328305 cells ml-1) in offshore waters.

5. Heavy Metal and Antibiotic Resistant Bacteria

Calculations have indicated that 70–80% of the drugs used in fish farming end up in the water and in the sediment beneath the fish farms reaching high concentrations (Samuelsen *et al.* 1992). The environmental fate of the antibiotic agents in the sediments is of great concern as persistent antibacterial substances may enhance unfavourable environmental effects and decrease benthic bacterial density by 50% (Lunestad *et al.* 1995).

In the Mediterranean Sea, the distribution of dissolved zinc, copper, lead and cadmium is primarily controlled by marine circulation, surface source dynamics and biological new production. The present relatively high content of these metals in the surface layer is due to non-steady-state cycles as a result of source increases probably following increases in industrial, agricultural and urban activities around the Sea since 1960. Unlike the open ocean, for which the deep water response time to perturbations is of the order of 1000 years, the Mediterranean response to environmental disturbances are perceptible in two decades. Comparison of surface with bottom concentrations permits an estimation of the growth of dissolvable anthropogenic discharges and a forecast of the biogeochemistry of this continental sea (Bethoux *et al.* 1990).

In a study by Matyar (2012), it aimed to determine the microbial diversity, level of antibiotic resistance patterns and distribution of heavy metal resistance of bacterial isolates from the Eastern Mediterranean Sea coast. The resistance of 255 Gram-negative bacterial isolates to 16 different antibiotics and to 5 heavy metals was investigated. The most common strains isolated from all samples were *Citrobacter koseri* (9.0 %), *Escherichia coli* (8.2 %) and *Pantoea agglomerans* (8.2 %). Our results revealed a high incidence of resistance to ampicillin (74.0 %), streptomycin (70.0 %) and cefazolin (48.3 %). The multiple antibiotic resistance (MAR) index ranged from 0.2 to 0.75. Isolates showed tolerances to different concentrations of heavy metals. Thus results show that the Eastern Mediterranean Sea coast has a significant proportion of antibiotic and heavy metal resistant pathogens, or opportunist Gram negative bacteria, and these bacteria may result in a potential public health hazar.

The previous study was similar to the findings of Pontes *et al.* (2009. The high degree of resistance to ampicillin found a total of 232 ampicillin-resistant Gram-negative isolates among 272 isolates (85.3 %) in the study. These results show resistance to carbapenems, third- and fourth-generation cephalosporins, was relatively infrequent among the isolates. Pontes *et al.* (2009) found in their study, performed in a tropical region, a high requency of multiresistant bacteria.

Another a study by Matyar *et al.* (2008) indicated at Iskenderun Bay, that a high percentage of bacteria were resistant to streptomycin (100 %), cefazolin (89.8 %), ampicillin (83.7 %) and trimethoprim-sulfamethoxazole (69.4 %), whereas a low percentage of bacteria were resistant to cefepime (12.3 %) and meropenem (14.3 %).Resistance to five heavy metals was as follows for Mersin, Karatas and Iskenderun isolates, respectively: to cadmium, 82.3 %, 58.8 % and 95.5 %; to chromium, 2.3 %, 2.5 %, and 4.5 %; to copper, 67.8 %, 41.3 %, and 97.7 %; lead, 2.3 %, 1.3 % and 2.3 %; and to manganese, 1.1 %, 2.5 % and 6.8 %. Resistance to lead was similar between Iskenderun and Mersin isolates.

The association between antibiotic resistance and resistance to heavy metals is very common in the same organism (also in the same plasmid, transposon, or integron), demonstrating that industrial pollution most likely selects for antibiotic resistance and vice versa (Baker- Austin *et al.* 2006).

In the present overview it has been clearly pointed out the potential role of incoming new pollutants. Future research should be focused on these novel substances (whose effects have still to be tested) and to their synergetic or cumulative effects with ‘‘classical pollutants’’ (particularly chemical pollutants such as fertilisers, pesticides, detergents-, industrial wastes, heavy metals and hydrocarbons). It is likely, indeed, that in the coming years the anti-pollution policy at the European level will enhance the control and the management of the Mediterranean Sea and will reduce the impact of the classical pollutants. However, the potential impact of the ‘‘novel chemical pollution’’ (i.e., substances that have potentially important biological effects) is still to be evaluated and the subtle impact could remain hidden for a long time before becoming apparent. As the main risk for Mediterranean health is the synergetic effect of different environmental variables=pollutants, systemic studies in targeted areas are recommended in the future.

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BIODIVERSITY OF MARINE BENTHIC MACROFLORA (SEAWEEDS / MACROALGAE AND SEAGRASSES) OF THE MEDITERRANEAN SEA

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1. Introduction

Turkey, which is surrounded by sea on three sides, the identification and protection of marine ecosystem and biodiversity are of great importance. Turkish government is party to various International Conventions such as the Convention on Biological Diversity and the Convention on the Protection of the Mediterranean from Pollution (Barcelona Convention); emphasizes the necessity of protecting and evaluating living marine resources in an effective and sustainable way. The "Specially Protected Areas and Biological Diversity in the Mediterranean" Protocol, adopted in 1995, adopted the Annexes in 1996 and identified strains of endangered species. Within the scope of the protocol, it has been decided to take some measures such as scientific monitoring and inventory studies for these species, protection measures against human activities. Again in the framework of the Barcelona Convention, coastal countries in the Mediterranean have adopted action plans for the conservation of certain species and species groups. One of these is the "Action Plan for the Protection of Marine Vegetation in the Mediterranean" (UNEP-MAP RAC / SPA 1999), adopted in 1999. The aims of this plan are;1) To ensure the preservation of macroscopic marine vegetation in the Mediterranean with the application of legal protection measures and to increase the information about these species at the same time with these measures. 2) Prevent the decline and loss of vegetation communities that are important for marine meadows and marine ecosystems that make up the marine habitats necessary for most Mediterranean life. 3) Posidonia is to protect marine vegetation communities, which may be considered natural monuments such as natural set reefs and *Cystoseira* arches.

Marine macroalgae and meadows, which make up the subject of this study, have adapted to physical factors such as structure of the substrate, quantity/quality of light in the environment and current values in the water (Koehl *et al.* 2003). In addition to being an oxygen source in the environment they are in, they have the characteristic of being a habitat by providing food, shelter, living and breeding environments for many marine life forms. Marine macroalgae and flowering plants, which constitute the main dominant creatures of the coastal zone, have great prospects in the marine ecosystem (Schiel *and* Hickford 2001), with features such as landholding structures, places in the food chain, and inter-species interactions. Changes in marine macroalgae and flowering plants affect the structural and functional state of ecosystems and direct the fauna in the environment (Dimech *et al.* 2002). Seagrass meadows show density and macrofaunal diversity when they are treated on the basis of taxa. Organic matter richness, especially of sprouting leaves such as posidonia, is ecologically important for benthic invertebrates, where molluscs are involved (Como *et al.* 2008). Their assets are at risk because they are subjected to many environmental pressures such as coastal settlement, tourism printing, pollution, cage fishery, trawl fishery etc. in the Mediterranean. For this reason, some of them have been protected by international treaties and laws.

Researces of macroflora on the Turkey's Mediterranean Coast are: Apaydın and Turna 2002; Aysel 1997a,b; Aysel and Gezerler-Şipal 1996; Aysel *et al.* 2002, 2006a,b,c; Cirik 1991; Cirik *and* Akçalı 2002; Çevik *et al.* 2007; Dipova and Okudan 2011; Durucan and Turna 2011; Ertan *et al.* 1997; Everest *et al.* 1997; Gökoğlu *et al.* 2010; Nicolaidou 2012; Okudan and Aysel 2006; Okudan *et al.* 2010; Öztürk, 1988, 1993, 1996a,b; Öztürk and Güner 1986; Özvarol *et al.* 2009; Taşkın *et al.* 2015; Turna *et al.* 2000, 2002; Yagcı 2006; Yağcı and Turna 2002.

In this study, the distribution of benthic macroflora individuals on the Mediterranean coast of Turkey, as well as the factors affecting them, are mentioned, including the sensitive species and their distribution areas, as mentioned above. Turkey has a total of 440 taxa species and subspecies distribution, including 256 red algae (Rhodophyta), 86 brown algae (Ochrophyta), 93 green algae (Chlorophyta), 5 seagrasses (Tracheophyta).

2. Material and Method

The Mediterranean coast of Turkey, which is 1577 meters long, is bordered by Dalaman Stream (Mugla) in the west and Samandağ (Hatay) in the east. The coastal line shows a Mediterranean offshore character with a more flat structure than the Aegean Sea (Figure 1).

In general, benthic macroflora under water studies are carried out between 0-40 m depth with SCUBA and free dives under water and vertical and horizontal scans. Coordinate and depth information are recorded for each sampled material. Underwater photographs of macroalgae and underwater and video images of the sampling area are taken during sampling. Some of the collected materials are identified in jars in the 4-6%

neutralized formaldehyde solution prepared with sea water, with the definitions and definitions being made later in the laboratory. Identification studies of materials are performed with stereo zoom and binocular light microscopes. Where necessary, the samples are numbered and stored

Figure 1. Mediterranean coast map of Turkey

3. Results

Turkey has a total of 440 taxa species and subspecies distribution, including 256 red algae (Rhodophyta), 86 brown algae (Ochrophyta), 93 green algae (Chlorophyta), and 5 sea grasses (Tracheophyta) (Table 1). When the percentages of the groups in the region are examined, it is seen that the most dominant group is Rhodophyta (58%). This group is followed by Chlorophyta (21%), Ochrophyta (20%) and Tracheophyta (1%), respectively (Figure 2).

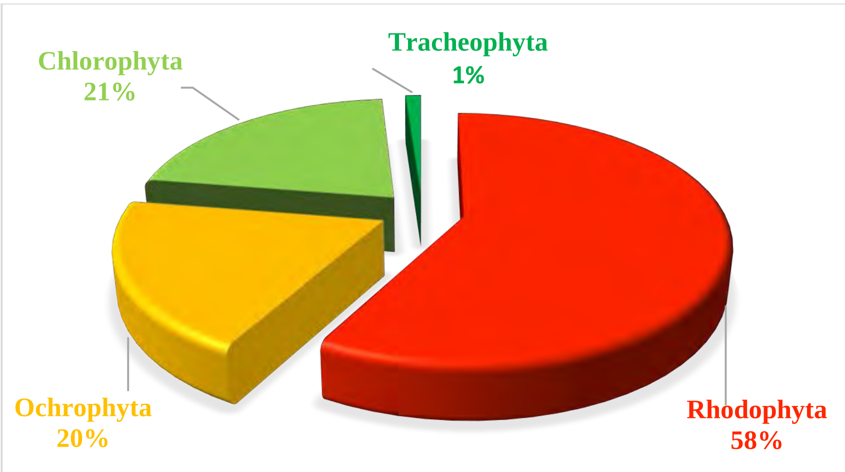

Figure 2. Percentage of systematic groups identified on the Mediterranean coast of Turkey.

Table 1. Macro flora on the Mediterranean coast of Turkey

RHODOPHYTA
Acanthophora nayadiformis (Delilei) Papenfuss
Acrochaetium crassipes (Børgesen) Børgesen
Acrochaetium mediterraneum (Levring) Boudouresque
Acrochaetium microscopicum (Nägeli *ex* Kützing) Nägeli
Acrochaetium rosulatum (Rosenvinge) Papenfuss
Acrochaetium savianum (Meneghini) Nägeli
Acrochaetium secundatum (Lyngbye) Nägeli
Acrochaetium virgatulum (Harvey) Batters
Acrodiscus vidovichii (Meneghini) Zanardini
Acrosorium ciliolatum (Harvey) Kylin
Acrosymphyton purpuriferum (J. Agardh) Sjostedt
Aglaothamnion caudatum (J. Agardh) Feldmann-Mazoyer
Aglaothamnion cordatum (Børgesen) Feldmann-Mazoyer
Aglaothamnion hookeri (Dilliwyn) Maggs and Hommersand
Aglaothamnion tenuissimum (Bonnemaison) Feldmann-Mazoyer
Aglaothamnion tripinnatum (C.Agardh) Feldmann-Mazoyer
Alsidium corallinum C. Agardh
Alsidium helminthochorton (Schwendimann) Kützing
Alsidium lanciferum Kützing
Amphiroa beauvoisii Lamouroux
Amphiroa cryptarthrodia Zanardini
Amphiroa rigida Lamouroux
Anotrichium barbatum (C. Agardh) Nägeli
Anotrichium tenue Nägeli (C.Agardh)
Antithamnion cruciatum (C.Agardh) Nägeli
Apoglossum ruscifolium (Turner) J. Agardh
Asparagopsis armata Harvey
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon
Bangia atropurpurea (Roth) C. Agardh
Boergeseniella fruticulosa (Wulfen) Kylin
Bonnemaisonia clavata G. Hamel
Botryocladia borgesenii Feldmann
Botryocladia botryoides (Wulfen) Feldmann
Botryocladia chiajeana (Meneghini) Kylin
Botryocladia madagascariensis G.Feldmann

Botryocladia microphysa (Hauck) Kylin

Callithamnion corymbosum (Smith) Lyngbye

Callithamnion granulatum (Ducluzeau) C. Agardh

Calosiphonia vermicularis (J. Agardh) Schmitz

Catenella caespitosa (Withering) Irvine *in* Parke and Dixon

Centroceras clavulatum (C. Agardh) Montagne

Ceramium ciliatum (Ellis) Ducluzeau

Ceramium ciliatum var. *robustum* (J. Agardh) Mazoyer

Ceramium cimbricum H.E.Petersen in Rosenvinge

Ceramium circinatum (Kützing) J. Agardh

Ceramium codii (H.Richards) Mazoyer

Ceramium deslongchampsii Chauvin *ex* Duby

Ceramium diaphanum var. *strictum* Celan and Serbanescu

Ceramium flaccidum (Kützing) Ardissone

Ceramium siliquosum (Kützing) Maggs *and* Hommersend

Ceramium siliquosum var. *elegans* G. Furnari (Roth) G. Fur., Cor. and Serio

Ceramium siliquosum . var *zostericola* (Feldmann-Mazoyer) G.Furnari et al.

Ceramium tenerrimum (G. Martens) Okamura

Ceramium tenerrimum var. *brevizonatum* (H.E.Petersen) Mazoyer

Ceramium tenuicorne (Kützing) Waern

Champia parvula (C. Agardh) Harvey

Chondracanthus acicularis (Roth) Fredericq

Chondria capillaris (Hudson) Wynne

Chondria dasyphylla (Woodward) C. Agardh

Chondria mairei Feldmann-Mazoyer

Chondrophycus paniculatus (C. Agardh) Furnari

Chondrophycus papillosus (C. Agardh) Garbary *and* J. Harper

Chondrophycus succisus (A.B.Cribb) K.W.Nam

Choreonema thuretii (Bornet) Schmitz

Chroodactylon ornatum (C. Agardh) Basson

Chrysymenia ventricosa (Lamouroux) J. Agardh

Chylocladia verticillata (Lightfoot) Bliding

Coccotylus truncatus (Pallas) MJWynne ve JNHeine

Colaconema codicola (Børgesen), Stegenka, Bolton *and* Anderson

Colaconema daviesii (Dillwyn) Stegenga

Compsothamnion thuyoides (J.E. Smith) Schmitz

Contarinia peyssonneliaeformis Zanardini

Contarinia squamariae (Meneghini) Denizot

Corallina elongata Ellis *and* Solander

Corallina officinalis Linnaeus

Corallina panizzoi R.Schnetter and U.Richter

Corallina pinnatifolia (Manza) Dawson

Corallophila cinnabarina (Grateloup *ex* Bory) R.E. Norris

Crouania attenuata (C. Agardh) J.Agardh

Cryptonemia lomation (Bertoloni) J. Agardh

Dasya baillouviana (Gmelin) Montagne

Dasya corymbifera J. Agardh

Dasya hutchinsiae Harvey *in* W.J. Hooker

Dasya ocellata Hooker 1833 yılında (Grateloup) Harvey

Dasya punicea (Zanardini) Meneghini ex Zanardini

Dasya rigidula (Kützing) Ardissone

Digenea simplex (Wulfen) C. Agardh

Dipterosiphonia rigens (Shousboei) Falkenberg

Dudresnaya verticillata (Withering) Le Jolis

Erythrocystis montagnei (Derbès *and* Solier) Silva

Erythroglossum laciniatum (Lightfoot) Maggs ve Hommersand

Erythrotrichia carnea (Dillwyn) J. Agardh

Eupogodon planus (C.Agardh) Kützing

Falkenbergia hildenbrandii (Bornet) Falkenberg

Falkenbergia rufolanosa (Harvey) Schmitz

Galaxaura oblongata (J.Ellis ve Solander) JVLamouroux

Ganonema farinosum (Lamouroux) Fan *and* Wang

Gayliella fimbriata (Setchell and Gardner) Cho and S.M.Boo in Cho *et al.*

Gayliella mazoyerae Tocho, Fredericq ve Hommersand

Gelidiella lubrica (Kützing) Feldmann *and* Hamel

Gelidiella nigrescens (Feldmann) Feldmann *and* Hamel

Gelidiella ramellosa (Kützing) Feldmann *and* Hamel

Gelidiocolax christinae J. Feldman et G. Feldman

Gelidium affine Schiffner in Schiffner and Vatova

Gelidium corneum (Hudson) Lamouroux

Gelidium corneum var. *pectinatum* Ardissone and Strafforello

Gelidium crinale (Hare *ex* Turner) Gaillon

Gelidium minusculum (Weber-van Bosse) R.E. Norris

Gelidium pulchellum (Turner) Kützing

Gelidium pusillum (Stackhouse) Le Jolis

Gelidium spathulatum (Kützing) Bornet

Gelidium spinosum (Gmelin) Silva

Gelidium spinosum var. *hystrix* (J.Agardh) G.Furnari in Cormaci *et al.*

Gracilaria bursa-pastoris (Gmelin) Silva

Gracilaria gracilis (Stackhouse) Steentoft, Irvine *and* Farnham

Grateloupia dichotoma J. Agardh

Grateloupia filicina (Lamouroux) C. Agardh

Grateloupia prolongata J. Agardh

Griffithsia devoniensis Harvey

Griffithsia phyllamphora J. Agardh

Griffithsia schousboei Montagne

Griffithsia schousboei var. *minor* Feldmann ex Feldmann-Mazoyer

Gymnogongrus griffithsiae (Turner) Martius

Gymnogongrus palmettoides (J.Agardh) Ardissone

Gymnothamnion elegans (Schousboe *ex* C. Agardh) J. Agardh

Halarachnion ligulatum (Woodward) Kützing

Haliptilon roseum (Lamarck) Garbary *and* Johansen

Haliptilon squamatum (Linnaeus) Johansen, Irvine *and* Webster

Haliptilon virgatum (Zanardini) Garbary *and* Johansen

Halopithys incurva (Hudson) Batters

Halymenia floresii (Clemente y Rubio) C. Agardh

Halymenia latifolia P.Crouan and H.Crouan ex Kützing

Herposiphonia secunda (C. Agardh) Ambronn

Herposiphonia secunda var. *tenella* (C Agardh) Ambronn

Heterosiphonia crispella (C. Agardh)Wynne

Hildenbrandia rubra (Sommerfelt) Meneghini

Hydrolithon farinosum (J.V.Lamouroux) D.Penrose and Chamberlain

Hydrolithon farinosum var *chalicodictyum* (WRTaylor) Serio

Hypnea divaricata (C.Agardh) Greville

Hypnea musciformis (Wulfen *in* Jaquin) Lamouroux

Hypnea spinella (C.Agardh) Kützing

Hypoglossum hypoglossoides (Stackhouse) Collins *and* Harvey

Jania adhaerens J.V.Lamouroux

Jania longifurca Zanardini

Jania rubens (Linnaeus) J.V.Lamouroux
Jania rubens var. *corniculata* (Linnaeus) Yendo
Kallymenia requienii (J. Agardh) J. Agardh
Laurencia glandulifera (Kützing) Kützing
Laurencia obtusa (Hudson) Lamouroux
Laurencia obtusa var. *gracilis* (C.Agardh) Zanardini
Laurencia obtusa var. *laxa* (R.Brown ex Turner) Ardissone
Laurencia obtusa var. *racemosa* Kützing
Laurencia pyramidalis Bory de Saint-Vincent *ex* Kützing
Lejolisia mediterranea Bornet
Liagora distenta (Mertens ex Roth) J.V.Lamouroux
Liagora viscida (Forsskål) C. Agardh
Lithophyllum byssoides (Lamarck) Foslie
Lithophyllum cystoseirae (Hauck) Heydrich
Lithophyllum incrustans Philippi
Lithophyllum tortuosum (Esper) Foslie
Lomentaria articulata (Hudson) Lyngbye
Lomentaria clavellosa (Turner) Gaillon
Lomentaria verticillata Funk
Lophocladia lallemandii (Montagne) Schmitz
Lophosiphonia cristata Falkenberg
Lophosiphonia obscura (C. Agardh) Falkenberg
Lophosiphonia scopulorum (Harvey) Womersley
Lophosiphonia subadunca (Kützing) Falkenberg
Melobesia membranacea (Esper) Lamouroux sensu Chanberline and Irvine
Meredithia microphylla (J. Agardh) J. Agardh
Mesophyllum expansum (Philippi) Cabioch and Mendoza
Mesophyllum lichenoides (Ellis) Lemoine
Metapeyssonnelia feldmannii Boudouresque, Coppejans and Marcot
Monosporus pedicellatus Castagne
Myriogramme minuta Kylin
Nemalion helminthoides (Velley) Batters
Nemastoma dichotomum J. Agardh
Neogoniolithon Brassica-florida (Harvey) Setchell and LR Mason
Nitophyllum punctatum (Stackhouse)Greville
Osmundaria volubilis (Linnaeus) R.E. Norris
Osmundea pelagosae (Schiffner) Nam

Osmundea pinnatifida (Hudson) Stackhouse

Palisada perforata (Bory) KWNam

Parviphycus antipai (Celan) Santelices

Parviphycus tenuissimus (Feldmann and Hamel) Santelices

Peyssonnelia bornetii Boudouresque *and* Denizot

Peyssonnelia crispata Boudouresque *and* Denizot

Peyssonnelia dubyi P.L. Crouan *and* H.M. Crouan

Peyssonnelia harveyana P.Crouan and H.Crouan ex J.Agardh

Peyssonnelia polymorpha (Zanardini) Schmitz

Peyssonnelia rosa-marina Boudouresque *and* Denizot

Peyssonnelia rubra (Greville) J. Agardh

Peyssonnelia squamaria (Gmelin) Decaisne

Phyllophora crispa (Hudson) Dixon

Phyllophora sicula (Kützing) Guiry and LMIrvine

Phymatolithon lenormandii (Areschoug) Adey

Platoma cyclocalpa (Montagne) Schmitz

Pleonosporium borreri (J.E. Smith) Nägeli

Plocamium cartilagineum Linnaeus (Dixon)

Polysiphonia atra Zanardini

Polysiphonia breviarticulata (C.Agardh) Zanardini

Polysiphonia deusta (Roth) sprengel

Polysiphonia elongata (Hudson) Sprengel

Polysiphonia flocculosa (C.Agardh) Endlichter

Polysiphonia fucoides (Hudson) Greville

Polysiphonia furcellata (C. Agardh) Harvey

Polysiphonia opaca (C. Agardh) Moris and De Notaris

Polysiphonia paniculata Montagne

Polysiphonia sanguinea (C.Agardh) Zanardini

Polysiphonia sertularioides (Grateloup) J. Agardh

Polysiphonia stricta (Dillwyn) Greville

Polysiphonia tenerrima Kützing

Polysiphonia tripinnata J. Agardh

Polysiphonia urceolata (Lightfoot ex Dillwyn) Greville

Polysiphonia variegata (C. Agardh) Zanardini

Porphyra leucosticta Thuret in Le Jolis

Porphyra minör Zanardini

Porphyra umbilicalis (Linnaeus) Kützing

Pterocladiella capillacea (Gmelin) Santelices *and* Hommersand
Pterocladiella melanoidea (Schousboe ex Bornet) Santelices and Hommersand
Pterocladiella melanoidea var. *filamentosa* (Sch. Ex Bornet) MJWynne
Pterocladiella melanoidea . var *gracilis* (Feldmann ve Hamel) MJWynne
Pterosiphonia pennata (C. Agardh) Sauvageau
Pterothamnion crispum (Ducluzeau) Nägeli
Pterothamnion plumula (Ellis) Nägeli
Ptilothamnion pluma Le Jolis içinde (Dillwyn) Thuret
Radicilingua thysanorhizans (Holmes) Papenfuss
Rhodophyllis divaricata (Stackhouse) Papenfuss
Rhodymenia ardissonei (Kuntze) Feldmann
Rhodymenia ardissonei var. *spathulata* (Schiffner) Okudan *and* Aysel
Rhodymenia ligulata Zanardini
Rhodymenia pseudopalmata (Lamouroux) Silva
Rytiphlaea tinctoria (Clemente) C. Agardh
Rodriguezella strafforelloi F.Schmitz ex JJRodríguez y Femenías
Sahlingia subintegra (Rosenvinge) Kornmann
Scinaia furcellata (Turner) J. Agardh
Schottera nicaeensis (J.V.Lamouroux ex Duby) Guiry and Hollenberg
Seirospora giraudyi (Kützing) De Toni
Spermothamnion flabellatum Bornet in Bornet and Thuret
Spermothamnion repens (Dillwyn) Rosenvinge
Spermothamnion repens var. *flagelliferum* (De Notaris) G.Feldmann
Spermatochnus paradoksus (Roth) Kützing
Sphaerococcus coronopifolius Stackhouse
Spyridia filamentosa (Wulfen) Harvey *in* W.J. Hooker
Spyridia hypnoides (Bory) Pepenfuss
Stylonema alsidii (Zanardini) K. Drew
Stylonema cornu-cervi Reinsch
Taenioma nanum (Kützing) Papenfuss
Tenarea tortuosa (Esper) M.Lemoine
Titanoderma pustulatum (Lamouroux) Nägeli
Titanoderma trochanter (Bory de Saint-Vincent) Benhissoune et al.
Trailliella intricata Batters
Tricleocarpa cylindrica (Ellis *and* Solander) Huisman *and* Borowitzka
Tricleocarpa fragilis (Linnaeus) Huisman *and* Townsend
Wrangelia penicillata (C. Agardh) C. Agardh

Wurdemannia miniata (Sprengel) Feldmann *and* Hamel
OCHROPHYTA
Acinetospora crinita (Carmichael) Sauvageau
Asperococcus bullosus Lamouroux
Asperococcus fistulosus (Hudson) W.J. Hooker
Cladosiphon mediterraneus Kützing
Cladosiphon zosterae (J.Agardh) Kylin
Cladostephus spongiosus (Hudson) C. Agardh
Cladostephus spongium f. *verticillatum* (Lightfoot) Prud'homme van Reine
Colpomenia sinuosa (Mertens ex Roth) Derbès *and* Solier
Corynophlaea umbellata (C.Agardh) Kützing
Cutleria chilosa (Falkenberg) Silva
Cutleria multifida (Turner) Greville
Cystoseira amentacea Bory
Cystoseira amentacea var. *stricta* Montagne
Cystoseira barbata (Stack house) C. Agardh
Cystoseira compressa (Esper) Gerloff and Nizamuddin
Cystoseira corniculata (Turner) Zanardini
Cystoseira crinita (Desfontaines) Bory
Cystoseira crinitophylla Ercegovic
Cystoseira dubia Valiante
Cystoseira elegans Sauvageau
Cystoseira foeniculacea (Linnaeus) Greville
Cystoseira foeniculacea f. *tenuiramosa* (Ercegovic) A.Gómez Garreta et al.
Cystoseira humulis Schousboe *ex* Kützing
Cystoseira mediterranea Sauvageau
Cystoseira mediterranea . var *valiantei* Sauvageau
Cystoseira spinosa Sauvageau
Cystoseira squarrosa De Notaris
Cystoseira schiffneri Hamel
Dictyopteris polypodioides (De Candolle) Lamouroux
Dictyota dichotoma (Hudson) Lamouroux
Dictyota dichotoma var. *intricata* (C.Agardh) Greville
Dictyota implexa (Desfontaines) JVLamouroux
Dictyota fasciola (Roth) Lamouroux
Dictyota fasciola var *repens* (J.Agardh) Ardissone
Dictyota linearis (C.Agardh) Greville
Dictyota mediterranea (Schiffner) G.Furnari in Cormaci *et al.*
Dictyota menstrualis (Hoyt) Schnetter, Hornig and Weber-Peukert
Dictyota spiralis Montagne

Ectocarpus fasciculatus Harvey
Ectocarpus siliculosus (Dillwyn) Lyngbye
Ectocarpus siliculosus var. *crouanii* (Thuret) T. Gallardo.
Ectocarpus siliculosus var. *hiemalis* (P.Crouan & H.Crouan ex Kjellman) Gallardo
Ectocarpus virescens Thuret ex Sauvageau
Feldmannia caespitula (J. Agardh) Knoepffler-Péguy
Feldmannia globifera (Kützing) Hamel
Feldmannia irregularis (Kützing) Hamel
Feldmannia lebelii (Areschoug ex P.Crouan and H.Crouan) Hamel
Feldmannia padinae (Buffham) Hamel
Giraudia sphacelarioides Derbès *and* Solier
Halopteris filicina (Grateloup) Kützing
Halopteris scoparia (Linnaeus) Sauvageau
Halopteris scoparia var. *patentissima* Sauvageau
Halothrix lumbricalis (Kützing) Reinke
Hapalospongidion macrocarpum (Feldmann) León-Álvarez & González-González
Hincksia mitchelliae (Harvey) Silva
Hincksia sandriana Silva (Zanardini) PC Silva
Hydroclathrus clathratus (C. Agardh) Howe
Leathesia mucosa Feldmann
Liebmannia leveillei J. Agardh
Lobophora variegata (Lamouroux) Womersley *ex* Oliveira
Myriactula arabica (Kützing) Feldmann
Myriactula rivulariae (Shur) Feldmann
Myrionema strangulans Greville
Myriotrichia clavaeformis Harvey
Padina pavonica (Linnaeus) Thivy
Petalonia fascia (O.F.Müller) Kuntze
Punctaria latifolia Greville
Ralfsia verrucosa (Areschoug) Areschoug
Sargassum acinarum (Linnaeus) Setchell
Sargassum hornschuchii C.Agardh
Sargassum vulgare C. Agardh
Scytosiphon simplicissimus (Clemente) Cremades
Sphacelaria cirrosa (Roth) C. Agardh
Sphacelaria cirrosa f. *mediterranea* Sauvageau
Sphacelaria fusca (Hudson) S.F. Gray
Sphacelaria plumula Zanardini
Sphacelaria rigidula Kützing
Sphacelaria tribuloides Meneghini
Sphaerotrichia divaricata (C. Agardh) Kylin

Stilophora tenella (Esper) Silva
Streblonema sphaericum (Derbès *and* Solier) Thuret
Stypopodium schimperi (Buchinger ex Kützing) Verlaque and Boudouresque
Taonia atomaria (Woodward) J. Agardh
Taonia atamaria f. *ciliata* (C.Agardh) Nizamuddin
Zanardinia typus (Nardo) Furnari
Zonaria tournefortii (Lamouroux) Montagne

CHLOROPHYTA

Acetabularia acetabulum (Linnaeus) Silva
Acrochaete repens Pringsheim
Anadyomene stellata (Wulfen) C. Agardh
Bolbocoleon piliferum Pringsheim
Bryopsis adriatica (J.Agardh) Frauenfeld
Bryopsis corymbosa J. Agardh
Bryopsis duplex De Notaris
Bryopsis flagellata Kützing
Bryopsis hypnoides Lamouroux
Bryopsis muscosa Lamouroux
Bryopsis pennata Lamouroux
Bryopsis plumosa (Hudson) C. Agardh
Caulerpa prolifera (Forsskål) Lamouroux
Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman and Boudouresque
Caulerpa racemosa var. *lamourouxii* f. *requienii* (Montagne) Weber-van Bosse
Caulerpa scalpelliformis var. *denticulata* (Dacaisne) Weber van Bosse
Caulerpa taxifolia var. *distichophylla* (Sonder) Verlag., Huisman and Procaccini in Jongma et al.
Chaetomorpha aerea (Dillwyn) Kützing
Chaetomorpha linum (Müller) Kützing
Chaetomorpha mediterranea (Kützing) Kützing
Chlorotylium cataractarum Kützing
Cladophora aegagropila (Linnaeus) Trevisan
Cladophora albida (Nees) Kützing
Cladophora catenata Kützing
Cladophora coelothrix Kützing
Cladophora dalmatica Kützing
Cladophora densissima Kützing
Cladophora flexuosa (O.F.Müller) Kützing
Cladophora glomerata (Linnaeus) Kützing

Cladophora glomerata f. *marina* (Kützing) Hauck

Cladophora hutchinsiae (Dillwyn) Kützing

Cladophora laetevirens (Dillwyn) Kützing

Cladophora lehmanniana (Lindenberg) Kützing

Cladophora mediterranea Hauck

Cladophora oblitterata Söderström

Cladophora pellucida (Hudson) Kützing

Cladophora prolifera (Roth) Kützing

Cladophora rupestris (Linnaeus) Kützing

Cladophora sericea (Hudson) Kützing

Cladophora trichotoma (C. Agardh) Kützing

Cladophoropsis modenensis (Kützing) Børgesen

Codium adhaerens 1822 C.Agardh

Codium bursa (Linnaeus) C. Agardh

Codium effusum (Rafinesque) Delle Chiaje

Codium fragile (Suringar) Hariot

Codium taylorii P.C.Silva

Codium tomentosum Stackhouse

Codium vermilara (Olivi) Delle Chiaje

Conferva densissima (Kützing) Zanardini

Dasycladus vermicularis (Scopoli) Krasser

Derbesia tenuissima (Morris & De Notaris) P. L. Crouan and H. M. Crouan

Enteromorpha clathrata (Roth) Greville

Enteromorpha compressa (Linnaeus) Nees

Enteromorpha flexuosa (Wulfen) J. Agardh

Enteromorpha intestinalis (Linnaeus) Nees

Enteromorpha kylinii Bliding

Enteromorpha linza (Linnaeus) J. Agardh

Enteromorpha linza var. *crispata* (Bertoloni) Hylmö

Enteromorpha linza f. *minor* Schiffner in Schiffner and Vatova

Enteromorpha prolifera (Müller) J. Agardh

Entocladia viridis Reinke

Epicladia flustrae Reinke

Flabellia petiolata (Turra) Nizamuddin

Gayralia oxysperma (Kützing) K.L.Vinogradova ex Scagel *et al.*

Gomontia polyrhiza (Leigerheim) Bornet *and* Flahault

Halimeda tuna (J.Ellis ve Solander) JVLamouroux
Microdictyon tenuius J.E. Gray
Palmophyllum crassum (Naccari) Rabenhorst
Parvocaulis parvula (Solms-Laubach) S. Berger et al.
Pedobesia simplex (Meneghini ex Kützing) Wynne and Leliaert
Penicillus capitatus Lamarck
Phaeophila dendroides (P. L. Crouan *and* H. M. Crouan) Batters
Planophila microcystis (Dangeard) Kornmann *and* Sahling
Pringsheimiella scutata (Reinke) Höhnel *ex* Marchewianka
Pseudobryopsis myura Oltmanns
Pseudochlorodesmis furcellata (Zanardini) Børgesen
Rhizoclonium riparium (Roth) Harvey
Rhizoclonium tortuosum (Dillwyn) Kützing
Siphonocladus pusillus (C.Agardh ex Kützing) Hauck
Sphaeroplea Annulina (Roth) C.Agardh
Ulothrix flacca Le Jolis bölgesindeki (Dillwyn) Thuret
Ulothrix implexa (Kützing) Kützing
Ulothrix zonata (Weber *and* Mohr) Kützing
Ulva curvata (Kützing) De Toni
Ulva fasciata Delile
Ulva lactuca Linnaeus
Ulva laetevirens Areschoug
Ulva polyclada Kraft
Ulva rigida C. Agardh
Ulvella lens P. L. Crouan *and* H. M. Crouan
Ulva taeniata (Setchell) Setchell and NLGardner
Valonia macrophysa Kützing
Valonia utricularis (Roth) C. Agardh

MAGNOLIOPHYTA

Cymodocea nodosa (Ucria) Ascherson
Halophila stipulacea (Forsskål) Ascherson
Posidonia oceanica (Linnaeus) Delile
Zostera marina Linnaeus
Zostera noltii Homermann

In spite of the fact that the strong flows in the east-west direction reduce the effect of the pollution on the coast, the pollution on the Mediterranean coast of Turkey has reached serious dimensions due to the increasing population density on the coastal belt in recent years. Mugla, Antalya, Mersin, Adana and Hatay are the cities of tourism and agriculture which are coastal to the Mediterranean and rapidly urbanized. Mediterranean coasts are gradually falling under the pressure of seawater quality, terrestrial pollutants, inflows from rivers and wastewater discharged to the sea, especially in İskenderun, Mersin, Antalya and Fethiye gulf coasts where city centers are located. The expansion of tourism-oriented areas, migration and rapid urbanization are the reasons for the continuous increase in population. In parallel to this, sea water pollution load is also increasing. This affects the transport capacities of living systems living in the marine environment and causes various changes in these systems.

The coastal strip has a flat structure due to the fact that the Taurus mountain range extends parallel to the coast along the Mediterranean Sea, and it shows offshore character. The coast, which is usually composed of shorelines and long sandy shorelines, is weak to meet the hard substrate structure required by the algae.

The Atlantic waters that pass through the Sicilian Straits increase their salinity as they move eastward. These waters, which can be found at depths of 150-300 m from the surface, increase in density due to excessive evaporation due to the warming, sinking to the bottom and forming the middle water layer of the Eastern Mediterranean as they progress in the east direction. Thus, the productive layer is deprived of the nutrient salts used in the primary production due to the surface waters. For this reason, the Eastern Mediterranean shows an oligotrophic character. In the Eastern Mediterranean, the salinity of surface water varies between 038.5% and 16-27 ºC. While these parameters show a decrease in large river deltas such as Ceyhan, Seyhan and the areas such as İskenderun Gulf, the salinity and temperature values may increase by 039.5% and 29.3 ºC respectively (Avşar 1999). The changing water quality parameters from the west to the east have an impact on the diversity and coverage of sea macroalgae and flowering plants. As we move to the east, we see a decrease in species diversity and coverage. Especially the marine meadows (*Posidonia oceanica* (Linnaeus) Delile) beds are disappearing from Sığacık/Mersin coasts.

When the Mediterranean coasts of Turkey are evaluated as regional, Iskenderun Gulf waters (mean 70m) located at the easternmost and shallow depth compared to the region are heavily mixed vertically due to dominant winds in the region. Industrialization on the Iskenderun Gulf coast is more favorable than Turkey's other Mediterranean coasts; iron and steel plants, fertilizer factories, oil filling plants etc Due to the industrial, especially population-intensive urban origin of these plants, agricultural and intensive harbor traffic pollution brought by the Ceyhan River which flows from Çukurova to the bay, the Iskenderun Gulf is under heavy pollution (Avşar 1999). This intense pollution in the bay has an impact on the diversity and coverage of macro and flowering plants. Öztürk and Taşkın (1999) and Taşkın *et al.* (2004) found 29 brown algae, 54 red algae and 27 green algae, respectively, in their studies on the shores of the Hatay province of Iskenderun Gulf.

The Antalya Gulf travertine limestone is similar to the calcium carbonate structure and abundant freshwater resources and the development of macroalgae. These limestone algae (*Amphiroa beauvoisii* Lamouroux, *Amphiroa cryptarthrodia* Zanardini, *Amphiroa rigida* Lamouroux, *Haliptilon roseum* (Lamarck) Garbary *and* Johansen, *Haliptilon squamatum* (Linnaeus) Johansen, Irvine *and* Webster, *Haliptilon virgatum* (Zanardini) Garbary *and* Johanse, *Jania longifurca* Zanardini, *Jania rubens* (Linnaeus) J.V.Lamouroux, *Lithophyllum cystoseirae* (Hauck) Heydrich, *Lithophyllum incrustans* Philippi, *Mesophyllum expansum* (Philippi) Cabioch and Mendoza, *Mesophyllum lichenoides* (Ellis) Lemoine), are covering values are 100% of the land area, these algae form a terrace structure. These biologically rich formations protect the rock layer they are on with the limestone layer they formed against coastal erosion. These biological structures that occur in areas open to shallow sublittoral wave effects are highly sensitive to changes and pollution in environmental conditions (Figure 3).

The region with the richest diversity of Turkey's Mediterranean coast is Gelidonya Burnu and Beş Adalar. In this region, where there are plenty of currents, there are species scattered in the Mediterranean coasts and have reached a high covering value (Figure 4).

Kaş and its environs are rich in species diversity, and Turkey is one of the most important regions of the Mediterranean coast, which is important in terms of sheltering all macro-aged and protected meadows (Figure 5).

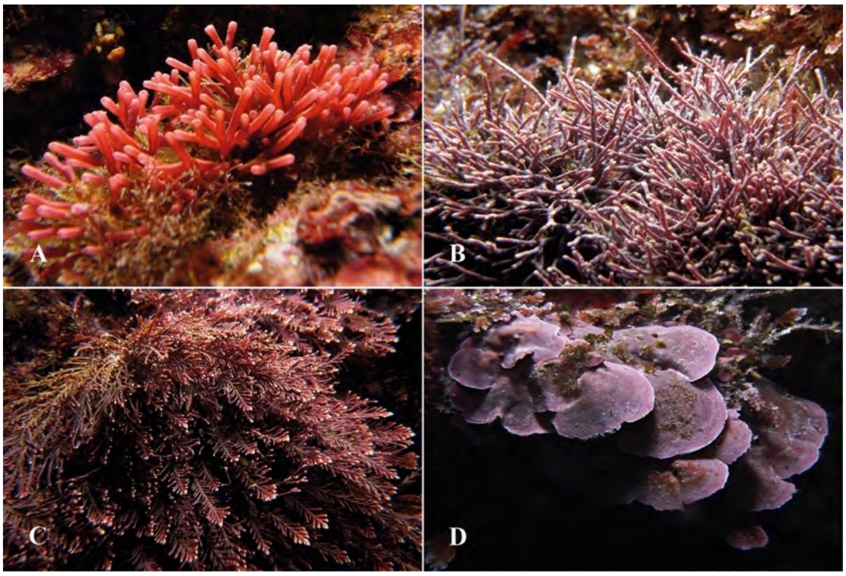

Figure 3. Underwater images of some of the algae distributed in the Antalya Gulf traverten cliffs. A: *Galaxaura oblongata,* B: *Amphiroa rigida*, C: *Corallina elongata*, D: *Lithophyllum stictaeforme*.

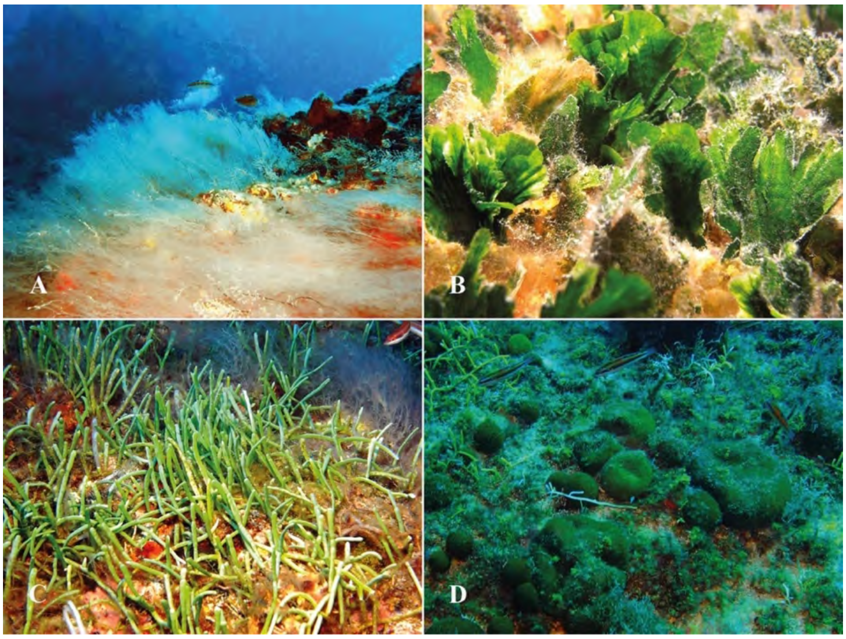

Figure 4. Antalya Underwater images of some of the algae that are distributed in the area of Beş Adalar. A: *Spyridia filamentosa*, B: *Flabellia petiolata*, C: *Caulerpa racemosa* [*lamourouxii*] f. *requienii*, D: *Codium bursa*.

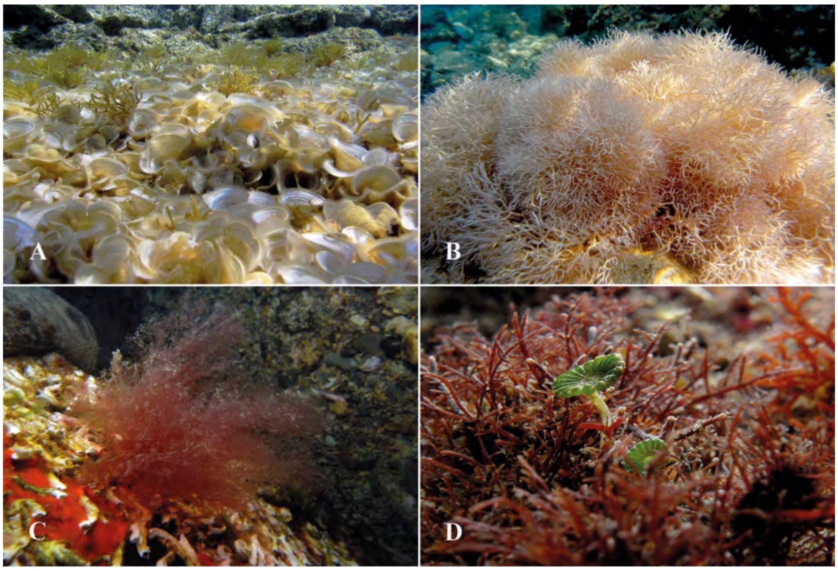

Figure 5. Underwater images of some of the algae scattered on the Kas shores. A: *Padina pavonica*, B: *Liagora viscida*, C: *Dudresnaya verticillata*, D: *Parvocaulis parvulus*.

3.1. Exotic Species Identified on the Mediterranean Coast of Turkey

A total of 22 exotic species, 10 red algae (*Acanthophora nayadiformis* (Delilei) Papenfuss, *Asparagopsis armata* Harvey, *Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, *Botryocladia madagascariensis* G. Feldmann, *Colaconema codicola* (Børgesen), Stegenka, Bolton and Anderson, *Ganonema farinosum* (Lamouroux) Fan and Wang, *Hypnea spinella* (C. Agardh) Kützing, *Lophocladia lallemandii* (Montagne) Schmitz, *Polysiphonia fucoides* (Hudson) Greville, *Polysiphonia paniculata* Montagne), 4 brown algae (*Cladosiphon zosterae* (J. Agardh) Kylin, *Ectocarpus siliculosus* var. *hiemalis* (P.Crouan and H.Crouan ex Kjellman) Gallardo, *Halothrix lumbricalis* (Kützing) Reinke, *Stypopodium schimperi* (Buchinger ex Kützing) Verlaque and Boudouresque), 7 green algae (*Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman and Boudouresque, *Caulerpa racemosa* var. *lamourouxii* f. *requienii* (Montagne) Weber-van Bosse, *Caulerpa scalpelliformis* var. *denticulata* (Dacaisne) Weber van Bosse, *Caulerpa taxifolia* var. *distichophylla* (Sonder) Verlaque, Huisman and Procaccini in Jongma *et al. Codium fragile* (Suringar) Hariot, *Codium taylorii* P.C. Silva, *Ulva fasciata* Delile) and 1 Seagrass (*Halophila stipulacea* (Forsskål) Ascherson) have been identified on Mediterranean coast of Turkey (Figures 6 and 7).

One of the factors that threaten marine biodiversity in the world is the transport of alien species. The natural distribution and migrations of species are degraded by human activities and the local communities of immigrant communities are threatened by individuals (Ruiz *et al.* 1997; Grosholz 2002; Bax *et al.* 2003). After the opening of the Suez Canal towards the end of the 1800s, living species called "Lessepsian Migrants" began to expand their distribution areas rapidly by entering the Mediterranean via the Indian Ocean and the Red Sea. Experts are concerned that foreign marine plant species in the Mediterranean will suppress native species in the middle of the twenty-first century, at this rate. A new entry into the exotic species of tropical origin is described as "biological occupation" or "biological contamination" (Cirik and Akçalı 2002). In transporting these alien species between zones, the hulls of the vessels, bilge and ballast waters are important factors. The best example of invasive algae and benthic community structures is *Caulerpa* species of tropical origin which cause alarm in the Mediterranean. (Boudouresque *et al.* 1995).

The coverage values of Caulerpa species distributed on the Mediterranean coast of Turkey are low, but their population dynamics should be monitored.

Caulerpa prolifera: This type of distribution, which is distributed in the Atlantic Ocean and the Mediterranean Sea, provides many living accommodation environments with its soft gage fixing feature.

***Caulerpa racemosa var. cylindracea*:** It is believed that this approach, which is not exactly known as the way to the Mediterranean, moved from Southwest Australia to the Mediterranean. The species is distributed on hard and soft substrates.

Caulerpa racemosa var. [lamourouxii] f. requienii: It is distributed in the Indo-Pacific and Atlantic Ocean. Entered the Mediterranean through the Suez Canal. The species is distributed on hard and soft substrates.

Caulerpa scalpelliformis var. denticulata: The entrance to the tidal Mediterranean, which is scattered in the Indian Ocean, has been through the Suez Canal Channel. The species is distributed on hard and soft substrates.

Caulerpa taxifolia var. distichophylla: The way to the Mediterranean, which is scattered in the Atlantic, Indian and Pacific Oceans, is not known precisely. The species is distributed on hard and soft substrates.

Figure 6. Underwater images of *Caulerpa* species distributed on the Mediterranean coast of Turkey. A: *Caulerpa racemosa*, B: *Caulerpa taxifolia* var. *distichophylla*, C: *Caulerpa prolifera*, D: *Caulerpa racemosa* var. [*lamourouxii*] f. *requienii*.

3.2 Threatened Species of Macroalgae and Phanerogams in the Mediterranean Coast of Turkey

According to Bern and Barcelona conventions, a total of 28 threatened species, 5 species belonging to sea grasses (*Posidonia oceanica* (Linnaeus) Delile, *Halophila stipulacea* (Forsskål) Ascherson in Anon., *Cymodocea nodosa* (Ucria) Ascherson, *Zostera marina* Linnaeus, *Zostera noltei* Hornemann) and 23 species belonging to macroalgae (*Lithophyllum byssoides* (Lamarck) Foslie, *Lithophyllum tortuosum* (Esper) Foslie, *Tenarea tortuosa* (Esper) M.Lemoine, *Titanoderma trochanter* (Bory de Saint-Vincent) Benhissoune, Boudouresque, Perret-Boudouresque and Verlaque, *Cystoseira amentacea* Bory, *Cystoseira amentacea* var. *stricta* Montagne, *Cystoseira barbata* (Stackhouse) C. Agardh, *Cystoseira crinita* (Desfontaines) Bory, *Cystoseira corniculata* (Turner) Zanardini, *Cystoseira crinitophylla* Ercegovic, *Cystoseira dubia* Valiante, *Cystoseira elegans* Sauvageau, *Cystoseira foeniculacea* (Linnaeus) Greville, *Cystoseira foeniculacea f. tenuiramosa* (Ercegovic) A.Gómez Garreta, M.C.Barceló, M.A. Ribera and J. Rull Lluch, *Cystoseira humulis* Schousboe ex Kützing, *Cystoseira mediterranea* Sauvageau, *Cystoseira mediterranea* . var *valiantei* Sauvageau, *Cystoseira spinosa* Sauvageau, *Cystoseira squarrosa* De Notaris, *Cystoseira schiffneri* Hamel, *Sargassum* *acinarum* (Linnaeus) Setchell, *Sargassum hornschuchii* C.Agardh, *Sargassum vulgare* C. Agardh) have been identified on Mediterranean coast of Turkey (Figure 7).

Lithophyllum byssoides (Lamarck) Foslie, *Tenarea tortuosa* (Esper) M. Lemoine, *Titanoderma trochanter* (Bory de Saint-Vincent) Benhissoune, Boudouresque, Perret-Boudouresque and Verlaque, Calalifera are a calcified red alga of the order Corallinales. Corallines members are hermatypic organisms and play important geological and ecological roles in marine ecosystems with their biological construction properties (Basso *et al.* 2005; Maneveldt *et al.* 2008; Okudan *et al.* 2014). These species develop at 0-1 m depth, open to wave effect, set with lots of light, and grow on the walls. In their environment, they have a 30-40% coverage feature. Their development continues throughout the year. These species, which are extremely sensitive to changes in the habitat, develop into clean and bright waters. Due to their susceptibility to contamination, the indicator carries live indicator for pollution, temperature and salinity (Bressan Babbini-Benussi 1996). These species, whose development process is very slow (1mm/year), require a long time for repair/re-development, even after appropriate destruction, even under favorable conditions.

Cystoseira sp. and Sargassum sp. generally develop in clean water at depths of 10-30 m. Due to the low tolerance of pollution, it provides clean environment indicator.

Figure 7. Underwater images of some exotic and protected species scattered on the Mediterranean coast of Turkey. A: *Sargassum acinarium*, B: *Asparagopsis taxiformis*, C: *Titanoderma trokanter*, D: *Tenarea tortuosa*.

3.3. Distribution of Fanerogams in Turkey's Mediterranean Coast

Four fanogam (*Posidonia oceanica*, *Zostera marina*, *Cymodocea nodosa* and *Halophila stipulacea*) form facies on Mediterranean coast of Turkey (Figure 8).

Figure 8. Underwater images of the species beneath some sea meadows scattered on the Mediterranean coast of Turkey. A: *Posidonia oceanica*, B: *Cymodocea nodosa*, C: *Halophila stipulacea* , D: *Posidonia oceanica* meadows (Photo by Hasan YOKEŞ)

Sea meadows are benthic marine flowering plants that prefer sandy and muddy areas, living between 0.2-40 m depths. They form a dense layer that stretches and spreads vertically and horizontally, capturing the sea bed. The sea floor in the area they are in is moving. With their roots, the sea-bottom coarse/muddy waters make these areas of rocky ground unsuitable for marine life transform into a stable structure, thus preventing both bottom erosion and stabilizing the bottom structure. In this view, the hanger hangs on the ground by holding the load and sediment. They form the habitat with the most robust biological and ecological structure that can exist on this ground. In the case of the destruction of grasses, the balance of organic matter, sediment and water distribution in the environment is disturbed and the whole water column is affected. The amount of suspended solids in the water column prevents turbulence from penetrating deep into the sunlight needed for photosynthesis. As a result, life in its entirety is destroyed and habitat and biotope losses occur in significant proportions (Paul and Roy 2006). Seagrass meadows, which form one of the first rings of the food chain in the sea, also have the characteristic of being a habitat by providing food, shelter, living and reproduction environment to many sea creatures. The diversion or destruction of sea meadows also leads to a decrease in biodiversity. With these features, the ecological and economic roles of seagrass meadows can not be ignored (Duarte 1999, 2002). Generations in general are at risk because of their exposure to many environmental pressures, such as coastal settlements, tourism printing, pollution, cage fishery, trawler hunting, boat hoeing and so on. Sea meadows on the IUCN Red List are protected by international treaties Bern (1996) and Barcelona (1995) and by law, including our country. Sea grass beds are considered as priority habitats in the European Union Habitats Directive.

In particular, the beds of *P. oceanica*, which have extensive knowledge of biology and ecology, contain biodiversity-rich ecosystems along the coastal zone (Pergent-Martini *et al.* 2006). Due to high sensitivity to environmental change at the littoral spot (Short *and* Wyllie-Echeverria 1996; Ruiz *and* Romero 2003) and having large distribution areas on the Mediterranean coast the coastal zone (Pasqualini *et al.* 1998; Procaccini *et al.* 2003) is used as a descriptive species in the evaluation of the overall environmental quality (Boudouresque *et al.* 2000; Moreno *et al.* 2001; Pergent-Martini *et al.* 2005).

Since the beginning of the 20. century, the loss of sea meadows has reached important levels in regions where urbanization and human activities are concentrated. Especially the anchors of boats anchored in closed waters cause significant damage to the benthos and habitat damage to marine meadows (Milazzo *et al.* 2002; Okudan *et al.* 2011). The mechanical effects of these anchors, which are used to anchor, vary according to the type and size of the anchors (Francour *et al.* 1999). Developing appropriate management and monitoring procedures is crucial to remove damage from such activities. For this reason, it should be determined where, how much and how well the grasslands are distributed. The study on the effects of boat hoees on the sea beds of our country is carried out by Okudan *et al*. (2011) in Fethiye-Göçek special protection zone. In these studies, 2500 technicians visited the site daily and found the damage in the village.

The marine meadows (especially Posidonia oceanica), which is distributed in the area with extensive ship traffic in the study area, have suffered great damage due to anchoring. *Posidonia oceanica* deposits show an unhealthy appearance where the anchor traces are found (Figure 8D).

3.4. A benthic mucilage event in Mediterranean Coast of Turkey.

Global warming, which has emerged as a result of the rapid increase in greenhouse gases (especially carbon dioxide) released into the atmosphere over the last

40-50 years, is one of the most important threats to the Earth. The effects of climate change manifest themselves at various stages of marine ecosystem processes.

The increase in global warming and organic entrainment causes the rapid increase of benthic mucilagenes, mostly composed of diatom and cyanobacteria colonies. Particularly Cyanobacteria are living creatures adorned with extreme environmental conditions. The increase in the diversity and density of Cyanobacteria in a region is a biological indicator of the change in water quality and is a sign of high levels of phosphorus, nitrogen, iron, organic carbon, etc.. Cyanobacteria colonies seen in areas of high organic contamination hold suspended particles, forming a thick, opaque covering on the substrate (Albert *et al.* 2005; Whitton *and* Potts 2000) (Figure 9).

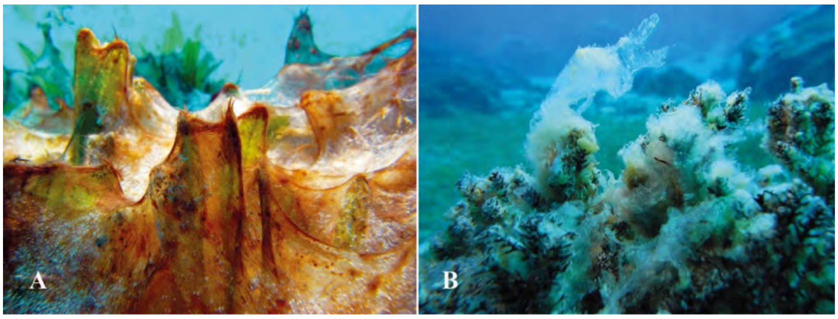

Figure 9. Benthic mucilagene formations on Mediterranean coast of Turkey.

Acknowledgements

We would like to thank Hasan YOKEŞ for his underwater photo (Figure 8D).

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ZOOPLANKTON OF THE TURKISH PART OF THE MEDITERRANEAN SEA

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1. Introduction

1.1. Ecological position in the food web

The ecological role of organisms is largely determined by its position and importance in the food web. Lenz (2000) stated that zooplankton play a key role in the pelagic food web by controlling phytoplankton production and shaping pelagic ecosystems. It is regarded as the most important biological factor by controlling commercial fish stocks in terms of food for the larvae of fishes. Indeed, zooplanktonic organisms by grazing on the photosynthetic organisms namely phytoplankton cause the transportation of protein which upper trophic levels need and therefore, determines the amount and composition of vertical particle flux (Gajbhiye 2002). It is important to study zooplankton for understanding and predicting the impact of environmental changes on fish stocks and for modelling the cycling of biogeochemical key elements such as carbon, nitrogen and phosphorous (Lenz 2000).

1.2. Factors affecting zooplankton distribution

Zooplankton distribution is generally affected by several physical (e.g.temperature, salinity, water circulations), biological (e.g. food availability, food quality, predation) and chemical (e.g. oxygen concentration, pollution) factors (Valiela 1995). Geographical environment of the region plays an important role on the distribution of planktonic organisms. Study done by Jespersen 1923 (cited in Ozel 1995) reveals that the zooplankton biomass decrease from west to the east of Mediterranean. The Strait of Gibraltar, which connects the Atlantic Ocean to the Mediterranean Sea, is not a barrier but isolate the transportation of Atlantic species into the Mediterranean. However, it is known that the Atlantic species were seen in the Lebanese waters (Lakkis 1976, 1984). The Strait of Gibraltar is shallow, therefore only the middle water Atlantic zooplankton species could pass the strait. Indeed, there are species which incoming to the Mediterranean Sea from the Red Sea and the Indian Ocean by the Suez Canal and from the Black Sea by the Turkish Straits Systems (Özel 1995). Water circulation system leads to the spreading of zooplankton species from offshore to shallow stations and vice versa (Siokou-Frongou *et al*. 1998).

In the Northeastern Mediterranean, the zooplankton abundance was affected by hydrographic properties. Transportation of nutrient rich coastal waters to the offshore regions especially in the gyre areas were a good source for zooplankton increase (Terbıyık *et al.* 2013; Kurt 2016). Besides abiotic factors, trophic conditions of the environment were an important factor affecting zooplankton (Terbıyık Kurt and Polat 2013, 2015; Kurt 2016). Trophic element was the main factor affecting the density distribution of zooplankton, whereas species distributions were more affected by hydrographical parameters, namely: seawater temperature and salinity (Terbıyık Kurt and Polat 2013). Indeed, between zooplankton abundance and biomass with temperature statistically no correlation were found, on the other hand with surface chlorophyll-*a* values there were positive correlation in the Cilician Basin (Uysal *et al.* 2008).

1.3. History of the zooplankton research

There are several zooplankton studies concerning the distribution and composition in the eastern Mediterranean Sea (El-Maghraby 1965; Kimor and Wood 1975; Lakkis 1976, 1984; Gücü 1987; Pancucci-Papadopoulou *et al.* 1992; Mazzochi *et al.* 1997; Uysal *et al.* 2002; Gotsis-Skretas *et al.* 1999; Mazzocchi *et. al.* 2014). Especially, zooplankton studies done in the Northeastern Mediterranean are generally focus on the determination of variations in distribution of zooplankton community, size structure, abundance and biomass. In the Turkish part of the Northeastern Mediterranean Sea, first attempt on plankton studies was started in Iskenderun Bay (Gokalp 1972) and many investigations have been carried on zooplankton until today. Zooplankton studies were mostly concentrated in the Mersin Bay (Gücü 1987; Uysal *et al.* 2002; Uysal and Shmeleva 2002; Zenginer Yilmaz and Besiktepe 2010; Uysal and Shmeleva 2012; Zenginer Yilmaz and Ak Orek 2016) and Iskenderun Bay (Toklu and Sarıhan 2003; Cevik *et al.* 2006; Toklu 2006; Lakkis and Toklu-Alıçlı 2007; Terbıyık Kurt and Polat 2013, 2014, 2015). Additionally, there were other studies accomplished in the Levantine Sea (Uysal and Murina 2005; Uysal *et al.* 2008; Terbıyık Kurt *et al.* 2010; Terbıyık Kurt *et al.* 2013; Uysal *et al.* 2014). In this chapter, you will find the distribution of species composition and main groups of zooplanktonic organisms in the ecologically different regions of Turkish waters in the Mediterranean Sea.

2. Methodology

Several studies were conducted in different parts of Mediterranean coast of Turkey. Zooplankton hauls were sampled with recently used WP-2 plankton net (200µm) in most of the studies (Donmez 2006; Toklu 2006; Lakkis and Toklu Alıçlı 2007; Terbıyık *et al.* 2007; Terbıyık and Sarihan 2008; Terbıyık *et al.* 2010; Terbıyık Kurt and Polat 2013, 2014, 2015; Kurt 2016; Uysal *et al.* 2014; Zenginer Yilmaz and Ak Orek 2016). In the previous studies, Nansen net was used with different mesh sizes such as 112 µm (Uysal *et al.* 2002; Uysal and Murina 2005; Zenginer- Yilmaz and

Besiktepe 2010; Uysal and Shmelava 2012) and 175 µm (Gücü 1987). Zooplankton abundance and biomass values were given in ind. m^{-3} and mg m^{-3}, respectively in these studies. Moreover, zooplankton biomass values could be calculated from biovolume by conversion factors between zooplankton volume and carbon content (Wiebe 1988; Alcaraz *et al.* 2003). There were some studies in which the biomass values were given in mm^3 m^{-3}. Recently, the use of imaging techniques such as Zooscan with associated semi-automatic classification technique enabled the estimation of size and biovolume of zooplanktonic organisms (Gorsky *et al.* 2010; Garcia-Comas 2014; Garijo and Hernández-León 2015; Dai *et al.* 2016). In this chapter, data about zooplankton groups and species distribution that have been collected in the Turkish part of Mediterranean Sea since from the first study were shown in Figure 1 will be discussed in the Results and Discussion part.

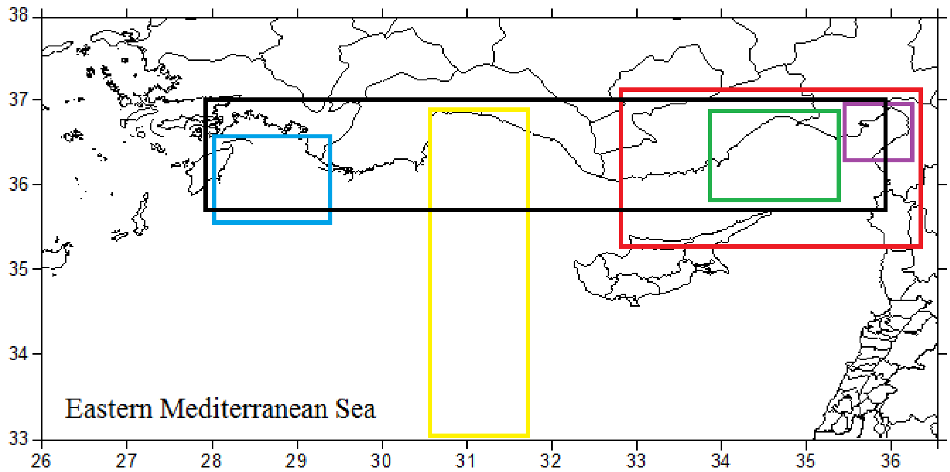

Figure 1. Studied areas in the Mediterranean parts of the Turkey. Blue square: Rhodos (Uysal *et al.* 2002), Yellow square: Antalya bay and its offshore (Terbıyık *et al.* 2010), Red square: Cilician Basin (Uysal *et al.* 2008; Kurt 2016); Green square: Mersin Bay (Gücü 1987; Uysal *et al.* 2002; Uysal and Murina 2005; Zenginer Yilmaz and Beşiktepe 2010; Uysal and Shmelava 2012; Zenginer-Yilmaz and Ak-Orek 2016); Purple square: Iskenderun Bay (Toklu 2006; Terbıyık *et al.* 2007; Terbıyık and Sarihan 2008; Terbıyık *et al.* 2010; Terbıyık *et al.* 2013, Terbıyık Kurt and Polat 2013, 2014, 2015; Kurt 2016); Black square: Zenginer Yılmaz, unpublished data)

3. Results and Discussion

3.1 Zooplankton standing stock

A conspectus of the regional and temporal distribution of zooplankton standing stock in the Turkish part of the Mediterranean Sea exhibits clear variations. In the

Northern Levantine Sea, zooplankton abundance was generally higher in the coastal stations of Mersin Bay in all seasons (Figure 2, unpublished data). The maximum zooplankton abundance was found in May 2013 with 14275 ind m^{-3} and 9465 ind m^{-3} at two coastal stations located in the Mersin Bay. Comparing the seasons, the minimum abundance values were observed in September. Moreover, the minimum abundance values were generally observed in the open waters (Figure 2, unpublished data). The biovolume values varied between 5 and 1700 mm^3 m^{-3} in the northern Levantine Sea. The highest biovolume values were observed in March 2013. The high biovolume values are coming from the existence of bigger organisms larger than >500 µm. (Figure 3, unpublished data).

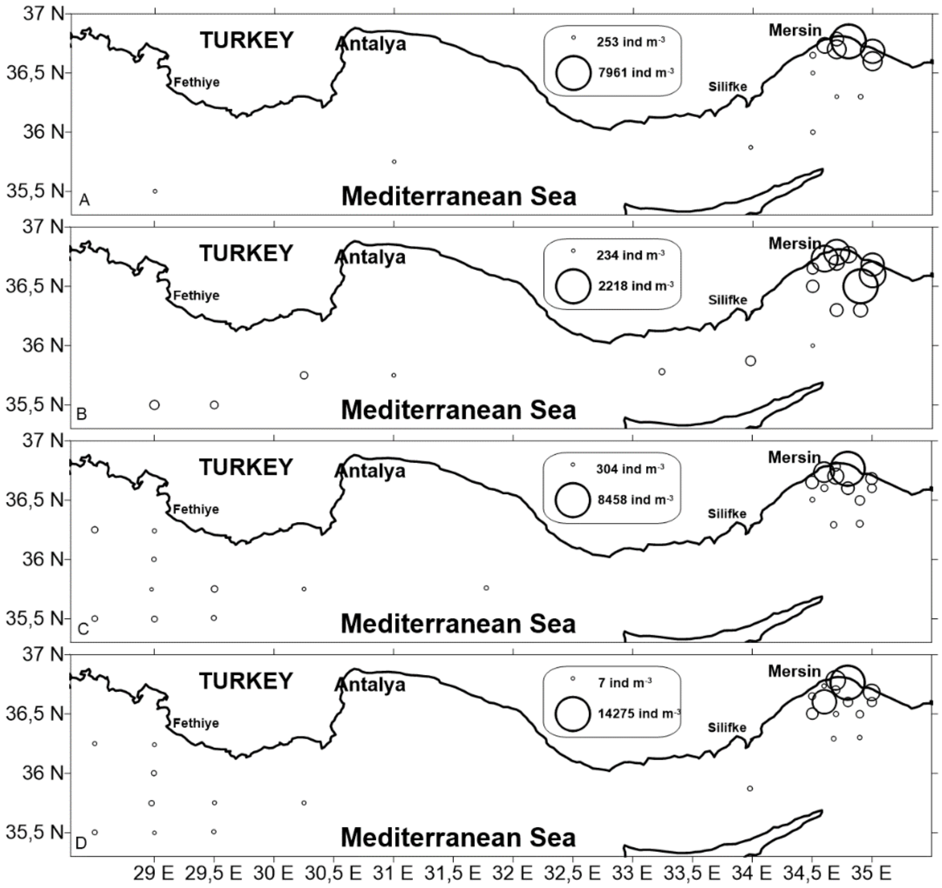

Figure 2. Spatial distribution of zooplankton abundance in the Northeastern Mediterranean Sea. A) July 2012, B) September 2012, C) March 2013, D) May 2013

Zooplankton standing stock is well described in the Cilician Basin and studies mostly concentrated in the Mersin and Iskenderun Bays. In Cilician Basin, average zooplankton abundance and biomass values varied from 977±564 ind m^{-3} (March 2007) to 2972±4272 ind m^{-3} (November 2005) and from 4.78±4.4 mg m^{-3} (September 2007) to 10.1±13.0 mg m^{-3} (November 2005), respectively. Smallest size fractions (100-200, 200-500 µm) were dominant in all seasons (Uysal *et al.* 2008). After these periods, a study done by Terbıyık Kurt *et al.* (2013) in the Cilician Basin showed that the mean zooplankton biomass in the integrated water column (0-200 m) was slightly more abundant in the spring 2008 (7.96 ± 6.3 mg m^{-3}) than the autumn 2008 (5.7 ± 3.1 mg m^{-3}) and fluctuated from 1.73 to 29.32 mg m^{-3} and from 1.68 to 11.5 mg m^{-3}, respectively (Figure 4). In general, zooplankton biomass was more abundant in coastal areas of the Cilician Basin. Zooplankton standing stock was concentrated in the upper layer (to a depth of 100 m) in sampling periods and sharply decreased with depth. Similar vertical distribution was observed in the offshore area of Antalya Basin (Terbıyık *et al.* 2010) and comparing with the Cilician Basin where having productive coastal areas, zooplankton abundance and biomass were low in Antalya Basin. These values were varied between 2.2-18.1 mg m^{-3}, 72.28-757.55 ind.m^{-3} in April 2008 and 0.98-4.67 mgm^{-3}, 99.54-492.52 ind.m^{-3} in October 2008, respectively. However, offshore regions of Cilician Basin had similarly low zooplankton standing stock (Uysal 2008; Terbıyık Kurt *et al.* 2013; Kurt 2016).

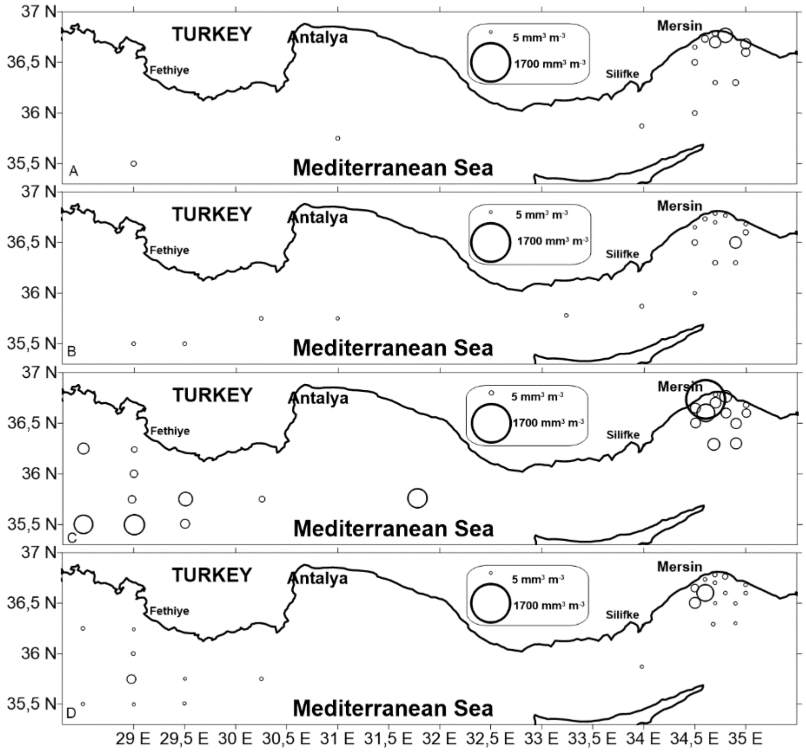

Figure 3. Spatial distribution of zooplankton biomass (in biovolume) in the Northeastern Mediterranean Sea. A) July 2012, B) September 2012, C) March 2013, D) May 2013

Zenginer Yilmaz and Besiktepe (2010) observed that on annual average, total zooplankton abundance were 603±368 ind m^{-3} and 4968±3538 ind m^{-3}, and total biomass were 3±1 mg m^{-3} and 22±19 mg m^{-3} in coastal (~20 m) and offshore waters (~200 m) of Mersin Bay, respectively (Figure 5a). The minimum and maximum abundance values in coastal (~20m), middle (~100m) and open (~200m) areas of the Mersin Bay changes between 146,3 - 6568,86 ind m^{-3}, 133,70 - 915,46 ind m^{-3} and 62,27 - 1003,44 ind m^{-3}, respectively. Moreover, minimum and maximum biomass values in coastal (~20m), middle (~100m) and open (~200m) stations changes between 7,77 - 384,51 mm^3 m^{-3}, 9,52 - 92,56 mm^3 m^{-3} ve 10,02 - 162,65 mm^3 m^{-3}, respectively (Zenginer Yılmaz and Ak Orek 2016). Smaller size fractions (200–500 and 112–200 µm) were always dominant in zooplankton abundance at both coastal and offshore area of Mersin Bay. Similarly, 200–500 µm size fraction was dominant in zooplankton biomass at the coastal, whereas >1000 µm size fraction was dominant at the offshore station (Zenginer Yilmaz and Besiktepe (2010).

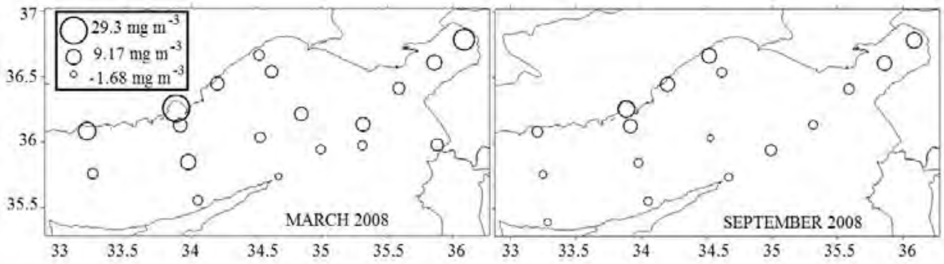

Figure 4. Zooplankton biomass distribution in the Cilician Basin (modified from Terbıyık *et al.* 2013)

In the Iskenderun Bay, mesozooplankton abundance fluctuated from 522 to 12931 ind. m^{-3} in the coastal area, while from 521 to 5443 ind. m^{-3} at offshore area. Annual biomass values changed between 3.14 - 21.72 mg m^{-3} in the coastal station and 3.31 - 8.99 mg m^{-3} in the offshore station (Figure 5b, unpublished data). Additionally, zooplankton abundance and biomass sometimes reached to 18275 ind m^{-3} and 52.9 mg m^{-3} in the western coastal area of Iskenderun Bay (Terbıyık Kurt and Polat 2013, 2015**).**

3.2 Zooplankton composition

Nearly thirty groups of zooplankton are defined in Mediterranean coast of Turkey, but little information is known about the diversity of species. Copepoda and Cladocera were the two main important groups which species diversity is known and studied for years. Copepoda was always dominant among other zooplankton groups in all studies mentioned before. Horizontal and vertical distribution of main zooplanktonic groups varied temporally and spatially in the Northeastern Mediterranean Sea. For instance, in Spring 2008 in the Northwestern part of the Levantine Sea, Copepoda and

Siphonophora were generally more abundant in the layer of 0-50m whereas, Doliloida and Appendicularia in layers of 0-50 and 50-100 m and Ostracoda in layers of 50-100 and 100-200 m (Terbıyık *et al.* 2010). On the other hand, in the Cilician Basin, the group Copepoda is followed by Appendicularia, Cladocera, Thecosomata, Hydrozoa and Chaetognatha in 0-50 m depth; Copepoda, Chaetognatha, Crustacea eggs and nauplii, Appendicularia, Hydrozoa and Siphonophora were more abundant in 50-100 m depth; and Copepoda, Ostracoda, Crustacea eggs and nauplii, and Chaetognatha dominated zooplankton in the third column (100-200 m depth) in the same period. (Kurt 2016). In autumn 2008, Copepoda, Chaetognatha, Siphonophora and Cladocera were more abundant in the layer 0-50 m, Ostracoda was abundant in the 50-100 m depth and Appendicularia was more abundant in the layers 0-50 and 50-100 m in the Northwest Levantine Sea (Terbıyık *et al.* 2010), while Copepoda preserved dominancy in both layers of 50-100m and 100-200m, then Appendicularia, Siphonophora and Ostracoda were abundant in the layer 50-100m and Ostracoda, Appendicularia and Chaetognatha were dominant in the layer 100-200 m in the Cilician Basin (Kurt 2016). Overall, Copepoda was the dominant group and followed by Appendicularia, Cladocera and Echinodermata in the Cilician Basin. Similarly, Copepoda, Crustacea nauplii, Mollusca larvae, Appendicularia, Cladocera and Chaetognatha were found to be the most abundant organisms in the Cilician Basin (Uysal *et al.* 2008). Each group showed different maximum values at different periods in a year such as Copepoda reached maximum abundance values with constituting 80% of all groups in September, Crustacea nauplii with 24% in January, Mollusca larvae with 5% in winter and spring period, Appendicularia with 4% in spring, Cladocera with 4% in spring and summer and finally, Chaetognatha with 2.6% in April. In Iskenderun Bay, evident seasonality was observed both in coastal and offshore area for the overall year (Terbıyık Kurt and Polat, 2013, 2015). Copepoda was generally dominant among zooplankton groups in coastal and offshore areas. Copepoda dominancy replaced with Salpa in February and March, Gastropoda in May and Cladocera in June and July in the coastal stations. Similarly, Copepoda was mainly dominant in the offshore station. However, Cladocera dominated the zooplankton during May and July, while Doliolida was most abundant group in September in the offshore area. Other important mesozooplankton groups besides dominant groups were Appendicularia, Bivalvia and Cirripedia in inshore station, while Salpa, Appendicularia, Chaetognatha and Bivalvia in offshore station (Terbıyık *et al.* 2016). In the Mersin Bay, Copepoda were the most abundant zooplankton group and determine the distribution of total zooplankton followed by Crustacea nauplii, Appendicularia, and Cladocera (Zenginer Yilmaz and Besiktepe 2010, Zenginer Yilmaz and Ak Orek 2016). In another study done with Zooscan equipment showed that Copepoda was responsible for the biggest part of the biomass in the coastal station, however together with Copepoda, Chaetognatha had an important contribution to the biomass values in the offshore stations. Indeed, Cladocera showed important contribution in the warmer periods (May, June and July) (Zenginer Yilmaz and Ak Orek 2016). A study done in the Northeastern Mediterranean Sea in 2012 (July and

September) and 2013 (March and May) showed that the most abundant groups were Copepoda, Cladocera, Appendicularia, Chaetognatha, Doliloida, Thecosomata, Ostrocoda, Gastropoda and Decapoda (Figure 6, unpublished data). Followed by Copepods, Cladocera and Chaetognatha were the most abundant groups in June 2012; Cladocera, Appendicularia and Doliolid in September 2012; Appendicularia, Doliolida and Gastropoda in March 2013; and finally Cladocera and Gastropoda in May 2013. Apparently, Cladocera was generally dominant in the coastal stations in June 2012 and May 2013.

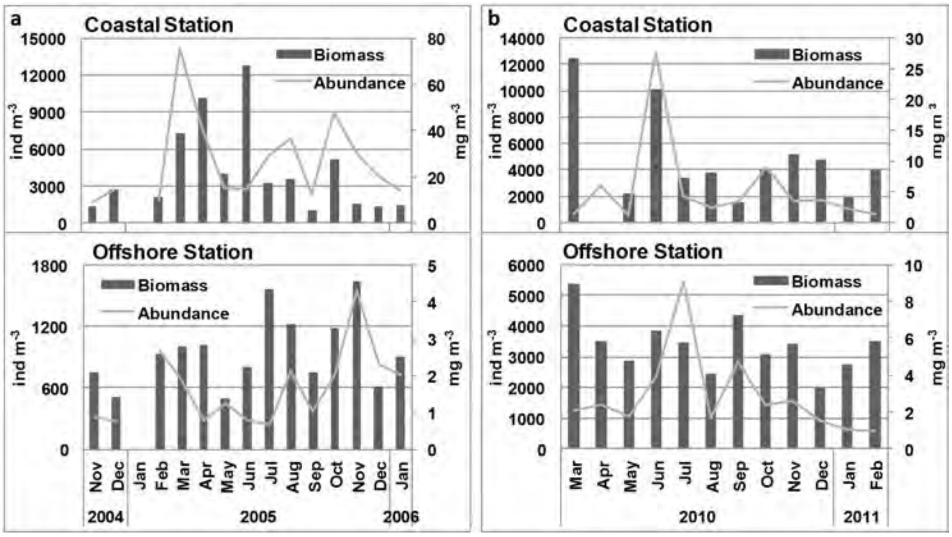

Figure 5. Monthly variations of zooplankton abundance and biomass a) Mersin Bay, b) Iskenderun Bay

The studies conducted in Northern Levantine Basin mostly focused on the spatial and temporal variations of Copepoda species. The majority of these studies are concentrated in the Iskenderun and Mersin Bays. Over 200 planktonic copepod species have been reported from Mediterranean coast of Turkey. Community structure of Copepoda varied seasonally in the area. In the Iskenderun Bay, *P. parvus, C. kroyeri, P. denudatus, T. stylifera, A. clausi, P. latisetosa* are the dominant copepod species in spring. In summer, *C. kroyeri* is still among the dominant species, *O. setigera* and *C. furcatus* accompanied with this species. *A. gibber* is being the dominant species with *O. plumifera, C. furcatus, C. eliptica, Labidocera pavo, P. parvus* in autumn. During the winter period, *P. parvus* is the dominant copepod species and C*alocalanus plumatus, Calocalanus pavo, O. plumifera, A. gibber* were the other common copepod species (Terbıyık Kurt and Polat 2013). Copepoda communities are slightly different in terms of seasonal variation and community structure in Iskenderun Bay, most probably due to using different types of nets and small size of mesh sizes. For instance, in late winter and early spring period *O. nana, Oithona* sp., *O. media, Oncaea* sp., *Calocalanus* *elegans, E. acutifros* and *O. zernovi* were the dominant species which structured the Copepoda community in Mersin Bay. *Calocalanus* sp., *C. elegans, Triconia dentipes, Oncaea* sp., *O. nana, Clausocalanus furcatus* and *Temora stylifera* dominated in summer, however, *Oncaea* sp., *Calocalanus* sp., *Oithona nana, Clausocalanus paululus, C. furcatus, Parvocalanus* sp. and *Calocalanus elegans* were dominant in autumn and early winter in same area (Uysal and Shmelava 2012).

In the Cilician Basin, basin scale studies on Copepoda usually carried out in the upper layer of the water column (0-200 m). In spring, *C. paululus* is common in neritic and oceanic regions of Cilician Basin. Moreover, *P. parvus, C. furcatus, A.clausi, O.nana, F. rostrata, C. paululus, O. media* group, *C. giesbrechti and C. styliremis* are commonly observed. *C. paululus, O. media* group and *F. rostrata* are more abundant copepod species in the surface layers of oceanic waters of the Cilician Basin. Contribution of *C. styliremis* to copepod abundance increases with depth and this species shaped the Copepoda community with *C. paululus* and *O. media*. Abundance of *O. setigera* and *H. longicornis* increased in just above the mesopelagic layer and dominated the Copepoda community with *C.paululus* and *O. media* group (Kurt 2016). In the offhore regions around Antalya Bay, *Calocalanus styliremis, Clausocalanus jobei, C. parapergens, C. paululus, Lucicutia flavicornis, Mecynocera clausi, Paracalanus denudatus,* dominated the upper 50 m whereas *C. contractus, Ctenocalanus vanus, Haloptilus longicornis, L. flavicornis, M. clausi, P. denudatus, P. nanus, F. rostrata, O setigera, Oncea media* dominated the 50-100 m depth layer. Finally, Copepod species namely *H. longicornis, O. setigera, Mormonilla minor* and *O. mediterranea* dominated the layer 100-200 (Terbıyık *et al.* 2010).

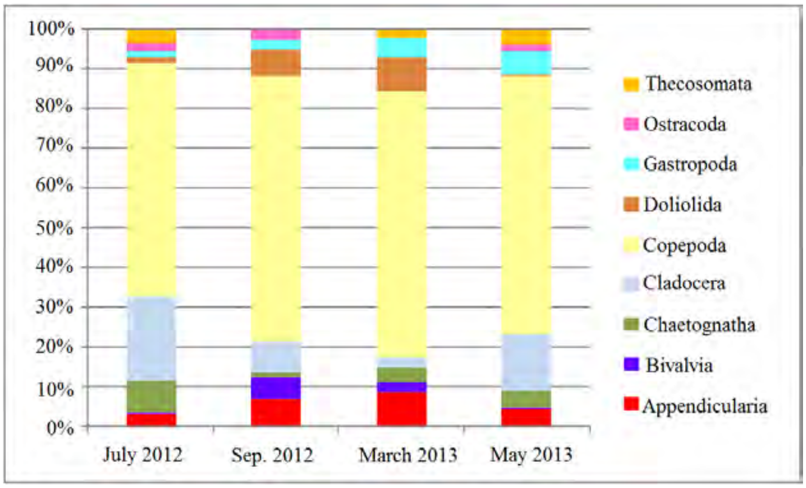

Figure 6. Percent composition of dominant zooplanktonic groups in different seasons.

In the area, the period autumn is marked with thermal stratification and mesozooplankton community was affected by this stratification. Unlike the areas in the west part of the Cilician Basin, Lessepsian species are common in the nearshore area of Iskenderun Bay and Goksu Delta (Kurt 2016). The species such as *A. gibber* and *C. elliptica* are dominant especially in autumn in the Iskenderun Bay (Terbıyık Kurt and Polat 2013). The ring current of the Mediterranean Sea plays an important role in carrying the alien species to the region. Hydrographic conditions of Iskenderun Bay are quite favorable for the spread of alien species (Çevik *et al.* 2006). In autumn, physical properties of the region are getting closer to Red Sea in terms of environmental conditions and the species living in the Red sea spreads in the Iskenderun Bay (Terbıyık Kurt and Polat 2013). A number of Lessepsian species are increasing overtime and some of these species leads to the formation of new populations in this region. In this respect, community structure in Cilician Basin is similar with southern areas of the Eastern Mediterranean, however high proportion of the Lessepsian species makes it more different from other areas in the region. Moreover, distribution of Lessepsian species and their contribution to zooplankton biodiversity in Mersin Bay is not quite low (Uysal and Shmelava 2012). In autumn, *A. gibber, O. plumifera, Clausocalanus furcatus, P. parvus* are predominant in the coastal area of Cilician Basin. *O. plumifera, C. furcatus, P. parvus, C. paululus ve L. flavicornis* characterized the upper layer of the water column, whereas *O. plumifera, C. furcatus, O. media* group, *C. paululus* are important in the following layer. In this period, vertical stratification is quite obvious, deep layers are seen as separated and dominance of mesopelagic species are increasing in these deep layers. *O. setigera, C. paululus* and *H. longicornis* were dominant in the deep layers of offshore waters, whereas the constribution of *O. media* and *M. clausi* are becoming important in the deep layers when getting closer to shore (Kurt 2016).

It is known that a total of six Cladoceran species (*Penilia avirostris, Evadne spinifera, Pseudoevadne tergestina, Evadne nordmanni, Podon intermedius* and *Pleopsis polyphemoides*) are distributed in the Mediterranean part of Turkey (Terbıyık Kurt and Polat 2013, 2014, Kurt 2016). Distribution of Cladoceran species varied seasonally in the region. *P. avirostris* is generally dominant among Cladoceran community in spring and summer period (Terbıyık Kurt and Polat 2013, 2014). Abundance of *E. spinifera and P. tergestina* reached higher levels (Terbıyık and Polat 2014) in the area. These species were more abundant in warmer periods. Especially, *E. spinifera* is dominant in the coastal regions of western part of Cilician Basin in autumn. It is observed that *P. intermedius* preferred relativelly colder waters and appeared in coastal area in early spring. Contribution of *P. polyphemoides* is very low in İskenderun Bay (Terbıyık Kurt and Polat 2013, 2014), however it is denser in some coastal areas of Mersin Bay where organic load is increased with some rivers such as Goksu river (Kurt 2016).

Studies on Chaetognatha species in Turkish coast of Mediterranean are concentrated in Cilician Basin. A total 16 Chaetognatha species are known (Ismen 2000, Hazar, 2006, Terbıyık *et al*. 2007, Terbıyık and Sarihan 2008, Uysal *et al*. 2008, Kurt 2016). *F. enflata,* a cosmopolitan species is dominant in Chaetognatha community (Ismen *et al*. 2003, Terbıyık and Sarihan 2008) and prefer coastal and neritic areas (Uysal *et al.* 2008). *M. minima,* S. *serratodentata* and *S. bipunctata* prefered cold waters and abundance of these species reached higher levels (Uysal *et al.* 2008), and generally concentrated in the joint areas of neritic and oceanic waters. *S. serratodentata* and *S. bipunctata* are other common Chaetognatha species distributed in the neritic waters and epipelagic layers of oceanic waters in the basin (Uysal *et al*. 2008). The structure of Chaetognath community is changed in the mesopelagic layer and deep layers of epipelagic regions of oceanic waters. Some species, *P. lyra, D. decipiens, K. subtilis, P. hexaptera* have been began to be observed. *P. lyra* which exhibits ontogenetic migration were found in coastal area (Uysal *et al.* 2008). Another species, *D. decipiens* being as indicator in the Levant intermediate waters is concentrated in the mesopelagic layer (Kurt 2016). Finally, *F. galerita* was firstly recorded in Iskenderun Bay (Terbıyık *et al.* 2007) in the Mediterranean Sea, then expanded its distribution to the Cilician Basin (Uysal *et al.* 2008).

Taxonomical studies on other zooplankton groups are very few, Uysal and Murina (2005) reported 5 phyla, 10 classes ve 34 families belonging to meroplankton. Pelagic nectochaete larvae of Spionidae (Polychaeta) and zoeas of Grapsidae (Decapoda) dominated meroplankton. In the area, reported pelagic Polychaeta species are *Tomopteris elegans, Vanadis studeri, Typhloscolex grandis, Travisiopsis lobifera, Pelagobia serrata,* and *Maupasia caeca*. Reported Polychaeta larvae are *Harmothoe imbricata, Priono caspersi, P. cirrifera, P. malmgreni, Polydora antennata, Scolelepis fuliginosa, Microspio mecznikowianus, Pygospio elegans, Nerine cirratulus, Spio filicornis* and *Audouinia filigera (*Uysal and Murina 2005). It was found that Polychaeta larve are abundant in December in Mersin Bay. Additionally, it is reported that *P. serrata*, a pelagic Polychaeta, is common in October and November. In the same study, some Gastropoda (*Haminoea navicula, Retusa truncatella, Limapontia capiata*) species are observed in the Mersin Bay (Uysal and Murina, 2005). Larvae of Decopoda species known in Mersin Bay are *Athanas nitescens, Cancer pagurus, Carnicus mediterraneaus, Schizophrys aspera.* Additionally, there are some species identified only at the genus or family level.

4. Conclusion

The zooplankton abundance and biomass values are higher especially in the wide continental shelf areas (such as Göksu Delta, İskenderun and Mersin Bays), when comparing with the other parts in the Levantine Sea. Coastal and offshore regions have different water characteristics in the area, the coastal regions have variable water characteristics and seasonally exposed to different intensities of anthropogenic and land-related influences. However, the offshore regions are more stable and show open water characteristics in the Northeastern Mediterranean. In relation to these variabilities, zooplankton abundance and composition shows evident differences between coastal and offshore stations. The species composition and distribution of groups have a similar structure as with other regions in the Eastern Mediterranean Sea (Siokou *et al.* 2010; Mazzocchi *et al.* 2014). In contrast, contribution of alien species is more recognizable in the autumn in this region. Similarly, zooplankton standing stock concentrated in the upper 100 m water column and decreases with depth. Zooplankton abundance and biomass values have shown that there were several peaks in a year. Generally, in spring and autumn totally two peaks are observed in a year in the Bays. In addition to that, the Cladocerans were found to be abundant in summer, therefore one more evident peak was observed in summer. Clear seasonal difference was observed in the area and especially it is known that the Lessepsian species are actively distributed in the region, especially they dominate the zooplankton in autumn in the Iskenderun Bay. Environmental factors lead to temporal and spatial variations of zooplankton standing stock and composition in the area.

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CALIGID COPEPODS PARASITIC ON FISHES OF THE EASTERN MEDITERRANEAN COAST OF TURKEY

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1. Introduction

Among the metazoan ectoparasitic groups on marine fishes and invertebrates, parasitic copepods is the most specious and the abundant group that may cause severe pathologies and disorders. To date, numerous species belonging to 30 families of copepods have been reported as ectoparasitic mainly on fishes (Boxshall 2005). Of these, the family Caligidae Burmeister, 1835 is the most common and the well known group of pests causing desquamation, necrosis, haemorrhages, respiratory stress and secondary infections leading to mortalities on both wild and cultured fishes in freshwater and marine environments (Johnson *et al.* 2004). In addition, reduced growth and fecundity, costs emerging from mortalities and treatment, decrease in wild fish populations and transmission of secondary infections from wild to cultured or cultured to wild fish stocks can also be listed as the impacts of Caligid copepods on aquaculture and fisheries (Johnson *et al.* 2004; Lester and Hayward 2006; Cruz-Lacierda *et al.* 2011). Therefore, monitoring the diversity, distribution and correct identification of these highly abundant Caligid copepods on fish species are important to develop pest management and conservation strategies to protect marine life (esp. threatened/ endangered fish species) and to conduct sustainable marine fish farming.

The aim of this chapter is to provide information on the diversity of the caligid copepods parasitic on marine fishes species of the eastern Mediterranean waters off the Turkish coast. In addition, we present the first report of *Euryphorus brachypterus* (Copepoda: Caligidae) collected from Bluefin Tuna, *Thunnus thynnus* (Linnaeus, 1758) caught in the Mediterranean waters off Antalya Bay, Turkey.

2. Caligidae Burmeister, 1835

The family Caligidae established by Burmeister (1835) is the most abundant group of parasitic copepods found exclusively on marine fishes. The family currently consists of 31 valid genera according to the recent revision by Dojiri and Ho (2013)

(Table 1). Of these 31 valid genera, the genus *Sciaenophilus* Van Beneden, 1852 was recently classified within the genus *Caligus* Müller, 1785 based on the new morphological observations made by Özak *et al.* (in press). However, we preferred to remain the genus *Sciaenophilus* as a separate genus during this review.

Table 1. Genera with in the family Caligidae Burmeister, 1835

1	*Abasia* Wilson C.B., 1908
2	*Alanlewisia* Boxshall, 2008
3	*Alebion* Krøyer, 1863
4	*Anchicaligus* Stebbing, 1900
5	*Anuretes* Heller, 1865
6	*Arrama* Dojiri & Cressey, 1991
7	*Avitocaligus* Boxshall & Justine, 2005
8	*Belizia* Cressey, 1990
9	*Caligodes* Heller, 1865
10	*Caligus* O.F. Müller, 1785
11	*Caritus* Cressey, 1967
12	*Dartevellia* Brian, 1939
13	*Echetus* Krøyer, 1863
14	*Euryphorus* Milne Edwards H., 1840
15	*Gloiopotes* Steenstrup & Lütken, 1861
16	*Hermilius* Heller, 1865
17	*Kabataella* Prabha & Pillai, 1983
18	*Lepeophtheirus* von Nordmann, 1832
19	*Mappates* Rangnekar, 1958
20	*Markevichus* Özdikmen, 2008
21	*Metacaligus* (Thomsen, 1949)
22	*Paralebion* Wilson C.B., 1911
23	*Parapetalus* Steenstrup & Lütken, 1861
24	*Parechetus* Pillai, 1962
25	*Pseudanuretes* Yamaguti, 1936
26	*Pseudechetus* Prabha & Pillai, 1979
27	*Pupulina* Van Beneden, 1892
28	*Sciaenophilus* Van Beneden, 1852
29	*Sinocaligus* Shen, 1957
30	*Synestius* Steenstrup & Lütken, 1861
31	*Tuxophorus* Wilson C.B., 1908

Currently, the Mediterranean Caligid copepods are represented by 39 valid species belonging to the following 6 genera: *Alebion* Krøyer, 1863; *Caligodes* Heller, 1865; *Caligus* O.F. Müller, 1785; *Euryphorus* Milne Edwards H., 1840; *Lepeophtheirus* von Nordmann, 1832; *Sciaenophilus* Van Beneden, 1852 (Raibaut *et al.* 1989; Demirkale *et al.* 2014; Walter and Boxshall 2016). Of these 6 genera, the genus *Caligus* Müller, 1785 is the most speciose genus within the family and currently represented by 28 valid species in the Mediterranean (Figure 1).

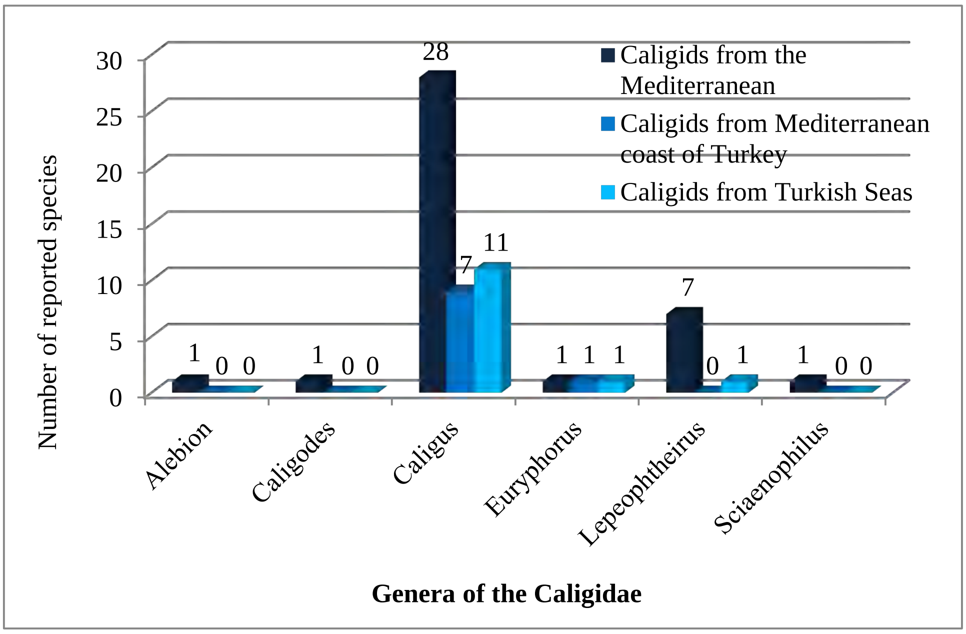

Figure 1. Species richness of the family Caligidae

In Turkish seas, Caligidae is represented by 12 species belonging to 2 genera: *Caligus* and *Lepeophtheirus* (Alaş *et al.* 2015). The genus *Caligus* is the most abundant group with 11 species in Turkish seas and approximately 63 % of these 11 species of Caligus were reported from the Mediterranean waters off the Turkish coast (Figure 1). According to Alaş *et al.* (2015), 19 species of parasitic copepods belonging to 6 different families have been reported from the Turkish Mediterranean coast, so far. However, recently reported three parasitic copepods: *Doridicola longicauda* (Claus, 1860) from *Sepia officinalis* (Linnaeus, 1758) (Cephalopoda, Sepiidae), *Hatschekia petiti* Nuñes-Ruivo, 1954 from *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817) (Perciformes, Epinephelinae) and *Philorthragoriscus serratus* (Krøyer, 1863) from *Mola mola* (Linnaeus, 1758) (Tetraodontiformes, Molidae) bring the number of parasitic copepod families in Turkish Mediterranean waters to 9 (Özak *et al.* 2016; Yalım *et al.* 2016; Yanar *et al.* 2016) (Figure 2).

Of the 7 species of Caligus reported from fishes in Turkish Mediterranean coast (Table 2), only *Caligus lagocephali* was found on two lessepsian fish species, *Lagocephalus spadiceus* (Richardson, 1845) and *Lagocephalus suezensis* Clark and Gohar, 1953 (Özak *et al.* 2012). Similar to C. lagocephali, three more alien parasitic copepods: *Lernanthropus callionymicola* El-Rashidy and Boxshall, 2012, Taeniacanthus lagocephali Pearse, 1952 and *Mitrapus oblongus* (Pillai, 1964) have been reported from marine fishes caught in Turkish Mediterranean coasts, so far (Castro and Öktener 2010; Özak *et al.* 2012, 2016).

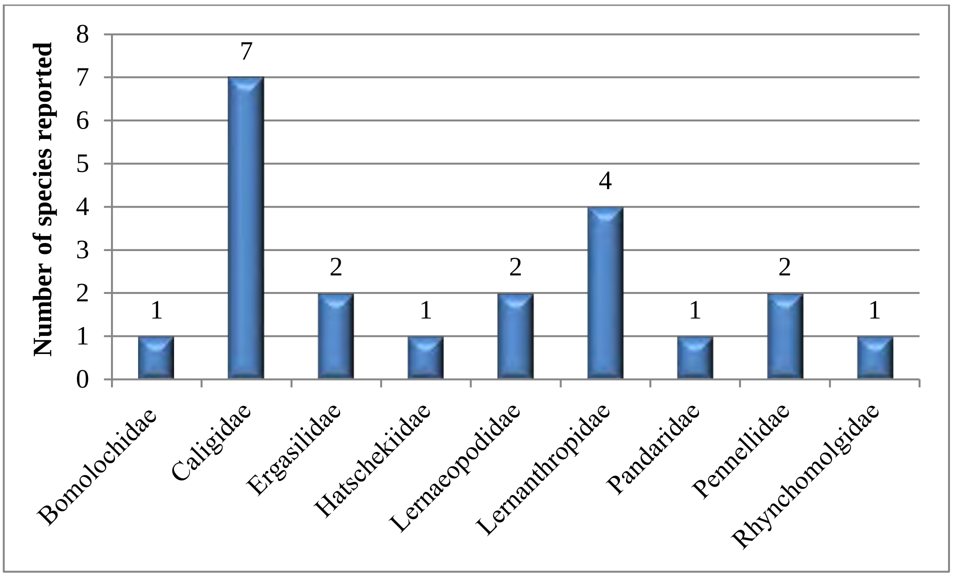

Figure 2. Species richness of the parasitic copepod families reported from fishes in Turkish Mediterranean waters.

In addition to the species reported above, here, we present the first record of a Caligid copepod, *Euryphorus brachypterus* (Gerstaecker, 1853) found on Atlantic Bluefin tuna, *Thunnus thynnus (*Linnaeus, 1758) caught in Mediterranean waters of the Turkish coast. *E. brachypterus*, is one of the three species belonging to the genus *Euryphorus* Milne-Edwards, 1840 within the family Caligidae Burmeister, 1835. Since its first description, this parasitic copepod has been treated many times as a new species by a number of researchers due to the morphological and morphometric differences observed during its' reproductive stages and also due to the intraspecific variations on its morphology. Although a recent detailed description was presented by Dojiri and Ho (2013), present authors aimed to highlight the fine details of the key diagnostic characters of *E. brachypterus* by using light microscopy (LM) and scanning electron microscopy (SEM). In addition, some newly observed additional characters, overlooked in the previous descriptions of *E. brachypterus*, were also presented.

Table 2. Caligid copepods parasitic on fishes in Mediterranean waters off the Turkish Coast (Ref.: Reference)

***Caligus* O.F. Müller, 1785** Parasite	Host	Location	Ref.
***Caligus apodus* (Brian, 1924)**	*Solea solea* (Linnaeus, 1758)	İskenderun Bay	1
***Caligus brevicaudatus* A. Scott, 1901**	*Solea solea* (Linnaeus, 1758) *Chelidonichthys lucerna* (Linnaeus, 1758)	İskenderun Bay	1; 2
***Caligus lagocephali* Pillai, 1961**	*Lagocephalus spadiceus* (Richardson, 1845) *Lagocephalus suezensis* Clark & Gohar, 1953	İskenderun Bay	3
***Caligus ligusticus* Brian, 1906**	*Lithognathus mormyrus* (Linnaeus, 1758)	İskenderun Bay	4
***Caligus minimus* Otto, 1821**	*Dicentrarchus labrax* (Linnaeus, 1758)	İskenderun Bay; Beymelek Lagoon, Antalya	5; 6; 7
***Caligus solea* Demirkale Demirkale, Özak, Yanar and Boxshall, 2014**	*Solea solea* (Linnaeus, 1758)	İskenderun Bay	8
***Caligus temnoontis* Brian, 1924**	*Pomatomus saltatrix* (Linnaeus, 1766)	İskenderun Bay	9
***Euryphorus* Milne Edwards H., 1840**			
***Euryphorus brachypterus* (Gerstaecker, 1853)**	*Thunnus thynnus* (Linnaeus, 1758)	Antalya Bay	10

1: Özak *et al.* (2013), **2:** Demirkale *et al.* (2015a), **3:** Özak *et al.* (2012), **4:** Demirkale *et al.* (2015b), **5:** Özak (2007), **6:** Canlı (2010), **7:** Yalım *et al.* (2014), **8:** Demirkale *et al.* (2014), **9:** Özak *et al.* (2010), **10:** Present study.

3. *Euryphorus brachypterus* (Gerstaecker, 1853)

An Atlantic Bluefin Tuna, *Thunnus thynnus (*Linnaeus, 1758) (total length: 82cm), caught in Mediterranean waters off Antalya Bay, Turkey was examined for the existence of parasitic copepods. Specimens of *E. brachypterus* were collected from inner opercular surface, preserved in 70% ethyl alcohol and cleared in lactic acid for 2 h prior to examination using an Olympus SZX16 dissecting microscope and Olympus BX51 compound microscope. Intact specimens and individual appendages were photographed with a digital camera on both microscopes. Measurements were made using an ocular micrometer and drawings were made with the aid of a drawing tube. All measurements are presented as the range followed by the mean in parentheses. The scientific and common names of fishes follow Froese and Pauly (2016) and the morphological terminology for the copepods follows Kabata (1979) and Huys and Boxshall (1991). The protocols for preparing crustaceans for scanning electron microscopy (SEM) outlined by Felgenhauer (1987) were followed. All specimens (subsamples) were identified to the species level consulting Kabata (1979) and Dojiri and Ho (2013).

Family: Caligidae Burmeister, 1835
Genus: *Euryphorus* Milne Edwards, 1840
***Euryphorus brachypterus* (Gerstaecker, 1853)**
Syns. *Arnaeus thynni* Krøyer,1863*; Caligeria bella* Dana,1849*; Dinematura thynni* (Krøyer, 1863)*; Dinemoura thynni* (Krøyer, 1863)*; Dysgamus longifurcatus* Wilson C.B., 1923*; Dysgamus sagamiensis* Shiino, 1958*; Elytrophora atlantica* Wilson C.B., 1932*; Elytrophora brachyptera* Gerstaecker, 1853*; Elytrophora hemiptera* Wilson C.B., 1921*; Elytrophora indica* Shiino, 1958*; Elytrophora thynni* (Krøyer, 1863)*; Euryphorus atlanticus* (Wilson C.B., 1932)*; Euryphorus bellus* (Dana, 1849)*; Euryphorus hemipterus* (Wilson C.B., 1921)*; Euryphorus indicus* (Shiino, 1958).

Material examined

Twenty-one ovigerous females and eight adult males, collected from the inner opercular surface of *Thunnus thynnus* L. caught in the north eastern Mediterranean waters off the Antalya Bay, Turkey, were examined.

Description (Figures 3 – 7)

Adult female (Figure 3A). Total body length 9.4-11.3 (10.28) mm (n=10). Cephalothorax suborbicular, lateral margins slightly indented through posterior, slightly wider than long 4.75-5.00 (4.94) × 4.76-5.2 (5) mm, posterior end of lateral zones extended beyond the posterior margin of thoracic zone. Frontal plate narrow. Lunules absent. Fourth pedigerous somite (Figure 3B), slightly wider than long (1.1 × 1.25mm); bearing a pair of dorsal plates (1.29 × 1.10mm) with rounded anterolateral corners, posterior part of dorsal plates covering anterior genital complex. Genital complex ovoid, longer than wide 2.75-3.75 (2.94) × 2.20-2.65 (2.4) mm, posterolateral corners consist of a pair of rounded extensions overlapping anterolateral corners of abdomen, dorsal and ventral surface of genital complex partly covered with irregular tiny swellings (Figure 3C, *inset*). Two spermatophores (0.592 × 0.429 mm) attached to left and right genital openings. Abdomen 2-segmented, first somite slightly wider than long 1.0-1.1 (1.05) × 1.2-1.45 (1.36) mm; second (anal) somite 0.85-1.05(0.94) × 0.9-1.05 (0.95) mm, subquadrangular. Caudal rami 0.75-0.88 (0.77) x 0.35-0.55 (0.43) mm each with 4 long plumose setae plus 2 smooth short setae, outermost seta bearing row of spinules at base. General organization of the appendages in the ventral surface of cephalothorax was identical to those of Caligids (Figure 4A). Antennule (Figure 4B) proximal segment robust, carrying 27 setae; distal segment slender, carrying 14 setae. Antenna (Figure 4C) 3-segmented. Proximal segment armed with blunt posteriorly-directed spinous process and supported anterolaterally with additional subrectangular segmentation derived from the base of cephalothorax; distal curved claw with 2 setation elements, a short single spine like seta proximally and a longer distal seta (109.23µm). Maxillule with posterior process tapering towards tip and anterior papilla carrying 3 unequal setae. Sternal furca (Figure 4D) with divergent, sharply pointed tines; Maxilla 2-segmented and brachiform; proximal segment (lacertus) unarmed; slender distal segment (brachium) with large serrated subterminal hyaline membrane (flabellum) (Figure 5A) on outer margin plus a small membranous process on inner margin (Figure 5B); tip of distal segment carrying 2 unequal processes (calamus and canna), both ornamented with spirally twisted serrate membranes. Maxilliped (Figure 5C) comprising robust protopod (corpus) and short distal subchela representing fused endopodal segments plus long, sharply curved claw; subchela armed with small seta at base of claw; distal half of the claw ornamented with longitudinal grooves (Figure 5D); outer distal part of corpus bearing two patches of tiny scale like processes (Figure 5E,F). Swimming leg 1 biramous, with 2-segmented exopod and 2-segmented endopod. Protopod armed with one long outer plumose seta and one short medial seta. First exopodal segment ornamented with even row of setules along free posterior margin and a small spine at outer distal corner. Distal exopodal segment (Figure 6A) with 3 spiniform elements plus a pinnate seta along distal margin, outer most two spiniform elements (spines 1 and 2) adjacent, with pectens at base and overlapping the third spine (spine 3) and the pinnate seta. First and second spine (spine 1 and 2) ornamented with minute denticles aligned dorsolaterally and oriented towards the tip. Inner margins of both spines (1 and 2) finely serrated. Third spiniform element (spine 3) bilaterally serrated. Posterior margin of distal exopodal segment with 3 long plumose setae. Endopod (Figure 6B) 2-segmented, first endopodal segment unarmed; second endopodal segment bearing 3 plumose setae plus row of setules on inner margin. Leg 2 (Figure 6C) biramous, with three segmented rami. Intercoxal sclerite fringed with membrane along free posterior margin. Coxa small, bearing large pinnate seta on posterior margin plus a single sensilla close to intercoxal sclerite, ornamented with patch of blunt spinules oriented posterior (Figures 6D,E). Mean width of spinules 705.45±36.06 nm (n=10). Basis with one small pinnate seta at outer distal angle, ornamented with one small terminal spine close to posteroventral margin, with membrane along free posterior margin. First exopodal segment about *c.*2 times longer than second; both segments with pinnate seta on inner margin and long oblique spine at outer distal corner. Spine at first segment reflexed back over surface of second segment, pecent present at base. Third segment with 6 pinnate seta and 2 spines, both margins of ventral spine serrated, dorsal spine with serrations on inner margin only. First endopodal segment with inner pinnate seta and ornamented with row of setules along outer margin; inner pinnate seta extending beyond the second and third endopodal segment; second endopodal segment with 2 pinnate seta and bearing row of setules on outer margin; third endopodal segment carrying 6 pinnate setae with the exception of 2 females with 7 pinnate setae. Ornamentations, spines and setae formulations of Leg 3 were identical with the previous descriptions (Kabata 1979; Dojiri and Ho 2013). Leg 4 (Figure 6F) biramous. Exopod 3-segmented. First segment, with bilaterally serrated outer spine and pecten at base. Second segment carrying bilaterally serrated outer spine and inner plumose seta. Third segment with three unequal bilaterally serrated spines plus 4 plumose seta. First endopodal segment with outer row of setules and one plumose inner seta. Second and third segment partially fused, second segment with one plumose inner seta and third segment with 3 plumose seta. Leg 5 comprising two papillae; first papilla with 1 plumose seta, and the second papilla carrying 3 plumose setae.

Adult male (Figure7A) total body length 6.92-9.32 (8.23) mm (n=8). Cephalothorax as in female, slightly longer than wide 3.87-4.48 (4.17) × 2.98-4.01 (3.9) mm. Fourth pedigerous somite, wider than long 0.79-0.99 (0.94) × 1.1-1.19 (1.15) mm; bearing a pair of dorsal plates 0.96-1.07 (1.02) × 0.89-1 (0.9) mm with rounded anterolateral corners, posterior part of dorsal plates covering anterior genital complex (Figure 7E). Genital complex ovoid, slightly longer than wide 1.89-1.98 (1.96) × 1.47-1.71 (1.66) mm, anterior part wider, antero-lateral margins convex. Abdomen 2-segmented, free abdominal somite wider than long 0.59-0.74 (0.68) × 0.85-0.91 (0.89) mm; anal somite subquadrangular, 0.85-1.05 (0.94) × 0.9-1.05 (0.95) mm. Caudal rami (Figure 7F) 0.72-0.80 (0.77) x 0.39-0.51 (0.44) mm, each with 4 long plumose setae plus 2 smooth short setae, outermost seta bearing row of spinules at base. Sternal furca (Figure 7B) with long, slightly convex, divergent and sharply pointed tines, box rectangular. Antenna (Figure 7C) 3-segmented; proximal segment with posteriorly-directed broad based triangular process; subrectangular middle segment with corrugated adhesion area near inner distal corner (Figure 7D); distal curved claw with 2 setation elements, a short single spine like seta proximally and a longer distal seta plus a curved tine on inner margin.

Remarks

The morphological features of our adult female and male specimens revealed similarities both in shape and morphometrics to *E. brachyprterus* as described by Kabata (1979) and Dojiri and Ho (2013). The body proportions of our specimens are also in the range given in these previous descriptions. However, our males differ slightly from those of Dojiri and Ho (2013) in having relatively longer body length, 8.23 (6.92-9.32 mm) [vs. 7.65 (6.78-8.51)]. In addition, we also report previously unrecognized tiny irregular swellings on dorsal and ventral surface of the female genital complex (Figure 3C, *inset*) for the first time. The discovery of *E. brachypterus* in Mediterranean waters of the Turkish coast bring the number of reported Caligid copepods to 8 and the number of species of Caligid copepods reported in Turkish seas reached to 13.

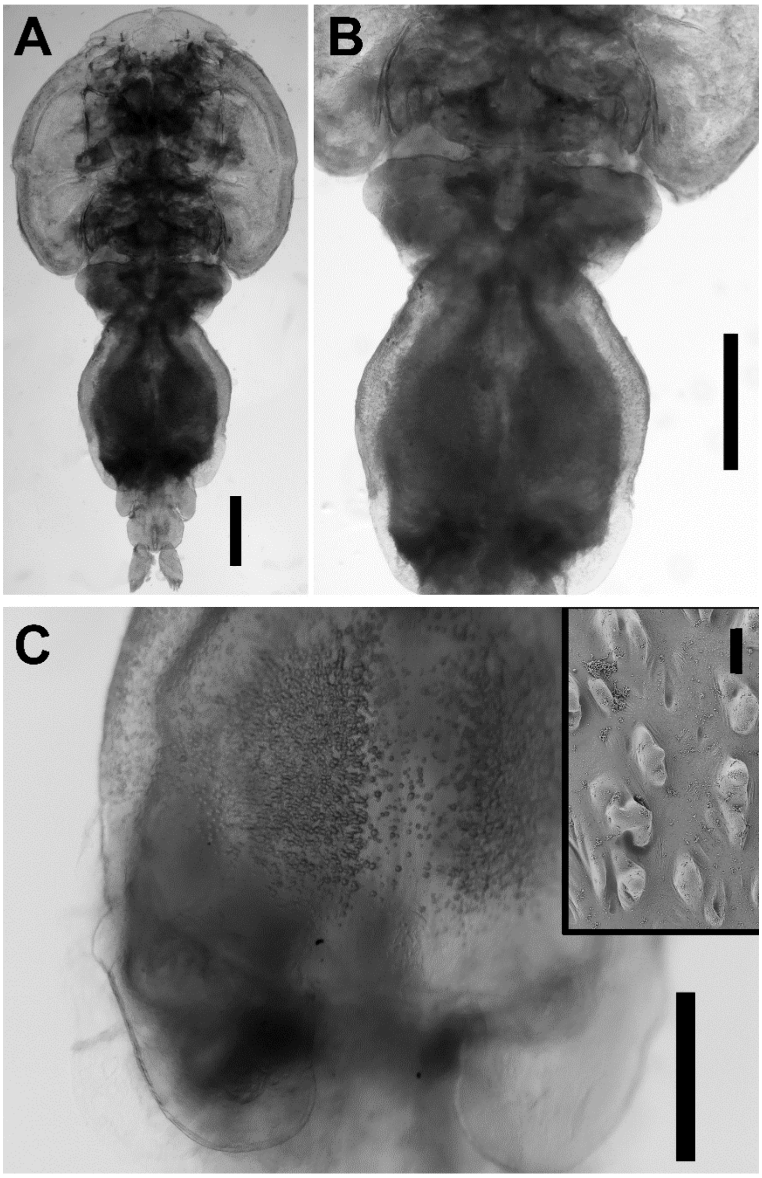

Figure 3. *Euryphorus brachypterus* (Female). A. Habitus (dorsal), B. Fourth pedigerous somite bearing pair of dorsal plates, C. Dorsal surface of genital complex covered with irregular swellings, SEM image of irregular swellings. *Scale bars*: A-B, 1 mm; C, 400 µm; C *inset*, 5 µm.

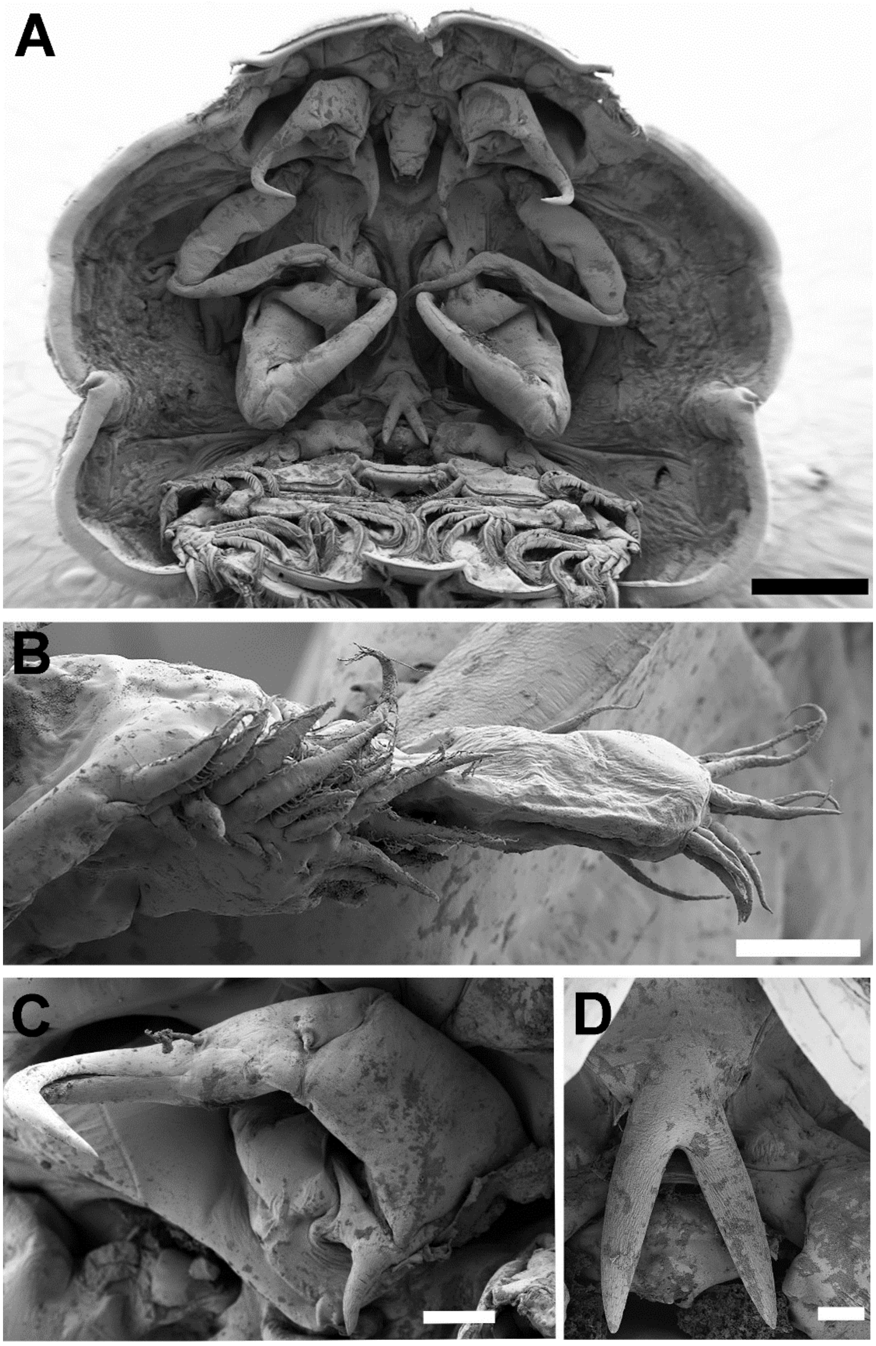

Figure 4. *Euryphorus brachypterus* (Female). A. Ventral view of cephalothorax, B. Antennule, C. Antenna, D. Sternal furca. *Scale bars*: A, 0.5 mm; B,D, 50 µm; C, 100 µm.

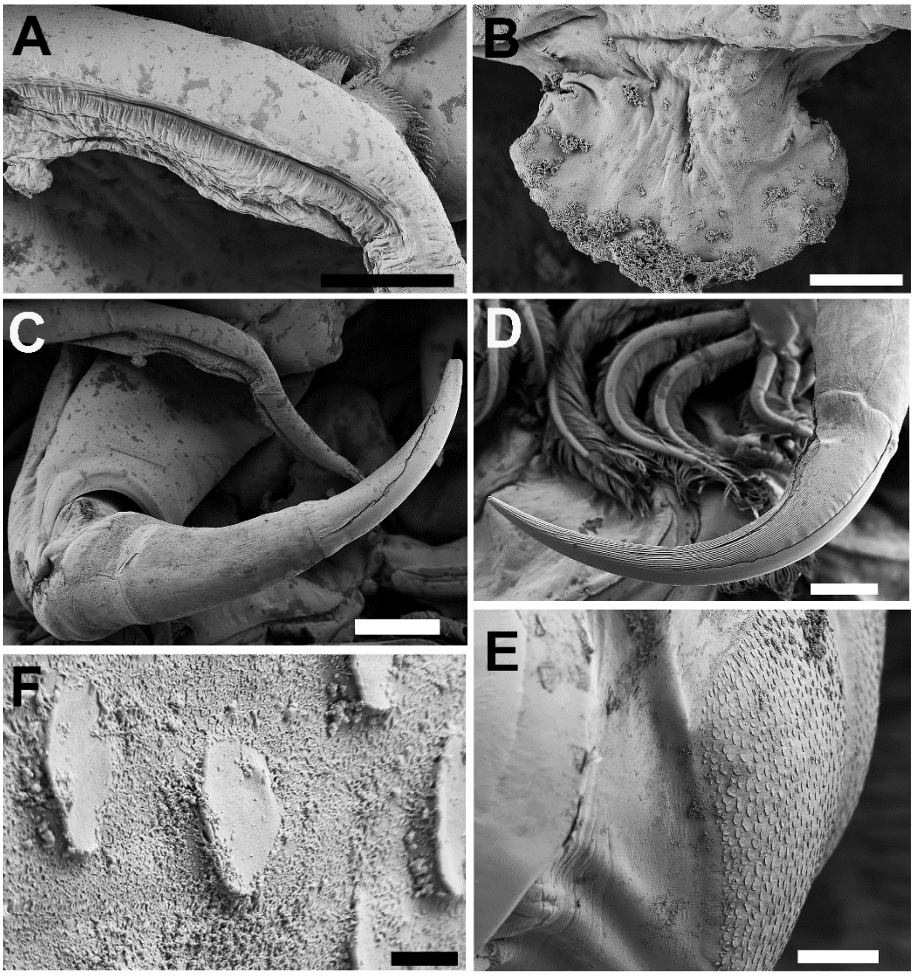

Figure 5. *Euryphorus brachypterus* (Female). A. Serrated flabellum on maxilla, B. Small membranous structure on opposite side of flabellum, C. Maxilliped, D. Distal half of maxilliped claw, E. Patches of scale like structures on dorsal, distal portion of corpus, F. closer view of scale like structures on corpus of maxilliped. *Scale bars*: A, 100 µm; B, 10 µm; C, 200 µm; D, 100 µm; E, 25 µm; F, 1 µm.

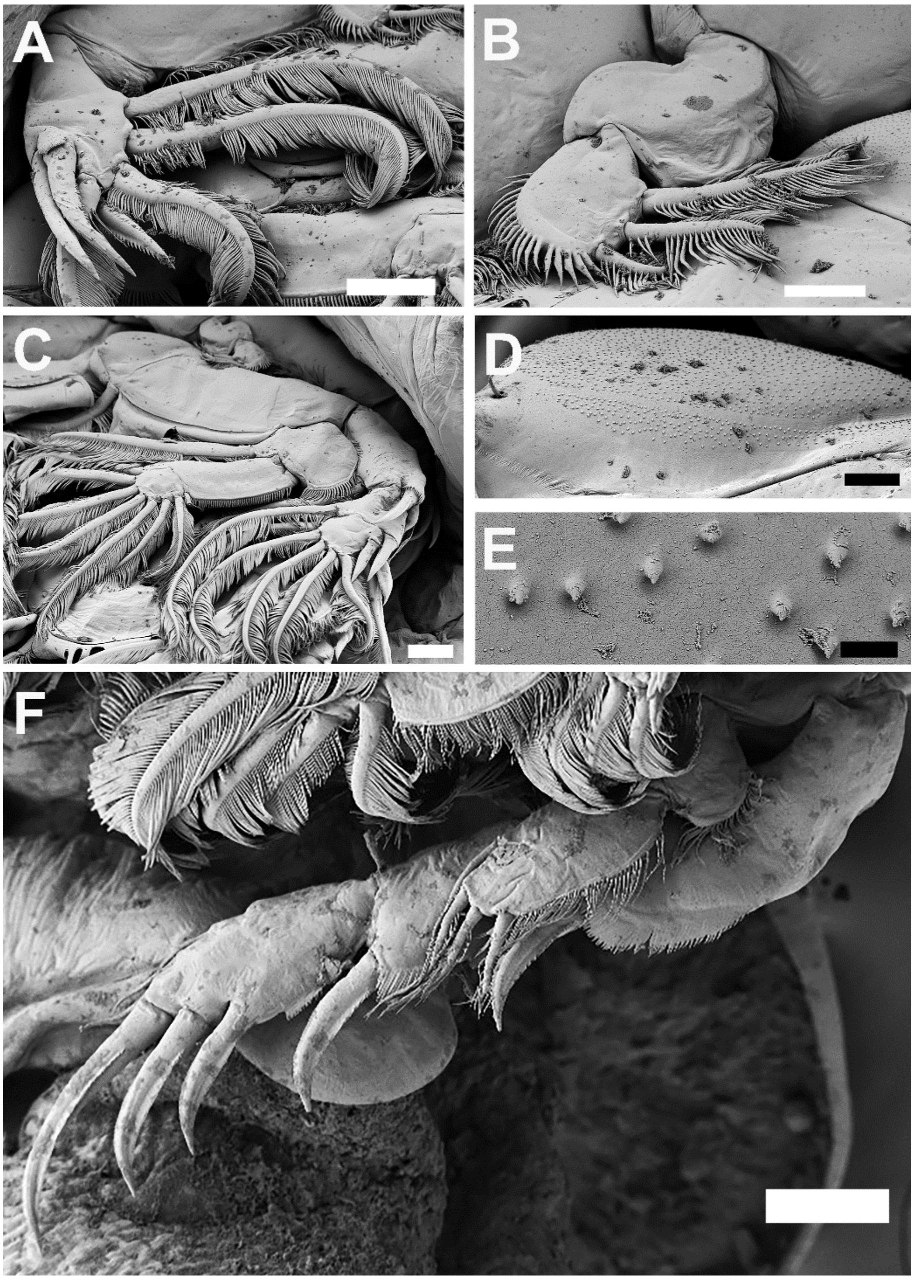

Figure 6. *Euryphorus brachypterus* (Female). A. Distal exopodal segment of leg 1, B. endopod of leg 1, C. Leg 2, D. Patch of spinules on proximal part of coxa of leg 2, E. Closer view of spinule on coxa of leg 2, F. Leg 4. *Scale bars*: A,C,F, 100 µm; B, 50 µm; D, 25 µm; E, 2 µm.

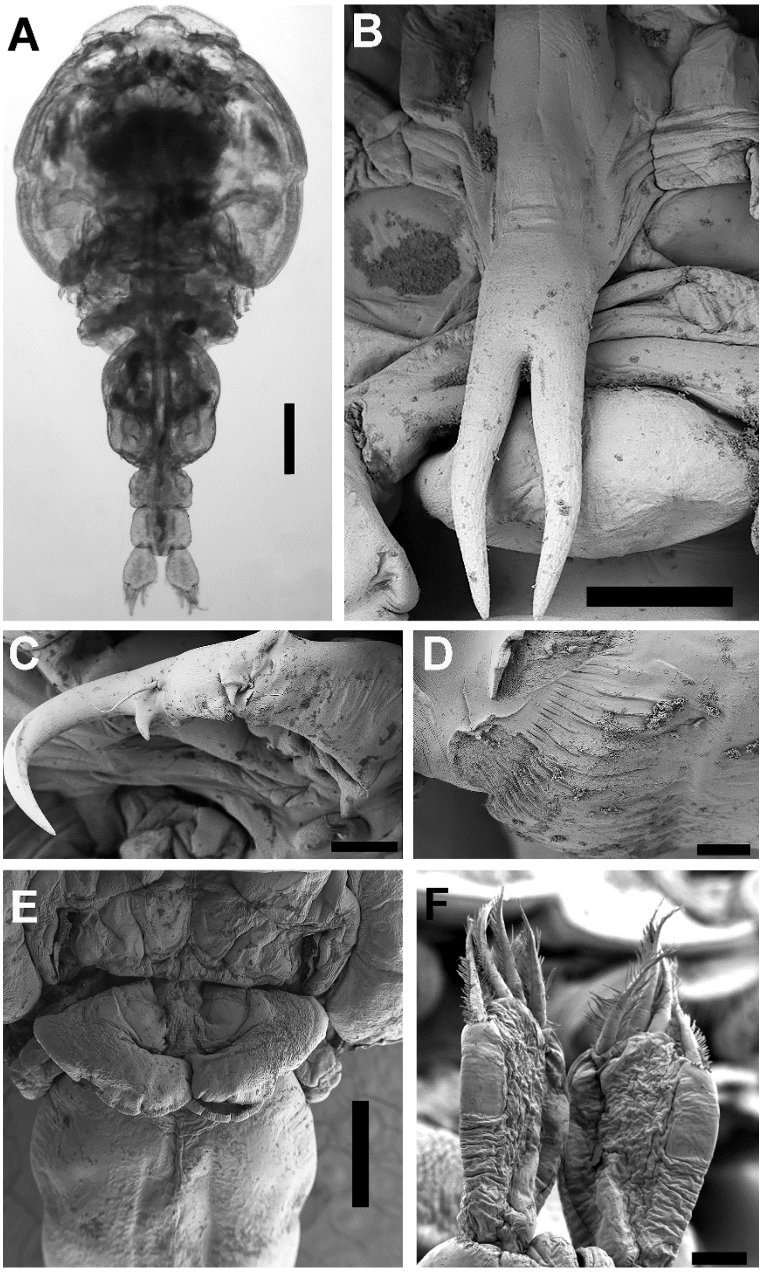

Figure 7. *Euryphorus brachypterus* (Male). A. Habitus (dorsal), B. Sternal furca, C. Antenna, D. Corrugated adhesion area near inner distal end of third segment, E. SEM images of dorsal plates, F. Caudal ramus. *Scale bars*: A, 1 mm; B,C,F, 100 µm; D, 10 µm; E,0.5 mm.

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RECENT OSTRACODA SPECIES OF THE TURKEY'S CONTINENTAL SHELF OF MEDITERRANEAN SEA: A REVIEW

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Introduction

Ostracoda are small ranging in length from 0.1 to 32 mm, bivalve aquatic crustaceans. This class of Crustacea is characterized with a body completely enclosed between two mostly calcified and tiny valves. They can be found in warm waters of tropical sand beaches, as well as in very cold environments, such as the deep sea and the polar seas or also freshwater environments (dams, lakes, ponds, acid lakes etc.). (Brandão *et al.* 2016). Marine ostracods have adopted both benthic and pelagic lifestyles, but most marine ostracods lives in benthic habitats and a few species are terrestrial in moist habitats (*Callistocypris mckenziei sp. nov., Callistocypris rossettii sp. nov., Terrestricypris wurdigae*) (Pinto *et al.* 2005). *Sheina orri* is known to be a parasitic on fish gills (Brusca and Brusca 2003). Almost all are free living, and most consume attached algae or detritus. Ostracods are important food of fishes, waterfowls, and various benthic and planktonic invertebrates. Marine ostracods most commonly reproduce sexually. Some of the freshwater forms can reproduce parthenogenetic. They are first identified in the 18th century. Concerning studies were related with simple collections and taxonomy. Accordingly studies continued with ecological, paleoecological and geochemical on Ostracoda (Holmes and Chivas 2002). Ostracods have a pair of carapace containing calcium carbonate. They leave fossils so they are sought and important materials for paleontological and paleoecological studies. Distribution and diversity of marine Ostracoda species belongs to several environmental and sedimentological factors like salinity, depth, mud percentage, nutrient source, wave actions, predation etc.

According to recent studies ostracod samples were collected from 1m^2 surface sediments in different depths from shallow littoral zone (by hand nets (200µm mesh size)) to deep sea levels (by Van Veen Grab). 400 ml of surface sediments were collected from each sediments in bottles including 70% alcohol or formaldehyde. Species were separated from mud and detritus with standard sieves (1 mm, 250-160 µm, and 80 µm mesh sizes) under pressurized tap water. This washed materials were preserved in 70 % ethanol.

Generic and specific features of carapace and soft parts were examined for species identification. Resulting materials were taken into micropaleontological slights or 1:1 70% ethanol and glycerin.

An updated checklist of the Ostracoda species of the marine and coastal brackish waters of Turkey are presented by Perçin-Paçal *et al.* (2015). Generally, when we examined the ostracod studies in Turkey, we saw that the species diversity of Mediterranean Sea was lower than the Marmara and Aegean Seas. This is also directly proportional to the number of studies and the number of species could probably increase with increasing scientific effort in the future studies. On the distribution and diversity of the marine ostracods have been conducted in the Mediterranean Sea by Nazik (1994); Şafak (2001; 2003; 2008); Perçin and Kubanç (2005); Külköylüoğlu *et al.* (2005; 2007); Ertekin and Tunoğlu (2005; 2008); Perçin-Paçal (2011) and Parlak and Nazik (2016).

The majority of the ostracod studies performed in territorial waters of Mediterranean Sea were carried in the continental shelf (<500 m) of Turkey. Up to date, totally 147 Ostracoda species were recorded from The Mediterranean Sea. (Table 1). The highest number of species was found in Genus *Loxoconcha* with 16 species in the Mediterranean Sea. An updated systematic of the Ostracoda is given below according to WoRMS (Worlds register of marine species) taxon details (WoRMS 2015):

Regnum: Animalia
Filum: Arthropoda
Subfilum: Crustacea
Superclass:Oligostraca
Class: Ostracoda

Table 1. Recent list of the Ostracoda species in the Mediterranean continental shelf.of Turkey

	Mediterranean Sea
OSTRACODA (Class)	
MYODOCOPA (Subclass)	
HALOCYPRİDA (Order)	
Polycope orbulinaeformis Breman, 1976	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Polycope reticulata G.W. Müeller, 1894	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Polycope tholiformis Bonaduce, Ciampo and Masoli, 1976	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
PODOCOPA (Subclass)	
PLATYCOPİDA (Order)	
Cytherella alvearium Bonaduce, Ciampo and Masoli, 1976	Perçin and Kubanç 2005; Perçin- Paçal 2011
Cytherella (Cytherelloidea) beckmanni Barbeito-Gonzales, 1971	Parlak and Nazik 2016

Cytherella terquemi Sissingh, 1972	Şafak 2001
Cytherella vandenboldi Sissingh, 1972	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin-Paçal 2011
Cytherella vulgata Ruggieri, 1962	Şafak 2001; Şafak 2003; Şafak 2008
Cytherelloidea sordida (Müller, 1894)	Nazik 1994; Şafak 2003; Perçin and Kubanç 2005; Perçin- Paçal 2011; Parlak and Nazik 2016
PODOCOPİDA (Order)	
Argilloecia acuminata Müller, 1894	Ertekin and Tunoğlu 2005; Ertekin and Tunoğlu 2008
Argilloecia conoidea Sars, 1923	Şafak 2001; Şafak 2003; Şafak 2008
Aurila arborescens (Brady,1865)	Parlak and Nazik 2016
Aurila convexa (Baird, 1850)	Nazik 1994; Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Külköylüoğlu *et al.* 2007; Şafak 2008; Perçin- Paçal 2011; Parlak and Nazik 2016
Aurila ducasseae Moyes 1961	Nazik 1994
Aurila speyeri (Brady, 1868	Şafak 2001; Şafak 2008
Aurila woodwardii (Brady, 1868)	Şafak 2003
Bairdia (Neonesidea) longevaginata Müller, 1894	Perçin and Kubanç 2005; Perçin- Paçal 2011
Basslerites berchoni (Brady, 1869)	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008
Basslerites teres (Brady, 1869)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Bathycythere mediterranea Ertekin 2005	Ertekin and Tunoğlu 2005
Bathycythere vanstraateni Sissingh, 1971	Ertekin and Tunoğlu 2008
Bosquetina carinella (Reuss, 1957)	Şafak 2001; Şafak 2008
Bosquetina rhodiensis Sissingh, 1972	Ertekin and Tunoğlu 2005
Bosquetina tarentina (Baird, 1850)	Ertekin and Tunoğlu 2008
Buntonia dertonensis (Ruggieri, 1954)	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Buntonia sublatissima (Neviani, 1906)	Ertekin and Tunoğlu, 2005;Ertekin and Tunoğlu 2008
Buntonia textilis Bonaduce, Ciampo and Masoli, 1976	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Bythocypris bosquetina (Brady, 1866)	Ertekin and Tunoğlu 2005
Bythocypris obtusata (Sars, 1866)	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Callistocythere crispata (Brady, 1868)	Perçin and Kubanç 2005; Perçin- Paçal, 2011
Callistocythere intricatoides (Ruggieri,1953) Sissingh, 1972	Parlak and Nazik 2016
Callistocythere mediterranea (Müller, 1894)	Şafak 2001; Şafak 2008
Callistocythere pallida (Müller, 1894)	Şafak 2001; Şafak 2008
Callistocythere vexata Bonaduce, Ciampo and Masoli, 1976	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Carinocythereis antiquata (Baird, 1850)	Nazik 1994; Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Külköylüoğlu *et al.* 2007; Şafak 2008

Carinocythereis carinata (Roemer, 1838)	Nazik 1994; Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011; Parlak and Nazik 2016
Carinocythereis quadridentata (Baird 1850)	Perçin and Kubanç 2005; Perçin- Paçal, 2011
Celtia quadridentata (Baird, 1850)	Şafak 2003
Cistacythereis caelatura Uliczny, 1969	Nazik 1994; Şafak 2001; Şafak 2008
Cistacythereis (Carinocythereis) pokornyi Ruggieri 1981	Şafak 2001; Şafak 2003; Şafak 2008
Costa batei (Brady 1866)	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008
Costa edwardsii (Roemer, 1838)	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Costa punctatissima Ruggieri, 1962	Şafak 2001; Şafak 2008
Cushmanidea (Pontocythere) elongata (Brady, 1868)	Nazik 1994; Şafak 2008; Parlak and Nazik 2016
Cythereis polygonata (Rome, 1942)	Külköylüoğlu *et al.* 2005
Cytheretta adriatica Ruggieri, 1952	Şafak 2001; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Külköylüoğlu *et al.* 2007; Şafak 2008; Perçin- Paçal 2011
Cytheretta semiornata, (Egger, 1858)	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008
Cytheretta subradiosa (Roemer, 1836)	Şafak 2001; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Cytheridea acuminata (Bosquet, 1952)	Nazik 1994; Ş Şafak 2001;Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Cytheridea neapolitana Kolmann, 1960	Şafak 2001; Perçin and Kubanç 2005; Perçin- Paçal 2011
Cytheridea paracuminata Kollmann, 1960	Şafak 2001; Şafak 2008
Cytherois fischeri (Sars, 1866)	Şafak 2001; Şafak 2003; Şafak 2008
Cyprideis seminulum (Reuss, 1850)	Şafak 2001; Şafak 2008
Cyprideis torosa (Jones, 1850)	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005;Külköylüoğlu *et al.* 2005; Külköylüoğlu *et al.* 2007; Şafak 2008;Perçin- Paçal 2011
Cytheropteron grossoalatum n.sp. Ertekin 2005	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Cytheropteron pseudoalatum Colalongo et Passini, 1980	Ertekin and Tunoğlu 2008
Cytheropteron rotundatum Müller, 1894	Ertekin and Tunoğlu, 2005;Ertekin and Tunoğlu 2008
Darwinula cylindrica (Straub, 1952)	Şafak 2001; Şafak 2008
Falunia (Hiltermanicythere) rugosa (Costa 1853) Sissingh, 1972	Nazik 1994
Henryhowella sarsi (Müller, 1894)	Ertekin and Tunoğlu, 2005;Ertekin and Tunoğlu 2008

Heterocythereis albomaculata (Baird, 1838)	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin-Paçal 2011
Hiltermannicythere emaciata (Brady, 1867)	Nazik 1994
Hiltermannicythere (Carinocythereis) rubra (Müller, 1894)	Perçin and Kubanç 2005; Perçin- Paçal 2011; Parlak and Nazik 2016
Hiltermannicythere turbida (Mueller, 1894)	Parlak and Nazik 2016
Hirschmannia viridis (O.F. Müller, 1785)	Şafak 2001; Şafak 2003; Şafak 2008
Jugosocythereis prava (Baird,1850)	Parlak and Nazik 2016
Ilyocypris bradyi Sars, 1890	Şafak 2003
Krithe bartonensis (T.R. Jones, 1857)	Şafak 2001; Şafak 2008
Krithe keyi Breman, 1978	Ertekin and Tunoğlu 2008
Krithe mersinensis n.sp. Ertekin 2005	Ertekin and Tunoğlu 2005
Krithe monosteracensis Sequenza, 1880	Ertekin and Tunoğlu 2008
Krithe reniformis (Brady, 1868)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Leptocythere lacertosa (Hirscmann, 1912)	Şafak 2003
Leptocythere macella Ruggieri, 1975	Perçin and Kubanç 2005; Perçin- Paçal 2011
Leptocythere multipunctata (Seguenza, 1942)	Şafak 2001; Şafak 2008
Leptocythere porcellanea (Brady, 1869)	Şafak 2001; Şafak 2003; Şafak 2008
Leptocythere ramosa (Rome, 1942)	Şafak 2001; Şafak 2003; Şafak 2008
Leptocythere rara (Müller, 1894)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loculicytheretta pavonia (Brady, 1866)	Nazik 1994; Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Külköylüoğlu *et al.* 2007; Şafak 2008; Perçin- Paçal 2011
Loxoconcha agilis Ruggieri, 1967	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin-Paçal 2011
Loxoconcha alata Brady, 1868	Nazik 1994
Loxoconcha bairdi (Müller, 1894)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha concentrica Bonaduce, Ciampo and Masoli, 1976	Nazik 1994; Şafak 2003
Loxoconcha elliptica Brady, 1868	Şafak 2003
Loxoconcha exagona Bonaduce, Ciampo and Masoli, 1976	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha granulata Sars, 1866	Şafak 2001; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Loxoconcha minima Müller, 1894	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha (Sagmatocythere) napoliana Puri, 1963	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha nea Barbeito and Gonzales, 1971	Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha ovulata (Costa, 1853)	Perçin and Kubanç 2005; Perçin- Paçal 2011

Loxoconcha parallela Müller,1894	Şafak 2003
Loxoconcha rhomboidea (Fischer, 1855)	Nazik 1994; Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Külköylüoğlu *et al.* 2007; Şafak 2008; Perçin- Paçal 2011; Parlak and Nazik 2016
Loxoconcha rubritincta Ruggieri, 1964	Perçin and Kubanç 2005; Perçin- Paçal, 2011
Loxoconcha stellifera Müller, 1894	Şafak 2001; Şafak 2008; Perçin and Kubanç 2005; Perçin- Paçal 2011
Loxoconcha tumida Chapman, 1902	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin-Paçal 2011
Macrocypris ligustica Bonaduce, Masoli andPugliese 1977	Ertekin and Tunoğlu 2005; Ertekin and Tunoğlu 2008;
Microcytherura fulva (Brady and Robertson, 1874)	Parlak and Nazik 2016
Monoceratina mediterranea Sissingh, 1972	Ertekin and Tunoğlu 2005; Ertekin and Tunoğlu 2008
Neocytherideis complicata (Ruggieri, 1953)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Neocytherideis cylindrica (Brady, 1868) Syn: Neocopytus cylindricus	Nazik 1994; Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Neocytherideis fasciata (Brady and Robertson, 1874)	Perçin and Kubanç 2005; Perçin- Paçal, 2011
Neocytherideis foveolata (Brady, 1870)	Şafak 2003; Perçin and Kubanç 2005; Perçin- Paçal, 2011
Neocytherideis subspiralis (Brady, Crosskey and Robertson, 1874)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Neonesidea (Bairdia) conformis (Terquem, 1878)	Ertekin and Tunoğlu 2005; Ertekin and Tunoğlu 2008
Neonesidea corpulenta (Mueller, 1894)	Parlak and Nazik 2016
Neonesidea formosa (Brady,1868)	Nazik 1994; Parlak and Nazik 2016
Paracytheridea depressa Müller, 1894	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008
Paracytheridea parallia Barbeito-Gonzales, 1971	Perçin and Kubanç 2005; Perçin- Paçal 2011
Paracytherois flexuosa (Brady, 1867)	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Paradoxostoma fuscum G.W. Müller, 1894	Perçin and Kubanç 2005; Perçin- Paçal 2011
Parakrithe dimorpha Bonaduce, Ciampo and Masoli, 1976	Perçin and Kubanç 2005; Perçin- Paçal 2011
Pontocythere (Cushmanidea) elongata (Brady, 1868) Oertli, 1956	Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Perçin- Paçal 2011
Pontocythere turbida Müller, 1894 (Müller, 1894) Morkhoven, 1963	Perçin and Kubanç 2005; Perçin- Paçal 2011
Procytherideis complicata (Ruggieri, 1953)	Nazik 1994
Propontocypris dispar G.W. Müller, 1894	Şafak 2003

Propontocypris pirifera (G.W. Müller, 1894)	Şafak 2001; Şafak 2008; Parlak and Nazik 2016
Pseudocythere caudata Sars, 1866	Ertekin and Tunoğlu 2005;Ertekin and Tunoğlu 2008
Pseudocytherura calcarata (Seguenza, 1880)	Şafak 2001; Şafak 2008
Pseudopsammocythere similis (G.W. Müller, 1894)	Şafak 2001; Şafak 2008
Pterigocythereis ceratoptera (Bosquet, 1852)	Parlak and Nazik 2016
Rectobuntonia inflata Colalongo and Pasini, 1980	Ertekin and Tunoğlu 2005
Sahnia fasciata (Brady and Robertson,1874)	Parlak and Nazik 2016
Semicytherura acuminata (Müller, 1894)	Şafak 2001; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Semicytherura acuticostata (Sars, 1866)	Şafak 2001; Şafak 2008
Semicytherura aenariensis Bonaduce, Ciampo and Masoli, 1976	Perçin and Kubanç 2005; Perçin- Paçal 2011
Semicytherura incongruens (Müller, 1894)	Nazik 1994; Şafak 2001; Şafak 2008
Semicytherura inversa (Seguenza, 1880)	Şafak 2001; Şafak 2008
Semicytherura ruggierii (Pucci, 1956)	Şafak 2001; Şafak 2008
Semicytherura sella (Sars, 1866)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Semicytherura sulcata (Müller, 1894)	Nazik 1994; Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin- Paçal 2011
Tegmenia (Falunia) rugosa (Costa, 1853)	Şafak 2001; Şafak 2003; Şafak 2008
Tenedocythere (Quadracythere) prava (Baird, 1850)	Nazik 1994; Perçin and Kubanç 2005; Perçin- Paçal 2011
Triebelina raripila (Mueller, 1894)	Parlak and Nazik 2016
Urocythereis colum Athersuch, 1977	Perçin and Kubanç 2005; Perçin- Paçal 2011
Urocythereis distinguenda Athersuch, 1978	Perçin and Kubanç 2005; Perçin- Paçal 2011
Urocythereis favosa (Roemer, 1838)	Nazik 1994; Şafak 2001; Şafak 2003; Külköylüoğlu *et al.* 2005; Külköylüoğlu *et al*. 2007; Şafak 2008
Urocythereis margaritifera (Müller, 1894)	Şafak 2001; Şafak 2008; Parlak and Nazik 2016
Urocythereis oblonga (Brady,1866)	Parlak and Nazik 2016
Urocythereis phantastica Athersuch and Ruggieri 1975	Perçin and Kubanç 2005; Perçin- Paçal 2011
Urocythereis sororcula (Seguenza, 1880)	Nazik 1994
Xestoleberis aurantia (Baird, 1838)	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008
Xestoleberis communis (Müller, 1894)	Şafak 2001; Şafak 2003; Perçin and Kubanç 2005; Şafak 2008; Perçin-Paçal 2011; Parlak and Nazik 2016
Xestoleberis decipiens G.W. Müller, 1894	Şafak 2001; Külköylüoğlu *et al.* 2005; Perçin and Kubanç 2005; Külköylüoğlu

	et al. 2007; Şafak 2008; Perçin- Paçal 2011
Xestoleberis depressa Sars, 1866	Nazik 1994; Şafak 2001; Şafak 2003; Şafak 2008; Parlak and Nazik 2016
Xestoleberis dispar Müller, 1894	Şafak 2001; Perçin and Kubanç 2005; Ertekin and Tunoğlu 2005; Ertekin and Tunoğlu 2008; Şafak 2008; Perçin-Paçal 2011; Parlak and Nazik 2016
Xestoleberis margaritea (Brady, 1866)	Perçin and Kubanç 2005; Perçin- Paçal 2011
Xestoleberis ventricosa (Müller, 1894)	Şafak 2003

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SPONGE FAUNA OF THE TURKISH MEDITERRANEAN COAST

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Background

While they have 5500 known species in the seas around the world (Brusca *et al.* 1990), the first written record of sponges in Turkish seas is Forbes (1843). In this study, Forbes (1843) did not identify species, but talked about the presence of sponges in the Anatolian shores. However, first species records of sponges in Turkish seas come from Colombo (1885). Colombo (1885) reported 5 species from the Dardanelles. This study was followed by Ostroumoff (1894, 1896), Demir (1954), Caspers (1968), Bayhan *et al.* (1989), Topaloğlu (2001a), Gözcelioğlu *et al.* (2015), Topaloğlu *et al.* (2016) studies, for the Turkish Straits and the Sea of Marmara. As of today, 75 sponge species were reported in studies performed in the straits and the Sea of Marmara.

On the Aegean shores of Turkey, 83 sponge species were reported in studies performed by Sarıtaş (1972, 1973), Yazıcı (1978), Geldiay and Kocataş (1972), Kocataş (1978), Ergüven *et al.* (1988), Katağan *et al.* (1991), Ergen *et al.* (1994), Çınar and Ergen (1998), Koçak *et al.* (1999), Topaloğlu (2001a, 2001b), Çınar *et al.* (2002), Gözcelioğlu *et al.* (2015). 13 sponge species were reported on Turkey's Black Sea shores (Topaloğlu *et al.* 2013; Evcen *et al.* 2016)).

The number of studies regarding the sponges found on the Levantine coast of Turkey is very limited. The first records available for the sponge species present in these shores was provided by Ünsal (1981). Ünsal (1981) reported 13 sponge species in his study named “Ecological and Benthic Studies in the Rocky Shores of the Akkuyu Bay”. No publications were noted after this until 2011. In 2011, Gözcelioğlu (2011) and Gözcelioğlu *et al.* (2011) reports 30 species. However the most extensive study on the sponges found in the southern coast of Turkey was performed by Evcen and Çınar (2012). In this study, Evcen and Çınar (2012) reported a total of 29 species, and also added the species reported in the previous studies on this subject and presented a checklist of the sponges found in Turkish shores. This checklist was updated by Topaloğlu and Evcen (2014) in 2014 and a new checklist was published.

Current Status

This study is compiled from the checklists provided by Evcen and Çınar (2012) and Topaloğlu and Evcen (2014), and the sponge species reported by the Ünsal (1981) were added. According to this information, it was determined that there are 57 sponge species belonging to three classes (Calcarea 3 species, Homoscleromorpha 1 species, Demospongiae 53 species) in the Mediterranean shores of Turkey (Figure 1, Table 1).

While a total of 85 sponge species were reported by the studies performed in the Levantine Sea, 681 species were reported in total in the entire Mediterranean (Coll *et al.* 2010; Evcen and Çınar 2012).

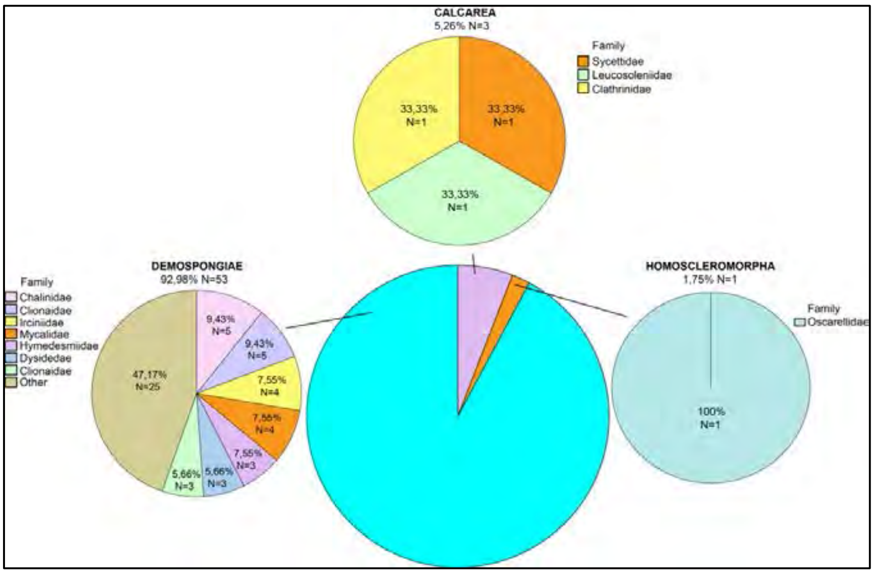

Figure 1. Number of species of Levantine coats of Turkey by family per class

This supports the general assumption that the number of species decreases as one moves from west to east. Also the number of zoobenthic studies performed in the Levantine Sea is lower than the number of studies in the Western Mediterranean. It can be expected that the number of species will increase in the Levantine Sea and the Levantine coast of Turkey with future studies.

Table 1. Species list of Porifera at Levantine coast of Turkey

Group/Species	Reference	Depth Range	Habitat*
Phylum: PORIFERA			
Class: Calcarea			
Family: Sycettidae			

Sycon raphanus Schmidt, 1862	Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Family: Leucosoleniidae			
Leucosolenia variabilis (Haeckel, 1870)	Evcen and Çınar (2012)	0–10 m	Hs
Family: Clathrinidae			
Clathrina clathrus (Schmidt, 1864)	Evcen and Çınar (2012)	0–10 m	Hs
Class: Homoscleromorpha			
Family: Oscarellidae			
Oscarella lobularis (Schmidt, 1862)	Gözcelioğlu (2011)	0–10 m and 11–50 m	Hs
Class: Demospongiae			
Family: Tethyidae			
Tethya aurantium (Pallas, 1766)	Ünal (1981) Topaloğlu *et al.* (2013)	0–10 m and 11–50 m	Hs
Family: Spirastrellidae			
Diplastrella bistellata (Schmidt, 1862)	Evcen and Çınar (2012)	0–10 m	Hs
Spirastrella cunctatrix Schmidt, 1868	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m and 11–50 m	Hs
Family: Clionaidae			
Cliona celata Grant, 1826	Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Cliona vermifera Hancock,1867	Ünsal (1981)	0-10 m	Hs
Cliona viridis (Schmidt, 1862)	Ünsal (1981) Gözcelioğlu (2011)	0–10 m and 11–50 m	Hs
Cliona schmidti (Ridley, 1881)	Ünsal (1981) Evcen and Çınar (2012)	0–10 m	Hs
Cliothosa hancocki (Topsent, 1888)	Ünsal (1981)	0-10 m	Hs
Family: Placospongiidae			
Placospongia decorticans(Hanitsch, 1895)	Ünsal (1981)	0-10 m	Hs
Family: Chalinidae			
Dendrectilla tremitensis Pulitzer-Finali 1983	Gözcelioğlu *et al.* (2011)	11–50 m	Hs
Haliclona flavescens (Topsent, 1893)	Gözcelioğlu (2011)	11–50 m	Hs
Haliclona fulva (Topsent, 1893)	Evcen and Çınar (2012)	0–10 m	Hs
Haliclona mediterranea Griessinger,1971	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Haliclona sarai (Pulitzer-Finali, 1969)	Gözcelioğlu *et al.* (2011)	11–50 m	Hs
Family: Phloeodictyidae			
Calyx nicaeensis (Risso, 1826)	Gözcelioğlu (2011)	11–50 m	Hs

Family: Petrosiidae			
Petrosia ficiformis (Poiret, 1789)	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Petrosia vansoesti B-, PansiniandUriz 1994	Evcen and Çınar (2012)	0–10 m	Hs
Family: Dictyonellidae			
Acanthella acuta Schmidt, 1862	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Dictyonella incisa (Schmidt, 1880)	Gözcelioğlu *et al*. (2011)	11–50 m	Hs
Family: Axinellidae			
Axinella cannabina (Esper, 1794)	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Axinella damicornis (Esper, 1794)	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Axinella verrucosa (Esper, 1794)	Gözcelioğlu (2011)	11–50 m	Hs
Family: Halichondriidae			
Ciocalypta carballoi V, B,C, ZibrowiusandPerez,2007	Uysal *et al*. (2002)	11–50 m	Hs
Family: Bubaridae			
Hymerhabdia intermedia Sarà and Siribelli, 1960	Evcen and Çınar (2012)	0–10 m	Hs
Family: Ancorinidae			
Holoxea furtiva Topsent, 1892	Ünsal (1981)	0-10 m	Hs
Family: Geodiidae			
Erylus discophorus (Schmidt, 1862)	Ünsal (1981) Evcen and Çınar (2012)	0–10 m	Hs
Geodia cydonium (Jameson, 1811)	Ünsal (1981)	0-10 m	Hs
Family: Thoosidae			
Alectona millari Carter, 1879	Ünsal (1981) Evcen and Çınar (2012)	0–10 m	Hs
Family: Mycalidae			
Mycale contareni (Martens, 1824)	Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Mycale rotalis (Bowerbank, 1874)	Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Mycale lingua (Bowerbank, 1866)	Evcen and Çınar (2012)	0–10 m	Hs

Mycale massa (Schmidt, 1862)	Ünsal (1981) Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Family: Agelasidae			
Agelas oroides (Schmidt, 1862)	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Family: Myxillidae			
Myxilla rosacea (Lieberkühn, 1859)	Ünsal (1981)	0-10 m	Hs
Family: Crambeidae			
Crambe crambe (Schmidt, 1862)	Ünsal (1981) Gözcelioğlu (2011),	0–10 m and 11–50 m	Hs
Family: Hymedesmiidae			
Hemimycale columella (Bowerbank, 1874)	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m	Hs
Phorbas fictitius (Bowerbank, 1866)	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m and 11–50 m	Hs
Sarcotragus spinosulus Schmidt, 1862	Gözcelioğlu (2011), Evcen and Çınar (2012)	11–50 m	Hs
Family: Dysideidae			
Dysidea avara (Schmidt, 1862)	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Dysidea fragilis (Montagu, 1818)	Gözcelioğlu *et al.* (2011)	0–10 m and 51–100 m	Hs
Pleraplysilla spinifera (Schulze, 1879)	Gözcelioğlu (2011)	11–50 m	Hs
Family: Thorectidae			
Hyrtios collectrix (Schulze, 1880)	Gözcelioğlu *et al.* (2011)	11–50 m	Hs
Scalarispongia scalaris (Schmidt, 1862)	Gözcelioğlu (2011), Gözcelioğlu *et al.* (2011)	0–10 m and 11–50 m	Hs
Family: Spongiidae			
Spongia officinalis Linnaeus, 1759	Gözcelioğlu (2011)	0–10 m and 51–100 m	Hs
Family: Aplysinidae			
Aplysina aerophoba Nardo, 1843	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m and 51–100 m	Hs
Family: Chondrillidae			
Chondrilla nucula Schmidt, 1862	Gözcelioğlu (2011)	11–50 m	Hs
Chondrosia reniformis Nardo, 1847	Gözcelioğlu (2011), Evcen and Çınar (2012)	0–10 m	Hs
Phorbas plumosus (Montagu, 1818)	Evcen and Çınar (2012)	0–10 m	Hs
Phorbas tenacior (Topsent, 1925)	Gözcelioğlu (2011)	11–50 m	Hs
Family: Desmacellidae			

Desmacella inornata (Bowerbank, 1866)	Evcen and Çınar (2012)	0–10 m	Hs
Family: Irciniidae			
Ircinia dendroides (Schmidt, 1862)	Evcen and Çınar (2012)	0–10 m	Hs
Ircinia variabilis (Schmidt, 1862)	Gözcelioğlu (2011)	0–10 m and 11–50 m	Hs
Sarcotragus foetidus Schmidt, 1862	Evcen and Çınar (2012)	0–10 m and 11–50 m	Hs

*Hs: Hard substrat

It is known that the Levantine Sea is a sea area where alien species, especially species that immigrated from the Red Sea (Lessepsian species) are heavily present. According to the Zenetos *et al*. (2010) study, 75% of the 955 alien species present in the Mediterranean are in the Eastern Mediterranean. While multiple alien species from especially mollusca, crustacea, polycahaeta are present in the Levantine Sea, there are no sponge species that are conclusively proven to be alien species. Even though 7 Red Sea immigrant species were reported to be present in the past, due to the uncertain taxonomic position of these species, these were removed from the list of alien species in the Mediterranean (Evcen and Çınar 2012).

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MARINE MOLLUSCS OF MEDITERRANEAN COAST OF TURKEY

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Background

The Levantine Sea, which covers the area to the east of the imaginary line that extends from the western end of Crete to Libya, is the second largest sea of the Mediterranean after the Ionian Sea. This part of the Levantine Sea has 4 significant trenches. These are Rhodes (4000m), Antalya (2500m), Cilicia (1000m) and Latakia (1500m) trenches (Özsoy *et al.* 1993). Turkish southern coast, with a total length of 1577km, also constitute most of the northern coast of the Levantine Sea.

First information regarding the mollusc species at the Turkish coasts was reported by the British scientist Forbes (1844). During the 18 month study Forbes performed in the Aegean Sea, he also reported 73 mollusc species from the Levantine coast of Turkey. After Forbes, there were no studies on mollusc species in the Mediterranean coast of Turkey until 1957. In 1957, during a study performed by Akyüz (1957) in Iskenderun Bay, the mollusc species found in sediment samples taken at the depths of 30-70m were identified, reported and added to the article by Dr. Muzaffer Demir. In this study, species like *Bittium reticulacum*, *Turritella communis, Papillicardium papillosum*, *Tellina donacina*, *Corbula gibba*, *Dentalium sp.* were reported in Iskenderun Bay. However, the first significant study of molluscs at the southern coast of Turkey was performed by Swennen (1961) in 1957 (In this study, samples were taken from the Black Sea (Trabzon) and the Turkish Levantine coast (Antalya and Mersin Bays) coast of Turkey). In this study, Sweenen (1961) reported 22 opsithobranc species at the shores of Antalya and Mersin Bays. Also, in this study, alien mollusc species (*Chelidonurafulvi punctata*, *Bursatella leachii*) were reported for the first time in Turkish seas. After this study, many studies were performed by different researchers at different times at the southern coast of Turkey (Falchi 1974; Artüz 1976; Ünsal 1981; Linder 1987; Buzzurro and Greppi 1994; Buzzurro *et al.* 1995; Tringali and Villa 1990; Çevik and Sarıhan 2004; Yokeş and Rudman 2004; Çevik *et al.* 2006; Öztürk and Aartsen 2006; Öztürk and Can 2006; Uysal *et al.* 2008; Özvarol *et al.* 2010; Mutlu and Ergev 2012). A significant part of these studies were performed by mostly foreign researchers and scientists and amateur collectors to determine alien species at the Levantine coast of Turkey. However, there are also species that aim to identify the overall mollusca fauna present that cover all species (native and alien). The most significant among these are the studies performed by Buzzurro and Greppi (1996), Çevik and Sarıhan (2004), Demir (2003), Uysal *et al.* (2008), Çınar *et al.* (2012) and Bitlis-Bakır *et al.* (2012). In 2014, the Turkish Seas Mollusca Fauna prepared by Öztürk and Çevik (2000) was revised by Öztürk *et al.* (2014). This study by Öztürk *et al.* (2014) lists the molluscs seen in the Levantine shores of Turkey alongside molluscs that are seen in the other seas of Turkey. The species presented in this study were gathered by taking them from the list of species at the southern coast of Turkey given in the aforementioned checklist. However, the number of species given here also includes three species identified by Öztürk *et al.* (2014) and one alien species identified by Çevik *et al.* (2015).

Current Status

As a result, studies performed in the Turkish Levantine coast have so far discovered a total of 813 molluscs species belonging to 6 classes (Caudofoveata 2, Polyplacophora 12, Gastropoda 543, Bivalvia 222, Cephalopoda 27, Scaphopoda 7) (Figure 1). As it can be seen table 1, most species observed in the Levantine coast of Turkey. Moreover as it can be seen in table 2 most of species were observed up to a depth of 100 meters.

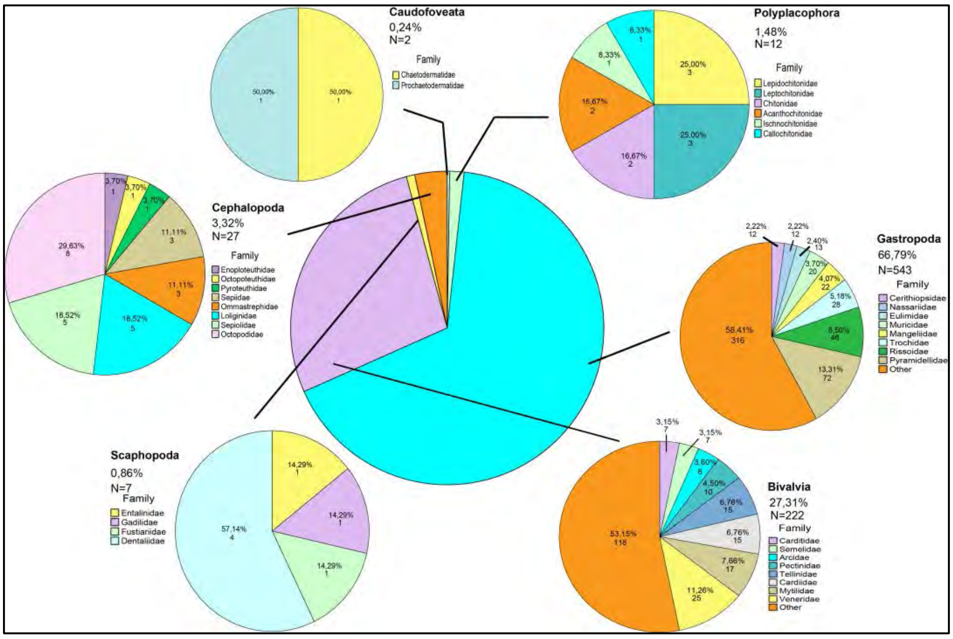

Figure 1. List of species of Levantine Coast of Turkey by family per class

697 of total species (85.7%) are native and 116 (14.3%) are alien mollusc species (Figure 2; Table 3). 19 of these species are classified as endangered or threatened according to the IUCU Red List and Barcelona/Bern Conventions (Table 4). The other

two classes of the Mollusca phylum, Solenogastres and Monoplacopora were not reported at the Mediterranean coast of Turkey so far.

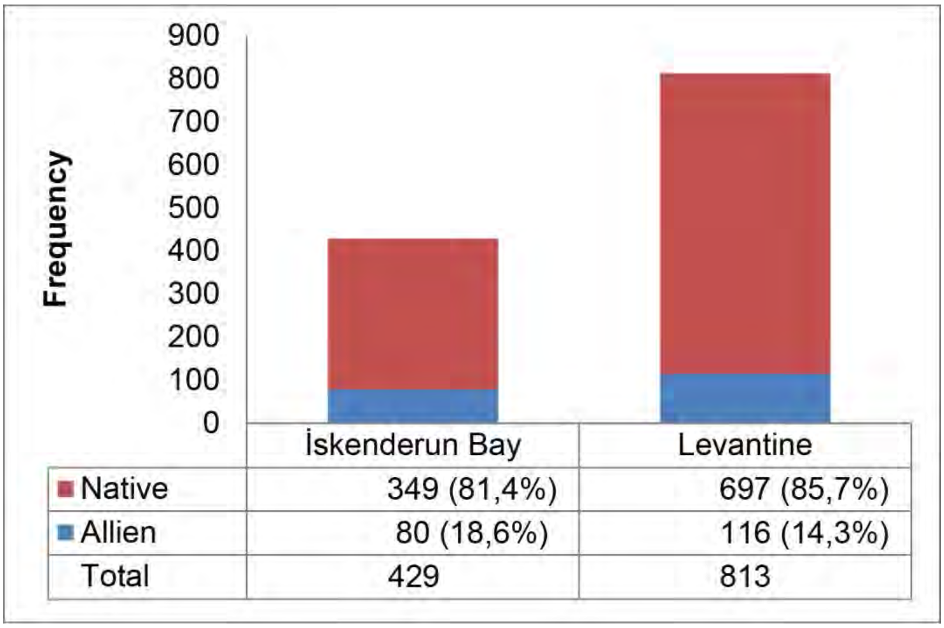

Figure 2. Number of native and alien species in the Levantine Coast of Turkey

Table 1. Habitat preferences of observed species in the Levantine Coast of Turkey

Habitat	Number of Species	Percent
Ss	334	41,1%
Hs and Ss	186	22,9%
Hs	135	16,6%
Pz	85	10,5%
P	25	3,1%
D	23	2,8%
Sub Total	788	97%
No data	25	3,1%
Total	813	100,0%

* Hs: Hard substratum; Ss: soft substratum; P: pelagic; D:Demersal; Pz: Parasite

It is known that the Mediterranean is being invaded by alien species that arrive from the Red Sea through the Suez Canal (60% of the number of alien species) and from other seas carried by ships (Zenetos *et al.* 2010; Table 3).

Table 2. Depth strata of observed species in the Levantine Coast of Turkey

Depth	Number of Species	Percent
0-10 m - 11-50 m	200	24,60
0-11 m	198	24,35
0-10 m - 51-100 m	125	15,38
0-10 m - 101-200 m	52	6,40
11-50 m	42	5,17
0-10 m - 600+ m	28	3,44
11-50 m - 101-200 m	28	3,44
11-50 m - 51-100 m	23	2,83
51-100 m - 600+ m	14	1,72
0-10 m - 201-400m	11	1,35
11-50 m - 600+ m	11	1,35
11-50 m - 201-400m	10	1,23
Other Depths	42	5,17
Subtotal	784	96,43
No data	29	3,57
Total	813	100

Up to 2010, 955 alien species were identified in the Mediterranean. Among these, molluscs constitute a significant number with 212 species (Zenetos *et al.* 2010, Çınar *et al.* 2012). Among Turkish seas, the Levantine coasts of Turkey are among the areas most affected by these alien species, mostly consisting of Lessepsian species. Among the 400 alien species reported in studies performed until 2011, 330 were reported in the Levantine shores and among the reported systematic groups, molluscs is the group that is represented in highest numbers with 105 species (Çınar 2011; Öztürk *et al.* 2015).

Table 3. List of alien species in the Levantine Coast of Turkey

Name of Species	Reference Source
Diodora ruppellii (Sowerby, G. B. I, 1835)	Enzenross *et al.* (1990)
Trochus erithreus (Brocchi, 1821)	Engl (1992)
Pseudominolia nedyma (Melvill, 1897)	Engl (1992), Engl (1995)
Stomatella impertusa (Burrow, 1815)	Schniebs (2000)
Parviturbo dibellai (Buzzurro and Cecalupo, 2007)	Buzzurro and Cecalupo (2006)
Lodderia novemcarinata (Melvill, 1906)	Öztürk *et al.* (2015)
Nerita sanguinolenta Menke, 1829	Falakalı-Mutaf *et al.* (2007)
Smaragdia souverbiana (Montrouzier, 1863)	Buzzurro and Greppi (1994)
Cerithidium diplax (Watson, 1886)	van Aartsen (2006)

Table 3. Continued

Cerithidium perparvulum (Watson, 1886)	Buzzurro and Greppi (1996),
Cerithium scabridum Philippi, 1848	Barash and Danin (1982)
Rhinoclavis kochi (Philippi, 1848)	Enzenross and Enzenross (1987)
Diala semistriata (Philippi, 1849)	Delongueville and Scaillet (2007)
Gibborissoia virgata (Philippi, 1849)	van Aartsen (2002)
Finella pupoides Adams, A., 1860	Tringali and Villa (1990)
Metaxia bacillum (Issel, 1869)	Engl (1992), Engl (1995)
Cerithiopsis pulvis (Issel, 1869)	Tringali and Villa (1990)
Cerithiopsis tenthrenois (Melvill, 1896)	Tringali and Villa (1990)
Cycloscala hyalina (Sowerby, 1844)	Giunchi *et al.* (2001)
Sticteulima lentiginosa (Adams, A., 1861)	Tringali (1994)
Alvania dorbignyi (Audouin, 1826)	Buzzurro and Greppi (1996)
Rissoina ambigua (Gould, 1849)	Mienis (2004)
Rissoina bertholleti (Issel, 1869)	Enzenross *et al.* (1990)
Caecum sepimentum de Folin, 1868	Ovalis and Mifsud (2014)
Conomurex persicus (Swainson, 1821)	NicolayandManoja (1983)
Eratoena sulcifera (Gray in Sowerby 1832)	Öztürk *et al.* (2015)
Purpuradusta gracilis notata (Gill, 1858)	Blöcher (1983)
Eunaticina papilla Gmelin, 1791	Öztürkand Bitlis-Bakır (2013c)
Ergalatax junionae (Houart, 2008)	Engl (1995)
Thaisella lacera (Born, 1778)	Niederhofer *et al.* (1991)
Zafra savignyi (Moazzo, 1939)	Tringali and Villa (1990)
Zafra obesula (Hervier, 1899)	Öztürk *et al.* (2015)
Zafra pumila (Dunker, 1858)	Öztürk *et al.* (2015)
Zafra selasphora (MelvilandStanden,1901)	Palazzi (1993)
Pseudorhaphitom aiodolabiata(HandMermod,1928)	Öztürk (2012)
Chrysallida fischeri (HornungandMermod,1925)	Micali and Palazzi (1992)
Chrysallida maiae (HornungandMermod, 1924)	van Aartsen (1977)
Chrysallida micronana Öztürk andAartsen,2006	Öztürk and van Aartsen (2006)
Chrysallida pirinthella (Melvill, 1910)	Micali and Palazzi (1992)
Cingulina isseli (Tryon,1886)	van Aartsen *et al.* (1989)
Iolaea neofelixoides (Nomura, 1936)	van Aartsen and Recevik (1998)
Monotygma lauta (Adams, A., 1853)	Micali and Palazzi (1992)
Odostomia lorioli (HornungandMermod,1924)	DelonguevilleandScaillet (2007)
Syrnola cinctella A. Adams, 1860	van Aartsen Recevik (1998)
Syrnola fasciata Jickeli, 1882	van Aartsen *et al.* (1989)

Table 3. Continued

Syrnola lendix (Adams, A., 1863)	Micali and Palazzi (1992)
Turbonilla edgarii (Melvill, 1896)	Engl (1992)
Amathina tricarinata (Linnaeus, 1767)	Çeviker and Albayrak (2006)
Leucotina cf. *eva* Thiele, 1925	Giunchi *et al.* (2001)
Leucotina natalensis Smith, E.A., 1910	Micali and Palazzi (1992)
Bulla arabica Malaquias and Reid, 2008	Yokeş and Rudman (2004)
Atys macandrewi Smith, E. A., 1872	van Aartsen and Goud (2006)
Haminoea cyanomarginata HellerandThompson1983	Yokeş and Rudman (2004)
Chelidonura fulvipunctata Baba, 1938	Swennen (1961)
Acteocina crithodes MelvillandStanden, 1907	Mienis (2004)
Acteocina mucronata (Philippi, 1849)	van Aartsen *et al.* (1989)
Cylichnina girardi (Audouin, 1826)	van Aartsen *et al.* (1990)
Pyrunculus fourierii (Audouin, 1826)	van Aartsen *et al.* (1989)
Oxynoe viridis (Pease, 1861)	Yokeş and Rudman (2004)
Elysia grandifolia Kelaart, 1857	Yokeş and Rudman (2004)
Elysia tomentosa Jensen, 1997	Yokeş and Rudman (2004)
Aplysia dactylomela Rang, 1828	Çınar *et al.* (2006)
Aplysia parvula Mörch, 1863	Swennen (1961)
Bursatella leachii de Blainville, 1817	Swennen (1961)
Notarchus punctatus Philippi, 1836	Yokeş (2009)
Syphonota geographica (Adams, A.andReeve, 1850)	Yokeş and Rudman (2004)
Chromodoris quadricolor (RüppellandLeuckart,1830)	Öztürk and Can (2006)
Goniobranchus annulatus (Eliot, 1904)	Gökoğlu and Özgür (2008)
Hypselodoris infucata (RüppellandLeuckart, 1830)	Çevik and Öztürk (2000)
Dendrodoris fumata (RüppelandLeuckart, 1830)	Çevik *et al.* (2012)
Plocamopherus ocellatus RüppellandLeuckart,1828	Yokeş and Rudman (2004)
Plocamopherus tilesii Bergh, 1877	Yokeş *et al.* (2012)
Melibe viridis (Kelaart, 1858)	Yokeş and Rudman (2004)
Baeolidia moebii Bergh, 1888	Turk and Furlan (2011)
Flabellina rubrolineata (O'Donoghue, 1929)	Yokeş and Rudman (2004)
Siphonaria belcheri Hanley, 1858	Albayrak and Çeviker (2001)
Siphonaria crenata de Blainville, 1827	Albayrak and Çeviker (2001)
Anadara natalensis (Krauss, 1848)	Enzenross *et al.* (1990)
Anadara transversa (Say, 1822)	Engl (1995)
Arcuatula perfragilis (Dunker, 1857)	Eleftheriou *et al.* (2011)

Table 3. Continued

Arcuatula senhousia (Benson in Cantor, 1842)	Uysal *et al.* (2008)
Brachidontes pharaonis (Fischer P., 1870)	Kinzelbach (1985)
Septifer bilocularis (Linnaeus, 1758)	Albayrak and Çağlar (2006)
Septifer cumingii Récluz, 1849	Albayrak and Çeviker (2001)
Electroma vexillum (Reeve, 1857)	Çevik *et al.* (2008)
Pinctada radiata (Leach, 1814)	Barash and Danin (1973)
Malleus regula (Forsskål in Niebuhr, 1775)	Falchi (1974)
Spondylus spinosus Schreibers, 1793	Engl and Çeviker (1999)
Crassostrea gigas (Thunberg, 1793)	Çevik *et al.* (2001)
Dendostrea frons (Linnaeus, 1758)	Çeviker (2001)
Saccostrea cucullata (Born, 1778)	Çevik *et al.* (2001)
Centrocardita akabana (Sturany, 1899)	Çeviker and Albayrak (2006)
Chama asperella Lamarck, 1819	Mifsud and Ovalis (2007)
Chama pacifica Broderip, 1835	Çeviker (2001)
Nudiscintilla cf. *glabra* Lützen and Nielsen,2005	Mifsud and Ovalis (2012)
Afrocardium richardi (Audouin, 1826)	van Aartsen and Goud (2000)
Fulvia fragilis (Forsskål in Niebuhr, 1775)	Lindner (1988)
Psammotreta praerupta (Salisbury, 1934)	Engl and Çeviker (1999)
Tellina valtonis Hanley, 1844	Giunchi *et al.* (2001)
Ervilia scaliola Issel, 1869	Zenetos and Ovalis (2014)
Antigona lamellaris Schumacher, 1817	Engl and Çeviker (1999)
Clementia papyracea (Gray, 1825)	Enzenross and Enzenross (1987)
Gafrarium pectinatum (Linnaeus, 1758)	Lindner (1987)
Gouldiopa consternans (OliverandZuschin,2001)	Ovalis and Mifsud (2013)
Paphia textile (Gmelin, 1791)	Enzenross *et al.* (1990)
Petricola fabagella Lamarck, 1818	Çeviker and Albayrak (2006)
Timoclea roemeriana (Issel, 1869)	Öztürk *et al.* (2014)
Sphenia rueppellii Adams A., 1850	Zenetos *et al.* (2010)
Martesia striata (Linnaeus, 1758)	Çevik *et al.* (2015)
Teredo bartschi Clapp, 1923	Borges *et al.* (2014)
Teredo navalis Linnaeus, 1758	Şen *et al.* (2009)
Teredothyra dominicensis (Bartsch, 1921)	Müller (2011)
Cucurbitula cymbium (Spengler, 1783)	Niederhofer *et al.* (1991)
Laternula anatina (Linnaeus, 1758)	Engl (1995)
Sepioteuthis lessoniana Lesson, 1830	Salman (2002)
Amphioctopus aegina (Gray, 1849)	Salman *et al.* (1999)

Iskenderun Bay, at the northeastern corner of the Levantine Sea, is one of the locations where both species coming in from the Suez Canal (Lessepsian species) and species that come in with ships (by ballast water or by attaching themselves onto vessels) are seen most often due to its location close to the Suez Canal, and its high marine traffic due to the presence of ports, industrial plants, oil pipelines, thermal power plants, steel mills, fishing and tourism industries (Figure 2). For this reason, Iskenderun Bay has a special importance regarding alien mollusc species.

Table 4. List of endangered/threatened species in the Levantine Coast of Turkey

Name of Species	Reference Source
Dendropoma petraeum (Monterosato, 1884)	Çevik and Sarıhan (2004)
Luria lurida (Linnaeus, 1758)	Gruvel (1931)
Zonaria pyrum (Gmelin, 1791)	Demir (2003)
Haliotis tuberculata lamellosa (Lamarck, 1822)	Buzzurro and Greppi (1996)
Cerithium vulgatum Bruguière, 1792	Forbes (1844)
Erosaria spurca (Linnaeus, 1758)	Buzzurro and Greppi (1996)
Tonna galea (Linnaeus, 1758)	Gruvel (1931)
Lithophaga lithophaga (Linnaeus, 1758)	Geldiay and Uysal (1971)
Pholas dactylus Linnaeus, 1758	Buzzurro and Greppi (1996)
Pinna nobilis Linnaeus, 1758	Buzzurro and Greppi (1996)
Eledone cirrhosa (Lamarck, 1798)	Salman *et al.* (2002)
Rondeletiola minor (Naef, 1912)	Salman and Katağan (2004)
Rossia macrosoma (Delle Chiaje, 1830)	Salman *et al.* (2002)
Sepia officinalis Linnaeus, 1758	Salman and Katağan (2004)
Sepia elegans de Blainville, 1827	Salman and Katağan (2004)
Sepia orbignyana Férrussac, 1826	Salman and Katağan (2004)
Sepietta oweniana Naef, 1916	Salman and Katağan (2004)
Sepietta neglecta Naef, 1916	Salman and Katağan (2004)
Sepiola steenstrupiana Lévy, 1912	Salman and Katağan (2004)

Because most alien molluscs species entering the Mediterranean (mostly Lessepsian) were first discovered in the Iskenderun Bay (Aartsen and Recevik 1998; Engl and Çeviker 1999; Albayrak and Çeviker 2001; Çeviker 2001; Çecik *et al.* 2008; Zenetos *et al.* 2010). Recently, *Lodderia novemcarinata*, *Zafra obesula* and *Z. pumila* reported by Öztürk *et al.* (2014) and *Martesia striata* reported by Çevik *et al.* (2015) were first identified in the Iskenderun Bay in the Mediterranean. According to studies performed to first quarter of 2016, among the 429 molluscs species present in the Iskenderun Bay, 349 (81.4%) are native species, and 80 (18.6%) are non-native molluscs species (Figure 2; Figure 3). The number of non-native dominant families are given in Figure 4. As seen in aforementioned tables and figures, the alien molluscs species in the Iskenderun Bay constitute a significant portion of total molluscs species.

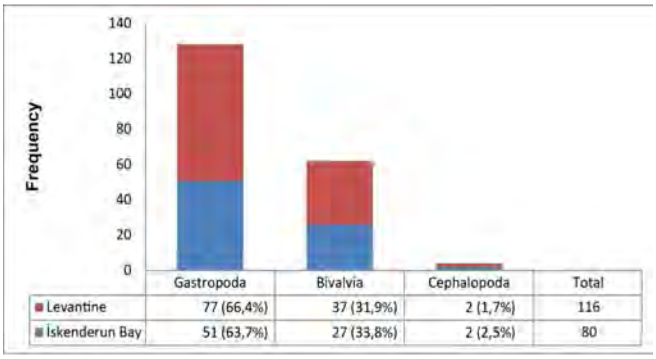

Figure 3. The number of non-native species per classes

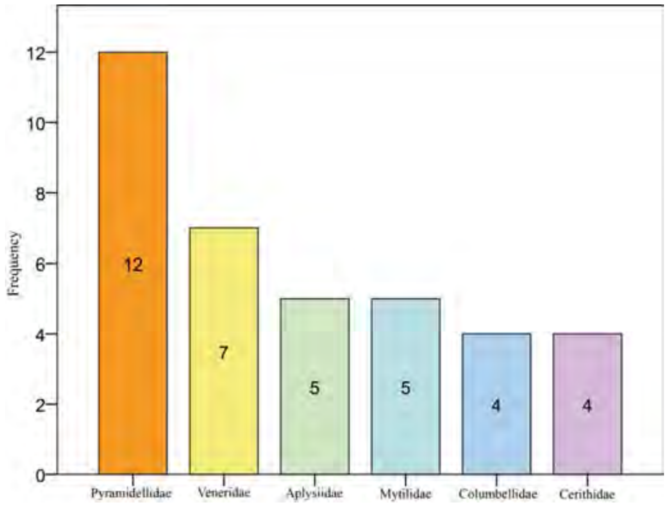

Figure 4. The number of non-native dominant families in the Levantine Coast of Turkey

With the expectation of increased migration through the Suez Canal, due to the recent plans for the expansion of the canal and the construction of a parallel second canal, it can be said that this number will be increasing in the future. For this reason, southern coasts of Turkey, especially the Iskenderun Bay, needs to be monitored through periodic studies, which would allow the identification of new alien species migrations and determination of the effects of these on local species. These species will provide significant data for us, which will help us to take precautions for future dangers and reduce this invasion and its effects.

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CEPHALOPODS OF THE TURKISH MEDITERRANEAN COAST

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Mediterranean coast of Turkey is located in northeast of Levant Sea and bathymetrically differs along east-west line. Its eastern part, also known as Cilicia Sea, has sandy muddy bottom due to Göksu River and at most eastern part Seyhan and Ceyhan rivers and has a long continental shelf.

In the western part, at Gulf of Antalya, where the continental shelf is much narrower, it was reported that even though depths exceeds to 2500 m the average is around 1000 m (Eryılmaz *and* Eryılmaz 2002). Yılmaz (2002) reported that the biogeochemical cycles of western and eastern coasts of both areas are different. According to Melanotte-Rizzoli *and* Bergamasco (1989) the topographical features of the seas controls the currents. Melanotte-Rizzoli *and* Bergamasco (1989), Rhodes Gyre where its velocity varies in western parts of Turkey according to seasons, effects our coasts as a result of narrow topographical continental shelf between Fethiye-Antalya. This also effects Turkey' Mediterranean western and eastern coasts water movements. These topographical and hydrographical formations also effect the cephalopod species in the areas. Species that has nocturnal migration, such as *Abralia veranyi, Ommastrephes bartramii* and *Todarodes sagittaus,* due to wide and very shallow continental shelf at the area between Mersin-Iskenderun, inhabits offshore areas.

Figure 1. Geomorphologic features of Mediterranean coasts Turkey (source; Google earth).

Even though the first study in eastern Mediterranean on cephalopods was conducted by Degner (1925) in southern coasts of Rhodes, the first study in Mediterranean coasts of Turkey on cephalopods was conducted by Katağan *et al.* (1992) on the distribution of *Ommastrephes bartramii* in Gulf of Fethiye.

In following years, Gücü and Bingel (1994) reported cephalopod species that can be caught by trawlers in northeastern Mediterranean. Between years 1991-1993, with the joint project on demersal fish stocks of Turkey between Republic of Turkey Ministry of Agriculture and Rural Affairs and Japanese International Collation Agency (JICA), Salman *et al.* (1999) reported species *Amphioctopus aegina* (as *Octopus aegina cf. kagoshimensis*) as first for the Mediterranean fauna. Than Salman *et al.* (2002) gave *Rossia macrosoma, Alloteuthis media* and *Eledone cirrhosa* species as new record for Teuthofauna of southern shores of Turkey. Subsequently that *Sepioteuthis lessoniana,* a lessepsian species from Teuthida ordo, was reported by Salman (2002). After studies conducted by Duysak *et al.* (2004; 2008) at northeastern coasts of Mediterranean Jereb *et al.* (2016) reported *Octopoteuthis sicula* from eastern Mediterranean in Octopoteuthidae family revision. As a result of these faunistic studies, in Turkey' Mediterranean western coasts from Iskenderun to Dalaman 33, and in eastern part 22, in total 37 cephalopod species were determined.

It was reported that in whole Mediterranean, teuthofauna is represented with 67 species (Salman 2015). In Turkey' Mediterranean coasts with today's records there are approximately 33 species, which corresponds to 55 % of Mediterranean teuthofauna. Salman (2015) reported that Aegean Sea teuthofauna compiles 75 % of the Mediterranean species. When compared with Aegean Sea teuthofauna it can be seen that Turkey' Mediterranean coasts are more poor. List of cephalopod species from the studies to date conducted in Turkey' Mediterranean coast is given in Table 1.

Species that prefer shallow and temperate waters as *Amphioctopus aegina* and *Macrotritopus defilippi* inhabit our eastern Mediterranean coasts where species such as *Abralia veranyi, Pyroteuthis margaritifera, Todarodes sagittatus* and *Pteroctopus tetracirrhus* that prefer relatively colder and deeper waters inhabit western parts.

After first observation records of *Amphioctopus aegina,* that has indo-pacific origin and belonging to family Octopodidae (Salman *et al.* 1999) and *Sepioteuthis lessoniana* that belongs to Loliginidae (Salman 2002) in eastern regions of Mediterranean coasts in Turkey, *S. lessoniana* extended its distribution to coasts of Rhodes Island (Greece) in west (Lefkaditou *et al.* 2009) and coasts of Gökova Bay (Turkey) in north (unpublished data) due to its planktonic paralarvae.

Genetic study by Güven (2011) to understand differentiation of sub-populations of *Sepia officinalis,* which has benthic eggs, in Aegean Sea and Mediterranean Sea has been reported that individuals in Turkish Aegean population have different genetic structure than individuals in Turkish Mediterranean population. Güven (2011) explained this differentiation by bio-ecology of the species and geographical barriers between the regions. The species has benthic eggs, which have limited movement, however coastal structure of the region between Antalya and Fenike (Figure 1) including narrow shallow zones and underwater walls with sharp deepening; these are the main reasons for genetic isolation.

Table 1. Cephalopod species found in both region of Mediterranean.

SPECIES	W MED	E MED
SEPIIDA		
Sepia officinalis Linnaeus, 1758	6	6,8,2,7
Sepia elegans Blainville, 1827	6	6,8,7
Sepia orbignyana Férussac, 1826	6	6
SEPIOLIDA		
Heteroteuthis dispar (Rüppell, 1844)	10	9
Sepiola steenstrupiana Lévy, 1912	6	6
Rondeletiola minor (Naef, 1912)	6	
Sepietta oweniana Naef, 1916	6	6
Sepietta neglecta Naef, 1916	6	
Rossia macrosoma (Delle Chiaje, 1830)	6	4,6
TEUTHIDA		
Loligo vulgaris Lamarck, 1798	6	6,8,2,7
Loligo forbesi Steenstrup, 1856	6	6
Alloteuthis media (Linnaeus, 1758)	6	4,6
Alloteuthis subulata (Lamack, 1798)		6
Sepioteuthis lessoniana Lesson, 1830		5
Ancisrocheirus lesueurii (d'Orbigny, 1842)	9	
Chiroteuthis veranii (Férussac, 1835)	10	
Chtenopteryx sicula (Vérany, 1851)	9	
Abralia veranyi (Rüppell, 1844)	6	
Histioteuthis reversa (Vérrill, 1880)	10	
Octopoteuthis sicula Rüppell, 1848	10	**11**
Illex coindetii (Vérany, 1839)	6	6,8
Todaropsis eblanae (Ball, 1841)	6	6
Todarodes sagittatus (Lamarck, 1798)	6,10	
Ommastrephes bartramii (Lesueur, 1821)	1,10	
Onychoteuthis banksii (Leach, 1817)	10	
Ancitroteuthis lichstensteini (d'Orbigny, 1839)	10	
Pyroteuthis margaritifera (Rüppell, 1844)	6,10	
OCTOPODA		
Amphioctopus aegina (Gray, 1849)		6,3,7
Callistoctopus macropus (Risso, 1826)	6	8
Macrotritopus defilippi (Verany, 1851)		6,7

Octopus vulgaris Cuvier, 1797	6	6,8,2,7
Scaeurgus unicirrhus (Della Chiaje in de Férrusac *and* d'Dorbigny, 1841)	6,10	6
Pteroctopus tetracirrhus (Della Chiaje, 1830)	6	
Eledone moschata (Lamarck, 1799)	6	6,8,2,7
Eledone cirrhosa (Lamarck, 1798)	4,10	8
Tremoctopus violaceus Delle Chiaje, 1830	10	
Argonauta argo Linnaeus, 1758	10	
Total numbers of species	***33***	***22***

1: Katagan *et al.* 1992; **2**: Gucu *and* Bingel 1994; **3**: Salman *et al.* 1999; **4**: Salman *et al.* 2002; **5**: Salman 2002; **6**: Salman *and* Katagan 2004; **7**: Duysak *et al.* 2004; **8**: Duysak *et al.* 2008; **9**: Karakulak *et al.* 2009; **10** Salman *and* Karakulak 2009; **11**: Jereb *et al.* inpress 2016.

Cephalopods have important roles in marine food web as prey and as predator. Chitin tooth of cephalopods can stay for long time in stomachs of predators (Xavier *et al.* 2016). Even though they can be identified in studies on stomach contents, it is hard to know where and how they became prey. Thus, regional existence records of cephalopod species from stomach contents are required to have the remnants that can digest easily.

A study from coasts of Mediterranean Sea in Turkey by Karakulak *et al.* (2009) has reported that cephalopods consists 37% of the food items of *Thunnus thynnus,* that is one of top predator fish, while Salman *and* Karakulak (2009) reported that cephalopods have a high dominancy with 95% in diet composition of *Thunnus alalunga,* that is another top predator fish. Karakulak *et al.* (2009) also reported *Ancistrocheirus lesueurii* and *Chtenopteryx sicula* as half digested cephalopod species in stomach contents of *Thunnus thynnus* from Antalya Bay, which is located western part of Mediterranean coasts in Turkey.

Studies on diet of cetaceans in coasts of Mediterranean in Turkey; Öztürk *et al.* (2007) and Dede *et al.* (2016) have reported seven and 12 cephalopod species, respectively in stomach contents of *Stenalla coeruleoalba*. Öztürk *et al.* (2007) has also reported 14 species of cephalopods in stomach content of *Gramphus griseus.* The common features of the cephalopod species found in stomach contents of cetaceans are they being nocturnal migrant and luminous species.

Fisheries of Cephalopods

Regarding the statistics of Turkish fisheries in 2013, 63% of total cephalopod fishing (1273 tons) belongs to coasts of Mediterranean in Turkey. *Sepia officinalis* that belongs to order Sepiida is the most dominantly fished species with 76.6% fishing yield among cephalopod species. Second dominant species is *Loligo vulgaris,* which belongs to order Loliginidae, with 18.6%. *Octopus spp* and *Eledone moschata* take third place with 4.8%. (Figure 2). Parallel to fishing yield in Mediterranean coasts, *S. officinalis* takes a part of 78.4% of the overall in Turkey. The species inhabits abundantly between subtidal zone and 100m depth, however their distribution is up to 200m in habitats of muddy-sandy textures of seabed (Jereb *and* Roper 2005). Fishing yield of *S. officinalis is* relatively abundant in Yumurtalık-Karataş towns of Adana and adjacent regions, where are located at the northeast of Mediterranean (Duysak 2007).

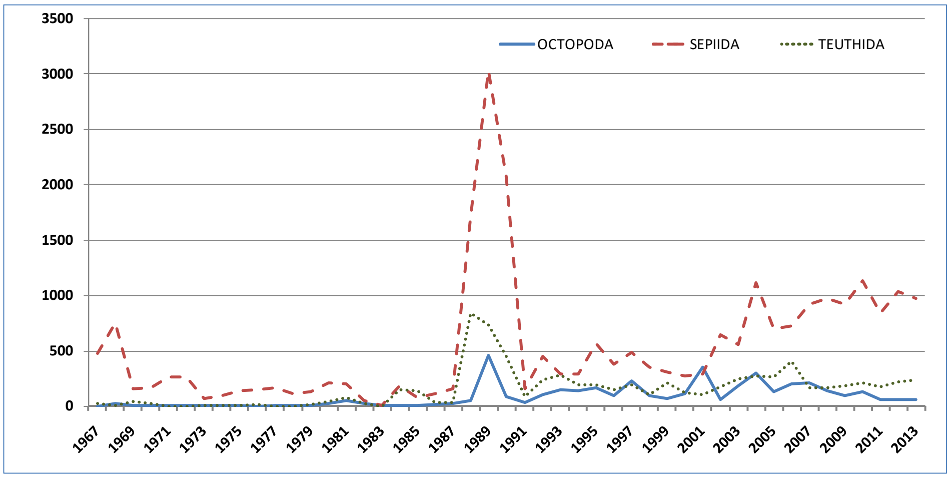

Figure 2. Annual catch amounts (tons) of main cephalopod yield groups in coasts of Mediterranean Sea in Turkey (1967-2013 TUIK).

Salman and Katagan (2004) studied seasonal fisheries yield of cephalopod species in Turkish seas between 0-500 m by deep trawl. They found most abundant yield of *Sepia ofiicinalis, Sepia orbignyana, Loligo forbesi* and *Octopus vulgaris* in the western region, while yields of cephalopod species such as *Sepia ofiicinalis, Sepia orbignyana, Loligo forbesi* and *Octopus vulgaris* were more abundant in the eastern region based on catch per unit time. It should be also noted that in this study difference in fishing gear can be reason for having more abundant catch of *S. officinalis* in the western region of Mediterranean than the eastern region.

New and detailed studies are required regarding to understand intraspesific properties of ecosystem due to settlement of lessepsian species in coasts of Mediterranean in Turkey and intrusion of exotic species by anthropogenic reasons in the other seas of Turkey.

As a result, number of scientific researches are limited in coasts of Mediterranean in Turkey, which also indicates that marine researches in the region are not valued. Thus, as being in many other faunistic marine groups, knowledge on cephalopods are not sufficient especially in coasts of Mediterranean. This situation will go on unless systematic marine researches are determined as strategy of the Turkey that is surrounded by four different seas.

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ECHINODERM FAUNA OF THE MEDITERRANEAN COAST OF TURKEY

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1. Introduction

Among 93 echinoderm species (two Crinoidea, 25 Asteroidea, 24 Ophiuroidea, 20 Echinoidea and 22 Holothuroidea) reported from Turkey, 65 (one Crinoidea, 22 Asteroidea, 19 Ophiuroidea, 15 Echinoidea and 8 Holothuroidea) were reported from the Mediterranean coast of Turkey.

2. Studies on Echinoderms

According to the available literature (Table 1), the echinoderm species in the Mediterranean coast of Turkey were first reported by Artüz (1967 and 1968) as 15 Asteroid and 9 Echinoid species. Later, Gücü and Bingel (1994) reported eight species with four new species to the region. Özaydın *et al.* (1995) found 22 species in the region and with their comprehensive study the number of species increased to 41. Between the years of 2000 and 2010, the reported number of echinoderm species reached to 57 with the contributions of the studies by Ergev (2002), Özgür (2004), Yokeş and Galil (2006), Özgür *et al.* (2008), Şahin (2008), and Stöhr *et al.* (2010). Ergev (2002) found 16 species in grab and six in sledge samples, however identified and reported only eight species at species level. Özvarol (2003) studied some biological characteristics of two sea urchins in the Gulf of Antalya. Özgür (2004) reported 16 echinoderm species together with the alien holothurian species *Synaptula reciprocans* in the Gulf of Fethiye and later, Çınar *et al.* (2006) also reported this species. Yokeş and Galil (2006) and Gökoğlu *et al.* (2007) reported the alien long-spined sea urcin, *Diadema setosum* in the Gulf of Antalya. Erkol (2008) reported 2 species in the Yumurtalık Bay and Şahin (2008) 10 species in the Gulf of Antalya. Stöhr *et al.* (2010) first recorded *Amphiodia obtecta* Mortensen, 1940 for the Mediterranean and *Ophiactis macrolepidota* Marktanner-Turneretscher, 1887 for Turkey and explained the taxonomy and distribution of 5 Ophiuroid species. Together with the new records given by Özgür Özbek (2013) and this study, the number of the echinoderm species now increased to 65 in the Mediterranean coast of Turkey.

The check-list of the echinoderm fauna of Turkey was first given by Özaydın *et al.* (1995). Özgür *et al.* (2008) and Özgür Özbek (2013) reviewed the list with the new findings from the Gulf of Antalya (E Mediterranean Sea). Recently the list was reviewed again by Öztoprak *et al.* (2014).

Only the two studies, Ergev (2002) and Özgür Özbek (2013) have investigated the temporal and spatial fluctuations of the echinoderms in the Mediterranean coast of Turkey. So the knowledge on the abundance, biomass and distribution as well as the environmental factors affecting them is limited to the results of these studies conducted in the Gulfs of Mersin and Antalya, respectively.

3. Echinoderm Fauna

Among 65 echinoderm species reported from the Mediterranean coast of Turkey, there are one Crinoid, 22 Asteroids, 19 Ophiuroids, 15 Echinoids and 8 Holothuroids. The original photos of the echinoderm species taken by the author, Elif Özgür Özbek (EÖÖ) were given in Figures 1 to 46.

Ceramaster grenadensis grenadensis (Perrier, 1881) is a new record for the Mediterranean coast of Turkey. It was sampled by a commercial trawler between the depths of 175- 345 m in the Gulf of Antalya, on 21 September 2013. The radius of the specimen was 23.8 mm (Figure 11).

Zoogeographical categories to which the echinoderm species are assigned are also presented in Table 1. The dominant components of the echinoderm fauna, in terms of number of species are the Atlanto-Mediterranean species accounting for 73.8% followed by the Mediterranean endemics (13.8%), the Indo-Pacific species (7.7%), the Cosmopolitan (3.1%) and Boreal species (1.5%).

Amphiodia obtecta, *Ophiactis macrolepidota*, *Ophiactis savignyi*, *Diadema setosum* and *Synaptula reciprocans* are the Erythrean alien echinoderms entered the Mediterranean Sea via the Suez Canal.

It is thought that the reason of the lower number of echinoderm species in the Mediterranean coast of Turkey (65) comparing to that of the Aegean Sea (76) is related to the lower number of scientific researches carried out in the Mediterranean as well as the oligotrophic conditions. The addition of eight species with a thesis (Özgür Özbek 2013) strengthens this view. As can be seen in Table 1, many rare species can be sampled only once and their presence could be determined only after carrying out many samplings. In the Gulf of Antalya, from the samplings of trawl *E. sepositus* classified as "abundant", and *A. mediterranea, A. placenta, C. longispinus, S. affinis, P. regalis* as "common" species. In the rocky habitats, *P. lividus* and *S. reciprocans* were found to be "common" species and the rest of the species as "rare" (Özgür Özbek 2013).

In the Gulf of Antalya, the mean echinoderm abundance was found to be 1,820.34 individuals/km^2 in trawl, 10,861.43 ind./km^2 in sledge and 2.93 ind./m^2 in grab samples. The most abundant species were found to be *S. affinis* (60.83%, 1107.24 ind./km^2) in trawl and *A. filiformis* in sledge (14.98%, 1627.16 ind./km^2) and grab (16.55%, 0.485 ind./m^2) samples. The mean echinoderm biomass was found to be 10,32668 g/km^2 in trawl, 21,177.97 g/km^2 in sledge and 1.41 g/m^2 in grab samples. The species that have the highest biomass were found to be *S. affinis* (%45.83; 4732.45 g/km^2) in trawl, *H. tubulosa* in sledge (%31.65; 6703.54 g/km^2) and *E. cordatum* in grab (%21.68; 0.306 g/m^2) samples (Özgür Özbek 2013).

4. Conclusion

The number of the echinoderm species is thought to be increased with further studies realized in the Mediterranean coast of Turkey. It is necessary to complete the knowledge on the fauna and flora on the Mediterranean coast because the region is extensively subjected to alien invasion. The majority of aliens reported from the Turkish coasts were found in shallow benthic habitats. Thus, monitoring programmes on spatio-temporal structures of communities particularly in the hot spot areas for aliens such as harbours, shallow, brackish and polluted waters should be undertaken (Çınar *et al.* 2005). Long-term approaches are required to monitor the alien species in proportion to local and endemic species, to examine the competition between them and to document the displacement and replacement events. Special interest and monitoring studies are needed in the Mediterranean coast of Turkey due to the prediction of the probable impacts to the native fauna and flora.

Table 1. The list of studies on the echinoderm fauna of the Mediterranean coast of Turkey. Origin: Atlanto-Mediterranean (AM), Boreal (B), Cosmopolit (C), Endemic (E), Indo-Pacific (IP).

Referans No		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Crinoidea																		
Antedon mediterranea (Lamarck, 1816)	**E**			+	+	+		+						+			+	
Asteroidea																		
Anseropoda placenta (Pennant, 1777)	**AM**	+			+												+	
Asterina gibbosa (Pennant, 1777)	**AM**	+			+												+	
Asterina pancerii (Gasco, 1870)	**E**	+			+													
Astropecten aranciacus (Linnaeus, 1758)	**AM**	+			+												+	
Astropecten bispinosus (Otto, 1823)	**AM**	+			+										+		+	
Astropecten irregularis pentacanthus (Delle Chiaje, 1827)	**AM**	+			+	+								+			+	
Astropecten jonstoni (Delle Chiaje, 1827)	**E**					+								+			+	
Astropecten spinulosus (Philippi, 1837)	**E**	+															+	
Ceramaster grenadensis grenadensis (Perrier, 1881)	**AM**																	+
Chaetaster longipes (Retzius, 1805)	**AM**	+															+	
Coscinasterias tenuispina (Lamarck, 1816)	**AM**	+			+												+	
Echinaster (Echinaster) sepositus sepositus (Retzius, 1783)	**AM**	+		+	+			+							+		+	
Hacelia attenuata Gray, 1840	**AM**																+	
Hymenodiscus coronata (G.O. Sars, 1872)	**AM**																+	

Luidia ciliaris (Philippi, 1837)	**AM**	+															+	
Luidia sarsi sarsi Düben & Koren, in Düben, 1845	**AM**	+															+	
Marthasterias glacialis (Linnaeus, 1758)	**AM**	+			+												+	
Odontaster mediterraneus (Marenzeller, 1893)	**AM**				+													
Ophidiaster ophidianus (Lamarck, 1816)	**AM**	+			+													
Peltaster placenta (Müller & Troschel, 1842)	**AM**	+			+												+	
Sclerasterias richardi (Perrier, 1882)	**AM**																+	
Tethyaster subinermis (Philippi, 1837)	**AM**				+												+	
Ophiuroidea																		
Acrocnida brachiata (Montagu, 1804)	**AM**				+												+	
Amphiodia (Amphispina) obtecta Mortensen, 1940	**IP**															+		
Amphipholis squamata (Delle Chiaje, 1828)	**K**					+		+				+	+			+	+	
Amphiura chiajei Forbes, 1843	**AM**					+		+					+	+			+	
Amphiura filiformis (O.F. Müller, 1776)	**AM**					+		+					+				+	
Ophiacantha setosa (Bruzelius, 1805)	**AM**																+	
Ophiactis macrolepidota Marktanner-Turneretscher, 1887	**IP**															+		
Ophiactis savignyi (Müller & Troschel, 1842)	**IP**															+	+	
Ophiactis virens (M. Sars, 1857)	**AM**				+			+									+	
Ophioderma longicauda (Bruzelius, 1805)	**AM**														+		+	
Ophiomyxa pentagona (Lamarck, 1816)	**AM**				+												+	
Ophiopholis aculeata (Linnaeus, 1767)	**B**					+												

Ophiopsila aranea Forbes, 1843	**AM**							+					+				+	
Ophiothrix fragilis (Abildgaard, in O.F. Müller, 1789)	**AM**				+			+							+	+	+	
Ophiothrix quinquemaculata (Delle Chiaje, 1828)	**E**							+					+					
Ophiura albida Forbes, 1839	**AM**				+									+			+	
Ophiura grubei Heller, 1863	**AM**																+	
Ophiura ophiura (Linnaeus, 1758)	**AM**			+	+												+	
Pectinura vestita Forbes, 1843	**E**				+													
Echinoidea																		
Arbacia lixula (Linnaeus, 1758)	**AM**		+		+		+	+							+			
Brissopsis lyrifera (Forbes, 1841)	**AM**		+		+			+									+	
Brissus unicolor (Leske, 1778)	**AM**														+			
Centrostephanus longispinus (Philippi, 1845)	**AM**			+	+												+	
Cidaris cidaris (Linnaeus, 1758)	**AM**		+	+	+												+	
Diadema setosum (Leske, 1778)	**IP**									+	+							
Echinocardium cordatum (Pennant, 1777)	**K**				+	+						+					+	
Echinocyamus pusillus (O.F. Müller, 1776)	**AM**		+					+					+				+	
Echinus melo Lamarck, 1816	**AM**																+	
Genocidaris maculata A. Agassiz, 1869	**AM**																+	
Paracentrotus lividus (Lamarck, 1816)	**AM**		+		+		+	+							+		+	
Psammechinus microtuberculatus (Blainville, 1825)	**E**		+		+												+	
Spatangus purpureus O.F. Müller, 1776	**AM**		+														+	

Sphaerechinus granularis (Lamarck, 1816)	**AM**		+	+	+			+									+	
Stylocidaris affinis (Philippi, 1845)	**AM**		+	+				+					+				+	
Holothuroidea																		
Holothuria (Holothuria) mammata Grube, 1840	**AM**														+		+	
Holothuria (Holothuria) tubulosa Gmelin, 1791	**AM**				+												+	
Holothuria (Platyperona) sanctori Delle Chiaje, 1823	**AM**														+		+	
Labidoplax digitata (Montagu, 1815)	**AM**				+													
Leptosynapta makrankyra (Ludwig, 1898)	**E**				+										+			
Ocnus syracusanus (Grube, 1840) Panning, 1949	**E**				+													
Parastichopus regalis (Cuvier, 1817)	**AM**			+	+												+	
Synaptula reciprocans (Forskal, 1775)	**IP**							+	+								+	
Toplam		**15**	**9**	**8**	**34**	**8**	**2**	**16**	**1**	**1**	**1**	**2**	**7**	**5**	**10**	**5**	**50**	**1**

1) Artüz (1967), **2)** Artüz (1968), **3)** Gücü and Bingel (1994)**, 4)** Özaydın *et al.* (1995), **5)** Ergev (2002), **6)** Özvarol (2003), **7)** Özgür (2004), **8)** Çınar *et al.* (2006), **9)** Yokeş and Galil (2006), **10)** Gökoğlu *et al.* (2007), **11)** Erkol (2008), **12)** Özgür *et al.* (2008), **13)** Mutlu and Ergev (2008), **14)** Şahin (2008), **15)** Stöhr *et al.* (2010), **16)** Özgür Özbek (2013), **17)** This study.

Figure 1. *Antedon mediterranea* (Lamarck, 1816) (İsmet SAYGU, Elif ÖZGÜR ÖZBEK (EÖÖ))

Figure 2. *Astropecten aranciacus* (Linnaeus, 1758) (EÖÖ)

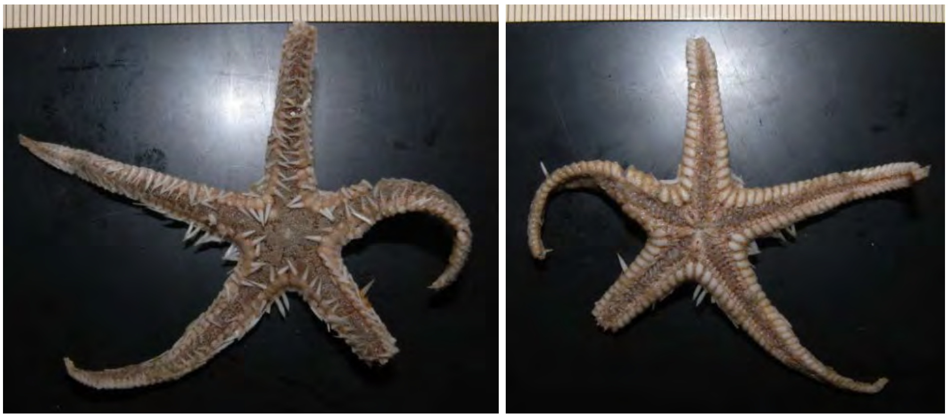

Figure 3. *Astropecten bispinosus* (Otto, 1823) (EÖÖ)

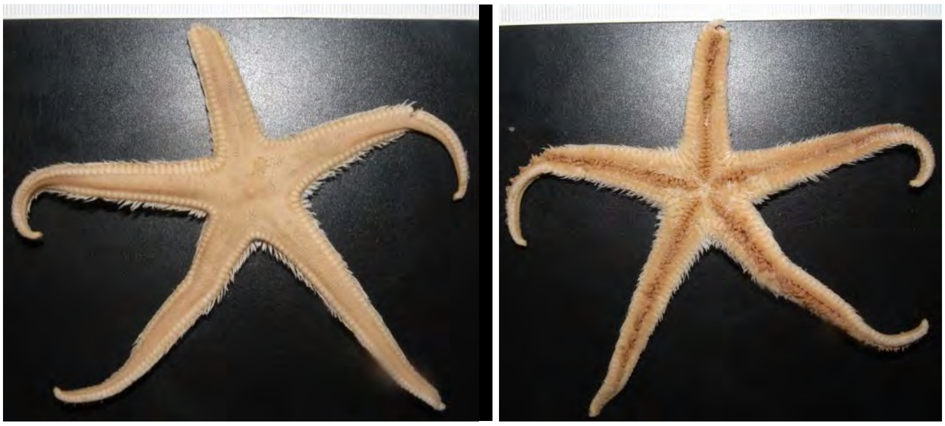

Figure 4. *Astropecten irregularis pentacanthus* (Delle Chiaje, 1827) (EÖÖ)

Figure 5. *Astropecten jonstoni* (Delle Chiaje, 1827) (EÖÖ)

Figure 6. *Astropecten spinulosus* (Philippi, 1837) (EÖÖ)

Figure 7. *Tethyaster subinermis* (Philippi, 1837) (EÖÖ)

Figure 8. *Luidia ciliaris* (Philippi, 1837)

Figure 9. *Luidia sarsi sarsi* Düben & Koren, in Düben, 1845 (EÖÖ)

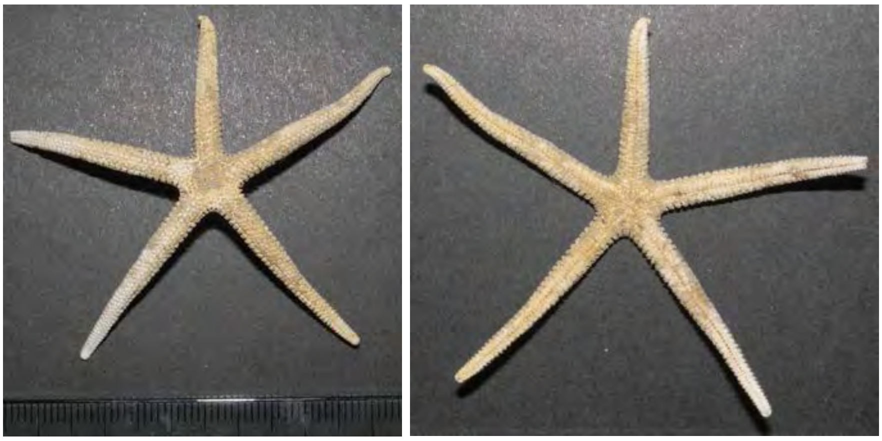
Figure 10. *Chaetaster longipes* (Retzius, 1805) (EÖÖ)


Figure 11. *Ceramaster grenadensis grenadensis* (Perrier, 1881) (EÖÖ)


Figure 12. *Peltaster placenta* (Müller & Troschel, 1842) (EÖÖ)


Figure 13. *Hacelia attenuata* Gray, 1840 (EÖÖ)

Figure 14. *Echinaster (Echinaster) sepositus sepositus* (Retzius, 1783) (EÖÖ)

Figure 15. *Anseropoda placenta* (Pennant, 1777) (EÖÖ)


Figure 16. *Coscinasterias tenuispina* (Lamarck, 1816) (EÖÖ)

Figure 17. *Marthasterias glacialis* (Linnaeus, 1758) (EÖÖ)

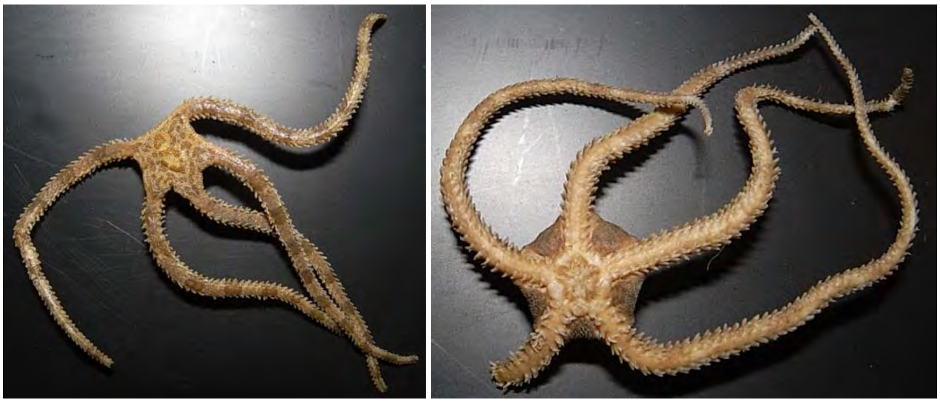

Figure 18. *Ophiomyxa pentagona* (Lamarck, 1816) (EÖÖ)

Figure 19. *Ophiothrix fragilis* (Abildgaard, in O.F. Müller, 1789) (EÖÖ)

Figure 20. *Ophiactis savignyi* (Müller & Troschel, 1842) (EÖÖ)

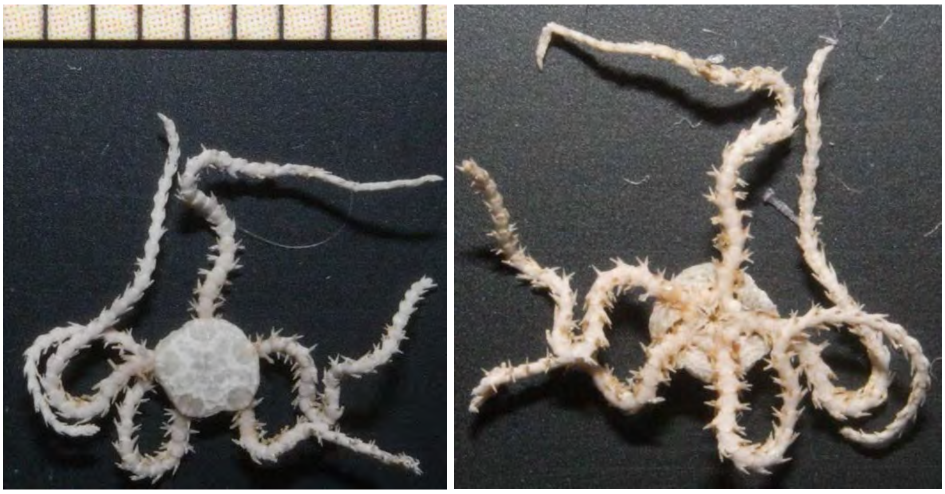

Figure 21. *Amphipholis squamata* (Delle Chiaje, 1828) (EÖÖ)

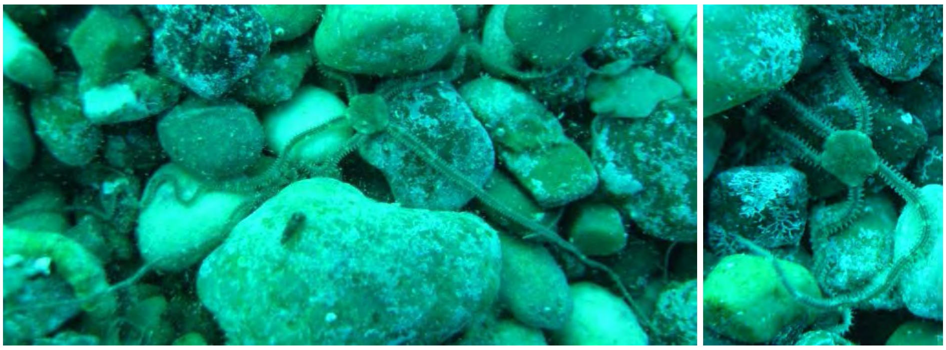

Figure 22. *Amphiura chiajei* Forbes, 1843 (EÖÖ)

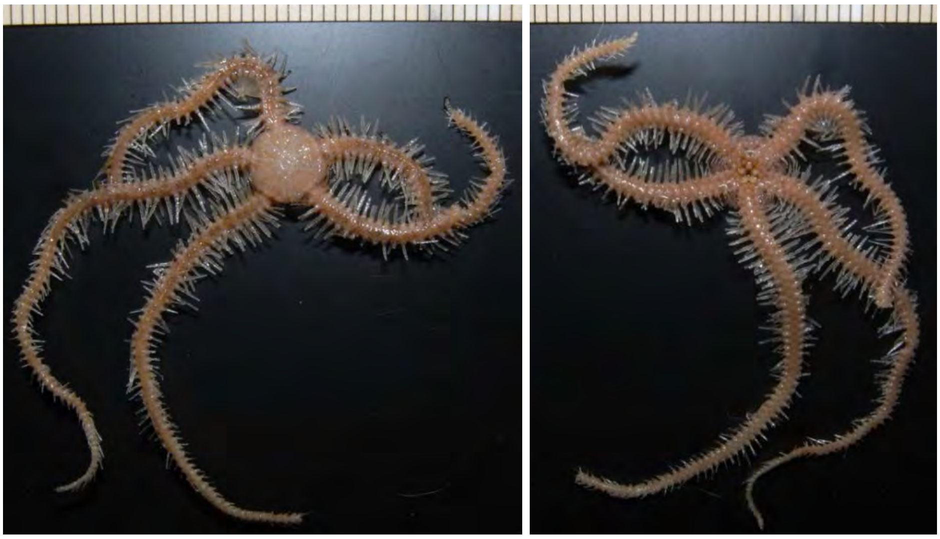

Figure 23. *Ophiacantha setosa* (Bruzelius, 1805) (EÖÖ)

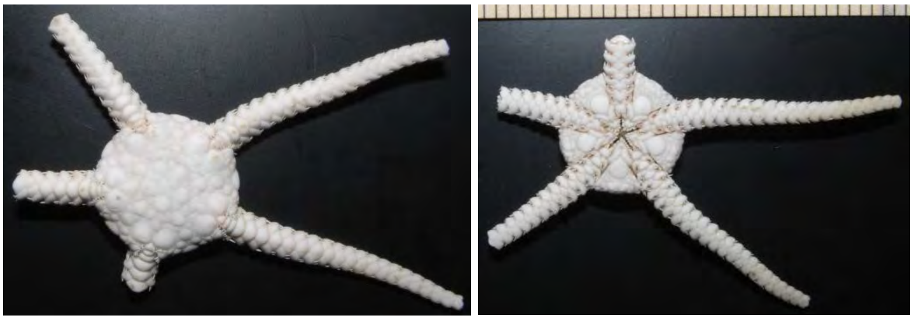

Figure 24. *Ophiura albida* Forbes, 1839 (EÖÖ)

Figure 25. *Ophiura grubei* Heller, 1863 (EÖÖ)

Figure 26. *Ophiura ophiura* (Linnaeus, 1758) (EÖÖ)

Figure 27. *Ophioderma longicauda* (Bruzelius, 1805) (EÖÖ)

Figure 28. *Cidaris cidaris* (Linnaeus, 1758) (EÖÖ)

Figure 29. *Stylocidaris affinis* (Philippi, 1845) (EÖÖ)

Figure 30. *Centrostephanus longispinus* (Philippi, 1845) (EÖÖ)

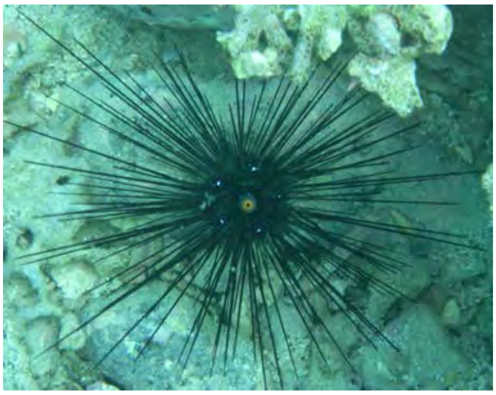

Figure 31. *Diadema setosum* (Leske, 1778)

Figure 32. *Arbacia lixula* (Linnaeus, 1758)

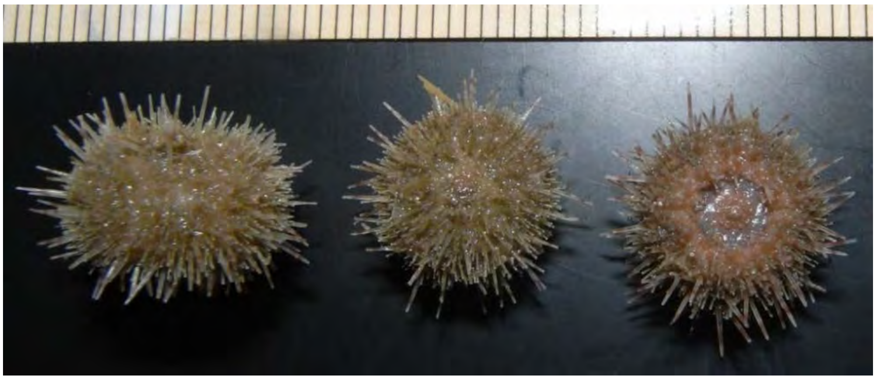

Figure 33. *Genocidaris maculata* A. Agassiz, 1869 (EÖÖ)

Figure 34. *Sphaerechinus granularis* (Lamarck, 1816) (EÖÖ)

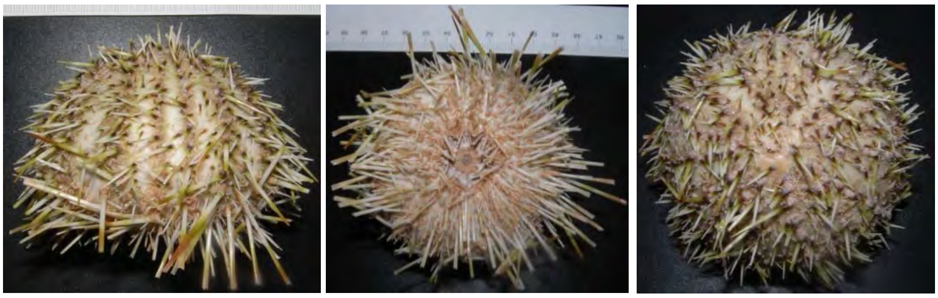

Figure 35. *Echinus melo* Lamarck, 1816 (EÖÖ)

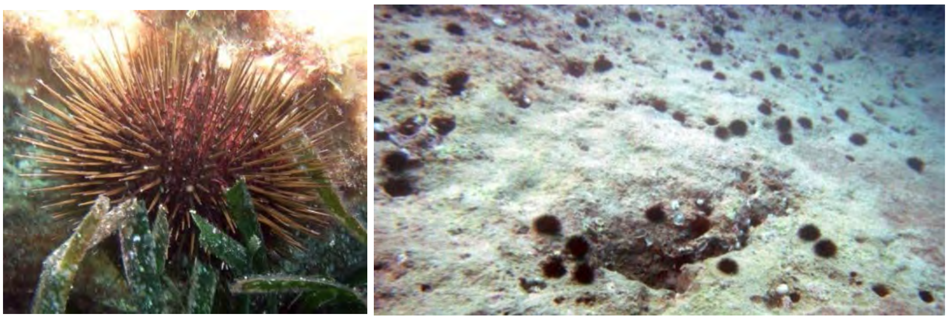

Figure 36. *Paracentrotus lividus* (Lamarck, 1816) (EÖÖ)

Figure 37. *Psammechinus microtuberculatus* (Blainville, 1825) (EÖÖ)

Figure 38. *Echinocyamus pusillus* (O.F. Müller, 1776) (EÖÖ)

Figure 39. *Spatangus purpureus* O.F. Müller, 1776 (EÖÖ)

Figure 40. *Brissopsis lyrifera* (Forbes, 1841) (EÖÖ)


Figure 41. *Brissus unicolor* (Leske, 1778)


Figure 42. *Echinocardium cordatum* (Pennant, 1777) (EÖÖ)

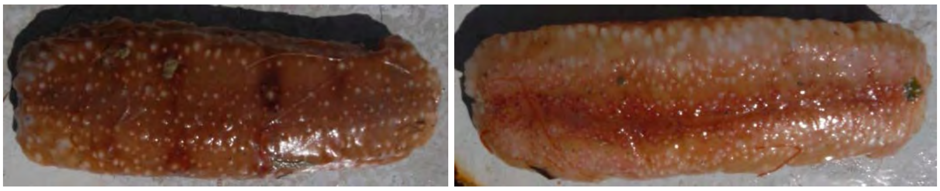
Figure 43. *Parastichopus regalis* (Cuvier, 1817) (EÖÖ)


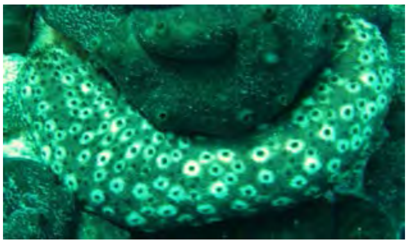
Figure 44. *Holothuria (Holothuria) mammata* Grube, 1840 (EÖÖ)
Figure 45. *Holothuria (Holothuria) tubulosa* Gmelin, 1791 (EÖÖ)


Figure 46. *Synaptula reciprocans* (Forskal, 1775) (EÖÖ)

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ICHTHYOPLANKTON OF THE MEDITERRANEAN SEA

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1. Introduction

Ichthyoplanktonic studies are known to be important tools in determining fish diversity, spawning fish population changes and ecologic interaction with the physical-chemical factors in marine ecosystems (Moser and Smith 1993). Densities and distributions of ichthyoplankton studies provide very important information about spawning grounds and spawning time of species which are ecologically important for marine food webs in the marine environment as mesopelagic and bathypelagic fish species (Tortonese 1970; Ahlstrom and Moser 1976). Early life stages of fish species are strongly influenced by biotic and abiotic processes. These are the most vulnerable stages to environmental variations (Miller and Kendall 2009). Fish eggs and larvae also indicate a pronounced variability in both density and species compositions, in related to the spawning cycles and reproductive strategies of the adults (Sabatés *et al.* 2007). Few studies have been done on the ichthyoplankton of the Turkish Mediterranean coast (Ak 2004; Oray and Karakulak 2005; Ak Orek and Uysal 2007; Uysal *et al.* 2008; Mavruk 2009; Oray *et al.* 2010; Avsar and Mavruk 2011; Banbul 2014; Mavruk 2015; Coker and Cihangir 2015).These researches have principally focused on the Cilician basin and local areas such as Iskenderun and Mersin Bay.

A warm-temperate sub-tropical climate prevails in Levant Basin (Por 2009), however it approximates to the tropical conditions in some ways such as high temperature and salinity, low primary productivity (Galil 1993) and ongoing tropicalization of biota (Bianchi 2007). The Cilician basin is located on the northeastern part of Levantine Basin between Cyprus and Turkey, has been one of the widest continental shelf areas along the Eastern Mediterranean. Iskenderun and Mersin Bay are important fisheries ground in the northeastern Mediterranean due to topography of region and most effective and suitable trawling areas along the Turkish Mediterranean coasts (Gücü and Bingel 1994). Large nutrient inputs from land-based sources are received into shallow and the wide shelf zone of the Cilician basin, including Mersin and Iskenderun Bays (Tugrul *et al.* 2005). Especially, Göksu, Lamas, Tarsus, Seyhan and Ceyhan rivers flow into the basin. These are the major sources of fresh water and nutrients for the Levantine basin (Ozsoy and Sözer 2006). Fish composition of the Northeastern Mediterranean is effected by Lessepsians which are originated from the Indo-Pacific region (Taskavak and Bilecenoglu 2001; Mavruk and Avsar 2008).

In this chapter we have presented a descriptive and inclusive overview of the spatial and temporal distribution and biodiversity of ichthyoplankton on the northeastern Mediterranean. The details of ichthyoplankton assemblages were given by re-evaluating the unpublished data which were collected within the context of the PhD thesis conducted by Mavruk (2015) and the project conducted by Ak Orek (Uysal *et al.* 2008).

2. History of Ichthyoplankton Studies in Anatolian Coasts of Mediterranean

In 1959, Demir published a paper in which she compared the morphology of *Engraulis encrasicolus* eggs from the Black Sea, Sea of Marmara, the Aegean Sea and Mediterranean Sea. This was the first consideration of ichthyoplankton in Turkish Mediterranean Coasts. Then, Donmez (2000) also considered the morphology and ecology of *E. encrasicolus* in Iskenderun Bay, Northeastern tip of Mediterranean.

During the last 15 years, much more information became available on this topic. The dissertation conducted by Ak (2004) was the first serious attempt about Levant Basin ichthyoplankton. In this study, Ak (2004) performed weekly samplings at three stations located at the 15, 90, 120 m depth contours off Erdemli, western coasts of Mersin Bay during three years from 1998 to 2001. This study presented an important background on the taxonomy of ichthyoplankton in this area by giving the morphological details of embryonic, prelarval and larval stage of 122 Teleost fishes.

In another major study, Uysal *et al.* (2008) evaluated ichthyoplankton of the North-eastern Levant Basin by conducting eight survey from November 2005 to September 2007. This was a basin scale study; in this context, they sampled up to 50 stations throughout all Cilician Basin from Iskenderun Bay to the Northern Cyprus. During these research, eggs and larvae of 202 species belonging to 10 ordo and 63 family were identified. Uysal *et al.* (2008) reported that the maximum embryonic, pre and postlarval abundances were observed during summer months (July 2006 and June 2007), whereas the minimum abundances were detected in Autumn period (November 2005). Diversity was also lowest in this period for embryonic (September 2007) and prelarval (November 2005) stages, however the minimum diversity was observed in summer for postlarval stages (July, 2006). In accordance with abundance values, the maximum diversity values were also measured in Spring for eggs (April 2007), pre and postlarval stages (March 2007). Additionally, the postlarval stages of seven previously unknown species, *Glossanodon leioglossus* (Valenciennes, 1848), *Lampanyctus alatus* Goode & Bean, 1896, *Bregmaceros* sp, *Aioliops* sp., *Lobianchia gemellarii* (Cocco, 1838), *Myctophum asperum* Richardson, 1845 and *Gonostoma denudatum* Rafinesque, 1810 were included to the Turkish ichthyofauna. Besides, larvae of two other species, *Lestidiops jayakari* (Boulenger, 1889) and *Arctozenus risso* (Bonaparte, 1840) were the first recorded ones for Anatolian coasts of Mediterranean.

Mavruk (2009) conducted the first comprehensive multispecies study dealing with the taxonomical properties of ichthyoplankters in Iskenderun Bay, Northeastern tip of Levant Basin. In context of this study, seasonal ichthyoplankton samples were collected from three stations located at the 10m depth contour off Yumurtalik, western coasts of Iskenderun Bay. Mavruk (2009), detected eggs and larvae of 56 fish species belonging to 26 families. In this study, ichthyoplankton abundance and diversity were minimum in winter, while the maximum values were observed in Spring and Summer.

The study performed by Oray *et al.* (2010) took a snapshot from ichthyoplankton assemblages in June 2004 from 104 stations between Mersin and Antalya bays. In this survey, the eggs and larvae of 53 taxonomic groups belonging to 37 families were presented. Because of the oceanic coverage of this study, the most dominant group was mesopelagic fishes.

Avsar and Mavruk (2011) studied a small scale near coastal area between Mersin and Antalya bays, Babadillimani Bay. In this study, Avsar and Mavruk (2011) took samples at nine stations with monthly intervals during one year. They collected the embryonic and larval stages of 23 species belonging to 18 families.

Banbul (2014)'s dissertation was the first comprehensive effort on the ichthyoplankton of Antalya Bay. In this study, distributions of fish eggs and larvae were investigated monthly at 20 stations by vertically stratified samplings. During the 12 cruises, embryonic and larval stages of 122 species belonging to 45 families were identified. In accordance with the previous ichthyoplankton studies in Turkish Mediterranean coasts, Banbul (2014) also detected that the diversity and abundance of eggs and larvae were maximum in late spring and summer though they were minimum in winter.

Mavruk (2015) investigated the meso-scale spatio-temporal variations of ichthyoplankton assemblages performed monthly at 28 stations in Iskenderun Bay. During the study period, 232 taxa belonging to 70 families were observed. Mavruk (2015) detected that the mesoscale spatial patterns of ichthyoplankton composition were more stable during winter, whereas the assemblages revealed apparent spatial variations during summer period. Author explained the observed spatio-temporal patterns by water mass dynamics and circulation.

The study performed by Coker and Cihangir (2015) was another cross sectional investigation of Turkish Mediterranean ichthyoplankton, which were conducted at 29 stations in July 1998 around the 300-1000m depth contours of Northern Cyprus marine area. Coker and Cihangir (2015) detected egg and larvae of 20 species in which mesopelagic taxa Myctophiforms and Stomiiforms were the most dominant groups. The authors attributed the reason of this to the hauling depths.

3. Sampling Methods of Ichthyoplankton Surveys

Most of the fish species in this area shed free-floating eggs which are released into the water column. However, some fishes produce demersal eggs which are either attached to the substrate (Gobiidae, Blennidae) or held (Atherinidae) into selected the nest in the northeastern Mediterranean coastal area. However, all ichthyoplankton work performed in the area has been generally carried out to determine the pelagic fish eggs and larvae. Ichthyoplankton samplings in the region have been carried out with vertical, horizontal or oblique hauls using various plankton nets (Table 1).

Table 1. Sampling methods of major studies in the Northeastern Mediterranean

References	Net Type	Mesh Size(μm)	Type of Haul	Study Area
Ak, 2004	Nansen Net	110	Vertical	Mersin Bay
Uysal *et al.* 2008	Hensen Net	300	Vertical	The Cilician Basin and Iskenderun Bay
Mavruk, 2009	Hensen Net	500	Horizontal	Iskenderun Bay
Oray *et al.* 2010	Bongo 60/90 Net	250/1000	Oblique/ Horizontal	The Northern Levantine Sea
Avsar and Mavruk 2011	Hensen Net	300	Horizontal	Babadillimani Bay
Banbul 2014	WP-2 Closing Net	200	Vertical	Antalya Bay
Coker and Cihangir 2015	WP-2 Net	250	Vertical	Turkish Republic of Northern Cyprus
Mavruk, 2015	Bongo 60 Net	300	Oblique	Iskenderun Bay

4. Seasonal Variations of Ichthyoplankton Assemblages

The seasonal variations of ichthyoplankton assemblages were investigated based on the data monthly collected from Iskenderun Bay between November-2009 and October 2010, in context of PhD thesis conducted by Mavruk (2015). In this regard, we evaluated the monthly variations of observed and expected number of species (Jackknife Estimation of species richness), abundance, Shannon-Wiener and Pielou indices.

The general temporal patterns of fish eggs and larvae were detected in accordance with each other. The spawning activities of Teleost fishes were high from late winter till early summer, whereas they decreased during late summer and autumn period (Figure 1). The maximum number of species were47 and 84 in April for eggs and larvae, respectively. According to Mavruk and Avsar (2015), the difference between egg and larval species numbers can be explained with the higher sampling efficiency of Bongo Net in larval stages. The jackknife estimation of maximum number of species reached 107±13 (95% CI) for larval stage in this period. Therefore, a considerable part of Teleost ichthyofauna is expected to be in spawning period in spring. The minimum richness values was 16 in December and January for eggs. The number of species was low also in late summer months, August and September. In larval stages, the lowest richness values were observed in August with 33 species.

Intra-annual variations of abundance values generally corresponded to the changes of richness. Egg and larval abundance were generally higher in spring and summer comparing to autumn and winter period. The egg abundance of Iskenderun Bay varied between 31.44±2.24 (November-2009) and 493.58±51.24 (May-2010) individual per 10 m^2 where these values were between 105.50±10.46 (January-2010) and 1092.25±18.25 (April-2010) individual per 10 m^2 for larvae. The average egg abundance was 138.41 individual per 10 m^2 where the larval abundance was 430.91 individual per 10 m^2 (Figure 1).

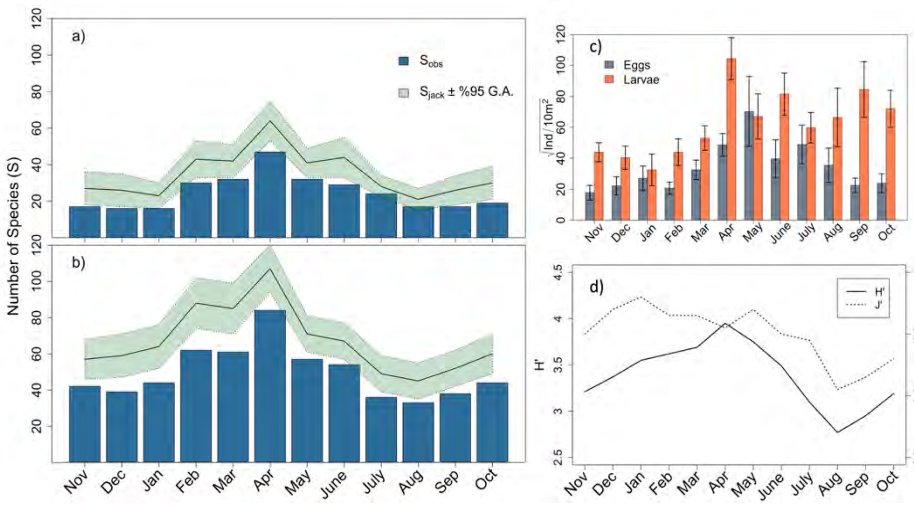

Figure 1. Intra-annual variations of observed (Sobs) and expected (Jackknife estimation of maximum number of species; Sjack) species richness for egg (a) and larvae (b), Intra-annual variations of egg and larval abundance (c) (Vertical bars show 95 % confidence intervals), Shannon Wiener Diversity Index (H') and its evenness component Pielou Evenness Index (J') (d).

Similar with the richness and abundance, the diversity was also maximum in spring months. Maximum Shannon-Wiener index value was observed in April as 3.96. Due to the over-dominance of larval stages of small pelagic fish species such as *Sardinella aurita* and *Engraulis encrasicolus*, evenness tended to decrease in this period. Therefore, the high number of species can be considered as the main reason of high diversity in spring. However, the number of species was low during winter months, abundance evenly distributed to the taxa. This high evenness increased the diversity by comparing summer months. In late summer, diversity was the lowest because of the low number of species and high dominancy. Minimum Shannon-Wiener diversity value was observed in August with 2.77. Pielous' evenness was also minimum in this period due to the over-dominance of Gobiid larvae (Figure 1).

Spawning periods of dominant fish species were given in Figure 2. Larval stages of *Saurida lessepsianus* (S_les) and *Bregramceros nectabanus* (B_nec) were observed throughout the year; but spawning of *S. lessepsianus* increased during spring and summer and *B. nectabanus* increased during autumn. Larvae of *E. encrasicolus* were present in the area throughout year except for winter, however Mavruk (2015) encountered eggs of this species in winter. *Alepes djeddaba* (A_dje), *Chelidonichthys lucernus* (C_luc), *Scomber colias* (S_col), *Solea solea* (S_sol), *Sardina pilchardus* (S_pil) and *Etrumeus golanii* (E_gol) were dominant species of winter ichthyoplankton assemblages in Iskenderun Bay. Larvae of *Pegusa lascaris* (P_las), *Buglossidium luteum* (B_lut) and *Sardinella aurita* (Sa_aur) were mostly observed in spring. Spawning periods of *Mullus barbatus* (M_bar), *Nemipterus randalli* (N_ran) started from spring and remained till summer. *Equulites klunzingeri* (E_klu) was among the typical summer spawners.

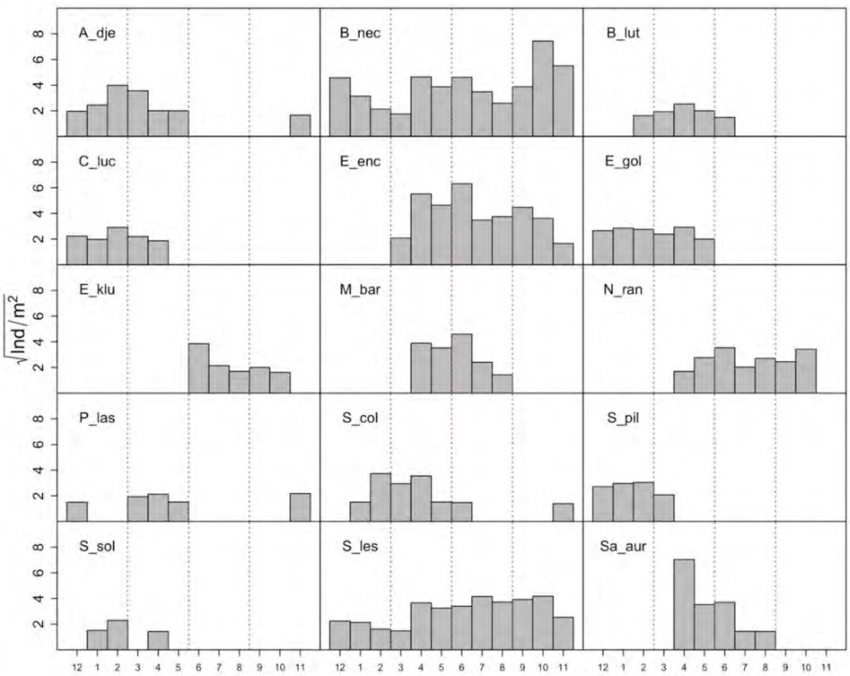

Figure 2. Spawning periods of dominant commercial fish species in Iskenderun Bay (Please see text for the abbreviations).

5. Spatial Variations of Ichthyoplankton Assemblages

The spatial distribution of larval fish assemblages in the Cilician basin between November-2005 and January 2007 were reported within the scope of TUBITAK project (project code:104Y277) by Uysal *et al.* (2008). Some results from this project which was the initial research for the entire basin were re-evaluated in this section.133 taxa of larval fish belonging to 42 families were identified in the Cilician Basin. The highest larval density were observed during the beginning of summer period (Figure 3). *Engraulis encrasicolus*, *Cyclothone braueri*, *Bregmaceros nectabanus*, Gobiidae sp1., *Euthynnus alletteratus* and *Sardinella maderensis* were found the maximum abundance (representing about 71 % of the total fish larvae) in this season, respectively. Larval density and species richness were increased during summer periods in the regions that located continental shelf areas along Turkish coast together with between the northeastern of Cyprus and Iskenderun bay (Figure 3).

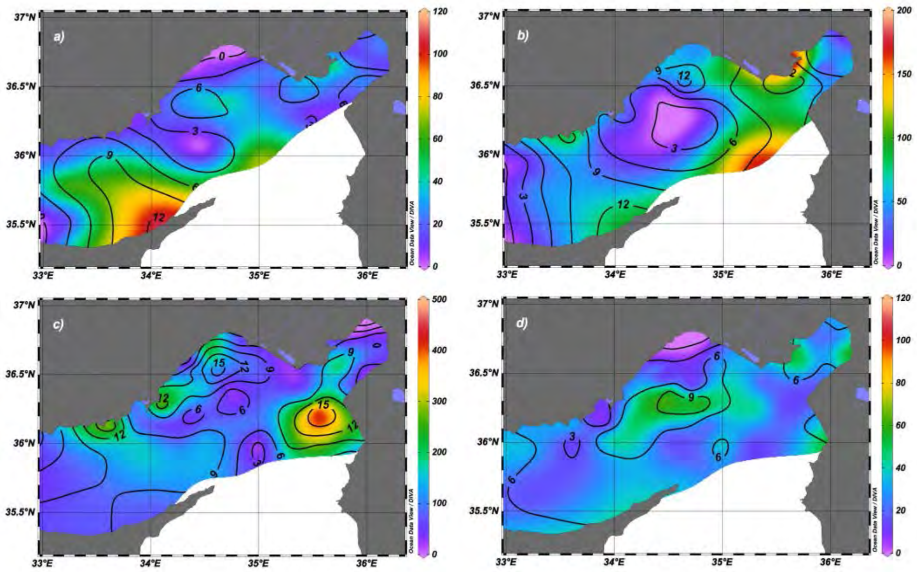

Figure 3. Seasonal distribution and abundance of fish larvae and species richness in the North Eastern Mediterranean (a: November 2005, b: March 2006, c: July 2006, d: January 2007)

Seasonal larval fish diversity and clustering Shannon-Weaver diversity (H) values were showed seasonally variations; diversity varied between 2.66 (July 2006) and 0.56 (January 2007) during sampling periods (Figure 4). Coastal species larvae were dispersed in shelf waters stations. Hence, larval fish diversity was high in continental shelf areas except in Northern Cyprus region. The lowest diversity values were found in off shore stations which were located at depths ranged between 500 and

1000 m. These stations were separated from the coastal stations. Four larval groups were observed in the study areas between November 2005 and January 2007 according to cluster analysis. In the first group, mesopelagic and bathypelagic larvae were abundant at open water stations. Second group also comprised the offshore stations but the larval fish composition were different than those of the first group. Larvae of *E. encrasicolus* (epipelagic) which were spawned preferably at inshore waters and *C. braueri* (bathypelagic) were determined the north western Syria waters (Group 2). Group 3 comprised the continental shelf stations, representing coastal species larvae were located at depths less than 70 m in the Mersin and Iskenderun bays. Group 4contained only two stations which were located in the plums of Ceyhan and Göksu rivers. Myctophidae, Gobiidae, Clupeidae and Engraulidae families were dominant in this group.

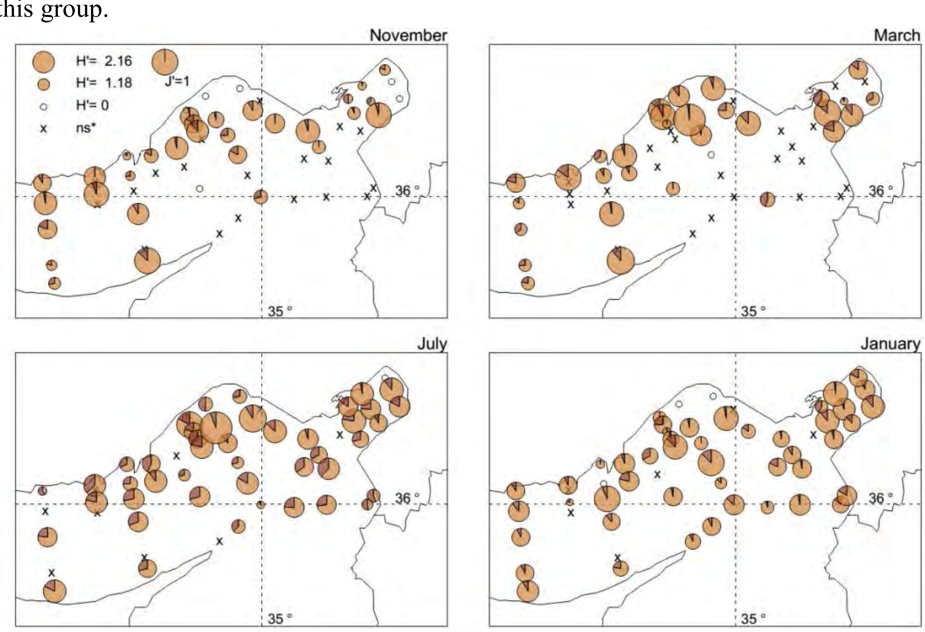

Figure 4. Seasonal larval species diversity in the North Eastern Mediterranean between November 2005-January 2007(H':Shannon-Weaver Diversity Index, J': Pielou Evenness Index, x: no sampling)

6. Conclusions

A synthesis of all these eight major multispecies ichthyoplankton studies revealed that a total of 236 taxa belonging to 85 families and 17 orders were identified in Anatolian Coasts of Mediterranean (Appendix 1). Although 191 of them could be identified at species level, 45 taxa had to be classed under higher taxonomic categories (morpho-groups) such as Genera and Family spp. These identifications especially concentrated on the rich families such as Sparidae, Gobiidae and Myctophidae

(Bilecenoglu *et al.* 2014). For example, Mavruk (2015) detected 10 different unidentified Gobiid larvae, however they were classified under Gobiidae spp. in this synthesis. Therefore, the total richness obtained by this way is strongly biased by underestimating the real number since these groups usually included more than one species.

According to Bilecenoglu *et al.* (2014) 378 Teleost fish species were recorded in Turkish Mediterranean coasts. Pinar *et al.* (2014) stated that 96 % of these taxa has planktonic embryonic and/or larval stages. While morpho-groups can be considered as the main reason of the difference between the checklist records and ichthyoplankton studies, a considerable gap still remains unexplained. Therefore, taxonomic studies seem still remaining as an open subject for the ichthyoplankton of the Anatolian coasts of Mediterranean.

The studies on the ichthyoplankton assemblages of Eastern Mediterranean conformably refer to clear seasonal variations as expected in mid and high latitudes (Sabataes *et al.* 2007; Moyano and Hernández-León 2009). This seasonality mostly occurs depending on the variations of spawning activities of fish populations (Miller, 2002).Therefore, it can be derived from the richness variations of ichthyoplankton assemblages, fishes of eastern Mediterranean mostly spawn between late winter and early summer periods.

Ichthyoplankton distributions and abundance in the Turkish Mediterranean Sea are strongly influenced by hydrodynamic circulation and topographic conditions. Additionally, temperature and salinity distributions play an important role in determining seasonal changes of species diversity in the region. Bathypelagic and mesopelajic fish larvae are dominant in the open waters, while the wide continental shelf area constitutes main spawning area of many economically important fish species.

By considering the overall composition of eggs and larvae in the basin, it is observed that *E. encrasicolus* was dominant. Recently, it was found that two genetically and morphologically differentiated anchovy forms were found in offshore and inshore waters (Karahan *et al.* 2014). The parallel execution of genetic and taxonomy studies indicate that is important in the determine of identification criteria in early life stages of these and similar species.

There are some variations among the diversity and abundance of ichthyoplankton assemblages determined by different studies conducted in the area. These differences may be due to the different spatial or temporal coverage of the studies. On the other hand, these results need to be interpreted with caution because of the different sampling strategies and intensities of the studies. Besides, the ichthyofaunal structure of the area is quite dynamic due to the Lessepsian intrusions

(Mavruk and Avsar 2008). So far, little is known about the description of their early life stages. Therefore, these species can not be identified at the species level. An identification standard should be created among the researchers. In order to reach this aim, researchers who works on ichthyoplankton in the region should be conducted meetings in order to provide a common consensus for identification and sampling criteria of ichthyoplanktonic stages.

In particular, the studies towards the elimination of references deficiencies in the early life stages of Lessepsian species should be initiated. It is necessary to liaise with the ichthyoplankton studies and fisheries researches for determining the marine fish population dynamics in the region. Earlier studies of the ichthyoplankton have generally been performed in limited geographic fields in the region. Therefore, developing of various long-term ichthyoplankton monitoring program has importance in the Turkish Mediterranean coasts.

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Appendix 1. List of identified Teleost eggs and larvae on the Turkey's Mediterranean coast between 2004-2015 [References: Ak, 2004 (1), Uysal *et al.* 2008 (2), Mavruk, 2009 (3), *Oray et al.* 2010 (4), Avsar and Mavruk, 2011(5), Banbul, 2014 (6), Mavruk, 2015 (7), Coker and Cihangir, 2015(8)]

Species List	References
Anguilliformes	
Anguilliformes spp.	(2)
Chlopsidae	
Chlopsis bicolor Rafinesque, 1810	(2, 7)
Muraenidae	
Gymnothorax unicolor (Delaroche, 1809)	(6, 7)
Muraena helena Linnaeus, 1758	(5)
Ophichthidae	
Dalophis imberbis (Delaroche, 1809)	(1, 2, 6, 7)
Echelus myrus (Linnaeus, 1758)	(1, 2, 4, 5, 6)
Ophichthidae spp.	(2, 7)
Ophichthus rufus (Rafinesque, 1810)	(6)
Ophisurus serpens (Linnaeus, 1758)	(2, 7)
Congridae	
Ariosoma balearicum (Linnaeus, 1758)	(2)
Conger conger (Linnaeus, 1758)	(4, 5)
Congridae spp.	(6)
Gnathophis mystax (Delaroche, 1809)	(1, 2, 6, 7)
Clupeiformes	
Clupeidae	
Clupeidae spp.	(1, 2, 7)
Herklotsichthys punctatus (Rüppell, 1837)	(2)
Sardina pilchardus (Walbaum, 1792)	(1, 2, 4, 6, 8, 7)
Sardinella aurita Valenciennes, 1847	(1, 2, 3, 4, 6, 8, 7)
Sardinella maderensis (Lowe, 1838)	(1, 2, 3, 6, 7)
Dussumieriidae	
Dussumieria elopsoides Bleeker, 1849	(2, 6, 8, 7)
Etrumeus golanii DiBattista, Randall &Bowen, 2012	(1, 2, 3, 6, 8, 7)
Engraulidae	
Engraulis encrasicolus (Linnaeus, 1758)	(1, 2, 3, 4, 5, 6, 8, 7)
Osmeriformes	
Argentinidae	
Argentina sphyraena Linnaeus, 1758	(2, 4)
Glossanodon leioglossus (Valenciennes, 1848)	(2)

Species List	**References**
Osmeridae	
Osmeridae spp.	(4)
Stomiiformes	
Gonostomatidae	
Cyclothone braueri Jespersen & Tåning, 1926	(1, 2, 4, 6, 7)
Gonostoma atlanticum Norman, 1930	(8)
Gonostoma denudatum Rafinesque, 1810	(1, 2, 6, 7)
Gonostomatidae spp.	(2, 6, 8, 7)
Sternoptychidae	
Argyropelecus hemigymnus Cocco, 1829	(2, 6, 8)
Maurolicus muelleri (Gmelin, 1789)	(1, 2, 8, 7)
Sternopticidae spp.	(6)
Phosichthyidae	
Ichthyococcus ovatus (Cocco, 1838)	(2)
Phosichthyidae spp.	(2, 6, 8, 7)
Vinciguerria attenuata (Cocco, 1838)	(1, 2, 4)
Vinciguerria poweriae (Cocco, 1838)	(2)
Stomiidae	
Chauliodus sloani Bloch & Schneider, 1801	(1, 2, 6, 7)
Stomias boa (Risso, 1810)	(2, 7)
Stomiidae spp.	(2)
Aulopiformes	
Aulopidae	
Aulopus filamentosus (Bloch, 1792)	(1, 2)
Chlorophthalmidae	
Chlorophthalmus agassizi Bonaparte, 1840	(1, 4, 6, 8, 7)
Synodontidae	
Saurida lessepsianus Russell, Golani & Tikochinski, 2015	(1, 2, 5, 6, 7)
Synodontidae spp.	(8)
Synodus saurus (Linnaeus, 1758)	(4, 5, 6, 8)
Paralepididae	
Arctozenus risso (Bonaparte, 1840)	(1, 2, 7)
Lestidiops jayakari (Boulenger, 1889)	(2)
Paralepididae spp.	(2, 4, 8, 7)
Sudis hyalina Rafinesque, 1810	(1, 2, 7)
Evermannellidae	
Evermannella balbo (Risso, 1820)	(4, 7)

Species List	References
Myctophiformes	
Myctophidae	
Benthosema glaciale (Reinhardt, 1837)	(1, 2)
Ceratoscopelus maderensis (Lowe, 1839)	(1, 2, 4, 6, 7)
Diaphus mollis Tåning, 1928	(6)
Diaphus rafinesquii (Cocco, 1838)	(2, 7)
Electrona risso (Cocco, 1829)	(1, 2, 4, 8, 7)
Gonichthys cocco (Cocco, 1829)	(2, 6)
Hygophum benoiti (Cocco, 1838)	(1, 2, 6, 8, 7)
Hygophum hygomii (Lütken, 1892)	(1, 2, 6, 7)
Hygophum reinhardtii (Lütken, 1892)	(2)
Lampadena luminosa (Garman, 1899)	(2, 6)
Lampanyctus alatus Goode & Bean, 1896	(2)
Lampanyctus crocodilus (Risso, 1810)	(1, 2, 6, 7)
Lampanyctus pusillus (Johnson, 1890)	(7)
Lobianchia dofleini (Zugmayer, 1911)	(1, 2, 6, 7)
Lobianchia gemellarii (Cocco, 1838)	(2)
Myctophidae spp.	(1, 2, 4, 6, 8, 7)
Myctophum asperum Richardson, 1845	(2)
Myctophum punctatum Rafinesque, 1810	(1, 2, 6)
Notoscopelus elongatus (Costa, 1844)	(6, 7)
Symbolophorus veranyi (Moreau, 1888)	(2)
Gadiformes	
Bregmacerotidae	
Bregmaceros nectabanus Whitley, 1941	(2, 6, 7)
Bregmacerotidae spp.	(6)
Macrouridae	
Macrouridae spp.	(2, 4)
Nezumia sclerorhynchus (Valenciennes, 1838)	(7)
Gadidae	
Gadidae spp.	(2, 4, 7)
Trisopterus luscus (Linnaeus, 1758)	(2)
Lotidae	
Gaidropsarus mediterraneus (Linnaeus, 1758)	(2, 6, 7)
Gaidropsarus vulgaris (Cloquet, 1824)	(1)
Lotidae sp.	(2)
Merlucciidae	

Species List	References
Merluccius merluccius (Linnaeus, 1758)	(1, 2, 5, 7)
Ophidiiformes	
Ophidiidae	
Ophidion barbatum Linnaeus, 1758	(1, 2, 6, 7)
Parophidion vassali (Risso, 1810)	(4)
Carapidae	
Carapus acus (Brünnich, 1768)	(1, 2)
Atheriniformes	
Atherinidae	
Atherina boyeri Risso, 1810	(3, 4, 7)
Beloniformes	
Hemiramphidae	
Hyporhamphus picarti (Valenciennes, 1847)	(3)
Exocoetidae	
Hirundichthys rondeletii(Valenciennes, 1847)	(7)
Beryciformes	
Holocentridae	
Sargocentron rubrum (Forsskål, 1775)	(2, 8, 7)
Zeiformes	
Zeidae	
Zeus faber Linnaeus, 1758	(7)
Syngnathiformes	
Fistulariidae	
Fistularia commersonii Rüppell, 1838	(2, 6, 7)
Centriscidae	
Macroramphosus scolopax (Linnaeus, 1758)	(2, 8, 7)
Syngnathidae	
Syngnathus acus Linnaeus, 1758	(5)
Scorpaeniformes	
Sebastidae	
Helicolenus dactylopterus (Delaroche, 1809)	(1, 2, 4, 7)
Scorpaenidae	
Scorpaena notata Rafinesque, 1810	(2)
Scorpaena porcus Linnaeus, 1758	(2, 7)
Scorpaena scrofa Linnaeus, 1758	(2, 6)
Scorpaenidae spp.	(1, 2, 4, 5, 7)
Platycephalidae	

Species List	**References**
Platycephalidae sp.	(7)
Dactylopteridae	
Dactylopterus volitans (Linnaeus, 1758)	(2, 6, 7)
Triglidae	
Chelidonichthys cuculus (Linnaeus, 1758)	(7)
Chelidonichthys lucerna (Linnaeus, 1758)	(1, 2, 5, 6, 7)
Eutrigla gurnardus (Linnaeus, 1758)	(2, 7)
Lepidotrigla cavillone (Lacepède, 1801)	(1, 2, 7)
Triglidae spp.	(1, 2, 3, 4, 6, 7)
Perciformes	
Moronidae	
Dicentrarchus labrax (Linnaeus, 1758)	(1, 2, 3, 4, 7)
Serranidae	
Anthias anthias (Linnaeus, 1758)	(7)
Serranidae spp.	(1, 2, 4, 6, 8, 7)
Serranus cabrilla (Linnaeus, 1758)	(1, 2, 3, 6, 7)
Serranus hepatus (Linnaeus, 1758)	(1, 2, 3, 4, 6, 7)
Serranus scriba (Linnaeus, 1758)	(1, 2, 3, 4, 6, 7)
Callanthiidae	
Callanthias ruber (Rafinesque, 1810)	(2)
Terapontidae	
Pelates quadrilineatus (Bloch, 1790)	(3, 7)
Apogonidae	
Apogon imberbis (Linnaeus, 1758)	(4)
Apogonidae spp.	(1, 2, 3, 6, 7)
Sillaginidae	
Sillago suezensis Golani, Fricke & Tikochinski, 2013	(2, 3, 6, 7)
Pomatomidae	
Pomatomus saltatrix (Linnaeus, 1766)	(2, 3, 8)
Echeneidae	
Echeneis naucrates Linnaeus, 1758	(7)
Carangidae	
Alepes djedaba (Forsskål, 1775)	(1, 2, 7)
Carangidae spp.	(1, 2, 6, 8, 7)
Caranx crysos (Mitchill, 1815)	(2, 4, 6, 7)
Caranx rhonchus Geoffroy Saint-Hilaire, 1817	(3, 6, 7)
Seriola dumerili (Risso, 1810)	(1, 2, 6, 7)

Species List	**References**
Trachinotus ovatus (Linnaeus, 1758)	(2)
Trachurus mediterraneus (Steindachner, 1868)	(1, 2, 4, 6)
Trachurus picturatus (Bowdich, 1825)	(2)
Trachurus trachurus (Linnaeus, 1758)	(1, 2, 3, 4, 6, 8, 7)
Coryphaenidade	
Coryphaena hippurus Linnaeus, 1758	(8)
Leiognathidae	
Equulites klunzingeri (Steindachner, 1898)	(1, 2, 6, 7)
Bramidae	
Brama brama (Bonnaterre, 1788)	(7)
Lobotidae	
Lobotes surinamensis (Bloch, 1790)	(7)
Sparidae	
Boops boops (Linnaeus, 1758)	(1, 2, 3, 4, 5, 6, 7)
Dentex dentex (Linnaeus, 1758)	(1, 2, 3, 6, 7)
Dentex gibbosus (Rafinesque, 1810)	(1, 2, 3, 6, 7)
Diplodus annularis (Linnaeus, 1758)	(1, 2, 3, 5, 6, 7)
Diplodus puntazzo (Walbaum, 1792)	(6)
Diplodus sargus (Linnaeus, 1758)	(1, 2, 3, 4, 6, 7)
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	(2, 3, 6, 7)
Lithognathus mormyrus (Linnaeus, 1758)	(1, 3, 6, 7)
Oblada melanura (Linnaeus, 1758)	(1, 2, 3, 7)
Pagellus bogaraveo (Brünnich, 1768)	(2)
Pagellus erythrinus (Linnaeus, 1758)	(2, 5)
Pagrus pagrus (Linnaeus, 1758)	(1, 2, 7)
Sparidae spp.	(1, 2, 3, 4, 6, 8, 7)
Sparus aurata Linnaeus, 1758	(1, 2, 3, 6, 7)
Centracanthidae	
Centracanthidae spp.	(1, 2, 3, 5, 6, 7)
Nemipteridae	
Nemipterus randalli Russell, 1986	(6, 7)
Sciaenidae	
Sciaena umbra Linnaeus, 1758	(2, 3, 7)
Sciaenidae spp.	(7)
Mullidae	
Mullidae sp.1	(1, 2, 3, 7)
Mullidae sp.2	(1, 2, 3, 7)

Species List	**References**
Mullidae spp.	(1, 2, 3, 5, 6, 8, 7)
Mullus barbatus Linnaeus, 1758	(1, 2, 3, 5, 6, 7)
Mullus surmuletus Linnaeus, 1758	(1, 2, 3, 5, 6, 7)
Pempheridae	
Pempheris mangula Cuvier, 1829	(2, 3)
Pomacentridae	
Chromis chromis (Linnaeus, 1758)	(3, 4, 7)
Cepolidae	
Cepola macrophthalma (Linnaeus, 1758)	(7)
Mugilidae	
Chelon labrosus (Risso, 1827)	(7)
Liza aurata (Risso, 1810)	(1, 6, 7)
Liza carinata (Valenciennes, 1836)	(1, 2, 7)
Liza ramada (Risso, 1827)	(7)
Liza saliens (Risso, 1810)	(1, 2, 3, 6, 7)
Mugil cephalus Linnaeus, 1758	(1, 2, 7)
Mugilidae spp.	(1, 2, 6)
Labridae	
Coris julis (Linnaeus, 1758)	(1, 2, 3, 4, 6, 7)
Labridae spp.	(2, 3, 4, 6, 7)
Pteragogus pelycus Randall, 1981	(2)
Symphodus roissali (Risso, 1810)	(6, 7)
Symphodus tinca (Linnaeus, 1758)	(7)
Thalassoma pavo (Linnaeus, 1758)	(2, 3, 6, 7)
Xyrichtys novacula (Linnaeus, 1758)	(1, 2, 6, 8, 7)
Scaridae	
Scaridae spp.	(2)
Sparisoma cretense (Linnaeus, 1758)	(2)
Champsodontidae	
Champsodon spp.	(7)
Ammodytidae	
Gymammodytes cicerellus(Rafinesque, 1810)	(8)
Trachinidae	
Echiichthys vipera (Cuvier, 1829)	(1, 2, 7)
Trachinidae spp.	(1, 2, 7)
Trachinus draco Linnaeus, 1758	(1, 2, 6, 7)
Trachinus radiatus Cuvier, 1829	(2)

Species List	References
Uranoscopidae	
Uranoscopus scaber Linnaeus, 1758	(1, 2, 4, 6, 7)
Tripterygiidae	
Tripterygion spp.	(3, 7)
Blenniidae	
Blenniidae spp.	(3, 7)
Blennius ocellaris Linnaeus, 1758	(1, 3, 7)
Parablennius gattorugine (Linnaeus, 1758)	(7)
Parablennius sanguinolentus (Pallas, 1814)	(2, 3, 7)
Parablennius tentacularis (Brünnich, 1768)	(2, 6, 7)
Salaria pavo (Risso, 1810)	(3)
Callionymidae	
Callionymidae spp.	(1, 2, 6, 8, 7)
Callionymus lyra Linnaeus, 1758	(1, 2, 3, 4, 5)
Callionymus maculatus Rafinesque, 1810	(2)
Callionymus pusillus Delaroche, 1809	(1, 2, 3, 7)
Gobiidae	
Aphia minuta (Risso, 1810)	(1, 2, 3, 6, 7)
Crystallogobius linearis (Düben, 1845)	(2)
Gobiidae spp.	(1, 2, 3, 4, 5, 6, 7)
Gobius niger Linnaeus, 1758	(1, 2, 6, 7)
Gobius paganellus Linnaeus, 1758	(1, 2, 6, 8, 7)
Lesueurigobius sanzi (de Buen, 1918)	(2)
Pomatoschistus marmoratus (Risso, 1810)	(1, 2, 7)
Pomatoschistus minutus (Pallas, 1770)	(1, 2, 6, 7)
Pomatoschistus pictus (Malm, 1865)	(1, 2, 6, 7)
Trypauchen vagina (Bloch & Schneider, 1801)	(7)
Microdesmidae	
Aioliops sp.	(2)
Siganidae	
Siganus sp.	(1, 2, 6, 7)
Sphyraenidae	
Sphyraena sphyraena (Linnaeus, 1758)	(2, 3, 6, 7)
Sphyraena spp.	(1, 2, 4, 6, 7)
Trichiuridae	
Lepidopus caudatus (Euphrasen, 1788)	(1, 2, 4, 8, 7)
Trichiuridae spp.	(2)

Species List	**References**
Trichiurus lepturus Linnaeus, 1758	(2, 6, 7)
Scombridae	
Auxis rochei (Risso, 1810)	(2, 4, 6)
Euthynnus alletteratus (Rafinesque, 1810)	(1, 2, 3, 4, 6, 7)
Katsuwonus pelamis (Linnaeus, 1758)	(1, 2, 3, 7)
Sarda sarda (Bloch, 1793)	(2, 4)
Scomber colias Gmelin, 1789	(1, 2, 3, 7)
Scomber scombrus Linnaeus, 1758	(1, 2, 3, 6, 7)
Scombridae spp.	(1, 2, 6, 8, 7)
Thunnus alalunga (Bonnaterre, 1788)	(1, 2, 6, 7)
Thunnus thynnus (Linnaeus, 1758)	(1, 2, 3, 4, 6, 8)
Xiphiidae	
Xiphias gladius Linnaeus, 1758	(2, 7)
Centrolophidae	
Centrolophus niger (Gmelin, 1789)	(2)
Caproidae	
Capros aper (Linnaeus, 1758)	(6, 7)
Pleuronectiformes	
Citharidae	
Citharus linguatula (Linnaeus, 1758)	(2, 5)
Scophthalmidae	
Lepidorhombus whiffiagonis (Walbaum, 1792)	(7)
Scophthalmidae spp	(6)
Bothidae	
Arnoglossus kessleri Schmidt, 1915	(1, 6, 7)
Arnoglossus laterna (Walbaum, 1792)	(1, 2, 4, 6, 7)
Arnoglossus thori Kyle, 1913	(1, 2, 7)
Bothidae spp.	(1, 2, 3, 6, 8, 7)
Bothus podas (Delaroche, 1809)	(1, 2, 4, 5, 7)
Pleuronectidae	
Platichthys flesus (Linnaeus, 1758)	(1)
Soleidae	
Buglossidium luteum (Risso, 1810)	(1, 2, 6, 7)
Dicologlossa cuneata (Moreau, 1881)	(2)
Microchirus ocellatus (Linnaeus, 1758)	(2, 7)
Microchirus variegatus (Donovan, 1808)	(7)
Pegusa lascaris (Risso, 1810)	(1, 2, 6, 7)

Species List	**References**
Pegusa nasuta (Pallas, 1814)	(2)
Solea solea (Linnaeus, 1758)	(1, 2, 5, 7)
Soleidae spp.	(1, 2, 3, 4, 8)
Cynoglossidae	
Cynoglossidae spp.	(7)
Cynoglossus sinusarabici (Chabanaud, 1931)	(1, 2, 5)
Tetraodontiformes	
Balistidae	
Balistes capriscus Gmelin, 1789	(1, 2, 4)
Monacanthidae	
Stephanolepis diaspros Fraser-Brunner, 1940	(2, 7)
Tetraodontidae	
Tetraodontidae spp.	(6, 7)

CARTILAGINOUS FISHES AND FISHERIES IN THE MEDITERRANEAN COAST OF TURKEY

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1. Introduction

Within the eastern Mediterranean, sharks skates and rays are caught primarily as non-targeted bycatch within various artisanal fisheries and discard due to low commercials value. Since rays are rarely landed, determining the fisheries induced impacts for these cartilaginous fish is difficult and severely inhibits accurate populations' assessment. Considering the landings of elasmobranch were reduced from 3980 tonnes in 2000 to 246.2 tonnes in 2015 in Turkey (Figure 1; TUIK 2015). The Mediterranean coast constitues 12.97% of sharks, 20.80% of angelsharks and 4.01% of the rays and skates of the total landing of Turkey during 2000-2015 period (TUIK 2015). The lowest elasmobranch landing amount in the Mediterranean coast of Turkey was recorded in 2015 (10.7 tonnes), indicating a sharp decline after the highest record in 1989 (897 tonnes), except for the 1973-1975 period that no data were recorded (Figure 2). The cartilaginous species are not targeted by the commercial fisheries in Turkey, but generally captured by trawl, gillnet and longline fishing and the giant species such as *Mobula* spp. by purse seine net in the Mediterranean coast of Turkey (Kabasakal 1998). In the Mediterranean, a total of 49 sharks and 36 ray species are known to exist (Bradai *et al.* 2012). More than 80% of these species are recognized as either vulnerable, endangered or critically endangered (Bradai *et al.* 2012). In this chapter, bio-ecological characteristics, fishing, production, population structure and fisheries management of cartilaginous fishes inhabiting in the eastern Mediterranean coasts of Turkey have been compiled.

2. Biodiversity and Systematics of Sharks, Skates and Rays in the Mediterranean Coasts of Turkey

In the Mediterranean region, approximately 86 species of cartilaginous fishes have been described (49 sharks and 37 rays including *Mobula japanica*) (Bradai *et al.* 2012). According to Serena (2005) only four batoid species (Maltese skate *Leucoraja melitensis*, speckled skate *Raja polystigma*, rough ray *R. radula* and giant devilray *Mobula mobular*) could be considered endemic and within the Mediterranean, the distribution of chondrichthyan fishes is not homogenous. The northeastern Mediterranean is known to be an important habitat for cartilaginous fish and is thought to encompass unique breeding and nursery grounds for most of elasmobranchs (Başusta 2016a). A total of 63 species of elasmobranchs occur in the Mediterranean coasts of Turkey (Bilecenoglu *et al.* 2014). This number comprises 32 species of sharks from 16 families and 31 batoids species from nine families. the Carcharhiniformes, Myliobatiformes, Rajiformes and Squaliformes are the most dominant groups in terms of abundance. A complete checklist of nominal chondrichthyan species in the Mediterranean Turkish waters is presented in Table 1 (Bilecenoğlu *et al.* 2014) with a recent addition of *Mobula japanica* from the Gulf of Antakya by Sakallı *et al.* (2016). The IUCN status of the elasmobranch species were given in Table 1 according to Dulvy *et al.* (2016) and 13 species were categorized as Critically Endangered (CR), 8 Endangered (EN), 8 Vulnerable (VU), 8 Near Threatened (NT), 7 Least Concern (LC), and 18 Data Deficient (DD). Since the two species are exotics, the categorization is not applicable to them. The original photos of the elasmobranch species taken by the authors, Nuri Başusta (NB) and Elif Özgür Özbek (EÖÖ) were given in Figures 7 to 37.

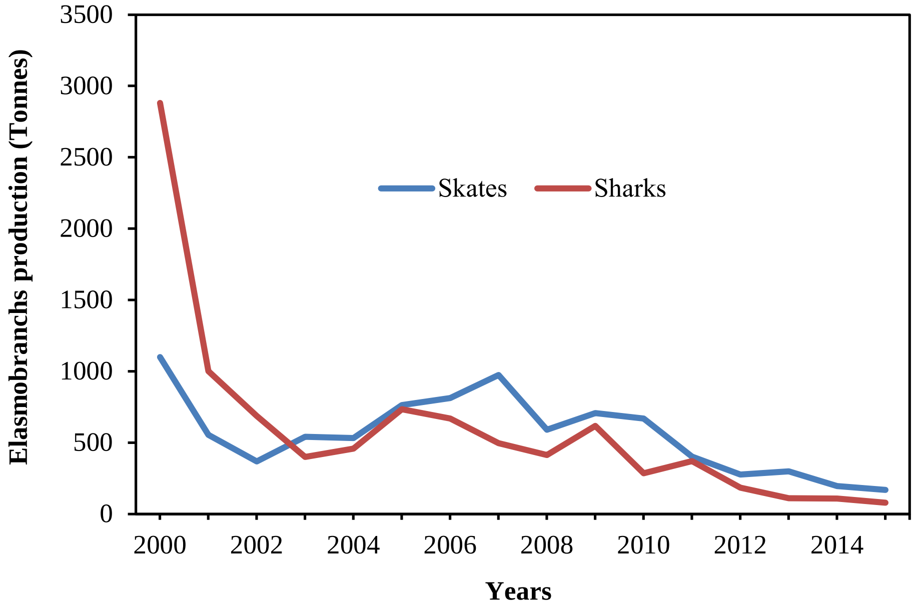

Figure 1. Elasmobranch landings during 2000-2015 period in Turkish waters (TUIK, 2015).

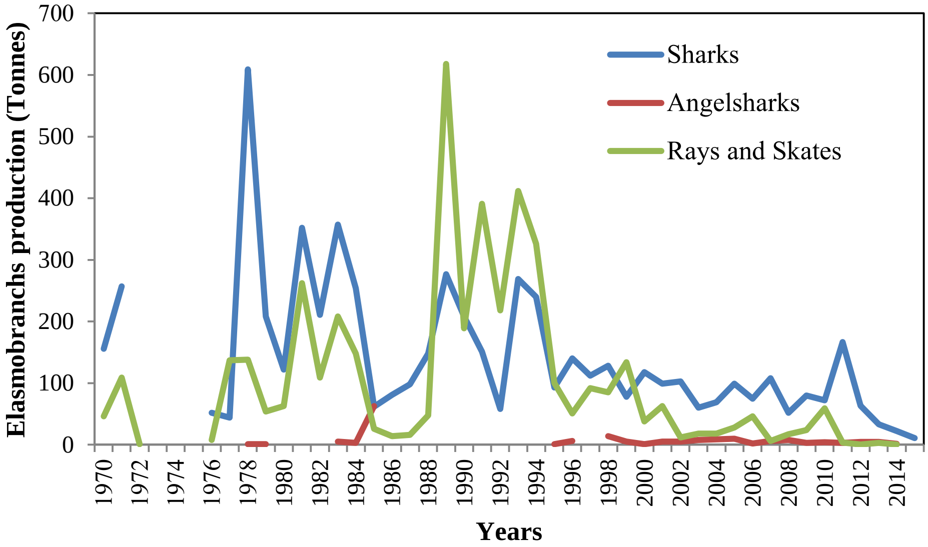

Figure 2. Elasmobranch landings during 1970-2015 period in the Mediterranean coasts of Turkey (FAO and TUIK 2015).

Table 1. Diversity of elasmobranchs in the Mediterranean Coasts of Turkey. IUCN status (CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern; DD: Data Deficient (Dulvy *et al.* 2016).

Latin Name	Common name	IUCN Status
Hexanchiformes		
Hexanchidae		
Heptranchias perlo (Bonnaterre, 1788)	Sharpnose sevengill shark	DD
Hexanchus griseus (Bonnaterre, 1788)	Bluntnose sixgill shark	LC
Lamniformes		
Odontaspididae		
Carcharias taurus Rafinesque, 1810	Sand tiger shark	CR
Odontaspis ferox (Risso, 1810)	Smalltooth sand tiger	CR
Lamnidae		
Carcharodon carcharias (Linnaeus, 1758)	Great white shark	CR
Isurus oxyrinchus Rafinesque, 1810	Shortfin mako	CR
Lamna nasus (Bonnaterre, 1788)	Porbeagle	CR
Alopiidae		
Alopias superciliosus Lowe, 1841	Bigeye thresher	EN
Alopias vulpinus (Bonnaterre, 1788)	Thresher shark	EN
Cetorhinidae		
Cetorhinus maximus (Gunnerus, 1765)	Basking shark	EN
Carcharhiniformes		
Scyliorhinidae		
Galeus melastomus Rafinesque, 1810	Blackmouth catshark	LC
Scyliorhinus canicula (Linnaeus, 1758)	Lesser spotted dogfish	LC
Scyliorhinus stellaris (Linnaeus, 1758)	Nursehound	NT
Triakidae		
Galeorhinus galeus (Linnaeus, 1758)	Tope shark	VU

Mustelus asterias Cloquet, 1821	Starry smooth-hound	VU
Mustelus mustelus (Linnaeus, 1758)	Smooth-hound	VU
Mustelus punctulatus Risso, 1827	Blackspotted smooth-hound	VU
Carcharhinidae		
Carcharhinus altimus (Springer, 1950)	Bignose shark	DD
Carcharhinus brevipinna (Müller & Henle, 1839)	Spinner shark	Not Applicable
Carcharhinus limbatus (Müller & Henle, 1839)	Blacktip shark	DD
Carcharhinus plumbeus (Nardo, 1827)	Sandbar shark	EN
Prionace glauca (Linnaeus, 1758)	Blue shark	CR
Sphyrnidae		
Sphyrna zygaena (Linnaeus, 1758)	Smooth hammerhead	CR
Squaliformes		
Dalatiidae		
Dalatias licha (Bonnaterre, 1788)	Kitefin shark	VU
Etmopteridae		
Etmopterus spinax (Linnaeus, 1758)	Velvet belly	LC
Oxynotidae		
Oxynotus centrina (Linnaeus, 1758)	Angular roughshark	CR
Centrophoridae		
Centrophorus granulosus (Bloch & Schneider, 1801)	Gulper shark	CR
Squalidae		
Squalus acanthias Linnaeus, 1758	Picked dogfish	EN
Squalus blainville (Risso, 1827)	Longnose spurdog	DD
Echinorhinidae		
Echinorhinus brucus (Bonnaterre, 1788)	Bramble shark	EN
Squatiniformes		
Squatinidae		
Squatina aculeata Cuvier, 1829	Sawback angelshark	CR
Squatina oculata Bonaparte, 1840	Smoothback angelshark	CR
Squatina squatina (Linnaeus, 1758)	Angelshark	CR
BATOIDS		
Torpediniformes		
Torpedinidae		
Torpedo nobiliana Bonaparte, 1835	Electric ray	LC
Torpedo marmorata Risso, 1810	Marbled electric ray	LC
Torpedo torpedo (Linnaeus, 1758)	Common torpedo	LC
Rajiformes		
Rhinobatidae		
Rhinobatos cemiculus Geoffroy St. Hilaire, 1817	Blackchin guitarfish	EN
Rhinobatos rhinobatos (Linnaeus, 1758)	Common guitarfish	EN
Rajidae		
Dipturus batis (Linnaeus, 1758)	Blue skate	CR
Dipturus oxyrinchus (Linnaeus, 1758)	Longnosed skate	NT
Leucoraja circularis (Couch, 1838)	Sandy ray	CR
Leucoraja fullonica (Linnaeus, 1758)	Shagreen ray	CR
Leucoraja naevus (Müller & Henle, 1841)	Cuckoo ray	NT
Raja asterias Delaroche, 1809	Mediterranean starry ray	NT
Raja clavata Linnaeus, 1758	Thornback ray	NT
Raja miraletus Linnaeus, 1758	Brown ray	LC
Raja montagui Fowler, 1910	Spotted ray	LC

Raja radula Delaroche, 1809	Rough ray	EN
Raja undulata Lacepède, 1802	Undulate ray	NT
Rostroraja alba (Lacepède, 1803)	White skate	EN
Myliobatiformes		
Dasyatidae		
Dasyatis centroura (Mitchill, 1815)	Roughtail stingray	VU
Dasyatis marmorata (Steindachner, 1892)	Marbled stingray	DD
Dasyatis pastinaca (Linnaeus, 1758)	Common stingray	VU
Dasyatis tortonesei Capapé, 1975	Tortonese's stingray	Not Evaluated
Himantura uarnak (Forsskål, 1775)	Honeycomb stingray	Not Applicable
Pteroplatytrygon violacea (Bonaparte, 1832)	Pelagic stingray	LC
Taeniura grabata (Geoffroy St. Hilaire, 1817)	Round stingray	DD
Gymnuridae		
Gymnura altavela (Linnaeus, 1758)	Spiny butterfly ray	CR
Myliobatidae		
Myliobatis aquila (Linnaeus, 1758)	Common eagle ray	VU
Pteromylaeus bovinus (Geoffroy St. Hilaire, 1817)	Bull ray	CR
Rhinoptera marginata (Geoffroy St. Hilaire, 1817)	Lusitanian cownose ray	DD
Mobula mobular (Bonnaterre, 1788)	Devil fish	EN
Mobula japanica (Müller & Henle, 1841)	Spinetail Devil Ray	Not Applicable
HOLOCEPHALI		
Chimaeriformes		
Chimaeridae		
Chimaera monstrosa Linnaeus, 1758	Rabbit fish	NT

3. Elasmobranch studies in the Mediterranean coast of Turkey

A list of studies on bio-ecological characteristics of cartilaginous fishes in the Turkish waters of the Mediterranean Sea are summarized in Table 2. According to the available literature, sixty-one studies have taken the topic and reported elasmobranch species from the Mediterranean coast of Turkey. *D. pastinaca, R. rhinobatos, G. altavela, R. clavata, and R. miraletus* are the top five species that were most frequently studied and reported in the region (Figure 3). Generally, these species were also reported to have the highest abundance and biomass values in the Mediterranean coast of Turkey (JICA 1993; Gücü and Bingel 1994; Salihoğlu and Mutlu 2000; Başusta *et al.* 2002; Yeldan and Avşar 2006; Saygu 2011; Yeldan *et al.* 2013; Yemişken *et al.* 2014; Özgür Özbek *et al.* 2015, 2016; Gökçe *et al.* 2016).

Table 2. List of studies on elasmobranchs in the Turkish coast of the Mediterranean Sea.

References	Type of study	Region	Species
JICA 1993	Biomass	Turkish coasts of Mediterranean	*S. canicula, M. asterias, M. mustelus, O. centrina, S. acanthias, S.blainville, S.oculata, S. squatina, D. oxyrinchus, R.asterias, R. clavata, R. alba, D. pastinaca, P. violacea, G. altavela*
Gücü and Bingel 1994	Trawl survey	Northeastern Mediterranean	*A. vulpinus, S. canicula, M.asterias, M. mustelus, S. squatina, T.marmorata, R. rhinobatos, R.clavata, R. miraletus, R. radula, D. pastinaca, G.altavela, M. aquila*
Başusta *et al.* 1998	First record	Iskenderun Bay	*T. grabata, H. uarnak*
Başusta and Erdem 2000	Biodiversity	Iskenderun Bay	*S. canicula, C.altimus, C. plumbeus, M. mustelus, O.centrina, S.oculata, T.nobiliana, T. marmorata, R.rhinobatos, R. radula, R. clavata, R. miraletus, R. asterias, D. pastinaca, D. centroura, T. grabata, G.altavela, P. bovinus, R. marginata*
Salihoğlu and Mutlu 2000	Trawl survey	Mediterranean	*S. canicula, M. mustelus, T.nobiliana, T. marmorata, R. rhinobatos, R.clavata, R.miraletus, R.radula, D. pastinaca, G. altavela, M.aquila, P. bovinus*
Başusta 2002	First record	Iskenderun Bay	*S. aculeata*
Başusta *et al.* 2002	Seasonal change and productivity index	Yumurtalık Bight	*T. marmorata, D. pastinaca, G. altavela, P. bovinus*
Işmen 2003	Age, growth, food and reproduction	Iskenderun Bay	*D. pastinaca*
Yılmaz and Akpınar 2003	Frozen storage	Iskenderun Bay	*R. rhinobatos*
Çiçek 2006	Trawl survey	Iskenderun Bay	*T. marmorata, R. rhinobatos, R. clavata, R. miraletus, R. radula, D. pastinaca, G. altavela, M. aquila*
Genç *et al.* 2006	Disease	Iskenderun Bay	*R. rhinobatos*
Yeldan and Avşar 2006	Sediment structure and occurrence	Mersin Bay	*R.asterias, R. clavata, R. radula, D. pastinaca, G. altavela*
Başusta *et al.* 2007	Feeding	Iskenderun Bay	*R. rhinobatos*
Işmen 2007	Age, growth, food and reproduction	Iskenderun Bay	*R. rhinobatos*
Yeldan and Avşar 2007	Length-weight relationships	Cilician Basin shelf waters	*R. clavata, R. radula, R. asterias, D. pastinaca, G. altavela*

Başusta *et al.* 2008	Age and growth	Iskenderun Bay	*R.rhinobatos*
Turan 2008	Molecular systematic	Northeastern Mediterranean	*R. alba, L. fullonica, D. oxyrinchus, D. batis, R. radula, R. miraletus, R. asterias*
Yeldan *et al.* 2008	Biological features	Northeastern Mediterranean	*R. clavata*
Çek *et al.* 2009	Reproduction biology	Iskenderun Bay	*R. rhinobatos*
Yeldan *et al.* 2009	Age, growth and feeding	Iskenderun Bay	*D. pastinaca*
Başusta *et al.* 2010	Age determination	Iskenderun Bay	*M.aquila, R.cemiculus*
Kebapçıoğlu *et al.* 2010	Trawl survey	Antalya Bay	*M. mustelus, R. rhinobatos, R. clavata, D. pastinaca, G.altavela*
Bircan Yıldırım *et al.* 2011	Histology	Iskenderun Bay	*R. rhinobatos*
Keskin *et al.* 2011	Biodiversity	Levantine Sea	*M. mustelus, T. marmorata, R. cemiculus, L. naevus, R. miraletus, R. montagui, R. radula, D. pastinaca, G. altavela, M. aquila*
Saygu 2011	Trawl survey	Antalya Bay	*T. marmorata, R. rhinobatos, Dipturus oxyrinchus, L. circularis, R. clavata, R. miraletus, R. radula, D. centroura, D. pastinaca, D. tortonesei, P. violacea, G.altavela*
Başusta *et al.* 2012a	Length-weight relationships	Iskenderun Bay	*R.rhinobatos, R.cemiculus, G. altavela, D. pastinaca, R.marginata, P.bovinus, T.nobiliana, R.miraletus, R.clavata*
Başusta *et al.* 2012b	Reproduction and nursery area	Iskenderun Bay	*R.marginata*
Başusta and Sulikowski 2012	Age determination	Iskenderun Bay	*D. centroura*
Dalyan 2012	Trawl survey	Northeastern Levantine Sea	*H. perlo, G. melastomus, S. canicula, D. licha, E. spinax, O. centrina, S. blainville, T. marmorata, D. oxyrinchus, R. asterias, R. clavata, R. radula, C. monstrosa*
Demirhan *et al.* 2012	Maturity and reproduction biology	Iskenderun Bay	*R.rhinobatos*
Gücü 2012	Discard ratio	Northeastern Mediterranean	*D. pastinaca, D. oxyrinchus, G. altavela, M. mustelus, M. aquila, R. clavata, R. radula, R. rhinobatos, S. canicula, S. stellaris*
Güven *et al.* 2012	Length-weight relationships	Antalya Bay	*S. canicula, G. melastomus, S. blainvillei, E. spinax, C. granulosus, H. perlo, D. licha, O. centrina, M. mustelus, C. plumbeus*
Bilecenoğlu *et al.* 2013	First record	Iskenderun Bay	*C. maximus, I. oxyrinchus*

Başusta *et al.* 2013	Age determination	Iskenderun Bay	*D. pastinaca*
Duman and Başusta 2013	Age and growth	Iskenderun Bay	*T. marmorata*
Yağlıoğlu *et al.* 2013	First record	Mediterranean Coast of Turkey	*M. mobular*
Yeldan *et al.* 2013	Temporal changes, CPUE	Iskenderun Bay	*D. pastinaca, G. altavela, R. rhinobatos, R. radula, M. aquila, T. marmorata*
Deval *et al.* 2014	Length-weight relationships	Antalya Bay	*L. circularis, D. centroura*
Saygu and Deval 2014	Post-release survival in bottom trawl	Antalya Bay	*R.clavata, R. miraletus*
Ergüden *et al.* 2014	First record	Northeastern Mediterranean	*D. marmorata*
Kapiris *et al.* 2014	Biodversity and First record	Iskenderun Bay	*M. asterias, D. marmorata*
Yemişken *et al.* 2014	Trawl survey	Iskenderun Bay	*M. mustelus, C. plumbeus, T. marmorata, T. torpedo, R. cemiculus, R. miraletus, R. radula, D. marmorata, D. pastinaca, G. altavela, P. bovinus*
Başusta and Başusta 2015	Additional record	Iskenderun Bay	*H. griseus*
Başusta *et al.* 2015	Reproduction and nursery area	Iskenderun Bay	*O.centrina*
Ergüden and Bayhan 2015	First record	Mersin Bay	*S. aculeata*
Ergüden *et al.* 2015	Distribution	Iskenderun Bay	*A. vulpinus*
Kabasakal 2015	Review of the records	Med.coast of Turkey	*O. centrina*
Özcan and Başusta 2015	Feeding	Iskenderun Bay	*S. canicula*
Özgür Özbek *et al.* 2015	Abundance, biomass and length-weight relationships	Antalya Bay	*D. pastinaca, D. marmorata, D. centroura, D. tortonesei*
Sakallı *et al.* 2015	First record	İskenderun Bay	*M. japanica*
Yağlıoğlu *et al.* 2015	Bycatch	İskenderun Bay	*D. pastinaca, G. altavela, R. clavata, R. rhinobatos, R. cemiculus, D. oxyrinchus, R.miraletus, T. marmorata, T. torpedo, M. mustelus, S. stellaris, S. canicula, G. melastomus, S. squatina, I. oxyrinchus, C. plumbeus, C. altimus, O. centrina, R. radula, R. marginata, P.bovinus*
Başusta 2016a	Reproduction and nursery area	Northeastern Mediterranean	*H.perlo, S.aculeata, E.spinax*
Başusta 2016b	Length-weight relationships	Iskenderun Bay	*C. plumbeus*

Başusta and Başusta 2016	Reproduction and nursery area	Northeastern Mediterranean	*G. melastomus*
Başusta *et al.* 2016	Disease	Antalya Bay	*P. bovinus, D. pastinaca, R. miraletus*
Girgin and Başusta 2016	Testing staining technics, age and growth	Iskenderun Bay	*D. pastinaca*
Gökçe *et al.* 2016	Trawl survey	Mersin Bay	*S. stellaris, M. mustelus, C. plumbeus, O. centrina, T. nobiliana, T. marmorata, R. rhinobatos, R. clavata, R. miraletus, D. pastinaca, D. tortonesei, G. altavela*
Kaya and Başusta 2016	Age and growth	Iskenderun Bay	*T. nobiliana*
Özcan and Başusta 2016	Feeding	Iskenderun Bay	*M. mustelus*
Özgür Özbek *et al.* 2016	Abundance, biomass and length-weight relationships	Antalya Bay	*G. altavela*
Başusta *et al.* in press	Age determination	Iskenderun Bay	*R. clavata, R. miraletus, R. asterias, T. marmorata, R. rhinobatos, G. altavela*

4. Life Histories

4.1. Reproductive Biology

Elasmobranchs displays a wide range of reproductive strategies with morphological and physiological specializations for oviparous (egg laying) and viviparous reproduction. These strategies are associated with one of three basic types of reproductive cycles; 1) reproductive throughout the year, 2) partially defined annual cycle with one or two peaks during the year, and 3) a well defined annual or biennial cycle (Wourms 1977; Hamlett and Koob 1999). Oviparous reproduction mode is exhibited by all members of the families Rajidae, Scyliorhinidae and Chimaeridae. In oviparous species, eggs are enclosed within the egg capsules that protects developing embryos, on the seafloor bed (Ebert 2005; Ebert and Davis 2007). Viviparous species, in which the developing embryos are retained within the mother's uterus (Musick and Ellis 2005). There is little information available on reproduction biology of elasmobranchs inhabiting the Mediterranean coast of Turkey. The main reproductive parameters of 2 species from the Turkish waters of the Mediterranean Sea are summarised in Table 3. Size at first sexual maturity of these species range between 43-45 cm for male and 46-49 cm for female in *D. pastinaca* and 43-45 cm for male and 46-49 cm for female in *R. rhinobatos*.

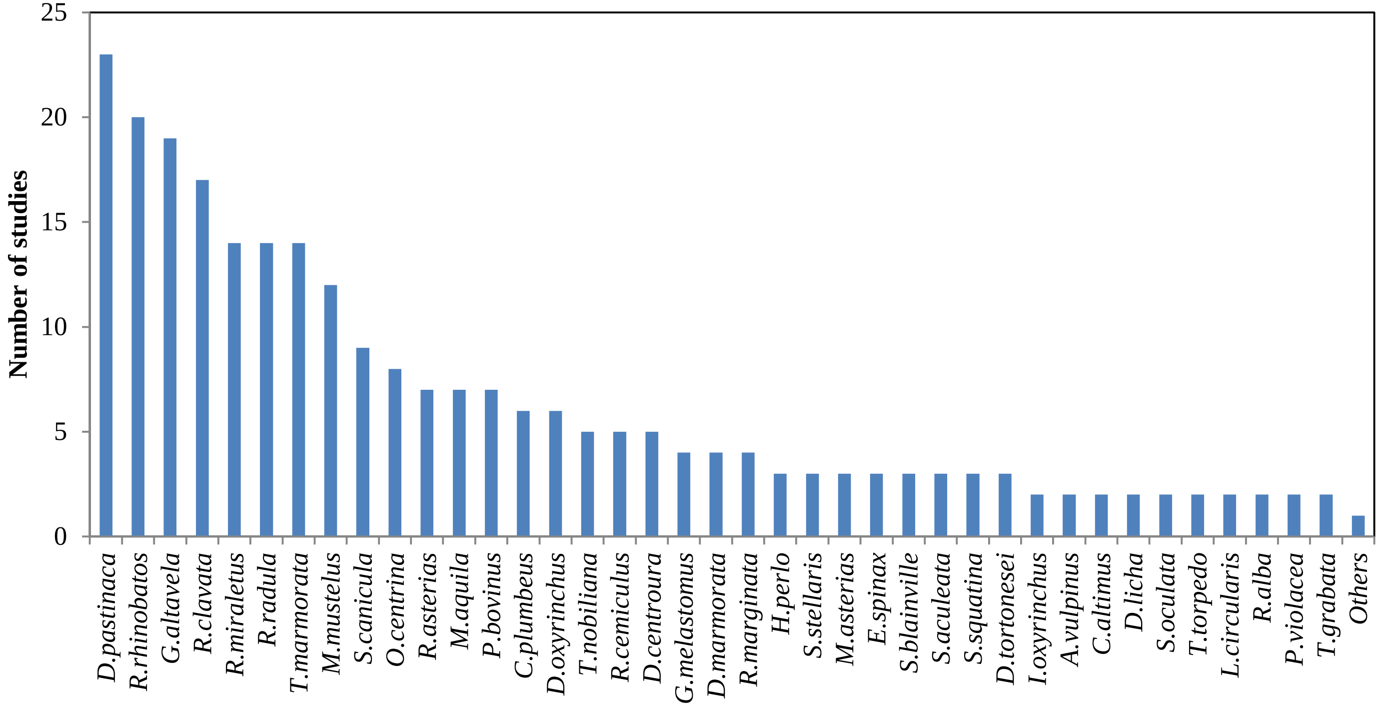

Figure 3. The number of studies reporting the elasmobranchs species in the Turkish coasts of the Mediterranean Sea (compiled from 61 studies given in Table 2)

Table 3. Available reproductive parameters of the elasmobranch species in the Mediterranean coasts of Turkey; N: Sample size, TL: Total Length, M: Male, F: Female

Species	Sex	N	Size at maturity cm (TL)	References
D. pastinaca	M	149	45	Yeldan *et al.* 2009
	F	195	49	
D. pastinaca	M	146	43	Ismen 2003
	F	110	46	
R.rhinobatos	M	129	68	Ismen *et al.* 2007
	F	96	69	
R.rhinobatos	M	49	70	Demirhan *et al.* 2010
	F	65	86	

4.2. Age and Growth

An understanding of the age structure and growth of a population is very important for effective conservation and management plans (Cortés 2004). Age and growth information is often utilized for determination of natural mortality and longevity and, ultimately for calculation of vital rates in demographic models (Goldman 2004). Generally vertebral sections, dorsal spines, and dermal denticles or caudal thorns are used for age determination in sharks, rays, and chimaeras (Cailliet and Goldman 2004). These structures tend to accumulate calcified growth material as they age, thus producing concentric areas that often have characteristics reflecting the time of year (season) in which this material is being deposited (Cailliet *et al.* 2006). In order to have clear reading of age rings, sectioned vertebrae should be bow-tie or butterfly shaped because it makes it possible to see bands on both sides of the sectioned vertebrae (Figure 4; Başusta *et al.* in press).

There are only 8 studies on the age and growth of cartilaginous fishes in the Turkish waters of the Mediterranean. These studies are given in Table 4 and reported the growth of *R. clavata, D. pastinaca, R. rhinobatos, T. marmorata,* and *T. nobiliana* in the Gulfs of Iskenderun and Mersin based on age and length. The results for *D. pastinaca* are different maybe due to the use of the disc width (fin width) to calculate $L\infty$, while the other studies used total length. Using the disc width is strongly recommended rather than using the total length when calculating growth values in Myliobatid species (Girgin and Başusta 2016). Other results are agreeing with previous reports in other regions in the Mediterranean. Generally, the Brody growth rate k was higher for females than for males of the cartilaginous fish in the eastern Mediterranean Sea.

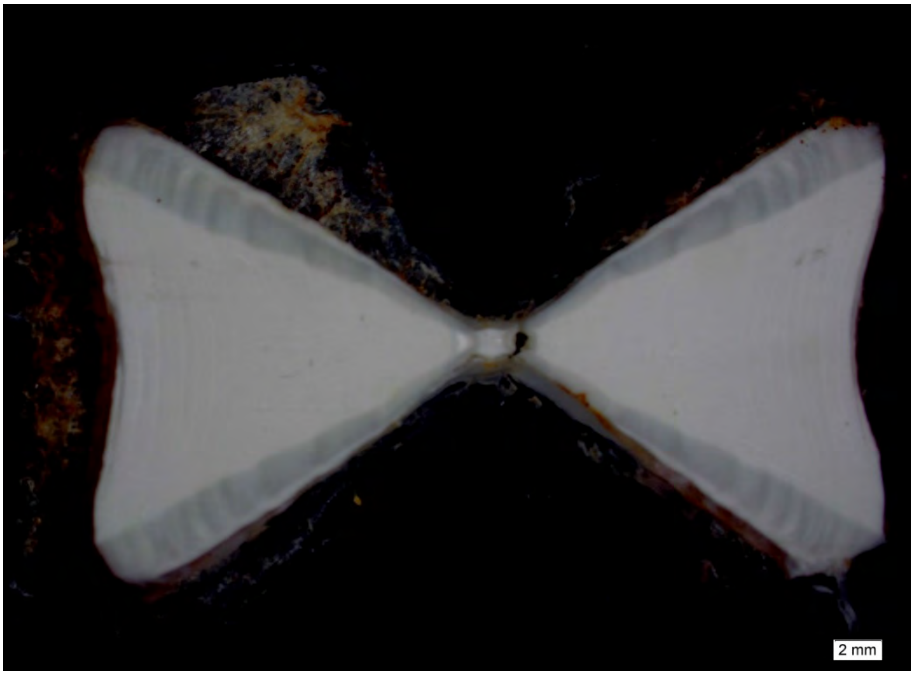

Figure 4. A thin-sectioned vertebral centrum from an estimated 10 years old sandbar shark, *Carcharhinus plumbeus* (Nuri Başusta (NB)).

Table 4. Von Bertalanffy (1938) growth model (VBGM) parameters: $L\infty$ (mm TL), k (year-1), t_0 (years). M: Male, F: Female, DW: Disc Width, TL: Total Length

Species	N	Sex	VBGM parameters			References
			$L\infty$	k	t_0	
R. clavata	90	All	79.66 (TL)	0.133	-3.03	Yeldan *et al.* (2008)
D. pastinaca	175	M	114.54 (DW)	0.041	-3.63	Girgin & Başusta (2016)
	209	F	127.06 (DW)	0.058	-1.51	
	384	All	104.43 (DW)	0.075	-1.43	
D. pastinaca	151	M	203.13 (TL)	0.039	-2.00	Yeldan *et al.* (2009)
	195	F	219.85 (TL)	0.041	-2.61	
	346	All	294.94 (TL)	0.029	-2.20	
D.pastinaca	256	All	121.50 (TL)	0.089	-1.615	Ismen (2003)
R. rhinobatos	41	M	121.65 (TL)	0.310	-0.131	Başusta *et al.* (2008)
	56	F	154.88 (TL)	0.134	-1.264	
	97	All	149.64 (TL)	0.155	-0.059	
R. rhinobatos	225	All	128.60 (TL)	0.29	-0.89	Ismen (2007)
T.marmorata	117	All	57.31 (TL)	0.187	-0.392	Duman & Başusta (2013)
T.nobiliana	93	All	74.47 (TL)	0.1089	-1.058	Kaya & Başusta (2016)

4.3. Feeding Ecology

Elasmobranchs are among the top predators in the marine environment, thus affecting the populations of both fish and invertebrates at the lower trophic levels (Ellis *et al.* 1996). Generally, skates and rays are benthic feeders, eating organisms such as small fish, mollusks, crustaceans and worms (Ellis *et al.* 1996). Studies in the Mediterranean Turkish waters report feeding habits of several species of sharks and rays based on stomach contents. These studies indicated that sharks and rays feed on a variety of organisms. Generally, crustaceans and teleost fishes are the main preys of *D. pastinaca, R. rhinobatos, R. clavata, S. canicula* and *M. mustelus* (Ismen 2003; Ismen *et al.* 2007; Başusta *et al.* 2007; Yeldan *et al.* 2008; Özcan and Başusta 2015; Özcan and Başusta 2016). Polychaeta and sipunculids have minor importance as food for *S. canicula* and *M. mustelus* (Özcan and Başusta 2015, 2016). Özcan and Başusta (2015, 2016) reported IRI (Index of Relative Importance) of prey items as crustacea 50.08%, and fish 46.7% consumed by *S. canicula* and crustacea 61.1 %, and fish 28.7% by *M. mustelus* in the northeastern Mediterranean Sea. The main prey items found in the stomachs for *R. rhinobatos* were unidentified shrimps (IRI%=35.89), unidentified teleosts (IRI%=34.51), unidentified crabs (IRI%=16.91), *Squilla mantis* (IRI%=5.11), and *Crangon crangon* (IRI%=4.69) (Başusta *et al.* 2007). Başusta *et al.* (2007) also found pelagic fishes in *R. rhinobatos* stomachs.

5. Fisheries, Management and Conservation

In the Mediterranean Sea, the majority of the cartilaginous fish species are demersal and reports indicate over 10,000 tons of annual bycatch by bottom trawlers (FAO 1995; Maravelias *et al.* 2012). Kabasakal (1998) and Yığın *et al.* (2015) reviewed shark and ray fisheries caught by otter trawls, purse-seines, bottom longlines and gillnets in Turkish waters of the the Black Sea and the Aegean Sea. Sharks and skates have been recently exploited commercially in Turkey by bottom trawlers, longlines and purse-seines since the 1990.

Elasmobranch consumption is rather limited In Turkey. They are consumed directly or such as surimi, fish protein concentrate, salami and sausage indirectly (Turan *et al.* 2007). Some of them such as guitarfishes have been used for human consumption by döner kebab and şiş kebab restaurants that are found in the Mediterranean coast line of Turkey (Çek *et al.* 2009). But some species are mainly processed for export. However, fins and livers of other sharks are processed and exported. For example, the meat of *S. acanthias* and *M. mustelus* are smoked or salted or marketed fresh as whole carcasses for export. Similarly, the wings of skates and rays are processed and marketed skinned and frozen (Kabasakal 1998; Yığın *et al.* 2015).

Fish stocks in Turkey are diminishing due to overfishing and IUU fisheries (illegal, unreported, and unregulated fishing) in recent years (Öztürk 2009). In Turkish fishery data, landings of elasmobranchs appear under generic names as “sharks”, “angelsharks”, and “rays” and do not reflect the diversity of elasmobranchs in Turkish waters at species level (Yığın *et al.* 2015) Unfortunately, at least 28 shark species in Turkey are listed in IUCN red list (Fricke *et al.* 2007). *G. altavela* is reported as Critically Endangered (CR) in the IUCN red list (Dulvy *et al.* 2016); however, it is commonly captured as discard with many other elasmobranchs by trawlers in the Turkish coasts of the NE Mediterranean (Figure 5). So it may not appear as threatened. The list of the species illegal to fish should be reassessed according to the recent IUCN categories by the General Directorate of Fisheries and Aquaculture, Ministry of Food, Agriculture and Livestock. Due to limited data at species level, fishing of many species of Elasmobranchs are not restricted despite declining populations. Therefore, there is an urgent need for species-specific fishing regulations based on reproduction period of many species of sharks and rays (Yığın *et al.* 2015).

On the other hand, cartilaginous fishes of the Mediterranean can not cope with the heavy fishing pressure due to their slow growth rate and long, costly and long embryo bearing, and extremely low fecundity. Yet, some of the species are already listed in the red lists and protected by national regional and international organisations such as IUCN and urgency in protecting their spawning and nursery grounds has been underlined.

Generally, fishermen are fishing in the international waters during the season (15 April-15 July) in which fishing is prohibited in the continental shelf. In the catch composition of the trawl fishing at the depths of 360-400 m in the international waters of Northeast Mediterranean, neonate sharks (belong to *H. perlo, S. aculeata, G. melastomus* and *E. spinax*) and juvenile skates (belong to *R. clavata* and *D. oxyrinchus*) have been caught as by-catch in May and June 2015 (Figure 6). We have also observed the eggs and mature individuals of some sharks in the same region in the following years. These findings show that some shark and skate species may use this region as a mating, breeding and nursery area. It can be said that the generation of cartilaginous fishes that produce limited number of eggs or juveniles are under threat in this region because of the fishing operations.

These findings should be taken into account and the countries should consider the declaration of marine protected areas with an international consensus under regional fisheries organizations such as GFCM.

Figure 5. Neonate specimens of *G. altavela* (NB)

Figure 6. Neonate and juveniles of some elasmobranchs caught by commercial trawlers in the international waters of NE Mediterranean.

Figure 7. *Heptranchias perlo* (Bonnaterre, 1788) (Nuri BAŞUSTA (NB))

Figure 8. *Hexanchus griseus* (Bonnaterre, 1788) (NB)

Figure 9. *Isurus oxyrinchus* Rafinesque, 1810 (NB)

Figure 10. *Galeus melastomus* Rafinesque, 1810 (NB)

Figure 11. *Scyliorhinus canicula* (Linnaeus, 1758) (NB)

Figure 12. *Mustelus asterias* Cloquet, 1821 (NB)

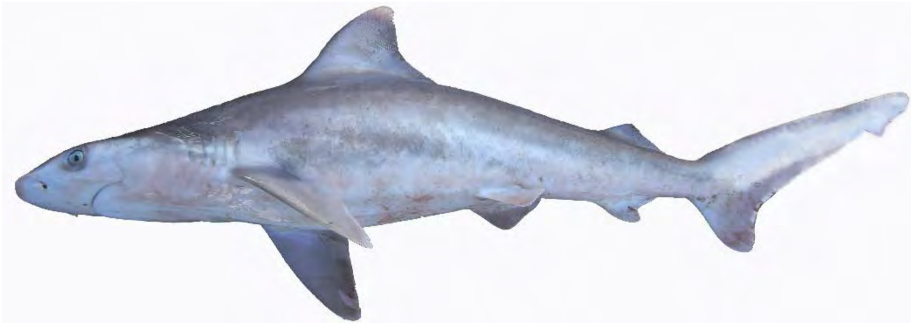

Figure 13. *Mustelus mustelus* (Linnaeus, 1758) (Elif ÖZGÜR ÖZBEK (EÖÖ))

Figure 14. *Carcharhinus plumbeus* (Nardo, 1827) (NB)

Figure 15. *Etmopterus spinax* (Linnaeus, 1758) (EÖÖ)

Figure 16. *Oxynotus centrina* (Linnaeus, 1758) (NB)

Figure 17. *Centrophorus granulosus* (Bloch & Schneider, 1801) (EÖÖ)

Figure 18. *Squalus blainville* (Risso, 1827) (NB)

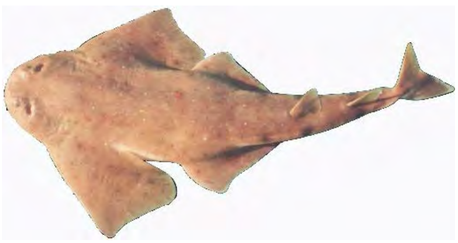

Figure 19. *S. aculeata* Cuvier, 1829 (NB) **Figure 20.** *S. oculata* Bonaparte, 1840 (NB)

Figure 21. *Rhinobatos cemiculus* Geoffroy St. Hilaire, 1817 (EÖÖ)

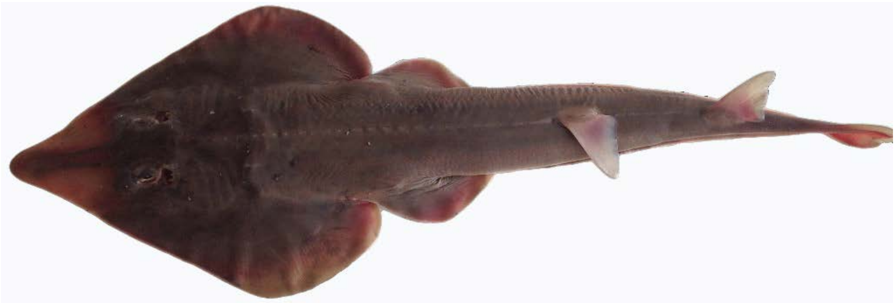

Figure 22. *Rhinobatos rhinobatos* (Linnaeus, 1758) (NB)

Figure 23. *T. marmorata* Risso, 1810 (NB) **Figure 24.** *D. oxyrinchus* (Linnaeus, 1758) (NB)

Figure 25. *R. clavata* Linnaeus, 1758 (NB) **Figure 26.** *R. miraletus* Linnaeus, 1758 (EÖÖ)

Figure 27. *R. montagui* Fowler, 1910 (NB) **Figure 28.** *D. centroura* (Mitchill, 1815) (EÖÖ)

Figure 29. *D. marmorata* (Steindachner, 1892) (EÖÖ) **Figure 30.** *D. pastinaca* (Linnaeus, 1758) (NB)

Figure 31. *D. tortonesei* Capapé, 1975 (NB)

Figure 32. *H. uarnak* (Forsskål, 1775) (NB) **Figure 33.** *P. violacea* (Bonaparte, 1832) (NB)

Figure 34. *T. grabata* (G.St. Hilaire, 1817) (NB) **Figure 35.** *R. marginata* (G.St. Hilaire, 1817) (NB)

Figure 36. *P. bovinus* (G.St. Hilaire, 1817) (NB) **Figure 37.** *G. altavela* (Linnaeus, 1758) (NB)

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AN EVALUATION OF THE FISHERY LANDING STATISTICS OF THE MEDITERRANEAN COAST OF TURKEY: STATISTICS OF WHICH SPECIES?

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1. Introduction

Landing statistics are important components of fishery management throughout the world. These data have also been used to calculate a few indices of ecosystem health, which would be calculated and reported at regular intervals to evaluate the effect of fishing on ecosystems (Pauly and Christensen 1995; Pauly *et al.* 1998; Coll *et al.* 2015). Moreover, it is difficult to analyze landing data due to the nature of multigear and multispecies.

Turkish landing statistics have been periodically collected by Ministry of Food, Agriculture and Livestock, then gathered up and published by Turkish Statistical Institute (TUIK) annually for about half a century, altough the names of establishments have changed in time. These statistics are also the basis of data reported to Food and Agriculture Organization (FAO) on Turkish fishery.

In most cases, the landings are the unique source of data on historical population trends of the exploited fish stocks, however there are significant accurracy issues on gathering this information. Taxonomic breakdown is among the most important source of errorr (Ulman 2014). The Turkish landing statistics have been collected with questionairres by using the traditional Turkish names of fishes. On the other hand, the cultural richness of Turkish people leads an important variablity on the traditional nomenclature of fishermen. Therefore, the same species often takes different names as well as different species or even different families are often called with the same local names. Hence, understanding the actual taxonomic coverage of landing statistics will significantly improve their usefullness in conservation and fishery management practices.

In recent years there has been an increasing interest on improving the usefullness of historical fishery statistics. Ulman *et al.* (2013) and Ulman and Pauly (2016) paid significant attention on the reconstruction of landing statistics and they defined that the actual catch is 63% higher than reported in TUIK databases. They also assigned scientific names of the records from Turkish landing data, however, these assignments cover all Turiksh coasts. On the other hand, a more specific and detailed effort is required since the local nomenclature varies significantly from area to area. Therefore, in this chapter, we investigated the TUIK landing categories by discussing their most probable systematic equivalents for the Mediterranean coast of Turkey and evaluated the trends of selected species.

2. Material and Methods

To analyze the taxonomical status of landing statistics for Mediterranean coast of Turkey, we investigated the data from TUIK and FAO. The most probable systematic equivalents of groups of landing statistics were discussed by using the available literature. The authors also used their field knowledge as well as consulted to the experienced local fishermen for the Turkish names of the fishes. For the evaluation of the statistics the results of the previous studies were also used for comparison.

The TUIK categories referring only one species were selected for trend analyses. Among them the analyses were conducted on the regularly recorded ones. The trends of landing data were analyzed with general linear and additive mixed models. In order to fit trend lines and curves, several auto-correlation (compound symmetric, auto regressive and auto regressive moving average) structures was examined against a model without auto-correlation. The best model was selected based on Akaike information criteria (Zuur *et al.* 2009). The models were fitted by using R 3.3 statistical calculation environment (R Core Team 2016) with the libraries “nlme” (Pinheiro *et al.* 2016) and “mgcv” (Wood 2006).

3. Results

Chondrichthyes: TUIK names refer not only a single species but a group, so all the commercial cartilaginous fishes should be considered with a separation as sharks, angelsharks, and skates and rays. FAO seems to accept these groups in a narrower classification. There are several studies in the region reporting the cartilaginous fishes in the trawl catches (JICA 1993, Gücü and Bingel 1994, Başusta and Erdem 2000, Salihoğlu and Mutlu 2000, Başusta *et al.* 2002, Çiçek 2006, Yeldan and Avşar 2006, Saygu 2011, Dalyan 2012, Yeldan *et al.* 2013, Yemişken *et al.* 2014, Özgür Özbek *et al.* 2015, 2016, Gökçe *et al.* 2016); however, usually they are not landed due to their low economical value.

***Conger conger* (Linnaeus, 1758):** FAO seems to make a mistake and reported the data of *Lithognathus mormyrus* (TUIK name: Mırmır) together with European conger (TUIK name: Mığrı). The data for conger are only available for the years of 2006, 2007, 2010, 2011, 2013, and 2014 in TUIK. For the other years in FAO, the data only belongs to the striped seabream. European conger was reported in the trawl catches by several studies (JICA 1993, Gücü and Bingel 1994, Çiçek 2006, Dalyan 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016).

Small pelagics: There are ten clupeiform fish species belonging to three different families (Clupeidae, Dussumieridae and Engraulidae) inhabiting in the Mediterranean coast of Turkey (Bilecenoğlu 2014). According to Sakınan (2014), five of them accounted for 66.2% of the small pelagics in the eastern part of the Mediterranean coast of Turkey. Among them *Sardinella aurita* constituted 38.7% of overall catch of small pelagics followed by *Sardina pilchardus* 11.1%; *Dussumieria elopsoides* 8%; *Etrumeus golanii* 6.9%; *Sardinella maderensis* 0.8%. *Herklotsichthys punctatus* was found to be less abundant. These species were gathered under four categories in TUIK reports. However *Alosa fallax* (Tirsi; TUIK name) and *Sprattus sprattus* (Çaça; TUIK name) are not common in the Mediterranean coast of Turkey (Sakınan 2014). TUIK assessed them into separate classes. So, most probably the local fishermen called another Clupeidae species with these names and the data actually belongs to other species or maybe the survey was made not with the local fishermen but with those who fish also in other seas and they may have reported the amounts caught from other regions. The two Engraulid species formed 6% of the total small pelagics (Sakınan, 2014); however, fishermen also call *Etrumeus golanii* and *Dussumieria elopsoides* as Mediterranean anchovy (Hamsi in TUIK) in this region. Therefore, the actual source of this group is unknown for the Mediterranean coast of Turkey. *Sardinella aurita* and *Sardina pilchardus* jointly constitute the most probable canditates of the "Sardalya" (TUIK name), European pilchard in FAO.

According to Sakınan (2014), 9 species of the Carangidae family (*Trachurus mediterraneus, Trachurus trachurus, Caranx rhonchus, Caranx crysos, Trachurus picturatus, Decapterus russelli, Alectis alexandrinus, Trachinotus ovatus* and *Alepes djedaba*) represented 18.7% of the small pelagics. The family was dominated by *Trachurus mediterraneus* (67%) and *Trachurus trachurus* (13%) (Sakınan 2014) and since the TUIK data only compromises these two *Trachurus* species, the other Carangidae species most probably was included into these statistics. Also, there is a complication with the TUIK names of the horse mackerels. Kraça (in Turkish) is used for the small individuals of the horse mackerels; however, FAO accepted this for the data of Mediterranean horse mackerel. The actual Turkish name of Mediterranean horse mackerel is Sarıkuyruk istavrit or traça. Karagöz istavrit (in Turkish) refers Atlantic horse mackerel and the acceptance is right; however, since this species is smaller than Mediterranean horse mackerel, the catch amount of this species most probably mixed with Kraça istavrit (TUIK name).

Large pelagics: Due to their high economic value, and species-specific bans (Anonymous 2016), these species have very specific common names which are hard to mix; so, the statistical data comparatively more reliable in respect of taxonomic breakdown. FAO recorded the TUIK data correctly as Lüfer (TUIK name) as *Pomatomus saltatrix*; Akya (TUIK name) as *Lichia amia*; Tombik (TUIK name) as *Auxis rochei*; Yazılı Orkinoz (TUIK name) as *Euthynnus alletteratus*; Palamut-Torik (TUIK name) as *Sarda sarda*; Kolyoz (TUIK name) as *Scomber colias*; Uskumru (TUIK name) as *Scomber scombrus*; Albakor-Patlakgöz (TUIK name) as *Thunnus alalunga*; Orkinoz (TUIK name) as *Thunnus thynnus*; Kılıç (TUIK name) as *Xiphias gladius*. Although, the landing data of two mackerels, Bluefin tuna and Swordfish reached out former years, the other Scombrids were counted since only 2004. Although, *S. sarda* is not a common species in the area; it comprises a significant amount of landing records of TUIK. Therefore, those scombrids could possibly be recorded under this category. FAO also only gives the total catch of *A. rochei, E. alletteratus, S. sarda, T. alalunga, T. thynnus; X. gladius* for Turkey as a GFCM area; so, the data for the Mediterranean coast of Turkey is only available in TUIK. In accordance with the statistics, according to Sakınan (2014), *Scomber colias* accounted for 9% of the small pelagics in the eastern part of the Mediterranean coast of Turkey. The data for *Seriola dumerili* is present in TUIK as Avcı; however, FAO did not record this important artisanal and recreational fishery species.

Synodontids: The Lessepsian species, brushtooth lizardfish *Saurida lessepsianus* was first recorded in 1953 in the Mediterranean and rapidly became an important part of the trawl catch (Ben-Yami and Glaser 1974). The native Mediterranean lizardfish, *Synodus saurus,* however became rarer in time (Goren and Galil 2005). The brushtooth lizardfish is now among the most common species, representing 16-42% of the total catch of the trawl fishery in the Mediterranean coast of Turkey (Gücü and Bingel 1994, Gücü *et al.* 1994, Çiçek 2006). The local fishermen do not separate these two species and also they call these fish with different Turkish names (Iskarmoz, Işkarmoz, Gümüş, Lokum, Turna, Zurna). Moreover, these local names are also used for different species, belonging to different families. For example; Zurna (TUIK name) is generally used for *Scomberesox saurus* in the region; however, FAO used the data for Synodontids. Very little information is available on the biology and population dynamics of Atlantic saury, especially for Turkish waters, so it is very difficult to evaluate the data. Gümüş (TUIK name) is also the common name for the family Atherinidae and may also be used for *Argentina sphyraena*; however the catch amounts seems to be very high just for these species; so most probably it also refers to the Synodontids catch. It is the same for İskarmoz (TUIK name) which is the common name of also barracudas (Sphyraenidae) but again, the available information on them are very scarce. So, it is very difficult to know which data is recorded for these species in statistics, and separate from each other.

Gadiformes: Although, the presence of *Phycis phycis* (Gücü and Bingel 1994, Yemişken *et al.* 2014), *Phycis blennoides* (Dalyan 2012, Gökçe *et al.* 2016) and

Gadiculus argenteus (Dalyan 2012) were reported in the trawl catches of the Mediterranean coast of Turkey, the available information on other species (*Merlangius merlangus, Micromesistius poutassou, Trisopterus minutus, Gaidropsarus mediterraneus, Molva macrophthalma*) are very scarce, so could be interpreted as that they are not common species in the region. The most common species among the Gadiformes is *Merluccius merluccius*, and it is one of the main target species of the demersal fishery in the region (JICA 1993, Gücü and Bingel 1994) representing 4-5% of the total catch (Çiçek 2006). Bakalorya and Berlam (TUIK names) are the common names for *M. merluccius*; however, FAO seems to make a mistake and reported the data for *Micromesistius poutassou*. Also, FAO accepted the data of Mezgit (TUIK name) for *Merlangius merlangus*; however it is also obvious that the data is for *M. merluccius*, which is also called deep-water whiting (Derinsu mezgiti in Turkish).

Lophiidae: Fener balığı (TUIK name) was accepted for *Lophius* spp. by FAO correctly. Anglerfishes, *Lophius budegassa* (Dalyan 2012, Gökçe *et al.* 2016) and *Lophius piscatorius* (JICA 1993, Çiçek 2006) were reported in the trawl catches of the Mediterranean coast of Turkey.

Beloniformes: Zargana (TUIK name) was accepted as the data for *Belone belone* by FAO. However, the local fishermen do not separate the native needlefishes, *Belone belone, Belone svetovidovi* and the lessepsian species *Tylosurus acus* and *Hemiramphus far*. The fishermen may also refer *Scomberesox saurus* in this group. The available information on the biology and population dynamics of Beloniformes is very scarce, so it is very difficult to evaluate the data.

Zeus faber: Dülger (TUIK name) data was used correctly for John dory by FAO. It was reported in the trawl catches of the Mediterranean coast of Turkey (JICA 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Dalyan 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016).

Scorpaenoidei: İskorpit and Lipsöz (TUIK names) are the local names of *Scorpaena porcus* and *Scorpaena scrofa*, respectively. However, the local fishermen also give the same names for the other species of the genus, Scorpaena (*S. elongata, S. loppei, S. maderensis, and S. notata*). As a correct acceptance, these two data in TUIK were given together in FAO as Scorpaenidae. However, the Blackbelly rosefish, *Helicolenus dactylopterus* was not taken into consideration in the statistics, meaning that the fishermen most probably refer it also in this group. Because in Turkish, it is called Derinsu iskorpiti (deep-water scorpion fish), a similar name with the other scorpion fishes and it was reported in the trawl catches of the Mediterranean coast of Turkey (JICA 1993, Dalyan 2012). Dalyan (2012) reported that it constituted 5% of the total catch between the depths of 221 and 777 m off the Gulf of Iskenderun. There are also available literatures of the trawl catches of the Scorpaena species (JICA 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Dalyan 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016).

Triglidae: Kırlangıç (TUIK name) is the common name of the family Triglidae in Turkish. However, Kırlangıç (Mazak) and Öksüz (TUIK names) are the local names of *Chelidonichthys lastoviza* and *Trigla lyra*, respectively. Fishermen generally do not separate these species and as a correct acceptance, these three data in TUIK were given together in FAO as Triglidae. The available literature reported *C. cuculus, C. lastoviza, C.lucernus, Lepidotrigla cavillone, L. dieuzeidei* and *T. lyra* in the trawl catches (JICA 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Dalyan 2012, Ok 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016). So, probably the other species (*Chelidonichthys gurnardus* and *C.obscurus*) are very scarce in the region. The most common species among the family is *C. lucernus* (Gücü and Bingel 1994, Yemişken *et al.* 2014) in the shallow and *L. cavillone* (Gücü and Bingel 1994, Dalyan 2012, Ok 2012) in the deeper waters.

Moronidae: Seabasses, *Dicentrarchus labrax* and *D. punctatus* are called Levrek in Turkish (TUIK name) and accepted as *Dicentrarchus* spp. by FAO correctly. *D. punctatus* is a rare species; therefore, this category mostly comprises *D. labrax*. Very little information is available on the natural population of the seabasses; so it is very difficult to evaluate the data.

Serranidae: Orfoz (TUIK name) data was used only for Dusky grouper, *Epinephelus marginatus*; Hani (TUIK name) was accepted as Serranidae; and Lahoz (TUIK name) as *Epinephelus* spp. by FAO. However, in 2000 and 2001, FAO recorded Kayabalığı Lahoz (TUIK name) data for Gobiidae and with the same acceptance Kayabalığı (TUIK name) data was recorded as Gobiidae. However, the gobids are very small fishes and not accepted as commercial fish by fishermen in Turkey, so there could be no landing data for this family. The confusion is mainly arising from the Turkish common names because "kaya" in Turkish means rock and "Kayabalığı" means rock fish. The fishermen could call a variety of fish living in rocky habitats as "Kayabalığı". For example, they call the members of the family, Sciaenidae as "Kaya levreği" which means "rock seabass". However, in the Mediterranean coast of Turkey, fishermen generally call the members of Serranidae as "kayabalığı". There are more specific names for *E. aeneus* as Lahoz, Lagos, Beyaz lagos, Kum lagosu, Grida, Kum gridası, Kaya hanisi, Taş hanisi; *E. marginatus* as Orfoz, Sarı hani; *E. caninus* as Sivridişli orfoz, Orfoz; *E. costae* as Altınbenekli Lahoz, Ziber balığı, Orfoz; *Hyporthodus haifensis* as Arap, Börtlek, Taş hanisi, Siyah orfoz; *M. rubra* as Sivriburun Lahoz, Züber, Orfoz, Taş hanisi; *Serranus cabrilla* as Asıl hani, Bayağı hani; *S. hepatus* as Benekli hani; and *S. scriba* as Çizgili hani, Yazılı hani. As can be understood from the great variety of the Turkish local names and since one name is used for more than one species, it is very hard to distinguish the statistical data. From the available literature reporting Serranids in the trawl catches, it could be easily seen that, the highest catch biomass belongs to *E. aeneus* among the family in the region (JICA 1993, Gücü and Bingel 1994, Başusta and Erdem 2000; Salihoğlu and Mutlu 2000; Başusta *et al.* 2002, Çiçek 2006, Özgür Özbek *et al.* 2013, Yemişken *et al.* 2014, Gökçe *et al.* 2016). So, most probably Lahoz (TUIK name) and Kayabalığı Lahoz (TUIK name) data solely belongs to *E. aeneus*. Although, *E. marginatus* is not common in the trawl catches, it is one of the main catch of traditional fishery (especially longline) and the fishermen would first understand this species as Orfoz (TUIK name), so the data also could be accepted solely for this species. Kayabalığı (TUIK name) and Hani (TUIK name) data however, could refer all members of the family.

Sparidae: FAO recorded the TUIK data correctly as Kupez (TUIK name) as *Boops boops*; Sinagrit (TUIK name) as *Dentex dentex*; Patlakgöz mercan (TUIK name) as *Dentex macrophthalmus*; Melanurya (TUIK name) as *Oblada melanura*; Sarpa (TUIK name) as *Sarpa salpa*; Çipura (TUIK name) as *Sparus aurata*. FAO transferred the data for Sarıgöz (TUIK name) as *Spondyliosoma cantharus* into their database. However, this species is quite rare in the area and this name is also used for *Diplodus sargus* (Can and Bilecenoğlu 2005), which is a prevalent fish in traditional and recreational fishery. Therefore, this data probably refers to *Diplodus sargus* at least in Mediterranean coast of Turkey. The catch of *Dentex gibbosus* may jointly be reported with other congeneric species *Dentex dentex* or as Trança (TUIK name). Additionally, *Dentex maroccanus* and *Pagellus bogaraveo* may also be reported as Patlakgöz mercan (TUIK name), however they are not so frequent in the area. İsparoz, Sivriburun karagöz and Karagöz (TUIK names) are the local names of *Diplodus annularis*, *D. puntazzo* and *D. vulgaris* respectively and due to their economic values; fishermen do not mix these species. As a correct acceptance, TUIK has given these species under separate categories. On the other hand, FAO aggregated this category under *Diplodus* spp. and in addition, probably *D. cervinus* was also included. Also, Fangri (TUIK name) and Trança (TUIK name) data in TUIK were given together in FAO as Sparidae. However, this acceptance could have lead to a misunderstanding as the total catch of all the sparids. There are more specific names for *Pagrus pagrus* as Fangri; *Pagrus caeruleostictus* as Trança; *Pagrus auriga* as Çizgili mercan; *Pagellus erythrinus* as Mercan or Kırmızı mercan; *Pagellus bogaraveo* as Mandagöz mercan; *Pagellus acarne* as Kırma mecan in Turkish. These six species belonging to two genera were represented under three names in TUIK (Trança, Fangri, and Mercan). Although these species are highly confused by fishermen, there is a general acceptance of *Pagrus* sp. as Fangri and *Pagellus* sp. as Mercan. Some fishermen may also call *D. dentex* and *D. gibbosus* as Trança. From the available literature reporting Sparids in the trawl catches, it could be easily seen that, the highest catch biomass belongs to *P. erythrinus* among the family in the region (JICA 1993, Gücü and Bingel 1994, Çiçek 2006, Ok 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016). FAO transferred the data of Mercan (TUIK name) into their database as *Pagrus pagrus*, however, this data highly likely refer *Pagellus erythrinus* for the area (İşmen *et al.* 2015). On the other hand, a recent Lessepsian fish, *Nemipterus randalli* (Kılkuyruk mercan in Turkish) introduced in 2008 (Bilecenoğlu and Russell, 2008) and quickly established in the area. Recent studies show that it also comprises a dominant component of the trawl catch and probably jointly reported under the TUIK category Mercan after 2008.

Centracanthidae: İzmarit (TUIK name) is the common name of the members of this family in Turkish. FAO recorded the TUIK data as *Spicara* spp; however, in addition, probably *Centracanthus cirrus* was included in this data. Although, the four species were reported from the trawl catches; the dominant species varies according to the different studies. *S. smaris* was reported to have the highest biomass among the family by JICA (1993), Çiçek (2006), and Gökçe *et al.* (2016); however, *S. flexuosa* by Gücü and Bingel (1994), Salihoğlu and Mutlu (2000), and Yemişken *et al.* (2014). Besides, some fishermen are calling the small size individuals of widespread demersal families such as Sparids, Haemulids and Teraponids as Centracanthids. Therefore, the source of data classified under this group is also hard to distinguish.

Sciaenidae: FAO seems correctly transferred the TUIK data for İşkine (TUIK name) as *Sciaena umbra*; Minekop (TUIK name) as *Umbrina cirrosa*; Grenyüz and Sarıağız (TUIK name) as *Argyrosomus regius* to their database. The TUIK data for *A. regius* was recorded as Grenyüz till 2005 and then as Sarıağız since 2006. In accordance with the landing data, *A. regius* was the most frequently reported species with the highest biomass among the family, followed by *U. cirrosa* (Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Başusta *et al.* 2002, Yemişken *et al.* 2014, Gökçe *et al.* 2016). *S. umbra* was only reported by Gücü and Bingel (1994).

Mullidae: The Turkish common names of the two native mullids *Mullus barbatus* and *Mullus surmuletus* are Barbunya and Tekir (TUIK names), respectively and there are three Lessepsian species *Upeneus moluccensis, Upeneus pori,* and *Parupeneus forsskali* distributed in the Mediterranean coast of Turkey. Since they are widely distributed and become a part of the commercial catch, they have Turkish common names for *U. moluccensis* as Paşa barbunu (TUIK names), Sarı barbun, Çizgili barbun, Nil barbunu and *U. pori* as Kara barbun, Ot barbunu, Nil barbunu, Benekli barbun. FAO recorded the TUIK data correctly for *M. surmuletus*; however, Barbunya and Paşa barbunu data in TUIK were given together in FAO as *M. barbatus* after 2007. TUIK started to record the data for *U. moluccensis* in 2007. Mullets are highly esteemed fish and the main target of many demersal fisheries. They were reported as the most abundant and frequent demersal species in the region (JICA 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Başusta *et al.* 2002, Çiçek 2006, Ok 2012, Yemişken *et al.* 2014). Among the five species, *M. barbatus* was reported as the most abundant (JICA 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Başusta *et al.* 2002); however, according the recent studies, Lessepsian mullets were generally accepted to occupy shallow waters, especially *U. pori* were reported to dominate the trawl catches in the region (Çiçek 2006, Yemişken *et al.* 2014). *P. forsskali* is still not a common species in the region. It has been encountered that the large individuals of *M. barbatus* called as *M. surmuletus* by fishermen, so there could be a mix in the data. With its gold band on the body, *U. moluccensis* is very easy to distinguish for the fishermen, so the data for this species is more reliable. However, although it was more abundant, the landing data was not recorded for *U. pori* and most probably included in the data of *M. barbatus*.

Mugilidae: FAO seems correctly transferred the TUIK data for Kefal (TUIK name), which is the common name of the members of this family in Turkish. Among the seven species reported from the Mediterranean coasts of Turkey (Bilecenoğlu *et al.* 2014), *Liza aurata* is the most frequently reported species (Gücü and Bingel 1994, Başusta and Erdem 2000; Başusta *et al.* 2002, Sakınan 2014, Gökçe *et al.* 2016) and also reported to have the highest biomass among the family (Sakınan 2014, Gökçe *et al.* 2016), followed by *Liza ramada, Liza carinata, Chelon labrosus* and *Mugil cephalus* according to Gökçe *et al.* (2016) and *M.cephalus, L. ramada*, and *Liza saliens* according to Sakınan (2014).

Pleuronectiformes: Dil (TUIK name) refers to the members of the families, Soleidae and Cynoglossidae and Pisi (TUIK name) of the Citharidae, Scopthalmidae, Bothidae, and Pleuronectidae. However, fishermen still can use these terms interchangeably. Until 2007, Dil and Pisi (TUIK names) data recorded together by TUIK and recorded as Pleuronectiformes by FAO. After 2007, TUIK started to record the data separately and Dil (TUIK name) was accepted as *Solea solea* and Pisi (TUIK name) as *Platichthys flesus* by FAO. However, *P. flesus* was not recorded in the Mediterraneran coasts of Turkey, so it should be considered as a mistake by FAO. *S. solea* is however, one of the target species of the fisheries in the region and reported as one of the economically important and locally marketed species (Bingel *et al.* 1993). Among twenty-four species reported from the Mediterranean coasts of Turkey (Dalyan 2012, Bilecenoğlu *et al.* 2014), *Citharus linguatula, Bothus podas, Arnoglossus laterna* and *Solea solea* were the most frequently reported species and have the highest biomass (JICA 1993, Bingel *et al.* 1993, Gücü and Bingel 1994, Salihoğlu and Mutlu 2000, Başusta *et al.* 2002, Çiçek 2006, Yemişken *et al.* 2014, Gökçe *et al.* 2016). Bingel *et al.* (1993) stated that the stocks of all these species were overfished in the region. In deep waters, however, *Lepidorhombus whiffiagonis* and *Symphurus ligulatus* were found to be abundant (Dalyan 2012). Since, *C. linguatula, B. podas,* and *A. laterna* are discard species (Gücü 2012, Yemişken *et al.* 2014, Gökçe *et al.* 2016); probabaly, *L. whiffiagonis* constitute the main catch of Pisi (TUIK name).

Jellyfish: Denizanası (TUIK name) is the common name of the jellyfish in Turkish and FAO recorded the TUIK data as *Rhopilema* spp. The data were recorded until 2006. However, the reliability of these data is doubtful because jellyfish are not used commercially, so the fishermen do not weigh them and have probably misjudged these species.

Arthropoda: Istakoz (TUIK name) is the common name of the lobsters in Turkish. FAO recorded the TUIK data as *Homarus gammarus*; however, this species is not present in the eastern Mediterranean (Holthuis 1991). Lobsters fished in the region instead are the slipper lobsters, *Scyllarus arctus* and *Scyllarides latus* (Butler *et al.* 2011a, 2011b). Böcek (TUIK name) data was transferred correctly as *Palinurus elephas* by FAO and Deniz kereviti (TUIK name) as *Nephrops norvegicus*. However, *N. norvegicus* is also not present in the eastern Mediterranean (Holthuis 1991) and the data was only recorded in 2008, most probably by mistake.

Shrimps are called Karides (TUIK name) in Turkish and they are the most important group in terms of biomass and economic value among the invertebrates. This group involves Jumbo karides, Kırmızı karides, Erkek karides, Pembe karides, and Karabiga karides (TUIK names), which are *Penaeus semisulcatus*, red shrimps (*Aristaeomorpha foliacea* and *Aristeus antennatus*), *Metapenaeus monoceros, Parapenaeus longirostris,* and *Penaeus kerathurus*, respectively. Until 2007, all shrimp species were recorded together by TUIK and transferred as Natantia by FAO. In 2007, TUIK started to record the data separately for five species; however, FAO just separate Pembe and Karabiga karides (TUIK names) as *P. longirostris* and *P. kerathurus,* respectively; and continue to record the other three species as Natantia. *P. semisulcatus, P. kerathurus,* and *M. monoceros* are the dominant commercial shrimp species inhabiting coastal area (Özbilgin *et al.* 2013, Bozaoğlu 2012), and caught by demersal trawl and prawn trammel net. Deep trawl fishery targets red. *A. foliacea* is the dominant species in the Gulf of Antalya (Deval and Kapiris 2016). Also, *P. longirostris* is another commercial deep-water species. In the northeastern Mediterranean, the Gulfs of Mersin and Iskenderun have large continental shelf supporting shrimp fisheries in the coastal area; however, the suitable areas for red shrimps are either narrow or outside the Turkish national waters. However, due to its narrow continental shelf, the Gulf of Antalya is one of the major grounds for red shrimps. We expect that fishermen do not mix commercial inshore shrimps due to their economic value, but other species having low biomass and abundance can be counted in any commercial groups. *Penaeus aztecus* and *Penaeus hathor* could be counted together with *Penaeus semisulcatus* due to their similar morphology. Most probably, all the deepwater red shrimps, including the *Plesionika* sp. were counted together by fishermen.

Yengeç (TUIK name) in Turkish means crab and FAO correctly transferred the total amount of all crab species as Brachyura. TUIK recorded the Blue crab, Mavi yengeç (TUIK name) data separately starting from 2007; so, it can be understood that the data were included in Yengeç (TUIK name) data till 2006. The spider crab, Ayna

(TUIK name) was only recorded in 2000. However, the Warty crab, Pavurya (TUIK name) was recorded regularly. Blue crab is one of the target species of the fisheries in the region and reported to have the highest biomass among the commercial crabs (Gücü and Bingel 1994, Başusta *et al.* 2002, Gökçe *et al.* 2016).

Mollusca: Mürekkepbalığı (TUIK name) is the common name of the cuttlefish in Turkish. FAO recorded the TUIK data correctly as *Sepia officinalis*; and this species is one of the target species of the fisheries in the region and reported as one of the economically important and locally marketed species (Bingel *et al.* 1993, Salman and Katağan 2004). Kalamerya (TUIK name) means squid in Turkish and there are four economically important squid species in the region (Salman and Katağan 2004) belonging to three genera. However, FAO accepted the data as *Loligo* spp. by excluding the other two genera. It is the same for the data of Ahtapot (TUIK name) which means octopus in Turkish and accepted as a single species as *Octopus vulgaris* by FAO, although there are four economically important species in the region (Salman and Katağan 2004). Fisheries of the bivalve molluscs was not developed in the Mediterranean coast of Turkey; however TUIK recorded data until 2007 for Midye, İstiridye, Tarak, Akivades-Kum midyesi and Beyaz kum midyesi (TUIK names) accepted as *Mytilus galloprovincialis, Ostrea edulis, Pecten jacobaeus,* Veneridae, and *Chamelea gallina* by FAO, respectively. These data are generally irregular and low that most probably recorded according to the information taken by the fishermen who fish also in other areas so the data were mixed with the other regions.

Table 1. The taxonomical status of the landing statistics of the Mediterranean coast of Turkey (% in Med.: percentage of the taxonomic group among all landings from the Mediterranean coast of Turkey during 2000-2015 period; % of Turkey: percentage of the Mediterranean coast among the total landing of Turkey during 2000-2015 period.

TUIK name in Turkish	FAO name	Common Name	Family/ Phylum	Probable Species Name	% in Med.	% of Turkey
Köpek	*Mustelus spp*	Sharks	Triakidae Squalidae	**Triakidae** *Galeorhinus galeus* Linnaeus, 1758 *Mustelus mustelus* Linnaeus, 1758 **Squalidae** *Squalus acanthias* Linnaeus, 1758 *Squalus blainvillei* (Risso, 1827)	0.35	12.97
Keler	Squatinidae	Angelsharks	Squatinidae Rhinobatidae	**Squatinidae** *Squatina aculeata* Cuvier, 1829 *Squatina oculata* Bonaparte, 1840 *Squatina squatina* (Linnaeus, 1758) **Rhinobatidae** *Rhinobatos rhinobatos* (Linnaeus, 1758)	0.02	20.80
Vatoz	Rajiformes	Skates and Rays	Rajidae Dasyatidae Gymnuridae Myliobatidae	**Rajidae** *Dipturus oxyrinchus* (Linnaeus, 1758) *Raja asterias* Delaroche, 1809 *Raja clavata* Linnaeus, 1758 *Raja miraletus* Linnaeus, 1758 *Raja montagui* Fowler, 1910 *Raja radula* Delaroche, 1809 **Dasyatidae** *Dasyatis centroura* (Mitchill, 1815) *Dasyatis marmorata* (Steindachner, 1892) *Dasyatis pastinaca* (Linnaeus, 1758) *Taeniura grabata* (Geoffroy St. Hilaire, 1817) **Gymnuridae** *Gymnura altavela* (Linnaeus, 1758) **Myliobatidae** *Myliobatis aquila* (Linnaeus, 1758) *Pteromylaeus bovinus* (Geoffroy St. Hilaire, 1817) *Rhinoptera marginata* (Geoffroy St. Hilaire, 1817) *Mobula mobular* (Bonnaterre, 1788)	0.10	4.01

Mığrı	*Conger conger* (*Lithognathus mormyrus* data (Mırmır in TUIK) was given as a mistake in FAO	European conger	Congridae	*Conger conger* (Linnaeus, 1758)	0.05	86.22
Tirsi	*Alosa* spp.	Twaite shad	Clupeidae	*Alosa fallax* (Lacepede, 1803)	0.40	4.88
Sardalya	*Sardina pilchardus*	European pilchard	Clupeidae Dussumieriidae	**Clupeidae** *Etrumeus golanii* DiBattista, Randall & Bowen, 2012 *Herklotsichthys punctatus* (Rüppell, 1837) *Sardina pilchardus* (Walbaum, 1792) *Sardinella aurita* Valenciennes, 1847 *Sardinella maderensis* (Lowe, 1838) **Dussumieriidae** *Dussumieria elopsoides* Bleeker, 1849	19.91	22.05
Çaça	*Sprattus sprattus*	Sprat	Clupeidae	*Sprattus sprattus* (Linnaeus, 1758)	0.01	0.00
Hamsi	*Engraulis encrasicolus*	Anchovy	Engraulidae Clupeidae Dussumieriidae	**Engraulidae** *Engraulis encrasicolus* (Linnaeus, 1758) *Stolephorus insularis* Hardenberg, 1933 **Clupeidae** *Etrumeus golanii* DiBattista, Randall & Bowen, 2012 **Dussumieriidae** *Dussumieria elopsoides* Bleeker, 1849	0.82	0.12
Zurna	Synodontidae	Saury	Synodontidae Scomberesocidae	**Scomberesocidae** *Scomberesox saurus* (Walbaum, 1792) **Synodontidae** *Saurida lessepsianus* Russell, Golani & Tikochinski, 2015 *Synodus saurus* (Linnaeus, 1758)	0.90	75.96
Mezgit	*Merlangius merlangus*	Whiting	Merluccidae	**Merluccidae** *Merluccius merluccius*	0.98	2.02
Gelincik	*Phycis blennoides*	Shore rockling	Gadidae Lotidae Phycidae	**Gadidae** *Gadiculus argenteus* Guichenot, 1850 *Merlangius merlangus* (Linnaeus, 1758) *Micromesistius poutassou* (Risso, 1827) *Trisopterus minutus* (Linnaeus, 1758) **Lotidae** *Gaidropsarus mediterraneus* (Linnaeus, 1758) *Molva macrophthalma* (Rafinesque, 1810)	0.02	24.82

				Phycidae *Phycis blennoides* (Brünnich, 1768) *Phycis phycis* (Linné, 1766)		
Bakalorya, Berlam	*Micromesistius poutassou (Merluccius merluccius* data (Bakalorya, Berlam in TUIK) was given as a mistake in FAO	Hake-European hake	Merlucciidae	*Merluccius merluccius* (Linnaeus, 1758)	0.48	2.69
Fener Balığı	*Lophius* spp.	Angler fish	Lophiidae	*Lophius budegassa* Spinola, 1807 *Lophius piscatorius* Linnaeus, 1758	0.10	9.75
Gümüş	Atherinidae	Sand smelt	Atherinidae Argentinidae Synodontidae	**Atherinidae** *Atherina boyeri* Risso, 1810 *Atherina hepsetus* Linnaeus, 1758 *Atherinomorus forskalii* (Rüppell, 1838) **Argentinidae** *Argentina sphyraena* Linnaeus, 1758 **Synodontidae** *Saurida lessepsianus* Russell, Golani & Tikochinski, 2015 *Synodus saurus* (Linnaeus, 1758)	3.76	86.35
Zargana	*Belone belone*	Needlefish	Belonidae Hemiramphidae Scomberesocidae	**Belonidae** *Belone belone* (Linnaeus, 1761) *Belone svetovidovi* Collette & Parin, 1970 *Tylosurus acus* (Lacepède, 1803) **Hemiramphidae** *Hemiramphus far* (Forsskål, 1775) **Scomberesocidae** *Scomberesox saurus* (Walbaum, 1792)	0.02	1.00
Dülger	*Zeus faber*	John dory	Zeidae	*Zeus faber* Linnaeus, 1758	0.08	22.61
İskorpit	Scorpaenidae (İskorpit and Lipsoz (in Turkish) data in TUIK were given together in FAO)	Black scorpion fish	Sebastidae Scorpaenidae	**Sebastidae** *Helicolenus dactylopterus* (Delaroche, 1809) **Scorpaenidae** *Scorpaena elongata* Cadenat, 1943 *Scorpaena loppei* Cadenat, 1943 *Scorpaena maderensis* Valenciennes, 1833 *Scorpaena notata* Rafinesque, 1810 *Scorpaena porcus* Linnaeus, 1758 *Scorpaena scrofa* Linnaeus, 1758	0.21	15.54

Lipsöz	Scorpaenidae (İskorpit and Lipsoz (in Turkish) data in TUIK were given together in FAO)	Small-scalled	Sebastidae Scorpaenidae	**Sebastidae** *Helicolenus dactylopterus* (Delaroche, 1809) **Scorpaenidae** *Scorpaena elongata* Cadenat, 1943 *Scorpaena loppei* Cadenat, 1943 *Scorpaena maderensis* Valenciennes, 1833 *Scorpaena notata* Rafinesque, 1810 *Scorpaena porcus* Linnaeus, 1758 *Scorpaena scrofa* Linnaeus, 1758	0.06	25.88
Kırlangıç	Triglidae (Kırlangıç, Kırlangıç (Mazak) and Öksüz (in Turkish) data in TUIK were given together in FAO)	Red gurnard	Triglidae	*Chelidonichthys cuculus* (Linnaeus, 1758) *Chelidonichthys lucernus* (Linnaeus, 1758) *Chelidonichthys obscurus* (Walbaum, 1792) *Trigla lyra* Linnaeus, 1758 *Trigloporus lastoviza* (Bonnaterre, 1788)	0.87	71.30
Kırlangıç Mazak	Triglidae (Kırlangıç, Kırlangıç (Mazak) and Öksüz (in Turkish) data in TUIK were given together in FAO)	Trigla lineate	Triglidae	*Chelidonichthys cuculus* (Linnaeus, 1758) *Chelidonichthys lastoviza* (Bonnaterre, 1788) *Chelidonichthys lucernus* (Linnaeus, 1758) *Chelidonichthys obscurus* (Walbaum, 1792) *Trigla lyra* Linnaeus, 1758	0.12	40.36
Öksüz	Triglidae (Kırlangıç, Kırlangıç (Mazak) and Öksüz (in Turkish) data in TUIK were given together in FAO)	Piper	Triglidae	*Chelidonichthys cuculus* (Linnaeus, 1758) *Chelidonichthys lastoviza* (Bonnaterre, 1788) *Chelidonichthys lucernus* (Linnaeus, 1758) *Chelidonichthys obscurus* (Walbaum, 1792) *Trigla lyra* Linnaeus, 1758	0.01	11.95
Levrek	*Dicentrarchus* spp.	Seabass	Moronidae	*Dicentrarchus labrax* (Linnaeus, 1758)	0.34	12.12
Orfoz	*Epinephelus marginatus*	Dusky grouper	Serranidae	*Epinephelus marginatus* (Lowe, 1834)	0.18	59.82
Lahoz	*Epinephelus* spp.	Waker	Serranidae	*Epinephelus aeneus* (Geoffroy St. Hilaire, 1817)	1.23	79.96
Kayabalığı Lahoz	Gobiidae		Serranidae	*Epinephelus aeneus* (Geoffroy St. Hilaire, 1817)	0.89	60.79
Kayabalığı	Gobiidae	Gobies	Serranidae	*Epinephelus aeneus* (Geoffroy St. Hilaire, 1817) *Epinephelus caninus* (Valenciennes, 1843) *Epinephelus costae* (Steindachner, 1878) *Epinephelus marginatus* (Lowe, 1834) *Hyporthodus haifensis* (Ben-Tuvia, 1953) *Mycteroperca rubra* (Bloch, 1793) *Serranus cabrilla* (Linnaeus, 1758)	0.43	74.30

				Serranus scriba (Linnaeus, 1758)		
Hani	Serranidae	Painted comber	Serranidae	*Serranus cabrilla* (Linnaeus, 1758) *Serranus scriba* (Linnaeus, 1758)	0.05	9.13
Lüfer	*Pomatomus saltatrix*	Bluefish	Pomatomidae	*Pomatomus saltatrix* (Linnaeus, 1766)	1.02	2.20
Akya	*Lichia amia*	Leerfish	Carangidae	*Lichia amia* (Linnaeus, 1758)	1.52	72.59
Avcı		Greater amberjack	Carangidae	*Seriola dumerili* (Risso, 1810)	0.17	78.69
İstavrit Kraça	*Trachurus mediterraneus*	Small individuals of Atlantic horse mackerel and Mediterranean horse mackerel	Carangidae	*Alepes djedaba* (Forsskål, 1775) *Campogramma glaycos* (Lacepède, 1801) *Caranx crysos* (Mitchill, 1815) *Caranx rhonchus* Goeffroy Saint-Hilaire, 1817 *Decapterus russelli* (Rüppell, 1830) *Pseudocaranx dentex* (Bloch & Schneider, 1801) *Trachurus mediterraneus* (Steindachner, 1868) *Trachurus picturatus* (Bowdich, 1825) *Trachurus trachurus* (Linnaeus, 1758)	3.24	3.98
İstavrit Karagöz	*Trachurus trachurus*	Atlantic horse mackerel	Carangidae	*Alepes djedaba* (Forsskål, 1775) *Campogramma glaycos* (Lacepède, 1801) *Caranx crysos* (Mitchill, 1815) *Caranx rhonchus* Goeffroy Saint-Hilaire, 1817 *Decapterus russelli* (Rüppell, 1830) *Pseudocaranx dentex* (Bloch & Schneider, 1801) *Trachurus mediterraneus* (Steindachner, 1868) *Trachurus picturatus* (Bowdich, 1825) *Trachurus trachurus* (Linnaeus, 1758)	1.80	4.79
Kupez	*Boops boops*	Bogue	Sparidae	*Boops boops* (Linnaeus, 1758)	1.74	16.97
İsparoz	*Diplodus* spp. (Isparoz, Sivriburun Karagöz and Karagöz (in Turkish) data in TUIK were given together in FAO)	Annular bream	Sparidae	*Diplodus annularis* (Linnaeus, 1758)	0.10	6.06
Sivriburun Karagöz	*Diplodus* spp. (Isparoz, Sivriburun Karagöz and Karagöz (in Turkish) data in TUIK were given together in	Sharpsnout seabream	Sparidae	*Diplodus puntazzo* (Cetti, 1777)	0.01	14.31

	FAO)					
Karagöz	*Diplodus* spp (Isparoz, Sivriburun Karagöz and Karagöz (in Turkish) data in TUIK were given together in FAO)	Two banded bream	Sparidae	*Diplodus vulgaris* (Geoffroy St. Hilaire, 1817)	0.36	32.38
Sinagrit	*Dentex dentex*	Common dentex Pink dentex	Sparidae	*Dentex dentex* (Linnaeus, 1758) *Dentex gibbosus* (Rafinesque, 1810)	0.11	22.49
Patlakgöz Mercan	*Dentex macrophthalmus*	Large-eye dentex Morocco dentex Blackspot seabream	Sparidae	*Dentex macrophthalmus* (Bloch, 1791) *Dentex maroccanus* Valenciennes, 1830 *Pagellus bogaraveo* (Brünnich, 1768)	0.14	44.78
Trança	Sparidae (Fangri and Trança (in Turkish) data in TUIK were given together in FAO)	Bluespotted seabream Common dentex Pink dentex	Sparidae	*Pagrus caeruleostictus* (Valenciennes, 1830) *Dentex dentex* (Linnaeus, 1758) *Dentex gibbosus* (Rafinesque, 1810)	0.10	36.20
Fangri	Sparidae (Fangri and Trança (in Turkish) data in TUIK were given together in FAO)	Red porgy Redbanded and Bluespotted seabream	Sparidae	*Pagrus pagrus* (Linnaeus, 1758) *Pagrus auriga* Valenciennes, 1843 *Pagrus caeruleostictus* (Valenciennes, 1830)	0.18	41.60
Mercan	*Pagrus pagrus*	Common pandora Axillary seabream Blackspot seabream	Sparidae Nemipteridae	*Pagellus erythrinus* (Linnaeus, 1758) *Pagellus acarne* (Risso, 1827) *Pagellus bogaraveo* (Brünnich, 1768) *Pagrus auriga* Valenciennes, 1843 *Pagrus caeruleostictus* (Valenciennes, 1830) *Pagrus pagrus* (Linnaeus, 1758) **Nemipteridae** *Nemipterus randalli* Russell, 1986	1.91	59.88
Mırmır	*Lithognathus mormyrus* data (Mırmır in TUIK) was given as *Conger conger* data as a mistake in FAO	Striped seabream	Sparidae	*Lithognathus mormyrus* (Linnaeus, 1758)	0.73	66.61
Melanurya	*Oblada melanura*	Saddled seabream	Sparidae	*Oblada melanura* (Linnaeus, 1758)	0.11	16.48
Sarpa	*Sarpa salpa*	Saupe	Sparidae	*Sarpa salpa* (Linnaeus, 1758)	0.07	6.36
Çipura	*Sparus aurata*	Seabream	Sparidae	*Sparus aurata* Linnaeus, 1758	2.11	49.98

Sarıgöz	*Spondyliosoma cantharus*	Black seabream White seabream	Sparidae	*Spondyliosoma cantharus* (Linnaeus, 1758) *Diplodus sargus sargus* (Linnaeus, 1758)	0.07	23.13
İzmarit	*Spicara* spp.	Picarel	Centracanthidae	*Centracanthus cirrus* Rafinesque, 1810 *Spicara flexuosa* Rafinesque, 1810 *Spicara maena* (Linnaeus, 1758) *Spicara smaris* (Linnaeus, 1758)	2.11	41.63
İşkine	*Sciaena umbra*	Brown meagre	Sciaenidae	*Sciaena umbra* Linnaeus, 1758	0.02	21.69
Minekop	*Umbrina cirrosa*	Croaker	Sciaenidae	*Umbrina cirrosa* (Linnaeus, 1758)	0.10	52.09
Grenyüz	*Argyrosomus regius*	Meagre	Sciaenidae	*Argyrosomus regius* (Asso, 1801)	0.09	70.76
Sarıağız	*Argyrosomus regius*	Meagre	Sciaenidae	*Argyrosomus regius* (Asso, 1801)	0.20	63.46
Barbunya	*Mullus barbatus* (Barbunya and Paşa Barbunu (in Turkish) data in TUIK were given together in FAO after 2007)	Red mullet	Mullidae	*Mullus barbatus* Linnaeus, 1758 *Upeneus pori* Ben-Tuvia & Golani, 1989	3.51	36.11
Tekir	*Mullus surmuletus*	Striped red	Mullidae	*Mullus barbatus* Linnaeus, 1758 *Mullus surmuletus* Linnaeus, 1758	0.30	2.80
Barbunya, Paşa Barbunu	*Mullus barbatus* (Barbunya and Paşa Barbunu (in Turkish) data in TUIK were given together in FAO after 2007)	Golden banded	Mullidae	*Upeneus moluccensis* (Bleeker, 1855) *Upeneus pori* Ben-Tuvia & Golani, 1989 *Mullus barbatus* Linnaeus, 1758	0.77	72.12
Kefal	Mugilidae	Mullets	Mugilidae	*Chelon labrosus* (Risso, 1827) *Liza aurata* (Risso, 1810) *Liza carinata* (Valenciennes, 1836) *Liza ramada* (Risso, 1810) *Liza saliens* (Risso, 1810) *Mugil cephalus* Linnaeus, 1758 *Oedalechilus labeo* (Cuvier, 1829)	4.94	12.81
İskarmoz	*Sphyraena* spp.	Barracuda	Sphyraenidae Synodontidae	**Sphyraenidae** *Sphyraena chrysotaenia* Klunzinger, 1884 *Sphyraena flavicauda* Rüppell, 1838 *Sphyraena sphyraena* (Linnaeus, 1758) *Sphyraena viridensis* Cuvier, 1829 **Synodontidae**	0.78	69.93

				Saurida lessepsianus Russell, Golani & Tikochinski, 2015 *Synodus saurus* (Linnaeus, 1758)		
Tombik	*Auxis thazard, A. rochei*	Bullet tuna	Scombridae	*Auxis rochei* (Risso, 1810)	1.96	41.07
Yazılı Orkinoz	*Euthynnus alletteratus*	Little tunny	Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	2.41	52.39
Palamut-Torik	*Sarda sarda*	Atlantic bonito	Scombridae	*Sarda sarda* (Bloch, 1793)	2.53	3.45
Kolyoz	*Scomber japonicus*	Chub mackerel	Scombridae	*Scomber colias* Gmelin, 1789	3.61	29.62
Uskumru	*Scomber scombrus*	Atlantic mackerel	Scombridae	*Scomber scombrus* Linnaeus, 1758	0.07	3.12
Albakor Patlakgöz	*Thunnus alalunga*	Albacore	Scombridae	*Thunnus alalunga* (Bonnaterre, 1788)	1.06	72.84
Orkinoz	*Thunnus thynnus*	Bluefin tuna	Scombridae	*Thunnus thynnus* (Linnaeus, 1758)	4.03	76.56
Kılıç	*Xiphias gladius*	Swordfish	Xiphiidae	*Xiphias gladius* Linnaeus, 1758	0.51	38.45
Dil-Pisi	Pleuronectiformes	Common sole	Citharidae Scopthalmidae Soleidae	**Citharidae** *Citharus linguatula* (Linnaeus, 1758) **Scopthalmidae** *Lepidorhombus whiffiagonis* (Walbaum, 1792) *Zeugopterus regius* (Bonnaterre, 1788) **Soleidae** *Microchirus ocellatus* (Linnaeus, 1758) *Microchirus variegatus* (Donovan, 1808) *Monochirus hispidus* Rafinesque, 1814 *Pegusa lascaris* (Risso, 1810) *Solea aegyptiaca* Chabanaud, 1927 *Solea solea* (Linnaeus, 1758) *Synapturichthys kleinii* (Risso, 1827)	1.54	39.01
Pisi	*Platichthys flesus*	Flounder	Citharidae Scopthalmidae	**Citharidae** *Citharus linguatula* (Linnaeus, 1758) **Scopthalmidae** *Lepidorhombus whiffiagonis* (Walbaum, 1792)	0.10	33.33
Dil	*Solea solea*	Common sole	Soleidae	**Soleidae** *Buglossidium luteum* (Risso, 1810) *Microchirus ocellatus* (Linnaeus, 1758) *Microchirus variegatus* (Donovan, 1808) *Monochirus hispidus* Rafinesque, 1814	2.06	61.50

				Pegusa impar (Bennett, 1831) *Pegusa lascaris* (Risso, 1810) *Solea aegyptiaca* Chabanaud, 1927 *Solea solea* (Linnaeus, 1758) *Synapturichthys kleinii* (Risso, 1827)		
Diğer balıklar	Osteichthyes	Other fishes		Other fishes	0.78	38.64
Deniz Anası	*Rhopilema* spp.	Jellyfish	Cnidaria	*Aurelia aurita* (Linnaeus, 1758) *Rhizostoma pulmo* (Macri, 1778) *Rhopilema nomadica* Galil, 1990	1.30	22.76
Deniz Kereviti	*Nephrops norvegicus*	Crayfish	Arthropoda		0.00	0.71
İstakoz	*Homarus gammarus*	Lobsters	Arthropoda	*Scyllarus arctus* (Linnaeus, 1758) *Scyllarides latus* (Latreille, 1803)	0.01	15.24
Böcek	*Palinurus elephas*	Spiny lobster	Arthropoda	*Palinurus elephas* (Fabricius, 1787)	0.01	12.99
Karides (All commercial shrimps were given together in TUIK till 2006)	Natantia	Shrimps	Arthropoda	*Aristaeomorpha foliacea* (Risso, 1827) *Aristeus antennatus* (Risso, 1816) *Metapenaeus monocerus* (Fabricius, 1798) *Metapenaeus stebbingi* Nobili, 1904 *Parapenaeus longirostris* (Lucas, 1846) *Penaeus aztecus* Ives, 1891 *Penaeus hathor* (Burkenroad, 1959) *Penaeus kerathurus* (Forskål, 1775) *Penaeus merguiensis* de Man, 1888 *Penaeus pulchricaudatus* Stebbing, 1914 *Penaeus semisulcatus* de Haan, 1844 *Penaeus subtilis* (Pérez Farfante, 1967) *Plesionika edwardsii* (Brandt, 1851) *Plesionika heterocarpus* (A. Costa, 1871) *Plesionika martia* (A. Milne-Edwards, 1883) *Plesionika narval* (Fabricius, 1787) *Trachysalambria curvirostris* (Stimpson, 1860)	2.23	12.75
Pembe Karides	*Parapenaeus longirostris*	Deep-water rose shrimp	Arthropoda	*Parapenaeus longirostris* (Lucas, 1846) *Trachysalambria curvirostris* (Stimpson, 1860)	1.60	17.54
Karabiga Karides	*Penaeus kerathurus*	Caramote prawn	Arthropoda	*Penaeus kerathurus* (Forskål, 1775)	1.51	71.33
Jumbo Karides		Green tiger prawn	Arthropoda	*Penaeus semisulcatus* de Haan, 1844	1.77	79.29

Kırmızı Karides		Red shrimps	Arthropoda	*Aristaeomorpha foliacea* (Risso, 1827) *Aristeus antennatus* (Risso, 1816) *Plesionika edwardsii* (Brandt, 1851) *Plesionika heterocarpus* (A. Costa, 1871) *Plesionika martia* (A. Milne-Edwards, 1883) *Plesionika narval* (Fabricius, 1787)	0.84	14.54
Erkek Karides		Brown shrimp	Arthropoda	*Metapenaeus monoceros* (Fabricius, 1798) *Metapenaeus stebbingi* Nobili, 1904	1.21	97.48
Yengeç (Mavi Yengeç data and maybe other commercial crabs were given together in TUIK till 2006)	Brachyura (Pavurya, Mavi Yengeç, Ayna, and Yengeç data in TUIK were given together in FAO)	Crabs	Arthropoda	*Carcinus aestuarii* Nardo, 1847 *Callinectes sapidus* (Rathbun, 1896) *Portunus segnis* (Forskål, 1775)	0.45	73.32
Pavurya		Warty crab	Arthropoda	*Eriphia verrucosa* (Forskål, 1775)	0.02	31.03
Mavi Yengeç (the data started to be given separately since 2007)		Blue crab	Arthropoda	*Callinectes sapidus* (Rathbun, 1896) *Portunus segnis* (Forskål, 1775)	0.08	91.89
Ayna		Spider crab	Arthropoda	*Neomaja goltziana* (d'Oliveira, 1889) *Maja squinado* (Herbst, 1788) *Maja crispata* Risso, 1827	0.00	7.14
Mürekkepbalığı	*Sepia officinalis*	Cuttlefish	Mollusca	*Sepia officinalis* Linnaeus, 1758	3.46	68.49
Kalamerya	*Loligo* spp	Squid	Mollusca	*Loligo vulgaris* Lamarck, 1798 *Loligo forbesi* Steenstrup, 1856 *Illex coindetii* (Vérany, 1839) *Todarodes sagittatus* (Lamarck, 1798)	0.93	39.01
Ahtapot	*Octopus vulgaris*	Octopus	Mollusca	*Octopus vulgaris* Cuvier, 1797 *Eledone moschata* (Lamarck, 1799) *Eledone cirrhosa* (Lamarck, 1798) *Callistoctopus macropus* (Risso, 1826)	0.62	18.86
Midye	*Mytilus galloprovincialis*	Mussel	Mollusca	*Mytilus galloprovincialis* Lamarck, 1819	2.89	11.12
İstiridye	*Ostrea edulis*	Oyster	Mollusca	*Ostrea edulis* Linnaeus, 1758	0.06	25.21

Tarak	*Pecten jacobaeus*	Scallop	Mollusca	*Pecten jacobaeus* (Linnaeus, 1758)	0.05	3.20
Akivades Kum Midyesi	Veneridae	Venus clams	Mollusca	Veneridae	0.00	0.00
Beyaz Kum Midyesi	*Chamelea gallina*	Striped venus	Mollusca	*Chamelea gallina* (Linnaeus, 1758)	0.00	0.00
Diğer Omurgasızlar	Mollusca (other invertebrates data in TUIK were given as Mollusca in FAO as a mistake)	Other commercial invertebrates		Other commercial invertebrates	0.06	5.27

4. Trend of Landings

According to the results of the trend analysis, landings of thirteen fish species were detected to be decreasing, whereas fifteen of them were increasing. The most remarkable decrement existed in *Auxis rochei* with 13.69±76.51 (95% CI) tonnes per year. Although, this decrement was not significant; the non-linear trend was. This was followed by *Epinephelus aeneus* with a linear decrement of 8.65±34.84 (95% CI) tonnes per year ($p>0.10$). On the other hand, the most remarkable increment was observed in a small pelagic fish, *Sardinella aurita*. The catch of this species increased 124.18 ± 89.48 (95% CI) tonnes per year in time ($p<0.01$). The landings of *Boops boops* (9.52 ± 10.87), *Solea solea* (10.56 ± 7.81) and *Thunnus thynnus* (24.69 ± 17.12) also significantly increased through time. Although, the linear trends were not significant; we found significant fluctuations in ten species. The average annual rate of variation was higher in pelagics (16.24 tonnes per year); however, there was no significant difference between demersal (1.30 tonnes per year) and pelagic species ($t = -1.33$, $df = 10$, p-value = 0.2133).

Table 2. Trends of the landing statistics (GLMM: general linear mixed model, GAMM: general additive mixed model, ACF: autocorrelation aunction, AR: auto-regressive, ARMA: auto-regressive moving average, NAC: the best model is without autocorrelation structure, edf: Effective degrees of freedom, * significant at 0.90, **: significant at 0.95, ***: significant at 0.99 confidence level, ^{ns}: non-significant $p>0.10$, ± shows 95% confidence intervals of parameter)

Species	GLMM			GAMM	
	a	b	ACF	edf	ACF
Argyrosomus regius	2638 ± 15608^{ns}	-1.28 ± 7.83^{ns}	AR	2.13^{ns}	AR
Auxis rochei	27636 ± 163587^{ns}	-13.69 ± 76.51^{ns}	AR	6.57***	AR
Boops boops	-18685 ± 21667^{ns}	9.52 ± 10.87$^{\cdot}$	AR	1.64^{ns}	AR
Diplodus annularis	724 ± 6922^{ns}	-0.34 ± 3.47$_{ns}$	ARMA	1.82^{ns}	AR
Dicentrarchus labrax	2437 ± 47919^{ns}	-1.1 ± 24.04^{ns}	AR	2.14^{ns}	AR
Diplodus sargus	758 ± 4586^{ns}	-0.36 ± 2.3^{ns}	NAC	2.04^{ns}	NAC
Diplodus vulgaris	1070 ± 34801^{ns}	-0.46 ± 17.46^{ns}	AR	8.25***	NAC
Epinephelus aeneus	17231 ± 69977^{ns}	-8.45 ± 34.84^{ns}	ARMA	1.24^{ns}	AR
Euthynnus alletteratus	-20288 ± 313608^{ns}	10.3 ± 156.06^{ns}	AR	4.18**	NAC
Epinephelus marginatus	1630 ± 19632^{ns}	-0.76 ± 9.85^{ns}	AR	2.75**	AR
Lichia amia	-10058 ± 48073^{ns}	5.24 ± 24.13^{ns}	AR	2.32*	AR
Lithognathus mormyrus	-5002 ± 18795^{ns}	2.59 ± 9.43^{ns}	AR	2.03^{ns}	AR

Mullus barbatus	-26748 ± 72403^{ns}	13.77 ± 36.34^{ns}	ARMA	4.03***	NAC
Merlucius merluccius	-1197 ± 176936^{ns}	0.77 ± 88.75^{ns}	AR	1.00^{ns}	AR
Oblada melanura	441 ± 7078^{ns}	-0.2 ± 3.55^{ns}	AR	4.17***	AR
Pagellus erythrinus	-10835 ± 19884^{ns}	5.64 ± 9.98^{ns}	AR	1.00^{ns}	AR
Pomatomus saltatrix	-1128 ± 35627^{ns}	0.61 ± 16.31^{ns}	ARMA	2.91***	NAC
Sparus aurata	-5524 ± 39515^{ns}	2.98 ± 19.83^{ns}	AR	2.00^{ns}	AR
Scombe. colias	-28267 ± 422839^{ns}	14.35 ± 114.35^{ns}	ARMA	7.16***	AR
Seriola dumerili	2719 ± 8411^{ns}	-1.32 ± 4.22^{ns}	ARMA	1.37^{ns}	AR
Sardinella aurita	-244991 ± 178286**	124.18 ± 89.48**	AR	1.00***	AR
Sarpa salpa	215 ± 20952^{ns}	-0.11 ± 10.06^{ns}	ARMA	6.49***	NAC
Solea solea	-20764 ± 15568**	10.56 ± 7.81**	AR	2.02***	AR
Thunnus alalunga	-5891 ± 135306^{ns}	3.05 ± 67.33^{ns}	NAC	1.75^{ns}	NAC
Thunnus thynnus	-48768 ± 34140**	24.69 ± 17.12**	AR	1.00***	AR
Umbrina cirrosa	2164 ± 15898^{ns}	-1.05 ± 7.97^{ns}	AR	1.00^{ns}	AR
Xiphias gladius	-3238 ± 10001^{ns}	1.67 ± 5.02^{ns}	AR	2.73**	AR
Zeus faber	66 ± 816^{ns}	-0.02 ± 0.41^{ns}	NAC	1.00^{ns}	NAC

5. Comments and Conclusion

According to the official landing statistics, the main catch in the Mediterranean coast of Turkey consist of Round sardinella, European pilchard, Goatfishes, Horse mackerels, Mullets, Bluefin tuna, Common cuttlefish, Brushtooth lizardfish, Atlantic chub mackerel, Common sole, Shrimps, Little tunny, Bullet tuna, Blotched picarel, Common pandora and Seabream. The results of the scientific surveys also support the composition of the main catch (JICA 1993; Bingel *et al.* 1993; Gücü and Bingel 1994; Ok 2012). Regardless of the amount, fisheries of some other species are also important since they are mainly caught from the Mediterranean coast of Turkey. More than 70% the fisheries of the following species are realized in the Mediterranean coasts: Penaeid shrimps, Blue crabs, Brushtooth lizardfish, European conger, Groupers, Greater amberjack, Bluefin tuna, Saury, Albacore, Leerfish, Golden banded goatfish, Gurnards, and Meagre.

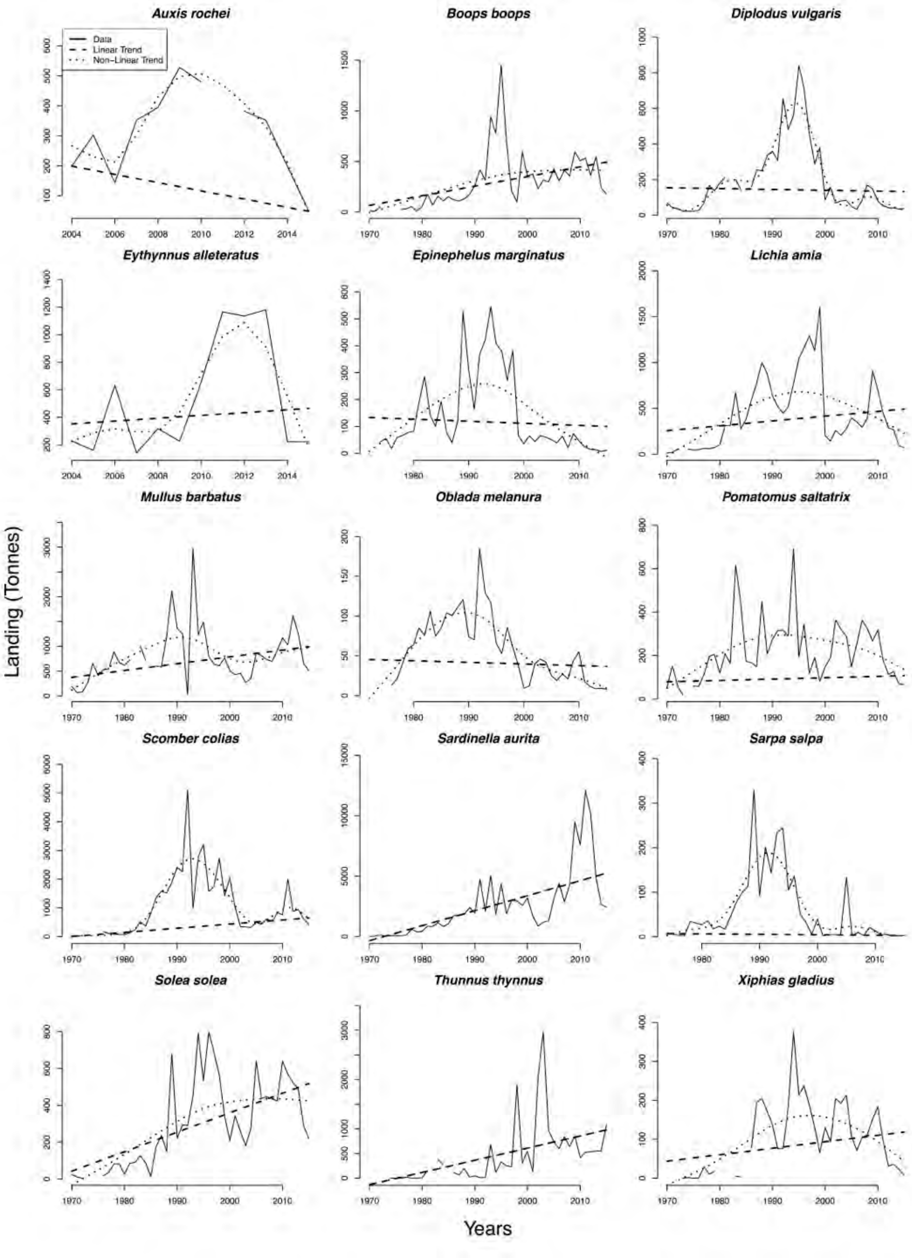

Figure 1. Significant trends in landings. (Dashed lines show linear, dotted lines show non-linear trends)

Landing data has been collected under 92 taxonomic categories in TUIK databases; however; only 40 of these categories refer a single species. Ulman *et al.* (2013) also reported the scientific names of fishes; however, some of these reports contradict with the present study. This is probably due to the differences among the local names of fishes among fishery areas in Turkish coasts. This seems a general problem in Turkish landing data. In order to resolve this problem, the data should be taxonomically evaluated within more specific sub-areas before it is transferred to the databases of FAO.

The faunal structure is highly dynamic in the eastern Mediterranean due to the continuous intrusions of new species mainly from Red Sea and occationally from Atlantic and other resources (Lessepsian Migration; Mavruk and Avşar 2007 and references therein). This can be considered as another reason of confusion in local nomenclature of species. In most cases, when a new intruder started to appear in catches, fishermen give either a new or an existed name, which the intruder most resembled. In the early period of invasion, one can easily distinguish this chaos; the local name of intruder even changes from port to port within a few miles. Then the number of alternatives decreases in time. This process could clearly be monitored in the establishment, progress and invation of *Nemipterus randalli*. This is a Red Sea species, which firstly recorded in 2008 (Bilecenoğlu and Russell, 2008) and quickly established after this period and become the dominant part of the catches (Edelist *et al.* 2013). Due to the excessive similarity with *Pagellus erythrinus*, fisherman firstly called this species as Mercan along with many other local names including Barbun, Kılkuyruk, Kılkuyruk Mercan, Piç Mercan, Kırmızıgöz Mercan. Recently, others seem to be eliminated and Kılkuyruk Mercan has selected as a name for this species. Consequently, new intrusions should be regularly monitored and the species lists should be updated in the landing statistics to prevent such chaos.

Trend analyses revealed that the landings are increasing in most of the species. This is probably due to the increment of fishery effort (Ulman *et al.* 2013) or increasing quality of fishery statistics in time. Therefore, a more specific effort is required to understand the underlying reasons on these variations.

The fisheries along the Mediterranean coast of Turkey take place mainly within the territorial waters. The reliability of the landing statistics collected by the questionnaires of the fishermen is very questionable. Data collection from a small-scale fishery with small and distinct landing places on a narrow strip extending several hundred kilometers (as in the case of the northern Levantine fisheries) has inherent deficiencies, due to the tax evasion motives of fisherman and time lags between actual catch date and time of reporting (Bingel *et al.* 1993). Although the landing statistics in this way could give a fair idea on periods of good or poor catches; it is insufficient to manage the fisheries. The data could be elaborated by recording data specific to the ports and months; however the data should always be supported by the results of the scientic surveys.

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FOOD WEB MODELLING AS A TOOL FOR ECOSYSTEM BASED FISHERIES MANAGEMENT IN THE EASTERN MEDITERRANEAN SEA

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1. Introduction

Anthropogenic impacts such as fishing, pollution, eutrophication, habitat loss, introduction of non-indigenous species and climate change, and their natural consequences are the pressing problems to the Mediterranean Sea ecosystem (Coll *et al.* 2010; Hattab *et al.* 2013). However, Jackson *et al.* (2001) stated that fishing pressure is the most significant problem and the main anthropogenic factor leading to degradation of all of the coastal areas in the Mediterranean Sea. Moreover, the ever-increasing introduction of Lessepsian species, which migrate from the Red Sea to the Mediterranean Sea via the Suez Canal and compete with native species, is an important threat especially in the eastern Mediterranean Sea. According to Golani (1998) the construction of the Suez Canal and the Aswan High Dam in the eastern Mediterranean were the greatest man-made interventions impacting a marine ecosystem. Thus, fishing and invasive species are the two main stressors that have heavily influenced the Levantine marine ecosystem.

Even though the continental shelf is narrow in most areas of the north-eastern Mediterranean, Mersin and Iskenderun Bays are relatively wide. They are very productive for demersal fish and crustacean species due to the large continental shelf, its bottom type and river discharges. Thus, the bottom trawl fishing fleet, which constitutes 30% of the Turkish trawl fleet, operates in the area. Small-scale fisheries including trammel nets, gillnets, and demersal longlines (Özbilgin *et al.* 2010, 2013) are also considerable. In the region, there are three main fleets: bottom trawlers, purse seiners and small scale fishing boats. Turkstat, (2012) reported that officially there are 205 trawlers, 57 purse seiners, 12 trawlers – purse seiners, 8 carrier vessels, and 1677 small scale fishing boats registered in the area.

Due to the multi-species nature of the fishery, fisheries management appears to be considerably complicated in the north-eastern Mediterranean like in other ecosystems of the Mediterranean Sea (Gücü 2012). The major problems are overfishing and bycatch and/or discards. Moreover, the region is also important for the migration of

Lessepsian species, some of which have long been exploited commercially (Gücü *et al.* 2010).

Fisheries are basically regulated with restrictions such as no-take zones, seasonal closures, minimum distance off the coast, and the shape and size of the nets (Kaykaç *et al.* 2012) by the Ministry of Agriculture and Rural Affairs. These regulations are designed for the targeted species and consider only their respective population characteristics. Although this approach is still dominant worldwide (Plaganyi 2007), an important approach to management of complex ecosystems is the Ecosystem-Based Fisheries Management (EBFM). EBFM considers the impacts of fishing on the ecosystem in terms of target and non-target species considering trophic interactions within the whole food web and environmental factors (Botsford 1997; Duda and Sherman 2002; Coll *et al.* 2008a; Coll and Libralato 2012). The EBFM approach has evolved over the last decades in response to increasing pressures on marine ecosystems as well as the tools available to develop EBFM strategies. The EU established a framework for community action in marine environmental policy in 2008 (Marine Strategy Framework Directive, MSFD) and since then many scientific studies have been carried out around this framework.

In the context of EBFM, a wide variety of ecosystem models were developed in the world to assess the relationship of fish and fisheries through ecological interactions (Plaganyi 2007). There are detailed descriptions and flow charts summarizing the classification of these models in the FAO report by Plaganyi (2007). While hydrodynamic and biogeochemical models have been used together to assess the interactions between the biological and physical processes in the marine environment on the level of lower trophic level processes, the models focusing on higher trophic level processes have also been developed such as Ecopath (Polovina 1984; Christensen and Pauly 1992), Ecosim (Walters *et al.* 1997, 2000), Ecospace (Walters *et al.* 1999) OSMOSE (Shin *et al.* 2004) and ATLANTIS (Fulton *et al.* 2011) to understand marine ecosystem structure and functioning, and assess the effect of anthropogenic factors on the ecosystems, particularly fisheries.

Ecopath with Ecosim (EwE) is the most widely used tool for this approach in the world (Christensen 2009). It is a trophic model that includes all trophic levels from primary producers to top predators and anthropogenic factors (Plaganyi 2007, Heymans *et al.* 2011). The National Oceanographic and Atmospheric Administration declared that EwE was one of the 10 major scientific breakthroughs in the last 200 years in its own history. The institute for European Environmental Policy also clarified that EwE is the most appropriate approach among the ecosystem models to describe ecosystem structure and provide future predictions (Sukhdev 2008; Coll and Libralato 2012). Over 400 publications have been published utilising EwE and an estimated number of 7000 users in the world (http://www.ecopath.org).

2. Food web modelling in the Mediterranean Sea

In the Mediterranean Sea, Coll and Libralato (2012) collated all 40 published EwE models and compared them with pair-wise tests. The main applications of EwE in the Mediterranean were described to explore ecosystem structure and dynamics by taking into account fishing; the application areas included, but not limited to, Southern Catalan Sea (Coll *et al.* 2006), North Central Adriatic Sea (Coll *et al.* 2007) North Adriatic Sea (Barausse *et al.* 2009), North Aegean Sea(Piroddi *et al.* 2010), North Ionian Sea (Tsagarakis *et al.* 2010), South Western Spain (Torres *et al.* 2013), Gulf of Lions and Balearic Sea (Bănaru *et al.* 2013; Corrales *et al.* 2015), Ionian Sea (Moutopoulos *et al.* 2013), and North Central Adriatic Sea (Fouzai *et al.* 2012).

A total of 3 models have been characterized in the north-eastern Mediterranean, with 2 models (Piroddi 2008; Piroddi *et al.* 2010) in the Ionian Sea and with 1 model (Tsagarakis *et al.* 2010) in the North Aegean Sea.

A recent mass balance food web model was developed in the Greek part of the Ionian Sea and the results highlighted that discards had greater impacts than landings on the food web energy flows and fisheries (Moutopoulos *et al.* 2013). Bottom trawl fisheries were determined to have the most notable impact on the trophic flows and commercially targeted demersal species in the Gulf of Gabes ecosystem (Hattab *et al.* 2013). Moreover, discards may be an important diet contribution for some species such as seabirds, crabs, and gadoids (Bosch *et al.* 1994; Hall 1999) and this may cause indirect effects in the energy flow (Hall 1999). Similarly, discards was one of the detritus groups in Tsagarakis *et al.* (2010) and the results highlighted that detrital dynamics are important (Tsagarakis *et al.* 2010; Coll and Libralato 2012). Comparative results of Ecopath applications in the Mediterranean Sea highlighted similar ecological structures across different regions, i.e. bentho – pelagic coupling, and indicated that groups such as small pelagic fishes, sharks, and detritus emerged to have key roles in their ecosystems (Tsagarakis *et al.* 2010; Coll and Libralato 2012; Torres *et al.* 2013; Hattab *et al.* 2013).

Further, the effects of invasive species on marine food webs have been evaluated with several efforts in the Mediterranean. The effects of Manila clam, which was introduced into the Venice Lagoon, were identified by Pranovi *et al.* (2003), the potential ecological role of invasive comb jellyfish *Mnemiopsis leidyi*, its predation on anchovy eggs and larvae have been described by Kideys (2002), Lebedeva and Shushkina (1994), Shiganova and Bulgakova (2000), Akoğlu *et al.* (2014) and the effects of overfishing (Daskalov 2002; Gücü 2002) on Black Sea trophic cascade was depicted by Akoğlu *et al.* (2014). Subsequently, the synergy between these two effects were explored by Bilio and Niermann (2004), Oguz (2007), Oguz *et al.* (2008a, 2008b). Pauly *et al.* (2009) carried out a meta-analysis by using Ecosim simulation to identify the jellyfish bloom in the Mediterranean Sea. The effects of invasive species *M. leidyi* on trophic flows in the eastern Mediterranean Sea was also described by Tsagarakis *et al.* (2010). Coll *et al.* (2008a, 2008b) evaluated the potential results of improved trawl selectivity within an ecosystem context by modifying the EwE model described for the same area (Coll *et al.* 2006). All these literature prove that the Mediterranean Sea is a hotspot for carrying out marine ecosystem research as an emerging region that is in need of urgent implementation of EBFM strategies.

3. Modelling potential: Ecopath with Ecosim

Modelling technique is basically chosen by data requirement, research questions, and other logistical constraints such as researchers working on the modelling approach (Plaganyi 2007; Heymans *et al.* 2016).

The problems in the region derive many aforementioned research questions all of which are still in need of further delineation and EwE can easily be utilised to address these research questions in terms of model boundaries and data availability and quality. To some extent, similar problems in the Mediterranean ecosystems have been investigated using EwE approach (see section 2).

Trophic mass-balance model (Ecopath) uses a set of linear equations to describe trophic interactions among functional groups, and provides a static snapshot of the ecosystem's food web. The topology of these networks or interactions are regulated by the energy balance in the trophic energy flow constituted by feeding relationships of the functional groups, and Ecopath works with two master equations to ensure the mass and energy balances of the model (Christensen and Walters 2004; Christensen *et al.* 2008).

Consumption (Q) = Production (P) + Respiration (R) + Unassimilated food (E)

Production (P) = Catch (Y) + Predation mortality (M2) + Biomass accumulation (BA) + Net migration (E) + Other mortality (1-EE)

$$\boldsymbol{Pi = \sum_j Bj.M2ij + Yi + +Ei + BAi + Pi.(1 - EEi)}$$

Where 'Pi' is the total production of functional group (i); 'Bj' is the biomass of group (j); '$M2ij$' is the predation mortality caused by group (j) on group (i); 'Yi' is the total fishery catch rate of (i); 'Ei' is the net migration rate of (i); 'BAi' is the biomass accumulation rate for (i); '$1 - EEi$' is the other mortality rate that is not attributed to predation or catches for (i); 'EEi' is the ecotrophic efficiency for (i). This equation can be re-expressed as:

$$\boldsymbol{Bi.(P/B)i = \sum_j Bj.(Q/B)j.DCij + Yi + Ei + BAi + Bi.(P/B)i.(1 - EEi)}$$

Where'Bi' is the biomass of group (i); '$(P/B)i$' is the production/biomass ratio for (i); '$(Q/B)i$' is the consumption/biomass ratio of predator (j); '$DCij$' is the fraction of prey (i) in the average diet of predator (j).

Among the four basic parameters; namely Biomass (B), Production/Biomass (P/B), Consumption/Biomass (Q/B), and Ecotrophic Efficiency (EE), at least three of them have to be known. In addition, diets and catches are needed as inputs for each functional group. Modellers usually let Ecopath estimate EE because it is difficult to calculate or obtain empirically. Moreover, in some cases, the P/Q ratio (the growth efficiency, GE) is used to let Ecopath estimate the P/B or Q/B ratio.

Ecosim uses time series data, based on Ecopath results, to provide dynamic simulation capability by simulating prey –predator dynamics over time. Considering the Mediterranean ecosystems, Ecosim could be utilised to predict the effects of fisheries, the impact of the introductions of Lessepsian species and environmental drivers on its ecosystem components.

The structure of functional groups depends on research questions and data availability. Input data can be taken from surveys, databases, and published and unpublished literature. The information should be primarily based on data collected from local studies, and then data from adjacent areas or similar ecosystems can be considered alternatively. However, biomass data should definitely be obtained with regional studies.

Here we summarised potential biomass data to that could be utilised to set up EwE models in the eastern Mediterranean Sea (Table 1).

25 major studies including biomass information have been carried out in the eastern Mediterranean coast of Turkey. While 11 studies are available (denoted with A in Table 1) as project report and/or thesis, 11 studies are unavailable (denoted with U in Table 1). Thus, contact with researchers is required to obtain these data sets. Also, hitherto, only 3 of these studies were published. Phytoplankton biomass and primary production could be obtained from in situ samplings besides satellite data. Also, there are some studies on zooplankton, macrobenthic epi/infauna, demersal trawl species, small pelagic fishes and sea grass from different bays along the eastern Mediterranean coast of Turkey. There is no estimation about the biomasses of macrozooplankton, pelagic sharks, medium pelagic fishes, large pelagic fishes, dolphins and sea birds. However, the biomass estimates of Atlantic bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*) could be obtained from stock assessment reports by ICCAT. Seabird biomass is not well known for the area. Audouin's Gull (*Larus audouinii*) is known to be the dominant species in the region (Coll *et al.* 2010), but there is little information about population density of the colonies in breeding pairs. Moreover, little is known about the migration patterns of these groups.

Table 1. The description of potential biomass data in eastern Mediterranean coast of Turkey (***P***: Published (as paper), ***A***: Available (as thesis or project report), **U**: Unavailable).

Study	Taxonomic Groups	Method				Area	Year	Reference	Availability
		Sampling Method	Station or Haul Numbers	Sampling Period	Sampling Depths (m)				
1	Demersal trawl species	Demersal trawl	12	Monthly	<200	Northeastern Mediterranean (between 36.2º N-33.8º E and 36.6º N-36.0º E)	1980-1981	(Gücü *et al.* 2010), (Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
2	Demersal trawl species	Demersal trawl	16	Monthly	<200	Northeastern Mediterranean (between 36.2º N-33.8º E and 36.6º N-36.0º E)	1981-1982	(Gücü *et al.* 2010), (Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
3	Demersal trawl species	Demersal trawl	153	Seasonal	20-500 m	Northeastern Mediterranean	1991-1992	(JICA 1993)	**A**
4	Demersal trawl species	Demersal trawl	168	Seasonal	<200	Northeastern Mediterranean (between 36.0º N-32.8º E and 36.6º N-36.0º E)	1983-1984	(Gücü *et al.* 2010), (Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
5	Demersal trawl species	Demersal trawl	96	Seasonal	<200	Northeastern Mediterranean (between 36.0º N-32.8º E and 36.2º N-33.8º E)	1999-2010	(Gücü *et al.* 2010), (Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
6	Demersal trawl species	Demersal trawl	5	Monthly	<200	Northeastern Mediterranean (36.565º N-34.265º E and 36.581º N-34.271º E)	2007-2016	(Ali Cemal Gücü, Middle East Technical University, personal communication), (Ok 2012)	**U**
7	Demersal trawl species	Demersal trawl	21	Seasonal	<200	Northeastern Mediterranean (between 36.0º N-32.8º E and 36.6º N-36.0º E)	2016-	(Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
8	Demersal trawl species	Demersal trawl	182	Monthly during fishing months (15 Sep. – 15 Apr.)	15-150	Mersin Bay, Northeastern Mediterranean	2009-2013	(Özbilgin *et al.* 2013)	**A**
9	Demersal trawl species	Demersal trawl	12	Monthly	400-560	Antalya Bay, Northeastern	2009-2010	(Mehmet Cengiz Deval, Akdeniz University, personal communication), (Deval and Kapiris	**U**

						Mediterranean		2016)	
10	Demersal trawl species	Demersal trawl	87	Monthly	200-900 (bathymetric strata, 100 m in-terval)	Antalya Bay, Northeastern Mediterranean	2010-2011	(Mehmet Cengiz Deval, Akdeniz University, personal communication), (Deval and Kapiris 2016)	**U**
11	Demersal trawl species	Demersal trawl	6	Seasonal	25-200	Antalya Bay, Northeastern Mediterranean	2009-2010	(Elif Özgür Özbek, Turkish Marine Research Foundation (TUDAV), personal communication), (Özbek *et al.* 2013), (Özbek *et al.* 2015), (Özbek *et al.* 2016)	**U**
	Macrobenthic epi/ infaunal species	Van Veen Grab and Sledge			5-200				
12	Demersal trawl species	Demersal trawl	2	Seasonal	10;20	Iskenderun Bay, Northeastern Mediterranean	2004-	(ISKEN Project: İsken Su Gözü Enerji Santrali Etki Alanı Deniz Ekolojisi İzleme Çalışması Projesi. Dursun Avşar, Çukurova University)	**U**
	Macrobenthic epi/ infaunal species	Van Veen Grab	4	Seasonal	20				
	Phytoplankton	In situ	5	Seasonal	5-15				
	Zooplankton	WP-2 net (200-µm)	5	Seasonal	5-15				
13	Small pelagic fishes	Acoustic survey	-	Monthly	<200	Northeastern Mediterranean (between 36.18º N-33.65º E and 35.93º N-35.91º E)	2009-2011	(Gücü *et al.* 2011)	**A**
14	Small pelagic fishes	Acoustic survey	-	Monthly	<200	Mersin Bay, Northeastern Mediterranean	2008-	(Gücü *et al.* 2011), (Ali Cemal Gücü, Middle East Technical University, personal communication)	**U**
15	Macrobenthic epi/ infaunal species	Van Veen Grab	21	Seasonal	10-200	Mersin Bay, Northeastern Mediterranean	2000	(Ergev 2002)	**A**
16	Sea meadows and sea grasses	Acoustic survey	-	-	5-50	Antalya Bay, Northeastern Mediterranean	2011-2012	(Mutlu 2014)	**A**
17	Zooplankton	Nansen closing net (112 µm)	2	Monthly	20;200	Mersin Bay, Northeastern Mediterranean	2004-2006	(Yilmaz and Besiktepe 2010)	**P**
18	Zooplankton	WP-2 net (200-µm)	5	Seasonal	5-15	Iskenderun Bay, Northeastern Mediterranean	2008	(Kurt and Polat, 2013)	**P**
19	Zooplankton	WP-2 net (200-µm)	5	Seasonal	5-15	Iskenderun Bay, Northeastern Mediterranean	2009-2011	(Kurt and Polat, 2015)	**P**
20	Zooplankton	WP-2 closing net (200-µm)	20	Periodic (stratification and mixing periods)	Upper 200 m	Northeastern Mediterranean (Clician Basin)	2006-2011	(SESAME Project: Southern European Seas Assessing And Modelling Ecosystems Changes Sustainable Development. Emin Özsoy, Middle East Technical University),	**A**

								(Kurt 2016), (Mazzocchi *et al.* 2014)	
21	Zooplankton	WP-2 closing net (200-µm)	2	Monthly	10;70	Iskenderun Bay, Northeastern Mediterranean	2009-2010	(Polat *et al.* 2011)	**A**
	Phytoplankton	In situ	2	Monthly	10;70				
22	Phytoplankton	In situ	4	Monthly	30;50;200;210	Mersin Bay	2008-2011	(Yücel 2013)	**A**
23	Zooplankton	WP-2 closing net (200-µm)	**17**	Seasonal	6-200	Mersin Bay	2008-2011	(TARAL-SINHA Project: Turkiye kıyılarında Kentsel Atıksu Yönetimi Sıcak Nokta Ve Hassas Alanların Yeniden Tanımlanması Atık Ozümseme Kapasitelerinin İzleme Modelleme Yöntemleriyle Belirlenmesi ve Sürdürülebilir Kentsel Atıksu Yatırım Planlarının Gelistirilmesi. Principal Coordinator Süleyman Tuğrul, Middle East Technical University) (Contact persons: Zahit UYSAL; Sevim POLAT and Yeşim AK ÖREK))	**A**
	Protozooplankton	Niskin bottle and filtered 20-µm)	**17**	Seasonal	0;20;50;75; 100; >100				
	Phytoplankton	In situ	**50**	Seasonal	Upper 200 m				
24	Zooplankton	Nansen net (112 µm)	18	Seasonal	19-1100	Northeastern Mediterranean (Clician Basin)	2005-2007	(Uysal *et al.* 2008)	**A**
	Phytoplankton	In situ	18	Seasonal	Upper 200 m				
25	Zooplankton	Nansen net (112 µm) and Hensen net (300 µm)	-	-	Upper 200 m	Northeastern Mediterranean (Rhodes – İskenderun Bay)	1995-1997	(Salihoğlu and Mutlu 2000)	**A**
	Phytoplankton	In situ	-	-	Upper 100 m				

[*] Geographical coordinates are approximate values and in decimal degrees.

Considering other Ecopath input parameters, the P/B and Q/B estimates can be obtained by laboratory experiments. However, due to the lack of knowledge on these data, empirical equations could be used to calculate these rates. The P/B ratio is assumed to be equivalent to the total mortality (Z, y^{-1}), which is equal to the sum of fishing mortality (F, y^{-1}) and natural mortality (M, y^{-1}) under steady-state conditions (Allen 1971). F is the ratio of catch (C) to biomass (B) (F=C/B) (Heymans *et al.* 2016). M can be estimated from empirical equations for fish (Pauly 1980). Similarly, the Q/B ratio can be estimated from empirical equations for finfish following Palomares and Pauly (1998), for benthic invertebrates, deposit feeders and detritus feeders following Cammen (1980), for seabirds following Nilsson and Nilsson (1976), and for dolphins following Innes *et al.* (1987).

Catch data could be obtained from the annual Fishery Statistics booklets published by the Turkish Statistical Institute. However, the problem is that these statistics are unreliable since the data have been collected with annual interviews carried out in the beginning of each year. Also, the statistics cover the entire Mediterranean coast of Turkey, and there is no information about the exact boundaries of the data. Moreover, there is no information on which gear is responsible for how much fish removals. Thus, catch per unit effort (CPUE) (Sparre and Venema 1998) may be used as a tool to assume landing by fishing gear, and discards may be estimated from discard ratios determined by scientific surveys.

Diet composition could be obtained from published and unpublished literature. The diet information should primarily be based on data collected from local studies, and then data from adjacent areas could be chosen alternatively. Because of regional dynamics like Lessepsian migration, diet information specific to the region is more relevant.

4. Conclusion

The metadata documented in Table 1 highlighted modelling potentialities for EwE in the eastern Mediterranean coast of Turkey. However, the problem is that majority of the field data is unavailable. Therefore, an a priori database construction is important in order to properly reveal the data that could be used in modelling approaches. Although the data on fisheries statistics and fishing effort are less reliable compared to the EU and Nordic countries, the data may be enough to set up models and investigate research questions. However, standardized time series catch and biomass data are crucial. In addition to all these, the area is very dynamic and precious for evaluating ecosystem impact of Lessepsian migration. Therefore, providing updated information on input data such as diet, discards, catch, and biomass is important.

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ATLANTIC BLUEFIN TUNA IN THE MEDITERRANEAN SEA: FISHERIES, FARMING, MANAGEMENT AND CONSERVATION

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1. Introduction

Atlantic bluefin tuna (ABFT) mainly live in the pelagic ecosystem of the entire North Atlantic and its adjacent seas, primarily the Mediterranean Sea. Among the tunas, ABFT has the widest geographical distribution and is the only large pelagic fish living permanently in temperate Atlantic waters (Bard *et al.* 1998; Fromentin and Fonteneau 2001). Archival tagging and tracking information confirmed that ABFT can sustain cold (down to 3°C) as well as warm (up to 30°C) temperatures, while maintaining stable internal body temperature (Block *et al.* 2001). ABFT is also a highly migratory species that seems to display a homing behavior and spawning site fidelity in both the Mediterranean Sea and Gulf of Mexico, which constitute the two main spawning areas being clearly identified today (Figure 1) (Fromentin, 2006).

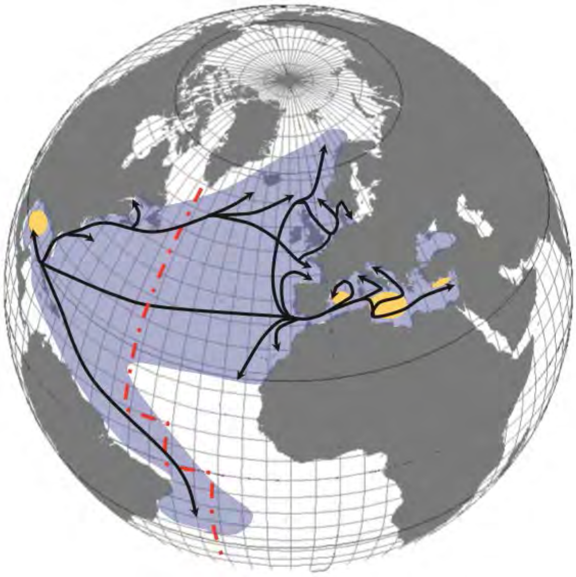

Figure 1. Map of the spatial distribution of ABFT (blue), main migration routes (black arrows) and main spawning grounds (yellow areas) (Fromentin and Powers 2005, Fromentin, 2006).

Cetti (1777) has first mentioned about migration of ABFT between Mediterranean and North Atlantic. Pavesi (1889) has put forward an idea to being a distinct stock in the Mediterranean as well and this hypothesis was accepted by many researchers. (Roule 1917; de Buen 1925; Scordia 1938). Migration between Mediterranean and North Atlantic was determined by tagging studies conducted in 1960s and 1970s and this migration was agreed (Sara, 1963; Mather *et al.* 1995; Fromentin and Powers, 2005). Electronic tagging results has been indicate that migration and movement patterns of ABFT might be varied among individuals, years, and areas (Lutcavage *et al.* 1999; Block *et al.* 2001).

Four defined ABFT spawning areas are known in the Mediterranean (Piccinetti *et al.* 1997; Nishida *et al.* 1998; Garcia *et al.* 2003; Oray *et al.* 2005): the Balearic Sea, around Malta Island, the north Levant Sea and defined marine areas to the east coast of Sicily and South Tyrrhenian Sea (Figure 2). Spawning period of ABFT is between May and July (Rodriguez-Roda, 1967; Susca *et al.* 2001; Medina *et al.* 2002; Karakulak *et al.* 2004; Heinisch *et al.* 2008). ABFT median sexual maturity (L_{50}) in the Mediterranean is 103.6 cm in fork length (FL) (3 years), %100 maturation length is 135 cm in FL (4-5 years) (Corriero *et al.* 2005).

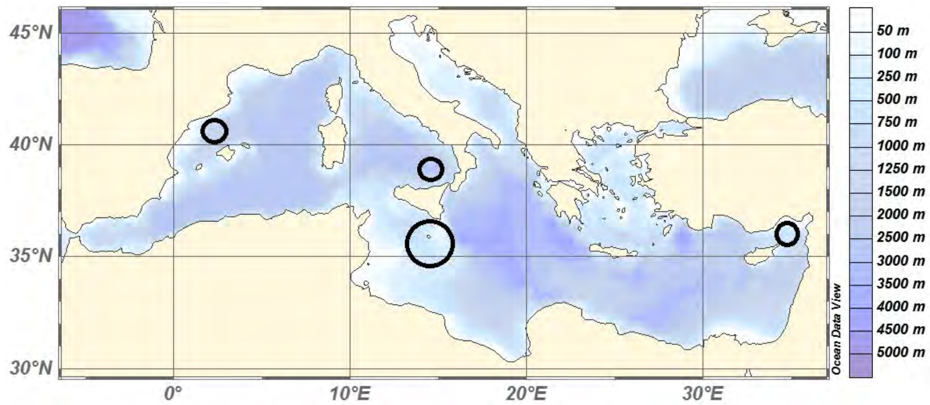

Figure 2. The spawning areas in the Mediterranean Sea (Karakulak *et al.* 2016).

ABFT are managed as two separate stocks by The International Commission for the Conservation of Atlantic Tunas (ICCAT): the western stock spawns in the Gulf of Mexico, whereas the eastern stock spawns in the Mediterranean Sea. Electronic tagging, genetics and microchemistry studies suggests that the population structure of ABFT is much more complex (Rooker *et al.* 2008; Riccioni *et al.* 2013). Support for the existence of two separate stocks of ABFT is provided by several genotypic and phenotypic markers. Analyses of DNA microsatellites (Carlsson *et al.* 2007), mitochondrial DNA (Boustany *et al.* 2008), otolith shape (Brophy *et al.* 2016), chemical composition of the otolith (Secor *et al.* 2002; Rooker *et al.* 2003) and isotopes in otoliths (Rooker and Secor, 2004) all show significant divergence of the two population. Moreover, some researchers suppose that ABFT also forms metapopulations between the eastern Atlantic and the Mediterranean (Fromentin and Powers, 2005).

Recent studies of ABFT genetic population structure within the Mediterranean are uncertain. Some researchers found significant heterogeneity among this species from western and eastern Mediterranean Sea (Broughton and Gold, 1997; Carlsson *et al.* 2004; Boustany *et al.* 2008). On the contrary, other genetic studied concluded that no genetic differences could be detected within Mediterranean ABFT (Alvarado Bremer *et al.* 1999; Vinãs, 2001; Vinãs, 2003; Vella *et al.* 2016). These contradictory results could be consequence of differential sampling and methodological techniques used among studies. In the case of ABFT population structure, genetic analyses need to be improved and standardized to avoid conflicting results.

ABFT Fishing

ABFT fishing has come to head with production of 53.335 ton in 1996. In comparison with the Atlantic Ocean, the Mediterranean Sea is an important fishing area (Figure 3). In 2000s, catch volumes have showed a decrease due to the quota implementation of ICCAT (Figure 4). The most decline in fishing has been seen in the Mediterranean Sea. Fishing gears used in the Mediterranean Sea during the recent years; set traps (almadrabas), longlines, bait boat, rod and reel, hand trolling and purse seines (Figure 5). Going into action of ABFT farming in the Mediterranean Sea in 1997 has changed ABFT fishing in the Mediterranean Sea and caused to increasing in purse seine fishing.

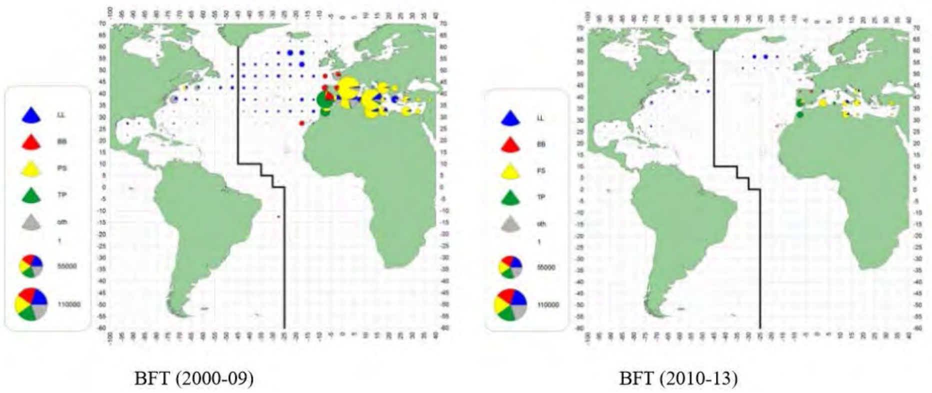

Figure 3. ABFT fishing areas with respect to main gears from 2000 to 2013 (LL-longline, BB-bait boat, PS-purse seine, TP-trap and OTH-other fishing gear) (ICCAT, 2016a).

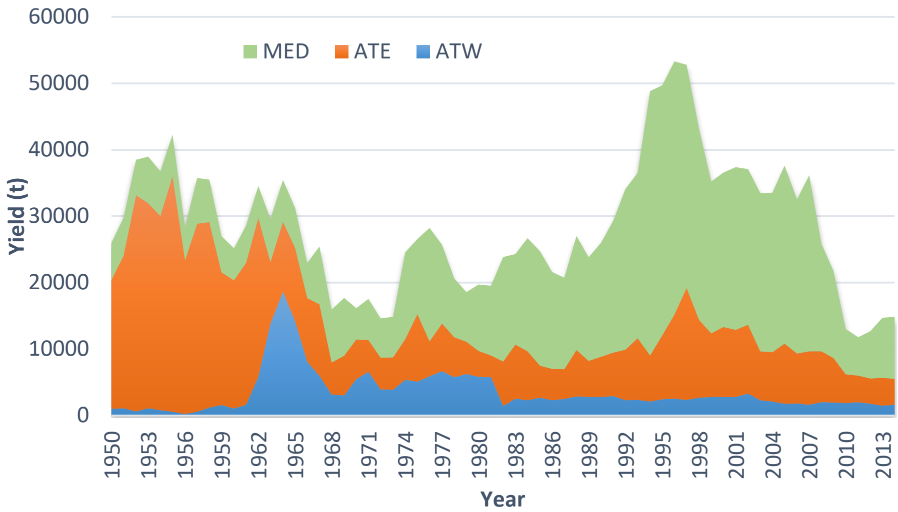

Figure 4. Reported catch for the West Atlantic, East Atlantic and Mediterranean from 1950 to 2014 split by main geographic areas (ICCAT, 2016a).

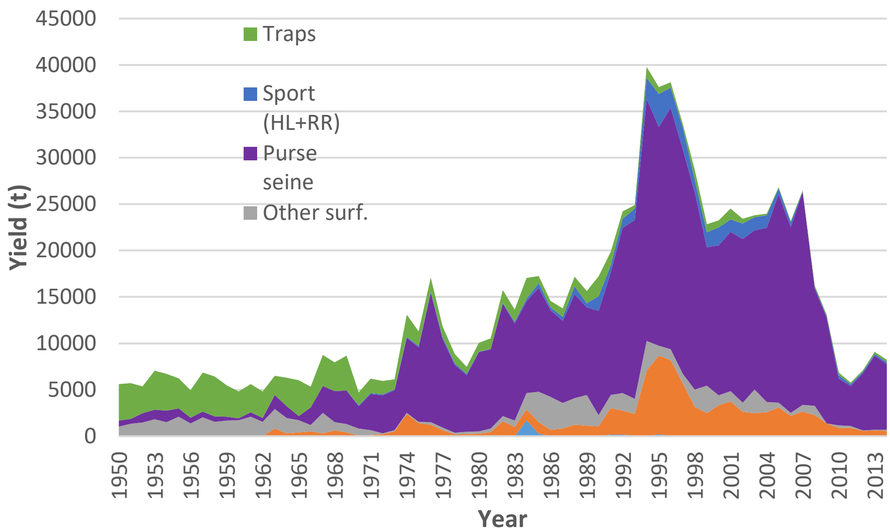

Figure 5. Reported catch for the Mediterranean from 1950 to 2014 split by gears (ICCAT, 2016a).

Catch amounts of ABFT between years of 2009 and 2014 by Mediterranean countries were given in Table 1. Countries that have the most fishery are France, Italy, Tunisia, Spain, Libya and Turkey. Japan and Korea Republic have fishing quotas with regard to historical fishing backgrounds (ICCAT 2016a).

According to the recommendations of ICCAT, ABFT fishing shall be done in 1 January-31 May for large-scale pelagic longline vessels, in 26 May-24 June for purse seine fishing, in 1 July-31 October for bait boats and trolling boats, in 16 June-14 October for recreational and sport fishing (ICCAT 2016b [Rec.14-04]).

Table 1. ABFT catch quotas by counties (ICCAT, 2016a).

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Albania	50	0	0	0	9	34
Algerie	0	0	0	69	244	244
EU.Croatia	619	389	371	369	384	385
EU.Cyprus	2	3	10	18	17	17
EU.Spain	1769	942	942	1064	948	1164
EU.France	3087	1754	805	791	2191	2207
EU.Greece	373	224	172	176	178	161
EU.Italy	2749	1060	1783	1788	1938	1946
EU.Malta	263	136	142	137	155	160
Egypt	0	0	0	64	77	155
Japan	18	0	0	0	0	0
Korea Rep.	102	0	0	77	80	81
Libya	1082	645	0	756	929	933
Morocco	369	205	182	223	309	310
Syria	0	34	0	0	0	0
Tunisia	1932	1042	852	1017	1057	1047
Turkey	665	409	519	536	551	555

Figure 6. Turkish purse seine vessel specialized for ABFT

Farming and fattening of ABFT in the Mediterranean Sea

ABFT farming and fattening in the Mediterranean Sea is a seasonal activity. Fishes have been caught from nature during spawning migration and kept in cages between 3 months and 2 year (Mylonas *et al.* 2010). Due to low muscle fat content of fish and market price during the catching period, the fishes keep within cages then they are sold to Asian markets notably Japanese at a premium when they have high fat content after a good nutrition. Under the date of January 2013, a total of 1.76 million $ were payed for a 222 kg ABFT in the Tokyo's Tsukji market (The Atlantic news, http://www.theatlantic.com/international/archive/2014/01/sushinomics-how-bluefin-tuna-became-a-million-dollar-fish/282826/).

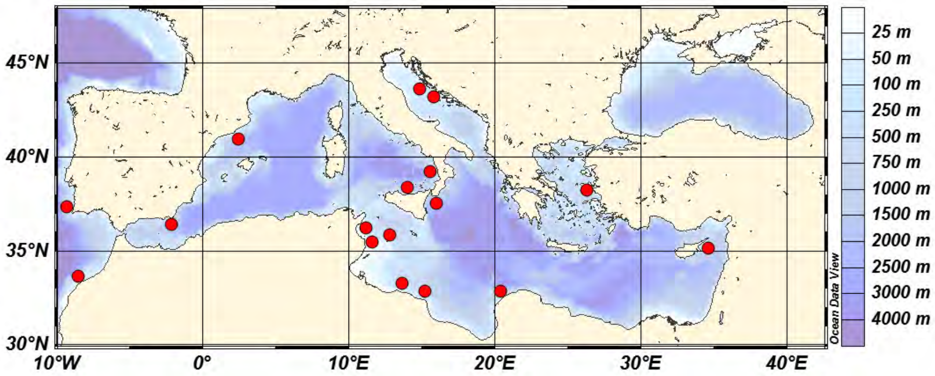

Figure 7. The locations of the bluefin tuna farms in Mediterranean Sea.

In the Mediterranean, the first ABFT farm was started in southern Spain in 1985 and farming activity immediately spread in 1997 (FAO 2005). In 2016, the number of farms registered to ICCAT in the Mediterranean is 53 and potential capacity is 58.562 tonnes (Table 2). The countries involved in ABFT farming in Mediterranean are Croatia, Cyprus, Greece, Italy, Libya, Malta, Spain, Tunisia and Turkey (Figure 7).

Table 2. Numbered of registered BFT farming in the Mediterranean in 2016 (ICCAT, 2016c).

	Numbered registered	Potential capacity (tonnes)	Starting date
EU Croatia	4	7.880	1996
EU Cyprus	3	3.000	2003
EU Greece	2	2.100	2004
EU Italy	14	12.600	2001
EU Malta	8	12.300	2000
EU Spain	10	11.852	1985
Libya	1	1.000	2003
Tunisia	5	1.690	2007
Turkey	6	6.140	2002

Fishes caught from sea for farming purpose have been composed of juvenile individuals which reach the first spawning length and mature individuals (between >30 kg – 600 kg). Minimum landing size was determined as 30 kg (115 cm fork length) for ABFT (ICCAT, 2016b [Rec.14-04]). Besides, it is allowed to catch fishes which ranged between 8-25 kg in weights for farming and to stock in cages at least two years in only Croatia.

The total Mediterranean tuna production derived from the farming activities is difficult to calculate as the initial cage stocking information, i.e. biomass and fish size, is only a rough estimate and any weight gain is generally kept confidential by the farmers (Ottolenghi, 2008). ICCAT has increased audits and controls for better ABFT stock assessments. Jurisdiction the farm is located shall ensure that transfer activities from cages to the farm shall monitored by video camera in the water. Besides that, all member countries to ICCAT are obliged to fill out ABFT catch documents (BCD) form during fishing and exporting.

ABFT farming activities have provided opportunities to new work areas and important income generations. Although ABFT farming activities are high in economic and social benefits, it caused some problems accompany. Tuna capture-based aquaculture generates impacts and conflicts with other resource users such as the traditional tuna trap and longline operator. The activity of tug boats towing tuna cages disturb the traditional longline fisheries in many countries (Italy, Malta, Tunisia) as well as reducing tuna catches. Bluefin tuna farmers in Croatia and Turkey have caused problems and strong conflicts with tourism activities in the use of the coastal zone (Ottolenghi, 2008; Karakulak, 2007; Karakulak *et al.* 2016).

ABFT Management and Conservation

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. The Commission, composed of 50 Contracting Parties (countries/political entities) is a Regional Fisheries Management Organization (RFMO) responsible for combining a wide array of scientific and socio-economic information into setting total allowable catch (TAC) of Atlantic tuna species.

Although much of the focus of tuna management in the Mediterranean Sea is on the actions of ICCAT, its yearly TAC is only a recommendation, with implementation left to the individual member states. Currently, it is not clear, any ICCAT members that manage their share of the TAC using tradable permits or Individual Transferable Quotas (ITQs) in the Mediterranean Sea. It appears that the majority of ICCAT members fishing in this area use licensing systems to manage their fisheries (Sumaila and Huang, 2012).

Both the over-fishing of this species during the decade 1998-2008 as well as the level of catch underreporting and/or misreporting and the dwindling weight/size structure of its population, spiraled out of control to such magnitudes, that the immediate commercial future of this particular fishery as well as the prospect of a proper scientific-based management, relying on pertinent size/age-at-catch datasets, became all but too seriously compromised (Ambrosio and Xandri, 2015).

Analysis on the status of eastern ABFT populations carried out by the ICCAT- the Standing Committee on Research and Statistics (SCRS) in 2006 and 2009 (ICCAT, 2007; ICCAT, 2010) pointed out to a rapid deterioration of the eastern ABFT stock. In particular, the analysis described a sharp increase of fishing mortality over the large spawner fraction of the population (age 8+) in recent past years, which was attributed to the high purse seiners catches driven by the increasing demand for large live-fish by Mediterranean tuna farms (ICCAT, 2007). Overfished ABFT was listed “endangered” species in the World Conservation Union (IUCN) Red List of Threatened Species (criterion A2bd) in 2011 (Collette *et al.* 2011).

Because of this situation, it was established an eastern ABFT Recovery-Plan which evolved around a number of stringent management measures: Fishing-fleet reduction, the banning of aerial tuna-spotting, real-time reporting, the BCD scheme, onboard observers, the contraction of fishing seasons, quotaslashes, fisheries policing both at port and at fishing grounds, war against IUU eastern ABFT trade, etc.

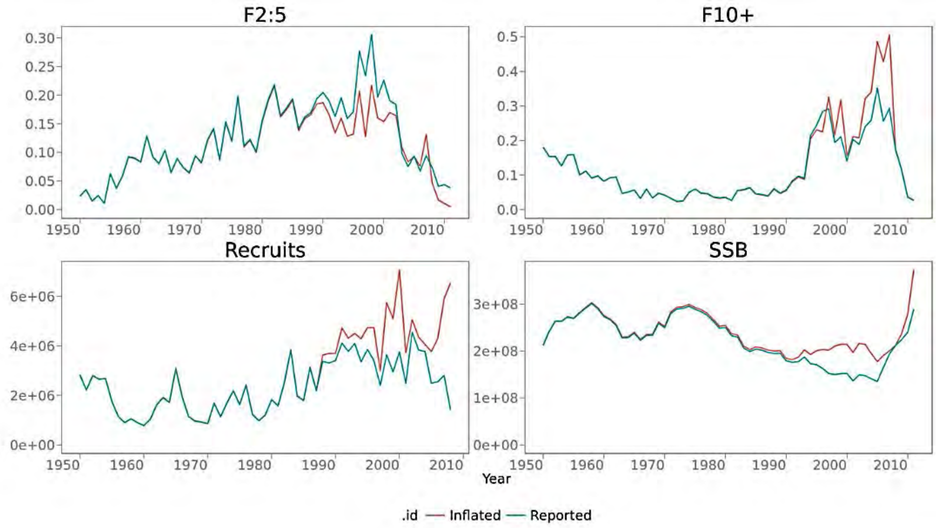

Figure 8. Fishing mortality (for ages 2 to 5 and 10+), spawning stock biomass (in tonnes) and recruitment (in number of fish) estimates from VPA continuity run. Blue line: reported catch; red line: inflated (from 1998 to 2007) catch (ICCAT, 2014).

According to ICCAT-SCRS latest 2014 updated eastern ABFT stock assessment, results indicated that the spawning stock biomass (SSB) showed clear signs of sharp increase in all the runs (Figure 8) that have been investigated by the ICCAT-SCRS accepted a general scientific precautionary approach to sound fisheries management that would rely on trustworthy accurate and comprehensive eastern ABFT size/age-at-catch historical datasets (ICCAT, 2014).

2. Conclusion

Nowadays most of ABFT fishing is aiming to fattening. At issue in the case of this activity has left ICCAT managers and scientists in a difficult situation during stock assessment and fishing management. In international trade of dead ABFT, presence of a certificate (BCD) is a necessity. However, since that is not in question for live fish, farmed fish can be exchanged. In this case, due to origin of farmed fish is not known control of the country whether exceed quota is getting difficult. Moreover, since fishes that caught and kept in cages cannot be enumerated and cannot be weighed owing to stress, stocks in the cages are not known.

ICCAT Atlantic wide research programme for ABFT (GBYP) was started in 2010. The main objective of the GBYP is to improve our knowledge and understanding of the ABFT stocks and populations. In recent years, various studies have been conducted to estimate the weight of fishes by video camera recording. At the same time, ABFT stock status have been investigated with fishing-independent researches. An improved understanding of ABFT migration patterns, spawning locations and stock structure is clearly necessary for fishery management regulations to be equitable and for rebuilding efforts to have maximal effect.

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STATUS OF HIGHLY MIGRATORY FISHERIES IN THE MEDITERRANEAN SEA, TURKEY

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1. Introduction

The Mediterranean, which owes its name to the Latin "Medius terrae", meaning "in the middle of land", is a sea according to oceanography definitions. The Mediterranean Sea, known as a semi-enclosed sea characterized by high salinities, temperatures and densities, is a landlocked sea with limited exchange with the world ocean. (Tanhua *et al.* 2013).

The Mediterranean Sea is an important area due to the highly migratory nature, widespread distributions, and global economic importance. Highly migratory species (HMS) is a term which has its origins in Article 64 of the United Nations Convention on the Law of the Sea (UNCLOS). This is a legal definition rather than a scientific definition based on the actual migratory behaviour of the species. It refers to fish species or stocks that carry out extensive migrations and can occur in both Exclusive Economic Zones (EEZ) and high seas and also have wide geographic distributions. About 200 species have been identified as being fished on the high seas either as highly migratory species, straddling fish stocks. Although there is insufficient scientific information to determine the actual number of stocks involved in these fisheries, 226 species (or species group) statistical area combinations have been reported on as stocks hitherto. The number of species and stocks are similar since many species occur in multiple stocks, but many stocks are made up of groups of more than one species. They include tuna and tuna-like species, oceanic sharks, marine turtles, pomfrets, sauries, and dolfinfish (Maguire *et al.* 2006).

Highly migratory fish species, according to the 1982 convention listed under Annex I, are following legally defined as; Albacore tuna (*Thunnus alalunga*), Bluefin tuna (*Thunnus thynnus*), Bigeye tuna (*Thunnus obesus*), Skipjack tuna (*Katsuwonus pelamis*), Yellowfin tuna (*Thunnus albacares*), Blackfin tuna (*Thunnus atlanticus*), Little tuna (*Euthynnus alletteratus*; *Euthynnus affinis*), Southern bluefin tuna (*Thunnus maccoyii*), Frigate mackerel (*Auxis thazard*; *Auxis rochei*), Pomfrets (Family Bramidae), Marlins (*Tetrapturus angustirostris*; *Tetrapturus belone*; *Tetrapturus pfluegeri*; *Tetrapturus albidus*; *Tetrapturus audax*; *Tetrapturus georgei*; *Makaira mazara*; *Makaira indica*; *Makaira nigricans*), Sail-fishes (*Istiophorus platypterus*; *Istiophorus albicans*), Swordfish (*Xiphias *gladius*), Sauries (*Scomberesox saurus*; *Cololabis saira*; *Cololabis adocetus*; *Scomberesox saurus scombroides),* Dolphin (*Coryphaena hippurus*; *Coryphaena equiselis*), Oceanic sharks (*Hexanchus griseus*; *Cetorhinus maximus*; Family Alopiidae; *Rhincodon typus*; Family Carcharhinidae; Family Sphyrnidae; Family Isuridae). There are 16 Osteichthyes fish species occurring in the Mediterranean Sea. The species which are commercially caught in Turkey are summarized in Table 1 according to their fishing methods and landings including the other countries for comparison. Other highly migratory species which are not included in Table 1 and have no high commercial interest but fished in the Turkish coast of Mediterranean Sea are *Tetrapturus belone*, Rafinesque, 1810 and *Coryphaena hippurus*, Linnaeus, 1758 (Bilecenoglu *et al.* 2002). Both of these species are caught by sportive fishing or by-catch.

Fisheries for highly migratory species are important in the Mediterranean Sea since they have high market value. The species found in Turkey contributes 7.34% in the Mediterranean Sea. In the last decades their catch was approximately four million tonnes, which represents about 1.04 % of the total catch of all tuna and tuna-like species, in Turkey (FAO 2014).

This paper provides the required background information on fisheries in Turkey for HMS which includes bony fish species in the Mediterranean Sea, using the best available information. The list of presented species is also evaluated in this paper, including their short description e.g., reproduction, habitat and distribution associated with fisheries for HMS.

Table 1. HMS fish species commercially caught in Turkey including the other Mediterranean countries according to last five years.

Scientific name	Fisheries	Country	Landing (Years-tonnes)					State of Exploitation
			2010	2011	2012	2013	2014	
Thunnus alalunga	All	All Mediterranean	2852*	5310*	2728*	2184*	3106*	Not known[1]
	Purse seine	HRV, ITA, TR	-	34**	68**	15**	14**	
	Longline	HRV, CYP, ESP, FRA, GRC, ITA, MLT, SYR	1720**	2341**	1965**	1399**	2326**	
	Drifnet	TR	402**	1396**	-	71**	-	
	Handline	HRV	2**	4**	5**	11**	15**	
	Trap	ESP	-	-	-	-	5**	
	Trawl	HRV	-	-	-	-	3**	
	Troll	ESP	1**	-	6**	-	3**	
	Unclassified	FRA, ITA, ESP	-	845**	3**	6**	11**	
Thunnus thymnus	All	All Mediterranean	6862*	6229*	7116*	9079*	8926*	Overfishing[1]
	Purse seine	ALB, DZA , HRV, CYP, ESP, FRA, CRC, ITA, MLT, PRK., LBY, MAR, SYR, TUN, TR, ISL, EGY, ICCAT(RMA)	5058**	4307**	6185**	7981**	8197**	
	Longline	DZA, PRC T, HRV, CYP, ESP, FRA, GRC, ITA, MLT, PRT, JPN, PRK., LBY, MAR, SYR, TR, ICCAT(RMA)	877**	867**	588**	604**	584**	

	Handline	DZA, HRV, CYP, ESP, GRC, ITA, MAR, TUN	158[**]	136[**]	164[**]	172[**]	220[**]	
	Trap	DZA, ITA, LYG, MAR, ICCAT (RMA)	281[**]	165[**]	125[**]	222[**]	231[**]	
	Baitboat	FRA, ICCAT (RMA)	-	-	2[**]	2[**]	-	
	Sport	HRV, ESP, FRA, ITA, MLT, PRT	195[**]	90[**]	13[**]	17[**]	19[**]	
	Trawl	FRA	1[**]	1[**]	1[**]	2[**]	1[**]	
	Trol	FRA, MLT, ICCAT(RMA)	-	-	-	18[**]	28[**]	
	Unclassified	ESP, FRA, GRC, ITA	273[**]	223[**]	25[**]	51[**]	51[**]	
Euthynnus alletteratus	All	All Mediterranean	5342[*]	5173[*]	5592[*]	5375[*]	4657[*]	Not known[2]
	Purse seine	DZA, HRV, FRA, GRC, ITA, MAR, TUN, TUR, EGU	1467[**]	2876[**]	3197[**]	3699[**]	2775[**]	
	Longline	DZA, HRV, ESP, ITA	129[**]	173[**]	204[**]	407[**]	349[**]	
	Trap	ESP	125[**]	177[**]	64[**]	78[**]	82[**]	
	Drifnet	HRV, MLT	7[**]	2[**]	5[**]	9[**]	3[**]	
	Handline	HRV, FRA	2[**]	1[**]	4[**]	4[**]	6[**]	
	Haul seine	HRV	-	-	1[**]	1[**]	1[**]	
	Trammel net	MLT	-	-	6[**]	2[**]	-	
	Trawl	HRV, ITA	-	1[**]	-	6[**]	7[**]	
	Troll	MLT	-	-	13[**]	2[**]	3[**]	
	Unclassified	DZA, ESP, ITA, MLT, SYR	437[**]	437[**]	693[**]	426[**]	214[**]	

Scientific name	Fisheries	Country	Landing (Years-tonnes)					State of Exploitation
			2010	2011	2012	2013	2014	
Auxis rochei, Auxis thazard	All	All Mediterranean	9604[*]	8985[*]	5731[*]	6499[*]	4011[*]	Not known[2]
	Purse seine	DZA, HRV, GRC, IRA, MAR, TUR, TUN, PRT	1811[**]	4791[**]	3140[**]	2496[**]	2477[**]	
	Longline	DZA, ITA, MAR	220[**]	282[**]	234[**]	302[**]	115[**]	
	Driftnet	DZA, HRV, ITA, MLT, MAR	355[**]	523[**]	438[**]	63[**]	2[**]	
	Handline	DZA, ITA, MAR	16[**]	4[**]	11[**]	17[**]	97[**]	
	Haul seine	HRV	-	-	1[**]	1[**]	-	
	Trammel net	MLT	-	-	2[**]	3[**]	-	
	Trap	ESP	39[**]	128[**]	156[**]	236[**]	135[**]	
	Trawl	DZA, ITA, FRA	-	5[**]	150[**]	3[**]	4[**]	
	Troll	MLT	10[**]	23[**]	1[**]	16[**]	14[**]	
	Unclassified	DZA, ESP, ITA, MLT, SYR	4753[**]	3221[**]	1601[**]	3355[**]	600[**]	
Xiphias gladius	All	All Mediterranean	13322[*]	11493[*]	9916[*]	10120[*]	9807[*]	Overexploited[1]
	Longline	DZA, HRV, CYP, EGY, GRC, FRA, ITA, JAP, LYB, PRK MLT, MAR, PRT, ESP, SYR, TUN	11585[**]	21824[**]	9066[**]	9197[**]	20939[**]	
	Drifnet	DZA, FRA, ITA, MAR, TUR	745[**]	578[**]	66[**]	869[**]	773[**]	
	Handline	DZA, HRV, FRA	1[**]	1[**]	2[**]	4[**]	3[**]	
	Harpoon	ITA	921[**]	-	-	-	-	
	Purse seine	DZA, HRV, ITA, SYR, TUR	3[**]	2[**]	34[**]	14[**]	6[**]	
	Trammel net	FRA	1[**]	-	-	1[**]	3[**]	
	Trap	ESP, FRA, ITA	2[**]	3[**]	2[**]	1[**]	1[**]	
	Trawl	DZA, FRA, ITA	3[**]	25[**]	15[**]	24[**]	10[**]	

	Unclassified	GRC, FRA, ITA	6	745	724	5	55	
Scombereso x saurus	All	All Mediterranean	264*	151*	2072*	116*	175*	Not known[1]
	Unclassified	ESP	264*	151*	2072*	116*	175*	
	Unclassified	TUR	565***	319.2***	283.3***	191.1***	218.8***	

*According to FAO; **According to ICCAT; ***According to TUIK; [1]ICCAT, 2006; [2]Maguire *et al.* 2006.

(Croatia: HRV, Italy: ITA, Turkey: TR, Malta: MLT, Syria: SYR, France: FRA, Spain: ESP, Lybia: LBY, Chinese Taipei: PRC T, Kore Republic: PRK, Albania: ALB, Algeria; DZA, Morocco: MAR, Tunisia: TUN, Iceland: ISL, Greece: GRC, Japan: JPN, Egypt: EGY; Portugal: PRT)

2. Highly Migratory Fish Species and Their Fisheries in Turkey

2. 1. *Thunnus alalunga* (Bonnaterre, 1788)

Common name : Albacore [En]
Family : Scombridae

Albacore is found from the Azores and Canaries north to Ireland and occurs in the western Mediterranean and in the northern part of the eastern Mediterranean, including the Adriatic but not the Black Sea. The size of fork length is up to 127 cm but commonly 100 cm, and 40 kg in weight. This species is commonly found in mixed schools with *Katsuwonus pelamis*, *Thunnus albacares* and *Thunnus maccoyii*. *T. alalunga* has been reported that it is often extending into cooler waters than most tunas and spawned in the summer in the Mediterranean (Collette and Nauen 1983; Whitehead *et al.* 1986; Froese and Pauly 2016). Maximum lifespan of albacore in the Atlantic is 13 years; while it is only 9 years in the Mediterranean (Megalofonou, 2000). According to Saber *et al.* (2015) the spawning season in the western Mediterranean Sea is from June to August and minimum length at sexual maturity of females was 56 cm FL. The Albacore reproductive season extends from May to July in the eastern Mediterranean Sea (Akaylı *et al.* 2013).

Fisheries: It is an important species in many commercial fisheries around the world. The Mediterranean albacore fisheries are characterized by high spatio-temporal variability in landings and fishing patterns. Albacore fishing is a traditional activity for a number of fleets including those of Cyprus, Greece, Italy, Spain, and Malta (Collette *et al.* 2011). There are four basic types of fishing operations such as longlining, live-bait fishing, trolling, and purse seining for Albacore fisheries. The driftnet fishery for albacore has been banned since January 2002 in the EU countries and from 2004 in all the ICCAT Mediterranean countries, but it is known that illegal fishing activity still occurs in some areas (STEFC 2007; *Collette et al.* 2011). However driftnet has been prohibited in Turkey since 2006 by the Turkish Ministry of Food, Agriculture and Livestock (Anon, 2006). Besides Turkish fisheries authorities have given a limited permission for traditional pelagic driftnet fishery until the July 2011. The general characteristics of driftnets used for albacore fisheries in Turkey are 170 mm stretched mesh size with rigged from 2000 to 7200 m in length and 300 to 600 mesh deepness (Akyol and Ceyhan 2012). Recently, purse seine, long line and line fishing are used for the fisheries of this species in Turkey. According to FAO worldwide landing data, there is an increasing trend are observed from 103678 t in 1950 to 202346 t in 2005 and reported total landings for this species as 238279 t in 2014 (FAO 2014). The largest landing area for this species in Turkey is the Aegean Sea with the amount of 57.8 tonnes and it follows the Mediterranean Sea with the amount of 12.8 tonnes in 2013 (TUIK 2013) and 53.3 tonnes in 2015 in the Mediterranean Sea (TUIK 2015). The total landings of Mediterranean Sea and Turkey are illustrated in Figure 1. Figure 2 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

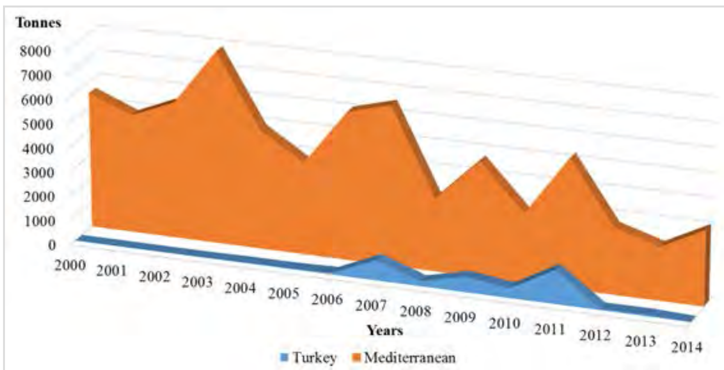

Figure 1. Total catch amount of *T. alalunga* in 2000-2014 (FAO 2014).

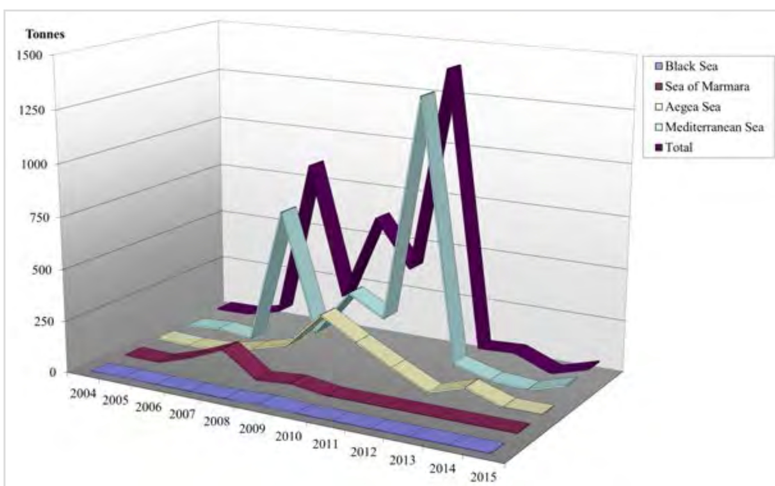

Figure 2. Total landings of *T. alalunga* in Turkey according to TUIK (2015).

2. 2. *Thunnus thynnus* (Linnaeus, 1758)

Common name : Atlantic bluefin tuna [En]
Family : Scombridae

Atlantic Bluefin tuna are the largest members of the family Scombridae and longevity is at least 35 years and possibly to 50 years (Santamaria *et al.* 2009). According to Santamaria *et al.* (2009) indicate a theoretical maximum length of 382 for males and 349 cm FL for females and, commonly 200 cm, 684.0 kg in weight. Atlantic Bluefin tuna exists in throughout the North Atlantic Ocean and adjacent seas, including the Mediterranean Sea and the southern part of the Black Sea. The sexual maturity reaches almost at 103.6 cm (FL), and females weighing between 270 and 300 kg produce as many as 10 million eggs per spawning season in the Mediterranean Sea (Corriero *et al.* 2005). The spawning season in in the Mediterranean are observed between May and July (Rodríguez-Roda, 1967; Susca *et al.* 2001; Medina *et al.* 2002; Corriero *et al.* 2003) where the fisheries are performed in the Mediterranean. Based on spawning sites ICCAT regulates the Bluefin tuna fishery currently recognizes two stocks: those of the west and the east Atlantic (the latter including the Mediterranean Sea), separated by the 45^0W meridian (Nemerson *et al.* 2000).

Fisheries: This species usually are taken by longline, trap and baitboat in the east Atlantic while purse-seine, longline and traps in the Mediterranean also recreational fishing may also be used. In Turkish waters, fisheries of this species have been particularly made by purse-seine. Very little longline catch was also used but mostly it was captured using by swordfish longlines as by catch (Ceyhan and Akyol 2014). However, it was fished using these nets as by catch until driftnets have been prohibited (Akyol *et al.* 2008). Because of its commercial importance, bluefin tuna is intensely fished and actually overexploited. Since 1970 the biomass of bluefin tuna broodstocks declined by 77% and 14% in the western and eastern populations, respectively (ICCAT 2005). *Thunnus thynnus* is known the most expensive among the tuna species. There are some regulations which have been made by ICCAT for tuna fisheries based on the regions since 1982. According to these regulations every country should be responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. Furthermore, there is still a considerable overfishing observed. The total catch reported for this species to FAO for 2014 was 14336 t. The countries with the largest catches were Spain (2446 t) and France (2419 t). The Mediterranean Sea is the majority of the catch area for the *Thunnus thynnus* as 62 percent of the global catch landed. The total landings of Mediterranean Sea and Turkey are illustrated in Figure 3. Figure 4 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

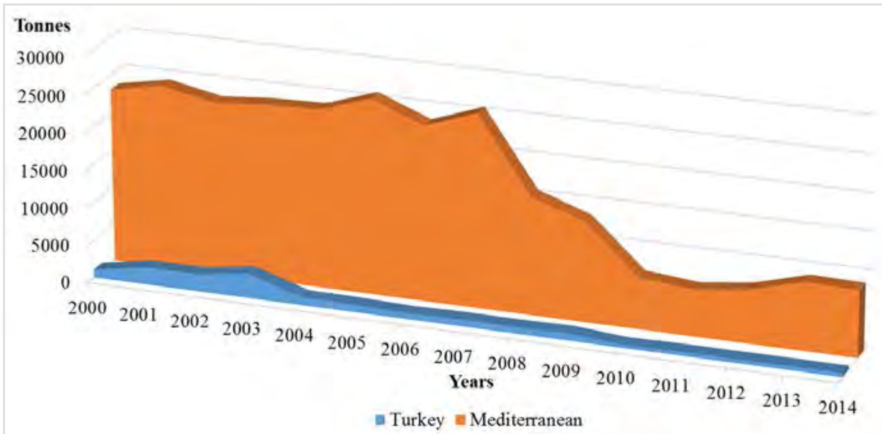

Figure 3. Total catch amount of *T. thynnus* in 2000-2014 (FAO, 2014).

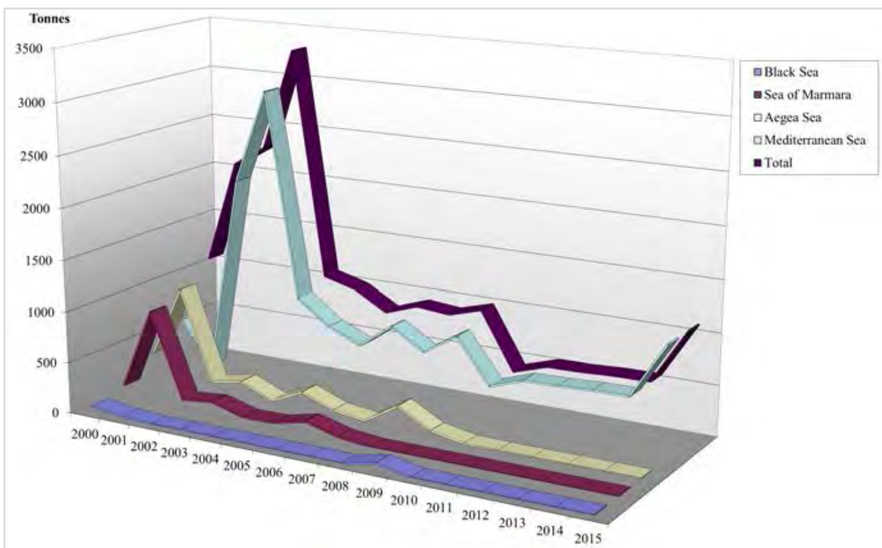

Figure 4. Total landings of *T. thynnus* in Turkey according to TUIK (2015).

2.3. *Euthynnus alletteratus* (Rafinesque, 1810)

Common name : Little tunny [En]
Family : Scombridae

E. alletteratus is schooling and less migratory than *Katsuwonus pelamis* or other tunas. This warm-water epipelagic Atlantic species is usually found in coastal areas with swift currents, near shoals and offshore islands and it is also found far offshore in the

Mediterranean including throughout the southern part of area except in the Black sea; rarely occurs north of the Iberian Peninsula; with a few isolated catches from Scottish and Scandinavian coasts. The size of fork length is up to 100 cm but commonly 85 cm, and 12 kg in weight (Whitehead *et al.* 1986; Froese and Pauly 2016). Little tunny spawns extensively, both geographically and temporally, throughout its respective range (Schaefer 2001). It has been reported that the spawning period extended from April to November (Whitehead *et al.* 1986). The spawning season of the little tunny in the Mediterranean is generally between May and September (Valerias and Abad 2006; Kahraman *et al.* 2008) but the most intensive spawning occurs between July and August (Hajjej *et al.* 2010). In the central Mediterranean Sea, the spawning period runs from June to September and minimum length at first sexual maturity are for male and female 42.8 and 44.8 cm and FL, respectively (Hajjej *et al.* 2010).

Fisheries: This commercial species is a part of multispecies fishery. In open waters it is taken with purse seines and trolling lines; juveniles are also taken with beach seines (Collette *et al.* 2011). Specialized traps (Madragues) are used in Tunisia and Morocco (Nobrega *et al.* 2009). Since several countries from the Mediterranean and Black Sea did not report catches to the ICCAT, it is commonly believed that catches of small tunas are strongly affected by unreported or underreported data in all areas (ICCAT 2009). The fisheries of small tunas are made mainly by coastal fisheries and often by artisanal fisheries also made, either as target species or as bycatch, by purse seiners, mid-water trawlers, handlines, troll lines, driftnets, surface drifting long-lines and small scale gillnets including several recreational fisheries. Almost all the commercial catches (99%) in the world are taken by purse-seiners (2067 t retained and 1434 t discarded) (STECF, 2009). Likewise commercial catch of the little tunny are fished by purse-seines in Turkey. According to FAO worldwide landing report the total catch amount of this species is 17053 t in 2014. Figure 5 shows the total landings of Mediterranean Sea and Turkey. Figure 6 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

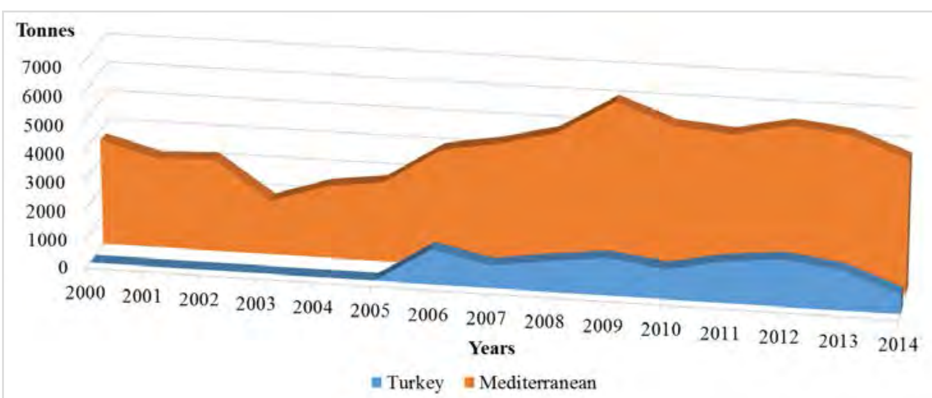

Figure 5. Total catch amount of *E. alletteratus* in 2000-2014 (FAO 2014).

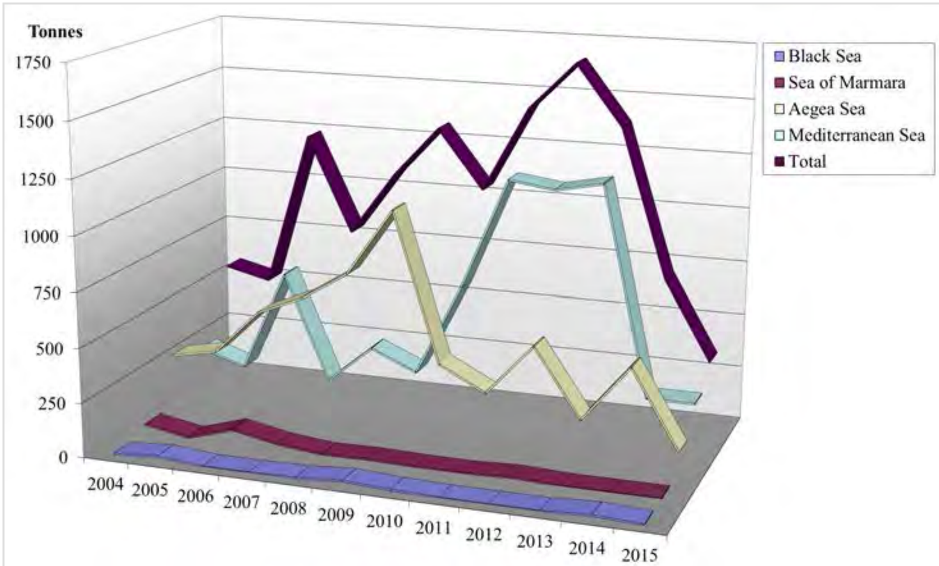

Figure 6. Total landings of *E. alletteratus* in Turkey according to TUIK (2015).

2.4. *Auxis rochei* (Risso, 1810)

Common name : Bullet tuna [En]
Family : Scombridae

A. rochei which forms large schools of similar sized individuals is an epipelagic species in inshore waters and near islands. This species is cosmopolitan in warm waters and present in the Atlantic, Indian, and Pacific oceans, including the Mediterranean Sea, widely distributed in the southern part of area and rarely north of the Iberian coast, except in the Black Sea (Collette 1986). The spawning season may vary from region to region depending on the hydrographical regime. In many parts of the Mediterranean and in the Straits of Gibraltar, maturing fish are common from May onwards, and more than 30% are spent by September. Extended spawning period is from November to August (Vassilopoulou *et al.* 2008). Bullet tuna are largely coastal spawners and spawning is thought to occur off Turkish water from May and September (Kahraman *et al.* 2010). Minimum and maximum catch length of this species reported that 28.5-44.5 cm and 34-48 cm from Aegean Sea and eastern Mediterranean Sea (Bök and Oray 2001; Kahraman *et al.* 2011).

Fisheries: It is caught mostly by purse seine, set surface gill nets, and small drift nets (the later was banned in EU countries in 2002), hand and troll lines, and traps. FAO does not report statistics for this species as Auxis spp. catches are generally not identified to species due to the similarity between *A. rochei* and *A. thazard*. Worldwide reported landings for Auxis spp show a gradual increase from 22 981 tonnes in 1950 to 480 971 in 2014 (FAO 2014). In the Mediterranean, this is a common species in fisheries and abundance changes from place to place every year. No assessment summary is given for this species from the Mediterranean because Auxis sp. catches are generally not identified to species due to the similarity between *A. rochei* and *A. thazard* (Collette *et al*. 2011). The statistics of ICCAT and FAO covers *A. rochei*, *A. thazard* and both of *A. rochei* and *A. thazard*. Over the period of 1999-2008, landings fluctuated between 288 128 and 366 559 t. Figure 7 shows the total landings of Mediterranean Sea and Turkey. Figure 8 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

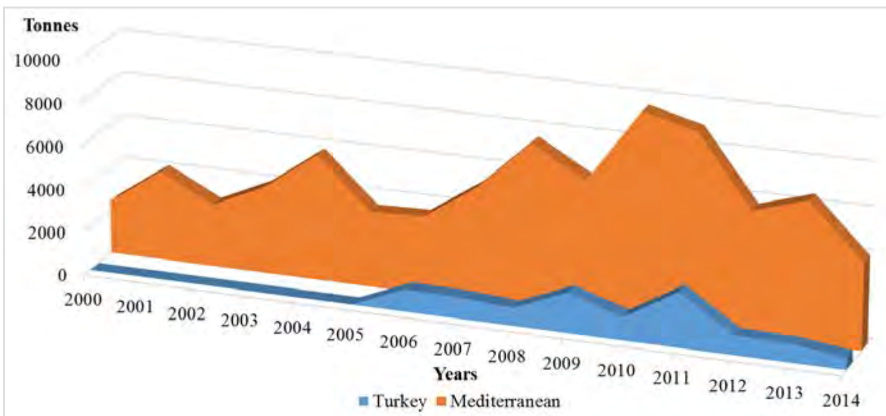

Figure 7. Total catch amount of *A. rochei* and *A. thazard* in 2000-2014 (FAO, 2014).

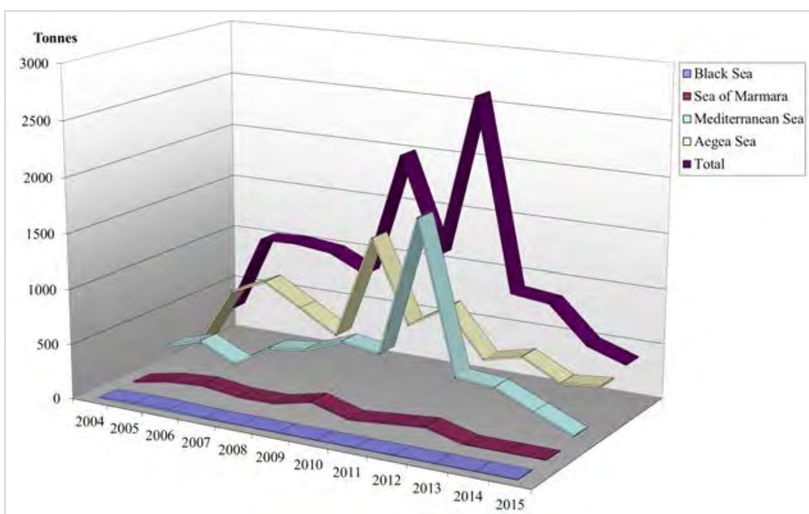

Figure 8. Total landings of *A. rochei* and *A. thazard* in Turkey according to TUIK (2015).

2.5. *Scomberesox saurus* (Walbaum, 1792)

Common name : Atlantic saury [En]
Family : Scomberesocidae

S. saurus is schooling and gregarious species which oceanic, epipelagic (usually in very upper layers) with a depth range of zero to 30 m and occasionally shoals close to shore in large numbers. This species is widely distributed in the subtropical and temperate areas of the north Atlantic including the Mediterranean Sea between 30° and 45° latitudes. *S. saurus* which is highly mobile is widespread in the Mediterranean Sea region, including in the Adriatic and Aegean Seas out to Israel, the coast of Tunisia and Morocco (Sauskan and Semenov 1968; Parin 1986; Wisner 1990; Frimodt 1995) and make large seasonal migrations. The species is more commonly present in late spring and summer in the north part of the Mediterranean Sea, and is more common in the south part in the winter (Collette, 2015). The size of total length is up to 50 cm (Robins and Ray 1986) but commonly 32 cm (Bauchot 1987), and mature at about 25 cm (Parin 1986; Froese and Pauly 2016). Atlantic Saury is a very fast-growing, short-lived species (Agüera and Brophy 2001). The reproductive period is extended all year long in the spawning areas, with characteristic spawning peaks at different locations occurring in slope waters and larvae have the potential to be broadly dispersed (Garcia 2011). Saury are likely batch spawners (Dudnik *et al.* 1981) accordingly intra-Mediterranean migration occurs for spawning (Fischer *et al.* 1987). It is also known to spawn in the central Mediterranean Sea from November to February (Potoschi 1996). Previously, it was reported that between 26 and 27 cm total length at least the fifty per cent of saury is already mature (L_{50}), for the north western Atlantic and the central Mediterranean Sea (Dudnik *et al.* 1981; Potoschi 1996; Collette 2002; Garcia 2011). Very little information is available on biology or population dynamics of Atlantic saury in Turkey (Deniz and Ateş 2015).

Fisheries: Atlantic saury has a minor commercial species in the Mediterranean Sea i.e. no substantial fishery. This species has an enormous fishing potential during several weeks in the spawning season due to its migratory behaviour. (García 2011; Collette 2015). Because the migratory character of the species with the timing of the fishing season varies geographically saury fisheries depends on season. Atlantic saury (García 2011) is mainly fished for human consumption as well as fresh and tinned and also used for bait. Saury have traditionally been targeted by a small scale fishing in southern Italy (Potoschi 1996) and have also supported a small scale industrial fishery on the Mediterranean coast of southern Spain as well as a seasonal fishery in the south Mediterranean (Abad and Giraldez 1990; Giraldez and Abad 1991). For instance, saury which is the object of a small scale fishery in the Bay of Biscay and in the Mediterranean Sea catches up to 2000 metric tonnes per year (García 2011). Small catches are also reported from Morocco, although it may be of potential commercial interest (Collette 2015). However driftnets have been banned in the Mediterranean Sea since 2002 for some species, including *S. saurus* (Collette 2015). In Turkey, saury which moves rarely with a small school of fish can be caught generally by surrounding nets, gill nets and occasionally by beach seines and baited longlines. Because there is no mass catching of these rarely fishing species, caught along with mass catching species throughout the year, regular marketing can not be done. The total landings of Mediterranean Sea and Turkey are illustrated in Figure 9. Figure 10 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

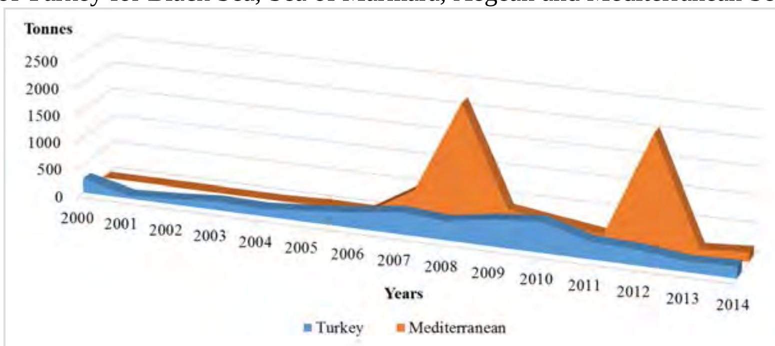

Figure 9. Total catch amount of *S. saurus* in 2000-2014 (FAO, 2014).

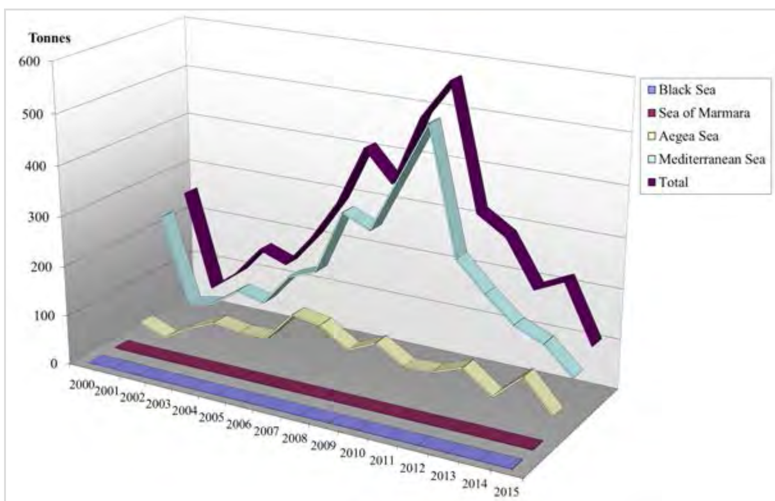

Figure 10. Total landings of *S. saurus* in Turkey according to TUIK (2015).

2.6. *Xiphias gladius* Linnaeus, 1758

Common name : Swordfish [En]
Family : Xiphiidae

X. gladius which is aggressive and strongly migratory exists in tropical and temperate waters down to 800 m as a solitary for the most part. The swordfish is a pelagic and oceanic species occurring in the Pacific, Indian and Atlantic Ocean, including the

Mediterranean Sea, Sea of Marmara, the Black Sea, and the Sea of Azov. The size of fork length is up to 455 cm but commonly 300 cm and 540 kg in weight. The weight of adults is rarely 230 kg in the Mediterranean and generally females are larger than males (Nakamura, 1985). Most of papers reported that its spawning occurs in the summer months, begins in June and continues until September (De Metrio and Megalofonou 1987; Tserpes and Tsimenides 1995; Orsi Relini *et al.* 1999; Tserpes *et al.* 2008) and migrates in the eastern Mediterranean toward the eastern Levantine Sea for spawning, concentrating in specific areas during the peak of spawning season (Tserpes *et al.* 2008). It was previously estimated that 50% of female swordfish in the Mediterranean Sea mature at 142 cm (De la Serna *et al.* 1996). In the Mediterranean Sea, sexual maturity of this species occurs at 2-5 year of age (De Metrio *et al.* 1989). In Turkish waters sexual maturity of this species reaches at 139.5 cm (Alıçlı *et al.* 2014) while in the Mediterranean, this size varies between 125 cm and 142 cm (de la Serna *et al.* 1996; Di Natale *et al.* 2002).

Fisheries: The fisheries of *X. gladius* in the Atlantic, Indian and Pacific oceans plays an important role especially regarding food and game species. Longline, harpoon, driftnet, set net and other fishing gear in commercial fisheries are widely used for swordfish fishery but swordfish is also taken as a bycatch in tuna longline fisheries. In the Mediterranean Sea, the fisheries of this species are performed by driftnets, long lines, harpoons, tuna traps as well as sport and recreational fisheries. Currently, fisheries of this species are widely made using by longline and harpoon (especially in the Aegean Sea) in Turkish waters. The average weight of the commercial swordfish caught by longliners ranges from 115 to 160 kg in the Mediterranean Sea and known as a good food fish, marketed fresh or frozen. Comparison of landings for the years it can be clearly seen that there is an increasing trend up to date from 1950. The highest amount of swordfish in the Mediterranean Sea is caught by, in the order, Italy, Greece, Spain and Morocco in the recent years. While it can be caught as a target in Algeria, Cyprus, Malta, Portugal, Tunisia and Turkey, catches of swordfish have also been incidentally taken by Albania, Croatia, France, Japan, and Libya in the Mediterranean. Another point of view it can be observed a high and growing trend as a fresh consumption for swordfish fisheries in most Mediterranean countries. The total landings of Mediterranean Sea and Turkey are illustrated in Figure 11. Figure 12 also shows the total landings of Turkey for Black Sea, Sea of Marmara, Aegean and Mediterranean Seas.

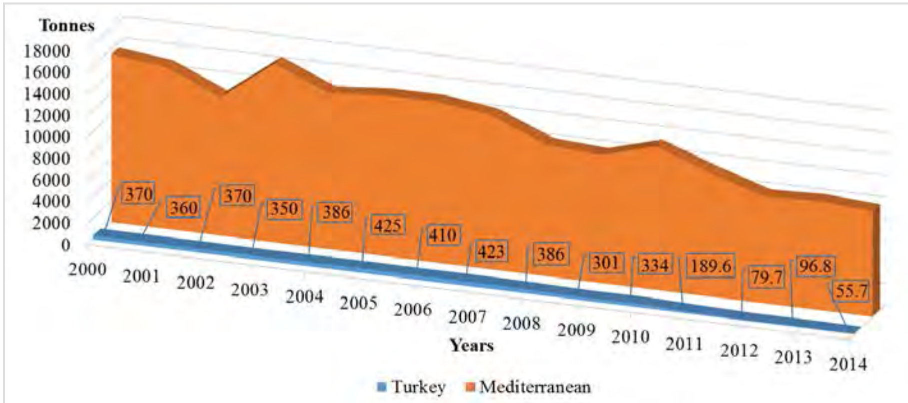

Figure 11. Total catch amount of *X. gladius* in 2000-2014 (FAO, 2014).

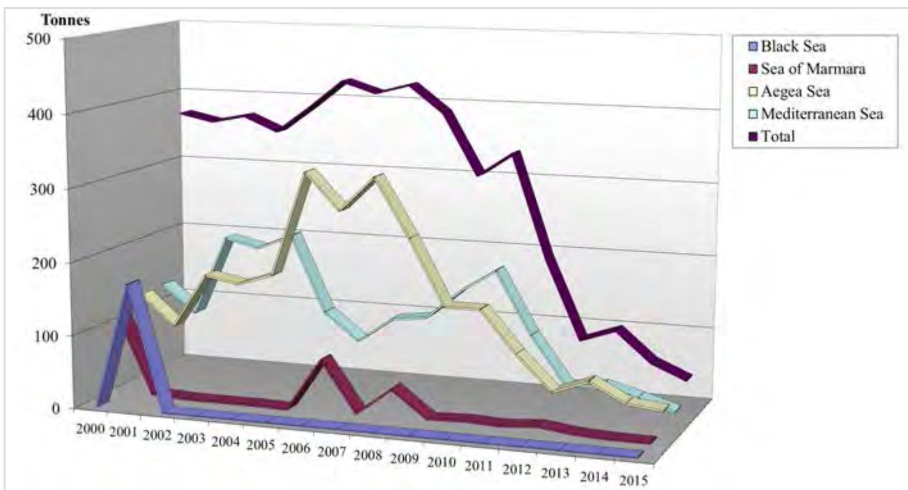

Figure 12. Total landings of *X. gladius* in Turkey according to TUIK (2015).

3. Conclusion

This paper deals with the highly migratory fish species observed in the Mediterranean Sea regarding to their short description e.g., reproduction, habitat and distribution associated with the commercial fisheries. HMS has the great value in the world and European commercial fisheries. There is limited number of studies on these species. Among 16 highly migratory bony fish species, only 4 or 5 species have been studied especially in the Mediterranean Sea related to Turkish HMS fisheries. Although these species are fished by longline, purse seine, driftnet, handline, haul seine, trammel net, trawl and troll in the Mediterranean, purse seine and longline are used in Turkey. All species cited here play an important role because of their volume of landings and high economic value for

Mediterranean Basin. However the total catch amount of these species is recorded approximately 1% (according to TUIK data) in the total fish landing of Turkey.

Highly migratory species which are commercially caught are *Thunnus alalunga*, *Thunnus thynnus*, *Euthynnus alletteratus*, *Auxis rochei/Auxis thazard*, *Xiphias gladius* and *Scomberesox saurus* in Turkey. Among them *T. thynnus* and *X. gladius* that are exported as fishery products have an importance economic contribution approximately with 39102935 $ (TUIK 2013). *T. alalunga*, *T. thynnus*, *E. alletteratus*, and *A. rochei/A. thazard* are commercially taken by purse-seine and they are also caught by longlines which are used for swordfish and leerfish fisheries as by catch. The swordfish fisheries are especially made by longline but the harpoon is still used in catching. There is no study reported on fishing gears and the fisheries of *S. saurus* which is caught mostly by-catch as well as recreational fishing. Besides all these, driftnets have been extensively using for the fisheries of *X. gladius*, *T. alalunga* and *E. alletteratus* for a long time until it was banned totally in 2011. In addition, HMS are generally caught by mutually as by-catch and evaluated economically i.e. Atlantic bluefin tuna caught in swordfish longline.

Fishing is a vibrant system that moves based on many different dynamics such as social, economic, environmental conditions etc. Therefore, fishery landings data are affected by various factors that lead to fluctuations of catch amounts. These fluctuations can be clearly seen from TUIK data according to the years. For instance, the dirft nets, which were banned in 2006 but continued to be modified until 2011 and completely banned from this date, was a highly effective and widely used fishing gear for the fisheries of *X. gladius*, *T. alalunga* and *A. rochei/A. thazard*. It is thought that the removing of driftnetes from the marine environment resulted in a decrease in the landings of *X. gladius*, *T. alalunga* and *A. rochei/A. thazard* from 97.4 tons to 31 tons, from 1308 tons to 59.3 tons and from 1741.6 tons to 382.9 tons, respectively. However, Atlantic bluefin tuna fishery is performed in Turkey depending on the country quotas determined by ICCAT (International Commission for the Conservation of the Atlantic Tunas), where Turkey is also a member. Therefore, ICCAT determines and implements prohibitions such as minimum landing size, time and catch amount related to fisheries for this species in the Mediterranean. Swordfish fishery is also regulated by ICCAT. Among other tuna and tuna-like species, the prohibitions to be implemented with the ICCAT's recommendation are left to the countries.

Fisheries targeting highly migratory fish must be managed at community level notably in the framework of the relevant regional fisheries organisations, namely the International Commission for the Conservation of the Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM). The community will actively promote multilateral management of these stocks, including as necessary catch limitations, technical measures and effort limitations (COM 2002). It is well known the methodology of fish stock assessment and prediction changes according to increasing availability of data. Assessing a fish stock has different steps which can be summarized to define the objectives of the assessment according to the development phase of the fisheries and the available information. Especially, fisheries commercial statistics are based on total and resource landings, catch per unit effort, fishing effort (number of trips, days, tows, spending time of fishing, etc.) and characteristics of the gears used. Types of operation of the fleets, fishing gears etc., and biological samplings are also necessary to asses on board commercial and research vessels in the landing area (Sparre and Venema 1998; Cadima 2003). The GFCM Scientific Advisory Committee on Fisheries (SAC) considers that several stocks are overexploited, some with a high risk of collapse, and that sustainable management requires that measures aimed at limiting the capture of juveniles are implemented (GFCM, 2016). Concerning on management of HMS species in Turkey is needed to be more updated scientific and statistical data for further sharing stock management regulated by international comities such as ICCAT, GFCM to get right owner of Turkish fisheries.

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FISHERIES IN ISKENDERUN BAY
FISHING GEARS, CATCHING METHODS AND THEIR MAIN PROBLEMS

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1. Introduction

Iskenderun Bay is the most important fishing area on the Turkey's Mediterranean coast. Fishing has become an important part of the life and culture of this area from past to present. In the mosaic of Thalassa the Sea in the Hatay Archaeological Museum (M.S.5), human figures catching fish by boat and line, even fishing by beach seine are clearly seen (Figure 1). This mosaic is a good example that the fishing culture of the region is based on past.

Figure 1. Mosaic of Thalassa the Sea (Hatay Archaeology Museum Inventory No:1017)

This deep-rooted culture has reached to the present day, in keeping with the conditions of our time. Today, there are 11 fishing ports on the 131 nm coast line from Karatas in the western tip of the bay to the border of Syria (Figure 2). In these fishing ports, almost all fishing methods such as gill and trammel nets, longline, pot, trawl and purse seine are applied and approximately 790 fishing boats whose sizes range from 5 to 38 m in length are operating.

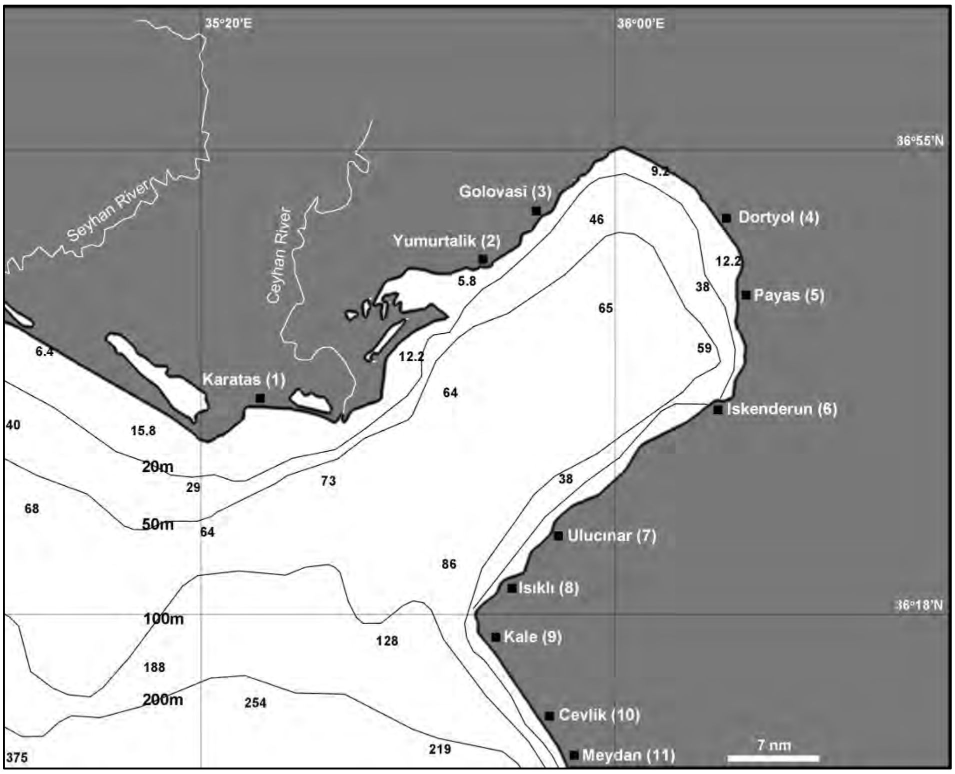

Figure 2. Iskenderun bay and fishing ports

2. Characteristics of Fishery in Iskenderun Bay

The size of the fishing boat determines the generally applied catching methods. While set nets, longline and pot fishing are performed small than 12m, trawl and purse seine fishing are carried out with fishing boats larger than 12 m. Therefore, fishing boats can be divided into two groups according to their length; < 12m (small scale) and ≥12m (trawl and purse siene) and the fishery structure of the region can be examined according to these length groups.

2.1. Small Scale Fishing in Iskenderun Bay

Under this heading, gill and trammel net, longline and pot fishery made with a fishing boats smaller than 12 m will be examined. In 11 ports mentioned above, a total of 657 boats are engaged in small-scale fishing. The majority of these boats can be used with several different catching methods. For example, a fishing boat makes shrimp catching with shrimp trammel nets between June and August, same boat can makes longline fishing between September and October, even it can make sole fishing with sole trammel nets between December and March. However, there are also boats that use only a catching method such as longline during the all fishing season.

2.1.1. Gill and trammel net fisheries in Iskenderun Bay

382 of the 657 boats dealing with small-scale fishing (smaller 12m) use gill and trammel net. These boats use gill and trammel nets more than 21000 panels. More than 80% of these panels are formed by sole and shrimp trammel nets. For this reason, gill and trammel nets in the bay can be subdivided into three groups, namely, sole trammel nets, shrimp trammel nets and other gill and trammel nets. The total numbers of panel for sole trammel net, shrimp trammel net and other gill and trammel nets according to the fishing port is given in Table 1. From this table, it is seen that the sole and shrimp trammel nets are used intensively in the fishing ports located in the western part of the bay. The number of the sole and shrimp trammel nets used in Karatas, Yumurtalik and Gölovası in the western part of the bay constitutes approximately 85% of the total number of sole and shrimp trammel nets. Iskenderun Gulf is surrounded by Cukurova in the west and Amanos Mountains in the east. The bottom structure in the marine area is also the continuation of these two geographic areas. The depth in the western part (region bounded to Cukurova) is slowly increasing and ın this area, the bottom is usually sandy and muddy. The depth increases very rapidly in the eastern part of the bay and the bottom has a very rocky structure. Naturally, the sole and shrimp fishing is carried out in the region where there is the sandy muddy bottom structure. The general characteristics of sole and shrimp trammel nets used in the region are given in Figure 3.

In the bay, the sole catching is usually carried out in a 10-65m depth contour between December and March and shrimp catching in 10-65m depth between June and November. It can be said that the sole (cold period) and the shrimp catching (hot period) are made in successive periods.

In the bay, the mean number of the sole trammel nets for per boat is around 40 panels. However, some boats have 120 panels. The fishermen of the region say that the maximum number of panels used in the boats at the beginning of 2000’s was around 20. But the number of panels increased as the catch rate decreased overtime and this incline goes on nowadays. This is a typical over fishing indicator. With the new legislation in 2016, the maximum number of the gill and trammel nets number that can be carried in a boat is limited to 60 panels (2016/35). This situation requires that some of the fishing boats reduce the number of sole trammel nets. In addition, according to the fishing regulations, the minimum mesh size that can be used in sole trammel nets is 80mm. However, in our field studies, we frequently observed the using of the sole trammel nest with a mesh size of 64mm. In the region, the sole fishing and the trawl fishing coincide in respect of both time and catching area. This causes frequent conflicts between these two fishing gears. This situation creates both a risk of ghost fishing and social problems among fishermen.

Table 1. Number of panels of gill and trammel nets used in Iskenderun Bay according to fishing ports (Özyurt *et al.* 2012).

Fishing Port	**Sole trammel net**		**Shrimp trammel net**		**Other gill and trammel nets**	
	Panel	**Fishing boat**	**Panel**	**Fishing boat**	**Panel**	**Fishing boat**
Karatas	5116	82	3080	102	496	23
Yumurtalik	1303	47	3145	103	1157	99
Golovasi	731	43	1235	47	308	54
Dortyol	270	13	298	9	637	32
Payas	0	0	107	8	105	8
Iskenderun	494	21	737	28	741	39
Arsuz	314	14	206	12	199	17
Konacik	0	0	0	0	84	6
Kale	0	0	0	0	135	9
Cevlik	253	7	0	0	147	12
Meydan	0	0	0	0	105	7
Total	8481	227	8808	309	4114	306

The mean number of shrimp trammel nets used for per boat in the bay is about 30 panels. However, the number of shrimp trammel nets number used in some boats is 60 panels. This catching method is used in the summer period when almost no other catching methods are used. For this reason, it is the most important source of income for fishermen who are engaged in small-scale fishing in summer. In this catching method, the most important problem that fishermen experience is that their nets are damaged very quickly. Shrimp nets are quite thin ($105/2^D$). Therefore, nets are affected very quickly by environmental conditions such as currents and waves. Fishermen mention that a panel shrimp trammel net is damaged maximum within up to 1-2 months. This makes the financial return difficult for these catching methods.

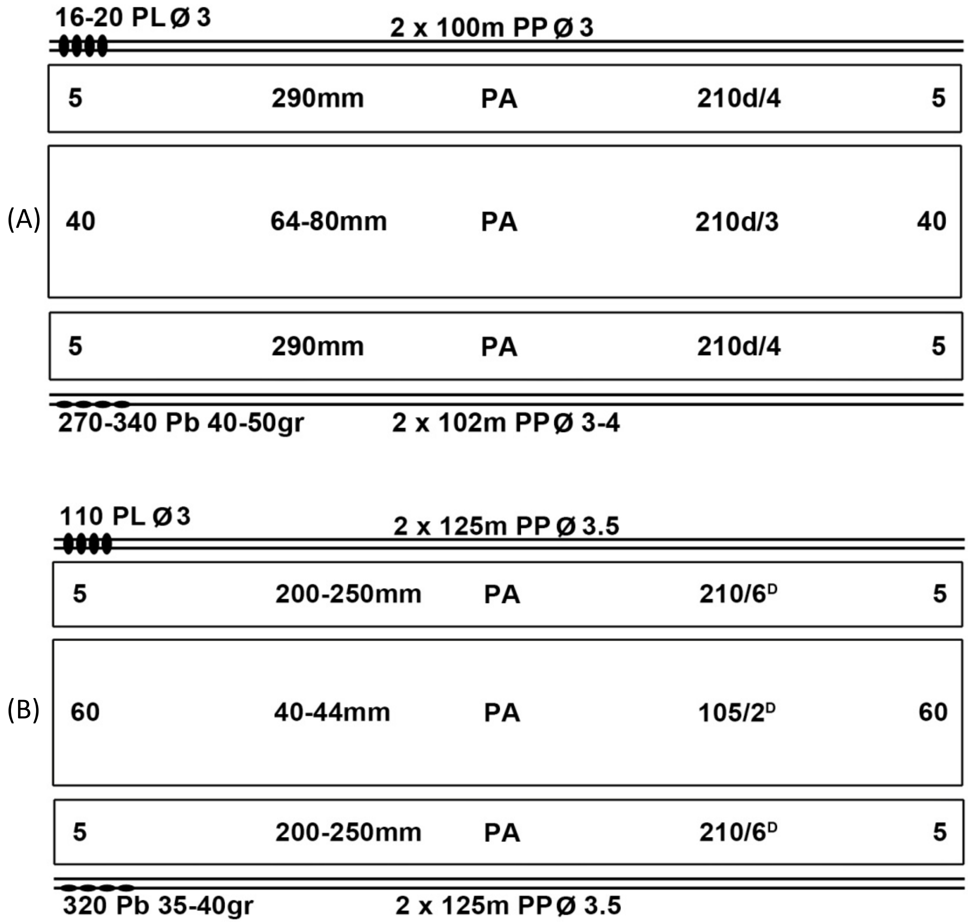

Figure 3. Technical characteristics of sole (A) and shrimp (B) trammel nets (Özyurt *et al.* 2008; Özyurt *et al.* 2009)

2.1.2. Longline Fishing

Longline fishing is practiced intensively in every fishing port in the Iskenderun Bay. The longline fishing is carried out in 467 of the 657 fishing boats. Almost all of the longline used in the region are at the demersal longline (Figure 4). In this type longline, target species are white grouper, common pandora, gilthead sea bream etc. In nearly all of the demersal longline; the mainline is made of 0.7-1 mm monofilament, and the snoods is made of 0.5 – 0.8 mm monofilament. The length of the snoods is between 0.9 and 2 m, and the distance between the snoods is between 3.5 and 9 m. The hooks numbers vary between 4 and 14. Sardines are usually used as bait.

Demersal longline catching continues throughout fishing season. However, this type of catching is particularly intense between September and November and April and May. The least intensive use of demersal longline is June, July and August. To obtain bait fish is difficult in these months. In addition, fishermen say that sharks have greatly damage longlines during this period.

As mentioned earlier, longline fishing is applied extensively in entire bay. However, the proportion of fishing boats that use only longline fishing is higher in the east of the bay. There are two fishing boats making only longline catching during the fishing season in Karatas fishing port. There is no fishing boat carrying out only longline catching all fishing season in Yumurtalik and Golovasi fishing ports. A considerable proportion of the fishing boats in Dortyol (36.23%), Payas (34.88%), Iskenderun (46.97%), Arsuz (36.76%) and Konacık (22.22%) are carried out only longline catching all fishing season. This case seems to be directly related to the bottom structure of the bay. In other words, the longline fishing is intensive in the region where there is rocky base structure.

Figure 4. Demersal longline used in Iskenderun Bay

In Turkey, white grouper (*Epinephelus aeneus*) catching was banned in 2016 (2016/35). White grouper is the most important target species for fishermen using demersal longline. In order that the fishermen obey this regulation, alternative solutions should be produced, otherwise; illegal catching in the region would be inevitable.

In the region, different types of pelagic longline are used such as shark longline, sword fish longline, sea bass longline, bluefish longline. However, the number of fishing boats using them is rather few. Due to the prohibition of the white grouper catching, some fishermen may head towards this type of pelagic longline. In some surveys, it was observed that sea birds and sea turtles were caught in the pelagic longline. Increased numbers of pelagic longline can lead to increased mortality in water birds and sea turtles.

2.1.3. Pot trap fishing

In Iskenderun Bay, 87 of the 657 fishing boats engaged in small-scale fishing (13.24%) carry out pot fishing. A total of 4741 pots is used in these boats. The pots are all circular and their diameter varies between 50 and 100 cm and their height varies between 40 and 50cm. The frame of the pots is made of iron rods (8-10mm) and this frame is covered with hexagonal wire netting (Figure 5). In this type of the catching, the pots are under water during the fishing season. Fishermen check the pots in every two days to take the fish caught and they bait the pots again. Sardines are usually used as bait. Pots are set under the water to wrap around the rocks. Target species in pot catching are white grouper and common pandora. However, other species of serranidae and sparidae are caught. Pots traps are heavily used between June and September. However, there are some areas where catching continues throughout the fishing season.

Figure 5. Pot traps used in Iskenderun Bay

Pot traps are never found in Karatas, Yumurtalik and Golovası fishing ports. On the contrary, they appear to have been used more or less in every fishing ports eastward from Dortyol (Table 2). This is probably related to the bottom structure of the bay. As mentioned earlier, the bottom of the western part of the bay is sandy and muddy (Karatas, Yumurtalık and Golovası), and the bottom of eastern part (Dortyol, Payas, Iskenderun, Arsuz, Konacik, Kale, Cevlik and Meydan) is rocky. Namely, the pot catching is carried out in regions where the bottom structure is rocky.

Pots fishing is prohibited in all Turkey's Mediterranean coasts in 2012 (2012/65). However, according to our observations, this type of catching continues in the region. The fishermen set pots without marker buoys to avoid of getting caught by the authorities. Therefore, the possibility of losing of pot traps is increasing. Namely, the risk of ghost fishing related to these fishing gears is high.

Table 2. Number of pot traps used in Iskenderun Bay according to the fishing ports (Özyurt *et al.* 2008)

Fishing Port	**Pot**	
	Number	**Fishing boat**
Karatas	0	0
Yumurtalik	0	0
Golovasi	0	0
Dortyol	120	2
Payas	850	10
Iskenderun	290	5
Arsuz	966	28
Konacik	1980	31
Kale	60	1
Cevlik	200	3
Meydan	275	7
Total	**4741**	**87**

2.2. Trawl and purse seine fishing

In this region, there were only two trawl boats in the 1940’s. In the 1950’s, this number increased to 14 trawl boats. In this period, the first findings of over fishing were revealed by Aasen and Akyüz (1956) and Akyüz (1957) in Iskenderun Bay. However, the rapid increase in the number of the boats continued until the 1980’s (Gücü *et al.* 2010). Today, approximately 100 boats, ranging in size from 12 m to 33 m in length are performing trawl catching in the bay. These boats are located in Karataş, Iskenderun and Cevlik fishing ports. About half of the trawl boats are in Karatas fishing port, the rest are in Iskenderun and Cevlik fishing ports. These trawl boats usually use the nets called traditional Mediterranean type or Ottoman type trawl net (Figure 6).

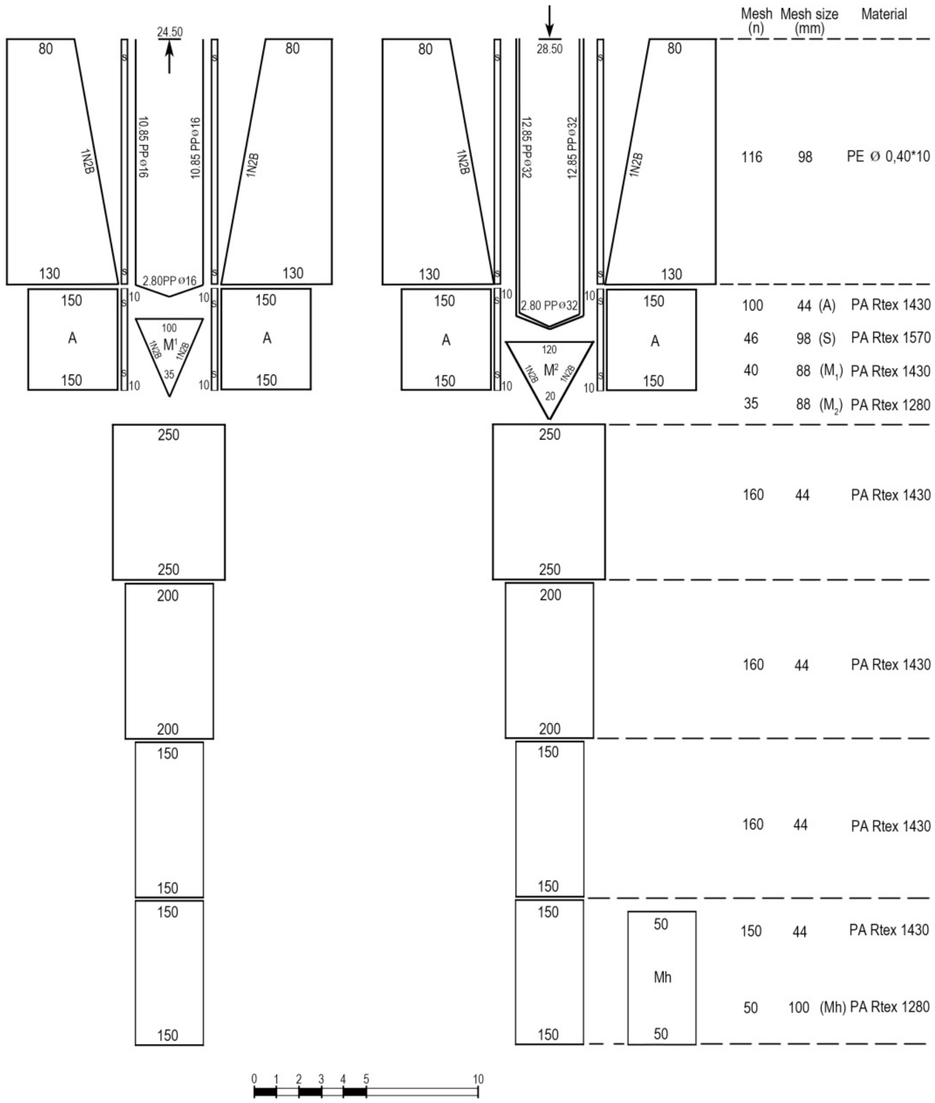

Figure 6. Technical characteristics of trawl net

The increase mentioned above in the number of the trawl boats over time has led to a more serious problem of overfishing in demersal stocks. Our observations show that in recent years almost all trawl boats has given up catching about three or four months before the fishing season is closed. In addition, ıt is common that the mesh size used in cod-end is smaller than the legal minimum mesh size (44 mm). These are indicative of overfishing pressure on demersal stocks. In the last few years, some trawl boats have left fishing fleet benefiting from the support of Republic of Turkey Ministry of Food, Agriculture and Livestock. Nevertheless, there is no significant decrease in the number of trawl boats.

Target species in bottom trawl fishing are naturally demersal species. However, it is observed that the target species in trawl fishing can change over time in the region. Iskenderun Bay is a region that is highly affected by invasive species, especially indopasific species. This colonizing species affect the catch composition of trawl fishing. For example, in the study conducted between 1980 and 1982, it was determined that teleost species forming main catch in trawl fishery were *Saurida undosquamis, Mullus barbatus, Equilites klunzinger Trigla lucerna, Arnoglossus laterna, Upeneus mollucensis*, *Solae solea* (Bingel et al.1993). In the study conducted in 2013, it was determined that the teleost species forming the main catch in the trawl fishing were *Equilites klunzingeri*, *Mullus barbatus*, *Nemipterus randalli*, *Saurida undosquamis, Pomadasys stridens* ve *Pagellus erytrinhus* (Özyurt, unpublished data). There are differences between the two studies in terms of the species that constitute the main catch. Moreover, the first records of *Nemipterus randalli* and *Pomadasys stridens* on the Mediterranean coast of Turkey, were given in 2008 and 2009, respectively (Bilecenoğlu and Russel 2008; Bilecenoğlu et al. 2009). That is to say, these two species were among the species forming main catch of trawl fishing in a very short time.

Until 1981, there is only one purse seine boat in İskenderun and Mersin Bay. However, strict prohibitions (such as 3 miles) and decrease in CPUE have caused the number of purse seines in this area to have increased rapidly by 6-8 at the beginning of the 1980s. In addition, 2-4 purse seines have migrated to the region from the Black Sea in the same period (Bingel et al. 1993). Today, about 30 purse seine boats whose lengths vary between 13 and 38 m operate in Iskenderun Bay. These 30 purse seine boats are located in the Karatas, Iskenderun and Cevlik Fishing ports. About 10 of these boats are located in Karatas Fishing ports, the rest are located in Iskenderun and Cevlik Fishing ports. The technical characteristics of the purse seine nets used in these fishing boats are generally similar (Figure 7). There are differences only in size.

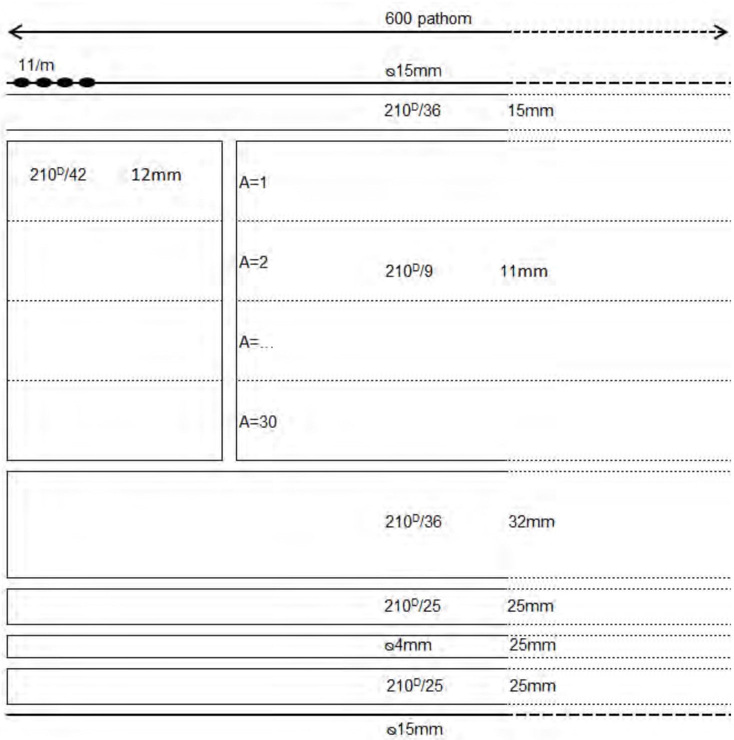

Figure 7. Technical characteristics of purse seine net (Taşdemir, 2002).

One of the most important problems in the seine fishing is catching with light. Catching with light in Turkey is prohibited both in territorial and in international waters. But the fishermen are opposed to the prohibition of catching by light in international waters.

3. The impact of the costal industry on fishery

In Iskenderun Bay, there are many industrial establishments such as iron and steel plant, thermal power plant, fertilizer factory, oil pipeline marine terminal on the coast between Yumurtalik and Iskenderun. The number of these industrial establishments continues to increase. The impact of such plants on the marine ecosystem and fisheries is quite complex and should be discussed and examined in detail. However, some effects of these can be easily observed. Due to the ports and piers of these plants and their security zone, the catching area of the fishing boats engaged in small-scale fishing is narrowing. Besides, these plants cause heavy maritime traffic that is one of the most important sources of pollution in the region. In the field study, we often come across the evidence of pollution from marine traffic (Figure 8).

Figure 8. Solid waste in trawl sampling

4. Conclusion

Classic indication of overfishing is a decrease in catch coincident with an increase in effort. This has been observed in every catching method in Iskenderun Bay for a long time. In this case, more than 2000 people who make a living by doing fishing are affected negatively. Hence, the fishermen tend to conduct poaching, even smuggling. Thus, fishermen are confronted with official authorities. It is necessary to reduce fishing effort to solve this problem. However, realistic alternative solutions should be produced for people engaged in fishing.

It is not possible to give up industrial activities in the bay. Nevertheless, the adverse effects of these activities on fisheries should not be overlooked. Necessary measures should be taken.

Note: A significant part of the data in this study was obtained from field studies conducted in the context of TÜBİTAK project (Project No:107Y221). In addition, we also used our individual observations in other studies in the region.

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DEEP-SEA ECOSYSTEMS OF THE EASTERN MEDITERRANEAN

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1. Overview of the special case of the Eastern Mediterranean Deep-Sea

The Eastern Mediterranean Basin is separated from its western counterpart through a narrow but deep Sicilian Strait. The maximum depth of the Eastern basin, near 5000 m, is significantly larger than that of the West (3000 m). Most of the Eastern Mediterranean consists of deep basins connected to shallower sub-basins such as the Adriatic Sea and the Aegean Sea. The Eastern Mediterranean deep-sea is also a relatively warm environment, with a 12 °C minimum in the deepest trenches, an order of magnitude warmer than the deep-water temperatures of the Atlantic and Pacific Oceans (2-4 °C). The Eastern Mediterranean is also significantly more oligotrophic than the Western basin, indeed being one of the most unproductive seas in the global ocean. When considered with the large depths in the basin, this implies that the organic carbon flux from the euphotic zone to the abyssal zone is minimal, putting an upper limit on the amount of biomass that can feed on exported organic carbon (Tselepides and Eleftheriou 1992). Since the dissolved O_2 levels and intermediate water temperatures are also relatively high, the water column decomposition rates are also higher, further limiting the arrival of organic matter to the deep-sea. In addition, the formation and westward migration of Levantine intermediate water (Özsoy *et al.*, 1993) can also transport surface ocean particles towards the Western Basin, putting an additional constraint on deep-sea ecosystems relying on heterotrophic lifestyles. This aspect renders the chemosynthetic in situ production a key ecological game-changer. As a result, the deep-seafloor ecosystems of the Eastern Mediterranean remains as a natural laboratory waiting to be explored to study biogeochemical and ecological feedbacks in a warming global ocean (WWF/IUCN 2004).

The oceanographic peculiarities of the EM are coupled to the unique geological history and present-day active tectonics of the region, together providing the driving force behind the formation of specific seafloor habitats. The EM is geologically much more active compared to the Western basin, harboring a quite complex geodynamics. with the break up and collision of Eurasian and African plates (Mascle *et al.* 2000). Basically it is the remnant of the ancient Tethys ocean (200 MA) – but the present-day seafloor is traced to a structurally younger Neotethys ocean floor (40 MA). The destruction of the ancient ocean floor still goes on as manifested by submarine volcanism over the Hellenic Arc, submarine and subaerial mountain building and numerous fault zones. About 5 million years ago the Mediterranean underwent a complete dry-up, called the Messinian Salinity Crisis. This event had a profound influence in the paleoclimate of the basin, but also contributes to the creation of unique habitats in the present day due to the channeling of salt towards seafloor and formation of ‘brine pools’ at the seafloor. Since the Messinian crisis, the Eastern Mediterranean responded to orbital climate forcing and changing hydrological regime in the surrounding continental environments (Schmiedl *et al.* 2010). Notable paleoevents include episodic anoxia in the deep Eastern Mediterranean basin, as recorded as organic rich sapropels in the sedimentary record (De Lange *et al.* 2008).

Combined action of long-term processes of tectonics and uplift and short term oceanographic and ecosystem processes result in the creation of unique deep-sea benthic habitats in the Eastern Mediterranean. A majority of the benthic habitat is in the form of soft bottom sediments that refer to soft, often muddy benthic environment dominated by the material accumulation from surface pelagic ocean. Submarine canyons cross-cut the continental shelf, connecting shelf to deep-basin and have a V-shaped cross-section with steep walls often with rock outcrops. Hydrothermal vents occur in volcanically active hotspots, spreading ridges or subduction zones and emit high-temperature fluids that are often laden with reducing chemicals. Cold seeps are the areas where hydrocarbon from deep Earth is advected towards the seafloor-water interface, as a mixture of gaseous light hydrocarbons such as methane (CH_4). Cold seeps over the seafloor include geomorphological features such as relatively small pockmarks but can be as extensive as kilometers-wide extrusive mud volcanoes. Seamounts are seafloor geomorphological elevations that rise at least 100 m above the surrounding seafloor that may be associated with active tectonism and therefore may host both hydrothermal vents and seeps along with the seamount itself serving as a refuge for many species. In the following section we will expand on these habitat types, focusing on their biogeochemical characteristics and some of their unique biological inhabitants.

2. Different habitat types, biogeochemical settings

2.1 Soft bottom Sedimented habitats

Much of the deep-sea soft bottom in the Eastern Mediterranean consists of fine-grained silt-mud material. Organic carbon levels in the surface levels area typically low (<2%wt). Although benthic high-resolution biogeochemical profiles are relatively few, high dissolved oxygen levels in the bottom waters must enable large O_2 penetration depths into the sediment. This is in contrast to Black Sea, for example, where bottom water O_2 is near zero and then sulfidic with increasing water depths. Despite low organic carbon fluxes, elevated concentrations of phytopigments can be found in deep basin such as in the surface sediments in the Ieapatra (2500-4500 m) basin in the south of Crete, indicative of episodic deposition of photosynthetic products. As a general pattern also found in the water column, the benthic biodiversity decreases from Western to Eastern basin (Danovaro *et al.*, 2010) although this must be analyzed with caution as much fewer studies have been conducted in the Eastern basin. Still some pattern emerge, such as foraminiferal diversity is lower in the East, parallel with the decreased organic carbon fluxes to sediments. Macrofaunal diversity is dominated by polychates in all depths, but deposit feeders are more dominant at shallower areas whereas subsurface deposit feeders and predators increase with depth (Kröncke *et al.* 2003). The total organic carbon content of the sediment is highly correlated with macrofaunal abundance, highlighting the importance of vertical food fluxes in the East Med soft bottom habitats. Nematodes are also common occupants of the soft bottom habitat, making up about 80% of the meiofaunal diversity (see Danovaro *et al.* 2010). The prokaryotic (bacterial + archaeal) diversity is only beginning to be uncovered but the limited studies show that a large fraction of prokaryotes are associated with the degradation of organic matter. Interestingly, the phytopigment levels and microbial activity indicators were order of magnitude higher in deep trenches (Hellenic and Pliny), pointing to lateral transport and accumulation of organic particles down steep trench slopes (Boetius *et al.* 1996). Anaerobic and chemosynthetic prokaryotic species are mostly associated with microbial mats over cold-seeps as reviewed in a later section. The soft bottom sedimented habitats in the vast Eastern Mediterranean basins (Iapetra or Levantine) are driven by the export of labile organic matter to the deep. Considering the low amount of photosynthetic organic matter originating from the surface waters, lateral transport of coastal and terrestrial origin organic matter should be important for Eastern Mediterranean basins, and a change in these fluxes in the near future can also effect deep-sea soft bottom ecosystems.

2.2 Submarine Canyons

Submarine canyons are incisions at the seafloor connection shelf to deep-basin, and can be major routes for the lateral transport of organic matter to the Eastern Mediterranean deep basins (Allen and Durrieu de Madron 2009). Almost nothing is known on these processes in the Eastern Mediterranean, as the distributions of submarine canyons is even only based on crude estimates. This knowledge gap is in stark contrast with the Western Mediterranean, where the role of submarine canyons in shelf-deep sea water mass and material transfer is well established. The morphology of the submarine canyons in the southeast Levantine Basin near Israel is relatively well studied (Clark and Cartwright, 2009). In the northern Levantine Basin, as reviewed by Öztürk *et al.* (2012) there areas where the presence of submarine canyons must be expected. Canyons are hotspots of biological life as compared to the surrounding soft bottom habitats at similar depths. Enhanced accumulation of organic matter can occur due to lateral transport of organic-rich water masses from the shelf to deep basin. The Northern Levantine Coast, near Anatolian mainland, is dissected by many short canyons. Near Kas and Finike a number of deep-dissecting canyons are likely to exist.

In the Eastern Cilician Basin, between Goksu Delta and Seyhan Delta at least two major canyon systems are estimated to be present. Almost nothing is known on the fauna and microbial communities in these canyons, neither their role on the physical oceanography of the general EM basins. Enhanced erosion may also occur in certain parts of the canyon (especially upper canyon), which may lead to exposure of hard bottom substrates that form suitable habitats for fragile species such as cold-water corals. While present-day living coral assemblages have not been documented, Taviani et al (2011) identified a range of cold-water coral (CWC) facies (predominantly Late Pleistocene) in the deep escarpments (max 600 m depth) near the margins of Crete, Rhodes and Karpathos. These are remnants of communities that were presumably established when the bottom waters were cooler. The Easternmost occurrence of dense CWC assemblages occur in the Ionian Sea (Taviani *et al.* 2011) but a solidary CWC was found in Eratosthenes Seamount (Galil and Zibrowius 1998). At present the deep water of the much of the EM may be too warm for CWCs, but again this may be due to the lack of studies along the known submarine canyons of particularly the high-relief Anatolian coasts.

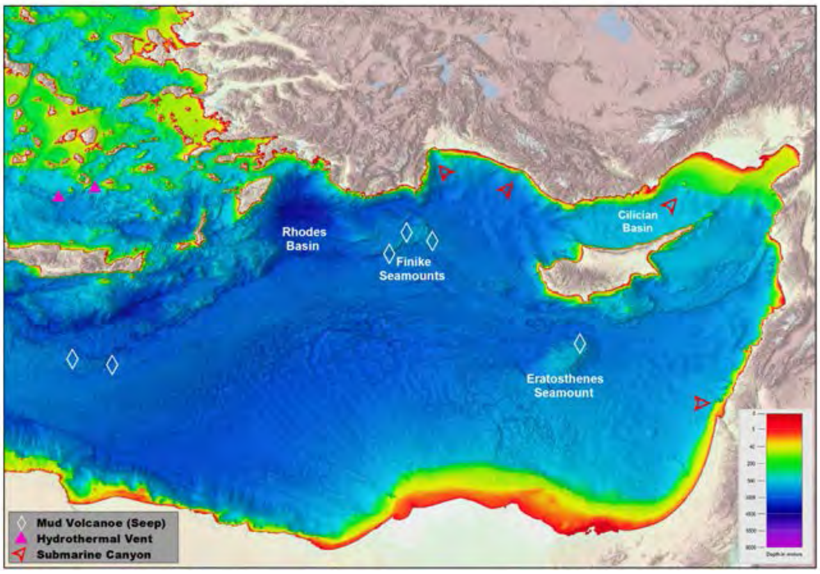

Figure 1. Major deep-sea habitats that host unique ecosystems in the Eastern Mediterranean. Please note that the shown seafloor habitats are only the most studies ones and possibly represent a small fraction of what actually exists. The bathymetry is taken from EMODnet Hydrography portal

2.3 Hydrothermal vents

Hydrothermal venting is more prevalent in the Eastern Mediterranean compared with the Western due to the active tectonics of the area. Particular concentration of high-temperature venting in the EM is confined to shallow <100 m depths, such as those venting found near Hellenic Volcanic Arc in the south Aegean Sea, but it is very likely that these volcanic hotspots extend much deeper. In deeper vents documented in Marsili seamount in the Tyrhennian Sea clusters of Siboglinidae tubeworms were found to be in symbiosis with chemosynthetic prokaryotes (Zimmermann *et al.* 2014). In the vents near Milos Island, dense mats of microbial hydrogen sulfide oxidizers were found (Yücel *et al.* 2013), and these microbial taxa were found to be close relatives of common hydrothermal vent sulfur oxidizing taxa detected in the well-studied East Pacific Rise seafloor vents. In the Levantine Basin no report of hydrothermal venting was available to the authors at least, but a closer look near the Northern Levantine Basin, near Anatolian Coast could be worthy as near Anaximander Seamount there are a range of faults and tectonic activity that may lead to small-scale hydrothermal phenomena. As the Hellenic Arc continues towards The Anatolian Coast in the Gökova Bay, which is relatively deep (700m), more instances of hydrothermal venting could be found here. Kilias et al (2013) noted that submarine venting occurs down to 600 m in the Santorini-Kolumbo hydrothermal vent field, with dense patches of chemosynthetic tubeworms and bivalves documented (Danovaro *et al.* 2010).

2.4. Cold Seeps in Mud Volcanoes and Pockmarks

Cold seeps refer to a general class of seafloor phenomena where hydrocarbons, mostly methane (CH_4) of thermogenic or biological origin, ascends from deep Earth towards sediment-bottom water interface. Cold seeps area the most frequently observed and relatively studied habitat type in the Eastern Mediterranean (Olu-Le Roy *et al.* 2004). Seepage occurs in a wide range of morphological spectrum from pockmarks, small depressions on the seafloor due to gentle gas seepage or as mud volcanoes, often kms-wide seafloor hills formed by the expulsion of deeper mud along with the gas ascend (Woodside *et al.* 1998). Notable mud volcanoes (MV) in the Eastern Mediterranean are Napoli and Milano MV in the Olimpi MV area south of Crete, Kazan and Amsterdam MV in the Anaximander/Finike Seamount and Chefren and Amon MV in the Nile Fan. Levantine Basin. Numerous pockmarks are also located in the vicinity of these areas and in shallower part of the continental shelves. The shelf offshore Lebanon and Israel, and the Turkish shelf along the Cilician Basin in the Northeastern Levantine Basin have pockmarks only a small fraction of which are explored and studied.

In cold seeps a primary process is the oxidation of upward seeping methane mediated by a range of archaeal and bacterial species. In the sediment interior, the oxidation of methane is often coupled to reduction of sulfate, in a process called ‘anaerobic oxidation of methane’, mediated by a syntrophic consortium of methane-oxidizing archaea and sulfate-reducing bacteria. The result of sulfate reduction is the accumulation of hydrogen sulfide, which can also diffuse to sediment-bottom water interface and lead to the presence of dense microbial mats that comprise of sulfide-oxidizing and carbon-fixing microbial communities. Therefore, cold seeps enable a multitude of heterotrophic and chemosynthetic metabolic pathways (Carlier *et al.* 2010), which also reflect in newly recognized high microbial diversity in these habitats (Pachiadaki *et al.* 2010). For instance, in an integrative analysis of microbial mats in cold seeps of the Amsterdam MV (Anaximander Seamount) and Nile Fan, Ristova et al (2015) found significantly higher diversity compared to non-seep soft bottom habitats. *Deltaproteobacteria, Epsilonproteobacteria* and *Gammaproteobacteria* dominated the seep community, with only 36% of the operational taxonomic units (OTUs) shared by non-seed sediments. Within several hundred meters across a seep site the microbial community composition also changed drastically, sharing less than %50 of the OTUs. The high spatial variation within a given seep site followed closely the geochemical gradients in sulfide and methane – an emerging ecological phenomenon also observed in hydrothermal vents and methane seeps in other parts of the ocean. In another integrative study Heijs *et al.* (2008) compared community composition from sediments of the Napoli MV, Milano MV, Kazan MV and Amsterdam MV. In addition to bacterial richness, the authors also reported archaeal sequences affiliated with *Methanosarcinales, Thermoplasmales, Halobacteriales* and *Crenarchaea*. The mats and top layer of MV sediments were dominated by organisms involved in O_2-reducing heterotrophy, sulfide-oxidizing chemoautotrophy and methanotrophy. Deeper sediments were habitats for sulfate-reducers and anaerobic methane oxidizers. At fine taxonomic levels each cold seep habitat showed uniqueness but microbial stratification with depth correlated well with downcore metabolic signatures. Omoregie *et al.* (2008) conducted a detailed study of white and orange mats in Chefren MV (Nile Fan). The white mat was mostly composed of sulfide-oxidizing and sulfur-precipitating *Arcobacter sulfidicus*, while the orange mat was due to iron-oxide precipitating neutrophilic Fe (II)-oxidizing betaproteobacterium *Leptothrix ochracea.* These findings show that besides sulfur and methane-dominated biogeochemical cycles, iron mobilization can occur in Eastern Mediterranean cold seeps supporting bacteria involved in the cycling of iron.

Strongly coupled to high metabolic and microbial diversity in cold seeps, macrofaunal species endemic to seafloor chemosynthetic habitats were also shown to colonize cold seep habitats of the Eastern Mediterranean. In symbiosis with methane oxidizing and sulfur oxidizing microbes, bivalves and siboglinid polychaetes dominate macrofaunal community. Olu-Le Roy *et al.* (2004) highlighted the particularly small size of the bivalves, belonging to the families Mylilidae, Thyasiridae, Vesicomyidae and Lucinidae. The large vestimentiferan *Lamellibranchia* sp. are typical polychaete inhabitants on the carbonate crusts that form as a result of excess inorganic carbonate formation due to methane oxidation (Rubin-Blum *et al.* 2014). As these invertebrates host symbiotic microorganisms, the density of the macrofaunal communities were hypothesized to correlate with methane fluxes, although the relatively few studies hinder further testing of this proposition (Shank *et al.* 2011). Besides chemosynthetic fauna, giant fauna (*Rhizaxinelle pyrifera*) and crabs (*Chaceon mediterraneu*) can be found, potentially feeding on the chemosynthetic production occurring nearby. Interesting to note that signature chemosynthetic macrofauna from seeps of the global ocean, such as giant Calyptogena clams or Bathymodiolus mussels are strictly absent from the Eastern Mediterranean cold seeps (WWF/IUCN 2004).

2.5 Seamounts

Major features in the Eastern Mediterranean seafloor landscape are two seamount complexes: Eratosthenes and Anaximander/Finike. However, as reviewed by Öztürk *et al.* (2015) in detail at least 12 more small-scale seamounts were found in the Eastern Mediterranean, between Crete and Lebanon, excluding the Aegean Sea. Only the Anaximander and Eratosthenes were explored, but even then the studies on ecosystem properties of seamounts are only in its infancy. Erastothenes seamount rises over 2000 km from the surrounding plain, with its summit reaching near 700m depth (Mitchell *et al.* 2013). Its flat summit is a remnant of subaerial exposure, erosion and chemical weathering during the Messinian dry-up of the Mediterranean. The summit hosts numerous pockmarks as well as the most eastern reported occurrence of living scleractinian corals in the Atlantic-Mediterranean system (Galil and Zibrowius 1998). Latest surveys (summarized in Mitchell *et al.* 2013) reported kms-long clam shells aggreagates, some of them alive near the active seepage areas. Tubeworms typical of seep environments were also observed. The seeps in the Eratosthenes Seamount were associated with the ascend of fluids due to the cracks and pores formed as a result of subduction of the seamount at the Cyprus trench.

Anaximander/Finike seamount, located very close to Anatolian mainland near Kaş and Finike, is actually composed of three seamounts: Anaximander, Anaxagoras and Anaximenes. The complex seamount formed due to the ongoing collision of the African and Anatolian plates. The complex is surrounded by the 4000m –deep Rhodes basin and 3000 m-deep Finike basin, and the seamount complex can rise to 1200 m depth. As discussed below, several large MVs are the primary chemosynthetic habitats: Kazan MV is located in the Anaximander seamount while the Amsterdam MV is located in the Anaximenes seamount. In between these seamounts lies a feature called 'Great Slide', remnant of a debris flow, and also a site of numerous pockmarks. Most detailed ROV surveys have been performed by R/V Nautilus (summarized by Shank *et al.* 2011): The seafloor of Anaximenes and Anaxagoras were mostly sediment covered. Also evidence for extinct seepage areas as indicated by dense aggregations of clam shells. Other than seep habitats, the rocky outcrops of the seamount can host patches of cold-water corals. The seamount complex is also important for pelagic organisms, for example Tserpres *et al.* (2008) suggested that the swordfish *Xiphias gladius* migrated towards the seamount complex. This points to a potential spawning ground in this area perhaps also due to the presence of nutrient-rich productive Rhodes gyre, the formation of which is influenced by the Anaximander/Finike seamount complex (Öztürk *et al.* 2012). Due to these reasons, the site is on target conservation areas (IUCN, OCEANA) and even declared as Special Protected Area by the Turkish Government (August 16, 2013, Official gazetteer number 28737).

2.6 Evolutionary and Biodiversity Aspects of the Eastern Mediterranean Deep-Sea Fauna

The Mediterranean is a young sea in terms of evolutionary time scale due to the almost complete dry-out during the Messinian salinity crisis approximately between 5.3 and 6 MYA (Krijgsman *et al.* 2001). The re-connection between Atlantic and Mediterranean in the early Pliocene and subsequent colonization from Atlantic is reflected in the similarity between Mediterranean and Atlantic biological diversity and the fact that 55-77% of all species has Atlantic origin (UNEP-MAP RAC/SPA 2010). Therefore, Mediterranean marine biological diversity might be considered largely nested in Atlantic marine biological diversity (Cartes *et al.* 2004), which is also evident in systematic fish samplings in deep Mediterranean basin (Haedrich and Merrett 1988). However, the shallow Gibraltar Strait (c. 300m) acts as a barrier between the deep sea habitats of the whole Mediterranean and Atlantic counterparts. Furthermore, shallow Siculo-Tunisian sill (c. 400m) separates the Western and Eastern Mediterranean deep sea habitats. This isolation among the populations of Mediterranean and Atlantic deep sea fauna, in combination with the high environmental heterogeneity and distinct evolutionary history of the Mediterranean Sea result in a distinct Mediterranean marine community (Cartes *et al.* 2004). Furthermore, certain Mediterranean deep-sea hotspots, such as submarine canyons harbour special faunas rich in endemic taxa (Gili *et al.* 1998; 2000). Cold seeps harboring chemosynthetic communities, brine pools, deep sea coral mounds and seamounts can be listed among these important deep sea habitat hotspots (Corselli and Basso 1996; Lampadariou *et al.* 2003; Tursi *et al.* 2004; Galil and Zibrowius 1998). Overall, c. 25% percent of Mediterranean marine life is estimated to be endemic (Ruffo 1998). The endemism ratio tends to decrease with depth (Fredj and Laubier 1985), however with a high variability among different groups of deep sea organisms. For example, organisms without pelagic larval stages (*e.g.*, Amphipoda) have much higher endemism ratios (Ruffo 1998), while no endemism is reported for deep sea cephalopods, which have free-pelagic larvae (Cartes *et al.* 2004).

Mediterranean deep sea fauna is dominated by fishes and decapod crustaceans. Abundance and species richness of deep sea fauna tend to decrease with depth, but with a peak of biomass between 1000 and 1500m for some taxa (Cartes *et al.* 2004). Fredj and Laubier (1985) reported approximately 2100 benthic macrofauna species below 200 m and 200 species below 2000 m depth. The faunal abundance and richness of Mediterranean deep sea is significantly lower than Atlantic and the benthic macrofauna tend to be smaller. The limited faunal richness in Mediterranean deep sea is especially more prononunced for fish (Stefanescu *et al.*, 1992), decapod crustaceans (Cartes 1993), mysids (Cartes and Sorbe 1995), echinoderms (Tortonese 1985), and gastropods (Bouchet and Taviani 1992) as well as for almost the absence of macroscopic foraminifera (Xenophyophora), glass sponges (Hexactinellida), sea-cucumbers (Elasipodida order), primitive stalked sea-lilies (Crinoidea) and sea-squirts (class Sorberacea) (Pérès 1985; Monniot and Monniot 1990). However, diversity of some groups of organisms, such as meiofauna, in the Mediterranean might still be as rich as Atlantic (Coll *et al.* 2010). Eastern Mediterranean basin is even poorer in species richness and abundance probably indicating the role of low primary production in Mediterranean diversity gradient (Danovaro *et al.* 2010). For example, fish samplings in the Levantine sea documented a poor fish fauna, however consisting some rare and new species (Klausewitz 1989; Galil and Goren 1994; Galil and Zibrowius 1998). However, specific hotspots like deep sea trenches can sustain significantly higher abundances most likely due to higher organic matter accumulation (Tselepides and Lampadariou 2004). The poorer deep water fauna in the Mediterranean deep sea has been proposed to be linked to the dispersal limitation due to shallow Gibraltar strait (Salas 1996) and also the shift of deep waters to a warmer regime during the halocene and subsequent loss of the species with lower thermal preferences (Bouchet and Taviani 1992).

Recent connection between the Mediterranean and the Western Indo Pacific marine ecoregion through Suez Canal had dramatic effects on Mediterranean ecosystems with pronounced community shifts. More than a thousand Lessepsian species have already been recorded in the Mediterranean (Zenetos 2010). However, no alien or invasive fish species have been recorded in the Mediterranean deep sea habitats to date (Goren 2014). The Suez Canal is very shallow and it seems to be an effective barrier for the dispersal of deep sea organisms. Furthermore, main introduction mechanisms, such as maritime traffic and fisheries, favor littoral organisms. Nonetheless, potential dispersal of deep sea fauna through pelagic larvae cannot be completely ruled out. Furthermore, even slight temperature changes in the deeper waters due to climate change are expected to induce dramatic effects on already warm deep Mediterranean waters (Danovaro *et al.* 2010). Although, life at the bathyal zone of the Mediterranean Sea has been noted since early 19th century (Risso 1816), still very little is known about the biological diversity at depths and this gap in the knowledge hampers effective management of the growing interest in the deep sea economy to better protect especially the deep sea hotspot habitats.

3. Challenges and opportunities in Eastern Mediterranean Deep Sea Research

Deep-sea is the final frontier in Earth exploration. Its unknown biological and process diversity remains to be uncovered, not only for conservation and management purposes but also for sustainable use of newly discovered deep-sea energy and mineral resources. Moreover, the deep waters serve to sequester anthropogenic CO_2, recycle ecosystem-driving nutrients and provide many more ecosystem services which are of indirect economic value. The services provided by Eastern Mediterranean deep waters, however, have not been extensively evaluated. Global warming will certainly affect how the ecosystem services will evolve. The Mediterranean deep-water turns over every 50 years, much faster than the global ocean. This makes the effect of climate warming to influence the deep Mediterranean basins much faster. Considering that the deep seafloor of the Eastern Mediterranean is already warm – it can be anticipated that the Eastern Mediterranean ecosystems will undergo a much faster change. Thus, conservation and management efforts should intensify and prioritized, but the undefined maritime boundaries in this contested environment makes the conservation of the deep ecosystems a fundamental management challenge (Özturk 2009). An integrated, effective management scheme is however needed specially to tackle the emerging exploitation modes of the deep-sea. But most importantly, management efforts must be strongly backed by fundamental, observation-driven and innovative research that uses the latest scientific paradigms to uncover the unique environmental dynamics of the deep Eastern Mediterranean.

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LAGOONS ALONG THE MEDITERRANEAN COAST OF TURKEY AND LAGOON FISHERIES (EXPLOITATION FEATURES)

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1. Lagoons

Lagoons, which have ecological importance, are fragile/sensitive ecosystems having a lot of functions and located between land and sea. They are generally influenced by terrestrial and marine environments as they are regions of transition between inland and marine waters. The ecology of the lagoon habitats displays various features depending on physical, chemical, and environmental conditions. Their structure changes from fresh water to highly saline water (Gilabert 2001). These high variable abiotic conditions (i.e., salinity, temperature, turbidity, dissolved oxygen (DO), freshwater inflow, structural attributes of habitat, depth, geographic distance from the estuary mouth, and hydrography) control the spatial and temporal distribution of fish species. In addition to abiotic factors Occurrences of fishes may be influenced by biologic and abiotic factors in coastal lagoons. Species competition and prey-predator relation and species reproductive biology are important biotic factors to affect spatial and temporal patterns of species (Akin *et al.* 2005).

Lagoons unique ecosystems are nutritionally rich habitats which lead high natural productivity because their shallow and brackish waters that offers food and shelter for numerous fish species to their larval- juvenile-adult stages.

Coastal lagoon is defined as shallow coastal lake or wet land which is separated from sea by coast (i.e. sand barriers), usually has brackish water characteristics and also has connection with the sea through one or more inlets (Joyeux and Ward, 1998).

Lagoons differ according to their location to the sea and number of the inlets that allow water change in its system. On the other hand, lagoons might be disconnected from the sea seasonally or constantly (Kocataş 2002). According to Kjervfe (1994), coastal lagoons, based on the number of inlets and level water change, are divided into three: (1) choked, (2) restricted, and (3) leaky systems (Figure 1).

Figure 1. Lagoon systems; 1. Choked, 2. Restricted, 3. Leaky (redrawn from Kjervfe, 1994).

Lagoons are particularly important for fisheries in many areas of the world, since marine fish species migrate towards the lagoons, which provide favorable conditions for feeding and shelter (Colombo 1977). This valuable migration has attracted human beings for centuries. Fishing traps have been used to harvest the fish schools on the inlet/s of a lagoon. Fishes are usually captured by using stationary barrier traps. Commercially exploited lagoons mainly by barrier traps are called as *Dalyan* in Turkey.

2. Fish Assemblages in Lagoons

In the confinement model which is based on colonization rates (Figure 2), lagoon fish species can be grouped under three categories (Pérez-Ruzafa and Marcos 1992; Gamito *et al.* 2005):

a) Marine stragglers

b) Marine migrants

c) Estuarine species

Marine stragglers: These species are occasional visitors, rare and often limited to the mouth of the inlets, and so have little influence on lagoon assemblages.

Marine migrants: Species that colonize regularly in the lagoon and can survive, but are unable to reproduce. These species support lagoon fisheries and have the largest group of fish assemblages (Pérez-Ruzafa *et al.* 2007).

Estuarine species: Species which colonize the lagoon and are able to reproduce in the lagoon environment.

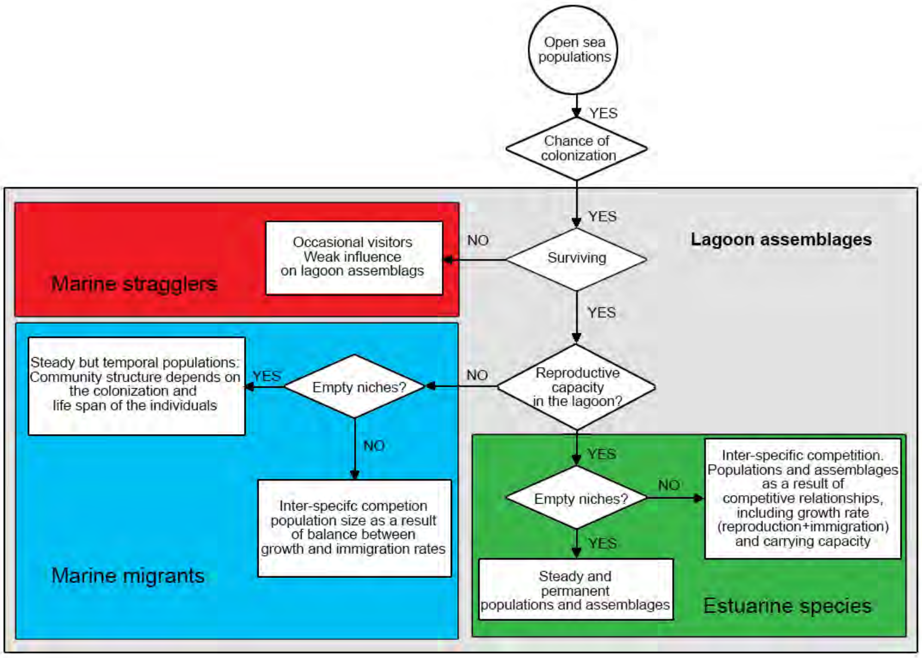


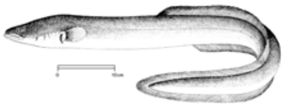
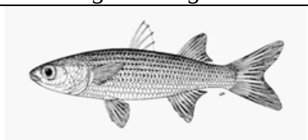
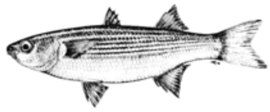
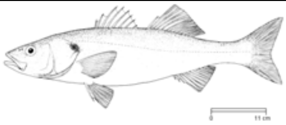
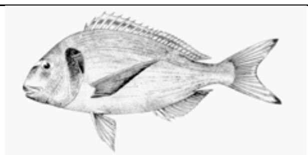
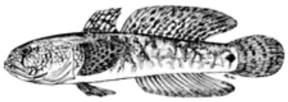
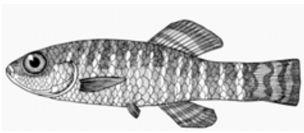
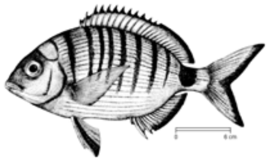
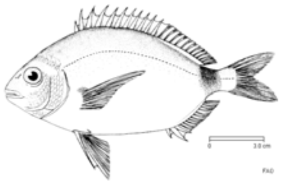
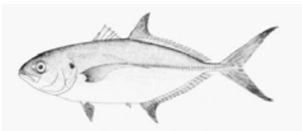
Figure 2. Fish assemblage in lagoon systems (redrawn from Pérez-Ruzafa *et al.* 2011)

Dominant fish assemblages, which are marine migrants, of the Mediterranean coastal lagoons consist of Grey mullet species (*Mugil cephalus*, *M. saliens*, *M. auratus*, *Oedalechilus labeo* and *Liza carinata*), Gilt-head Sea bream (*Sparus aurata*), Sea bass (*Dicentrachus labrax*) and European eel (*Anguilla anguilla*). In addition to these species, marine stragglers (Big scale sand smelt (*Atherina boyeri*), Sardine (*Sardina pilchardus*)) and estuarine species (Grass goby (*Zosterisessor ophiocephalus*), Blue crab (*Callinectes sapidus*)) share the lagoon systems. Species available in the Mediterranean lagoons are given in Table 1.

3. Mediterranean Lagoons

There are 26 commercially exploited lagoons between the İskenderun Bay and the Meriç River, Edirne (Sarıkaya 1980). All those lagoons are public domain, among these lagoons, 25 of them belong to the state (govern by Ministry of Food, Agriculture and Livestock) and one belongs to the private sector. 17 of them are located in the Mediterranean region (Table 2). Total surface area of the Mediterranean lagoons is approximately 10600 hectare (TKB 1997).

Table 1. Fish and crustacean species of the lagoons along the Mediterranean coast of Turkey (Photo credit www.fishbase.org).

1	 *Anguilla anguilla*	*2*	 *Atherina boyeri*
3	 *Mugil cephalus*	*4*	 *Mugil auratus*
5	 *Mugil saliens*	*6*	 *Oedalechilus labeo*
7	 *Liza carinata*	*8*	 *Dicentrachus labrax*
9	 *Sparus aurata*	*10*	 *Zosterisessor ophiocephalus*
11	 *Aphanius cypris*	*12*	 *Diplodus sargus*
13	 *Diplodus annularis*	*14*	 *Caranx crysos*

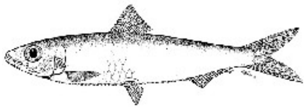
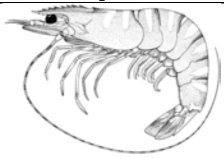
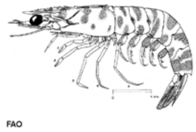
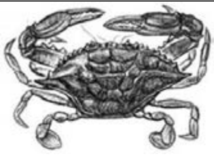
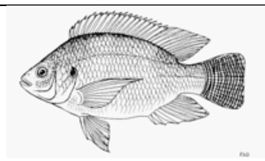
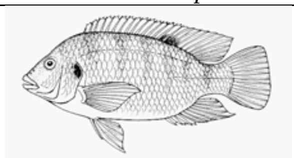
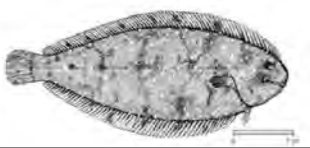
			
15	*Sardina pilchardus*	*16*	*Rhinobatos rhinobatos*
			
17	*Panaeus semisulcatus*	*18*	*Melicertus kerathurus*
			
19	*Callinectes sapidus*	*20*	*Oreochromis niloticus*
			
21	*Oreochromis aureus*	*22*	*Solea solea*
			
23	*Palaemon elegans*		

Table 2. List of the Mediterranean lagoons (TKB, 1997) report

City	County	Lagoon Name	Surface Area (ha)
Hatay	Samandağ	Tuz Pond	6
	Dörtyol	Katiboğlu Area Pond	13
		Tigem Pond	24
		Tarım İl Md. Pond	8
		Seçil Puddle	5
		Yeniyurt Puddles	9
	Erzin	İkizler Sand Pit	13
Adana	Yumurtalık	Yelkoma Lagoon*	640
		Çamlık Lagoon*	1300
		Ağyatan Lagoon*	1100

	Karataş	Akyatan Lagoon*	5000
	Tuzla	Tuzla Lagoon*	800
Mersin	Tarsus	Dipsiz Lagoon*	50
	Silifke	Paradeniz*	590
		Akgöl*	820
Antalya	Beymelek	Beymelek Lagoon	250
	Kaş	Gelemiş Lake	7

* Commercially leased lagoons in 2014 by Ministry of Food, Agriculture andLivestock, General Directorate of Fisheries and Aquaculture

At present, only 7 lagoons have commercial importance in Mediterranean region and they have been leased by the local fisheries cooperatives and private enterprises (Figure 3). Of these, Dipsiz and Akgöl Lagoons are leased together while Beymelek Lagoon is run with joint venture system shared by the Mediterranean Fisheries Research, Production and Training Institute affiliated with Ministry of Food, Agriculture and Livestock and local fishermen. Brief information of these 7 lagoons is given below.

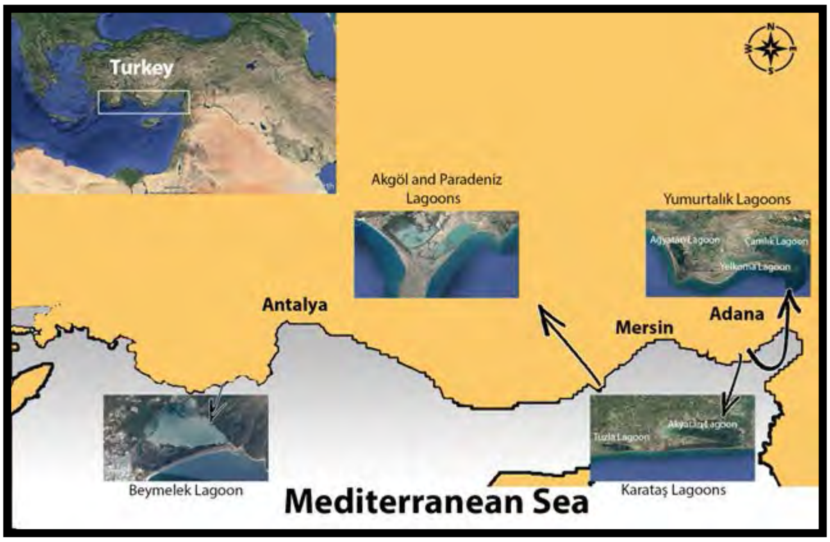


Figure 3. Commercially leased lagoons in Mediterranean region of Turkey.

Yelkoma Lagoon: Yelkoma lagoon is located in the west side of Yumurtalık District of Adana. Total surface area of the lagoon is approximately 800 hectare. Its depth is around 0.30 – 1 m. It is one of the important fishery areas of Yumurtalık. Species captured in this lagoon are Grey mullet, Sea bream and Sea bass. Annual landings changes from 30 to 50 tons. In addition, 300 –500 kg Grey mullet roe is also produced here. There are two barrier traps, which are made of wood and reed.

Ağyatan Lagoon: It is in Karataş District of Adana. Its maximum surface area is 1100 hectare. The depth of the lagoon can reach to 1.2 meters at its maximum. This lagoon has a metal trap system (bars of the lagoon barriers was made of iron material).

Akyatan Lagoon: Akyatan Lagoon is the biggest one of Turkey. It is located in Karataş District of Adana. Lagoon is connected to the sea from its southeastern side through an inlet of 2 km long. This lagoon has a metal trap system and conveyor belt provides quick and easy harvest.

Tuzla Lagoon: It is in Karataş District of Adana, which is near Tuzla, a small town, in the northeast side of the area. Tuzla Lagoon has been emerged as a result of sediments brought by the River Seyhan and wind-wave movements. Its surface area is 1038 hectare depending on seasonal changes. There is one barrier trap, which is made of wood and reed.

Akgöl- Paradeniz Lagoon systems: These two lagoons are located in Göksu delta in Silifke District of Mersin. Akgöl and Paradeniz Lagoons are lagoon systems that are connected to each other. These systems are connected to sea by the inlet of the Paradeniz Lagoon. Total surface area of both lagoons is approximately 2050 hectare (Akgöl 1400 and Paradeniz 650 hectare). The average depth of Akgöl is 1.1 metre. Each of these lagoons has one metal trap system on their inlets.

Beymelek Lagoon: Beymelek Lagoon is near Kale (Demre) in the District of Kaş in Antalya. Its maximum surface area is 355 hectare. There is no commercial fishery activity in this lagoon.

4. Lagoon Fisheries

Lagoons are areas that, when compared to the sea, could get warm early and cool down much earlier. This characteristic of lagoons causes fishes to gather into these areas during spring season when the waters get warm earlier then the sea does. Fishery exploitation in these lagoons is traditional extensive culture based on seasonal ongoing migration movements of fry and adult fish between sea and lagoons. The lagoon fisheries are based on the passage of fish from these important nursery and feeding grounds. These fishes are trapped at the lagoon-sea interface by passive and fixed gears during their movement from the lagoon ecosystem to the seaward (Katselis *et al.* 2013; Tosunoğlu *et al.* 2015).

Traditional lagoon fishery is a stationary barrier trap, inlet of the lagoon is blocked with the trap for a certain period of the fishing season. This barrier traps are made of reeds and woods or iron bars (Figure 4).

Figure 4. Lagoon stationery barriers and traps made of woods and reeds

The fish in lagoons, when they are in periods of production or because of some sudden changes (such as changes in temperature or storms), rush to the inlets of the lagoons in order to reach to the sea. In the meantime, they get caught in the trap and this is called as *furya* times by fishermen. Those that are captured in traps of the stationary barriers are harvested by using scoop nets. Most commonly captured species in Mediterranean lagoons are Grey mullet species, Sea bream, Sea bass, European eel and Blue crab. Commercial value of *dalyan* fishery is getting less every year. This can easily be observed when we look at the annual rate of landing in Akyatan Lagoon, which is one of the biggest in the Mediterranean (Figure 5). While the amount of fish produced in lagoon is 300 tons in 1970s, it drops to 50 tons in 1990s. Today (In 2015?), it is about 100 tons.

The main reason for the rate of production seems to be the drop in the numbers of total catch of certain species such as Gilt-head sea bream, Grey mullet and Sea bass. However, the amount of eel reported during these years seem to have remained the same (Figure 6). Apart from these, shrimps, White sea bream, and grouper species have also been caugt in the traps and has highly comercial value. Nevertheless, statistical data is not available for these species.

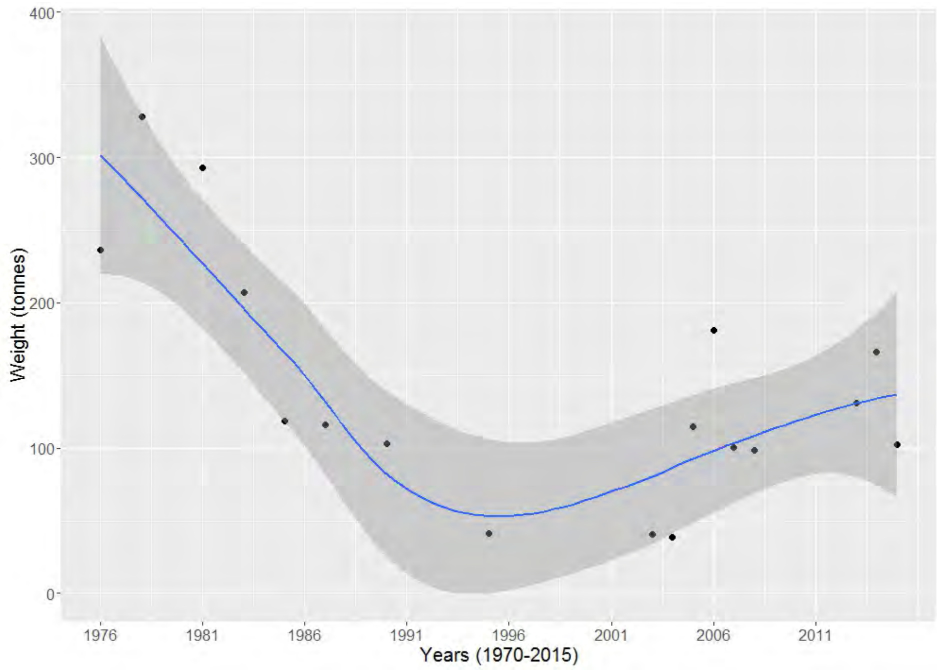


Figure 5. Total fish landings of Akyatan Lagoon (TKB, 1997; non-official record).

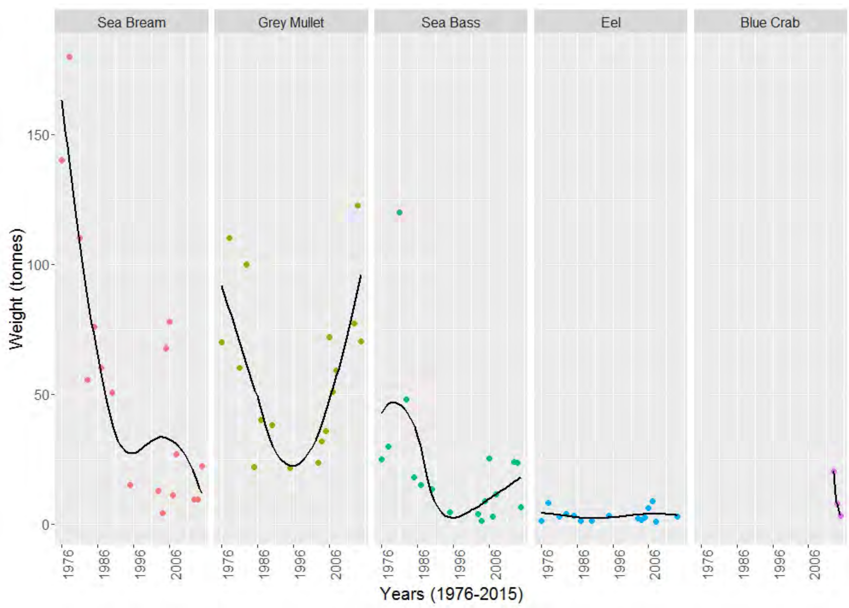


Figure 6. Total catch by species for Akyatan Lagoon (TKB, 1997; SGM 2016).

In the lagoon fishery, fishermen usually use trammel nets, longlines and fyke nets with the lagoon stationary barrier trap. The target species of these fishing gears are Sea bass, Sea bream, Grey mullet, European eel and shrimp species.

Turkish *dalyan* fishery is regulated under the article for Dalyans and Lagoons in the commercial fisheries regulations (Anonymous 2016). The most important fishing rules implemented for lagoons are *i.* Lagoon inlets have to be open in a certain time of the year *ii.* Minimum 10 percent of mature mullets should be released from the lagoons to the seaward *iii.* Distance between the reeds (stick) should not be less than 3 cm (minimum openness) in lagoon barrier traps. Minimum openness regulation is given in Table 3.

Table 3. Lagoon barrier minimum openness regulation.

Publication date of the regulations	Minimum openness size	Area
2.12.1978 [a]	-	-
2.28.1985 [a]	2 cm	All Lagoons
2.28.1988 [a]	3 cm	All Lagoons
2.28.1990 [a]	2 cm 3 cm	Mediterranean Lagoons Aegean Lagoons
2.21.1992 [a]	1.7 cm 3 cm	Mediterranean Lagoons Aegean Lagoons
3.9.1997 [a]	3 cm	All Lagoons
3.5.1998 [a]	1.7 cm 3 cm	Mediterranean Lagoons Aegean Lagoons
8.21.2008[b]	3 cm	All Lagoons
8.18.2012 [b]	1.7 cm 3 cm	Mediterranean Lagoons Aegean Lagoons
4.15.2014 [b]	3 cm	All Lagoons
8.13.2016 [b]	3 cm	All Lagoons

[a] Citations, [b] Circular/Notification

When the regulations are examined, it is seen that, in time, there is a constant change in Dalyan regulations for the measurement of distance between the reeds in Turkey. However, it is hard to discern on what these changes are based on. The distance between the reeds changes from 1.7 to 2 or 3 cm in Mediterranean Lagoons and *Dalyans* stretchs from Yardımcı Cape to Syrian border.

Limitations in terms of the species capture in *Dalyan* fishery have to be implemented with the prohibitions on weight and length as stated in the regulations. Another important rule related to Lagoons and *Dalyans* is that it is strictly prohibited to catch of juveniles for the purpose of Aquaculture (Anonymous 2016).

5. Problems and Suggestions

Similar to the Mediterranean lagoons (Cataudella *et al.* 2015), *Dalyans* that locate at southern part of the Turkey are threatened by the various problems. The most important problem for Turkish lagoons in terms of landing is the fall in the amount of fresh fish production and related to that, a similar drop in Grey mullet roes. An increasing interest for recreational fishery causes illegal fishery in lagoons and inevitably disturbs *Dalyan* managers. Moreover, the fact that an increase in the number of settlement areas (urbanization) around lagoons and that of rivers and inlets feeding lagoons are polluted by industrial, agricultural and domestic waste make lagoon species risky for human consumption.

The inlet of relatively young and choked Mediterranean lagoon systems are obstructed with sediment deposition constantly due to wave movements. As a result of the amount of sediment in the rivers and sand dune erosion caused by the storms, lagoons get shallower and their productivity levels and existence are put at risk.

New vegetation areas are planted to decrease the effects of sand dune erosion and deepening activities are made by the owners of the *dalyan* enterprises. Although, these efforts seems to solve the shallowing problem, they are not going to be the solution to protect the area in the long term.

In some of the lagoons, fresh water sources are dried up or decrease in a certain time of the season. Such a decrease results the salinity of the lagoon water to increase causing the necessity for more fresh water. Despite the efforts of increasing fresh water inputs into the lagoons through canals, there is no specific analysis done so far on the extent of fresh water needed in the lagoons.

In conclusion, Mediterranean lagoons are threatened, by several factors, including sediment deposition, siltation of the both whole lagoon area and its inlets to the sea and also industrial, agricultural and domestic pollution. Fishery exploitation is an essential activity for the sustainability of the lagoons. Due to overexploitation, traditional *dalyan* fishery model has become unsustainable. Urgent management strategies are needed to protect not only the lagoon itself but also catchment area and productive zones of the lagoons.

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COMMERCIAL CRUSTACEANS ON THE LEVANTINE SEA COAST OF TURKEY

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1. Introduction

Marine fisheries are very important to the economy and well-being of coastal communities, providing food security, job opportunities, income and livelihoods as well as traditional cultural identity (FAO 2011). Decapod and stomatopod crustaceans are one of the most valuable resources of the world's trawl fisheries. Crustaceans of commercial importance on the Levantine coast of Turkey are generally fished. These are penaeid shrimps, *Aristaeomorpha foliacea* (Risso, 1827), *Aristeus antennatus* (Risso, 1816), *Fenneropenaeus merguiensis* (de Man, 1888), *Metapenaeus monocerus* (Fabricius, 1798), *Metapenaeus stebbingi* Nobili, 1904, *Metapenaeopsis mogiensis consobrina* (Nobili, 1904), *Parapenaeus longirostris* (Lucas, 1846), *Penaeus aztecus* Ives, 1891, *Penaeus hathor* (Burkenroad, 1959), *Penaeus kerathurus* (Forskål, 1775), *Penaeus pulchricaudatus* Stebbing, 1914,n*Penaeus semisulcatus* de Haan, 1844, *Penaeus subtilis* (Pérez Farfante, 1967) , *Trachysalambria curvirostris* (Stimpson, 1860), scyllarid lobsters, *Scyllarides latus* (Latreille, 1803), *Scyllarus arctus* (Linnaeus, 1758), and portunid crabs, *Callinectes sapidus* Rathbun, 1896 and *Portunus segnis* (Forskål, 1775).

Fisheries of crustaceans in the Turkish Seas changed quickly due to the dense established populations of exotic species penetrated from Red Sea to the eastern Mediterranean Sea by Suez Canal since 1920s. Before 1920s the target species of crustacean fisheries were native penaids, such as *A. antennatus*, *A. foliacea*, *P. kerathurus*, and *P. longirostris*. At the present time, almost all species of decapods and stomatopods that are fished at the coastal area are alien. Also, demersal resources on the Turkish coasts have been subjected to increasing exploitation since 1960. Rapid increase in trawling capacity has resulted in the decline of the resources and operations have become less profitable (Ateş *et al.* 2015). The overfishing and formation of dense populations of exotic species have changed the biodiversity and socio-economic status on the Levantine coasts of Turkey rapidly. However, a number of prevention, protection, and regulations about this subject should be considered in future.

2. Decapod and Stomatopod Crustaceans in Turkish Seas

A recent paper by Bakır *et al*. (2014) includes a total of 254 species of decapod and 8 stomatopod crustaceans reported from the Turkish coasts. 207 of these are distributed on Levantine coast of Turkey. In recent years, the number of species known on Levantine coast of Turkey shows an increasing with penetrations of new exotics. Most of the established exotic shrimps on the Levantine coast of Turkey are commercially important.

3. Commercial species in the Turkish waters of the Levantine Sea

Doğan *et al*. (2007) reported a total of 57 species of invertebrates found in the Turkish Seas are commercially valuables. Among these, 48 species are distributed on the Levantine coasts of Turkey. 18 of these 48 species are decapods and stomatopods. Yet, the number of economical important decapod and stomatopod crustaceans known from the Turkish Levantine coast is 29 (Table 1).

3.1. Shrimp fisheries

Prawns are the most important species in terms of fishery on our coasts, especially Penaeids and Pandalids. Penaeid prawns are among the continuously available of commercial trawl fishery due to their economic values. The exotic shrimps which have economical value, of the Turkish coasts are *F. merguiensis, M. monocerus, M. stebbingi, M. mogiensis consobrina, P. aztecus, P. hathor, P. pulchricaudatus, P. semisulcatus, P. subtilis* and *T. curvirostris*. Besides, the native *A. foliacea, A. antennatus* and *P. longirostris* are the most important species for deep-sea fishery. The others are fished at the depths between 0 and 100 m. Prawn fishery is carried out on all coasts, excluding the Black Sea. According to data of year 2014, prawns fishery is composed of 5 species and 4416.3 tonnes. Approximately 82% of this amount is composed of deep-sea shrimps such as *P. longirostris, A. foliacea,* and *A. antennatus* (TUİK 2014). Despite the small amount of the contribution of other shrimp species are economically more valuable.

Four species of the genus *Plesionika* occur along the continental shelf and slope of the Turkish Levantine Sea coast. *P. heterocarpus* is abundant in the mud assemblage of the shelf-slope break and on the upper slope of the Alboran Sea (SW Mediterranean), while *P. edwardsii* and *P. martia* are dominant in bathyal communities of the upper and middle slope (Fanelli and Cartes 2004). Among these species, *P. heterocarpus* is considered to be economical and others are non-target. However, *P. longirostris* is sold in fish markets in Mersin and İskenderun with *P. heterocarpus*. When these species are densely fished during the deep-sea fishery activities, they are used as bait.

Table 1. Decapod and Stomatopod crustaceans with commercially importance on Levantine Sea of Turkish coast (*: exotic species).

Dendrobranchiata
Aristaeomorpha foliacea (Risso, 1827)
Aristeus antennatus (Risso, 1816)
Metapenaeus monocerus (Fabricius, 1798)*
Metapenaeus stebbingi Nobili, 1904*
Metapenaeopsis mogiensis consobrina (Nobili, 1904)*
Parapenaeus longirostris (Lucas, 1846)
Penaeus aztecus Ives, 1891*
Penaeus hathor (Burkenroad, 1959)*
Penaeus kerathurus (Forskål, 1775)
Penaeus merguiensis de Man, 1888*
Penaeus pulchricaudatus Stebbing, 1914 *
Penaeus semisulcatus de Haan, 1844*
Penaeus subtilis (Pérez Farfante, 1967) *
Trachysalambria curvirostris (Stimpson, 1860)*
Caridea
Pasiphaea multidentata Esmark, 1866
Pasiphaea sivado (Risso, 1816)
Plesionika edwardsii (Brandt, 1851)
Plesionika heterocarpus (A. Costa, 1871)
Plesionika martia (A. Milne-Edwards, 1883)
Plesionika narval (Fabricius, 1787)
Macrura Reptantia
Scyllarides latus (Latreille, 1803)
Scyllarus arctus (Linnaeus, 1758)
Brachyura
Callinectes sapidus Rathbun, 1896*
Carcinus aestuarii Nardo, 1847
Eriphia verrucosa (Forskål, 1775)
Maja squinado (Herbst, 1788)
Portunus segnis (Forskål, 1775) *
Stomatopada
Erugosquilla massavensis (Kossmann, 1880)*
Squilla mantis (Linnaeus, 1758)

3.1.1. *Aristaeomorpha foliacea* (Risso, 1827)

The giant red shrimp, *A. foliacea* is a demersal species and it has a relatively narrow depth range between 250 and 1300 m, though it is only abundant (at least in the Mediterranean) at mid-slope depths between 450 and 600 m (Cartes 1995). *A. foliacea* is abundantly captured by means of deep trawl at the depth of 400 m in Mersin Bay with another penaid, *P. longirostris*. Likewise, *A. folicacea* is also dominant in Antalya Bay (Bayhan *et al.* 2015). According to data of 2014, the capturing amounts of red shrimps, *A. foliacea* and *A. antennatus* declined since 2012. The fishing amounts of the species by the years 2012, 2013 and 2014 are 2157.7, 1363.6 and 1119.6 tonnes respectively (TUIK 2014).

3.1.2. *Aristeus antennatus* (Risso, 1816)

Red shrimp, *A. antennatus* stock has a commercial importance on the Levantine Sea coast of Turkey (Kocataş and Katağan, 2003). *A. antennatus* is one of the important species with regard to fisheries activities in international waters and it is known as common species in deep sea fisheries off Cyprus for 2 months.

3.1.3. *Metapenaeus monocerus* (Fabricius, 1798)

Speckled shrimp, *M. monocerus* is distributed in the Indo-west Pacific Ocean, from Red Sea to Malaysia and in Mediterranean Sea and it is only known from the coast of the Levantine Sea across the Turkey (Bakır *et al.* 2014). Besides, *M. monocerus* is an economic species in Egypt, Tunisia and Turkey and it is sold as jumbo or male prawn in our fishing markets. *M. monocerus* is one of 5 economic species in Turkish Mediterranean coast (Türkmen 2005) and it was caught a total of 237.9 tons in 2013 (TUIK 2013). Entire of this amount was derived from the Levantine Sea, but this data is presented with those of *M. stebbingi*.

3.1.4. *Metapenaeopsis mogiensis consobrina* (Nobili, 1904)

Penaeid prawn, *M. mogiensis consobrina* is distributed in the Indo-west Pacific Ocean, from Red Sea to Indonesia and in the Mediterranean Sea. It was only reported from Levantine coast of Turkey up to date (Bakır *et al.* 2014). The economical value of *M. mogiensis consobrina* is quite low and sometimes it is marketed with *T. curvirostris, P. longirostris* and other small-sized penaeid species.

3.1.5. *Metapenaeus stebbingi* Nobili, 1904

Peregrine shrimp, *Metapenaeus stebbingi* is distributed in the Indian Ocean, from Red Sea to India, and in Mediterranean Sea and it appears only on the Levantine coast of Turkey (Bakır *et al.* 2014). *M. stebbingi* is known as a species with commercial value in Egypt, Israel and Turkey, therefore it is stated in fisheries data. This species is sold in fish markets of İskenderun and Mersin Bays with *M. monocerus*. Therefore, the fishing data belong to *M. monocerus* should be stated for both two species.

3.1.6. *Parapenaeus longirostris* (Lucas, 1846)

Deep water rose prawn, *Parapenaeus longirostris* composes the part of 60% approximately of prawn fisheries in Turkey. Approximately, 72% of this shrimp harvest on Turkish coast was obtained by the stocks of the Sea of Marmara (Zengin *et al.* 2004). On the other hand, *P. longirostris*' economical value is lower than those of other penaeids and it is among the most important species in trawl fisheries of Turkey. *P. longirostris* is caught at the depths under 70 m on the Turkish Levantine coast. This species is sold between 10 and 15 Turkish Liras per kg. and it is caught in summer periods with aristeids and pandalids especially at international waters.

3.1.7. *Penaeus aztecus* Ives, 1891

Brown shrimp, *F. aztecus* is distribution in the western Atlantic Ocean from Massachusetts to Florida Keys and throughout the northern Gulf to the northwestern Yucatan in Mexico (Anonymous, 2016). Exotic shrimp, *F. aztecus* was for the first time reported from Antalya Bay in 2009 (Deval *et al.* 2010) and it is known from İskederun and Mersin Bays in the eastern Mediterranean (Gökoğlu and Özvarol 2013a), Thermaikos Bay in Greece (Nikolopoulou *et al.* 2013) and Boka Kotorska Bay in the southern Adriatic (Marković *et al.* 2014). About 96% of the brown shrimp harvested in the United States comes from the Gulf of Mexico which were mainly landed in Texas and Louisiana. In 2013, commercial fishermen brought in more than 106 million pounds of Gulf brown shrimp with revenues of nearly $246 million. Nearly 49 million pounds came from Texas (with revenues of $148 million) and 39 million pounds from Louisiana (with revenues of nearly $50 million) (Anonymous, 2016). Its amount fished in Turkey increases day by day and it has an economic value as *P. semisulcatus* known as Jumbo prawn. Fishing activities, prices in marketing, and the present status of the population effect the production by years. Besides, *F. aztecus* seems similar to *P. kerathurus* in terms of lifecycle and lifespan. Therefore, *F. aztecus* is considered to be a potential risk for populations of the native prqwn *P. kerathurus* (Kevrekidis, 2014).

3.1.8. *Penaeus hathor* (Burkenroad, 1959)

Penaeus hathor have a commercial value in Indian Ocean, Red Sea to Myanmar, and in the Mediterranean Sea (Figure 1). *P. hathor* penetrated to the Mediterranean ecosystem by Suez Canal and created dense populations in the Levantine Basin (particularly in İskenderun, Mersin and Antalya Bays) (Özcan *et al.* 2008). After its first record from the Mediterranean, the species was reported on the Turkish coast in 1997 (Kumlu *et al.* 2002). A lot of its specimens were captured during the fisheries activities carried out in the Turkish Levantine coast by means of line nets in 2005. Then, it was encountered from our Aegean Sea coast in 2007 (Yokeş *et al.* 2007). This species has shown an excess spread from İskenderun to Antalya bays and it is known as an economical species (Türkmen 2005).

Figure 1. The alien shrimp, *Penaeus hathor* (Burkenroad, 1959) (Photo by T. Özcan).

3.1.9. *Penaeus merguiensis* de Man, 1888

Banana prawn, *P. merguiensis* is distributed in the Indo-West Pacific Ocean and Mediterranean Sea and was only reported with one specimen from Levantine coast of Turkey up to date (Özcan *et al.* 2006). This case shows that this species could not established a constant population on Turkish coasts. Because of this, there is no detailed data on fisheries of this species on the Levantine coast of Turkey. The economical value of *P. merguiensis* is quite high on other countries and it is raised in extensive and semi-extensive ponds in southeast Asia and Australia.

3.1.10. *Penaeus kerathurus* (Forskål, 1775)

Penaeus kerathurus's geographical distribution range is limited to the eastern Atlantic coasts from the northern Angola to the southern England and the Mediterranean (Ateş *et al.* 2015). *P. kerathurus* which is an endemic to the Mediterranean, lives on sandy muddy bottoms of the depths ranged from 5 to 90 m (it is dense mostly at the depth of 40 m) (Kocataş *et al.* 1991). The populations of this species in the Levantine basin of the Mediterranean have been decreasing in last 25 years. The main reason of this decreasing is probably the invasion of *P. kerathurus*' natural habits by an alien penaid, *P. pulchricaudatus* (known formerly as *Penaeus japonicus*). A significant reduction was observed in fishing in recent years. According to TUIK data, this species was fished as 354.4 tonnes from the Turkish Seas in 2013 and 271.9 tonnes in 2014.

3.1.11. *Penaeus pulchricaudatus* Stebbing, 1914

Penaeus pulchricaudatus Stebbing, 1914 is distributed from Indo-West Pacific to Red Sea. This species migrated to the Mediterranean Sea via Suez Canal and creates dense populations in the Levantine Basin (particularly in Iskederun and Mersin Bay), but its records are also known in Greece, the Sea of Marmara, Italy, France, and Spain. Likewise, *P. pulchricaudatus* occurs in the north Atlantic Ocean including the Celtic Sea, the English Channel, and the north-west France (Quigley *et al.* 2013). The species has penetrated to the Mediterranean ecosystem in 1920s. Formerly, it was known as *Penaeus japonicus* Spence Bate, 1888. But recent phylogenetic study is stated that, the distribution area of *P. japonicus* is limited with East and northern South China Sea and the Mediterranean population belongs to *P. pulchricaudatus* (Tsoi *et al.* 2014). Also, *P. pulchricaudatus* is specified as one of the 100 dangerous invasive species for biodiversity and fisheries in the Mediterranean (Streftaris and Zenetos 2006).

3.1.12. *Penaeus semisulcatus* de Haan, 1844

Zoogeographical distribution of green tiger shrimp, *P. semisulcatus* contains the Indo-West Pacific Ocean, the coast from Red Sea to Fiji, and the Mediterranean Sea. *P. semisulcatus* is found in the Sea of Marmara and in our Levantine coast (Bakır *et al.* 2014). It has a great commercial value in Egypt, Israel and Turkey. *P. semisulcatus* is marketed as jumbo shrimp with the prices between 45 and 60 Turkish Liras per kg. This species was obtained by means of fishing a total of 451.8 tonnes in 2013 (TUIK 2013). TUİK data show that, this amount was caught from the Black Sea, the Sea of Marmara and the Aegean Sea. However, This species was reported only from the Turkish Levantine coast (Bakır *et al.* 2014). Because of this, the amount cited above should be obtained only from the Levantine coast of Turkey.

3.1.13. *Penaeus subtilis* (Pérez Farfante, 1967)

Brown shrimp, *Penaeus subtilis* distributed in Cuba, the Antilles, Honduras, along the Caribbean coast of central and the south America and the Atlantic coast of the south America to Rio de Janeiro, Brazil. This species prefers the estuarines and marine environments up to 90 m, rarely to 192 m (Pérez Farfante 1988). The Alien shrimp, *P. subtilis* was reported firstly from Antalya Bay in 2012 for entire Mediterranean Sea. Most likely, *P. subtilis* which is known as an economic shrimp in whole markets of the world, migrated to the Mediterranean ecosystem by Gibraltar Strait (Gökoğlu and Özvarol 2013b). The species is one of the most important species for fisheries of Brazilian coast. Due to the low population in the Mediterranean Sea, there is no knowledge on its economical status.

3.1.14. *Trachysalambria curvirostris* (Stimpson, 1860)

South rough shrimp, *T. curvirostris* is distributed in the Red Sea and Mediterranean Sea and was reported from Levantine coast of Turkey (Bakır *et al.* 2014). The economical value of *T. curvirostris* is quite low and it is marketed with *P.*

longirostris and other pandalids. *T. curvirostris* is known to be sold as bait in Mersin and İskenderun Bays.

3.1.15. *Plesionika edwardsii* (Brandt, 1851)

The pandalid shrimp, *Plesionika edwardsii* occurs within a depth range of 269 to 522 m. The highest percentage occurrence in the western Mediterranean Sea was found between 300 and 500 m (Carbonell and Abello 1998). There is no detailed data on fisheries of this species on the Levantine Sea coast of Turkey.

3.1.16. *Plesionika heterocarpus* (A. Costa, 1871)

P. heterocarpus have a distribution restricted to the Mediterranean Sea and the Eastern Atlantic both in temperate and tropical waters (Holthuis 1980). In Turkish Aegean Sea, Sığacık and Kuşadası Bays mainline of fishing efforts was directed to shrimps *P. longirostris, P. heterocarpus, Aegaeon lacazei* (Gourret, 1887) and *Pasiphaea sivado* (Risso, 1816) (Akçınar *et al.* 2007). *P. heterocarpus* has a minor commercial importance and is usually sold as admixtures with above mentioned species. In a similar manner, *P. heterocarpus* is sold in the markets of Tunusia and Italy with other shrimps (Holthuis 1980). It is fished during deep-sea fisheries activities in Levantine Basin of Turkey and occasionally, it is sold with other small pandalids as fishing bait.

3.1.17. *Plesionika martia* (A. Milne-Edwards, 1883)

Golden shrimp, *P. martia* is distributed both in temperate and tropical waters (Holthuis 1980) and is captured as discard in Sığacık Bay (the Aegean Sea of Turkey) (Özcan and Katağan 2011). There is no detailed data on fisheries of this species on the Levantine Sea coast of Turkey.

3.2. Lobsters

3.2.1. *Scyllarus arctus* (Linnaeus, 1758)

The small european locust lobster, *Scyllarus arctus* is commonly found in the Mediterranean Sea and in the north-eastern Atlantic waters (Butler *et al.* 2013b). The species is an economic species and consumed by human. As an footnote, the Turkish fishery regulation circular (TFRC) arrange the prohibitions for lobster fishing. The fishing of all lobster species in Turkish coasts is prohibited between 15 April and 15 June (Anonymous 2007).

3.2.2. *Scyllarides latus* (Latreille, 1803)

According to Butler *et al*. (2013a) Mediterranean Slipper Lobster is still quite common in the eastern Mediterranean along the coasts of Israel, Cyprus, Greece, Turkey and the north African coast (Figure 2). Data shows that a total of 7.0 tons of lobsters (0.5 tonne from the Sea of Marmara, 6.5 ton from the Turkish Aegean Sea) in the Turkish Seas were fished (TUIK 2013).

Figure 2. The Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1803) (Photo by T. Özcan).

3.3. Portunid crabs

Portunid crabs are cultured in some countries and they have commercial value around the world. Among these, *Callinectes sapidus* Rathbun, 1896 and *Portunus segnis* (Forskål, 1775) occur in the Turkish Sea (Özcan 2012). The amount of blue crab, *C. sapidus* fished from the Turkish coast was roughly 1.5 tonnes in 2014 (TUIK 2014). More likely, this total amout mixed with the data of *P. segnis* and also don't comprise real fishing data. Because, *C. sapidus* and *P. segnis* are fished along the entire Levantine coast of Turkey and they are sold in commerical markets (0.25 to 0.42 Euro per individual) (Özcan 2012). *C. sapidus* also existed and fished aroun 1 ton in a day in the summer period in lagoons around the Dardanelles (Ateş *et al.* 2015).

3.3.1. *Callinectes sapidus* (Rathbun, 1896)

Blue crab, *Callinectes sapidus* has a native distribution on the east coast of the America from Nova Scotia to the northern Argentina (Figure 3). It was introduced to the eastern Atlantic (in the north Sea, and SW of France), to the northern and eastern Mediterranean Sea (the north Adriatic Sea, the southern Italy) and also to Japan (FAO, 2016). Blue crab is an important economical species in its native area. It represented one of the most valuable fishery resource in the Chesapeake Bay and the mid-Atlantic states of Maryland, Virginia, and the north Carolina, with 2001 fishery value of 150 million US$ (Zmora *et al.* 2005). *C. sapidus* is hunted in coastal kiddles (İskenderun, Mersin, Antalya, Fethiye Bays) along the Levantine coast of Turkey and it was processed after collecting in Karataş and Yumurtalık in 2002, its daily amount was ranged to 1.5 and 2 tonnes (Özcan *et al.* 2003). *C. sapidus* has been also fishing around

1 ton per day in the kiddles especially in Enes Lagoon located in Saros Bay on the Northern Aegean Sea (per. communication T. Özcan).

Figure 3. Blue crab, *Callinectes sapidus* (Rathbun, 1896) (Photo by A.S. Ateş).

3.3.2. *Carcinus aestuarii* Nardo, 1847

The Mediterranean shore crab, *Carcinus aestuarii* is commonly found in the estuaries and lagoons of the Turkish coasts. This species is litttle economical value in Turkish coast and sometimes consumed by human. Mostly small specimens are sold as bait for sea bream and sea bass. There is no detailed data on fisheries of this species on the Levantine coast of Turkey.

3.3.3. *Eriphia verrucosa* (Forskål, 1775)

The common shore crab or warty crab (Pavurya: in Turkish), *Eriphia verrucosa* is distributed in the Atlantic Ocean, Mediterranean Sea and Black Sea. The species has high economical value in Turkish coast and consumed by human. According to TUIK data, this species was catch as 7.3 tons (5.2 tonnes western Black Sea, 0.9 tonne Marmara Sea, 0.3 tonne Aegean Sea and 0.9 tonne Levantine Sea) from the Turkish Seas in 2013 and 4.5 tonnes in 2014 (TUIK 2013; TUIK 2014).

3.3.4. *Maja squinado* (Herbst, 1788)

The common spider crab (Ayna: in Turkish), *M. squinado* is distributed in the north-east Atlantic Ocean, Mediterranean Sea and Black Sea. The species is very litttle economical value in Turkish coast and sometimes consumed by human. *M. squinado* is also a species under protection and hunting of it is prohibited with Bern Convention and Turkish Notification of Fisheries ((No:2012/65).

3.3.5. *Portunus segnis* (Forskål, 1775)

Portunus segnis which is consumed as human food is distributed in entire Indo-West Pacific region from Pakistan to the southern Africa and the Mediterranean Sea (Lai *et al.* 2010). Lessepsian crab, *P. segnis* was observed on the coasts of Egypt, Palestine, Turkey, Syria, Cyprus, Italy and Greece (Özcan 2012). According to a newly revision work of Lai *et al*. (2010), the name of this species was changed from *P. pelagicus* to *P. segnis*. *P. segnis* which is observed in the İskenderun Bay is called with local names as blue or spotted. Single specimen is sold 0.25 to 0.42 Euro in fish markets near İskenderun Bay (Özcan 2012) and only 20 percent of the crab specimens captured are evaluated economically and remainder are excreted (Özcan 2003).

3.5. Stomatopod Fisheries

Stomatopods which are also called mantis shrimps, are important economic resources in the global crustacean trawl fishery and commercially exploited in the south Africa, America, India, China, Taiwan, Hong Kong, and especially Japan (Lui, 2005; Pillai and Thirumilu, 2012). They are also used as human food in some Mediterranean countries. Nevertheless, stomatopod species in Turkey are usually neglected fishery resources among the crustaceans. However, they can be potential fishery interest besides demersal fish and decapod crustacean fisheries in the future (Von Vaupel Klein *et al.* 2013).

3.5.1. *Erugosquilla massavensis* (Kossmann, 1880)

Indo-Pacific orginated mantis shrimp, *E. massavensis* is distributed in the Red Sea, Persian Gulf and Mediterranean Sea (Figure 4). It is captured commercially in the Levantine basin of the Mediterranean (Holthuis 1987). Although this species is comsumed rarely as human food or used as bait in fish hunting in our Levantine coast. It is captured with endemic *Squilla mantis* to market abroad (Per. comm. T. Özcan). Also, *E. massavensis* is observed to compete with *S. mantis* during sampling works.

Figure 4. Indo-Pacific mantis shrimp, *Erugosquilla massavensis* (Kossmann, 1880) (Photo by T. Özcan).

3.5.2. *Squilla mantis* (Linnaeus, 1758)

The spottail mantis shrimp, *Squilla mantis* is distributed in the Atlantic Ocean and in entire Mediterranean Sea. It is found on all Turkish coasts excluding the Black Sea shores (Bakır *et al.* 2014). This stomatopod species has a fairly high or little economic importance on the Mediterranean coasts (Italy, Spain, France, Egypt, Tunisian, Turkey and Israel) (Pillai and Thirumilu 2012; Vila *et al.* 2013; Mili *et al.* 2013). Recently, the lessepsian stomatopod *E. massavensis* has established dense populations especially at the depths of 75 m in the Turkish coasts. It began creating ecological stress on *S. Mantis*.

4. Conclusion

In studies on economic invertebrates were stated the existence of 18 decapod and stomatopod species on the Turkish Levantine coast (Doğan *et al.* 2007). The present study showed that the total of 29 decapod and stomatopod species have economic value on our coasts. Approximately, 45% of them are represented with exotic species. The exotic shrimps especially in terms of economic value attract attention. Besides, these species form the basis of economic input in Iskenderun and Mersin Bays.

As a result, ecologically and economically sustainable management of native and alien species in our coasts is of great importance for the interests of the country.

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THE EUROPEAN EEL IN TURKEY

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1. Introduction

Eel is a part of human life in early historic time, Paleolithic world (Brown *et al.* 2013) as an important food. The distinctive biological characteristics such as panmictic, semelparity, facultative catadromy (Tsukamoto and Aoyama 1998) and metamorphosis make European eel unique among the other fish species. In addition, they have a magnificent migration patterns. They cruise about 5000 miles in the Atlantic and Mediterranean. They have great economic importance on nearly all distribution area in Europe and Northern Africa. However, particularly after 1980s the population of this species dramatically declined in all over the distribution area (Dekker 2003). After that various conservation activities, management plans, internationally regulations follow one the other and European Union countries has been studying on recovery and sustainable fisheries of this species. Turkey has included these attetmps with the other non-EU countries in 2010.

European eel is found nearly all the lagoons, rivers with tributaries flow into Mediterranean, Aegean, Marmara and even Black Sea in Turkey. The limited records on natural abundance with biological and fisheries data cause difficulty on assessment of stock and also insufficiency in implementation of eel management plan in Turkey. However, some attempts on compiling new scientific data and improving management plan for European Eel in Turkey. Turkey has an important role on the whole European eel stock with the suitable climatic conditions for growing European eel in freshwaters. In this chapter the studies on distribution, biology, population trends, threats and regulations of European Eeel in Turkey were compiled.

2. Distribution of European Eel

European eel, *Anguilla anguilla* (L.), is distributed through western coasts of Europe and North Africa and found along all the coasts of the Mediterranean Sea (Schmidt 1909, Dekker 2003). The southern limit is in Mauritania (30ºN) and its northern limit is in the Barents Sea (72ºN) and spans all Mediterranean Basin.

The European eel is found in Turkish rivers and streams, draining into the Mediterranean, the Aegean Sea and part of the Black Sea (Oray 1987; Geldiay and Balık 1996; İkiz *et al.* 1998; Koca 2001; Küçük and İkiz 2004; Onaran *et al.* 2006). The European eel, is found also brackish waters and coastal lagoons in Mediterranean and Aegean. Asi, Ceyhan, Seyhan, Koprucay and Manavgat Rivers draining into Mediterranean; Esen and Dalaman Creeks; Koyceğiz lagoon system, Buyuk Menderes, Kucuk Menderes, Gediz, Kavak and Meric Rivers draining into Aegean Sea are the particular habitats of this species (Geldiay and Balik 1996; Küçük 1997; Ikiz *et al.* 1998). There is little information on the occurrence of eel in rivers draining into the Black Sea (Koca 2001). Also records on the occurrence of this species on the rivers drain into Çanakkale strait and even Gökceada are present (Ulutürk *et al.* 1986; Balkan 2016).

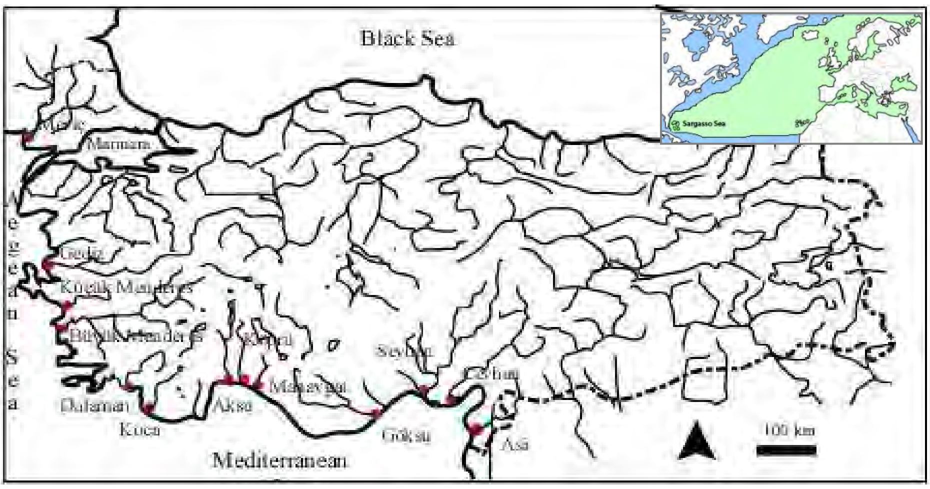

Figure 1. Distribution area of European Eel.

3. Biology of European Eel

The life history of European eel is complex and they spawn only one time during their life and they have a metamorphosis (Figure 2). The spawning area of eel assumed Sargasso Sea which is in Atlantic Ocean between late winter and early spring (Schimidt 1912; Aarestrup *et al.* 2009). The hatched leptocephalus larvae look like a leaflet and drift with golf stream ocean currents to Europe and North Africa coasts. During this passive migration larvae metamorphose into glass eels and enter continental shelf. In the marine, brackish and also freshwater coastal habitats they become pigmented and the growth stages begins as known yellow eel. The growing period may take place in coastal marine habitats or freshwaters, rivers, lakes. Particularly in rivers they may hundreds km far away from the river mouth. The growing period of yellow eels takes about 2-25 years, sometimes it may exceed 50 years, before the another metamorphosis "silver eel" stage. The silver eel stages is known as mature stages and assumed that mature silver eels migrate to Sargasso Sea for spawning and after spawning they die due to they don't feed on during their long journey and their digestive system atrophies (Tesch 1977).

The biology of European eel has little attention in Turkish waters comparing to Europe. There are few studies on the seasonality of silver eel migration (Oray 1987), the size of migration stocks (İkiz *et al.* 1998), distribution patterns (Geldiay ve Balık 1996), migration patterns (Güven *et al.* 2002b), catching devices (Demirci and Demirci 2009), feeding patterns (Yalçın Özdilek and Solak 2007). There is only one study describes the growth parameters of European eel in a Turkish waters, Asi River in Turkey (Yalçın *et al.* 2006).In recent years, acceleration has been observed in eel studies particularly on the parasites (Genç *et al.* 2005), haematology (Şahan *et al.* 2007), toxicology (Yılmaz 2009; Yıldız *et al.* 2010; Yılmaz and Koç 2016), habitat use (Lin *et al.* 2011), migratory indices (Rad *et al.* 2013), microbial flora of skin and slime (Uğur *et al.* 2002), artificial feeding (Güven *et al.* 2002a; Engin *et al.* 2003) and food quality and processing (Ünlü Sayın 1999; Toku 2005; Algan 2007; Olgunoğlu *et al.* 2010; Özoğul 2012; Küçükgülmez *et al.* 2013).

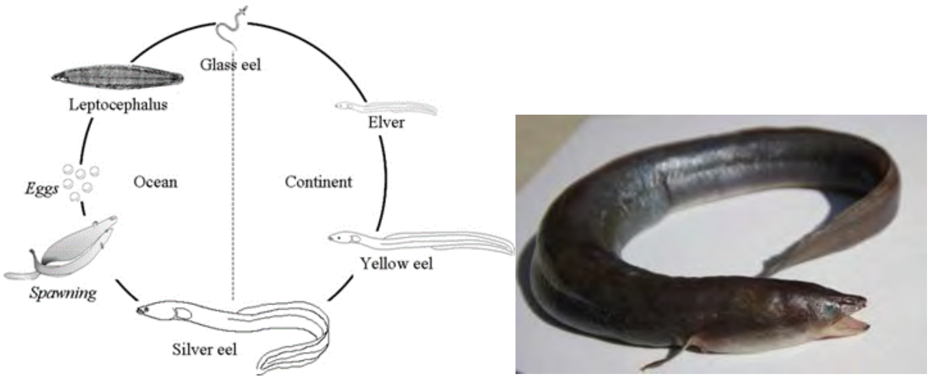

Figure 2. Life cycle of European eel (Dekker 2002) and a picture of eel.

Age, growth and migration patterns

The knowledge about age and growth of a species within and between stocks may be important to assess the sustainable fisheries management. The growth and biology of European Eel in the fresh and coastal waters is well documented in Europe (for example; Aprahamian 2000; Carpenter 1983; Naismith and Knights 1988; Barak and Mason 1992), but there is only one study from the River Asi (Yalçın Özdilek *et al.* 2006). The age of European eel ranges 1 - 18 years in Asi river is an extreme upmost arid population and data indicates that European eel has a fast growth rate (9-13 cm per year) comparing to western populations and longer than 60 cm specimens are exploited by fisheries activities. In Asi River, the sizes and ages of female specimens are larger than those of the male eels and females are predominantly found up-river, while males are concentrated in the river mouth. Meanwhile the growth parameters of European eel are recorded by Güven *et al.* (2002a) and Altun *et al.* (2005) in different aquaculture conditions.

The migration pattern of this species is scarcely known in Turkey. The migration period of glass eels into freshwaters in Turkey is partly studied by İkiz *et al.* 1998. Güven *et al.* (2002b) also stated that they collected some glass eels from Antalya Köprüçay in the April 1989 and from Fethiye Karadere-Özlen Stream in the May 1989 and May 1990. They revealed the importance of Özlen Stream as an ideal habitat for elvers with the catch data of about 587 glass eels in three days. They stated that the mean total length and weight of glass eels were 6.5 cm and 0.380g in May 1989 and 6.0-6.8cm and 0.270-0.380g in May 1990 in Özlen Stream.

Habitat use and diets

The European eel is known as facultative catadromy species it means that they do not need to migrate to freshwaters and they may spend all (Tsukamoto and Aoyama., 1998; Daverat *et al.* 2006) or a part of their life (Arai *et al.* 2006) in marine waters. While probability of living in the lower reaches of watersheds are high at upper latitudes (Daverat *et al.* 2006), Marohn *et al.* (2013) pointed to particularly the importance of brackish waters in temperate latitudes. Sr/Ca ratios of *A. anguilla* otoliths collected from Asi River indicates that the yellow eels spent their entire yellow eel stage in fresh water and did not return to salt water after they recruited to the River Asi (Lin *et al.* 2011).

The main food organisms of eel were mainly fish particularly *Carasobarbus chantrei* and insect larvae, Trichoptera and Odonata in the River Asi. Diet of European eel have a seasonal variation, while fish were consumed during rainy season, invertebrates were consumed mostly in hot dry season in the River Asi (Yalçın Özdilek and Solak, 2007). Similarly, mostly Crustaceae, Polichaeta and Oligochaeta members were recorded in the stomach contents of European eel in Karamenderes river mouth, Çanakkale (Balkan 2016). However, stable isotope analysis results a little different from this classical stomach content analyse results and fish particularly invasive *Carassius gibelio* and native *Squalius cii* and *Alburnus cf attalus* takes important place on the diet of the eels in the Karamenderes River, Çanakkale (Balkan 2016). Trophic position of European eel is calculated by using stomach content analyses and $\delta^{15}N$ ratio and recorded as 3.47 and 3.25 ± 0.27 in lipid extracted specimens in Karamenderes River, Çanakkale (Balkan 2016).

4. Population trends

European eel is exploited in countries in nearly all distribution area. The exploitation of the stock is currently unsustainable (ICES, 2016). Dekker and Beaulaton (2016) claimed that the eel stock is in decline dates from early 1800s and some measurements on recovery of stock had been initiated and after 1950, slow but consistent decline was going on and a dramatically decline in glass eel recruitment in 1980. The glass and yellow eel recruitment time-series have been assessed two categories:'continental NorthSea' and 'Elsewhere Europe' (ICES 2010) and a recruitment index is used a reconstructed prediction in order to assess population trend (ICES, 2016). As seen Figure 3, with respect to 1960-1979 reference level, the 2016 recruitment level is 2.7% for the North Sea and 10.7% elsewhere in the distribution area (ICES, 2016). From this, it is obvious that the population is still decreasing.

There isn't any eel stage recruitment analyse and/or data recorded from Turkey. Only total landing data from country by country has been collected and assessed by Turkish Statistical Institute (TURKSTAT). This time series data indicates that there are step by step dramatic decreases in Turkey total landing data in 1990s, 2000s and 2010 (Figure 4). The main reason of the last decrease might be limitation on the export quota. In that year because European eel has listed in Appendix II of CITES and the exporting of this species has been banned. Most of the landed European eel is exported and the consuming of this species in Turkey is very low. Therefore, the rapid incline on the annual catch data on 2010 probably resulted from this export regulation.

Muğla, Adana, Aydın and Çanakkale are prominent cities in terms of amount of annual catch data (Figure 5). Particularly the declining trend was observed for every city after regulation of export, however, increasing on the the percentages of annual catch data with respect to total annual catch on Canakkale is interesting. From this point of view, Adana and Muğla might be two important cities that have an important habitats in eel fisheries and also in eel exports.

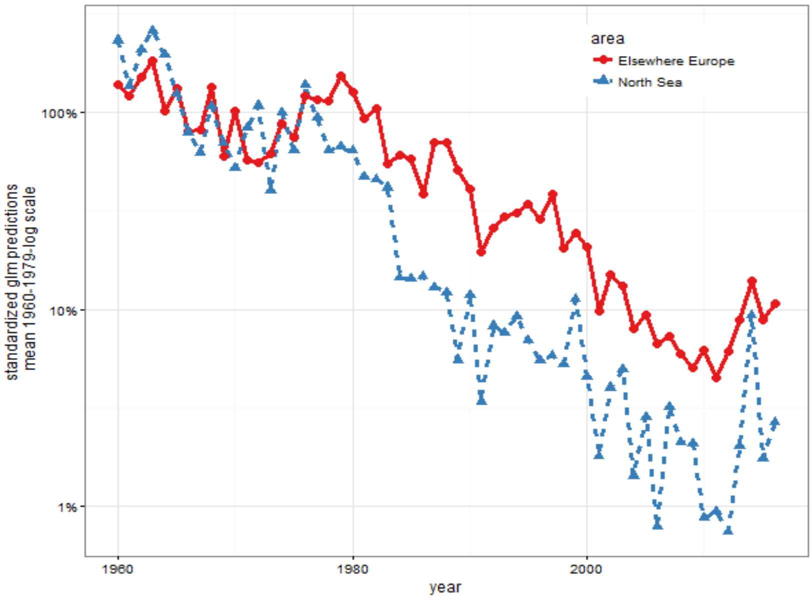

Figure 3. WGEEL recruitment index. See ICES (2016) for details.

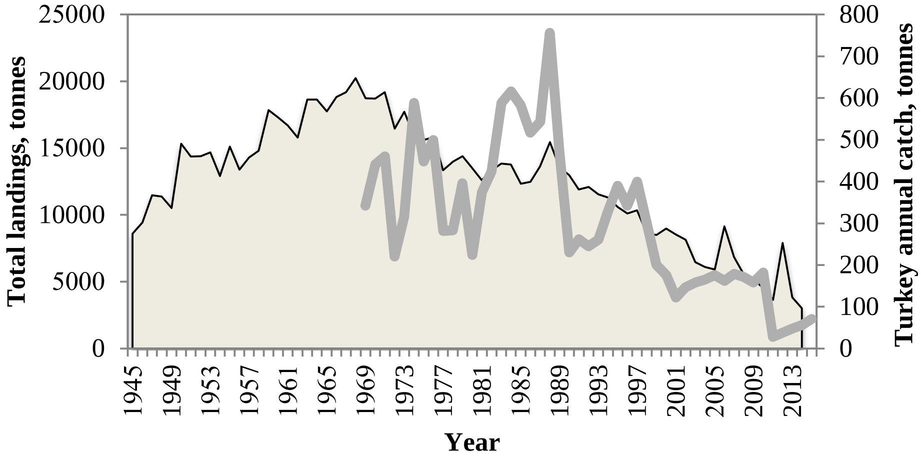

Figure 4. Time-series of commercial eel fishery landings, as reported to FAO (2015),data from ICES (2016) and annual catch data in Turkey.

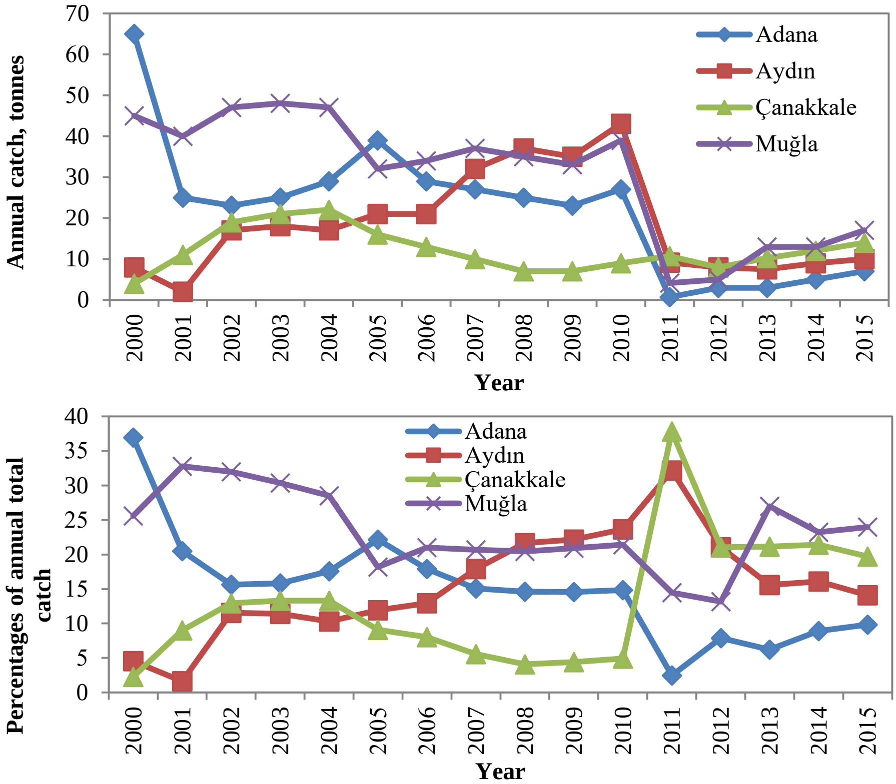

Figure 5. Time series of annual catch data in four prominent cities in Turkey (up) and percentages of annual total catch data from Turkey (down). Data obtained from TURKSTAT (2016).

5. Anthropogenic and other impacts

The decline on European eel population may resulted from overexploitation, hydropower turbines and pumps, migration barriers, habitat loss, pollution, pathogenes, parasites, diseases, predators, competition with non-native species, oceanic factors and climate changes (ICES 2016). The studies on the direct and indirect impacts of some anthropogenic activities such as fisheries, hydropowers and pollution on the eel stock are documented in Europe. In Turkey, there are limited studies on the impacts of some constituents on the eel stock. Generally, Güven (2013) blamed for tourism and agricultural activities that glass eel entrance can not observed in Dalyan (Köyceğiz) and Enez (Gala Lake) which are the most two important European eel habitats. In addition the other prominent problems are summarized below.

Fisheries

According to FAO landing data, about 73% of total landing recorded from six countries, France, Egypt, UK, Netherlands, Sweden and Denmark (ICES 2016). Aquaculture production of European eel is recorded about 4000-6500t in 2015/2016 in Europe (ICES 2016). In Turkey, there is no commercial aquaculture activity on the European eel. However, there are some studies and suggestions on the culturing of this species (Güven *et al.* 2001, 2002a; Altun *et al.* 2005). Turkey account for only 0.5% to 6.6% of the total FAO landings and the ratio of annual catch data of Turkey with respect to total landings data indicates a declining trend particularly after 1990s (Figure 6). The commercially eel fisheries are concentrated on the main lagoons such as Akyatan, Ağyatan in Adana, Akgöl, Paradeniz, Dipsiz in Mersin, Beymelek in Antalya, Güllük, Köyceğiz and Dalaman in Muğla, İzmir lagoons, Gala and Enez lagoons in Edirne. The main commercial fishing gear is fyke net and hooks are the second fishing device for particularly in recreational fisheries. The recreational fisheries are concentrated on the rivers in Turkey.

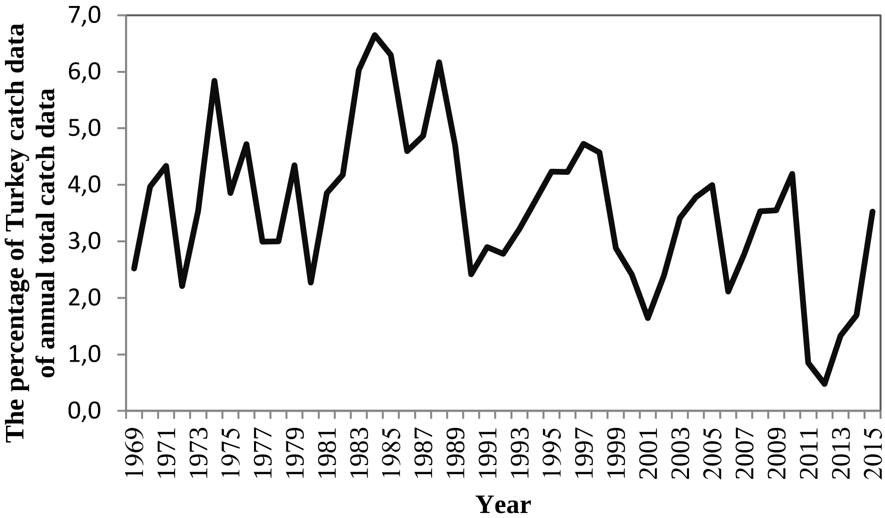

Figure 6. The ratio of annual catch data of Turkey to total landings of European eel. Data based on FAO 2015 and obtained from ICES 2016.

Parasite infestion

Blood-sucking swimbladder nematods *Anguilicola crassus*, *A. novaezelandiae* and the gill monogeneans *Pseudodactylogyrus anguillae* and *P. bini*are the main parasites of European eel. These parasites have been introduced into Europe through the live eel imports in 1980s (Molnar *et al.* 1993). Little evidence to expect *A. anguillae* and *P. bini* affect *A. anguilla* migration success, however, the potential cumulative energetic effects of *A. crassuss* intensity is high (Køie 1991,Newbold *et al.* 2015). One obligatory intermediate host (copepods) and one non-obligatory paratenic host (small fish such as *Cyprinus carpio* or *Leuciscus idus*) is needed for the completing of life cycle of *A. crassus* (De Charleroy *et al.* 1990). *A. crassus* infestion causes mortality in eeels (Sartı *et al.* 1985, Boon *et al.* 1989) and maintaining the collapse of European eel populations across its range (Barry *et al.* 2014). Parasitic *A. crassus* may weaken the migration ability of European eels to complete life cycle (Kirk 2003; Tahri *et al.* 2016). The last studies indicates that this parasite effect particularly the silver eels in terms of reducing the capacity to cope with reactive oxygen species by affecting the activity of superoxide dismutase (Schneebauer *et al.* 2016).

In Europe, about 30 to 100% of eel populations are infected with the nematode (ICES 2008). In Turkey, 22.6% of the Asi River eel's swim bladder were infected by *A. crassus* (Yalçın Özdilek and Solak 2007). Genç *et al.* (2005) also recorded as about 78% of population was infected by this parasite in Ceyhan River. Şimşek *et al.* (2016) has also recorded the nematode *Rhaphidascaris acus* Bloch, 1779 on eel intestin collected from Büyük Menderes.

Pollution

Pollution is claimed as one of the curial element for declining European eel population (Belpaire 2008). Bioaccumulation of chemical substances might be an important parameter effecting spawning quality and reduction on reproduction success of eel (Geeraerts and Belpaire 2010). Contaminants are taken as organochlorines (such as PCPs, herbicides, pesticides), heavy metals, cyanotoxins and the accumulation of these contaminants in body fat, tissues and gonads of European eel (Belpaire *et al.* 2008). Pannetier *et al.* (2016) indicates that European eels may be particularly at riskof Cd and Pb toxicity. The effects of organic and metal contaminats on development and survival of eel embryos (Palstra *et al.* 2006), tyroid endocrine status (Couderc *et al.* 2016), genotoxic and histopathological effects (Pacheco and Santos 2002), mortality (Corsi *et al.* 2005; Geerarts and Belpaire 2010), genome based responses and polygenic selection (Laporte *et al.* 2016) is well documented.

In Turkey, heavy metals Cd, Cu and Zn were recorded as highest level in liver and Mn and Pb in gills, while the lowest metal contents in edible muscle parts of European eel in Koyceğiz (Yılmaz 2009). In addition, Yılmaz (2009) noticed that amount of Pb, Zn and Cd for *A. anguilla* were dedected as out of upper limits of both Turkish Food Codex and European Units and World Health Organization for human consumption. Similarly in Gediz river, the bioaccumulation of heavy metals were recorded as Cd>Mn>Cu, Cr>Ni>Zn and Cd>Pb>Ni in liver, gill and muscle of European eel, respectively. They also recorded as some histopathological abnormalies but no genotoxic disorders.

Migration barriers

Migration barriers are important for European eels, because they spawn only one times in their life and they have to migrate up and down migration on the stream for completing their life cycle. The human pressure on the continental life stages as dam/barrier instructions and consequencies such as direct mortality and habitat change/loss are the other important determinant claimed declining population. Direct effects of hydropowers on the fish mortality were studied in Europe (such as Winter *et al.* 2006; Calles *et al.* 2010). In Turkey, migration barriers were discussed in some literature in Turkey (Aksungur *et al.* 2011; Üçüncü and Altındağ 2012). There is not any detailed study on the direct negative impact of barriers on European eel in Turkey. However, Alp *et al.* (2004) and Kara *et al.* (2010) stated that *A. anguilla* has become extinct in the inland section of Ceyhan River.

6. Conservation status and legislations

About 50 countries are in the geographic range of the European eel and these countries are members of some global and regional organisations such as ICES (International Council for the Exporation of the Sea), EIFAAC (European Inland Fisheries and Aquaculture Advisory Commission), GFCM (General Fisheries Commission for the Mediterranean), EU (European Union), CMS (convention and the Conservation of Migratory Species of Wild Animals), CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora), IUCN (TheInternational Union for the Conservation of Nature), etc. which are involved in European eel management (ICES, 2016). A management framework for eel within the EU was established in 2007 through an EU regulation (EC Regulation No. 1100/2007; EC, 2007). The EU Member States aim sustainable use of the eel stock and in order to achieve internationaly coordinated management plan for the whole stock area, they have developed Eel Management Plan (EMP) for every eel management units (EMUs). These EMPs are designed to allow at least 40% of the pristin silver eel biomass to escape to sea with high probability by mitigating the anthropogenic influences impacted the stock (ICES, 2009, 2010). In addition EU countries which catch glass eels (juvenile eel less than 12 cm long) need to reserve 60% of their catches for restocking whitin the EU (1100/2007). Folowing this EU regulation (1100/2007) on eel, member states were enforced international regulation for this species when CITES (the Convention on International Trade in kendangered Species of Wild Fauna and Flora) listed this species on Appendix II (into force in March 2009). In addition as listed Appendix II, all international trade of European eel into and out of the EU was banned in 2010 within CITES convention. *A. anguilla* is listed Critically Endangered (CR) by IUCN (International Union for Conservation of Nature) in 2008 and the status of this species is unchanged yet (Jacoby and Gollock 2014).

Turkey took part in the monitoring of glass eel recruitment in the scope of an European Union supported project (EU-98/076, Dekker 2002) and described how the glass eels might be monitored in two river systems, Asi River and Gözlen Creek (Yalçın and Küçük 2002). In that report, within a European glass eel monitoring network, options were discussed for monitoring recruitment of glass eels in two habitats one is from the east (the River Asi) and the other is from the west (Gözlen Creek). Any glass eel monitoring program has not been implemented in Turkey since that report.

In 2010, there is a recommendation of development of management plans for European eel covering all subregions of the Mediterranean in GFCM level. In addition a case study on European eel and the feasibility of implementing multiannual management plan were discussed in 2013 in Tunusia. Turkey attented to this meeting and the challenges, opportunities and priorities for research and management of eels in the Mediterranean countries were expressed in that meeting. Following that workshop, in 2014, EIFAAC/ICES/GFCM/WGEEL started a pilot action to collect basic data for setting up a methodology for assessment and a preliminary evaluation of reference points (biomass and mortality parameters) for Mediterranean eel local subpopulations and an adaptive regional management plan that considers existing national measures. Turkey has involved in a pilot action which estimates the Mediterranean base stock assessment using the previous literature data. Local stock assessments were analysed by ESAM (Eel Stock Assessment Model) for lagoons that represent the most suitable habitat for eels in the Mediterranean area. By the way, Aalto *et al.* (2015) quantified a long term a region-wide decline in eel catch in the southern Mediterranean. Model explaines that the current escapement is 35% of escapement at pristine biomass levels which is under target set by EC regulation (1100/2007). In Turkey calculated current escapement is %49 of escapement at the pristine biomass levels which is above target set by this regulation in this model. However, Turkey is among data poor sites in that model and the lack of site-specific data on fishing is one the limitation discussed in this paper.

In 2015 EIFAAC/ICES/GFCM/WGEEL meeting in Antalya the results of this pilot study was presented for an assessment of eel local stocks for the Mediterranean area. GFCM supported a Liaison Action in 2016 in order to implement harmonization among GFCM countries and support the coordinated participation of Mediterranean countries to the WGEEL. As a member of GFCM Turkey have the regulations on fisheries an aquaculture based on the 3/1 and 3/2 number of notificatios. Related with European eel notifications based on size and trade restrictions and allows catches only smaller than 50 cm total length and a particular quota which is also regulated by CITES internationally. Turkey has not compiled a National Eel Management Plan and an assessment of local stocks. However the administrator TRMFAL-GDFA (Republic of Turkey Ministry of Food, Agriculture and Livestock, General Directorate of Fisheries and Aquaculture) has involved in GFCM/EIFAAC/ICES/WGEEL actions on sustainable use of eel resources and attempts to collect some scientific data for estimating stock indicators.

7. Conclusions

European eel is not only an important economic species because of its unique biological properties, but also ecologically important due to its trophic position. The wide distributional area increases its socio-economic and ecological importance of this species. In Turkey European eel is found nearly all freshwaters flow into Mediterranean, Aegean, Marmara and Black Sea. Particularly, in Mediterranean and Aegean sections of Turkey, local people are highly interested in this species by recreational fisheries. As in Serçin village in Söke, recently annual festivals of fisheries of European eel indicate how much the public has put this issue in their focus. The eel stock is declining trend in all distributional area and and there is no commercially catch data from Black sea after 1998 in Turkey. Anthropogenic factors such as overexploitaiton, migration barriers, pollution, habitat loss, pathogens, and parasites are the prominent factors affecting the eel population in Turkey and other countries. Monitoring is as a part of management plan essential for sustainable use of resources and is a good tool for the revising the present plan or to get extra experience for future plan. There are many population parameters, indices and models; each serves particular objectives of assessment and management goals. In order to assess anthropogenic impacts on stock, ICES advices the basic indicators and reference points for European eel used in trend analysis. In Turkey, as seen other some countries, insufficiency on minimum data requirements in assessment of stock is one of the biggest challenge in implementation sustainable management of European eel. Total landing data do not give the real stock of eel, therefore it is hard to estimate the eel stock in Turkey. However, declining trend in annual catch data reflect changes in fishing yields. The reason of sharp rapid decline in annual catch after CITES-wide ban on export in 2010 hardly means that sharp rapid eel stock declining in Turkey. A comprehensive scientific base studied should be assess the present and past European eel stock in Turkey. In addition, the stock assessment of European eel should be taken in a holistic approach and convergence design methodology may be an innovative solution taking into consideration all distributional area.

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AQUACULTURE ON THE COASTAL ZONE OF THE MEDITERRANEAN SEA OF TURKEY

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1. Introduction

Aquaculture activities, that had been initiated in the mid 1970's with some freshwater fish (i.e. carp and trout) and early 1980's with marine fish (i.e. sea bass and sea bream) has been expanded dramatically since then reaching to 240,334 tons by 2015 in Turkey, but majority of the production has been gathered from only a few aquatic species, namely trout (*Oncorhynchus mykiss*) in the cold-freshwater sources, whilst European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) in marine waters. Recent statistics have shown that aquaculture sector produced 100,411 tons of trout, 75,164 tons of seabass and 51,844 of sea bream in 2015 in Turkey. The country is leader in trout production amongst the Mediterranean as well as EU states. As for marine fish production, Turkey is also ranked first in European seabass, while second, behind Greece, in seabream farming (FEAP 2015). Despite continueing attempts by a few commercial and state/university marine hatcheries to diversify species for the sector, limited success has been achieved so far at commercial scale. Studies have mainly focused on marine alternative fish species such as common seabream (*Pagrus pagrus*), Dentex (*Dentex* sp.), Meagre (*Argyrosomus regius*), Sharpsnout sea bream (*Diplodus puntazzo*) etc. but farming of other candidate groups such as freshwater fish species (e.g. catfish, tilapia, carp etc.), or more importantly bivalves (e.g. mussels, oysters and clams) and crustaceans (e.g. crayfish or shrimps) have been disregarded in the country.

Trout farming has been expanded throughout the cold water-sources, while marine fish production has been mostly concentrated in the western coasts (mainly Muğla and İzmir city boundaries) of the country. Among different regions, the Mediterranean has taken one of the least shares in terms of aquaculture production until present time, due to various reasons. As further noted in the following parts of this review, the Mediterranean region does not geographically provide so suitable conditions to foster aquaculture as in the Aegean Region. The coastline does not offer either protected bays for conventional cage-farming of marine species (Figure 1), or enough cold freshwater resources (especially lakes) suiting trout farming in the region. Although off-shore cage farming is possible and that higher average water temperature is known to favor faster fish growth in the warmer Mediterranean Sea as compared with the cooler Aegean Sea (see Figure 2), the risks of crop losses and the difficulties of working under harsh conditions at offshore sites should not be rulled out. Inland tank or pond culture systems are suggested to be more suitable particularly for new candidate species that can grow faster under the sub-tropical Mediterranean climatic conditions. However, temperature fluctuations or extreme values confronted within the year, especially under farming conditions, can cause distress and disease problems on aquatic species, making it necessary to employ more sophisticated production techniques to sustain better growth rate and achieve higher yield. Therefore, new species and novel specific production techniques are suggested if aquaculture is to be expanded in the Mediterranean region, as also discussed in the last part of this review.

2. Geography of the Region

Turkish Mediterranean coast of Turkey lies between the city Hatay in the far southeastern part and Antalya in the western part and represent the warmest part of the country. The Mediterranean coastline covers 1,577 km in length has a typical Mediterranean climate, with hot, dry summers and mild to cool, wet winters, but a semi-arid continental climate in the interior with hot, dry summers and cold, snowy winters. Unlike mountainous areas, coastal air temperature rarely falls below minus degrees while in the summer months temperature may rise above 40°C for during a couple of months (July – August). On the coastline, the summers are very hot and dry with almost no rain for several weeks, while winters are mild and rainy.

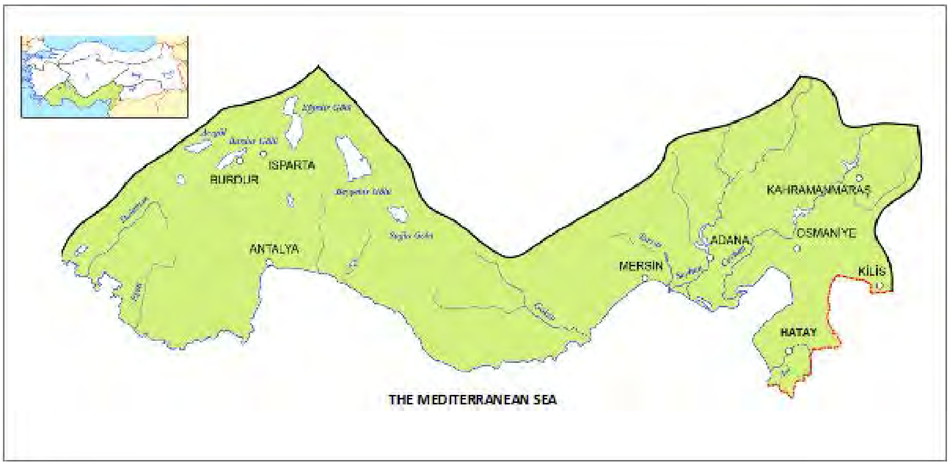

Figure 1. Map of the Mediterranean Region of Turkey.

Several rivers, including Asi, Seyhan, Ceyhan, Göksu, Manavgat, Aksu and Dalaman flow into the sea with high freshwater contribution during winters and very low flow rate during arid summers. The region is rich in terms of lakes, mostly situated far away from the coastline. The mojor lakes are including Beyşehir, Eğirdir, Burdur, Kovada, Acıgöl, Suğla, Söğüt, Salda, Elmalı and Avlan lakes, not to mention numerous smaller ones. Several dam lakes (i.e. Seyhan, Asi, Manavgat and Aslantaş) are also present in the region. On the coastline, some of the largest lagoons of the country are situated mainly in the Çukurova Delta, including Akyatan, Akyayan, Tuzla, Çamlık and Yelkoma lagoons. The Mediterranean Sea is the warmest and most saline sea (39 ppt) of the country. The region is also country's warmest and sunniest part with shortest winter season, starting from mid December to mid of March (about 3 months). Some of the most fertile flatlands (i.e. Çukurova, Amik and Antalya) are situated in this region.

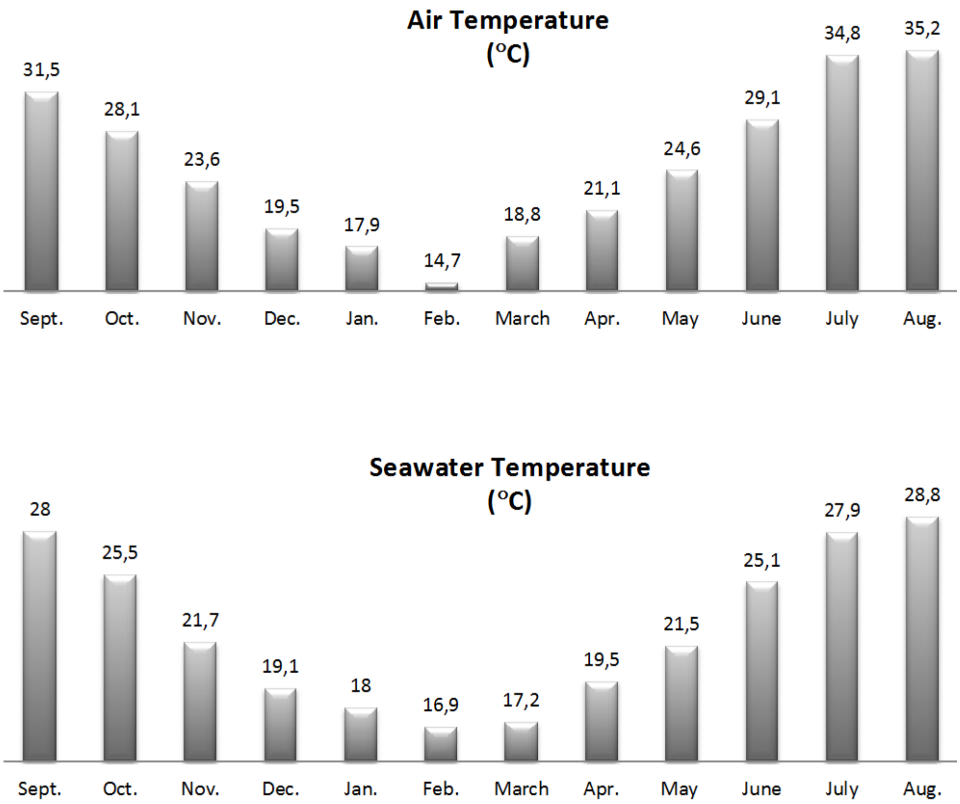

Figure 2. Average monthly air and surface water temperature of Mediterranean region (measured in Mersin)

There are four big cities (Antalya, Mersin (İçel), Adana and Hatay), having coasts to the Mediterranean sea and this review will focuse mostly on marine aquaculture activities that are taking place in the territory of these cities, excluding cold-species aquaculture activities that are performed in cold, mountainous areas, away from the coastline.

3. Fisheries and Aquaculture on the Coastal Zone of the Mediterranean Sea

Capture fisheries production of Turkey was reported as 431,907 tons, while aquaculture production rose to 240,334 tons in 2015 (TÜİK 2016). The majority of marine aquaculture production has come from mainly cage farming of European sea bass and gilthead seabream; on the other hand, rainbow trout farming dominated freshwater aquaculture activities in the country. Capture fisheries on the coasts of the Mediterranean region contributed to only 2.3% of the total national capture fisheries production, and likewise aquaculture share of this region was also only 2% of the whole country's aquaculture production. The region produced 3,705 tons of freshwater fish (mainly trout) and 1,217 tons of marine fish (again mainly seabass and gilthead seabream), with some minor productions of other species. There is no doubt that such low figures clearly indicate that aquaculture production in the Mediterranean region, with so long coastline and lots of freshwater resources, is extremely low and urgently needs to be increased.

Table 1. Fisheries and aquaculture production in Turkish coastal zone of the Mediterranean Sea (i.e. Antalya, Mersin, Adana and Hatay) in 2015 (TUIK 2016).

	CAPTURE PRODUCTION (Tons)	
Groups	**National**	**Mediterranean Coast**
Marine Capture Fish	345,765	8,599.9
Other Marine Capture Species	51,966	1,431.1
Inland Fisheries Production	34,176	1,581.0
Sub TOTAL (Capture)	**431,907**	**11,612**
AQUACULTURE PRODUCTION		(Tons)
Inland Aquaculture Production	101,455	3,705
Marine Aquaculture Production	138,879	1,217
Sub TOTAL (Aquaculture)	**240,334**	**4,922**
TOTAL (Capture + Aquaculture)	**672,241**	**16,534**

Aquaculture activities in Antalya region were yielded a value of total 2,534 tons, with a large proportion came from rainbow trout production (Table 2). A total of 83 licenced-farms produced 2,213 tons of trout and that 3 hatcheries cultured 39 million fry in this region in 2015. There appear to be interest to many other aquatic species including tuna, sturgeon, common carp, slug and even frog for culture in Antalya, but only 1 farm actively producing 30 tons of common carp in the region. Highest number of ornamental fish (5 million) in the Mediterranean were produced in the Antalya region in 2015.

In Adana region, a total of 1,125 tons of seafood commodities (i.e. trout and sturgeon) were produced in 2015 (Table 3). Hatchery trout fry production was reported as over 10 million, while seabass/seabream fry production was 54 million in that year.

Table 2. Farmed groups/species, production capacity and number of farms located within the territory of Antalya city (BSGM 2016).

Farmed Groups/ Species	**Production Capacity**		**Number of Farms/Hatcheries With Licence**	**Total Production** (Tons)
	Tons	Number of Fry		
Rainbow Trout	3,070	-	82	2,213
Hatchery for Trout	-	39,000,000	3	-
Seabass / Seabream	3,550		4	285
Hatchery for	-	20,000,000	(State Hatchery)	-
Tuna	300		1	-
Sturgeon	30	-	1	-
Common Carp (*Cyprinus*	41	-	3	36
Slug	0.3	-	1	-
Frog	84	-	3	-
Ornamental Fish	-	5,000,000	2	-
TOTAL	**7,345**	**-**	**100**	**2,534**

Table 3. Farmed groups/species, production capacity and number of farms located within the territory of Adana city (BSGM 2016).

Farmed Groups/ Species	**Production Capacity**		**Number of Farms/Hatcheries With Licence**	**Total Production** (Tons)
	Tons	Number of Fry		
Rainbow Trout	3,186	-	25	1,102
Hatchery for Trout	-	10,805,000	11	-
Seabass / Seabream	227.5		2	-
Hatchery for Seabass/Seabream	-	54,000,000	2	-
Sturgeon	54	-	2	23
Common Carp (*Cyprinus carpio*)	55	-	3	-
Spirulina sp.	3	-	3	-
Ornamental Fish	-	1,010,000	2	-
TOTAL	**3,525.5**	**-**	**50**	**1,125**

Two freshwater (trout and common carp) and two marine fish species (seabream/seabass) were produced as food commodities within the territory of Hatay in 2015. The total aquaculture production figure was realized as 510 tons for that year (Table 4). Only one ornamental fish farm did produce 100.000 fish for aquarium sector in the region.

Table 4. Farmed groups/species, production capacity and number of farms located within the territory of Hatay (BSGM 2016).

Farmed Groups/ Species	**Production Capacity**		**Number of Farms With Licence**	**Total Production** (Tons)
	Tons	Number of Fry		
Rainbow Trout	142	-	6	15
Seabass / Seabream	1539		4	482
Common Carp (*Cyprinus carpio*)	58	-	2	13
Ornamental Fish	-	100,000	1	-
TOTAL	**1,739**	**-**	**13**	**510**

A total of 55 aquafarms/hatcheries were registered with official authorities in the Mersin region, with majority engaged in trout farming (Table 5). A production level of 303 tons of trout and 450 tons of seabream/seabass were reported in 2015 in the region (total 703 tons). Five farms in the Mersin territory produced 2,666,000 of ornamental fish in that year.

Table 5. Farmed groups/species, production capacity and number of farms located within the territory of Mersin region (BSGM 2016).

Farmed Groups/ Species	**Production Capacity**		**Number of Farms/Hatcheries With Licence**	**Total Production** (Tons)
	Tons	Number of Fry		
Rainbow Trout	479	-	37	303
Hatchery for Trout	-	10,554,000	4	-
Seabass / Seabream	2,330	-	7	450
Common Carp (*Cyprinus carpio*)	25	-	1	-
Catfish	10	-	1	-
Ornamental Fish	-	2,660,000	5	-
TOTAL	**2,844**	**-**	**55**	**753**

Officials from the Ministry of Food, Agriculture and Livestok have stated that there have been a great number of aquafarm project applications received in 2016 and these are all under evaluation by the ministry. The number of applications have been reported to be 63 for Hatay, 35 for Mersin, 15 for Adana and 3 for Antalya in 2016.

3. Mediterranean Coastal Lagoons

Overall, Turkey has 72 lagoons covering approximately 37,389 ha surface area along the 8,333 km long national coastline. The major activitiy in most of these lagoons is traditional fishing, yielding a total of 2,700 tons. Among all the coastal lagoons, 17 of them (Table 6), making up an area of approximately 11,600 ha, are situated in the Mediterranean southern coastal areas with an overall production of 430 tonnes gathered from fishing activities. The Mediterranean lagoons are mainly found in the delta areas of the only three major fluvial systems along this coastline: the Meric River near Silifke, and the rivers of Seyhan and Ceyhan in the Çukurova Delta. The lagoons of the latter (i.e. Akyatan, Ağyatan, Yumurtalık, Camlık, Tuzla and Yelkoma Lagoons) stand out as among the most important of Turkey by their size, fish production potential and ecological interests (FAO 2015). Different types of nature and wildlife protections have been declared for a majority of the lagoons in the Çukurova Delta.

Table 6. Lagoons along the Mediterranean coast of Turkey (FAO 2015)

Name of Lagoon	Surface Area (ha)	Province	District
Gelemis	7	Antalya	Kaş
Beymelek	250	Antalya	Kale
Akgol	820	İçel	Silifke
Paradeniz	590	İçel	Silifke
Dipsiz	50	İçel	Tarsus
Tuzla	800	Adana	Tuzla
Akyatan	5,000	Adana	Karataş
Ağyatan	1,100	Adana	Karataş
Çamlık	1,300	Adana	Yumurtalık
Yelkoma	640	Adana	Yumurtalık
İkizler Kum	13	Hatay	Erzin
Yeniyurt	9	Hatay	Dörtyol
Seçil	5	Hatay	Dörtyol
Tarım İl	8	Hatay	Dörtyol
TIGEM	24	Hatay	Dörtyol
Katipoğlu	13	Hatay	Dörtyol
Tuz Lake	6	Hatay	Samandağ

The lagoons are utilised for many purposes and the following criteria were established for classification by MoFAL (1997): fishing, aquaculture, recreational, tourism, hunting, wildlife protection, reed harvesting, cattle grazing, leech collection, research and training. Despite great potential in terms of land and water availability in and around these lagoons, authorities are not given permission to establish fish farms as the lagoons are under protection. The Ministry of Food, Agriculture and Livestock prohibited collection of fish juveniles from the wild for aquaculture purposes since 2000 and no any actions to enhance productivity (pre-fattening, artificial nursery areas, restocking, intensive aquaculture, predator control, selective fishery, wintering strategies and seaweeds control) have been allowed since then. However, it is believed that where there is a way of safe discharging possibilities of wastewater in or around the lagoonar areas, a lot of opportunities can be explored to increase pond aquaculture production of various fish, bivalves or crustaceans on the coastal areas of the Medieterranean Sea.

4. Aquaculture Potential on The Coastal Zones of The Turkish Mediterranean Sea

Turkish seafood industry has been remarkably growing since the late 1970s and the production has increased from about 3000 tons in 1986 to an outstanding figure of close to 250,000 tons in 2015. This increasing trend is expected to continue to reach about 500,000 tons by 2023, according to data released by the country's General Directorate of Fisheries and Aquaculture. Today, Turkey is Europe's number one player in trout production, while also one of the top players in the production of seabream and seabass. Currently Turkish aquaculture sector exports seafood to more than 80 countries worldwide. The rapidly growing aquaculture sector is now fully integrated with modern and advanced technologic capabilities in production (hatcheries to on-growing farms), processing and packaging facilities, feed factories and other plants producing packaging and technical equipments that are in use by the sector. It is well acknowledged that a greater proportion of the fish that are consumed in EU countries are exported by Turkish aquaculture sector. The sector has been clearly squeezed into culture of only a few species for long and diversification both in terms of species and culture techniques could provide benefits and help sustainability of the sector in the long run. Obviously, offering a wider range of seafood products to international as well as domestic markets would provide the sector a chance to get better and competitive prices in the markets worldwide. Therefore, in addition to finfish farming, new opportunities have to be urgently explored with a wide range of shellfish and crustaceans in some regions of the country, including the Mediterranean Sea. In order to invest into new species, R&D studies have to be intensified and new production practices need to be tested under local conditions. New hatcheries are a prerequsite in order to regularly supply high quality seeds throughout the year for any new species to be farmed in the country.

Currently, most of marine finfish production in the country is based on cage farming that is mostly concentrated in the Aegean region and that there are only a few cage farms and almost none land-based pond production systems in the warmer coastal Mediterranean zone, which offers very suitable areas for inland farming of fish (temperate species, i.e. sesabass/seabream, sole, tilapia, catfish, carp etc.), bivalves (i.e. oyster, clams) or crustaceans (tropical crayfish, crabs or freshwater and marine shrimps). In fact, subtropical climatic conditions, long coastline, clean coastal waters, rich lagoonar areas and good quality warm underground waters are some of the main reasons favoring inland aquafarming in the Mediterranean coasts of Turkey.

5. New Species For Farming on the Coastal Zone of the Mediterranean Sea

5.1. Fish

In addition to pond-culture of seabass/seabream, which offer a chance to farm tastier and premium crops for local markets (Figure 3), to be developed in the coastal areas of the Mediterranean Sea, some other species of finfish can also be suggested for farming, including catfish (*Silurus* sp., and *Clarias* sp.), Nile tilapia (*Oreochromis niloticus*), common carp or even Asian sea bass commonly named as barramundi (*Lates calcarifier*). The catfish, Nile tilapia and common carp command very good prices in Hatay and the Middle Eastern countries particularly in Syria, Iraq and other southern countries around the country. While tilapia culture has been undertaken for over 30 years in Çukurova Region (Figure 4) and that this fish has been widespread in all the streams, river, water channels and small lakes therein, still no significant breakthrough in its farming at commercial level has achived as yet. Folowing recent R&D studies, that have been carried out by local scientific institutes (Turan and Çek, 2007; Bircan and Turan, 2010; Turan and Güragaç, 2014), some new attempts to farm *Clarias* sp. and *Silurus* sp. have been initated (Figure 5) in the region at a small scale.

Figure 3. Earthen-pond farmed sea bass and sea bream from Çukurova Region of the Mediterranean Sea.

All these alternative fish species possess very good attributes for aquaculture especially in warm water conditions and thus underground well waters and greehousing systems must be incorporated into their culture models if to sustain cost-effective solutions. Carp farming has unfortunately not become widespread in the country, but as stated earlier, this fish is also popular in the Middle Eastern countries and hence it's farming should seriously be considered for export purposes for that market. Barramundi is a fast growing tropical fish, non-native to Turkey, but it's potential for aquaculture in recirculating systems (RAS) under greenhouses should be studied and tested in the warmer Mediterranean regions prior to upscaling to commercial level. This species is reported to reach a marketable size of about ½ kg in 6 months an 2 kg in 12 months with 1.5-2 FCR and 30-40 kg/m^3 in ponds under appropriate conditions in either fresh or brackish waters (Schipp *et al.* 2007). It gows well at 28-30°C, as all other tropical species, but growth is ceased at temperatures below 20°C. Therefore, in order to maintain fast growth rate, bore water and climate controlled or insulated sheds have to be used. Being a tasty and well-known species, barramundi is regarded as a very promising species especially for European as well as domestic markets. Though at its initial stages, R&D studies to develop culture techniques of various species of grouper have been underway in local universities in Adana and Hatay regions (Yılmaz *et al.* 2015; Eroldoğan *et al.* 2016; Genç *et al.* 2016).

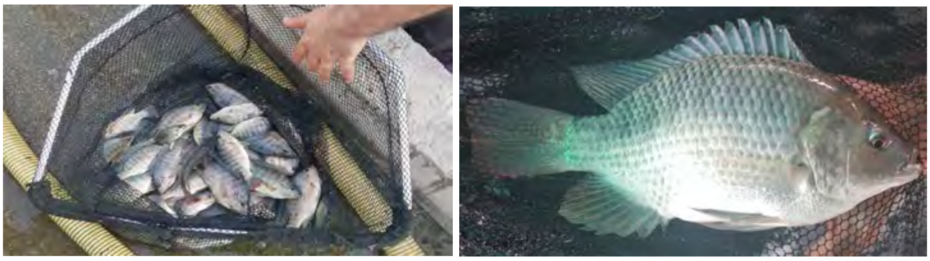

Figure 4. Farmed tilapia and a 6-month old specimen (*Oreochromis niloticus)* in southern part of Turkey (Çukurova University, Adana).

a. Bivalves

Another group of aquatic organisms, that are neglected to be farmed in the Mediterranean Region as well as in the whole country, are bivalves e.g. osyters (*Crassostrea gigas*) or clams (*Tapes* sp.) in rack, sack or some other type of cultures (i.e. longline, raft) in ponds for European market. As the region is warm, tropical oyster species such as Pacific oyster or tropical clams suc as Manila clam (*Tapes philippinarum*) can be considered as good candidates for farming in the region. Although non-native to Turkey, in fact their occurance has been reported in Iskenderun Bay and/or some other parts of Agean Sae or the Marmara Sea in the country. Hence, broodstock of Pacific oyster or Manila clam can readily be found in our local stocks for farming purposes, as also their sterile and disease-free seeds can be imported from internationally recognized institutes if necessary permissions are taken from the Ministry of Food, Agriculture and Livestock. Both clams and oysters culture can be achieved by using relatively cheap materials that ultimately placed in fertilized ponds or directly into the coastal areas of the sea (Kumlu, 2001). The southeastern part of the Mediterranean region of Turkey is considered to be too warm for Mussel to be farmed and as a matter of fact this bivalve does not habituate this part of the Mediterranean at all.

Figure 5. African catfish farmed in the Mediterranean region by a small commercial farm.

5.3. Crustaceans

Majority of the production in crustaceans come from mainly marine shrimps and freshwater crayfish as capture from the wild in Turkey. A high percentage of shrimps are caught in the Sea of Marmara, whilst crayfish are fished in cooler regions of the Anatolia. One of the most studied groups of aquatic organisms in the Mediterranean Region are crustaceans, particularly marine shrimps and tropical crayfish by universities situated in the region. In Turkey, the eastern coastal Mediterranean part is one of the most suitable region for farming warm water crustacean species i.e. marine tropical shrimps, prawns, crayfish as well as crabs. There are numerous shrimp species that inhabit the Mediterranean and a great majority of them are of Indo-Pacific (e.g. *Penaeus semisulcatus*, *P. japonicus*, *Metapenaeus monoceros* etc.) or even of Atlantic in origin (e.g. *Penaeus aztecus*). Unfortunately, there is no any indigenous shrimp species in the Mediterranean Sea that is even considered suitable for aquaculture. Inspite of a few unsuccessful attempts concerning shrimp farming on the Turkish Mediterranean coasts earlier in the 1990's, increasingly accumulated national R&D experiences and preliminary growth trials related to new culture techniques of shrimps have started to take more attention of the developing aquaculture sector. A new shrimp farming attempts on the coasts of the Turkish Mediterranean Region are expected in the very near future.

Figure 6. Pacific white shrimp farmed from eggs till marketable size (4-5 months) in Çukurova Region by researchers from Çukurova University in southern part of Turkey (Kumlu *et al.* 2016).

The biological attributes of marine shrimp tend to promote a production cycle based on late-spring stocking followed by harvest in the late-autumn of the same year, with all harvesting taking place at the end of the summer season when demand is naturally falling. Unlike in the tropics, within the limited grow-out period in this climate (5-6 months), one crop per year can only be realized. A number of strategies may be suggested to produce more crops or increase final marketable size of shrimps grown in farms in the sub-tropics. The first may be to produce post-larvae (PL) pre-seasonally in order to allow shrimp farms to stock grow-out ponds with shrimps earlier in the year. To achieve this, spawning, larval and nursery culture of penaeid shrimps has to be carried out in covered ponds during winter months until water temperature of grow-out ponds is warm enough for fast growth. Another strategy could be to utilize geothermal waters or to over-winter PLs throughout the cold season at the cheapest possible cost and then stock them into grow-out ponds in the next warm season (Kumlu *et al.* 2003). In either case, holding shrimp over the winter leads to extra cost and would naturally reduce competitiveness.

While local marine shrimps (e.g. *Penaeus semisulcatus*) in open earthen ponds at low stocking densities yields only one crop per year, the Pacific white shrimp (*Penaeus vannamei*) in RAS systems yields 2-3 crops per year. The pilot trials carried out by a reaserch team from Çukurova University with the latter has proven good results and R&D studies has been intensified on various culture strategy of Pacific white shrimp in Çukurova Region (Figure 6) (Kumlu *et al.* unpublished data). This shrimp species can be stocked at very high densities (200-400 pieces/m^2) and, even at such crowding conditions, they can reach marketable size in less than 4 months with good FCR's, compared to 6 months of our local species (i.e. *P. semisulcatus*) at much lower stocking rates (20-30 pieces/m^2). Therefore, if a shrimp-farming sector is to be developed in the country, there is no much choice but to prefer the farming of the fast growing and disease-free strains of Pacific white shrimp, as has been done by other 50-60 countries worldwide. At the start, one thing that might be reasonable is to restrict the importation of broodstock/seeds from only reputable hatcheries and that RAS systems are allowed before expanding the sector to open ponds.

Concerning inland waters, our endemic crayfish species *A. leptodactylus* does not appear to emerge as a candidate for farming in the country in the coming future because of its susceptibility to crayfish plague disease and slow growth rate. If we are to grow crustaceans in our inland waters in warmer freshwater sources, we will have to consider and discuss possibilities of farming non-indegenous species on the coastal Mediterranean regions. Among these, the giant prawn *Macrobrachium rosenbergii* and the red-claw Australian crayfish *Cherax quadricarinatus* will have to be considered for cultivation in land-based pond farms along the sub-tropical coastline. Both of these species are fast-growing crustaceans; capable of reaching to marketable size within one growing season (5-6 months) and this has already been demonstrated in many projects carried out in Çukurova Region by the researchers from Çukurova University (Figs. 7 and 8). These species of prawn and tropical crayfish can be reared throughout the year in the coastal Mediterranean Region if RAS systems and greenhouses are integrated into production model. Currently, several comprehensive R&D projects are underway to test and find out the most suitable production strategy for farming tropical marine shrimps and the red-claw crayfish in Çukurova Region of the Mediterranean Sea.

Figure 7. The giant freshwater prawn (*Macrobrachium rosenbergii*) farmed from postlarval stage to marketable size (5 moths) in Çukurova Region by researchers from Çukurova University.

Other groups of crustaceans such as crabs particularly *Callinectes sapidus* and *Portunus pelagicus*, that are abundant in coastal waters and lagoon systems in the region, have also aquaculture potential in southern part of Turkey. However, the main factors affecting future development of crustaceans' production in the land-based systems are availability of comparatively large suitable sites, easier licensing procedures, more proper production planning, economical over-wintering solutions, and well marketing strategies if to become successful and remain competitive (Kumlu and Lök 2007).

Figure 8. The red claw crayfish (*Cherax quadricarinatus*) farmed in Çukurova University in southern part of Turkey.

6. Future Perspectives and Conclusions

∗ It is clear that the Mediterranean coasts of Turkey is way under utilized in terms of aquaculture and that this sector has to be urgently expanded in this region,
∗ In the coastal zone of the Mediterranean Sea, marine cage-farming does not appear to develop at a pace like in the Aegean Sea at least in the near future, rather small inland pond/tank aquaculture farms would have better chance to expand in the region,
∗ The coastal Mediterranean Sea of Turkey provides potential to farm freshwater, brackishwater and marine species of tropical in origin, but overwintering facilities and warm underground waters as well as coast-effective greehouses have to be integrated into culture systems in the area,
∗ The very new aquatic species with aquaculture potential that have already been tested in the region or elsewhere are;

FINFISH - Nile tilapia, catfish (*Silurus* sp. and *Clarias* sp.), common carp, European seabass/seabream, Asian seabass (barramundi) in ponds/tanks,
BIVALVES – Pacific oyster, Manila clam,
CRUSTACEANS – Pacific white shrimp, giant frewhwater prawn, the red claw crayfish

∗ Except Asian seabass, Pacific oyster and Manila clam, the rest of the above species have already been tested for their suitability for aquaculture in the Mediterranean region of Turkey,

∗ With regard to farming non-endemic species in the coastal Mediterranean zone, one thing that might be reasonable is to restrict the importation of broodstock/seeds from only reputable hatcheries and that RAS systems are allowed before expanding the sector to open ponds.

∗ Though Nile tilapia, common carp, catfish have not well acknowledged by Turkish consumers especially on the castal areas, these species have great potential to be marketed at high prices in the neighbouring Middle Eastern countries.

∗ Pacific oysters, Manila clams and the tropical crustaceans that are listed above should be marketed fresh in order to be competitive against suppliars from the Far Eastern countries, while the red claw crayfish should be exported live to European Union and other international markets (e.g. Scandinavian countries).

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GENETIC STUDIES IN TURKISH MARINE WATERS OF THE MEDITERRANEAN SEA

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1. Introduction

Mediterranean Sea, an intercontinental sea that stretches from the Atlantic Ocean on the west to Asia on the east and separates Europe from Africa. Its west-east extent—from the Strait of Gibraltar between Spain and Morocco to the shores of the Gulf of Iskenderun on the southwestern coast of Turkey—is approximately 2,500 miles (4,000 km), and its average north-south extent, between Croatia. The biodiversity and total biomass is being reduced in the Aegean Sea due to factors such as pollution, over-fishing, transportations and other anthropogenic effects. On the other hand, the global climate change increase the number of introduced invasive lessepsian species and put more pressure on native stocks (Turan *et al.* 2016). Due to these undesirable negative factors, there is a high demand on population genetic and phylogenetic studies to elucidate current status and structure of stocks and species in the Mediterranean Sea that allow us to take conservation actions. In this chapter, the population genetics and phylogenetic studies which have been conducted on the Mediterranean species are reviewed.

2. Genetic diversity of Species in the Mediterranean Sea

The Mediterranean Sea is a sea connected to the Atlantic Ocean, surrounded by the Mediterranean Basin and almost completely enclosed by land: on the north by Southern Europe and Anatolia, on the south by North Africa, and on the east by the Levant. The Mediterranean Sea is a very important biological corridor for many migratory species of fish and mammals from the Mediterranean to the Red Sea via Suez Canal. Therefore, the Mediterranean Sea may be a sieve to select or eliminate some genetic traits for the migratory species. Furthermore, there are other factors such as overfishing, tourism and climate change that cause variation in the genetic diversity of population of a species in the Mediterranean Sea. The Mediterranean Sea is under pressure of heavy fishing, high industrialized factories and tourism activities which cause pollutions and habitat degradations that constraints marine life. This kind of pressures seems to be shifting the marine species richness and structure and open a door for invasive species. After the opening of the Suez Canal in 1869, a migration began from the Red Sea with many species of Indo-Pacific origin penetrating the eastern Mediterranean Sea. Many lessepsian fish species able to adapt rapidly to the new environment spread to the Mediterranean to establish new populations (Erguden *et al.* 2009a). Therefore, some endemic species can take the place with other lessepsian species. Over-fishing of native species result in decrease in native populations over time. A decrease in native species results in a formation of space and the abundance of nutrients which may generate presence of a suitable environment for the lessepsian species. Lessepsian species pressure on Mediterranean Sea marine life result in declining native species, and lessepsian species become common in these areas by establishing their diet tend to increase the reproductive ability. Therefore, genetic studies should be conducted especially on endangered or fragile species to elucidate genetic structure and take conservation actions accordingly.

3. Genetic and Morphological Studies on the Mediterranean Sea Marine Biota

There are numerous population genetic and phylogenetic studies on population of a species in the Mediterranean Sea (Table 1) which are largely based on fishes, and limited numbers of studies were conducted on invertebrates. Genetic and morphological techniques are commonly used to describe population structuring of a species in the Mediterranean Sea. Morphological characters such as morphometrics, meristics, otolith shape and chemistry are commonly used characters for population identifications in the Mediterranean Sea that usually reflect genetic differentiation. Genetic markers that is allozyme, Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), Microsatellites, DNA sequencing, DNA barcoding and Environmental DNA techniques have been used for population and species identifications and also phylogenetic relationships, until recently. The first genetic study on fishes was conducted with allozyme analysis by Turan *et al.* (2004a) and on sea turtles by Kaska *et al.* (1998). The first DNA barcoding approach on marine species in Turkish waters was done by Kochzius *et al.* (2008) and Kochzius *et al.* (2010) who studied DNA barcoding using three mitochondrial genes 16S rRNA (16S), cytochrome b (cyt b), and cytochrome oxidase subunit I (COI) for the identification of 50 marine fish species on in European waters, including Turkish seas and found that Cyt b and COI are suitable for unambiguous identification of marine fishes. The first environmental DNA study was conducted on marine fishes of Turkey by Dogdu and Turan (2016).

Table 1. Genetic and morphological studies in Turkish coasts of Mediterranean Sea.

Author	Marker	Species
Kaska *et al.* (1998)	mtDNA sequencing	*Chelonia mydas*
Laurent *et al.* (1998)	mtDNA sequencing	*Caretta caretta*
Kaska (2000)	mtDNA sequencing	*Caretta caretta* and *Chelonia mydas*
Turan and Basusta (2001)	Morphometric characters	*Alosa fallax nilotica*
Turan (2004)	Morphologic differentiation	*Trachurus mediterraneus*
Turan *et al.* (2004a)	Allozyme	Mugilidae
Turan *et al.* (2004b)	Morphology	*Engraulis encrasicolus*
Castilho and Ciftci (2005)	Microsatellites	*Dicentrarchus labrax*
Erguden and Turan (2005)	Allozyme and Morphologic differentiation	*Dicentrarchus labrax*
Carreras *et al.* (2006)	mtDNA sequencing	*Caretta caretta*
Turan (2006)	Allozyme and Morphology	*Mullus barbatus*, *M. surmuletus*, *Upeneus moluccensis*, *U. pori*, *M.b. ponticus*
Turan *et al.* (2006)	Morphometric and Meristic characters	*Pomatomus saltatrix*
Bowen *et al.* (2007)	mtDNA sequencing	*Caretta caretta* and *Chelonia mydas*
Garoia *et al.* (2007)	AFLP and Microsatellite	*Solea solea*
Casale *et al.* (2008)	mtDNA sequencing	*Caretta caretta*

Kochzius *et al.* (2008)	DNA Barcoding	*Boops boops, Engraulis encrasicolus, Helicolenus dactylopterus, Lophius budegassa, Pagellus acarne, Scomber scombrus, Serranus cabrilla, Sparus aurata, Trachurus trachurus, Trigla lyra*
Sarmasik *et al.* (2008)	mtDNA sequencing	*Sardina pilchardus*
Turan (2008)	mtDNA sequencing	Rajiformes
Erguden *et al.* (2009b)	Morphometric and Meristic characters	*Scomber japonicus*
Garofalo *et al.* (2009)	mtDNA sequencing	*Caretta caretta*
Turan *et al.* (2009a)	RFLP	*Trachurus mediterraneus*
Turan *et al.* (2009b)	mtDNA sequencing and Morphology	*Helicolenus dactylopterus, Scorpaena maderensis, S. porcus, S. elongata, S. scrofa, S. notata*
Turan *et al.* (2009c)	RFLP	*Trachurus trachurus*
Erguden *et al.* (2010)	mtDNA sequencing	*Mugil cephalus, Chelon labrosus, Oedalechilus labeo, Liza abu, L. aurata, L. saliens, L. ramada, L. haematocheilus*
Gubili *et al.* (2010)	mtDNA sequencing	*Carcharodon carcharias*
Kochzius *et al.* (2010)	DNA Barcoding	Marine species
Turan and Yaglioglu (2010)	RFLP, Morphology and Cuttlebone chemistry	*Sepia officinalis*

Keskin and Atar (2011)	mtDNA sequencing	*Octopus vulgaris*
Turan (2011)	mtDNA sequencing	*Spicara maena, S. flexuosa, S. smaris, Centracanthus cirrus*
Yılmaz *et al.* (2011)	mtDNA sequencing and Microsatellite	*Caretta caretta*
Bagda *et al.* (2012)	mtDNA sequencing and Microsatellite	*Chelonia mydas*
Keskin and Atar (2012)	mtDNA sequencing	*Engraulis encrasicolus*
Yaglioglu and Turan (2012)	mtDNA sequencing	*Saurida undosquamis*
Gurlek *et al.* (2013)	RFLP	*Trachurus trachurus*
Keskin and Atar (2013)	DNA barcoding	Marine species
Karahan *et al.* (2014)	Microsatellite, Geometric Morphometrics and Otolith shape	*Engraulis encrasicolus*
Tuncay and Bardakci (2014)	Microsatellite	*Engraulis encrasicolus*
Turan and Gungor (2014)	RFLP	*Patella caerulea*
Turan (2015)	Microsatellites	*Sarda sarda*
Turan *et al.* (2015a)	mtDNA sequencing	*Alosa caspia, A. fallax nilotica, A. maeotica A. immaculata, A. tanaica*
Turan *et al.* (2015b)	mtDNA sequencing	*Sarda sarda*

Dogdu and Turan (2016)	Environmental DNA	*Epinephelus aeneus*, *E. caninus*, *E. costae*, *E. marginatus*, *Hyporthodus haifensis*, *Mycteroperca rubra*
Seyhan and Turan (2016)	DNA Barcoding	Scombridae
Sonmez *et al.* (2016)	Morphology	*Chelonia mydas*
Uyan and Turan (2016)	mtDNA sequencing and Morphology	*Chelidonichthys lucerna*

There are numerous population genetic studies of the Mediterranean Sea species (Table 1) that are primarily based on fishes. However, there is limited number of studies based on other groups such as invertebrates, unfortunately. Morphological techniques are frequently used with/without genetic techniques to describe population structure, as well. Morphological characters such as morphometrics, meristics, otolith shape and chemistry are useful characters that usually reflect genetic differentiation. However, morphological differentiation may not have genetic bases due to high plasticity feature of fish for adaptation in different environmental conditions.

Kaska *et al.* (1998) studied genetic sequence diversity in the mitochondrial DNA control region of the green turtle (*Chelonia mydas*) population of Northern Cyprus. No polymorphisms were found among the 17 samples. This finding lowers the estimated genetic diversity for the green turtle population nesting on Cyprus and fails to detect any genetic exchange with the Atlantic population.

Laurent *et al.* (1998) conducted a study based on an extensive sampling regime from both nesting populations and bycatch, frequency analyses of mitochondrial mtDNA control region haplotypes in the Mediterranean were used to assess the genetic structure and stock composition of the loggerhead sea turtle, *Caretta caretta*, in different marine fisheries. The analyses showed that present impact of fishery-related mortality on the Mediterranean nesting population is probably incompatible with its long-term conservation, sea turtle conservation regulations are urgently needed for the Mediterranean fisheries and the significant divergence of mtDNA haplotype frequencies of the Turkish loggerhead colonies define this nesting population as a particularly important management unit.

Kaska (2000) analyzed the mitochondrial DNA (mtDNA) control region sequences of two species (*Caretta caretta* and *Chelonia mydas*) of sea turtles from the Mediterranean using samples from Northern Cyprus. The results suggested that the Mediterranean population of sea turtles were separated from their Atlantic relatives and in order to protect these endangered sea turtles and to preserve the genetic diversity of the sea turtle population in the Mediterranean, individual nesting sites must be protected.

Turan and Basusta (2001) evaluated degree of differentiation among populations of twaite shad, *Alosa fallax nilotica* using the truss morphometric method. Plotting discriminant function 1 and 2 explained 100% of total between group variability and clearly discriminated Eastern Mediterranean sea sample from the Black and Aegean Sea samples. Principal component analysis (PCA) revealed that the observed differences were mainly from posterior morphometric measurements of body.

Turan (2004) investigated morphologic differentiation among stocks of the Mediterranean horse mackerel, *Trachurus mediterraneus*, throughout the Eastern Mediterranean, Aegean Marmara and Black Seas using morphometric and meristic characters. The overall assignment of individuals into their original sample by DFA was 57%. Most mis-assignments within groups were from the Black sea samples. The proportion of correctly classified Marmara sample to their original group was highest (88%), showing a clear separation from all others.

Turan *et al.* (2004a) investigated phylogenetic relationships of *Mugil cephalus*, *M. soiuy*, *Liza ramada*, *L. aurata*, *L. abu*, *L. saliens*, *L. carinata*, *Chelon labrosus*, *Oedalechilus labeo*) by means of allozyme electrophoresis using a seven enzyme system comprising eleven putative loci. The highest genetic divergence was 1.299, detected between *M. cephalus* and *L. aurata* and the lowest (0.280) was found between *L. carinata* and *L. saliens*. The amount of genetic divergence between the genera *Chelon* and *Oedalechilus* did not appear to be high (0.285).

Turan *et al.* (2004b) investigated population structure of *Engraulis encrasicolus* in the Eastern Mediterranean, Aegean and Black Seas using morphometric characters with the truss network system. They found statistically significant differences between populations of different Seas. Principal components analysis indicated that the observed differences were mainly from the measurements taken from the head.

Castilho and Ciftci (2005) examined genetic characterization of between eastern Mediterranean *Dicentrarchus labrax* populations and noticed that differentiation at nine microsatellite loci revealed that a Levantine Basin sea bass *Dicentrarchus labrax* population probably represents a further subdivision of this species in the eastern Mediterranean.

Erguden and Turan (2005) studied genetic and morphologic structure of the sea-bass, *Dicentrarchus labrax*, from the North-eastern Mediterranean, Aegean, Marmara and Black Seas using 9 loci. Fisher's exact test revealed that there were no genetic differences between populations for all loci, and genetic distance was 0.0001 between the Black Sea and Mediterranean samples. On the other hand, Trabzon sample was genetically different when only two loci were considered.

Carreras *et al.* (2006) analyzed genetic structuring of loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea using by mitochondrial DNA sequence analysis. As a consequence, the foraging grounds off the North-African coast and the Gimnesies Islands are shown to be inhabited mainly by turtles of the Atlantic stocks, whereas the foraging grounds off the European shore of the western Mediterranean are shown to be inhabited mainly by turtles from the Eastern Mediterranean rookeries.

Turan (2006) studied phylogenetic relationships of Mullidae species in the Mediterranean Sea (*Mullus barbatus*, *M. surmuletus*, *Upeneus moluccensis*, *U. pori*) and one subspecies (*M.b. ponticus*) based on genetic and morphologic data using 12 enzymatic systems. Pairwise comparisons of genetic distance were found to be 0.034 between *M. barbatus* and *M.b. ponticus*, and 0.341 between *M. barbatus* and *M. surmuletus* within the genus Mullus. Relatively higher genetic differentiation (D=0.628) was observed between *U. moluccensis* and *U. pori*. For intergeneric comparisons, the highest genetic distance (1.250) was detected between *M. surmuletus* and *U. pori*, and the lowest (D=1.056) was observed between *M. surmuletus* and *U. moluccensis*. Remarkably *U. pori* was genetically the most distinct species from the genus Mullus. Morphological data using meristic characters was congruent with the genetic data and revealed similar patterns of relationships among four Mullidae species.

Turan *et al.* (2006) investigated morphological variation of *Pomatomus saltatrix* were studied based on morphometric and meristic analyses of samples collected throughout the Black Seas, Marmara, Aegean and eastern Mediterranean Seas. In discriminant function analysis, plotting first and second discriminant functions explained 61 and 77% of the between-group variation for morphometric and meristic analyses, respectively, and indicated existence of three morphologically differentiated groups of *P. saltatrix*. Consistent differences in the summer and winter samples of the eastern Black Sea, the adjacent sea populations of western Black Sea, Marmara Sea and Aegean Sea, which were overlapping and northeastern Mediterranean samples were observed. The detected pattern of morphological differentiation also reflects their geographic isolation. Both for morphometric and meristic analysis, the highest reclassification rate was observed for the eastern Black Sea and northeastern Mediterranean Sea samples, the most clearly isolated groups.

Bowen *et al.* (2007) analyzed genetic diversity and phylogeography of sea turtles *Caretta caretta* and *Chelonia mydas* with mtDNA sequences. Analysis showed strong population structure among nesting colonies while nuclear loci reveal a contrasting pattern of male-mediated gene flow, a phenomenon termed 'complex population structure'. Mixed-stock analyses indicated that multiple nesting colonies can contribute to feeding aggregates, such that exploitation of turtles in these habitats can reduce breeding populations across the region.

Garoia *et al.* (2007) tested *Solea vulgaris* populations collected in the Mediterranean using different molecular markers AFLPs and microsatellite and found a correlation between microsatellite and AFLPs in detecting genetic differentiation among samples. However, on a small geographical scale, AFLPs were able to discriminate individuals from neighboring populations whereas microsatellite were not, and the percentage of individuals correctly assigned to their population of origin was higher with AFLPs than with microsatellite.

Casale *et al.* (2008) assessed genetic characterization of loggerhead sea turtles (*Caretta caretta*) populations using mtDNA sequencing analysis. Specific haplotypes indicated contributions from distant rookeries such as Turkey and the Atlantic, which showed that Atlantic turtles entering the Mediterranean while in the oceanic phase use at least one Mediterranean continental shelf as a neritic foraging ground.

Kochzius *et al.* (2008) developed a DNA microarray to be able to investigate its potential as a tool for the identification of fish species from European Seas based on mitochondrial 16S rDNA sequences. Oligonucleotide probes were designed based on the 16S rDNA sequences obtained from 230 individuals of 27 fish species. Study demonstrated that the 16S rDNA gene is suitable for designing oligonucleotide probes, which can be used to differentiate 11 fish species. These data were a solid basis for the second step to create a "Fish Chip" for approximately 50 fish species relevant in marine environmental and fisheries research, as well as control of fisheries products.

Sarmasik *et al.* (2008) examined to assess the genetic diversity of sardine (*Sardina pilchardus*) populations in Turkish coastal waters. The results of sequence analysis determined the existence of variations in 16 single nucleotide sites within the 452 bp fragment of the cyt b gene examined. The results revealed a pattern of high nucleotide homology among the adjacent populations, and a small number of nucleotide changes among disjunct populations, leading to concluded that there is a genetic admixture among the populations inhabiting the coastal waters of Turkey.

Turan (2008) conducted molecular systematic analysis of Rajiformes including 9 species (*Rostroraja alba*, *Leucoraja fullonica*, *Dipturus oxyrinchus*, *D. batis*, *Raja clavata*, *R. montagui*, *R. asterias*, *R. miraletus*, and *R. radula*). The mean nucleotide diversity (Pi) was 0.018. The genetic distances between pairs of species showed genetic homogeneity between *R. clavata* and *R. montagui*. The highest value of sequence divergence was detected between *D. oxyrinchus* and *R. asterias* (0.040). Low genetic distances were shown by the comparisons of *R. montagui* with *R. miraletus* and of *R. clavata* with *R. miraletus*.

Erguden *et al.* (2009b) used morphometric and meristic characters to discriminate stocks of chub mackerel *Scomber japonicus* throughout the Black, Marmara, Aegean, and northeastern Mediterranean Seas. Morphometric and meristic analyses showed a similar pattern of differentiation between *S. japonicus* stocks and revealed a clear discreteness of two groups, northeastern Mediterranean (Antalya Bay–Iskenderun Bay) and the northern group, including the Aegean, Marmara, and Black Seas. The contribution of each variable in distinguishing between the stocks for the first discriminant function revealed high contribution from head size measurements for morphometrics, and first and second dorsal fin rays for meristics. Plotting all specimens on the first two discriminant functions accounted for 76% of total variance for morphometric and 69% of total variance for meristic analyses, and both plots resulted in two main groupings. The overall random assignment of individuals to their original group was higher in morphometric than in meristic analysis.

Garofalo *et al.* (2009) sequenced 815 bp of the mtDNA of loggerhead turtles (*Caretta caretta*) population in the Mediterranean. The results narrowed the gap between haplotypes recorded in feeding grounds and those found in nesting grounds. Analyses of population structure showed a strong maternal isolation, with Calabria and east Turkey displaying far more diversity than expected considering their census size.

Turan *et al.* (2009a) investigated the genetic population structure of Mediterranean horse mackerel, *Trachurus mediterraneus*, from seven locations throughout the Black, Marmara, Aegean and eastern Mediterranean Seas using restriction fragment length polymorphism (RFLP) analysis of the mtDNA 16S rDNA region. Average haplotype diversity within samples was moderate (0.38), and nucleotide diversity was low (0.00435). Nucleotide divergence among samples was moderate, with the highest value detected between the Aegean Sea (Izmir) and the eastern Black Sea (Trabzon) populations (0.007055), and the lowest (-0.000043) between the Marmara Sea (Adalar) and the western Black Sea (Sile) populations. Mantel's test indicated that the nucleotide divergence among populations of *T. mediterraneus* was not significantly associated with their geographical isolation ($r = -0.2963$; $P > 0.05$). Consequently, the mtDNA 16S rDNA region provided evidence for the existence of three distinct *T. mediterraneus* populations (Sinop, Trabzon and Iskenderun Bay) in the Black and north-eastern Mediterranean Seas.

Turan *et al.* (2009b) investigated with morphological and mitochondrial 16S rDNA sequence data of Scorpaeniformes species in the Mediterranean Sea (*Helicolenus dactylopterus*, *Scorpaena maderensis*, *S. porcus*, *S. elongata*, *S. scrofa*, *S. notata*). The mean nucleotide diversity was found to be 0.0792. Average sequence divergence between species of Sebastidae and Scorpaenidae was 8.4%, and 6.4% between species of the genus Scorpaena. High levels of nucleotide divergence were detected between species of two families, and the maximum value was found to be 14.5% between *H. dactylopterus* and *S. elongata*. The highest morphological divergence was observed between *H. dactylopterus* and *S. porcus*, and the lowest was detected between *S. elongata* and *S. notata*.

Turan *et al*. (2009c) investigated geographic variations of *Trachurus trachurus* based on mitochondrial 16S rDNA gene from 8 locations, including the Black, Marmara Aegean and north-eastern Mediterranean Seas. Restriction fragment length polymorphism (RFLP) analyses revealed 14 different composite haplotypes for 307 individuals and diagnostic restriction sites for discriminating among populations. Average haplotype diversity within populations was high (0.7311), and nucleotide diversity was low (0.0071). The highest value of pairwise inter-group nucleotide divergence was detected between the West and East Black Sea samples (0.01119), and the lowest (-0.00018) between the two North-eastern Mediterranean samples. Mantel's test showed that genetic distances between these populations were not associated with their geographical distances ($r=0.326$; $P>0.05$).

Erguden *et al.* (2010) examined *Mugil cephalus*, *Chelon labrosus*, *Oedalechilus labeo*, *Liza abu*, *L. aurata*, *L. saliens*, *L. ramada* and *L. haematocheilus* on the basis 16S rDNA gene of mitochondrial DNA. The 16S rDNA dataset contained 121 variable and parsimony informative sites and the mean nucleotide diversity (Pi) was found to be 0.05. Haplotype diversity was found to be 0.88 and 7 different haplotypes were observed. Sequencing analysis revealed that *M. cephalus* was clearly separated from the other species. For inter-generic comparisons, there was no genetic difference between C. *labrosus* and *L. ramada*.

Gubili *et al.* (2010) sequenced the mitochondrial control region of four rare Mediterranean white sharks (*Carcharodon carcharias*). The juvenile sequences were identical although collected at different locations and times, showing little genetic differentiation from Indo-Pacific lineages, but strong separation from geographically closer Atlantic/western Indian Ocean haplotypes.

Kochzius *et al.* (2010) aimed to evaluate the applicability of the three mitochondrial genes 16S rRNA (16S), cytochrome b (Cyt b), and cytochrome oxidase subunit I (COI) for the identification of 50 European marine fish species by combining techniques of ‘‘DNA barcoding’’ and microarrays in their study. In a DNA barcoding approach, neighbour Joining (NJ) phylogenetic trees of 369 16S, 212 Cyt b, and 447 COI sequences indicated that Cyt b and COI were suitable for unambiguous identification, whereas 16S failed to discriminate closely related flatfish and gurnard species. None of the markers provided probes to discriminate the sibling flatfish and gurnard species. 16S was more suitable for DNA microarray probe design than Cyt b and COI.

Turan and Yaglioglu (2010) studied the population structures of the common cuttlefish *Sepia officinalis* from the north-eastern Mediterranean (Antalya and Iskenderun Bays), Aegean (Izmir Bay) and Marmara Seas with mtDNA PCR-RFLP, body morphometry and cuttlebone chemistry. Analysis of a ND 5/6 gene segment of mtDNA revealed seven haplotypes from 120 individuals. No haplotype sharing was observed among sampling sites. The average nucleotide divergence between samples was 0.009390, and the highest genetic divergence (0.015279) was observed between the Iskenderun Bay and Marmara Sea samples. The lowest genetic divergence (0.003786) was between the Aegean Sea and Antalya Bay samples. In the morphometric analysis, only the Marmara Sea and Iskenderun Bay samples were differentiated from each other, and the rest of the samples overlapped each other. In cuttlebone chemistry analysis, univariate statistics revealed highly significant ($P<0.001$) differences among locations for 12 elements: Al, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Pb, Zn.

Keskin and Atar (2011) analyzed to determine interpopulational variation of common octopus (*Octopus vulgaris*) species sampled along eastern Mediterranean. Highest divergence was found between Didim and Aydincik-Fethiye populations; with a genetic distance value of 0.039 (3.9%).

Turan (2011) studied molecular systematic status of the Mediterranean Spicara species (Centracanthidae) using mitochondrial 16S rDNA sequence and morphological data. Haplotype diversity was found to be 0.71. Genetic differences were not observed between *S. maena* and *S. smaris*, and the genetic divergence between *S. flexuosa* and both *S. maena* and *S. smaris* was found to be 0.005. The intergeneric divergence was found to be very high (0.237) between *S. alta* and *C. cirrus*. For the other Spicara species, intergeneric divergence ranged from 0.170 between *C. cirrus* and both *S. maena* and *S. smaris* to 0.176 between *C. cirrus* and *S. flexuosa*. Multivariate analysis of morphological data was congruent with the genetic data and revealed similar pattern of relationship among Centracanthidae species.

Yilmaz *et al.* (2011) investigated genetic structure of loggerhead turtle (*Caretta caretta*) for conservation purposes using both mitochondrial and nuclear DNA markers. Seven distinct haplotypes were detected, of which three have previously been reported from the Mediterranean and one from the Atlantic. Both mtDNA and microsatellite analyses determined genetic structuring (mtDNA: $F_{st:}$ 0.214, $p<0.01$; nDNA $F_{st:}$ 0.0004

$p<0.05$) among nesting aggregates of *C. caretta* throughout the study area and enabled the detection of the different haplotypes to inform conservation strategies.

Bagda *et al.* (2012) analyzed genetic structure of *Chelonia mydas* in the nesting beaches of Turkey and Northern Cyprus using mitochondrial DNA control region and nuclear DNA. Sequencing of 859 bp fragment of control region revealed six distinct mtDNA haplotypes of which three were described for the first time in this study. Low level of mtDNA variation in green turtle across the study area makes it impractical for determination of genetic structuring of nesting aggregates and female philopatry. The study showed higher genetic variation and structuring in nDNA than mtDNA among the Mediterranean nesting aggregates.

Keskin and Atar (2012) analyzed European anchovy (*Engraulis encrasicolus*) populations from the Black Sea, Marmara Sea, Aegean Sea and Mediterranean using mitochondrial DNA sequence variation of the COI. They found the highest nucleotide divergence between samples of eastern Mediterranean and northern Aegean (2,2%). Diverging pattern of the European anchovy populations correlated with geographic dispersion supports the genetic structuring through the Black Sea-Marmara Sea-Aegean Sea-Mediterranean Sea quad.

Yaglioglu and Turan (2012) analyzed using mtDNA 16S gene region with mtDNA PCR-RFLP method with 6 restriction enzymes (*Bsur*I, *Alu*I, *Hin6*I, *Rsa*I, *Xho*I, *Ehe*I) and examined genetic pathway of colonization of Lessepsian lizardfish *Saurida undosquamis* populations on the way from the Red Sea to Mediterranean Sea. A total of 16 haplotypes were detected from 150 individuals. The average haplotype diversity and genetic diversity within populations were 0.4579 and 0.009179, respectively. The average genetic diversity and genetic divergence between populations were calculated 0.025294 and 0.016115, respectively. In Monte Carlo (X^2) pairwise comparisons highly significant differences ($P< 0.001$) between all populations were detected. *S. undosquamis* showed high genetic changes on the pathway of its colonization from south to northward, and there is lack of genetic migration between the Red Sea and Mediterranean.

Gurlek *et al.* (2013) investigated systematic relationship of three species of genus Trachurus (*Trachurus trachurus*, *Trachurus mediterraneus*, *Trachurus picturatus*) from Turkish marine waters was investigated using restriction fragment length polymorphism (RFLP) analysis of the mtDNA 16S rDNA, ND 3/4 and ND 5/6 genes. Analysis of three mtDNA gene resulted in different patterns of phylogenetic relationship among the species of Trachurus genus, and only two genes of mitochondrial genes (16S rDNA and ND 5/6) showed polymorphisms.

Keskin and Atar (2013) used DNA barcoding in the identification of 89 commercially important freshwater and marine fish species found in Turkish ichthyofauna. A total of 1765 DNA barcodes using a 654-bp-long fragment of the mitochondrial cytochrome c oxidase subunit I gene were generated for 89 commercially important freshwater and marine fish species found in Turkish ichthyofauna. These species belong to 70 genera, 40 families and 19 orders from class Actinopterygii, and all were associated with a distinct DNA barcode.

Karahan *et al.* (2014) distinguished two anchovy species (*Engraulis encrasicolus* and *E. albidus*) in the Eastern Mediterranean Sea using geometric morphometrics, Fourier analysis of otolith shape, and nuclear DNA markers. Significant differences in body shape, which was analyzed through geometric morphometrics, and in otolith shape, examined using Fourier analysis, separated the two forms. Length polymorphisms at two intron and 9 microsatellite loci showed strong genetic differences between the two forms. Mersin Bay Blue anchovy were genetically related to *Engraulis encrasicolus* from the Western Mediterranean Sea. Mersin Bay Silver anchovy possessed an original genetic composition that distinguished them from both *E. encrasicolus* and *E. albidus* at the two intron loci, while presenting affinities to *E. albidus* based on microsatellite markers.

Tuncay and Bardakci (2014) investigated population genetics of European anchovy (*Engraulis encrasicolus* L.) in Turkish Seas based on microsatellite analysis and examined 13 microsatellite loci in total 541 individual genotype data to determine population genetic structuring and genetic stocks of European anchovy in the Turkish territorial waters. The genetic variability was high among population, the average alleles numbers per locus per population ranged from 11.0 to 22.8. Observed heterozygosity per population was ranged from 0.612 (Mersin) to 0.733 (Istanbul) while expected heterozygosity was ranged from 0.774 (Mersin) to 0.823 (Persembe). The highest genetic distance was found between Antalya and Trabzon populations (F_{st}=0.06949), the lowest between Antalya and Iskenderun populations (0,00010). Analyses of 13 microsatellite loci were showed that there was low population structuring among all anchovy population (F_{st}: 0,024; SE 0,005).

Turan and Gungor (2014) analyzed the genetic structure of Mediterranean limpet (*Patella caerulea*) populations from Turkish Seas with mtDNA PCR-RFLP method. Samples were collected from Black Sea, Marmara Sea, Aegean Sea and Mediterranean Sea. The complete 16S rRNA gene of mtDNA amplified by PCR were digested with four restriction enzymes. As a result, a total of eight haplotypes were detected from 150 individuals. The average haplotype diversity and nucleotide diversity within populations were 0.5971 and 0.006760 respectively. The average nucleotide diversity and nucleotide divergence among to populations were 0.012150 and 0.005390 respectively. The highest genetic divergence was observed between Black Sea and Mediterranean sample

(0.012867), and the lowest genetic divergence was observed between the Aegean Sea and Mediterranean Sea (0.000960).

Turan (2015) investigated population genetic structure of Atlantic bonito *Sarda sarda* from the Black Sea, Marmara Sea, Aegean Sea, north-eastern Mediterranean Sea and Adriatic Sea by using microsatellite analysis. Overall average observed heterozygosity was high (0.93). Average observed heterozygosity per locus ranged from 0.79 to 0.98. Pairwise F_{st} estimates for all loci between populations ranged from 0 to 0.07626, and significant F_{st} values (P<0.001) were detected between populations; the Black Sea and Marmara Sea samples were not significantly different from each other, but significant different from the other samples, and Aegean Sea and north-eastern Mediterranean Sea samples were also not significantly different from each other, but significantly different from all other samples. The Adriatic Sea sample was significant different from all other samples.

Turan *et al.* (2015a) investigated phylogenetic relationship among five shad species (*Alosa caspia*, *A. fallax nilotica*, *Alosa maeotica*, *Alosa immaculata*, *Alosa tanaica*) from Turkish marine waters with mitochondrial DNA PCR-RFLP. The six gene segments, NADH 5/6, NADH 3/4, cytochrome b, COX, 16S rRNA and D-Loop, of mtDNA amplified by PCR were digested with seven restriction enzymes, *Bsur*I, *Alu*I, *Ehe*I, *Hin6*I, *Rsa*I, *Xho*I *Bsh1236*I. The average haplotype diversity and nucleotide diversity within species were 0.8809 and 0.0022 respectively. The average nucleotide diversity and nucleotide divergence among species were 0.009248 and 0.007080 respectively. The highest genetic divergence was observed between *A. caspia* and *A. maeotica* (0.013727) and the lowest between *A. immaculate* and *A. tanaica* (0.003073).

Turan *et al.* (2015b) used to investigate genetic structure of 11 Atlantic bonito *Sarda sarda* populations with mitochondrial DNA D-loop gene sequencing from the Black Sea, Marmara, Aegean, Mediterranean Seas and Adriatic Sea. The total sequence length, variable sites and parsimony informative sites were 868 bp, 12 bp and 7 bp from 222 individuals, respectively. The nucleotide frequencies were 32.55% A, 31.32% T, 14.44% C, and 21.68% G. The total number of haplotypes was 19, and the highest number of different haplotypes was observed in the northeastern Mediterranean (the Iskenderun Bay) sample, and the lowest was observed in the Bulgarian sample. Low genetic diversity was observed within populations, and the mean genetic diversity within populations and the mean genetic divergence between populations were 0.0009 and 0.0013, respectively. In the statistical analysis, *S. sarda* was divided into three genetically different populations (P<0.001); the Black and Marmara Sea populations comprise one genetic unit, and the Aegean and Mediterranean coast of Turkey populations constitute the genetically different second unit. The Adriatic Sea population from Croatian coast was also genetically different from these two units.

Dogdu and Turan (2016) investigated the potential of using metabarcoding of environmental DNA (eDNA) obtained directly from seawater samples to detect endangered grouper species (*Ephinephesus* spp.). Cytochrome c oxidase subunit I (COI) fragment of mtDNA was used to detect groupers species in the Mediterranean Coasts. They conducted eDNA sampling at sites by underwater diving across the range of the Grouper species habitats in Northeastern Mediterranean (Antalya-Kas Region and Iskenderun Bay). eDNA was isolated from 2 liter seawater samples which were vacuum-filtered onto 0.45-mm membrane filters. Filters were then folded inwards, placed in 2 ml tubes and stored at -20 ^{o}C until DNA extraction, which took place within 24 hours. DNA was extracted from the water sample filters using the DNeasy Blood and Tissue Kit (Qiagen, USA). Manufacturer's protocols were used during all steps. PCR amplification of eDNA samples were done using selective primers of COI region of mitochondrial DNA, and next-generation DNA sequencing of PCR amplicons was conducted. For the successfully obtained COI sequences, maximum matching rates were revealed as 80% for *Epinephelus marginatus*, 78,95% for *Epinephelus aeneus*, 73,48% for *Epinephelus costae*, 63,45% for *Epinephelus caninus*, 60,12% for *Mycteroperca rubra* and 57,12% for *Hyporthodus haifensis*.

Seyhan and Turan (2016) sequenced mitochondrial DNA Cytochrome Oxidase subunit I (COI) gene and obtained barcodes of nine Scombrid species (*Thunnus alalunga*, *T. thynnus*, *Euthynnus alletteratus*, *Auxis rochei*, *Katsuwonus pelamis*, *Sarda sarda*, *Scomber colias*, *S. scombrus*, *Scomberomorus commerson*) in Turkish Seas. Mean genetic diversity within and between species were 0.002 and 0.117 respectively. The number of detected different haplotypes were 22 out of 35 sequences, and haplotype diversity was 0.96. The highest genetic diversity (0.005) within species were observed for *S. commerson*, and lowest genetic diversity (0.000) was observed for *K. pelamis* and *E. alletteratus*. The highest and lowest nucleotide divergence was observed between *S. commerson* and *S. colias* (0.201) and between *T. alalunga* and *T. thynnus* (0.005) respectively.

Sonmez *et al.* (2016) investigated morphological differences between female and male hatchlings of green sea turtle (*Chelonia mydas*) in order to identify key morphological characters for sex determination. A total of 152 dead hatchlings of green sea turtles were examined for 14 morphometric and 7 meristic characters on Samandag Beach in the north-eastern Mediterranean Sea, Turkey. Multivariate statistics revealed significant differences in three morphometric characters between females and males. Principal component analysis also supported the detected differences between sexes.

Uyan and Turan (2016) examined genetic and morphological structure of tub gurnard *Chelidonichthys lucerna* populations in Turkish marine waters using with mtDNA DNA sequencing of 16S rRNA gene and morphological characters. The lowest genetic diversity (0.000462) was found in the eastern Mediterranean (Iskenderun Bay) population, while the highest genetic diversity (0.001858) was found in the Marmara population with overall average value of genetic diversity (0.001467) within populations. The highest haplotype diversity was found in the Black Sea whereas the lowest was found in the eastern Mediterranean population (Iskenderun Bay) with an average value of 0.7292. The Black Sea and Iskenderun Bay populations showed the least genetic divergence (0.001081), while the highest level of genetic divergence was found between the Marmara Sea and eastern Mediterranean (Antalya Bay) populations (0.002067). Discriminant function analysis of morphological characters showed that only the Black Sea population is completely different from the other populations which were overlapped together in the discriminant space.

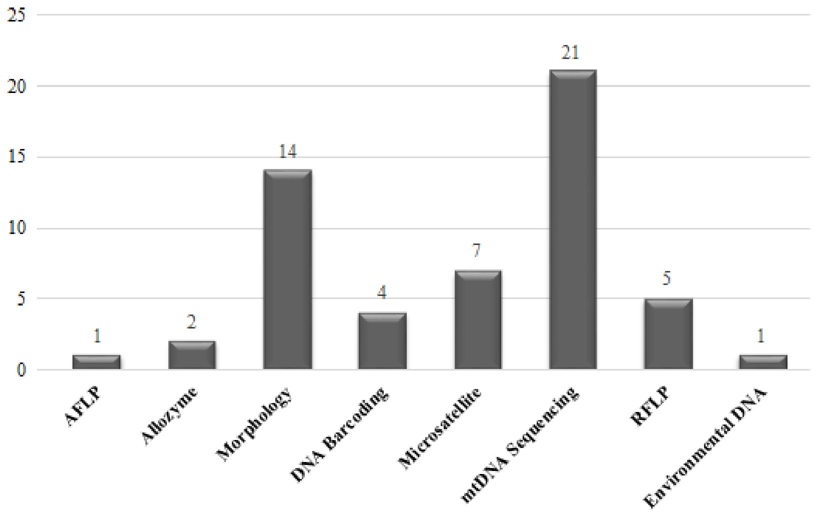

Figure 1. A total number of genetic and morphological techniques used on marine fishes of Turkey.

As can be seen in Figure 1, among genetic techniques, mtDNA sequencing technique has been widely used for population structuring and species identification so far. The microsatellites has been also relatively more used for population genetics studies. The RFLP technique has not been used commonly for population structuring and species identification. Furthermore, the allozyme and AFLP techniques have been no longer used widely by researchers, as well. In recent years, DNA barcoding and Environmental DNA techniques have been started to be used for species identification. Moreover, multiple species identification could be carried out in any area with Environmental DNA technique. Beside genetic techniques, morphological techniques that contains morphometrics, meristics, geometric morphometrics, otolith shape and chemistry have been mostly used for morphological variations among populations and species.

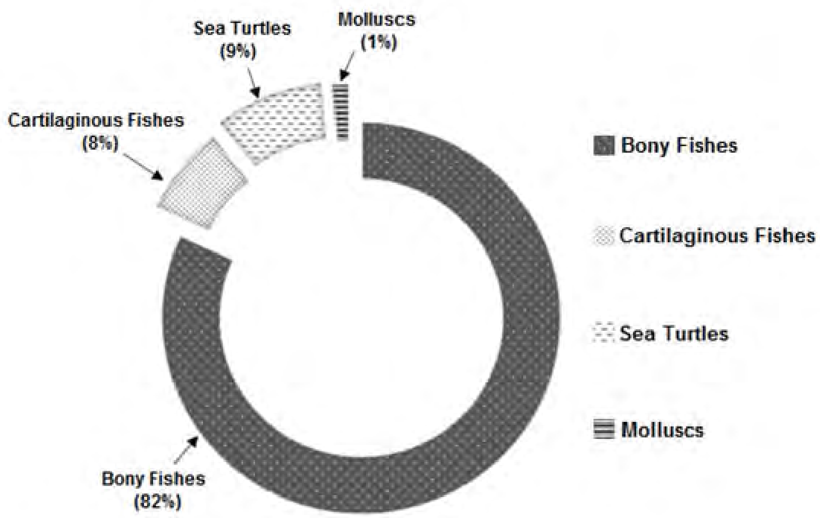

Figure 2. Percentage of distributions of the genetically studied marine species groups

In studies conducted in the Mediterranean so far, the bony fishes constitutes the portion of 82% which were the most studied marine species groups. Sea turtles, cartilaginous fishes and molluscs constitutes the portion of 9%, 8% and %1, respectively (Figure 2).

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ALIEN SPECIES OF THE TURKISH PART OF THE MEDITERRANEAN

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1. Introduction

The Mediterranean Sea has a rich diversity of species incorporating more than 1500 Mollusca, 1000 Arthropoda (only in Crustacea and Pycnogonida) and 650 fish species (Quignard and Tomasini 2000; Ponder and Lindberg 2008; Coll *et al.* 2010; Öztürk *et al.* 2014; Bakır *et al.* 2014; Bilecenoglu *et al.* 2014).

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. 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).

The Suez Canal was deepened and widened several times through time and is at present 400 meters wide and 25 meters deep and 162.5 km long (Golani 2010, Galil et al, 2015). After the opening of the Suez Canal, a migration started from Red Sea to the Mediterranean and a lot of Indo-Pacific originated species penetrated to the Mediterranean Sea.

The Eastern Mediterranean Sea includes two major bodies of water: the Levant Sea and the Aegean Sea, together with the smaller Sea of Marmara, which connects it to the Black Sea. The Levant Sea is warmer than the rest of the Mediterranean and harbours a significant number of circumtropical species. Atlantic-Mediterranean elements and Mediterranean endemics are comparatively scarce (Morri *et al.* 2009).

During the last decades, coastal habitats of the eastern and western Mediterranean Sea, Turkey have been extensively subjected to the establishment of alien fish species, mostly of Indo-Pacific and Red Sea origin (Doğdu *et al.* 2016; Gurlek *et al.* 2016a; Gurlek *et al.* 2016b).

This paper reviews the alien species reported from the Turkish part of Mediterranean and constitutes the first comprehensive database for future studies.

2. Distribution of Alien Species in the Turkish Mediterranean Coasts

Several factors may enhance the spread and establishment of alien species. The main important factor, rising sea-water temperatures will enable the potentially temperature-limited species in expanding their present distributions in the Mediterranean Sea, but also climate change may determine much of the success and geographical expansion and colonization of alien species from the Red Sea into the Mediterranean Sea (Turan *et al.* 2016).

The opening of the Suez Canal in 1869 initiated a significant event, the joining of two biogeographical provinces, the Red Sea and the Mediterranean. Since 1869 over 1000 Red Sea species have been recorded in the eastern Mediterranean. The review estimates that the rate of introductions has been elevated to 1 species every 9 days (Zenetos 2010).

Recently many alien species were recorded to the Turkish waters. Especially some species have become important in the composition of the eastern Mediterranean ichthyofauna communities and also acquired an economic importance in those regional fisheries (Bilecenoglu and Kaya 2002; Bariche *et al.* 2004).

The majority of Mediterranean Sea species are of Atlantic origin (about 67%), migrants through the Suez Canal represent 12% of the southeastern part of the Mediterranean (Fredj *et al.* 1992).

The composition of alien species in the Mediterranean Sea constitute the highest rates of 27% molluscs with consisting the lowest rates represent the Ascidian and Sponge with 3%. Fish is the second largest group (21.6%) after than mollusc (Figure 1). The majority of aliens of Mediterranean Sea are composed of molluscs, fishs and crustaceans (Turan *et al.* 2016). According to Coll *et al.* (2010), seventy-three echinoderm species are known to occur in the Levantine Sea, whereas 51 species have been reported from the Levantine coast of Turkey to date. Six echinoderms (*Asterias rubens, Amphiodia (Amphispina) obtecta, Ophiactis macrolepidota, Ophiactis savignyi, Diadema setosum* and *Synaptula reciprocans*) were regarded as alien species in the Medterranean cost of Turkey (Stöhr *et al.* 2010; Öztoprak *et al.* 2014). The established alien species are categorized by their origins, the first reported years of the species together with the author(s) for each species of the Turkish part of Mediterranean are given in Table 1.

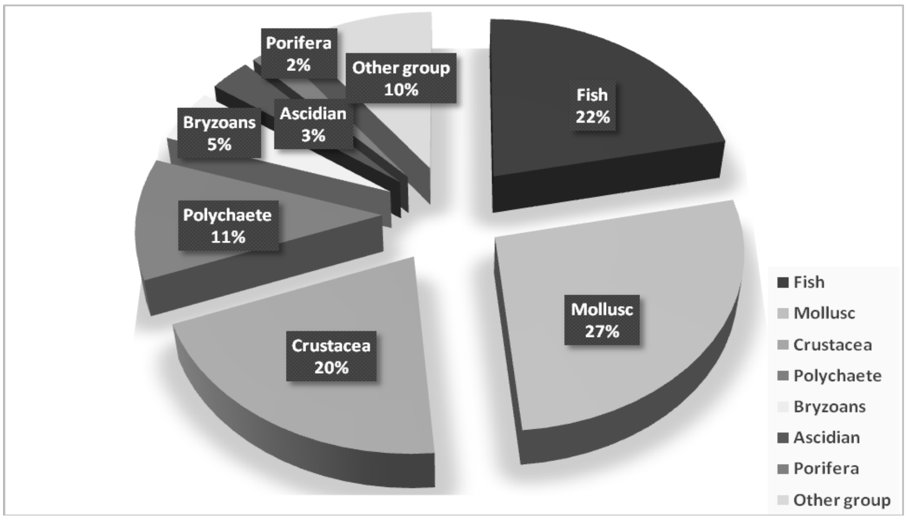

Figure 1. The distribution rate of alien species in the Mediterranean.

Table 1. The origin of the Indo Pasific and Atlantic invertebrates species record on the Mediterranean coast of Turkey

Family	Species	Origin	Year	Author(s)
Diadematidae	*Diadema setosum*	Indo Pasific	2006	Yokes and Galil
Rhizostomatidae	*Rhopilema nomadica*	Indo Pasific	1995	Kideys and Gücü
Cassiopeidae	*Cassiopea andromeda*	Indo Pasific	2006	Çevik *et al.*
Aglaopheniidae	*Macrorhynchia philippina*	Indo-Pacific	2006	Çınar *et al.*
Oculinidae	*Oculina patagonica*	Atlantic	2006	Çınar *et al.*
Sabellidae	*Branchiomma luctuosum*	Indian	2006	Çınar *et al.*
Aplysiidae	*Aplysia dactylomela*	Atlantic	2006	Çınar *et al.*
Synaptidae	*Synaptula reciprocans*	Indo Pacific	2006	Çınar *et al.*
Ascidiidae	*Phallusia nigra*	Indo Pacific	2006	Çınar *et al.*
Pyuridae	*Herdmania momus*	Indo Pacific	2006	Çınar *et al.*
Styelidae	*Symplegma brakenhielmi*	Indo Pacific	2006	Çınar *et al.*
Amphinomidae	*Pseudeurythoea carunculata*	Central Pacific	1997	Ergen and Çınar
Nereidae	*Pseudonereis anomala*	Indo-Pacific	1989	Ben-Eliahu
Eunicidae	*Lysidice collaris*	Cosmopolitan	1997	Ergen and Çınar
Arcidae	*Anadara demiri*	Indian Ocean	1977	Demir
Mytilidae	*Brachidontes pharaonis*	Indian Ocean	2007	Doğan *et al.*
Aplysiidae	*Bursatella leachi*	Circumtropical	1961	Swennen
Chamidae	*Chama pacifica*	Indo-Pacific	2001	Çeviker
Cerithiidae	*Cerithium scabridum*	Red Sea	1990	Enzenross *et al.*
Cerithiidae	*Cerithium scabridum*	Red Sea	2001	Albayrak
Ostreidae	*Crassostrea gigas*	North West Pacific	2001	Çevik
Mytilidae	*Musculista senhousia*	Western Pacific	2008	Uysal *et al.*
Mytilidae	*Musculista perfragilis*	Indo-Pacific	2011	Çevik *et al.*
Myidae	*Mya arenaria*	North Atlantic Ocean	2011	Çınar *et al.*
Portunidae	*Charybdis longicollis*	Red Sea	2005	Özcan *et al.*

To date, the number of reported fish species is increasing with new alien species arriving by several transmission routes (Bilecenoglu *et al.* 2014, Turan *et al.* 2016). The number of alien fish species found along the Turkish Mediterranean coasts and their modes of introduction are presented in Figure 2. A total of 69 Suez Canal, 2 Gibraltar, 1 Cosmopolitan, 1 Aquarium and 1 unknown species were reported along the Turkish Mediterranean coast.

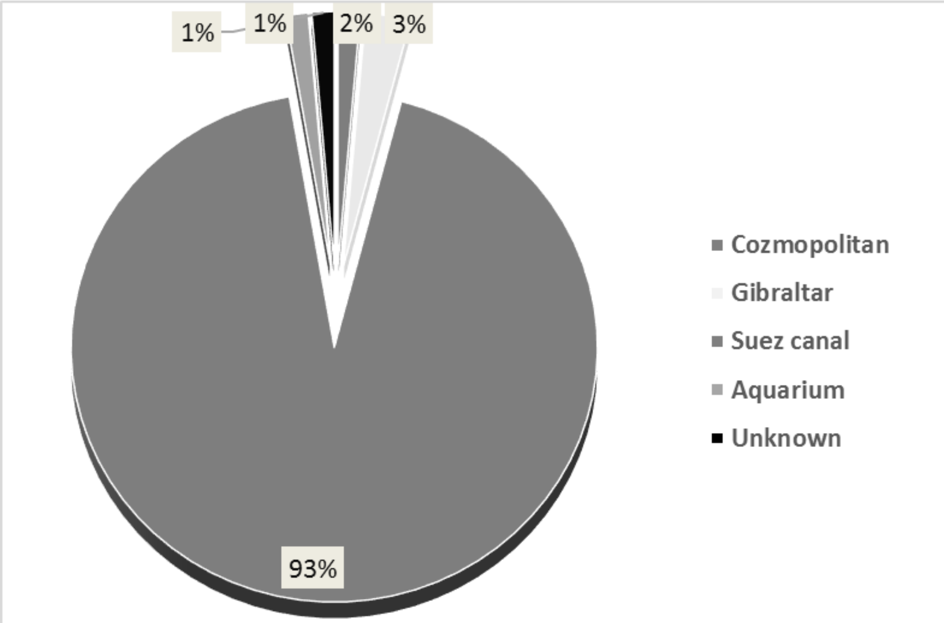

Figure 2. Percentage of composition of introduce routes for alien species in Mediterranean coast of Turkey.

3. List of Alien Fish Species from the Turkish Mediterranean Coasts

In the Mediterranean, there have been nearly 650 fish species recorded (Quignard and Tomasini 2000; Coll *et al.* 2010). But these numbers are variable, and they have been rising because of alien species added by various means, such as the Suez Canal, Gibraltar, shipping activities and other vectors.

The establishment success is assigned for each species of the Turkish part of Mediterranean are given in Table 2. The alien species are categorized by their origins, the first reported years of the species together with the relavant publications (Table 2).

The geographic distribution of alien fish species in the Mediterranean Sea is biased. The alien species distribution is concentrated in the Levantine Basin, the western and eastern Mediterranean Sea coast of Turkey (Figure 3). The regional trend of alien fish distribution in the Mediterranean Sea is highly increasing for the last decade (Figure 4). According to Lasram and Mouillot (2009) the successful introductions of Indo-Pacific species from the Red Sea and Atlantic species from lower latitudes to the Mediterranean Sea is in correlation with the abioatic and bioatic factors, especially increasing seawater temperature of the Mediterranean Sea.

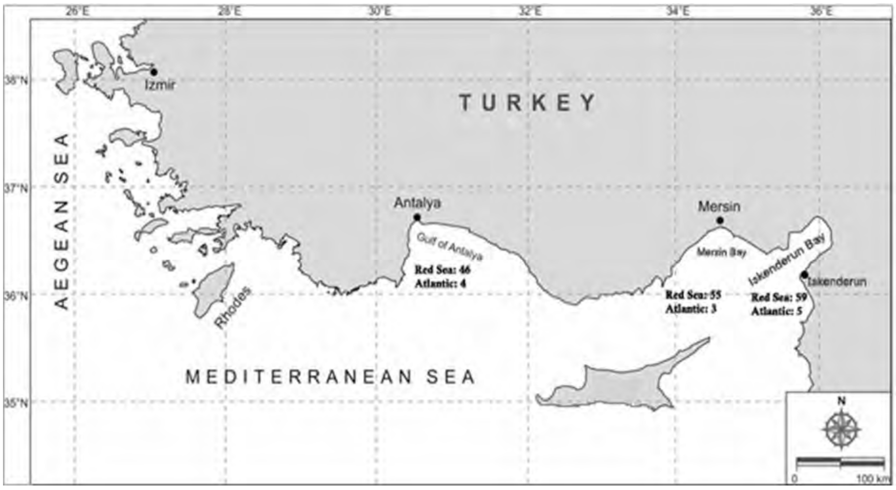

Figure 3. The distribution of alien fish species in the western and eastern Mediterranean Sea, Turkey

Table 2. The origin of the Indo Pacific and Atlantic fish species record on the Mediterranean coast of Turkey

Family	Species	Origin	Year	Author(s)
Carcharhinidae	*Carcharhinus altimus*	Tropical Atlantic	2000	Başusta and Erdem
Dasyatidae	*Taeniura grabata*	Tropical Atlantic	1998	Başusta *et al.*
	Himantura uarnak	Indo Pasific	1998	Başusta *et al.*
Ophichthidae	*Pisodonophis semicinctus*	Tropical Atlantic	2016	Yaglioglu and Ayas
Muraenidae	*Enchelycore anatina*	Tropical Atlantic	2002	Yokes *et al.*
Clupeidae	*Dussumieria elopsoides*	Indo Pasific	1953	Ben Tuvia
	Herklotsichthys punctatus	Indo Pasific	1984	Whitehead *et al.*
	Etrumeus golanii	Indo Pasific	1997	Başusta *et al.*
Engraulidae	*Stolephorus insularis*	Indo Pasific	2014	Dalyan *et al.*
Chanidae	*Chanos chanos*	Indo Pasific	2012	Özvarol and Gökoğlu
Plotosidae	*Plotosus lineatus*	Indo Pasific	2016	Doğdu *et al.*
Synodontidae	*Saurida undosquamis*	Indo Pasific	1966	Ben Tuvia
Exocoetidae	*Parexocoetus mento*	Indo Pasific	2000	Avşar and Çiçek
Hemiramphidae	*Hemiramphus far*	Indo Pasific	1950	Koswig
Fistulariidae	*Fistularia commersonii*	Indo Pasific	2002	Bilecenoğlu *et al.*
Bregmacoretidae	*Bregmaceros atlanticus*	Tropical Atlantic	2005	Yılmaz *et al.*
Syngnathidae	*Hippocampus fuscus*	Indo Pasific	2002	Gökoğlu *et al.*
	Syngnathus rostellatus	Boreal Atlantic	2004	Gökoğlu *et al.*
Atherinidae	*Atherinomorus forskali*	Indo Pasific	1950	Koswig
Holocentridae	*Sargocentron rubrum*	Indo Pasific	1950	Koswig
Scorpaenidae	*Pterois miles*	Indo Pasific	2014	Turan *et al.*
	Pterois volitans	Tropical Atlantic	2016	Gürlek *et al.*

Serranidae	*Epinephelus coioides*	Indo Pasific	2015	Gokoglu *et al.*
Synanceiidae	*Synanceia verrucosa*	Indo Pasific	2011	Bilecenoğlu
Teraponidae	*Pelates quadrilineatus*	Indo Pasific	1987	Mater and Kaya
Apogonidae	*Apogonichthyoides pharaonis*	Indo Pasific	1987	Mater and Kaya
	Ostorhinhus fasciatus	Indo Pasific	2010	Turan *et al.*
	Jaydia queketti	Indo Pasific	2006	Eryılmaz and Dalyan
	Jaydia smithi	Indo Pasific	2008	Goren *et al.*
	Cheilodipterus novemstriatus	Indo Pasific	2015	Turan *et al.*
Sillaginidae	*Sillago sihama*	Indo Pasific	1994	Gücü *et al.*
Carangidae	*Alepes djedaba*	Indo Pasific	1957	Akyüz
	Decapterus russelli	Indo Pasific	2011	Sakınan *et al.*
	Trachurus indicus	Indo Pasific	2009	Dalyan and Eryılmaz
	Trachurus declivis	Indo Pasific	2016	Gürlek *et al.*
	Seriola fasciata	Indo Pasific	2014	Özvarol and Gökoğlu
Leiognathidae	*Equulites klunzingeri*	Indo Pasific	1943	Erazi
	Equulites elongatus	Indo Pasific	2015	Irmak *et al.*
Mullidae	*Upenus moluccensis*	Indo Pasific	1950	Koswig
	Upenus pori	Indo Pasific	1950	Koswig
	Parupeneus forsskali	Indo Pasific	2006	Çınar *et al.*
Lethrinidae	*Monotaxis grandoculis*	Indo Pasific	2007	Bilecenoğlu
Haemulidae	*Pomadasys stridens*	Indo Pasific	2009	Bilecenoğlu *et al.*
Nemipteridae	*Nemipterus randalli*	Indo Pasific	2008	Bilecenoğlu and Russel
Sparidae	*Argyrops filamentosus*	Indo Pasific	2016	Gürlek *et al.*
Pempheridae	*Pempheris vanicolensis*	Indo Pasific	1994	Gücü *et al.*
Chaetodontidae	*Heniochus intermedius*	Indo Pasific	2003	Gökoğlu *et al.*
Mugilidae	*Liza carinata*	Indo Pasific	1957	Koswig
Sphyraenidae	*Sphyraena chrysotaenia*	Indo Pasific	1957	Akyüz
	Sphyraena flaviacauda	Indo Pasific	2002	Bilecenoglu *et al.*
Labridae	*Pteragogus pelycus*	Indo Pasific	2000	Taşkavak *et al.*
Scaridae	*Scarus ghobban*	Indo Pasific	2014	Turan *et al.*
Champsodontidae	*Champsodon capensis*	Indo Pasific	2012	Dalyan *et al.*
	Champsodan nudivittis	Indo Pasific	2009	Çiçek ve Bilecenoğlu
	Champsodon vorax	Indo Pasific	2013	Gökoğlu ve Özvarol
Blenniidae	*Petroscirtes ancylodon*	Indo Pasific	2000	Taşkavak *et al.*
	Parablennius thysanius	Indo Pasific	2013	Özbek *et al.*
Gobiidae	*Vanderhorstia mertensi*	Indo Pasific	2008	Bilecenoğlu *et al.*
	Trypauchen vagina	Indo Pasific	2011	Akamca *et al.*
	Oxyurichthys papuensis	Indo Pasific	1992	Kaya *et al.*
Callionymidae	*Callionymus filamentosus*	Indo Pasific	1994	Gücü *et al.*
	Synchiropus sechellensis	Indo Pasific	2014	Gökoğlu *et al.*
Siganidae	*Siganus rivulatus*	Indo Pasific	1947	Has and Steinitz
	Siganus luridis	Indo Pasific	1973	Ben Tuvia
Scombridae	*Scomberomorus commerson*	Indo Pasific	1994	Gücü *et al.*
Cynoglossidae	*Cynoglossus sinusarabici*	Indo Pasific	1957	Akyüz
Monacanthidae	*Stephanolepis diaspros*	Indo Pasific	1950	Koswig
Tetraodontidae	*Lagocephalus spadiceus*	Indo Pasific	1950	Koswig
	Lagocephalus suezensis	Indo Pasific	1999	Avşar and Çiçek
	Torquigener flavimaculusus	Indo Pasific	2003	Bilecenoğlu
	Lagocephalus sceleratus	Indo Pasific	2011	Torcu-Koç *et al.*
	Tylerius spinosissimus	Indo Pasific	2011	Turan and Yağlıoğlu
	Sphoeroides pachygaster	Tropical Atlantic	2011	Ergüden *et al.*
Diodontidae	*Cyliycthys spilostylus*	Indo Pasific	2012	Ergüden *et al.*

To date there has been recorded 74 alien fish species (66 Indo Pasific, 8 Atlantic) in Turkish Mediterranean waters (Turan 2014) (Figure 4). Recently, four new alien species (Indo Pasific origin), *Argyrops filamentosus*, *Trachurus declivis* (Gurlek *et al.* 2016a,b) *Plotosus lineatus* (Doğdu *et al.* 2016) and *Pterois volitans* (Gurlek *et al.* 2016c) have been reported eastern Mediterranean Sea and added from Turkish Mediterranean ichthyofauna. According to Kalogirou *et al.* (2010) and Turan *et al.* (2016), the success to establish of this alien species can be also depend on appropriate food resources in the recipient community as well as competitive abilities and level of competition in the food web within habitats.

The distribution of alien species by habitat and depth is given in Figure 5 and Figure 6. The majority of alien species collected from the Turkish Mediterranean coasts were found in shallow waters. Pelagic and sandy and rocky habitats inhabited 88% of the total number of alien species (Figure 5). Thirteen species the pelagic environment distributed at depths ranging from 0 to 10 m, and fifty six species at the depths interval 0-50 m and 0-100 m (Figure 6).

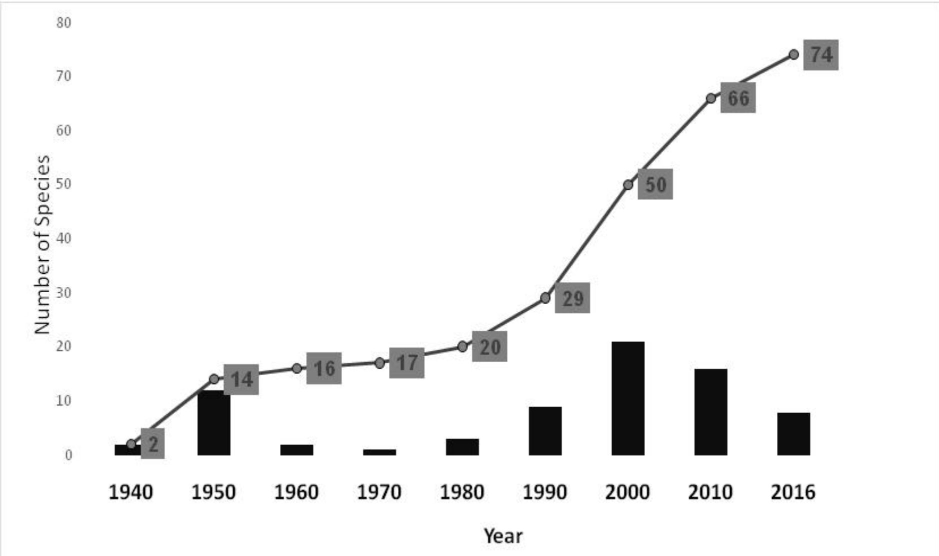

Figure 4. Trends of alien species in marine waters of Turkey between 1940 to 2016 years.

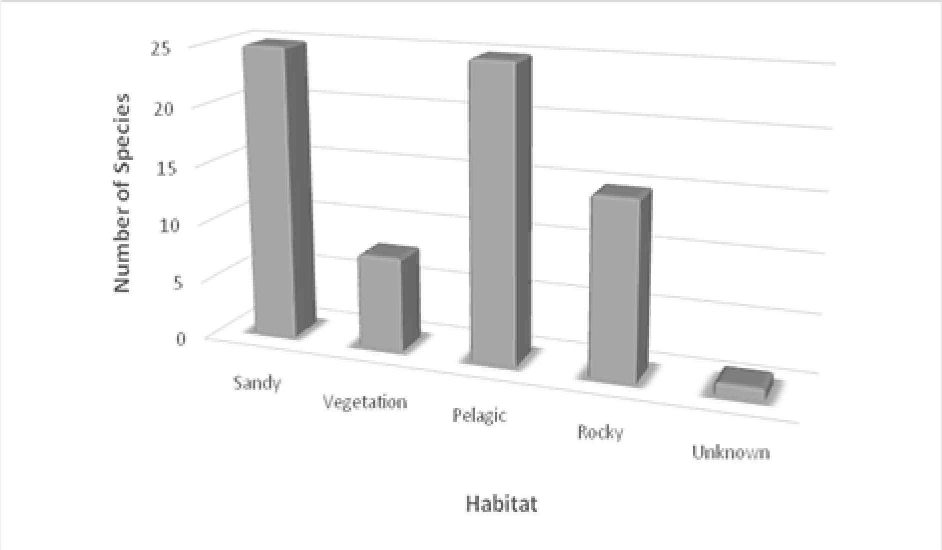

Figure 5. The habitat preferences of alien species along the Turkish Mediterranean coasts.

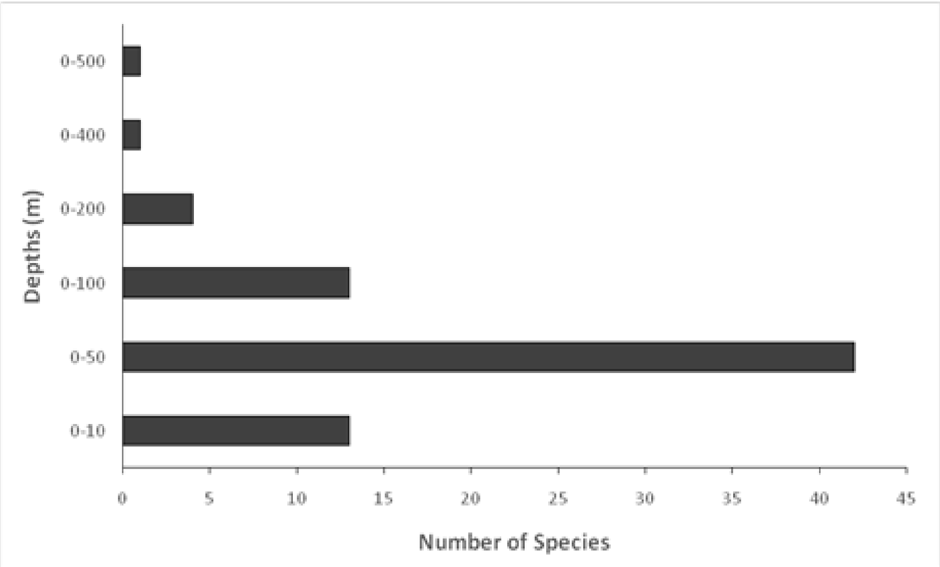

Figure 6. The depth (m) preferences of alien species along the Turkish Mediterranean coasts.

4. Impacts of Alien Species in the Mediterranean Sea

To date, several alien fish species may have the ability to change the trophic food web by being highly dominant at a habitat or competing for food resources with indigenous inhabitants (Kalogirou 2011). Besides, alien species are believed to accelerate the decline of native populations already under environmental stress, leading to population losses and extinctions on a local scale (Ricciardi 2004; Sreftaris and Zenetos 2006).

Nowadays, a large number of aliens inhabiting the Turkish coasts, only a few species commercial value, mostly belonging to fishes and crustaceans. The great number of alien fish species caught during various fisheries activities. However, eleven alien fish commercial species (*Upeneus moluccensis*, *Upeneus pori*, *Saurida lessepsianus*, *Scomberomorus commerson*, *Dussumieria elopsoides*, *Etrumeus golanii Sphyraena chyrosotaenia*, *Siganus luridus*, *Siganus rivulatus*, *Nemipterus randalli*, *Pomadasys stridens*) of the economic inportance are captured and in large amounts by bottom trawls, purse seine and trammel nets, and consumed throughout the Mediterranean coast of Turkey.

According to Çınar *et al.* (2005), among alien crustaceans, the highest annual production belongs to blue crab, *Callinectes sapidus*, which is captured especially in lagoon systems in amounts as much as 2 tonnes/day during summer periods. In addition to, *Marsupenaeus japonicus* is one the most valuable commercial shrimp species along the Mediterranean coast and consumed throught in this area.

However, negative effects is harm of alien species such as puffer fish, *Lagocephalus sceleratu*s with economic interest. *L. sceleratu*s possess one of the strongest paralytic toxin known today, tetrodotoxin (Sabrah *et al.* 2006). It has been regarded as one of the "worst alien fish" of the Mediterranean Sea (Streftaris and Zenetos 2006); harmfull to human health, fishing gears (Katsanevakis *et al.* 2009) and biodiversity (Bilecenoglu 2010). Besides, Turan (2010) reported that some local fishermen are affected by *L. Sceleratus*, tearing gill nets and cut long lining hooks by strong jaws and teeths. Furthermore, the alien jellyfish species (*Cassiopea andromeda*, *Phyllorhiza punctata* and *Rhopilema nomadica*) occurred only along the Levantine coasts of Turkey (Çınar *et al.* 2014). Especially, the venomous jelly fish, *Rhopilema nomadica* off the Levantine coast of Turkey was reported to have negative consequences on human health, tourism and fisheries. Especially, many swimmers were stung and sought medical treatment. (Kıdeys and Gücü 1995; Turan 2010). The impacts of the alien species to the tourism and human health investiagted and hospitalized events in Turkey were recorded at five areas with 815 events (Öztürk and İşinibilir 2010). In addition, Silfen *et al.* (2003) reported some serious injury of the *R. nomadica*. According to Çınar *et al.* (2005), the blockage of nets of fishermen by individuals of *R.*

nomadica also caused major economical losses. The distribution of major alien harmful and dangerous species according to families in Mediterranean coast of Turkey are given in Table 3. When we look at the establishment of alien species according to harmful effects, the most number of species assembled in the jellyfish (Cnidaria: Hydrozoa) (Figure 7).

Table 3. The harmfull and dangerous of alien species in the Mediterranean coast of Turkey. R, rare; A, abundant; E, established.

Family	Species	Establishment	Harmful	Venomous
Tetradontidae	*Lagocephalus sceleratus*	E	+	+
Diadematidae	*Diadema setasum*	E		+
Rhizostomatidae	*Rhopilema nomadica*	E	+	+
Cassiopeidae	*Cassiopea andromeda*	E		+
Aglaopheniidae	*Macrorhynchia philippina*	E		+
Scorpaenidae	*Pterois miles*	E		+
Scorpaenidae	*Pterois volitans*	E		+
Synanceiidae	*Synanceia verrucosa*	E	+	+
Amphinomidae	*Eurythoe complanata*	E		+

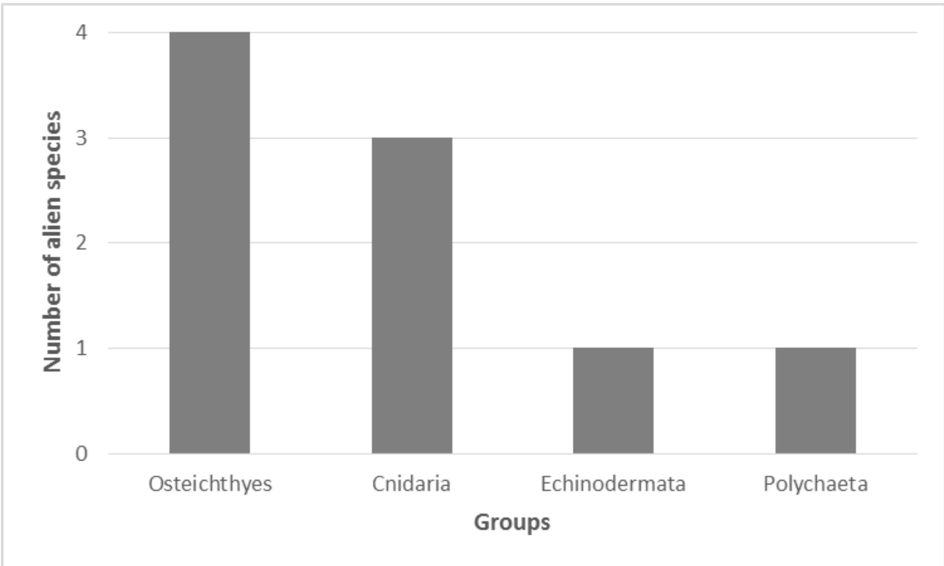

Figure 7. The distribution of harmful alien species according to taxonomic group along the Turkish Mediterraenan coasts.

5. Conclusion

The effects of global warming and the role of prevailing currents favored the expansion of alien species in the Eastern Mediterranean. Especially, the currents contributed either by transferring the planktonic stages and by forming favorable environmental conditions for the survival, growth and reproduction of immigrating Indo-Pacific species.

In the Mediterranean, the success of alien fishes in colonizing along the Levantine coasts could be attributed to a combination of factors, like a particular ability of adaptation to the new ecosystem, overcoming environmental impediments like temperature, salinity, currents, the ability to occupy available and diversified niches, life history strategies, food habits and feeding strategy, anti-predator adaptations, schooling, limited competition and predation (Golani 2010; Turan *et al.* 2016).

The control of new migrant alien species is difficult because there are no physical border between the Red Sea and Mediterranean. In addition, a new Suez Canal had been opened on 9 August 2015, which has made a big chance for fish to move into the Mediterranean Sea. On other hand, the climatic changes in the world, especially in the eastern Mediterranean, are making the environment very suitable for invasive species in terms of the temperature, food, and the place for reproduction (Sorte *et al.* 2010; Turan *et al.* 2016). Thus, the significant change of hydrological conditions in the eastern Mediterranean were also investigated.

Besides, the success and impact of the alien species can be indicated by the history of its introduction in earlier invaded ecosystems. Therefore, the importance of monitoring studies with environmental parameters enable us to better understand the migration mechanisms and pathways of alien species.

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STATE OF POLLUTION IN NORTH EASTERN MEDITERRANEAN BASIN

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Introduction

The aim of this chapter is to summarize the present level of pollutant and the state of pollution in the North Eastern Mediterranean. The demographic growth in the region, industrial and recreational activities, climate change and over exploitation are exerting exceptional pressure on the environment, its ecosystems and resources. The pollutant loads from land-based sources, as a result of these activities, will also be discussed. The discussion and the conclusions are based on:

a) A compilation of the data obtained at Northeastern Mediterranean from the so called coastal and reference (open sea) stations.

b) A compilation of the data obtained from the land based sources (rivers, industrial discharges, sewage) along the southern coast of Turkey.

The above mentioned data collection covers the period between 1983-2009 and a wide range of matrices such as waste water, river water, sea water, suspended solids, biota and sediment.

The quality assurance of the data of the work is done by checking the accuracy and precision of the methods used. To do so interlaboratory comparison of the analytical performance was done with certified reference materials (CRM`s). Among those which worth to mention are the CRM's of NBS (National Bureau of Standards, USA), BCR (Community Bureau of Reference, EEC), EPA (Environmental Protection Agency, USA) and IAEA (International Atomic Energy Agency).

Intercalibration exercises were performed for the data validation. Those were the ones organized and/or run by IAEA Monaco Laboratories, ICES Marine Chemistry Working Group, Intergovernmental Oceanographic Commission of UNESCO.

General Knowledge of the Region

The studied area (Northeastern Mediterranean) is bordered to the north by Turkey, to the east by Syria and Lebanon and to the west by the strait of Crete. The southern border extent up to 34^{o} N (Figure 1).

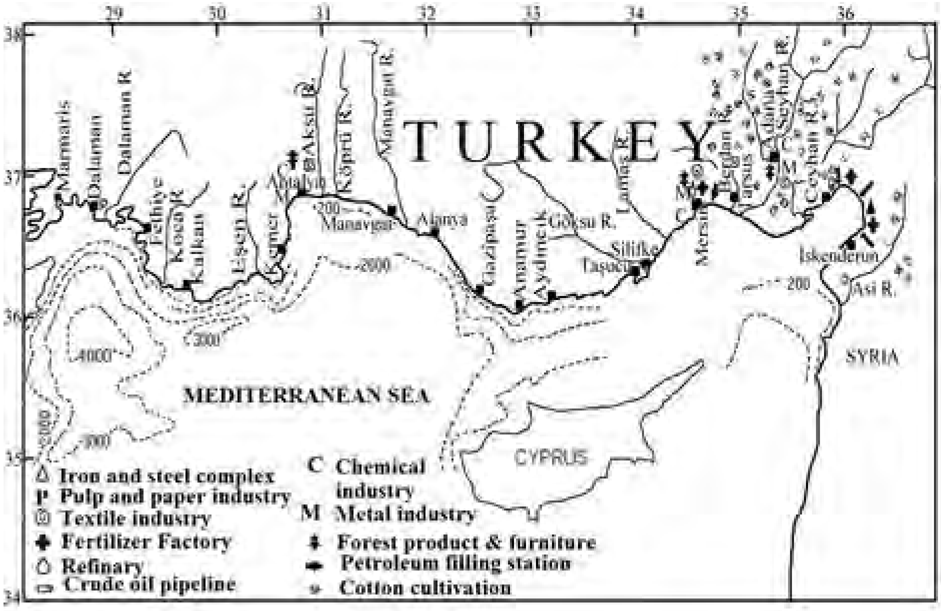

Figure 1. Studied area and potential pollutant sources.

The physical oceanography of the north eastern Mediterranean has been extensively studied by Özsoy *et al.* (1989;1991;1993; 2014), Katrin *et al.* 2012 and they reported that the Levantine basin circulation show interacting mesoscale dynamical features such as sub basin scale and mesoscale eddies and jets, interconnected basin-wide current systems which evolve on seasonal to interannual time scales. Cyclonic eddies are generally located in the northern Levantine (Rhodes gyre being the permanent, strong and a relatively large-scale one) and the anticyclonic ones are located in the southern Levantine basin and some of the small scale ones are observed in Antalya bay and Cilician basin (Figure 2). A permanent feature of the general circulation is the meandering westward flow along the southern coast of Turkey, called the Asia Minor Current (AMC). The surface current system of the Mediterranean shows a migration of less saline Atlantic water towards the east along the Africa coasts, then it turns north in the west and east of Cyprus with numerous eddies e.g. an anticyclonic eddy off İskenderun bay. The general water circulation in the region is from south to north along Syria and Lebanon coasts and from east to west along Turkish coast.

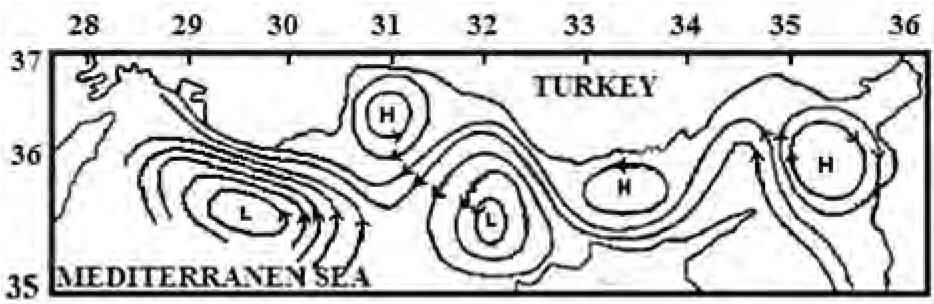

Figure 2. The general surface circulation in northern Levantine (Özsoy *et al.* 1989).

Land Based Pollutant Sources

Turkey rank first in discharging fresh water in to eastern Mediterranean. The annual fresh water discharge by the main rivers in the southern coast of Turkey amounts about $3.21x10^{10}m^{3}$. This amount constitutes about 8% of the total fresh water input in to the whole Mediterranean Sea. The main rivers draining in to the region from Turkey and potential pollutant sources along the Turkish coast of Mediterranean Sea are shown on Figure 1.

Discharges of domestic and industrial wastes, agricultural run-offs, and rivers draining into the northern Levantine are responsible for the major portion (~ 80-90%) of the marine pollution. The annual water discharge by the industries and cities established at the southern coast of Turkey is about $1.331x10^{9}$ m^{3} (Figure 1). The annual water inputs from each identified source and the annual input of the selected pollutants are summarized in Figure 3. Atmospheric flux, offshore activities and exchange with the connected seas play secondary role. Population increase in the last decades together with the urbanization and industrialization in the southern coasts of Turkey create coastal pollution problems as well as the whole basin wide scale marine pollution since the circulation system carry the pollutants offshore, as the same problems were strongly observed in the western Mediterranean. The coastline between Mersin and İskenderun provinces in the Northeastern Mediterranean is intensively industrialized such as textile, plastic, soda, paint, pulp and paper products, ferrochrome, food, artificial fertilizers and petroleum industry. Consequently and in general, uncontrolled mechanism of waste disposal is going on in this part of the Mediterranean as in most of the other Mediterranean countries. Mersin Bay deserves a special attention since it is one of the most polluted areas of all over the Mediterranean coast of Turkey. The transparency of the bay water is very low ranging between 1.0 – 4.5 m. (Tuğrul *et al.* 2005). This is the evident of the fact that there are abundances of the suspended matter and the dissolved organic matters absorbing the sun light. At the waters near the coastal region with high nitrate concentration, nitrite ion values and total phosphorous concentration demonstrate a clear increase. The concentration of chlorophyll-a is very high in the surface waters and is generally in the range of 1.0-4.6 µg/L at the coastal waters (Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol 2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009). The total suspended solid concentration of Mersin Bay water is very high and varied in between 10-15 mg/L in the coastal waters (Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009). If we consider these characteristics and findings together, we reach to the conclusion that there is eutrophication danger at the Mersin bay. The estimated average annual discharges of Cd and Hg from various sources in to the bay are 12 kg and 25 kg respectively. Both figures are considerably high. The annual total mercury input into the N. eastern Mediterranean from land-based sources is about 7.3 tons. This finding is consistent with the UNEP, (1984) estimation. UNEP (1984) estimation was 7.1 t/y. More than half of the mercury (about 80%) introduced in to the sea is in the particulate form. Thus, after entering in the sea most of the introduced mercury is expected to settle down by precipitation of the particulate materials and incorporated in the sediment. The atmospheric input in to the NE Mediterranean is calculated as 5 t/y (Salihoğlu *et al.* 1989). The estimated cadmium input from land-based sources to the N Levantine is 6.3 t/y and about 90% of this is carried by rivers. About 70% of the Cd introduced in to the region is in the particulate form.

The calculated land based PAH input in to the NE Mediterranean is about 209 t/y. This amount must be considered as an under estimation. Because of lack of data, inputs from some of the discharges does not included in this amount. The actual PAH input in to the region must be much greater than my estimation. The heavy shipping traffic, especially contribution of tanker traffic is large. Furthermore discharged oil by tankers at the existing legal oil discharging areas in the Mediterranean creates another source to the studied region and increases the PAH concentration in the Northeastern Mediterranean.

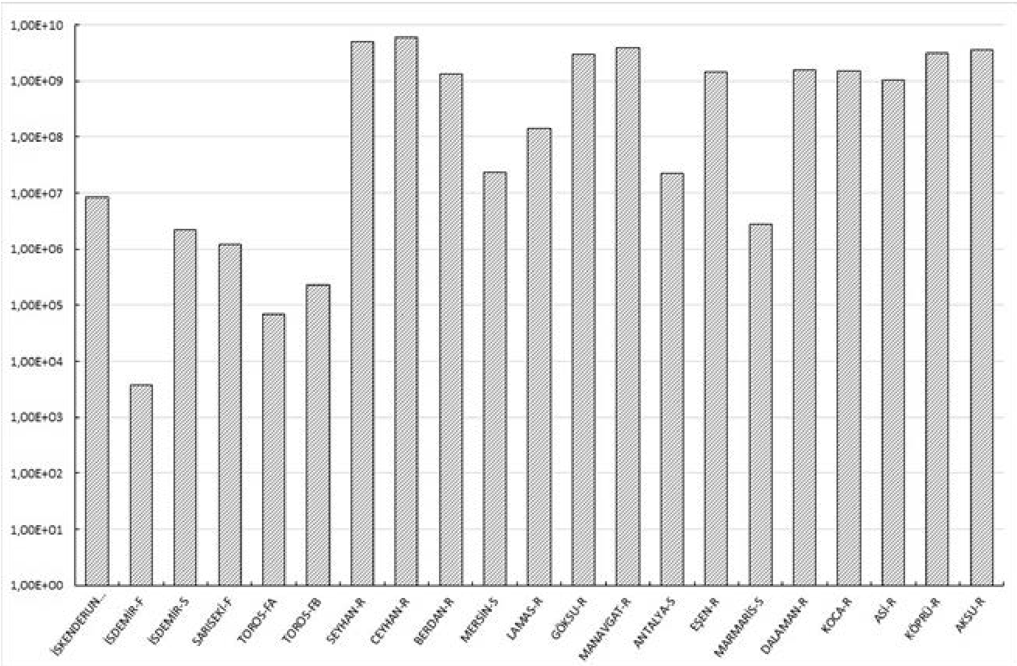

Figure 3. Annual water discharges from rivers main cities and industries.

SEA WATER
Persistent Organic Pollutants

The polyaromatic hydrocarbon (PAH) concentrations in the North Levantine basin varies between >0.01-2 µg/L and the average is 0.5 µg/L (Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol 2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009). The surface distribution of the PAH shows great seasonal variations. However, recent and careful measurements revealed that, there is a considerable decrease in the levels of PAH and this is attributed to the decrease of the inputs. (IMS-METU 1995; Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol 2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009). It is estimated that PAH concentrations are inversely correlated with the temperature of the seawater (Kılıc 1986; Saydam *et al.* 1988). The lowest PAH concentrations in surface waters were reported during the autumn and they increase during winter and spring seasons reaching the maximum levels in late spring.

The Halogenated Hydrocarbons in the seawater at the NE Mediterranean are rather low. Kıdeyş (1987) reported not detectable (ND)-1 ng/L of op-DDT, ND-3 ng/L pp-DDT, 0.1-0.8 BHC, (ND)-1 ng/L Dieldrin and 1-31 ng/L PCBs.

Roether and Schlitzer (1991) and Roether *et al.* (1996) reported 1.1 pmol/kg CCl_2F_2 (CFC-12) concentration at the surface waters of the N. Levantine. The concentration of CFC-12, as expected, decreases with depth.

The total mercury concentration in the N. Levantine seawater ranges between >0.15-6.17 ng/L having an average of 2.81 ± 1.49 ng/L. Those high concentrations were measured at the coastal stations, which are under the direct influence of land-based sources. Detailed studies of mercury distribution in the region is done by several authors and can be found in Salihoğlu and Yemenicioğlu (1986); Salihoğlu *et al.* (1987)[a]; Salihoğlu *et al.* (1989) and Salihoğlu (1989).

The dissolved Cd levels in the sea water at the N. E. Mediterranean is always below the detection limit (0.05 ng/L) of the applied methods (IMS-METU 1995) thus the values presented here are those associated to the particulate material. In the particulate matter Cd concentration is between 2-252 ng/L with an average of 4 ng/L. The high Cd concentrations have been reported near the discharge area of an iron and steel complex in the İskenderun Bay. Since the particulate bound cadmium forms only 20% of the total (Roth and Hornung 1977) the total cadmium concentration in the N. E. Mediterranean coastal regions is expected to be higher than this amount.

The average total tin concentration in the N. Levantine coastal surface waters is estimated as 11 ng/L. Tuğrul *et al.* (1990) studied the methyltin species in the river discharges and found that almost 100% of the tin is in inorganic form. In the coastal marine waters inorganic tin concentrations showed great variations, in the relatively unpolluted areas *i.e.* areas receiving only river discharges are between 3.5 and 48 ng/L, while in the areas receiving industrial discharges, concentrations between 319 and 7700 ng/L were reported (Yemenicioğlu *et al.* 1987). In the seawater monomethyltin species varied from undetectable to 42 ng/L and dimethyl tin from undetectable to 40 ng/L. Butyl tins and methyltin species in the subsurface seawater from the harbors, marinas, river deltas and open sea, were recently reported by Yemenicioglu and Mora (2009) and Yemenicioğlu *et al.* 1997. The authors reported trimethyl tin concentrations up to 44 ng/L (as chlorides) close to Seyhan River discharge area. This river is known to receive domestic and agricultural effluents. Monobutyl tin, dibutyl tin and tributyltin concentrations were between 0.4-2774 ng/L, 0.8-677 ng/L and 8-935 ng/L (as chlorides) respectively in the harbors and marinas), Yemenicioglu and Mora (2009). At the river deltas, only Monobutyl tin was detectable while in the open sea no butyl tins were detected.

Biota

Saydam *et al.* (1988) reported that Polyaromatic Petroleum Hydrocarbon (PAH) concentrations in *Solea solea, Mullus barbatus* and *Epinephelus* can reach maximum levels of 1.2, 1.5, and 5 µg/g (dry weight) respectively and livers of these fishes are more susceptible to accumulation as compared to their muscle. Recent surveys showed almost the same quantities, *i.e.* 1.2 µg/g in *Solea solea,* 2.52 µg/g in *Mullus barbatus* and 2.97 µg/g in *Mugil auratus* of PAH concentration. (Yemenicioğlu and Salihoğlu 1997; Yemenicioğlu and Salihoğlu 1998; Yemenicioğlu and Salihoğlu 1999; Yemenicioğlu 2000; Yemenicioğlu 2001; Yemenicioğlu 2002; Yemenicioğlu 2003; Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol 2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009).

With the exception of Patella caerulea Chlorinated Hydrocarbons (PCBs) were absent in all species (Baştürk *et al.* 1980). This was explained with low usage and co-distillation processes. The total-DDT concentrations were found to correlate linearly with the fat (extractable organic material) content of the organisms. This is a reasonable trend because organochlorines are fat-soluble and mostly accumulate in fatty tissues. The t-DDT concentrations in Mugil auratus reported from N. Levantine varies between 28 and 409 ng/g dry weight. The long-term study carried out in IMS-METU between the years 1997-2009 showed that the DDT was absent in fish samples (*M. Barbatus*), but its derivatives in the fish samples from the coastal and reference zone ranges between 16-33 ng/g for DDE and 0.35-1.58 ng/g for DDD.

Mercury concentrations in the flesh of *Sardine pichardus* varies between 36 - 38 ng/g, *Solea solea* 86- 254 ng/g, *Mullus barbatus* ND - 165 ng/g and *Mugil auratus* from 15 - 28 ng/g (on dry weight basis). In general, mercury concentrations in the fish samples from northeastern Mediterranean are lower than those reported from the other areas of the Mediterranean except *U. moluccensis*. The concentrations reported for this organism are such as 2503±1205 ng/g (on dry weight bases). It has been reported that, *U. moluccensis* has an accumulating capacity 4-5 times higher than the other *mullidae* family species (Balkaş *et al.*1982; Salihoğlu and Yemenicioğlu 1986).

The long-term trend monitoring study carried out in IMS-METU under the umbrella of UNEP-MEP (MEDPOL) between the years 1997-2009 showed that there is no any trend with respect to mercury.

The concentration of cadmium in both benthic and pelagic fish is lower than the concentrations in their prey and thus no bio magnification is evident. The cadmium concentrations in fish flesh caught from northeastern Mediterranean are ranging between ND-8 ng/g (fresh weight) for *M. barbatus,* ND-19.5 ng/g for *M. auratus* and ND-15 for *S. solea* (IMS-METU 1995). The highest Cd concentrations were reported from Gulf of İskenderun, which receives discharges of both industrial and domestic origin.

The long-term trend monitoring study carried out in IMS-METU under the umbrella of UNEP-MEP (MEDPOL) between the years 1997-2009 showed that there are a downward trend with respect to cadmium in the region extending from Mersin bay, to the Göksu river estuary.

Lead concentrations in the fish flesh is unexpectedly high, (241 ng/g (dry weight)) in *S. solea* and 430 ng/g (dry wt.) in *M. barbatus* from the N. Levantine. *M .auratus* values although were less, Varied In Between 20-54 Ng/G (Dry Wt.) (IMS-METU, 1995).

Sediment

Lead Concentrations From The Coastal Sediments Of N. Levantine Basin Varied From 46 To 280 Mg/G (Dry Weight). The maximum concentrations are reported from the Mersin Harbor, which is known to receive domestic effluents and riverine discharges. Those results from the vicinity of Erdemli have more or less the same concentrations with the open sea sediments. Recent data on the quantities of Pb concentrations in the sediments of the same regions are lower. Most probably due to the advancement of the analytical techniques, rather than the improvement of the environmental conditions.

The background concentrations of Cu in the Mediterranean are estimated to be in the range of 10-44 mg/kg. In the N. Levantine, deep sea and coastal sediments ranged from 21 to 368 mg/kg. The lowest values have been observed in the deep-sea sediments and are within the range of the background values, while the highest concentration (368 mg/g) was measured from the Mersin Harbor. From the distribution of Cu in the region, the effect of the Toros (Taurus) Mountains as a source of sediments is apparent. This reflects the abundant supply of Cu within Toros Mountains where there are several economic deposits.

The studies related to the organometallic tin species in the coastal sediments of the N. Levantine showed that mono-, di-, and tri- methyl tins are always present in sediments. This observations show the microbial activity within the sediment and/or sediment-sea interface. Another tin specie that was widely present is monomethyltin (Kubilay *et al.* 1996).

Mercury is one of the most extensively studied element in the world and in the N. Levantine coastal sediments. In the areas under the influence of the discharges, Hg concentrations varies from 16 to 47 ng/g dry weight with an average of 26±12 ng/g dry weight. However, in the polluted regions the concentrations are much above this average. In the Lamas River discharge area 401 ng/g of Hg is reported recently (Yemenicioğlu and Salihoğlu 1997; Yemenicioğlu and Salihoğlu 1998; Yemenicioğlu and Salihoğlu 1999; Yemenicioğlu 2000; Yemenicioğlu 2001, 2002, 2003; Yemenicioğlu *et al.* 2004; Tuğrul *et al.* 2005; Tuğrul, *et al.* 2006; Tuğrul *et al.* 2007 (vol 1); Tuğrul *et al.* 2007 (vol 2); Tuğrul *et al.* 2008; Tuğrul *et al.* 2009).

The chlorinated hydrocarbons mostly used as pesticide or insecticide for agricultural purposes, are carried to the sea by rivers and agricultural runoff. Very limited up-to-date data is available for the southern coast of Turkey. DDT's and its metabolites and PCBs are entirely absent. This is attributed to both low usage of these compounds in the region and to the seawater temperature and evaporation. BHC, Aldrin and Lindane, although low concentrations still are in measurable quantities.

The Petroleum Hydrocarbons reported from the N. Levantine are mainly the polyaromatic hydrocarbons (PAH). Salihoğlu *et al.* (1987)[b] measured PAH quantities in 67 sediment samples obtained from the Cilician basin up to 1.3 mg/g and attributed this high value to the crude oil introduced into the Gulf of İskenderun accidentally. Due to the temperature effects and microbiological degradation of PAH's in the marine environment they concluded that petroleum hydrocarbon pollution in the sediments has not yet reached to critical values.

Input of contaminants from Dardanelles strait

The Aegean Sea is a special part of the Mediterranean Sea. It is a passage between Mediterranean and Black Sea. The less saline and cold Black Sea water effects the northern part and the warmer and saline water of the Mediterranean Sea effects the southern part of the Aegean Sea. Aegean Sea receives water of Black Sea origin via Dardanelles Strait, Atlantic originating waters, Eastern Mediterranean water, deep water and river water. The major rivers discharging in the Turkish territorial of region are, Meric River, B. Menderes River, K. Menderes River and Gediz River. Because of these different water sources, Aegean receives pollutants originating from a wide variety of sources. These pollutants include the aeolian originating materials that are transported by rivers, materials carried by the Dardanelles from the Black Sea, from the Mediterranean Sea, the atmosphere and coastal erosion. The amount and type of the materials transported by rivers depend on the characteristics and texture of the catchment area of the river. The north-western Black Sea coastal waters transported to the Bosphorus region by along shore currents are drastically polluted by large inputs of organic and inorganic materials (Bologa 1985; Mee 1992; Meybeck 1982) which are carried by rivers such as Danube (which receives whole central European wastes) and other rivers draining in the region. The Bosphorus Strait carries the polluted Black Sea surface water into the Marmara Sea, which is exported to the Aegean Sea by Dardanelles Strait. The loads carried by Dardanelles Strait are estimated and published by several authors elsewhere (Polat and Tuğrul 1996; Yemenicioğlu *et al.* 1996; Yemenicioğlu 1990) are summarized in Table 1. A comparison of the pollutant concentrations in surface water of the Black Sea entrance of Bosphorus and Marmara entrance of Dardanelles shows that within the Marmara basin some of the liable chemicals which exist in the Black Sea inflow are naturally exported to the lower layer in the form of biogenic or inorganic particulate matter (as in the case of metals) until the Aegean basin of the Mediterranean is reached via Dardanelles Strait. On the other hand, DOC and DON in the Black Sea inflow reach as far as Aegean basin of the Mediterranean Sea due to their low decay rates.

Conclusions

- Research and monitoring programs about crude oil and related compounds has shown that there is an actual decline in their concentrations within the last 15 years in the Mediterranean Turkish coastal waters.
- Although in the enclosed regions such as İskenderun Bay and İzmir Bay the pollutant levels reaches to a critical levels, generally the Turkish coastal areas along the Mediterranean Sea and Aegean Sea are not acute from pollution standpoint.
- In some economic and extensively consumed fishes, some of the toxic substances (mercury and organotins) seem to be biomagnified.
- The work done until now was not planned for the flux determination of the pollutants, but the accumulated quantitative data allowed us to produce a true picture of the state of pollution.
- The pollutant gradients (especially in sediments) in the coastal regions must be determined for better understanding the origin and sources of each pollutant.
- The exchange between open sea and coastal regions and also the vertical distributions and dynamics (both in seawater and sediments) of some conservative pollutants need to be investigated.
- The information regarding the radionuclides in the region is very scarce.
- The chlorinated pesticide levels are decreasing continuously during last decade and dropped below the detection limits of the methods employed.

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LAND BASE POLLUTION OF THE TURKISH MEDITERRANEAN SEA

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1. Introduction

Land-based pollution signifies the single most important cause of marine pollution problem since it primarily affects coastal waters, which have high productivity. It incorparates contaminations in coastal waters that may pose serious risks to marine ecosystems as well as human health. Most pollution derives in one of five sectors: energy, agriculture, industry, transport, or municipal. The way of introduction of pollutants varies in the Turkish Mediterrenean Sea covering (i) from the coast, including from outfalls discharging directly into the marine environment and through run-off, (ii) through watercourses including rivers, canals and underground watercourses, (iii) via the atmosphere. The land-based pollution are more serious in shallow enclosed or semi-enclosed coastal sea areas than open seas.

In the Eastern Mediterrenean Sea, the most of the data is available through MEDPOL (MEDPOL Monitoring Programme 2003-2011) and national monitoring programme (Tugrul *et al.* 2014-2016). The north-eastern part of the sea, which comprises two main submarine sedimentation centres (Mersin Bay and Iskenderun Bay), has variety of industrial sectors including iron and steel, fertilizer industry, oil refinary, petroleum filling terminal, oil pipeline chemical, metal industry and machinary, textile industry, and pulp and paper factory. The western part of the sea has immense tourism and agriculture activities as well as pulp and paper factory and forest product and furniture sector in the region. Majority of the available data fo the region covers organochlorines, hydrocarbons and trace metal. This chapter attemps to cover historical data sets of the data and apprises the current status of the pollutants in the region.

2. Organic pollutants in sediment, seawater and biota

The Mediterranean coast of Turkey, where substantial of the country's greenhouse production is performed, hosts some of the big industrial facilities. As a consequence of that pollutions created from those sources are undoubtedly introduced in the marine ecosystem. Long term regional level monitoring programme mostly focuses on pollution of pesticides and hydrocarbons in sediment and biota. Other pollutants data are very scarce restricting robust interpretation over the impact on ecosystem.

2.1 Organochlorines

Persistent organic pollutants (POPs) containing chlorinated biphenyls and pesticides, insecticides and fungicides, which have a cumulative impact on the marine and coastal environment. The danger of these pollutants is cumulative because the chemicals are not easily excreted due to their low solubility in water. The effects of these pollutants are long term. Due to their persistence and ability to travel long distances they could be sufficiently transported regionally and globally. According to a study by UNEP (1990), the Mediterranean Sea takes around 567 tons of pesticides per year. It compromises mostly by DDT and similar compounds (196 tons), HCH and Lindane (194 tons), Aldrin-Dieldrin-Endrin (29 tons) and other organochlorine compounds (148 tons).

During the MEDPOL study in the period of 2003-2006, Mersin, Tirtar and Goksu regions were monitored in order to quantify organochlorine compounds in marine fish, *Mullus barbatus*. Polychlorinated biphenyls (PCBs), hexachlorocyclohexanes (HCHs), hexachlorobenzene (HCB), and dichlorodiphenyltrichloroethane (DDT) are among the initial 12 persistent organic pollutants (POPs) included in The Stockholm Convention on POPs (UNEP 2008).

Results from this monitoring program for the period 2003-2006 indicates that based on the location and temporal variability among the dominance of PCBs (with its congeners), DDTs [metabolites including dichlorodiphenyldichloroethylene (DDE (*pp′*-DDE, oo′-DDE)], HCB, and HCHs (α-, β-, and γ-HCH) varied in biota samples. For example, in 2003 in Mersin, while the amount of contaminants in the fish found as in the order of HCB > DDTs > HCHs > PCBs, the following year found as HCB > PCBs > DDTs > HCHs. Total amount of extracted organochlorines from fishes, caught in those 3 regions, varied between 33.5 and 2175.2 ng g^{-1} in the period of 2003-2006. In MEDPOL study between the period of 2003-2009, surface sediments samples were also monitored in Iskenderun, Karatas, Mersin, Goksu, Tasucu and Antalya regions. Predominant groups were PCBs, varied between around non-detectable to 200 ng g^{-1} among the stations.

The National Monitoring Programme (Tugrul *et al.* 2014-2016) has been performed in recent years in all Turkish seas to monitor many parameters including contaminants in sediment and biota. In this context, the Mediterranean Sea has been also monitored for pollution of organochlorines in sediments (10 stations) and biota samples (5 sites) in 2014 and 2015. In sediment samples, stations nearby Seyhan River and Antalya represent the highest DDTs values in the both years. While Iskenderun Bay sediments have less than 2 ng g^{-1} DDT and its congeners, increasing around 12 ng g^{-1} DDT and its congeners around Antalya district. Total PCBs did not exceeded 4.5 ng g^{-1} in sediments in both years in the Mediterranean coast of the Turkey.

In 2014 and 2015, in biota (*Mullus barbatus*), DDT and its congeners were detected quite high, approximately 120-165 ng g^{-1} dry weight, in fish samples collected from Seyhan and Karataş regions. However, fishes collected from Tırtar, Goksu and Anamur stations were measured less than 25 ng g^{-1} dry weight DDT and its congeners. The amount of PCBs in fish samples was less than 10 ng g^{-1} wet weight in both years, which were less than the legal limits (75 ng g^{-1} wet weight) described in Turkish Food Codex Regulation.

2.2 Hydrocarbons

There has been an overwhelming debate among scientist about what to use as a hydrocarbon pollution indicator in the marine environment. The earlier data sets evaluated aliphatic and aromatic hydrocarbons separately and had quite large different compounds concentration in their datasets. However, since last four decades, measurements focus on more total hydrocarbon concentrations and 16 U.S. EPA priority pollutant polycyclic aromatic compounds (PAHs) (Keith and Telliard 1979). Due to the high toxicity of PAHs, they are considered as a good indicator for hydrocarbon pollution in marine ecosystems. EPA's sampling method and instrumental analysis method are being standardized worldwide for more consistent measurements and intercomparable data sets.

PAHs are primarily formed as a result of incomplete combustion of carbon-containing fuels such as wood, coal, and oil. They are toxic, persistent and bioaccumulate in marine organisms. The sources and pathways of PAHs to the marine environment are highly varied and cover river and atmospheric inputs from land-based industries, offshore oil industry and operational and accidental spills of oil from shipping. As a result, PAHs become one of the most widespread organic pollutants in the marine environment. Hydrocarbons, especially PAHs, are strongly bioaccumulative in food chains and can bind to organic materials in sediments affecting marine organisms' growth and reproduction. Some PAH compounds show carcinogenic and mutagenic impacts.

Hydrocarbons analysis in different matrix have been conducted in different regions in the Eastern Mediterranean from 1980s until the present either during MEDPOL studies or other national and international projects. These analysis substantially focused on sediment hydrocarbon analysis, nevertheless, analysis of hydrocarbons in seawater are ignored in the region. An earlier report (Yilmaz *et al.* 1998) summarizes the findings till 1996 from the MEDPOL studies. According to this report, PAH concentrations in the seawater ranged between 0.01 and 4.14 µg L^{-1} in the period of 1985-1986 and 1995-1996; the average of PAH concentrations was around 0.25 µg L^{-1}. While sediment PAHs concentration was 0.51±0.1 µg L^{-1} in 1985-1986, it increased to 2.6±0.3 µg L^{-1} in 1995 and further increase was observed for the following year as 4.75±1.0 µg L^{-1} (Yilmaz *et al.* 1998). Fish and shrimp samples were also analyzed regarding their PAH concentrations between 1987 and 1996. While the highest PAH concentrations were found in *Mugil* sp. (in 1987 and 1996), approximately 10.7 µg g^{-1} dry weight, the lowest one was in *Mullus* sp. (in 1991), 1.1±0.4 µg g^{-1} dry weight (Yilmaz *et al.* 1998).

In the period of 2003-2015, in MEDPOL studies, hydrocarbon concentrations were measured. While the study focus on the eastern part of the North-Eastern Mediterranean coast of Turkey, Antalya was the only station visited in the west part of the study. The average aliphatic and aromatic hydrocarbons concentrations for surface sediments are given in Figure 2.1. The data set that aliphatic hydrocarbons reach maximum 3 µg g^{-1}, and aromatics is peaked around 1.5 µg g^{-1} in sediment for this region. While the variations among different years are quite high, the variation is less pronounced for the different stations, suggesting bias in sampling and measurements methods.

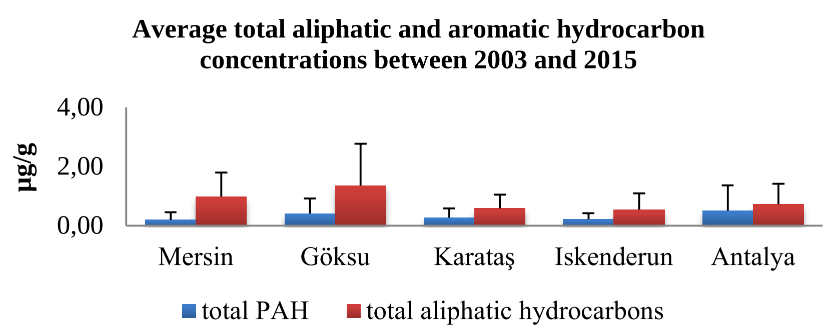

Figure 2.1 Aromatic and aliphatic hydrocarbon concentrations (µg g^{-1}) in sediment matrix in various stations in the Eastern Mediterranean between 2003 and 2015

Besides MEDPOL project, Kucuksezgin *et al.* (2013) investigated Cilician Basin coastal sediments for PAH distribution and their sources. Total PAH concentrations, reported between 5.43 and 271 ng g^{-1} dry wt, are comparable with the MEDPOL results. Sources of PAHs determined in sediments were identified by using Flu/Flu+Pyr and

Phe/Ant ratios, found mostly pyrolytic sources in that study. Tuncel and Topal (2015) also analyzed 25 sediment samples from the western part of the Eastern Mediterranean, calculated the average total PAH concentrations as1.85 ± 1.39 µg g^{-1}. Their findings also pointed out the pyrolytic sources of PAHs in the region.

For the region both individual and systematic data is available, yet, mostly focus on the eastern part of the region. In one of the earlier study (de Walle *et al.* 1993), the average PAH concentraions in muscles and livers of fish collected from Iskenderun Bay were 0.13 and 0.79 µg g^{-1} dry weight. Studies during MEDPOL programme between 2003 and 2010 focused on Mersin, Goksu and Tirtar regions regarding PAH content of fishes. PAH in fish muscle varied between 0.02 and 22.5 ng g^{-1} in these regions (Figure 2.2) implying a slight increase in PAH concentrations from west to east. The data collected in recent years (Figure 2.3) show that there is no apparent change of PAH concentrations in the region (National Monitoring Programme) compared to the averages of the 2003-2010 period.

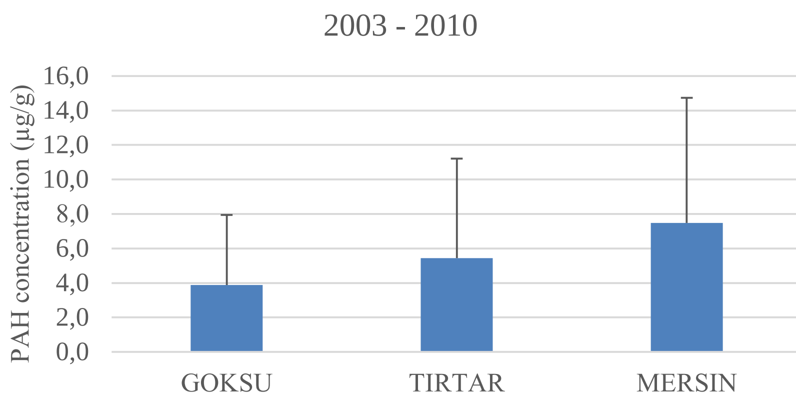

Figure 2.2 Polycyclic aromatic hydrocarbons (PAH) in fishes caught from Mersin, Goksu and Tirtar regions between 2003 and 2006

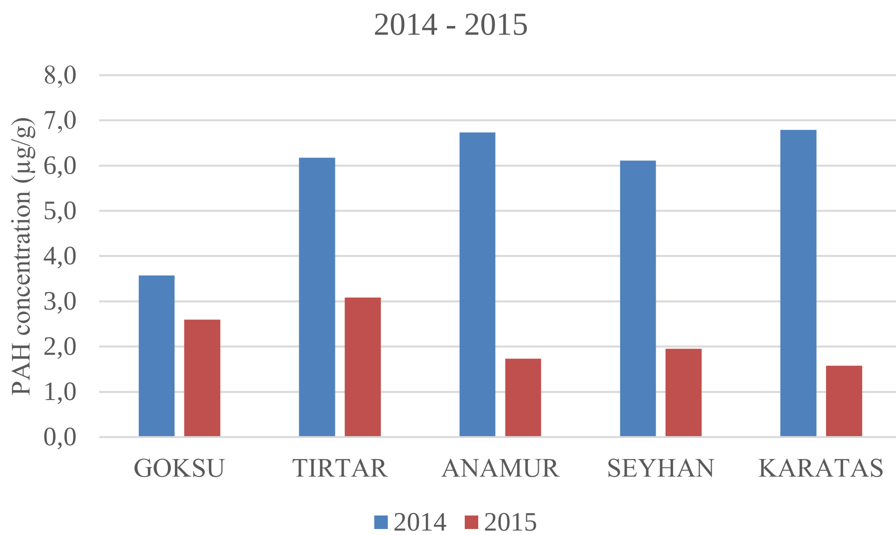

Figure 2.3 Polycyclic aromatic hydrocarbons (PAH) in fishes caught from Goksu, Tirtar, Anamur, Seyhan and Karatas regions between 2014 and 2015

3. Heavy and trace metal pollution in the North-Eastern Mediterranean

Metals contaminate the marine environment by accumulating in sediment, or bio-accumulating in marine organisms. The majority of the anthropogenic metal loads in seawater, biota and sediments has a terrestrial origin including mining and industrial activities along major rivers and estuaries, leading to the development of hotspots of heavy metal in coastal regions. Heavy metal contamination in sediment could affect the water quality and bioaccumulation/bioassimilation of metals in aquatic organisms, resulting in potential long-term effects on human health and ecosystem. Long term monitoring and quantification of the land-derived metal fluxes into the sea is therefore an essential factor to ascertain at which extent those inputs can influence natural biogeochemical processes of the elements in the marine ecosystem. In this context, understanding spatial and temporal distribution of metals in sediments and biota is of major importance to determine the contaminants history in aquatic systems and organisms. And, it provides an essential information for identifying the possible sources and helps coastal management and remediation activities.

During MEDPOL programme conducted between 1999-2008, metals in surface sediments were measured in 4 different regions in Turkish coastal part of the Mediterranean

Sea; namely, Antalya, Tasucu, Mersin and Iskenderun Bays. The average concentrations of Cu, Cd, Cr, Hg and Zn in these regions are depicted in Figure 2.3. While there is a high temporal variation, the spatial variation is less pronounced among the stations. Apparently, Cr concentrations increase from west to east, and there is no evident contaminated site among those stations.

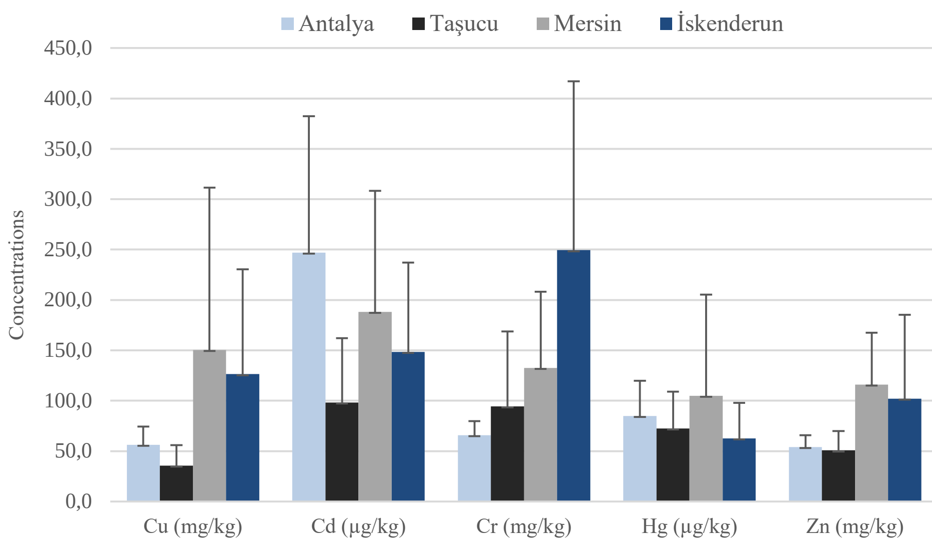

Figure 2.3 Metal concentrations in sediment in Antalya, Tasucu, Mersin and Iskenderun between 1999 and 2008 in MEDPOL programme

In more recent national pollution monitoring programme (Tugrul *et al.* 2014-2016), metal concentrations have been measured at 11 surface sediment stations throughout the Mediterranean coast of Turkey between 2014 and 2016 (Figure 2.4). While some metals has low variability (Cu, Zn, Al and Pb), Cd and Cr indicated high spatial variations.

Spatial variations of average values of the last 3-years metal concentrations in (Figure 2.5) displayed remarkable regional variations. While Cu concentrations are less prominent in Iskenderun Bay, but more noticeable in Marmaris and Mersin Bay regions. Surface sediments in the Marmaris Bay have relatively high Cr, Pb and Zn concentrations. The highest Hg concentrations is mostly seen in the coastal sediments contaminated fed by Goksu River inflows with higher concentrations of fine particles.

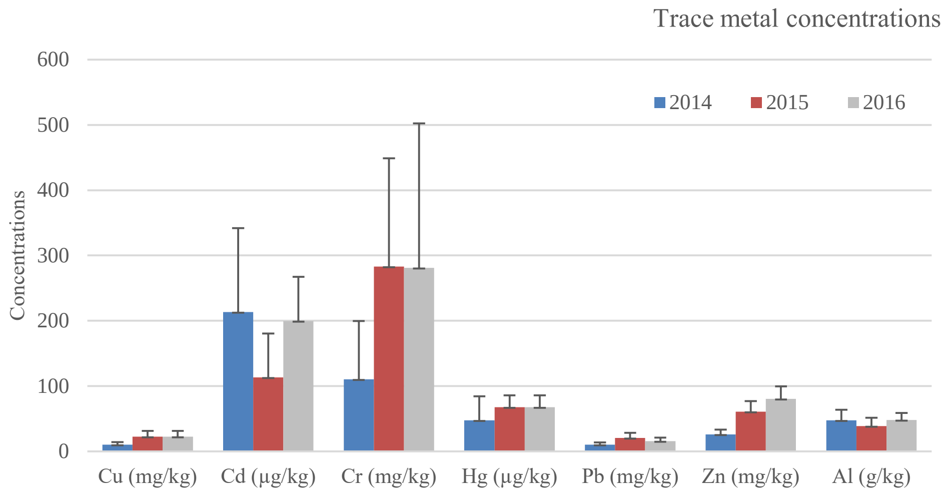

Figure 2.4 The averages of metal concentrations in sediments determined in Marmaris, Antalya, Goksu, Tirtar, Mersin, Seyhan, Karatas, Yumurtalik and Iskenderun stations in the National Pollution Monitoring Programme.

Besides those periodical monitoring studies, other individual studies were conducted in the region. However, there are very rare studies prior to 1996 in this region. After Shaw and Bush study (1978), there is a big time lag, then after 1990s the studies of sediment geochemistry were initiated back in the regions. Findings from those studies are summarized in Table 2.1. While the most focus was given to the eastern part (Mersin and Iskenderun Bays), one of the rare studies (Ergin 2004) was conducted in Antalya Bay using sediment corers. In this study, many metals were analyzed in cores and the selected metal concentrations are summarized in Table 2.2. Another independent study conducted by Yemencioglu and Tunc (2013) analyzed many metals in 45 core samples taken from Mersin and Iskenderun Bays. Their results were in accordance with the MEDPOL average concentration values (Table 2.3).

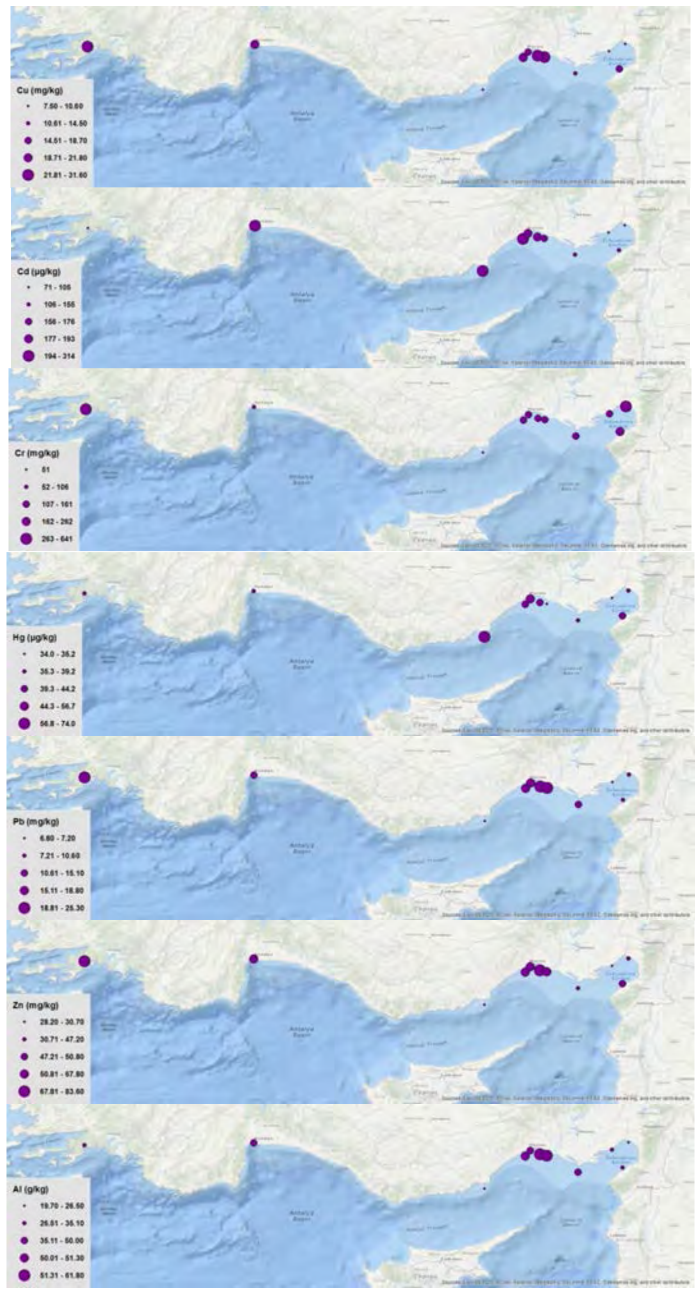

Figure 2.5 Average metal concentrations in sediment in throughout the Mediterranean between 2014 and 2016

Table 2.1 Average value of metal concentrations in total of 21 sediment cores in Antalya Bay [min-max (average)]

Mo (mg kg^{-1})	Cu (mg kg^{-1})	Pb (mg kg^{-1})	Zn (mg kg^{-1})	Ni (mg kg^{-1})
0.3-2.2 (0.82)	2-37 (24)	6.0-51 (17)	14-100 (62)	3-195 (101)
Cr (mg kg^{-1})	**Co (mg kg^{-1})**	**Mn (mg kg^{-1})**	**Fe (%)**	**As (mg kg^{-1})**
10-146 (101)	5-22 (15)	256-947 (510)	0.7-4.1 (2.8)	9-70 (18)

Table 2.2 Average value of metal concentrations in sediment in Mersin and Iskenderun Bays prior to 1996

Location	Fe (%)	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Ni (mg kg^{-1})	Cr (mg kg^{-1})	Zn (mg kg^{-1})	Co (mg kg^{-1})	Reference
İskenderun Bay	0.4–5.7	411–1517	9–37	32–563	25–252	23–286	1–92	Ergin *et al.*1996
Mersin Bay	1.5-9.0	281–1130	9–39	179–808	70–694	30–117	6–99	Shaw and Bush 1978
İskenderun Bay	0.4–5.7	411–1517	9–37	32–563	25–252	23–286	1–92	Ergin *et al.*1996

Table 2.3 Average value of metal concentrations in sediment of 45 stations in Mersin and Iskenderun Bays in 2003

	Cu (mg kg^{-1})	Cr (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Ni (mg kg^{-1})	Co (mg kg^{-1})
Average	26,4	157,3	63,8	675,2	274,1	4,6
Std. dev	6,5	58,6	37,9	161,1	138,2	3,8

Metal data in biota from the NE Mediterranean is limited; the pollution monitoring (MEDPOL) programme has selected a demersal fish species, *Mullus Barbatus,* as a pollution indicator because the high salinity of the Mediterranean Sea does not allow widely inhabitance of mussels, *Mytilus* sp., in the Eastern Mediterranean. However, mussel species is widely used in other seas in the Aegean, Marmara and Black Sea coastal waters of Turkey.

For heavy metal analyses, fish samples were taken between 1999 and 2010 in the MEDPOL programme in Mersin, Goksu and Tirtar regions. Metals in fish body displayed relatively low spatial variations compared to temporal variations (Table 2.4). In 2015 and 2016, metal concentrations in fish were determined at the selected sites from Iskenderun Bay to Anamur region during the National Pollution Monitoring programme (Table 2.5). The spatial variability were relatively low, compared to the results between 1999 and 2010. In the two years, lower concentrations of Cd, Cu and Cr were determined in fish samples, due most probably to methodological changes made in digestion and instrumental analysis of fish samples.

Table 2.4 Average, minimum and maximum values of metal concentrations measured in biota *Mullus Barbatus* muscle tissue during MEDPOL programme between 1999 and 2010

Mersin (1999-2010)	Cd (µg kg^{-1})	Cr (µg kg^{-1})	Cu (mg kg^{-1})	Hg (µg kg^{-1})	Zn (mg kg^{-1})
Average	153,9	481,1	16,8	188,8	20,8
Std dev	172,3	651,4	19,3	169,2	18,4
Min	13,8	3,6	1,3	13,4	1,5
Max	888,7	3858,5	166,2	786,0	89,5
Goksu (1999-2009)	**Cd (µg kg^{-1})**	**Cr (µg kg^{-1})**	**Cu (mg kg^{-1})**	**Hg (µg kg^{-1})**	**Zn (mg kg^{-1})**
Average	139,9	471,4	13,4	148,3	23,3
Std dev	186,8	358,2	11,5	176,4	20,1
Min	6,7	8,1	1,5	7,4	1,2
Max	811,5	1314,1	55,7	969,1	82,4
Tirtar (1999-2009)	**Cd (µg kg^{-1})**	**Cr (µg kg^{-1})**	**Cu (mg kg^{-1})**	**Hg (µg kg^{-1})**	**Zn (mg kg^{-1})**
Average	123,1	719,1	15,6	132,7	18,8
Std dev	169,4	1012,3	16,1	107,5	12,1
Min	4,6	63,6	0,9	9,3	2,0
Max	759,5	7620,0	69,9	570,8	67,3

Table 2.5 Average, minimum and maximum values of metal concentrations measured in biota *Mullus Barbatus* muscle tissue during the National Monitoring Programme between 2015 and 2016

All stations (2015- 2016)	Cd (µg kg^{-1})	Cr (µg kg^{-1})	Cu (mg kg^{-1})	Hg (µg kg^{-1})	Zn (mg kg^{-1})
Average	9,8	291,7	1,0	250,5	16,1
Std dev	7,9	175,5	0,2	188,5	1,7
Min	4,1	105,5	1,0	124,2	12,8
Max	25,5	694,1	1,4	657,5	19,1

Conclusion

In the NE Mediterranean, marine pollution of industrial and domestic origins are more apparent mainly in Iskenderun and Mersin Bays. Background concentrations of some metals (Cr, Ni) are relatively high in the NE Mediterranean, especially in Marmaris and Antalya Bays. Moreover, chemical pollutant data in biota is very limited to assess spatial and temporal trends in the area. In order to seek solutions to these problems, a comprehensive strategy of cooperation to improve the existing management problem is required. Because the problem is both national and international, the control of the land based pollution in marine environment needs to be dealt with globally and regionally. Therefore, periodical monitoring of the organic/metal contaminants in biota and sediments is necessary to keep track of the pollution and take required precautions at the anthropogenic sources along the coastal zone.

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MARINE LITTER IN THE MEDITERRANEAN COAST OF TURKEY: FROM A MARINE STRATEGIC FRAMEWORK DIRECTIVE (MSFD) PERSPECTIVE

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1. Introduction

The industrial and agricultural revolutions and the rapid rise in growth and development have created unforeseen problems for the world we live in today. One of these problems is due to the lack of or inadequate waste management practices all around the world; when substantial amounts of litter is transported into the marine environment from land by wind, rivers, drainage and/or sewage systems (UNEP and NOAA, 2012). Other potential sources of litter transportation to the marine environment are through sea based activities such as shipping, the fishing industry and offshore oil and gas installations. The relevant EU Marine Strategy Framework Directive (MSFD) task group (TG 10) defines the "Marine litter" as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (Galgani *et al.* 2010).

Marine litter is a rapidly growing concern for the marine environment. Several worldwide organizations (NOAA, UN, EU) are focussing on scientific assessments of pressure and the impact of marine litter on the marine environment in search of quantifiable targets to tackle the issue.

The harm caused by marine litter to the marine environment has been divided into three general categories for global assessments (Galgani *et al.* 2010):

a) Social

As marine litter decreases the attractiveness of coastal areas, it also reduces beach user enjoyment and surrounding property values (Mouat *et al.* 2010). Additionally, accumulated litter adversely affects public health and safety.

b) Economical

Whilst marine litter reduces the economic benefits derived from marine and coastal activities, it also increases the costs associated with these activities (National Research Council, 2008). For example;

- Floating marine litter presents a navigational hazard causing operational problems for industrial and recreational boats.

- Causes economic losses to aquaculture producers as a result of maintenance costs for damaged vessels and equipment (UNEP 2009).
- Poor aesthetic quality of beaches due to litter presence deters visitors from using the area resulting in lost revenue from tourism besides clean-up costs for local authorities.

c) Ecological:

Marine litter contaminates various habitats (shorelines, coral reefs, shallow bays, estuaries, the open ocean and the deep sea) and wildlife from the poles to the equator. Pressures arising from the marine litter problem cause a range of adverse ecological impacts, including;

- *Entanglement/Entrapment*: Entanglement by marine litter, such as ghost nets or various types of plastic litter, limits the mobility of animals and leads to starvation, suffocation, laceration, subsequent infection, and possible mortality.
- *Ingestion*: Marine animals ingesting litter, primarily small sized plastic items, mistaken as food is a common problem in the marine environment. As a result, ingested litter items can physically obstruct the digestive tracts of these animals or even cause nutrient deficiency and starvation in time.
- *Habitat Destruction*: Marine litter can also lead to habitat destruction by marine habitat alteration, degradation, or destruction through physical interferences (UNEP and NOAA, 2012).
- *Transport of Chemicals and Food Chain Implications*: Marine litter, particularly plastic items, in addition to the physical hazards may also cause chemical hazards in the marine environment (Rochman, 2015). Chemical contaminants, such as polychlorinated biphenyls (PCBs) and organochlorine pesticides, associated with the marine litter constitutes acute and chronic threats to both aquatic and terrestrial food webs.
- *Introduction and Spread of Invasive Species*: floating marine litter is one of the vectors for transporting invasive species (Wilson *et al.* 2009)

2. Marine Strategic Framework Directive (MSFD) perspective

The Marine Strategy Framework Directive (EUR-Lex 2008) aims to achieve Good Environmental Status (GES) of EU marine waters by 2020 using eleven descriptors. Once marine waters are able to provide goods and services at a sustainable level whilst the marine environment remains clean, healthy and productive; GES will be considered to be achieved (EUR-Lex 2008). In order to achieve GES, Member States are required by the MSFD to develop marine strategies that serve as an Action Plan applying the Ecosystem Approach (EA) and using existing regional cooperative agreements (e.g. OSPAR, HELCOM Bucharest and and Barcelona conventions).

11 Descriptors have been listed following the Commission Decision (EUR-Lex 2010), on the criteria and methodological standards required for the Good Environmental Status of marine waters as guidelines for the assessment of progress towards GES. Those 11 Descriptors have further been sub-divided into 29 criteria with 56 associated indicators. Task Group Reports have supported the Decision, and they have provided respective documents at the descriptor level.

The GES descriptive 10 of the MSFD is described as "Properties and quantities of marine litter which do not cause harm to the coastal and marine environment" in Annex I. The four indicators under the following two criteria of D10 identified by the Commission Decision (EUR-Lex 2010) are as follows: -

Criteria 10.1 Characteristics of litter in the marine and coastal environment

(1) Trends in the amounts of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)

(2) Trends in the amounts of litter in the water column (including surface floating) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)

(3) Trends in the amount, distribution and, where possible, composition of microparticles (in particular microplastics) (10.1.3)

Criteria 10.2 Impacts of litter on marine life

(4) Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1)

3. Status of Marine Litter Pressure on the Mediterranean Coastlines of Turkey

Large data gaps and lack of awareness exists on the status of the marine litter problem of the Mediterranean coastlines of Turkey. Most of the available data, related to marine litter pressure in the area, comes from local scientific surveys published mainly during the last fifteen years. Due to different land use characteristics, the area should be evaluated under two main subdomains, namely the West (Muğla and Antalya provinces) and the East (Mersin, Adana and İskenderun provinces).

West Domain

Beaches are not only important natural resources but also generate an impact on the economy especially on a regional scale. The economic evaluation of beaches is an important tool for coastal and tourism managers to fully understand their customers (Blakemore and Williams 2008). Marine litter is known as a vector that has numerous economic implications especially on the tourism sector. There are two studies which provide an insight into the possible negative impacts of beach litter on the tourism sector in the west sub-domain. Blakemore and Williams (2008) investigated the economic value that British tourists, as the majority (70%) user group, placed on their beach experiences at Ölü Deniz beach (Turkey), preferred for both recreational activities and to enjoy open space and scenery. The majority of respondents reported the three main dislikes negative qualities of the beach were washed up litter and man-made debris (41%), water quality (31%), and dog faeces (24%) in the area. In subsequent years in a similar study carried out at two of the most popular beaches located in the same area (Ölü Deniz and Belek), researchers evaluated the potentially unsustainable conflict between tourism and conservation of marine turtles as a problem in need of resources (Sayan *et al.* 2011). The common factor featured in both studies was that cleanliness is the most important factor influencing beach choice both for domestic and foreign tourists (Blakemore and Williams 2008; Sayan *et al.* 2011).

The main obstacle for efficient management of the marine litter problem is a lack of proper methodology to determine the litter sources. With the purpose of providing a methodology, two studies were carried out in the west domain as pilot study area. Within the scope of an international cooperative study, the standing crop of litter along a 100 meter stretch of four beaches located in Antalya Bay (Kemer, Çıralı, Side and Konyaaltı) was evaluated to identify the possible sources (Tudor *et al.* 2002). Large amounts of "beach user" items (cigarette ends; 'take-away'/convenience food wrappers and containers; confectionery wrappers, etc.) constituted the main litter type in the survey area. Balas et al. (2003) also concentrated on the same region, applying a seasonal sampling scheme with four time points to 100 meter stretches of beach at Kemer, Konyaaltı, Çiralı, Side and Belek. Similar to the previous study, a distinct result of the litter surveys available for the Antalya region is the prevalence of litter resulting from beach users.

Results obtained from several assessment programs carried out in the Mediterranean Sea show that the seafloor, mainly the deeper sections, constitute the ultimate sink for marine litter (Galgani *et al.* 2000; Tubaua et al. 2015). One other study carried out in the bathyal depths (between 200 m and 800 m) of Antalya Bay, addressing seafloor litter, aimed to understand the current status of the marine litter problem on the seafloor and provided baseline data on the abundance, distribution and qualification of different litter categories according to their material (Güven et al. 2013). The amount of litter recorded ranged from 115 to 2762 items/km^2. As stated by Galgani et al. (2015) and the same on a global scale, plastic is the main component of marine litter distributed throughout the study area and in the three main highly concentrated debris accumulation zones reported in the sampling area.

East Domain

There are a number of studies in the Eastern region of the area that focus on marine litter including microplastics and their impacts. One of the first studies in the record is a pilot survey (Bingel *et al.* 1987) carried out as a landmark for the assessment of coastal and marine plastic litter in the Levant Sea (the eastern Mediterranean). Based on the findings of this study, plastic litter accumulation on the bottom appears to be correlated with the basic oceanographic conditions of the region such as the closed gyres in Iskenderun Bay, the mean currents of the north eastern Mediterranean Sea, net currents along the shelf and fresh water inlets. Three important accumulation areas, influenced by oceanographic conditions were identified in that study (Figure 1). The most intensive accumulation occurred in the Bay of Iskenderun. The other areas of accumulation were the eastern and western extensions of the shelf areas of Mersin and Taşucu bays and finally the bays located in the western region of Taşucu.

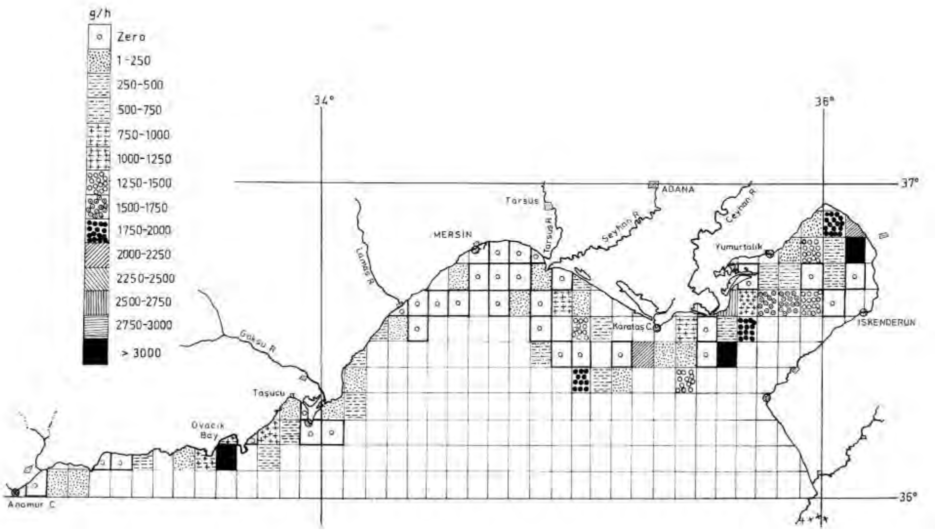

Figure 1. Distribution of plastic materials in northern Levantine waters between 1983 and 1984 (Bingel, *et al.* 1987)

In subsequent years (Yılmaz *et al.* 2002) carried out trawl surveys to determine the effects of currents on the accumulation of plastic materials along the south-eastern region of Iskenderun Bay. One observation from both studies is the trans-boundary plastic marine litter problem with intense accumulation in Iskenderun Bay under the influence of mean currents of the north eastern Mediterranean Sea.

Sea turtle species are known to be one of the groups most affected by marine litter pressure in the marine environment. While adults are known to be affected by either entanglement or ingestion of plastic debris, hatchlings are also prone to entanglement or entrapment in marine debris on their journey to the sea (Kasparek, 1995; Triessing *et al.* 2012) In the province of Hatay (Antioch), ten 10 meter wide transects were sampled in mid-summer and early autumn at different distances North and South of the Asi river delta (Ozdilek et al. 2006). The aim of this study was the determination of the relationship between sea turtle hatchling success and litter accumulation. High levels of solid waste accumulation was determined in the area. The percentage of successful hatchlings which managed to reach to sea was found to be negatively correlated with the litter accumulation in the evaluated area (Ozdilek et al. 2006).

One international recent project, carried out by the Institute of Marine Sciences (METU), that has provided new data regarding marine litter pressure on the Mediterranean coastline of Turkey is “Marine Environmental targets linked to Regional Management schemes based on Indicators Developed for the Mediterranean” MERMAID project (SEAS-ERA-EU FP7 ERA-NET / TUBITAK: 112Y394). One of the aims of this project is to perform an assessment of environmental quality in terms of five descriptors, including D10-Marine litter, of the MSFD by taking into account existing knowledge and new data collected from pilot surveys. In this context, three short term pilot-surveys were carried out between 2013 and 2016 in the Cilician Basin covering the amount and composition of macro litter washed ashore and/or deposited on the coastline. Both the status of the marine environment regarding microplastic pollution and the effects of microplastics on biota (digestive tract analysis of bony fishes) have also been covered within the project.

The first pilot study which set out to gather data on the standing crop of litter and to identify the likely sources of encountered litter from beaches was undertaken in April 2014 in coastal areas of the Cilician Basin (Aydın *et al.* 2016). Thirteen sites representing the area were evaluated throughout the study (Figure 2). The average litter density was found to be 0.92 ± 0.36 items/m^2 in the area. Plastic items on average constituted over 80% of the dominant material type. Data from this study which also provides baseline information for the area, was used to create a sound and easily applicable methodology for litter source determination.

Results obtained from the study showed that beaches located in the area were exposed to high levels of litter pollution, with eight out of 13 beaches being classified as either dirty or extremely dirty according to the Clean-Coast Index (Alkalay et al. 2007). Beach use has been shown to be the major source of the litter abundance. Amongst other functional litter categories “Take-away/convenience food wrappers and containers, drink containers (Rapd)” and “Cigarettes, cigarette butts and cigarette/filter/tobacco packages (Smo)” were the most prevalent litter functions in the area.

Another pilot study focused on litter washed ashore and/or deposited on the coastline at a protected beach (belonging to the IMS-METU) located in the Cilician Basin between September 2013 and August 2014 (Figure 3). The aim of the study was to understand the seasonality of distribution, composition and accumulation points of litter during one full year-by considering the effects of meteorological events on transportation. Through the one-year survey, weekly sampling was carried out at four sub-sites (L, O1, O3, and O6) along the beach. Both macro and micro litter samples were collected from the selected sampling areas. All methods used for the evaluation of the litter were in compliance with the JRS's marine litter monitoring guidance for European seas (Galgani *et al.* 2013).

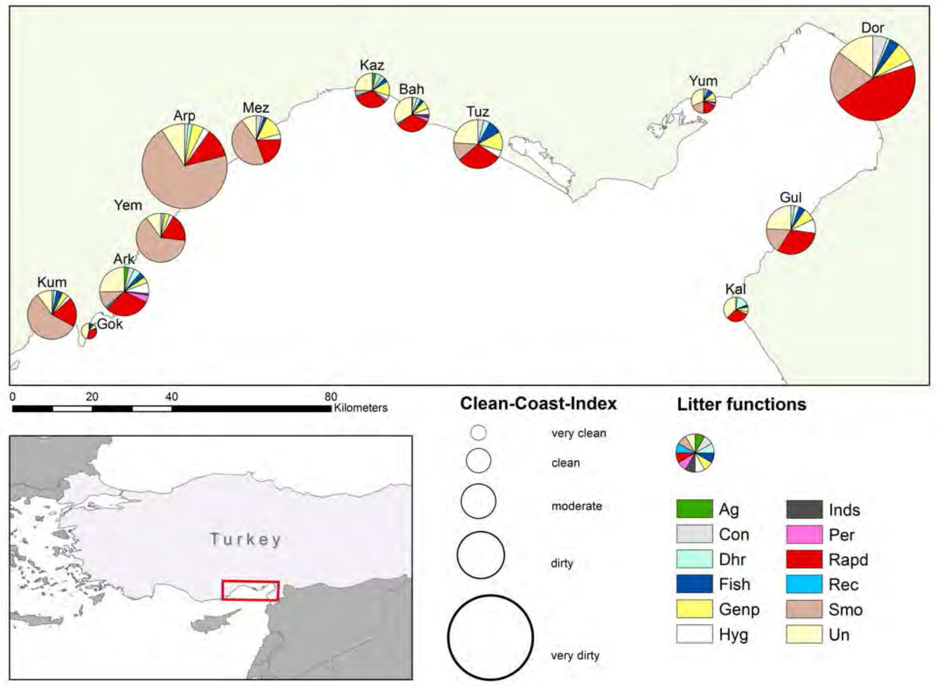

Figure 2. Composition of coastal litter in the Cilician Basin according to functions. The sizes of the pie charts vary according to the pollution status of the beach, expressed using the Clean Coast Index (Alkalay et al. 2007), with larger pie charts representing higher litter densities. (Ag: Agriculture, Con: Construction, Dhr: Domestic and Household, Fish: Fishing, Genp: General Packaging, Hyg: Medical and Personal Hygiene, Inds: Industrial, Per: Personal Use, Rapd: Rapid Consumption, Rec: Recreation, Smo: Smoking, Un: Unclassified) (Aydin *et al.* 2016).

Figure 3. Four stations (L, O1, O3, and O) sampled weekly for the evaluation of litter washed ashore and/or deposited on the coastline at a protected beach (belonging to the IMS-METU, shown with the filled circle) located in the Cilician Basin between September 2013 and August 2014.

Evaluation of microplastic pollution in the marine environment along the coastal zone of the Cilician Basin performed within the framework of another two pilot studies (TUBITAK ÇAYDAG projects 114Y244 and 115Y627).

The major aim from the TUBITAK ÇAYDAG project 114Y244 (entitled "Estimating the quantity and composition of microplastics in the Mediterranean coast of Turkey; the potential for bioaccumulation in seafood") is the initial assessment of the extent of microplastic pollution in both water and sediment samples along the coastal zone of the Cilician Basin. A total of 18 locations were selected and evaluated in the area (Figure 4). Results obtained from the study revealed the extend of the microplastic pollution in the area, a marine issue that has been receiving much global attention in recent years. The data gathered from the study provides baseline information for future studies focusing on the effects of microplastic pollution on other aspects of the surrounding environment.

Other aims of this project TUBITAK: 114Y244) are;

- To evaluate the quantity, distribution and composition of micro-plastics, their biological impacts and assess potential toxicity in the Mediterranean coast of Turkey in accordance with the Marine Strategic Framework directive (MSFD).
- Bioaccumulation in fish (*Sparus aurata*) will be evaluated upon dietary exposure and water exposure under controlled laboratory conditions.
- Bioaccumulation of microplastics through the food chain will be monitored in the natural environment through the analysis of a range of species of marine fauna.

Aims of the second TUBITAK project (ÇAYDAG 115Y627 "Impacts of Microplastic Particles and Bisphenol A (BPA) as a Chemical Additive in Zooplankton Species of Mersin Bay") are;

- Evaluation of the spatial and temporal distribution of microplastics and BPA in the water column and determination of changes in land-based BPA contamination input to the marine environment in Mersin Bay
- Determination of the potential effect of microplastic existence on zooplankton biomass assessments.
- Understand the impacts of microplastics and BPA on the various life stages of zooplankton species
- Reveal the genotoxic effect of BPA on zooplankton species.

Figure 4. Water (Surface water and water column) and sediment sampling stations for microplastics in the Cilician basin undertaken within the framework TUBITAK ÇAYDAG Project 144Y244.

As part of a national marine monitoring programme (Integrated Pollution Monitoring Project at Sea), carried out by the T.C. Ministry of Environment and Urbanization, microplastic pollution was monitored at three selected areas located in Mersin Bay (Figure 5). Between 2014 and 2015, sea water and sediment samples were analysed for this project. An inter-calibration exercise was carried out for microplastic evaluation from different sources (sea water and sediment) within the framework of the national monitoring program in 2015. The exercise was performed by the Middle East Technical University, Institute of Marine Sciences (IMS-METU) with the participation of Istanbul University, Institute of Marine Sciences (IMS-IU) and TUBITAK Marmara Research Center, Environment and Cleaner Production Institute (MAM-ÇE). Microfiber contamination originated from the working environment and cloths of the staff fond to be the main factor for the inaccurate results determined by the participant groups. In the context of the work carried out it was determined that, there were differences in the results obtained by the different participant groups for sea water samples. Microfiber contamination originated from the working environment and cloths of the staff found to be the main factor for the inaccurate results determined by the participant groups. Possibly due to the high dynamism of the sea, sea surface and water column samples produced wider ranges of differences among the results obtained by the participating groups. The most similar results obtained from the evaluation of the sediment samples. In the report, alternative methods were also proposed for improving methods for a more efficient microplastic analysis in sea water samples as the following:

For removing high amounts of organic matter existence in the water samples: 1) Addition of hydrogen peroxide to water samples right after the sampling, 2) Using a separation column with different sized meshes (500 µm, 200 µm and 100 µm), 3) Replacing traditionally used small pore sized fiberglass filters with 26 µm mesh sized filters, that is resistant to the chemical use, to be used in the final step of the filtration process. For more accurate evaluation the microplastic existence in the seawater samples, a three-replicate sampling recommended. In 2016, the evaluation of microplastics from the digestive system of several species of fishes were also initiated.

Another study was carried out for the evaluation of microplastic existence in the discharge waters at 8 wastewater treatment facilities (Figure 6) in 2015. Microplastic diversity was found to be statistically different between wastewater treatment facilities. Facilities operating in the Hatay province found to be contain lower amounts of microplastics in their discharge water. For all the assessed facilities, the dominant microplastic type was micro fiber particles (ÇŞB, 2015).

Figure 5. Microplastic sampling locations within the national monitoring program of 2015.

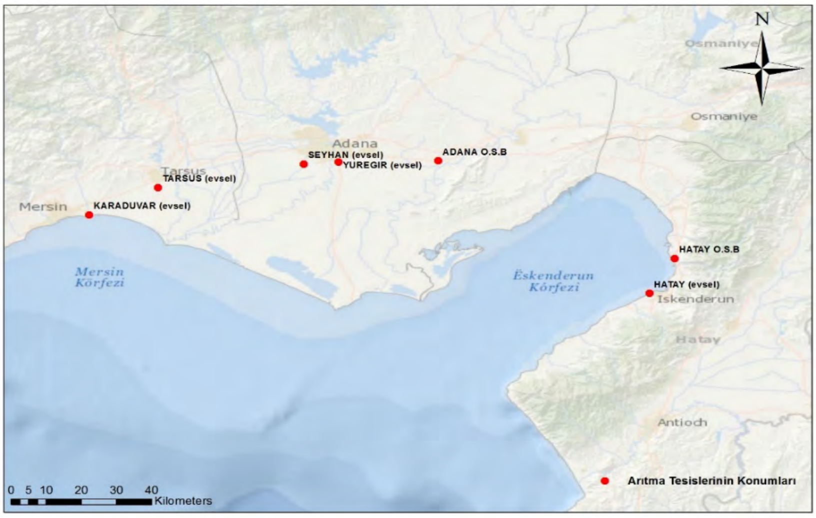

Figure 6. Wastewater treatment facilities evaluated for their microplastics inflow in the Cilicia Basin during 2015.

4. Contact information for the above mentioned projects

- ❖ (SEAS-ERA-EU FP7 ERA-NET / TUBITAK: 112Y394) – **M**arine **E**nvironmental targets linked to **R**egional **MA**nagement schemes based on **I**ndicators **D**eveloped for the Mediterranean" (MERMAID)
  Duration: February 2013 – September 2015

  Website: http://mermaid-era.eu/home/

  Project Coordinator: Dr. Helen KABERI, Hellenic Center for Marine Research (HCMR) - ekaberi@hcmr.gr

  Contact Person (Turkey): Associate Prof. Dr. Bariş SALİHOĞLU, Middle East Technical University (METU) - baris@ims.metu.edu.tr

- ❖ (TUBITAK: 114Y244) – Estimating the quantity and composition of microplastics in the Mediterranean coast of Turkey; the potential for bioaccumulation in seafood.
  Duration: March 2015 – March 2018

  Project Coordinator: Prof. Dr. Ahmet E. KIDEYŞ, Middle East Technical University (METU) - kideys@ims.metu.edu.tr

- ❖ (TUBITAK: 115Y627) – Impacts of Microplastic Particles and Bisphenol A as a Chemical Additive in Zooplankton Species of Mersin Bay
  Duration: April 2016 – April 2018

  Project Coordinator: Prof. Dr. Ahmet E. KIDEYŞ, Middle East Technical University (METU) - kideys@ims.metu.edu.tr

Immense amount of data to be gathered from all all these studies will be available soon which will provide valuable information for the baseline assessments of marine litter and microplastics from the Mediterranean costs of Turkey in complying with the MFSD of the EU.

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MARINE AND COASTAL PROTECTED AREAS OF TURKISH LEVANTINE COASTS (EASTERN MEDITERRANEAN)

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1. Introduction

The Turkish Levantine Coasts (eastern Mediterranean) is delimited between Dalaman Creek in the west and Samandağ – at the Turkish-Syrian border – in the east. It measures about 860 n. miles. Unlike Turkish Aegean, the mountains lay parallel to coasts that result in rather linear coasts in this part of the country. Although, this part of the Mediterranean Sea is one of the most oligotrophic regions in the world – with low primary productivity –, it still hosts significant marine biodiversity and habitats. This basin also severely impacted by the invasion of species, in particular Lessepsian migrants (*e.g.* Coll *et al.* 2010; Şekercioğlu *et al.* 2011; Çınar and Bilecenoğlu 2014). Although this region hosts marine biodiversity and habitats," significant threats on the marine and coastal ecosystems were emhasized in the latest UNEP –MAP (2012) technical report "State of the Mediterranean Marine and Coastal Environment. These comprise; coastal development and sprawl, chemical contamination, eutrophication, marine litter, marine noise, invasive non-indigenous species, over exploitation of natural resources, damaged sea floor integrity and changed hydrographic conditions. In the light of these major findings and under the framework of integrated coastal zone management principles, marine and coastal protected areas (MCPAs) can play an important management role to mitigate the effects of these threats at least in the marine and coastal biodiversity hot spots.

In parallel, the major outcome of the United Nations Conference on Sustainable Development (Rio+20) "The Future We Want" document underlined "the importance of the conservation and sustainable use of the oceans and seas and of their resources for sustainable development", and the article 177 dictated that the "importance of area-based conservation measures, including marine protected areas", and stressed that "decision X/2 of the tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD), that by 2020 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, [were] to be conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures" (Turkish Ministry of Development 2012).

From the point of view of aforementioned threats to be mitigated and protection measures recommended by the CBD, and as was also the purpose of the previous publication of the author on the Turkish Aegean Sea (Güçlüsoy 2015), Turkey's current status on MCPAs establishment and management in the Turkish Levantine coasts was briefed in this chapter.

2. National legislation and administration

There was neither change in the respective primary legislation nor in the administrative structures nor the number of MCPAs of Turkey since the previous publication of the author (Güçlüsoy 2015). All the SEPAs are under the authorization of the General Directorate for Protection of Natural Assets under the Ministry of Environment and Urbanization and the remainder below mentioned MCPAs are under the authorization of the General Directorate for Nature Conservation and National Parks under the Ministry of Forestry and Water Affairs.

3. MCPAs of Turkish Levantine Coasts

A total of 6 MCPAs comprising 5 Special Environmental Protection Areas (SEPAs) and 1 Strict Nature Reserve (SNR) located on the Turkish Levantine coasts (see Fig. 1). In addition, though it does not have any marine component, but located on the coast, Beydağları National Park (NP), Belek SEPA and Akyatan Wildlife Refuge (WR) were also taken into account. Current knowledge on MCPAs on the Turkish Levantine coasts – from west to east – was briefed below.

3.1 Fethiye-Göcek SEPA

Fethiye-Göcek SEPA was founded in 1988 (Official gazetted No. 19863, 05 July 1988), and its borders changed twice and reached its current delimitation in 2006 (Official gazetted No. 26371, 09 December 2006) (EPASA, 2011; TVKGM, 2014a). Fethiye-Göcek was declared as a SEPA to protect natural and historical assets of the region. The area is important for having nesting and breeding areas of loggerhead turtle *Caretta caretta*, and endemic species sweet gum *Liquidambar orientalis* forming forest in streams, deltas and in the places where ground water level is high (EPASA 2011). Some metrics of this SEPA are given in Table 1.

Fethiye-Göcek SEPA is one of the most studied MCPAs in Turkey. A local and a short-term study on the physical, hydro-chemical and biodiversity study was carried out in February 2007 on the western part of the Fethiye Bay. As the result of this study, Okuş *et al.* (2007) concluded that biodiversity and natural ecosystem of the bay is damaged in long term seriously. In another local study, 118 marine macro species including 7 facies forming species were determined in Göcek Bay and its surroundings for the marine vessels carrying capacity assessment (DEÜ-DBTE, 2007). In their comprehensive study in the zone between 0 and 55 m depth DERINSU (2009) inventoried 1,545 marine species belonging to 24 taxonomic groups. Among these, Polychaeta (n=347), Mollusca (n=288) and Crustacea (n=264) were the most represented groups. While 40 species under protection in Mediterranean level were identified, 93 exotic species were also determined. Among 32 MCPAs and marine sites baring rocky reef ecosystems in the Mediterranean basin, Fethiye-Göcek SEPA was assessed to be 28th in terms of fish biomass and the 1st with largest cover of bare rock (31%) – without any benthic organisms (Sala *et al.* 2012). Fethiye Beach is one of the important nesting sites of *C. caretta* with a range of nesting between 72 and 191 (Türkozan and Kaska, 2010). Southwest of this SEPA coinciding with the Rhodes Basin is one of the most important Sperm whale encountered areas (Öztürk *et al.* 2013). Moreover, deep diving cetaceans including beaked whales and Risso's dolphins strandings were also recorded for this SEPA (Öztürk *et al.* 2011).

Bann and Başak (2013) also assessed the Fethiye-Göcek SEPA's marine and coastal ecosystem services and the total annual value of these services was estimated to be around US$ 210 million per year. Due to its attraction in high touristic season, an assessment on legislation and infrastructural requirements to mitigate the ship-based marine pollution was made for Göcek and Dalaman coves, and action plan was prepared (Battal, 2011). The sea turtle nests count and water quality monitoring programmes continue since 1993 and 2006 respectively. (Türkozan and Kaska 2010; G. Ergün pers comm. 18 Oct. 2016). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.2 Patara SEPA

Patara SEPA was established in 1990 (Decree of Cabinet of Ministers no 90/77, 18 Jan. 1990), and its borders were revised to reach its current limits in 2007 (Official gazetted No. 26551, 13 June 1997). Patara was declared as a SEPA to protect natural and historical assets – engulfs a 1st degree archaeological site – of the region (EPASA, 2011). Patara SEPA has one of the important coastal dune areas that are used for recreation especially touristic summer season (Avcı *et al.* 2015). This SEPA is an important nesting area for logger head turtle – nesting range 33-239 –, and even rare nesting of green turtle – 2-3 – was also encountered (Türkozan and Kaska 2010; Olgun *et al.* 2016). Some metrics of this SEPA are given in Table 1.

The sea turtle nests count and water quality monitoring programmes continue since 1989 and 2006 respectively (Türkozan and Kaska 2010; G. Ergün pers comm. 18 Oct. 2016). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.3 Kaş-Kekova SEPA

Kekova was determined and declared by the decree of Cabinet of Ministers number 90/77 and date 18.01.90. Afterwards, part of Kaş town was also circumscribed with the border change and approved by the Cabinet of Ministers number 2006/ 11266 and dated 8.11.06 as Kaş-Kekova SEPA. The decree was published in official gazette dated 9.12.06 and numbered 25371 (EPASA 2011). Some descriptors of this SEPA are given in Table 1.

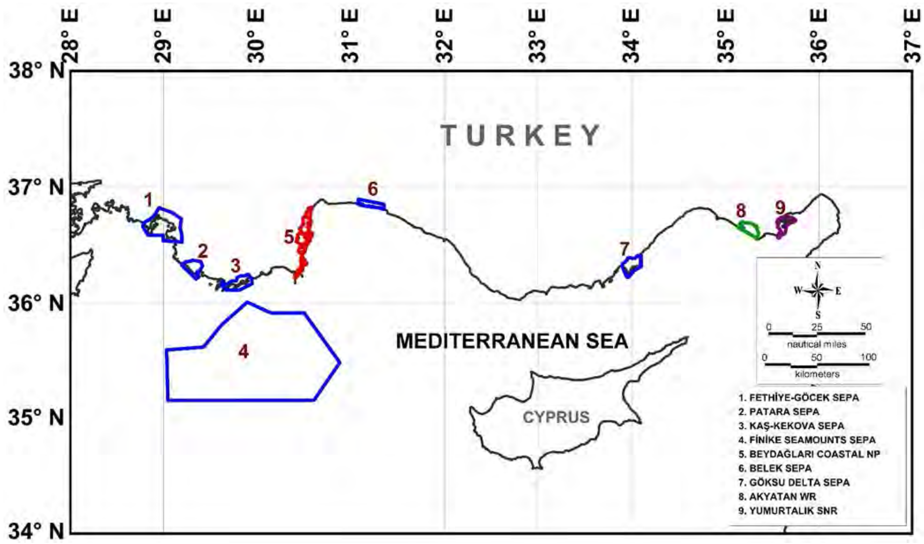

Figure 1. MCPAs of the Turkish Levantine coasts

In 2010, during marine vessel carrying capacity assessment (MVCCA), a total of 191 maco-animal species and 60 maco-plant species were identified in the Keova Channel. Among plants, facies were formed by 5 species and 2 orders. These species are *Cymodocea nodosa, Zostera marina, Posidonia oceanica*, *Halophila stipulacea* and *Penicillus capitatus*; one order includes 6 species belonging to Cystoseira genus and 10 of the Corallina species belong to the other order (Akçalı *et al.* 2013). After the foundation of the no fishing zones in 2012, three-year assessment on the fish populations revealed Epinephelinae and Sparidae species' populations recovering with varying degrees (Arda and Yokeş 2014). As it was carried for Fethiye SEPA, Sala et al. (2012) also assessed marine sites of Kaş-Kekova SEPA baring rocky reef ecosystems, and reported this MCPA was 26th in terms of fish biomass, and the 2nd with largest cover of bare rock (20%) – without any benthic organisms – among 32 Mediterranean MCPAs.

Table 1. The foundation years, IUCN categories and some metrics of MCPAs on Turkish Levantine coasts

	Foundation Year	IUCN Category	Coastal length (km)[11,12]	Total Area Coverage (ha)[5,8,9,11]	Marine area coverage (ha)[11,12]	No of NFZs as core zone[13]
Fethiye-Göcek SEPA	1988[1]	IV[10]	195.71	80,537.30	33887	2
Patara SEPA	1990[2]	IV[10]	22.87	19,710.60	4517	0
Kaş-Kekova SEPA	1990[3]	IV[10]	80.55	25,783.68	15762	5
Finike Seamount SEPA	2013[4]	IV[11]	0	1,124,173.00	1124173	0
Beydağları Coastal NP	1972[5]	II[10]	~91	31,018.00	0	0
Belek SEPA	1990[6]	IV[11]	26.62	11,179.14	0	0
Göksu Delta SEPA	1990[7]	IV[10]	35.16	22,850.11	9837	0
Akyatan WR	2005[8]	IV[12]	~21	15,291.10	0	0
Yumurtalık Lagoon SNR	1994[9]	Ia[12]	~33	16,979.94	?	1
TOTAL			**505.91**	**1347522.87**	**1,188,176+**	**8**

1) ÇŞB-TVKGM. (n.d) Fethiye -Göcek -Fethiye-Göcek Özel Çevre Koruma Bölgesi. Retrieved October 17,2016, from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=203
2) ÇŞB-TVKGM. (n.d) Patara - Patara Özel Çevre Koruma Bölgesi. Retrieved October 17,2016, from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=200
3) ÇŞB-TVKGM. (n.d) Kaş-Kekova - Kaş-Kekova Özel Çevre Koruma Bölgesi. Retrieved October 17,2016, from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=197
4) ÇŞB-TVKGM. (n.d) Finike Denizaltı Dağları Özel Çevre Koruma Bölgesi. Retrieved October 17,2016, from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=13564
5) OSB-DKMPGM (n.d.) Beydağları Sahil Milli Parkı. Retrieved October 17, 2015, from http://www.milliparklar.gov.tr/mp/beydaglari/index.htm
6) ÇŞB-TVKGM. (n.d) Belek - Belek Özel Çevre Koruma Bölgesi. Retrieved October 17,2016, from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=189
7) ÇŞB-TVKGM. (n.d) Göksu Deltası - Göksu Deltası Özel Çevre Koruma Bölgesi. Retrieved October 17,2016,from http://www.csb.gov.tr/gm/tabiat/index.php?Sayfa=sayfa&Tur=webmenu&Id=194
8) OSB-DKMPGM (n.d.) Yaban hayatı geliştirme sahaları. Retrieved October 17, 2015, from http://www.milliparklar.gov.tr/belge/yhgs.pdf
9) OSB-DKMPGM (n.d.) Tabiat koruma alanlarına ait liste. Retrieved October 17, 2015., from http://www.milliparklar.gov.tr/belge/tka.pdf
10) Kaboğlu et al. (2005); **11)** G. Ergün (pers. comm., 18 October 2016); **12)** İ. Uysal (pers. comm., 19 October 2016); **13)** Ministry of Food, Agriculture and Livestock (2016)

Table 2. The baseline studies and management of MCPAs on Turkish Levantine coasts

	Field office[1,2]	Baseline marine biodiversity study[1,2]	Baseline Socio-economic structure study[1,2]	Management Plan[1,2]	Business Plan[1,2]	Monitoring [1,2]	Surveillance[1,2]
Fethiye-Göcek SEPA	0	1	1	0	0	1	**
Patara SEPA	0	0	1	1"	0	1	**
Kaş-Kekova SEPA	0	1	1	1	0	1	*
Finike Seamount SEPA	0	0	0	0	0	0	*
Beydağları Coastal NP	1	0	0	1'	0	1	**
Belek SEPA	0	0	1	1"	0	1	**
Göksu Delta SEPA	0	0	1	1"	0	1	**
Akyatan WR	0	1	1	1"	0	1	**
Yumurtalık Lagoon SNR	0	1	0	1"	0	1	**
TOTAL	**1/9**	**4**	**6**	**7**	**0**	**8**	

": for only terrestrial and/or wetland part

': Long Term Development Plan exists

*: Surveillence in place under Coast Guard Command

**: Surveillence in place under Coast Guard Command and on the coast for the marine turtle nestings by the respective authority

1) G. Ergün (pers. comm., 19 October 2016)

2) İ. Uysal (pers. comm., 19 October 2016)

The indicator marine fish populations and water quality monitoring programme continue since 2002 and 2006 respectively (Arda and Yokeş, 2014, G. Ergün pers comm. 18 Oct. 2016). In 2010, for the MVCCA of the Kekova Channel, ecological components cover was calculated at 2,245 km^2 that comprises 42.4 % of the total coverage of reduction factors (Akçalı *et al.* 2013). Başak (2012) prepared an economic assessment of Kaş-Kekova Marine Protected Area's effects on the sustainability of local development. More information on the baseline studies and management of this SEPA are presented in Table 2.

3.4 Finike Seamounts SEPA

Prior to its establishment, the area was proposed as a High Seas MPA by Öztürk (2009) and later as the first SPAMI of Turkey (Öztürk *et al.* 2012). Eventually, the Cabinet Decree, which declares Finike seamounts (Aneximender seamounts) – is the first marine space without any land component as SEPA, entered into force on 16 August 2013 (Official Gazette no: 28737). Finike seamounts was declared as a SEPA due to its unique habitats hosting deep sea marine biodiversity, especially having mud volcanoes and methane cold seep (Öztürk *et al.* 2015, TVKGM, 2015). Some metrics of this SEPA are given in Table 1.

This SEPA engulfs Finike-Anaximander Sea mount complex comprising Anaxagoras (peak depth 920-930 m & base depth 1,510-1,520 m), Anaximander-Finike (peak depth 1,110-1,120 m & base depth 2,000-2,010 m) and Anaximenes (peak depth 690-700 m & base depth 1,500-1,510 m), Seamounts that are located between the Hellenic and Cyprus arcs (Öztürk *et al.* 2015). The marine species inventory studies identified several taxa, including chemosynthetic communities that were dominated by small- sized bivalves belonging to Mytilidae, Vesicomyidae, Thyasiridae and Lucinidae families (Olu-Le Roy *et al.* 2004). Siboglinid tubeworms (Lamellabrachia sp.), amphipods, brachyuran crabs, echinoid sea urchins, galatheid squat lobsters, were also observed (Öztürk *et al.* 2015). In addition, 8 fish, 4 deep sea shrimps and 1 cephalapod species were sampled from this SEPA (Öztürk *et al.* 2010). The density distribution of the swordfish during peak spawning period base on GAM predictions revealed that major spawning ground located near this SEPA (Tserpes *et al.* 2008). This SEPA is also an important sites for deep diving marine mammals including Cuvier's beaked whales (*Ziphius carvirostris*) and sperm whales (*Physeter macrocephalus*) (Woodside *et al.* 2006; Öztürk *et al.* 2013).

To date, neither monitoring programme nor management of the area is in place since its establishment (*see* Table 2.)

3.5 Beydağları Coastal NP

Although it is on the coast, Beydağları Coastal NP does not comprise any marine space. This NP has a significant value in terms of natural and historical assets. The ancient Phaselis City is located in this NP (DKMPGM, 2012). Due to tourism development in the area, the NP lost around 50% of its original size since its establishment in 1972. This development resulted in the loss of ecologically important areas particularly in coastline while changes in agricultural areas end up with abundance of the traditional lad use patterns (Atik *et al.* 2006). Some descriptors of this NP are given in Table 1.

As it was carried for Fethiye and Kaş-Kekova SEPAs, Sala *et al.* (2012) also assessed marine site Adrasan of Beydağları NP baring rocky reef ecosystems, and reported this MCPA was 24th in terms of fish biomass among 32 Mediterranean MCPAs. In addition, Çıralı beach is one of nesting area for logger head turtle – nesting range 23-96 –, in this NP (Tükozan and Kaska 2010). The latest monk seal presence was described in 2007 by Güçlüsoy *et al.* (2008) and Gücü *et al.* (2009). The latter authors identified 39 coastal caves among which 8 were placed with 11 camera-traps. As result 4 individuals – 2 adults and 2 juveniles – were identified. Üçadalar, Olympos and Adrasan were proposed to be protected strictly. The recent Cuvier's beaked whales (*Ziphius carvirostris*) encounters were also reported close to the coast of this NP (Baş *et al.* 2016).

The sea turtle nest count programme continues since 1994 (Türkozan and Kaska, 2010). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.6 Belek SEPA

The Cabinet Decree, declared Belek as SEPA in 1990 (Decree no. 90/1117, 22 Oct. 1990) (EPASA, 2011). Though it is on the coast, Belek SEPA does not engulf any marine terrain. It was declared mainly due to its coastal and dune areas, sea turtle nesting beaches and flora diversity. Some descriptors of this SEPA are given in Table 1.

The coastal habitat types observed were forest, stable sand dune area-scrubs, partially stable sand dune hills, moving sand dunes, seasonal wetland, permanent wetland and agriculture land. However, Belek SEPA's coastal dune areas are in use by tourist facilities and golf courses and facilities (Avcı *et al.* 2015). The bird inventory revealed 213 bird species (EPASA 2011). A total of 29.3 km long beach is hosting one of the most important sea turtle nesting grounds. Loggerhead turtle *C. caretta* nesting range between 69 and 819 while green turtle *Chelonia mydas* between 2 and 8 (Türkozan and Kaska, 2010).

The sea turtle nests count and water quality monitoring programmes continue since 1994 and 2006 respectively. (Türkozan and Kaska, 2010, G. Ergün pers comm. 18 Oct. 2016). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.7 Göksu Delta SEPA

Göksu Delta SEPA determined and founded by Decree of Cabinet of Ministers in 1990 (No. 90/77, 18 Jan. 1990) and it borders had changed once to reach its current limits in 2006 (Decree of Cabinet of Ministers No. 2006/11266, 08 Nov.2006). Göksu Delta was declared as a SEPA to protect natural assets of the region. *C. caretta* – nesting range 36-151 – and *C. mydas* – nesting range 3-20 – lay eggs on its beaches that are nourished by the dune areas. Moreover, the soft-shell Nile turtle *Trionyx triunguis* can also be encountered in its waters. The area is also a Ramsar wetland and is an important location on the route of many migratory birds (EPASA 2011; Türkozan and Kaska 2010; Avcı *et al.* 2015). Some metrics of this SEPA are given in Table 1.

The sea turtle nests count and water quality monitoring programmes continue since 1991 and 2006 respectively. (Türkozan and Kaska 2010; G. Ergün pers comm. 18 Oct. 2016). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.8 Akyatan Wildlife Refuge (WR)

Though it is coastal, Akyatan WR does not circumscribe any marine space. Akyatan lagoon was established as the Water Birds and Black Francolin Protection and Reproduction Field in 1986 under the Hunting Code (No. 3167). In 2005, Akyaka lagoon reached its final status as Wildlife Refuge. This area is also listed as one of the Ramsar sites and declared as 1st degree Natural SIT area in Turkey. One of the largest sand dune areas is between Akyatan lagoon and the sea side (DAD, 2013). This area is a major green turtle nesting site. A total of 1,335 nests of *C. mydas* and 21 *C. caretta* were recorded between 2006 and 2011. The main threats upon the turtles were predation of the eggs and hatchlings by jackals, plastic pollution and vehicle ruts that hindered the hatchlings progress to the sea (Yılmaz *et al.* 2015). The studies revealed that Akyaka lagoon is polluted at various degrees by total and faecal coliforms (Yetis and Selek, 2015), and even water quality parameters of the lagoon is affected by the freshwater influx by way of the constructed drainage channels which collect water from the catchment area and discharge it into the lagoon (Yetis *et al.* 2014). All of these ill developments may affect the coastal marine areas too.

For this WR, sea turtle nests count programme continues since 1991 (Türkozan and Kaska 2010). More information on the baseline studies and management of this SEPA are presented in Table 2.

3.9 Yumurtalık Lagoon SNR

Yumurtalık Lagoon was established as 1st degree Natural SIT area in 1993, a year later, in 1994, it received SNR status. The area is also designated as one of the Ramsar sites in 2005 (Erdem and Saraç 2007). The area received SNR status to protect the breeding ground of endangered green turtle *Chelonia mydas*, and one of the few locations of the Aleppo pine *Pinus halepensis* (Yılmaz 1998). In the study about the natural and cultivated plants of this SNR, a total of 186 genera and 234 species belonging to 65 families were identified: 223 of the 234 species are natural – three of these were endemic – and 11 are cultivated (Altınözlü 2004). Furthermore, the length-weight relationships of 33 marine fishes inhabiting littoral habitats off Yumurtalık coast were given by Gökçe *et al.* (2010). Though, it has important dune areas, this is not a major sea turtle nesting site (Türkozan and Kaska 2010; Yılmaz *et al.* 2015).

Yılmaz *et al.* (2003) proposed to merge and manage two protected areas Yumurtalık and Ayatan with an integrated model, and suggest that best model as the Specially Protected Areas of Mediterranean Importance (SPAMI). Some metrics, baseline figures and management activities of this SNR are given in Table 1 and 2.

4. Conclusion

It is worth noting that three of the coastal protected areas overviewed above had no marine terrain. In 2013, the first marine protected area – the Finike Seamount SEPA – only confined to marine space was established in the Turkish Levant Sea. As proposed by Güçlüsoy (2015), the drafted National Strategy of Marine and Coastal Protected Areas of Turkey (TVKGM 2014b) is still needed to be approved by the Ministry of Environment and Urbanization. In line with this Strategy, the marine area coverage of MCPAs should be increased from 4% to reach CBD's 10% target by 2020. In addition, proposed high sea marine protected areas (*e.g.* Öztürk 2009) in this sea need further attention of the riparian countries' officials. Finally, for the better management of SEPAs, management units should be operational to implement management plans confined to each MCPA. Kaş-Kekova SEPA is a good candidate to be upgraded as SPAMIs under Barcelona Convention.

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SEA TURTLES AND CONSERVATION OF THE TURKISH PART OF THE MEDITERRANEAN SEA

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1. General Remark

As a group, sea turtles represent an ancient and distinctive part of the world's biological diversity, they were common in the Cretaceous, 130 million years ago, and their fossil record extends back to at least 200 million years (Marquez 1990). The living sea turtles originated in the period from the early Eocene to the Pleistocene, between 60 and 110 million years ago. Seven species of sea turtles, grouped into two families, Dermochelyidae and Cheloniidae. Dermochelyidae has a single species, the leatherback (*Dermochelys coriacea,* Vandelli, 1761) and Cheloniidae contains six species in five genera, the green turtle (*Chelonia mydas*, Linnaeus, 1758), the loggerhead (*Caretta caretta,* Linnaeus, 1758), the hawksbill (*Eretmochelys imbricata,* Linnaeus, 1766), the Kemp's ridley (*Lepidochelys kempii,* Garman, 1880*),* the olive ridley (*Lepidochelys olivacea,* Eschscholtz, 1829), the flatback (*Natator depressus* Garman, 1880). The black turtle or East Pacific green turtle (*Chelonia agassizii*) is currently classed as belonging to *C. mydas (*Meylan and Meylan 1999). Sea turtles have many morphological adaptations for life in the sea and long migration. All species share features such as paddle-shaped limbs and glands, that is, modified to remove excess salts from body fluids, and shells (characterized by a reduced amount of bone). Whereas, there is some morphological differences between Dermochelyidae and Cheloniidae families. The family of Dermochelyidae is characterized by the extreme reduction of bones of the carapace and plastron. Shell has seven prominent longitudinal ridges, and there are no claws and shell scutes. Adults have smooth skin and very large body size. Carapace generally black, with variable degrees of white or paler spotting and plastron has generally light pigment (Pricthard 1997) (Figure 1a). The family of Cheloniidae has extensively roofed skull, and the shell has horny scutes that variable in numbers, and the claws being reduced to one or two on each limb. Straight carapace length (SCL) for the body size of adult is changed between 72 cm and 120 cm (Pricthard 1997) (Figure 1b).

Figure 1. The morphological differences between Dermochelyidae and Cheloniidae families

2. The life history of sea turtles

In general, the life history of sea turtle is similar in all species (Figure 2, see Miller 1997 for review). The migratory behavior of all species is migrating from foraging areas to mating areas, and then the males return to the foraging areas, but the females move to the nesting areas (Miller 1997). Female turtles mate in near-shore waters, and they lay eggs in nests dug on beaches. Egg number per clutch is change roughly 50-200 eggs, depending on the species. In general, the egg size of sea turtles is variable among the species, and egg diameter range 3.5 cm and 5.5 cm for *C. mydas* (Sönmez 2016). The females of most species appear to lay several clutches per nesting season at intervals of 9 -30 days. The female sea turtle usually do not reproduce every year (Miller 1997). Whereas, the male sea turtle may breed every year (Limpus 1993). Incubated time of sea turtle egg is about two months, and then hatchlings emerge after incubation period and enter an oceanic habitat where they may remain for several years until the juvenile period (Carr 1987). This early pelagic phase, originally referred to as the "lost year" by Carr (1986). Depending on the species and geographic area, sexual maturity is ranging 15 to 50 years or more (roughly 6 - 10 yr in *E. imbricata* and *L. kempii*, 15-20 in *C. caretta*, 20 50 in *C. mydas*) (Balazs 1982; Bjorndal and Zug 1995). The leatherbacks may grow to maturity much more quickly compared to other species (13 - 14 yr, Davenport 1997). The female sea turtles are assumed tend to renest the same beach. Under the "natal homing hypothesis", it is known that females faithfully return to the their natal beach to breed (Carr 1967).

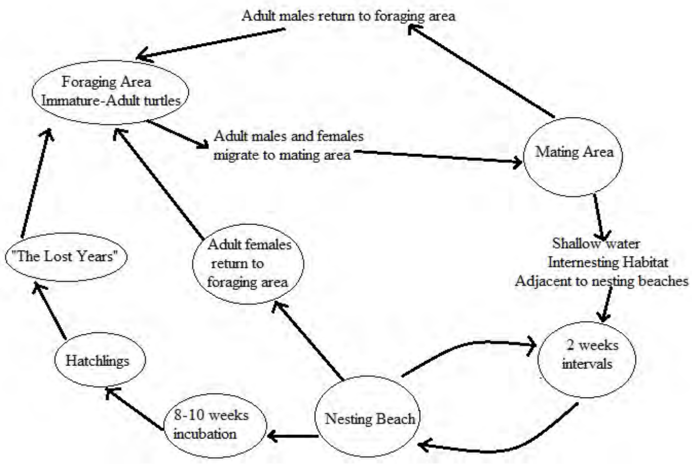

Figure 2. Generalized life cycle of sea turtles.

3. Distributions of Sea Turtle

Most species of sea turtles are distributed throughout tropical and subtropical waters on the world. The exception to this is the leatherback turtle, that is found from the North sea and Gulf of Alaska (Northern Hemisphere), to Chile and New Zeland (Southern Hemisphere) (Hamann *et al.* 2006). Unlike to the them, the flatback turtle is endemic to the Australian continental shelf (Northern Australia, the Gulf of Papua New Guinea and Southern Indonesia) (Meylan and Meylan 1999).

Five species of sea turtles were recorded on previous research in the Mediterranean (Baran and Kasparek 1989). These species *are C. caretta, C. mydas, E. imbricata, L. kempii, D. coriacea,* but only two of them have nesting on the Mediterranean beaches, that is, *C. mydas* and *C. caretta*. The record of *E. imbricata* and *L. kempii* in the Mediterranean basin is very limited. Laurent and Lescure (1991) reported that the seven records for the *E. imbricata* in the Mediterranean. Meylan and Donnelly (1999) reported that nesting beaches can occur on the beaches of Red Sea in the Egypt and Sudan. The report of *L. kempii* is very limited in the Mediterranean. The one captured sample was reported by Brongersma and Carr (1983) in the Mediterranean, off the island of Malta (central Mediterranean). Also, one individual was captured in a gill-net at Santa Pola, Alicante (Spain) (Tomas *et al.* 2003). There are large data about leatherback turtle on whole Mediterranean (Casale *et al.* 2003). Casale *et al.* (2003) stated that 411 individuals were recorded in the Mediterranean and 152 of these from Italy. Rees *et al.* (2004) reported a live leatherback turtle during a survey on the coast of Syria in the East Mediterranean, and Levy *et al.* (2005) reported a leatherback incidentally captured in a trawler just off the coast of Israel. Leatherback turtle has been observed periodically from Turkish coasts of the Mediterranean. Baran and Kasparek (1989) first documented record reported from Antalya in 1983. Oruç *et al.* (1996) stated a single dead leatherback turtle, in 1995, İskenderun Bay, Turkey. Another stranded record was reported from the Bozyazı, Mersin, Turkey (Taşkavak and Farkas 1998). Sönmez *et al.* (2008) stated that stranded leatherback turtle was found from İskenderun Bay, Turkey.

The other species, *C. mydas* and *C. caretta,* are occurring nesting beaches on coast of different country in the Mediterranean. The most important *C. caretta* nesting beaches in the Mediterranean are found Greece (Margaritouilis *et al.* 2003), Turkey (Baran and Kasparek 1989), Libya (Laurent *et al.* 1997) and Cyprus (Broderick *et al.* 2002). Furthermore, the other nesting beaches with lower density are found Tunisia, Syria and Israel (Kasparek *et al.* 2001). The most important *C. mydas* nesting beaches in the Mediterranean are situated in Turkey (Baran and Kasparek 1989, Yerli and Demirayak 1996) and Cyprus (Broderick *et al.* 2002). The *C. caretta* is globally categorized as Vulnerable (VU) on the IUCN red list, with the criteria of A2b (ver 3.1) and the current population trend is decreasing (Casale and Tucker 2015). Whereas, the Mediterranean sub-population of the *C. caretta* is categorized as Least Concern (LC) (ver 3.1) and the current population trend is increasing (Casale 2015). The *C. mydas* is globally categorized as Endangered using criteria A2bd (ver 3.1), but the Mediterranean subpopulation is listed as critically endangered (Hilton-Taylor 2000) based on criteria A1a, B1+2ce, E. Both the species are listed on Appendix 1 of CITES and, are protected under the Bern Convention.

4. Studies on the Turkish Part of Mediterranean Sea

The first study about sea turtles on Turkey coasts was published by Hathaway (1972), and he stated the high probability of *C. caretta* and *C. mydas* nesting in Turkey. Başoglu (1973) identified two *C. caretta* carapaces in the Izmir region and one in Koycegiz. Başoglu and Baran (1982) provided information on a *C. caretta* in the Ege University Museum collection. The more detailed survey on both species in the Mediterranean population were performed by Geldiay and Koray (1982) and Geldiay (1984). Later, Baran and Kasparek (1989) surveyed nesting activity of both species throughout Turkish coastline between Kuşadası (Aegean Region) and Samandağ (close to the Syrian border). In total, 2456 km was checked and they identified 17 important nesting beaches in this survey. Also, they classified thirteen of the nesting beaches as ''with a high density'' and four as ''with a lower density'. These nesting beaches from west to east in the Turkish coastline; Ekincik, Dalyan, Dalaman, Fethiye, Patara, Kumluca, Kale, Tekirova, Belek, Kızılot, Demirtaş, Gazipaşa, Anamur, Göksu Deltası, Kazanlı, Akyatan and Samandağ. An additional nesting beaches were recorded Ağyatan, Çıralı, Yumurtalık (Türkozan *et al.* 2003, Canbolat 2004), Alata (Aymak *et al.* 2005) and Kale (Hatay) (Yalçın Özdilek and Sönmez 2006) (Figure 3). The latest study performed by Turkozan and Kaska (2010) and they stated that Turkish coastline has 25 nesting beaches for both species. Of these beaches, including sporadic nesting beaches in the western Mediterranean, *C. mydas* nest on the 16 beaches in Turkish coastline. Some of these beaches are important for *C. mydas* (Alata, Kazanlı, Akyatan, Yumurtalık (Sugözü) and Samandağ).

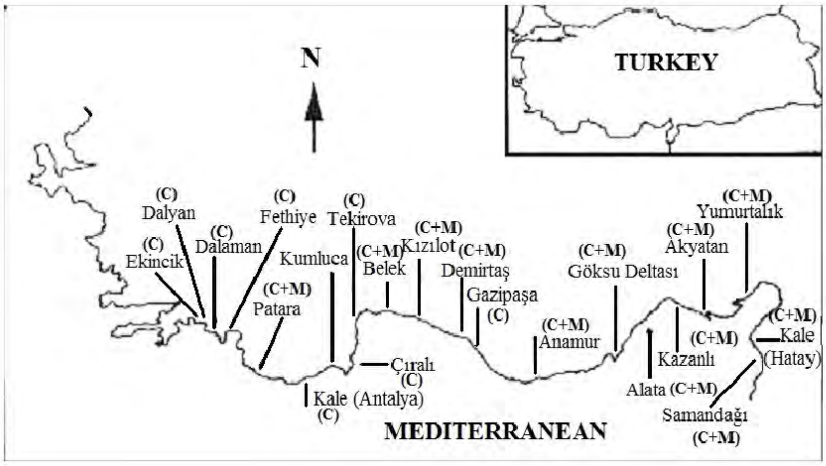

Figure 3. Nesting beaches of *C. caretta* and *C. mydas* in Turkish coastline (C: *Caretta caretta*, M: *Chelonia mydas*).

The nest number varies from species to species in Turkish coast. Margaritoulis *et al.* (2003) estimated that average annual number of *C. carretta* is 5031 nest/season in the whole Mediterranean basin, and of these nests occur 1366 nest/season in Turkish coast. *C. caretta* nests per season throughout Turkish coast was reported as 1267 by Türkozan *et al.* (2003). Similarly, Canbolat (2004) estimated 2000 nest/season. Kaska *et al.* (2005) estimated as 1360 - 2710 in the in Turkish coast. More recently, Türkozan and Kaska (2010) published a report on Turkey sea turtles and they estimated that annual number of *C. caretta* nest ranged from 769 to 3521 nests. There are estimates on number of *C. mydas* nest in the Mediteranean. Kasparek *et al.* (2001) estimated 350 - 1750 *C. mydas* nests and, Broderick *et al.* (2002) estimated 339-360 *C. mydas* nesting annually in the Mediterranean. In another report, annual nest number of *C. mydas* ranged 391 - 910, and the mean nest number is 648 for Turkish coast (Canbolat 2004). Kaska *et al.* (2005) estimated 700-1150 *C. mydas* nest in Turkish coast. More recently, Türkozan and Kaska (2010) published a report on Turkey sea turtles and they estimated that annual number of *C. mydas* nest ranged from 452 to 2051 nests.

The loggerhead colonies on Turkey coast are showing significant divergence of mtDNA haplotype frequencies (Laurent *et al.* 1998, Carreras *et al.* 2007). Yılmaz *et al.* (2008) showed that the loggerhead colonies on Turkey coast have the highest haplotype diversity than the other countries in Mediterranean. As a result of these findings, the loggerhead colonies in Turkey are important management units in the Mediterranean. Bağda *et al.* (2008) identified six haplotype in Turkey and Cyprus and three of them were new haplotype for green sea turtle. Green turtle in the Mediterranean has low mtDNA variation (Bağda *et al.* 2008). Also, they suggested that each nesting beach should be considered as a management unit due to rare mtDNA haplotype and various numbers of alleles at nDNA.

All the conservation based scientific studies are concentrated on the nesting beaches of sea turtle in Turkey. However, sea turtles use the marine coastal areas for foraging activities. In the Mediterranean the foraging habitats were described by Godley *et al.* (2002) and Türkecan and Yerli (2011) based on satellite tracking data. In Turkey, there is a big gap on the marine habitats of sea turtle. However, there are some records from non nesting areas of sea turtles such as Black Sea (Öztürk *et al.* 2011, Ak *et al.* 2016), Canakkale Strait (Akdeniz *et al.* 2012) and Northern Aegean (Panagopoulos *et al.* 2003). These studies are an evidence that Turkey coasts are used for foraging habitats by both *C. caretta* and *C. mydas*. To be recorded of sea turtle in non-nesting areas shouldn't be mean that sea turtle use solely the northern part of the Turkey coasts as a feeding habitat. Türkozan and Durmuş (2000) reported that western coast of Turkey may be feeding area for juvenile *C. mydas* based on stranded juvenile sea turtle. Sea turtle may also use the coasts near the nesting beaches with a strong probability. Yalçın Özdilek and Aureggi (2006) noticed on this subject at the Samandağ Coasts, which is one of the most important nesting beaches of green turtles in Mediterranean. Looking at the length distribution of stranding sea turtle (Turkozan *et al.* 2013) not only the Iskenderun Bay, but also coastal areas near the other nesting beaches is probably used for foraging area.

5. Threats of sea turtles in Turkey coasts

After the exploration of the nesting beaches of sea turtles in Turkish coast, sea turtle conservation activities were mainly focused on terrestrial ecosystems in the various beaches. These activities are mostly based on the problems faced by sea turtles nest and hatchlings. Site specific problems for every nesting beaches were analyzed by various scientists and conservationist. These problems can be discussed under two habitat categories; threats in the terrestrial habitats and threats in the marine habitats.

In the terrestrial habitats, the presence of human activities such as tourism or agriculture, secondary houses, lighting, driving, pollution, sand mining, beach erosion, predation are the main problems on the nesting beaches in Turkey. The presence of human activities such as agriculture is recorded as the main problem for Kazanlı nesting beaches (Kasparek *et al.* 2001). Big hotel complex and secondary houses are effect with artificial lighting, invaded in front of their complex with umbrellas and sunbed on the sea turtles nesting beaches in Samandağ. Big hotel complex also use heavy machine to the smooth and clean the beach (Figure 4). Human presence is mostly under the control at Dalyan and Patara beach, because public access is forbidden at nights.

Figure 4. Using the heavy machine as a result of the rehabilitation of the beach (Samandağ).

Solid waste pollution is the most important problem in the eastern beaches of Turkey. Özdilek *et al.* (2006) recorded 1251 grams per square meter of solid waste on Samandağ beach in 2006. This problem on the beach negatively affects *C. mydas* hatchlings trying to reach the sea (Özdilek *et al.* 2006). The yearly monitoring studies indicate that despite collection of solid waste from the beach it becomes polluted again within a short time (Sönmez 2015). The another Akyatan beach is suffering from the same problem (Türkozan and Kaska 2010). Marine debris washes ashore at Akyatan beach (Kasparek *et al.* 2001). Kasparek *et al.* (2001) stated that solid wastes, including plastic materials have been found in delta area on Göksu Rivers. Chemical pollution is maybe more important for sea turtles in the marine area of Kazanli beach. Following of accidental discharge from the factory, chemical waste occurred in marine area, in 2001, over the 30 *C. caretta* stranded on Kazanlı beach (Aureggi 2001). The solid debris, oil and tar and organochlorine residues have been investigated within the Mediterranean region (Gramentz 1988). However, heavy metal researches on sea turtles in Turkey are limited. Kaska and Furness (2001) investigated heavy metal contaminants in eggshells, yolk and embryonic livers of loggerhead turtles from Turkey. Moreover, heavy metal contaminants have been investigated on stranded turtle (Kaska *et al.* 2004) and their nesting environment (Çelik *et al.* 2006) from Turkey.

Sand mining and beach erosion are important for nest of sea turtles. Kasparek *et al.* (2001) found that the greatest conservation problem at Samandağ beach is illegal sand extraction from the nesting beach, and beach erosion causes a land loss between 3 and 14 meters annually. Previous studies showed that Samandağ beach has been negatively affected by sea water as a result of its exposure to continuous flooding (Sönmez and Yalçın Özdilek 2013, Sönmez *et al.* 2013). Sönmez and Yalçın Özdilek (2013) stated that nests closer to sea were at higher risk of tidal inundation on

Samandağ beach, which means the distance to mean 20 m from sea. Kasparek *et al.* (2001) reported that large part of sand dunes, especially next to Akgöl in Göksu Delta has been lost due to sand extraction. Similarly, beach erosion on Kazanlı was reported by Kasparek *et al.* (2001) and they stated that K3 subsection was mostly affected. The effective conservation plan for the sea turtles nests that under the risk of beach erosion or tidal inundation are relocated or hatchery (Türkozan and Yılmaz 2007, Sönmez *et al.* 2011, Sönmez and Yalçın Özdilek 2013). However; hatcheries should be considered as a last option (Mortimer 1999). Since there are potential negative effects of hatcheries such as sex ratio alteration (Godfrey and Mrosovsky 1999) or reduction of hatching success relative to natural nests (Limpus *et al.* 1979). Sönmez *et al.* (2011) and Türkozan and Yılmaz (2007) stated that relocating of nests is effect morphological differences on turtles. Furthermore, nest relocation over long term may distort gene pools (Mrosovsky 2006). Other publications have suggested that increasing hatchling success, either with nest conservation and/or nest relocation, can have positive impacts on population (Dutton *et al.* 2005). If the same conditions in a new nest area are ensured, it can show similar hatching success. And also, artificial nests do not affect the hatching success if it is done before attachment of the yolk sac membrane to the shell within 24 h after egg deposition (Limpus *et al.* 1979). This proves that the handling of eggs during relocation does not affect the hatching success within 24 h after egg deposition. This conservation activity was used on different beaches in Turkish coastline (Başkale and Kaska 2005, Türkozan and Yılmaz 2007, Ilgaz *et al.* 2011, Sönmez *et al.* 2011, Sönmez and Yalçın Özdilek 2013).

The many studies stated that eggs, hatchling and adult sea turtles have been exposed to predation by various organisms on the nesting beach. The best known of them are jackals, foxes, crabs, birds, and they are very common on nesting beaches in Turkey. Türkozan (2000) reported that *C. caretta* eggs were destroyed by fox and jackal in Fethiye and Kızılot beaches. On Akayatan beach, 66 % of the total number of eggs was predated by golden jackal during 2006 nesting season (Türkozan *et al.* 2006). Peters and Verhoeven (1992) stated that jackals have more impact on hatchling survival than on nest. Similarly, 32 % of hatchlings was predated by foxes, and 60 % of hatchlings was predated by crabs, and 0.8 % of hatchlings was predated by birds in three seasons at the Dalyan beach (Türkozan and Kaska 2010). On Patara beach, during two seasons, of the predated hatchlings, 13 % was predated by foxes, 82 % by crabs (Türkozan and Kaska 2010). Brown and Macdonald (1995) reported that 64% of *C. mydas* nest was predated by wild canids on Akyatan beach. On same beach, during 1995 nesting season, 24 % of *C. mydas* nest was predated by wild canids as well (Aureggi *et al.* 1999). In last seven years, Jackal perdation is very important for hatching success on Samandağ beach, and nest that predated by jackal is ranging 2 % and 11 % for *C. mydas* (Sönmez 2015). Predation is not limited with hatchlings and eggs. There is some report about jackals killed adult female sea turtles. Van Piggelen (1991) was reported that four *C. caretta* females were killed by jackals. Similarly, two adult *C. mydas* female was killed by jackals on Göksu Delta (Akçınar *et al.* 2006). In last 5 years, one *C. mydas* female was killed by jackals on Samandağ beach (Yalçın-Özdilek *et al.* 2015). To reduce the effects of predation, metal grids (72 × 72 cm, with a 9-cm wire meshes) can place above the nest at a depth of 20 cm from the surface. This method can increase to hatching success rate on beach (Başkale and Kaska 2005, Sönmez 2015).The another recorded predation is invertebrata infestation on the nesting beach. On Kızılot beach, Türkozan *et al.* (2003) reported that 18 % predated eggs were infested by coleopteran larvae. Similarly, Baran *et al.* (2001) investigated damage caused by some invertebrates to the eggs and hatchlings of *C. caretta* during 1999 and 2000 on Fethiye beach, and they stated that almost 50% of nests contained tenebrionid larvae. At the same beach, Özdemir *et al.* (2004) reported that invertebrate (i.e.*Pimelia sp*., *Musca sp.* and acarids) were determined as infesting the *C. caretta* turtle nests on Fethiye Beach in 2001.

The most important aspect that threatens sea turtle populations at the marine habitat is fishery activities (Taşkavak and Gürkan 2015). There is limited research about marine habitat in Turkey. The sea turtles in the marine habitat are faced by bycatch and intentional killing. Oruç *et al.* (1996) reported that a total of 160 *C. mydas* and 26 *C. caretta* were captured between Mersin and Samandağ marine area in 1996 trawling season. One year later in the same area, a total of 306 *C. mydas* and 112 *C. caretta* were captured (Oruç 2001). The exclusion of sea turtles on the prawn trawls was tested by Atabey and Taşkavak (2001) in the eastern Mediterranean, Turkey. They stated that Turtle Excluder Devices (TEDs) have positive effect on out off sea turtles in the trawl. There are reports killing of adult sea turtles by fisherman (Yerli and Demirayak 1996). Also, Türkozan and Durmuş (2000) reported that 9 juvenile C. *mydas* were recorded during 6 year survey on the Fethiye beach. A total 27 injured sea turtles (22 *C.caretta* and 5 *C. mydas*) were stranded between 2009 and 2015 nesting season at Samandağ beach. Except two of them all injured sea turtles have skull fractures (Sönmez 2015). This adverse condition may be an evidence that man intended to kill sea turtles. Similarly, a total of 155 injured sea turtles were brought to sea turtle research rescue and rehabilitation center (DEKAMER) at Dalyan beach, Muğla. Cause of injures of them is propeller cuts from boats, fishing line cuts, fishing hook ingestion, speed boat crash, gun shot wounds (Dekamer 2015). Türkozan *et al.* (2013) reported that a total of 276 stranded dead turtles were found throughout eastern Mediterranean in Turkey coast. Of these, 142 were *C. caretta* and 126 were *C. mydas* and 6 were unidentified. Similarly, Yalçın Özdilek and Aureggi (2006) reported that 22 *C. mydas* were stranded at Samandağ beach during 2002 nesting season. There is need to more research in the marine habitat. Especially, knowing of interaction on fisheries activity and sea turtles can provide information on real size of mortality rate and injured turtles. By this way, it can be obtained information about wintering and foraging area in the Turkish coast of Mediterranean. These results could supported by satellite tracking. Türkecan and Yerli (2011) deployed 2 satellite transmitters on *C. mydas* for determine the post- nesting migration routes and the foraging grounds of green turtles nesting at Akyatan Beach. One of them stayed Antalya and the another in Gulf of Sidra. Similar research in Mediterranean was performed by Godley *et al.* (2002), Broderick *et al.* (2007) and Rees *et al.* (2008). There is more need satellite tracking research in Turkish coast of Mediterranean.

In the last 41 years, sea temperature in the Mediterranean has shown increased due to global climate change, and the increase of the temperature effects on the biodiversity in the Turkish marine waters (Turan *et al.* 2016). Because sea turtles use both marine and terrestrial habitats during their life cycles, global climate change is very important in sea turtles. The effects of climate change are likely to have a destructive effect on sea turtles such as shifts in nesting phenology, leading to trophic mismatch, increases in nesting beach temperature, incubation success, inundation of nesting beach habitat, increased disease transmission and changes in migration behaviour (Kaska *et al.* 1998, Chaloupka *et al.* 2008, Sönmez and Yalçın Özdilek 2013). Because sea turtles are show temperature-dependent sex (TDS), the temperature of incubation during the middle third of embryonic development determines the sex of hatchlings. Due to global climate change, high temperature is produce females hatchlings (Kaska *et al.* 1998), and long term survival depends on female and male hatchlings production. There are researches on how the effect of climate change on sex ratio of hatchlings for both species in Turkish coast (Kaska *et al.* 1998, Öz *et al.* 2004, Kılıç and Candan 2014, Yalçın Özdilek *et al.* 2016). The results of these researches have shown a female biased sex ratio for both species on Turkish coasts. The other effects of global climate change should be investigated, and real effects of climate change on sea turtle can revealed for both species in Turkish coasts.

6. Policy and management of sea turtles in Turkey

The Republic of Turkey has legislation for conservation of sea turtles, and Directorate of Nature Conservation and National Parks of Ministry Forest and Water Affairs has responsibility for sea turtles. They have been funding projects every year for sea turtle monitoring and conservation program for all sea turtle nesting beaches in Turkey. The funding of projects should be not annually. The effective monitoring and protection depends on long term studies. This positive approach is important for sea turtles protections. In Turkey waters, 1380th Water Products Circular regarding the law on water products and, thus the collecting and hunting of sea turtles is forbidden. Moreover, 3621st Coastal Law, 2873rd National Park Law, 2872nd Environment Law and 2863rd Law of Protection of Nature and Culture Beauties have been serving sea turtle protection in Turkey. As well as National Laws, Turkey has been part of international conventions such as the Paris Declaration (since 1983), Bern Convention (since 1984), Barcelona Convention (since 1988), Rio Convention (since 1996) and CITES (since 1996). All sea turtles nesting beach have been declared as "sea turtle nesting beach" by Ministry Forest and Water Affairs. On the other hand, some nesting beach was protected under the "Specially Protected Area" (some part of Dalyan beach, some part of Dalaman beach, Belek, Göksu Delta, Patara and Fethiye beaches). Also, some part of Dalyan, Dalaman, Belek, Kale, Gazipaşa, Anamur, Akyatan beaches and whole Çıralı, Alata and Kazanlı under the natural SIT status. Moreover, Göksu Delta and Akayatan are a Ramsar area. There is no protection status for Samandağ, Kumluca, Tekirova and Kızılot beaches. It should be not forgotten that knowledge is protect to nature that is not laws.

Non-Governmental Organizations (NGO) have an important role in studies of protection of sea turtles. WWF-Turkey is supporting many sea turtle projects in Turkish coasts, and have supported in the past. They are studying for better protection and effective management of sea turtle nesting beaches in Turkey. They have carried out important studies such as “Sea Turtle Nesting Site Evaluation” in Turkish coasts, 2003 and 2013, “First National Sea Turtle Symposium” in Turkey, and “Sea Turtle Handling Guidebook for Fishermen”. Also, they are still supporting monitoring program at Akyatan and Çıralı beaches. The another NGO is EKAD, and they have carried out protection and research program on several beaches such as Belek beach in Turkey. Society for Environmental Protection and Tourism of Samandağ have been supporting sea turtle monitoring and conservation program on Samandağ beach.

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**COASTAL ZONE MANAGEMENT OF
THE TURKISH PART OF THE MEDITERRANEAN SEA**

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Introduction

Coastal areas have been the most desirable areas throughout the history by means of their natural, social, cultural and economic potentials. As a result of this, industrialization, trade and population growth have been emerged at those areas. Those problems triggered the destruction of coastal areas over time and the loss of biodiversity, the reduction of coastal resources and pollution at the same time. The increasing pressure on the coastal areas and the potential danger which have started to be faced, have required the long-term measures in a systematic and sustainable way. Although, various policies have been developed to prevent these damage of the coastal areas, Coastal Zone Management (CZM) has been emerged as the main tool to protect coastal areas.

Coastal Zone Management a process which has struggled the environmental pollution at the coastal areas. However, this process has evolved another concept 'Integrated Coastal Zone Management' (ICZM) which is more comprehensive, dynamic and multidisciplinary. "Sustainability" has been indicated as of a primary purpose. The planning and the management of the coasts are considered as a dynamic and versatile process by ICZM.

As a geography, the Mediterranean basin, where natural beauty, history and cultures coexist, has natural reserves that rarely found in the world's coastal ecosystems. Due to the fact that the Mediterranean Region has been the centre of civilization for many years, has caused environmental degradation in the area especially coastal zones. The irreversible damages have emerged as pollution, the loss of biological diversity, especially forests and wetlands, scarcity of water resources, waste and erosion at the coastal zone of the Mediterranean Region. The issues caused the potential danger of losing the natural values has indicated that a long-term approach 'Integrated Coastal Zone Management' should be adopted to overcome the harms caused by dense usage of the coastal areas (Prem 2002:26).

The countries bordering the Mediterranean Sea, have taken an action to prevent further harm and attempted to preserve the coastal era. Therefore, Barcelona

Convention have been adopted for the management of integrated coastal areas in the Mediterranean. The protection of the Mediterranean and the sustainability of coastal areas of the era have been the issues that attached as priorities by United Nations Environment Programme (UNEP) since Mediterranean Action Plan (1975). Following this, the last protocol of the Barcelona Convention 'Integrated Coastal Zone Management in the Mediterranean' was adopted by the Council On 13 September 2010 and decision to ratify the Protocol on Integrated Coastal Zone Management to the Barcelona Convention (Council Decision 2010/631/EU).

1. The Conception of Coastal Area in Turkey

Coastal areas are the most variable units among the various kinds of areas on earth. The coast area is a vital and highly dynamic environment and a unique environment in which atmosphere, hydrosphere and lithosphere contact with each other (Dellepiane *et al.* 2004; Alesheikh *et al.* 2004:1461). Turkish coastline's length including the islands is 8,333 kilometres, of which 1,067 kilometres are island shores respectively. Also, the country has a long coastline surrounded by the Mediterranean 1707 kilometres (%20.5), Aegean Sea 3484 kilometres (%41.8), the Black Sea 1701 kilometres (%20.4) and the Sea of Marmara 1441 kilometres (%17.3) (Günay 1987).

1.1 General Terms About Coastal Zones in Turkey

According to the Directives of Practice relating to the 1992 Coastal Law Turkey;
Coastal Line: Since this line is separating sea and land changes based on meteorological events, determination of this line in a concrete manner depends on making a choice between different water levels.

Coast Edge Line: This indicates the border of the coast in the direction of the land.
Coast: This is the area between the coastal line and the coast edge line.

In terms of the Constitution Law (43th Article) "Coastal area is under the control and disposal of the State". Coastal areas are mandatory to be used for the benefit of public which are open for the equal and free use of everyone (Republic of Turkey, Ministry of Environment and Urbanisation).

1.2. The Problems of Coastal Zones in Turkey

Turkey is a country which surrounded by the sea on three sides. On the other hand, Turkey has a long coastline that are preferred by various sectors due to natural beauty, cultural and historical values. The coasts especially in our country offer suitable environment for human actions. However, this actions may cause environmental problems and irreversible damages to coastal areas. The problems of coastal areas in Turkey can be listed as follows;

- Unplanned urbanization because of rapid construction and irregular settlements,
- Land invasion through uncontrolled growth in coastal zones,
- Construction of residential buildings or roads by creating new land from ocean, riverbeds, or lake beds (reclamation),
- The lack of technical and social infrastructure on coastal.
-

The problems which have been occurring on coastal have damaged the public interest severely. Considering the economic opportunities and natural resources they offer; an effective action is needed to maintain and restore the coastal areas. The answer to design, protect and manage the coastal areas "Integrated Coastal Zone Management".

2. Integrated Coastal Zone Management

As Post and Lundin (1996:1) indicated "ICZM is a process of governance and consists of the legal and institutional framework necessary to ensure that development and management plans for coastal zones are integrated with environmental (including social) goals and are made with the participation of those affected. The purpose of ICZM is to maximize the benefits provided by the coastal zone and to minimize the conflicts and harmful effects of activities upon each other, on resources and on the environment". In other words, Integrated Coastal Zone Management is a holistic approach that allows coastal areas to be used in a balanced, long-term and an effective manner as well as to prevent coastal degradation and sustainable use on coastal areas. The aim of the Integrated Coastal Zone Management is to form a continuous and preventive management process, which is achieved through harmonization of public and local groups for sustainable development as considering that coastal areas are sensitive ecosystems.

Coastal Zone Management has been launched in the USA as "Coastal Zone Management Act of 1972". After that, "The Mediterranean Action Plan" signed 1976 has ensured the concept of coastal management in the Mediterranean Countries. However, the notion has gained a new dimension with the Rio Summit at 1992. The adaptation of the concept of 'Integrated Coastal Zone Management' as a tool for protecting coastal areas and achieving sustainable development in the 1992 United Nations Conference on Environment and Development (Rio Summit) has been a milestone globally. ICZM has been defined by European Commission at 1996 as 'Integrated Coastal Zone Management (ICZM) is a dynamic, multi-disciplinary and iterative process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICZM uses the informed participation and co-operation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICZM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics. "Integrated" in ICZM refers to the integration of objectives and also to the integration of the many instruments needed to meet these objectives. It means integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space' (European Commission, 2000:25).

2.1. Coastal Zone Management in the Mediterranean

The Mediterranean is a characteristic basin which is being home to various civilizations throughout the history. This is because it is a region where conflicts and trade relations have been developing between diverse cultures and civilizations. The region has strengthened its strategic importance along with improvements in transportation and communication. Also, The Mediterranean Basin has been the cradle of world's greatest civilizations such as Egypt, Greece, Rome, Arab and Ottoman. Likewise, the religions; Judaism, Christianity and Islam, have also developed in this region (UN,2013). Currently, there are 24 Mediterranean countries are those that surround the Mediterranean Sea; Albania, Bosnia and Herzegovina, Gibraltar (United Kingdom), Algeria, Morocco, Palestine, France, Croatia, Spain, Israel, Italy, Montenegro, Southern Cyprus, Lebanon, Libya, Malta, Egypt, Monaco, Slovenia, Syria, Tunisia, Turkey, The TRNC (Turkish Republic of Northern Cyprus) and Greece[1].

Since the Mediterranean Region has been the centre of civilizations for many years, it caused the activities which has detrimental effects to coastal areas. The pressure created by these activities on natural sources and the problem of the insufficient coastal area has affected the distribution of economic activities and settlements on the region. Along with the increasing urbanization in coastal areas, environmental degradation has been occurring and the quality of life decreasing. Furthermore, the increasing number of tourist arrivals to the area has been worsening the present situation. Rising water consumption has reached the maximum level between eastern and southern countries. Also, the problems such as pollution, the loss of biological diversity, (especially habitats, forests and wetlands), erosion and waste have been indicating the need for a new approach to reduce the environmental degradation which is "Integrated Coastal Zone Management".

[1] Palestine, TRNC and Gibraltar are not party to Barcelona Convention in accordance with United Nation (UN) rules.

The environmental problems and the threats to environmental security that have taken place in the Mediterranean Basin have fostered the states of the region to cooperate prompted them to form a legal basis for Integrated Coastal Zone Management in the Mediterranean. In June 1972, the United Nations Conference on the Human Environment was held in Stockholm and as a result of the conference The United Nations Environment Programme (UNEP) was founded. On the work of its first session was held June 1973 the Regional Seas Programme launched in 1974 as one of UNEP's most significant achievement in the past 35 years (UNEP,1973). The Mediterranean became the first region to adapt an Action Plan (MAP) in Barcelona in 1975 as a regional arrangement to deal with common problems of marine pollution. After one year, in 1976, coastal states of the Mediterranean Region were convened by UNEP again in Barcelona for the protection of Mediterranean Sea. Three associated protocols were adopted at the conference; (1) 'the Convention for the Protection of the Mediterranean Sea Against Pollution', (2) 'the Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (Dumping Protocol)', (3) 'the Protocol concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency (Emergency Protocol)' (Algan, 1998:38). The general aims of Regional Seas Programme to deal with the world's oceans and coastal areas degradation thanks to the sustainable management by the joint and comprehensive actions of shared marine environment countries. It is also observed that the focal point is to control of marine pollution as well as integrated planning and management of natural sources in the area.

After the United Nations Conference on Environment and Development which was held in Rio de Janerio, Brazil, 3 to 14 June 1992, the countries that are parties to the Mediterranean Action Plan have decided to implement their activities in line with Rio documents. The report of the first meeting of the working group of experts on the preparation of an Agenda 21 for the Mediterranean "MED 21" was launched in Tunisia, 1994 (Algan, 1997:42). In MED 21, Mediterranean Basin is seen as the pattern for an "ecoregion" likely to be a pilot area for a re-reading at regional level of the decisions reached at the Earth Summit'. Also, it can be observed that sustainable development requirements and the significance of the protection of Mediterranean Sea were underlined in the document (MED 21,1994).

The Convention for Protection of the Mediterranean Sea against Pollution (simply Barcelona Convention) signed in Barcelona on 16 February 1976, was last amended in 1995 to include coastal areas as well as the marine environment. Besides, the sustainable development, increased public participation and environmental impact assessment were integrated into the Convention and its Protocols. Also, its mandate has been widened to include planning and the integrated management of the coastal region (Barcelona Convention,1995). In the 9th ordinary session of the member states held in Barcelona in 1995, Rio Principles was revised and "Integrated Coastal Zone

Management" has been recommended as a methodological tool to manage and develop the marine environment in the Mediterranean. The convention was renamed as "The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean" and entered force on 9 June,2004. Turkey has become a Party to the Convention in 2002 (MFA,2011).

2.1.1. Mediterranean Commission on Sustainable Development (MSCD)

The creation of the "Mediterranean Commission on Sustainable Development (MCSD)" in 1995 as an advisory body to the MAP was one of the most significant steps during this process. The main purpose of the MCSD is to provide a bridge between the desire to pursue sustainable development and its effective implementation (IUCN,2012). Also, the commission has an importance because of being the first working group to focus on coastal zone management and making recommendations on the sustainable management of coastal zones.

2.1.2. Mediterranean Environmental Technical Assistance Programme (METAP)

Another important programme for the Integrated Coastal Zone Management in the Mediterranean is the "Mediterranean Environmental Technical Assistance Programme" (METAP) (Chakrapani,2006). The programme was initiated by the World Bank and the European Investment Bank (EIB) in 1990. It was an informal partnership between four donor partners (European Union, European Investment Bank, United Nations and World Bank) and fourteen countries bordering the Mediterranean Sea. Reducing environmental degradation was aimed in the coastal countries (Those beneficiary countries are at present Albania, Algeria, Bosnia-Herzegovina, Croatia, Egypt, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, Turkey, and West Bank and Gaza[2]) (Ennabli; Whitford, 2005:1). by providing technical and financial assistance (TA) for two purposes: (a) to generate investments by providing project preparation support in selected environmental areas, and (b) to build capacity at the national and regional levels. The general objectives of the programme; strengthening the institutional capacity needed to overcome environmental problems, accelerating the environmental activities in the region and formulating a series of key policies which is affecting Mediterranean environment (Bennet, 2002:66). One of the Project of METAP in Turkey is Belek Beach. Apart from this, the programme has provided a technical and financial support for some projects in Turkey such as solid waste management, coastal zone management and strengthening of the Ministry of Environment as institutionally (Sain,2002).

[2] Cyprus and Slovenia ceased to be active beneficiaries upon joining the EU in May 2004. Malta was a beneficiary only in METAP I.

2.1.3 Priority Actions Programme/Regional Activity Centre (PAP/RAC)

The Priority Action Programme Activity Centre (PAP/RAC), which constitutes the most significant key component of the Mediterranean Action Plan and a part of the United Nations Environment Programme (UNEP) was established in 1977. PAP, is located in a roman city which is one of the UNESCO heritage sites Split, Crotia.

Integrated Coastal Zone Management in the Mediterranean is the main activity of PAP/RAC. The Integrated Coastal Zone Management is described by PAP as follows (Priority Action Programme,1997);

- A management process which is tailored the needs and conditions of the coastal areas,
- Comprehensive,
- Based on rational approach and scientific evidence,
- Interdisciplinary,
- Providing suitable conditions for sustainable development

Also, the programme has been supporting the activities of Mediterranean Commission on Sustainable Development (MSCD). The Priority Action Program Activity is a Mediterranean Action Plan centre which is under the control of MED-UNIT and the responsible for the coordination Coastal Areas Management Programme (CAMP). The Coastal Areas Management Programme (CAMP) was approved at the 6th Ordinary Meeting of the Contracting Parties of the Barcelona Convention in 1989. The programme has been beginning with the pilot projects implemented by the PAP/RAC in 1989-1989. Since 1980, PAP/RAC has been forcing Integrated Coastal Zone Management as a major tool to implement sustainable development in the Mediterranean. Coastal Area Management Programmes (CAMPS) was initiated most effective ways to develop sustainable development methodologies in local level.

PAP/RAC is a programme in which Mediterranean Countries may share their practical activities and experiences at the technical level and also the programme may create a field for appropriate cooperation. The aim of the programme is to provide an assistance to the Mediterranean Countries for implementation of Article 4(i) of the Barcelona Convention. Recently, there is another task of the programme which is supporting to be implemented of the “ICZM Protocol of the Mediterranean” (Prem,2009:261). The protocol on Integrated Coastal Zone Management (ICZM) was signed in Madrid on 21 January 2008 at the Conference of the Plenipotentiaries on the Integrated Coastal Zone Management Protocol. 14 Contracting Parties to the Barcelona Convention signed the Protocol at the Conference. However, Turkey has not yet become a party to the Convention (European Union,2012).

2.2. The Coastal Zone Management in the Turkish Part of the Mediterranean

It can be said that a new tendency has begun with the 1992 Rio Summit in Turkey. It also not be wrong to say that after Agenda 21 the coastal area management has begun to adapt in international field. So, the effects of Agenda 21 and Rio have showed themselves in the coastal management programs of Turkey directly or indirectly. The legal framework and institutional arrangements for ICZM in Turkey have not been established yet however some studies have been conducted. Nevertheless, the level of institutional organization related to ICZM and the quantity of relevant experts involved in these studies are rather limited. As stated previously, the decisions of using coastal areas in Turkey have been taken by the central government and the government is the responsible for making decisions about establishing and operating in the coastal. In this centralized structure, the financial sources, the authorities and the capacities of local governments are very limited.

The management and planning of integrated coastal areas approach has been tried to apply in Turkey as spreading faster all over the world. İzmit Bay (Kocaeli-Yalova), İskenderun Bay and Samsun Integrated Planning and Management Projects of Coastal Areas have been produced in various regions in Turkey. Similar works have been carrying out in İzmir, Artvin and Rize. In this section, the projects of Integrated Coastal Zone Managements in the Mediterranean will be discussed.

2.2.1. Izmir Bay Coastal Zone Management

The first management programme for a specific coastal zone in Turkey is the "İzmir Bay Coastal Zone Management". The features of programme have followed the coastal zone management principles of 1992 Rio Conference. Also, the programme has been planned to finish by 1993 as the first field study of Mediterranean Action Plan. The project which is also supported by the Metropolitan Municipality of Izmir had two objectives; (1) addressing the environmental issues affecting İzmir Bay (2) implementation of ICZM in the region. Geographical Information System (GIS) and educational studies were carried out while the implementation of ICZM in İzmir. Local authorities have been strengthened for the activities and educated people have been involved to the projects. Solid waste treatment has been included in to the programme to reduce pollution in the İzmir Bay. Observation and pollution control, projects for reducing climate change risks, the inclusion of geographic information systems in urban planning and development programmes and so forth were carried out in İzmir within the scope of Mediterranean Action Plan. A Report on the evaluation of the results of METAP and PAP projects has indicated that studies carried out in İzmir Bay were successful in some areas however could be considered as unsuccessful in others such as the lack of public participation in coastal management practices, the problems of slums, the financial problems in local governments (Trumbic,1997:43).

2.2.2 Antalya Integrated Coastal Zone Management Project

The project has been prepared as a pilot and a pioneer project. It covers nearly 600 km. length coastal band which is the lengthiest coastal zone management plan in Turkey. The strategies of the plan are determined as follows; coordination between the institutions which are the authority to plan and prepare the models should be developed, participation of all partners and people should be provided, the areas which are in public use should be protected, natural and cultural resources and values of coastal zone should be preserved.

Belek and Çıralı have been selected for Antalya Coastal Zone Management Project. The Coastal Zone Management and Tourism Project at Belek and Çıralı remains one of the most important coastal tourism management projects started after 1990 in Turkey. One key aspect of this project is that it did not remained at the academic or planning level, but reached its implementation to quite some extend. From this point of view the studies carried out in Cirali are far ahead of other coastal zone management programs in the country (Coastlearn).

a. The Program of Belek Coastal Management

The project has been supported by World Bank as a part of a program “Mediterranean Environmental Technical Programme (METAP)”. In the area, implementation of Integrated Coastal Zone Management was aimed however, participation of private sector and public cooperation was not able to be successful.

The establishing of a monitoring system for changes, which may occur in environmental, social and economic area, is also included in the plan. The plan developed for Belek includes construction plan, activities for tourism, water quality, urban development, preservation of nature, protection of sea turtles. Besides, it covers education and participation of local community.

b. The program of Çıralı Coastal Management

In this programme, preparation of a zoning plan for conservation, development of environmental friendly tourism, support for ecological agriculture, education of local people and children, opening courses for young people, examinations on flora and fauna on the region have been aimed. Generally, protecting ecosystems along with their environmental and archaeological values in Çıralı, development of social services are the main purposes of the plan.

2.2.3 The Plan of Patara Special Environmental Protection Area

Patara was declared as a special environmental protection area in 1990 (Atik,1997). The support of Mediterranean Environmental Technical Assistance Programme (METAP) and the European Union has assisted the preparation of a management plan for Patara. The researches of Patara management plan were supported by METAP and the World Bank and carried out by Ministries of Culture and

Environment. The purpose of the plan is to determine what should be done to provide the economic and social development of local people in the area. Also, the main principles have been determined to protect natural and cultural resources and leave them future generations (Duru 2003). Thus, sustainable development has been emphasized and referred to integrated coastal area management.

Evaluation and Conclusion

"Integrated Coastal Zone Management" projects have drawn an attention in the countries where they were implemented. Pilot projects, particularly at the local level, have visible effects on the management of coastal resources. Despite the great efforts to bring Mediterranean Coastal Zones desired conditions, there are still a few issues cannot be overcome such as the misuse of coastal resources, threats to biodiversity, pollution. Recommendations to increase ICZM effectiveness has been underlined at the meetings of contracting parties, at the Mediterranean Sustainable Development Commission and at the international meetings of the MAP. For instance,

- The projects should be at the national or regional level as well as at the local level activities and focused on sustainable development,
- The private sector should be included and drawn into the project all along,
- Active participation of the public sector and NGOs should be guaranteed,
- Sharing experiences is an essential point to overcome the issues.

It would be quite helpful for the region that the use of policy implementations adopted by MAP in line with the integrated coastal zone management approach in the following years. Thanks to these implementations, it would be possible to achieve a balance between northern and southern coastlines and also in the hinterlands. Additionally, protection of environment and equilibrating socio economic conditions would be enabled. Another issue is that the process of ICZM should focus on integrative issues for preferable coordination between the institutions and the parties.

Considering Turkey's coastal zone management in the Mediterranean, integrated Coastal zone management is the key factor to protect ecosystem and providing the integrity of the coastal areas. Therefore, studies on this issue should be passed on through the preparation and the planning of ICZM strategies. In addition to this, the platforms for discussion should be prepared, contradictions and conflicts should be analysed. Technical analyses should be made and policies should be evaluated against possible future consequences.

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CETACEANS IN THE TURKISH WATERS OF THE MEDITERRANEAN SEA

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1. Introduction

Turkey has a long coast line along the Eastern Mediterranean, including the Aegean Sea, extending more than 5000 km in total. As shown in Table 1, seven species of cetaceans are known to occur regularly in this area. Besides, other four species as well as *Mesoplodon* sp. are visitor species which are encountered only occasionally (Beaubrun 1995; Öztürk 1996; Notarbartolo di Sciara and Birkun 2010; Öztürk *et al.* 2014).

Table 1. A list of cetacean species inhabiting the Mediterranean coasts of Turkey

	Common name	Scientific name
Regular species	Fin whale	*Balaenoptera physalus*
	Sperm whale	*Physeter macrocephalus*
	Short-beaked common dolphin	*Delphinus delphis*
	Bottlenose dolphin	*Tursiops truncatus*
	Striped dolphin	*Stenella coeruleoalba*
	Risso's dolphin	*Grampus griseus*
	Cuvier's beaked whale	*Ziphius cavirostris*
Visitor species	Minke whale	*Balaenoptara acutorostrata*
	Rough-toothed dolphin	*Steno bredanensis*
	Long-finned pilot whale	*Globicephala melas*
	False killer whale	*Pseudorca crassidens*
		Mesoplodon sp.

In general, there have been limited studies on the cetaceans in the Turkish water of the Eastern Mediterranean Sea and most knowledge has been collected by sporadic sightings and by studying strandings.

For *Globicephala melas,* there have been some observations by fishermen in the Turkish waters. One of them was in Antalya Bay at the depth of 2000m in 1989 (pers. comm. from the fishermen by B. Öztürk). Beside that one, however, we have not confirmed their presence. Therefore, we list it as a visitor species here.

During the surveys made by International Fund for Animal Welfare (IFAW) in 2007 (Boisseau *et al.* 2010) and IFAW/Marine Conservation Research (MCR) on the Song of the Whale in 2013 (Ryan *et al*. 2013), *Steno bredanensis* and *Pseudorca crassidens* were sighted in the eastern Mediterranean Sea. Although the locations were around Cyprus and not exactly in the Turkish waters, we include them in our inventory as they potentially occur in our waters.

2. Distribution and Stock Structure, Abundance

Very few surveys have been conducted on cetacean fauna in the Eastern Mediterranean Sea. According to Dede *et al.* (2012), *Physeter macrocephalus, Stenella coeruleoalba, Grampus griseus, Delphinus delphis, Tursiops truncatus* were recorded (Figure 1). An acoustic/visual survey was also made by the Song of the Whale in the Levantine Sea in 2007 (Boisseau *et al*.,4 2010) and in the whole Aegean Sea and eastern Mediterranean in 2013 (Ryan *et al*. 2013). These surveys were not, however, dedicated surveys for learning the abundance of cetaceans. Any information regarding the abundance and stock structure is absent.

Between 1994 and 2012, 37 sightings of sperm whales (*Physeter macrocephalus*) were reported in the Turkish part of the Mediterranean Sea. Most of the sightings were located near the Fethiye Canyon which is one of the deepest parts of the Mediterranean Sea (Öztürk *et al.* 2013). In another study Cuvier's beaked whales were sighted once on each of three different surveys over Antalya Canyon, in June and September 2015 (Akkaya Baş *et al*. 2016). A seasonal area use of bottlenose dolphins where the highest sightings recorded in spring and early summer suggested based on the boat and land-based surveys carried out in 2015-2016 in Antalya Bay (Akkaya Baş and Eleman 2016).

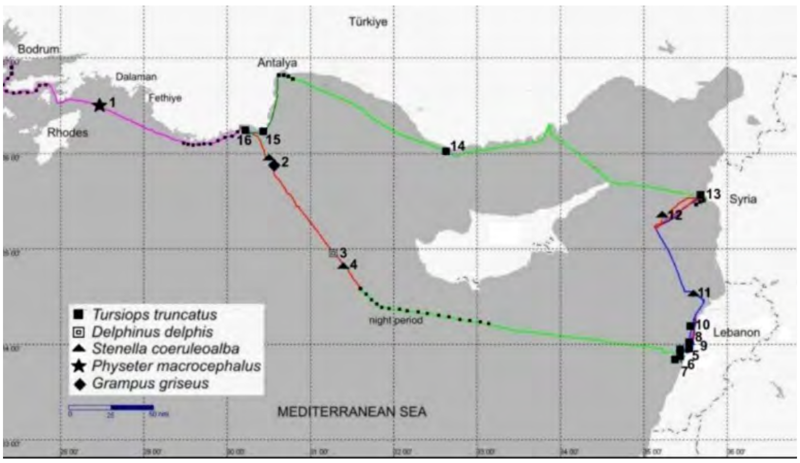

Figure 1. Survey track and cetacean sightings in the Eastern Mediterranean Sea (Dede *et al*. 2012)

3. Strandings and Bycatch

Between 1993-2016 totally 17 individuals (4 *T. truncatus*, 1 *S. coeruleoalba*, 5 *Z. cavirostris*, 2 *G. griseus*, 2 *B. physalus*, 2 *B. acutorostrata* 1 *Mesoplodon* sp.) were found stranded on the Turkish coasts of the Aegean and Mediterranean Sea (Öztürk and Öztürk 1998; Öztürk *et al*. 2001; 2011; 2015; 2016; Bachara and Norman 2013).

Additionally, there is a rare record of *Mesoplodon* sp., possibly *Mesoplodon europaeunus*, which has stranded alive near Fethiye in 2009 (Notarbartolo di Sciara and Birkun 2010; Öztürk *et al*. 2011). The species identification of this animal, however, is still controversial and recently re-identified as *Z. cavirostris* (W. Bachara, pers.commn). In this paper, it is listed as *Mesoplodon* sp., following the initial identification in Notarbartolo di Sciara (2009). Öztürk *et al*. (2016) reported three strandings of *Z. cavirostris* (misidentified as *Mesoplodon mirus* at first, later corrected based on the genetic analysis) on the Aegean and Mediterranean coast of Turkey, including one on Yakacık-Gazipaşa.

Besides, *S. coeruleoalba* and *G. griseus* have been incidentally caught in the swordfish driftnet fishery in the Turkish waters (Öztürk *et al*. 2001; Dede 2008) until this fishery was banned in 2006. *S. coeruleoalba* was the most effected species, followed by *T. truncatus* and *G. griseus* (Öztürk *et al*. 2014). Off Fethiye, a female sperm whale was found by the local fishermen and there were pieces of drift nets entangling the lower jaw and the tail. TUDAV team rescued this whale successfully with the cooperation of the Turkish Navy on 21 June 2002 (Öztürk *et al.* 2013)

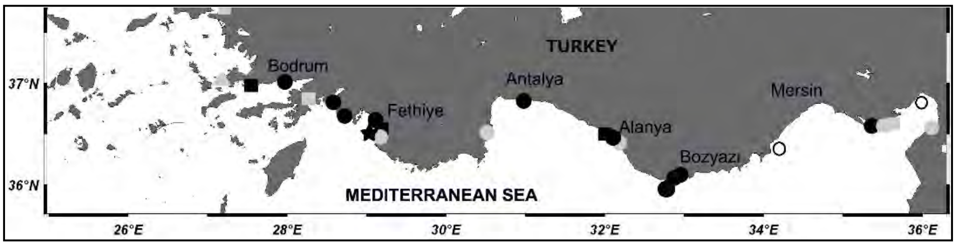

Figure 2. Strandings of cetaceans on the Mediterranean coasts of Turkey.
(Black dots: *Z. cavirostris*, square: *G. griseus*, star: *Mesoplodon* sp.) (Grey dots: *T. truncatus*, square: *S. coeruleoalba*, triangle: *D. delphis*) (open circle: *B. acutorostrata*)

4. Ecology

Some studies have been made on stomach content and parasites of cetaceans in the Turkish Mediterranean Sea. Cephalopod remains from the stomachs of three bycaught

S. coeruleoalba and two *G. griseus* were examined. For *S. coeruleoalba*, *Abralia veranyi* was the most common prey (51.2% of all the beaks found in this species), followed by *Onychoteuthis banksii* and *Heteroteuthis dispar*. For *G. griseus*, *Histioteuthis reversa* was the most common species (Öztürk *et al*. 2007). In the stomachs of *S. coeruleoalba*, there were remains of some fish and shrimps, while only cephalopod remains were detected in those of *G. griseus* (Öztürk *et al.* 2007). In another study on stomach contents of six *S. coeruleoalba*, small-sized mesopelagic and bathypelagic fish species *Diaphus* spp. and *Ceratoscopelus maderensis* were the most common. On the other hand *O. banksii*, was the only cephalopod species found in all stomach content analyses (Dede *et al*. 2016). Macroparasites; *Anisakis* spp., *Contraceucum* spp., *Pseudoterronova* spp. and *Steneurus minor* were identified in the stomach of the bycaught *S. coeruleoalba* (Aytemiz *et al*. 2012).

Besides, the ectoparasite, copepod *Pennella balaenoptera* had been reported on fin whale stranded on the beach in Yumurtalık in 2002 (Çiçek *et al*. 2007).

5. Conservation

All cetaceans have been under legal protection in all Turkish waters since 1983. However, there are no conservation measures implemented particularly for these animals. Cetaceans in the Turkish Mediterranean Sea are facing threats such as habitat degradation due to mass tourism, prey depletion due to overfishing, bycatch due to illegal drift netting. Turkey has not yet become a member of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area) but has signed the Barcelona Convention and has been an active member of GFCM (General Fisheries Commission for the Mediterranean) under FAO, by which Turkey takes responsibility to monitor environmental status and fishery and to implement the regional action plan for the conservation of cetacean species. There is no Turkish national action plan for cetacean conservation yet, in spite of an initiative in the early 1990's. Not only elaboration but also implementation of a national action plan for cetacean conservation is urgently needed. Creating Marine Protected Areas for these animals and the whole ecosystem can be an effective measure. Regional cooperation with other countries surrounding the Levantine Sea is also crucial to protect these highly mobile animals.

6. Conclusion

There have been some progress in the data collection on cetaceans in the Turkish coast of the Mediterranean Sea. The number of both researchers and local people who are interested in cetaceans has been increasing. However, there should be government initiative or strategy to actively protect these species because they are facing variety of threats in the area already.

Some species are already known as common in the area, while others, are known by few sightings or strandings, which may be the result of lack of effort. Increasing public awareness and organizing systematic surveys at the same time will contribute to the understanding of cetacean fauna and their distribution in the Turkish Mediterranean Sea.

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A REVIEW OF HISTORY, DISTRIBUTION, THREATS AND CONSERVATION OF MARINE TURTLES IN TURKEY

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1. Introduction

Marine turtles are impressive creatures that have been living in the world for over 110 million years. They usually inhabit in tropical or subtropical regions. There are seven species of marine turtles, which are categorized in reptile class, living in the oceans all around the world. In many cultures, marine turtles represent longevity, productivity, durability, and being the symbol of protection from wickedness, as they are well-respected species from Australia to Asia, Africa to Pacific coasts, Central and South America to Mediterranean and Europe.

Six of the seven species of marine turtle (*Dermochelys coriacea, Lepidochelys kempii, Lepidochelys olivacea, Chelonia mydas, Caretta caretta, Eretmochelys imbricata,*) are recognized as vulnerable, endangered or critically endangered by IUCN (IUCN SSC, 2008, 2015).

Until recently, it was believed that marine turtles where they go ashore to nest in tropical and subtropical places were safe. However, the marine turtle populations have been rapidly decreasing because of the combination of different reasons such as being hunted for meat, shell and eggs;loss of habitats, incidental catch, international trade, pollution, maritime traffic, predators, and illnesses.

Marine turtles are migratory species and they spend all phases of their lives, except for egg-laying in the sea. However, existence and ecological, cultural and economical value of these species depend on a joint effort globally. All marine turtles pass through different countries in continental and nautical habitats and swim around international waters throughout their life. It takes 15-20 years for them to reach maturity after hatching. In this period of time, as the duration is long and complicated, this brings the marine turtles to face many challenges to survive throughout their life cycle.

Negative effects of human activities on the population of Mediterranean marine turtles have increased in last 50 years. The most serious influences and threats of those human activities:

- Damaged habitats that have crucial influence on marine turtles' life cycle in regards of nesting, feeding, wintering and migrating areas.
- Direct impacts on marine turtle populations; for instance, incidental catch, hunting, depletion and boat damaging.
- The pollution that has a negative impact on both habitats and the species.
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The most efficient and sustainable method to protect the Mediterranean marine turtles is combination of all actions, such as managing the Mediterranean in one hand, setting the ecosystem concept in minds, taking advantage of the initiatives of relevant organizations, cooperation of all organizations including the UNEP Mediterranean Action Plan (MAP), Fisherman Management Plans (FAO/GFCM), International Union for Conservation of Nature(IUCN/SSC), International Commission for the Conservation of Atlantic Tunas (ICCAT), The Mediterranean Science Commission (CIESM), universities, research institutes and non-governmental organizations in both national and international level.

Studies and works have been continually on-going in international level with full attendance and support of relevant institutions to plan protection/management, scientific research/observation, create awareness, capacity building/education and coordination actions to be able to protect marine turtles and their living environments.

Two of the marine turtle species nest regularly along the Mediterranean coast of Turkey: the loggerhead turtle, *Caretta caretta* and the green turtle, *Chelonia mydas*.

In Turkey, the first documentation about nesting of loggerhead turtle, *C. caretta* and green turtle, *C. mydas* were published by Hathaway (Hathaway 1972). After that, Basoglu (1973) and Basoglu and Baran (1982) have provided information from Izmir, Koycegiz and Fethiye about carapax scutes that belong to the *C. caretta*. Geldiay and Koray(1982), Geldiay *et al.* (1982) and Geldiay (1983, 1984) have done studies about population and conservation of the nesting beaches along the Mediterranean coasts (Türkozan and Kaska 2010).

WWF supported a survey of the entire Turkish Mediterranean coast (2,456 kilometers) in 1988 to identify the most important marine turtle nesting sites. 17 beaches on the Turkish Mediterranean coast were officially designated as Marine Turtle Nesting Site (Baran and Kasparek 1989).

In 1994, an assessment survey was carried out with WWF's support by the DHKD, on the 17 major nesting sites. As a result of this assessment, it was found that marine turtles and their habitats in Turkey, were not adequately protected (Yerli and Demirayak 1996). Similarly, Yerli and Canbolat (1998a and 1998b) and Yerli *et al.*(1998) have done surveys about marine turtle nesting beaches between 1996 and 1998 with the support of the Ministry of Environment.

A few records of non-nesting leatherback turtle, *Dermochelys coriacea*, have been reported from the Turkish Mediterranean and Aegean Coasts (Oruç *et al.*1997, Taşkavak *et al.*1998).

In Turkey, an increasing trend on marine turtle studies especially after 1988. The studies carried up to date covers all nesting sites and information on those nesting beaches are available. However, the real potential of some nesting beaches is still unknown either due to the lack of studies covering overall beaches or the whole breeding season (Kaska and Türkozan 2010).

In Turkey, efforts by marine turtle researchers and conservationists have been focused, for a long time, on marine turtle nesting sites. Therefore, there are limited data on feeding, breeding and wintering sites together with the impact of fishery related activities on marine turtle populations (Oruç et al. 2011).

In Turkey, as a part of UNEP MAP, ''National Species Action Plan of the Marine Turtles'' was completed under the coordination of Ministry of Environment and Forestry in a meeting with the attendance of all relevant institutions in 2009 and updated in 2012.

2. Nesting Sites

Since 1988, 21 important nesting beaches for marine turtles have been identified along the Mediterranean coast of Turkey. These are the following, starting from west to the east: Ekincik, Dalyan, Dalaman, Fethiye, Patara, Kale, Kumluca, Çirali, Tekirova, Belek, Kizilot, Demirtas, Gazipasa, Anamur, Goksu Delta, Alata, Davultepe, Kazanli, Akyatan, Yumurtalik and Samandag. In Turkey, marine turtles are under threat due to loss of nesting habitats, boat traffic/collision and incidental catch.

Over the past decade the marine turtle nesting beaches increased in number from 17 to 21. In consequence of the long term monitoring studies carried out in Çıralı, Alata, Yumurtalık (including Sugözü beaches) and Davultepe beaches four more site has gained nesting beach status.

All of the 21 nesting beaches has the status of being official nesting beach by the force of the Circular of Marine Turtles issued by Ministry of Forestry and Water Affairs.

Today, most clutches are laid in Greece, Turkey, Cyprus and Libya for *C.caretta*. In the entire Mediterranean, the average number of documented nests is over 7200/yr. For *C.mydas*, most clutches are laid in Turkey, Cyprus and Syria. For the Mediterranean, the average number of documented nests is over 1500/yr (Casale and Margaritoulis 2010).

Based on the nest numbers, Turkey holds the most important *C. mydas* stocks and the second most important *C.caretta* stocks in the Mediterranean. The average annual number of *C.caretta* throughout the Mediterranean reaches 5031 nest/season and of these 27.2% (1366 nests/season) occurs in Turkey. Having reviewed the nesting beaches in the Mediterranean coast of Turkey, Canbolat (2004) estimated 2000 nests/year for the *C.caretta* (Türkozan and Kaska 2010).

C.mydas is mostly confined to the eastern Mediterranean coasts of Turkey. Kasparek *et al.* (2001) estimated 350-1750 clutches per year from which annual nesting population of 115 to 580 females has been estimated. Broderick *et al.* (2002) estimated 339-360 green turtle nesting annually at some sites in the Mediterranean. Canbolat (2004) estimated annual mean nest numbers of *C.mydas* along the Mediterranean coast of Turkey as 648. Kaska *et al.* (2005a) estimated 700-1150 *C.mydas* nests on Mediterranean coast of Turkey (Türkozan and Kaska 2010).

In 2003, the existing statuses of nesting beaches of marine turtles on Turkish Mediterranean coasts and the extent of threats to these sites were assessed by WWF-Turkey with technical support from experts of universities.

The assessments undertaken on the 20 nesting beaches in 2003 have shown that 64% of the beaches were in a bad condition. Although precautionary measures were required to be taken immediately, such measures have not been put in place due to the restructuring processes of the responsible organizations.

WWF-Turkey has conducted an assessment study in order to reveal the current state of the 21 nesting beaches of marine turtles on the Mediterranean coasts in Turkey in 2013.

The Marine Turtle Nesting Beaches Comparative Assessment Survey 2013 aimed to update the former study over the 10-year period between 2003 and 2013, and assess the impacts of conservation measures that had been taken in order to protect marine turtles nesting beaches in Turkey. It has also been targeted to put forward positive changes as well as threats that the beaches have been facing over the last 10 years. Changes in the physical condition of the nesting beaches have been assessed timely, as a result of the study.

Table 1. Summary of nesting data for *C.caretta* and *C.mydas* in Turkey (Türkozan and Kaska, 2010)

Beach name	**Length of the beach (km)**	***C.caretta***	***C.mydas***
Ekincik	1	9-12	
Dalyan	4,7	57-330	
Dalaman	10,4	69-112	
Fethiye	8,3	72-191	
Patara	14	35-127	2-2
Kale	8,5	39-109	
Finike	21	75-305	0-7
Çıralı	3,2	23-96	
Tekirova	3,7	4-23	
Belek	29,3	68-819	2-8
Kızılot	15,7	50-270	0-3
Demirtaş	7,8	41-137	
Gazipaşa	7	14-53	
Anamur	12,2	146-674	1-1
Göksu Deltası	25,6	36-151	3-20
Alata	3	16-32	20-198
Kazanlı	4,5	2-26	73 – 403
Tuzla	25		4-9
Akyatan	22	3-31	108-735
Karataş	7		3-3
Ağyatan	8,5	2-2	0-3
Yelkoma	23,1		2-3
Sugözü	3,4		213-213
Yumurtalık	6	1-1	1-3
Samandağ	14,2	7-20	20-440
Toplam	**289,1 km**	**769-3521**	**452-2051**

On a regular basis the monitoring studies are in progress in 12 nesting sites of 21 (Dalyan, Fethiye, Patara, Çıralı, Belek, Göksu Delta, Alata, Davultepe, Kazanlı, Akyatan, Yumurtalık, Samandağ).

Regular monitoring studies are required in 9 nesting sites.

Only 2 of the nesting sites are very well protected (Dalyan and Akyatan which are already protected areas). Serious problems exist in 8 sites due to the legislative regulation not to be applied adequately (Fethiye, Demre, Kumluca, Tekirova, Belek, Anamur, Kazanlı, Samandağ).

Improvement activities are required in 10 sites (Ekincik, Dalaman, Patara, Çıralı, Demirtaş, Gazipaşa, Göksu Delta, Alata, Davultepe, Yumurtalık) (Oruç *et al.* 2015).

10 of the marine turtle nesitng beaches have at least one or a more protected status. Turkey signed and implemented Bern, Barcelona and Biodiversity conventions. Therewithal applicable national legislations are developed. In 2009 National Species Conservation Action Plan for Marine Turtles is completed. A large part of problems designated in the sites and solution proposals took part in the reports that's been prepared since 1988. To be maintained many applications infringing the laws and not to be implemented the current laws are the basis of the designated problems.

For better solutions:

1. Priority habitats of marine turtles must take place in environment/zoning plans as the areas of the essence in terms of environmental sustainability.
2. Current acts towards conservation of marine turtles and their habitats must be improved and implemented. Main reason of continuing depredation is deficiency on enforcing the laws. Local monitoring methods must be developed for nesting sites.
3. Financial resources must be created for monitoring studies.
4. Efforts for creating awareness in order to contribute collaboration of volunteers and local non-governmental organizations in observation works must be popularised.

3. Hunting Story of Marine Turtles in the Iskenderun Bay

Marine turtle populations in the Eastern Mediterranean were severely exploited in first half of the 20th century by human activities.

In modern times, marine turtles have been viewed as an economic resource in the eastern Mediterranean since before the beginning of the 20th century. A fishing company from Iskenderun began to purchase marine turtles from local fishermen along the coasts of Mersin, Adana and Antakya. Turtle hunting in Turkey started in the early 1950s and continued until the end of the 1960s. FAO fishery statistics mention about 1000 tons of turtles caught in Turkey in this period.

Between 1952 and 1965, up to 15,000 specimens were taken from the shores of Mersin. In May 1965, 100 specimens or more were caught around Adana, all *Chelonia* *mydas*. In this single area, by May 1965, more than 10,000 turtles had been captured for their meat to be exported to Europe (Sella,1982).

Hunting for their meat and body fat is a major cause of the drastic decline in marine turtle populations. The hunting of and trade in marine turtles were prohibited in Turkey in 1984.

Official documents gathered in the archive survey and one-on-one interviews reveal that marine turtle hunting in Turkey is mainly export-oriented.

The oldest document in this field is an article in the newspaper Cumhuriyet dated August 5th, 1932. According to this article on marine turtle exports, 67 marine turtles were loaded in Mersin to a vessel named Bilbis belonging to the company Hidiviye, to be exported to Alexandria. Their total weight amounted to 5000 (five thousand) kilos, and accordingly, their average weight was slightly over 74 kilos.

The April-May 1955 issue of the magazine Balık ve Balıkçılık Dergisi (Fish and Fisheries), issued by the General Directorate of Meat and Fish Production features an article entitled "Efforts to Enhance Fishing in İskenderun", part of a series of articles on private enterprise in fishing. In the interview it is mentioned that marine turtles figure among the marine products frozen by the company to be exported abroad.

According to statistics from the FAO Archive, a total of 981 tons of marine turtles were hunted in the Mediterranean coast of Turkey from 1962 till 1984 (Data is not available for the years 1963, 1966, 1967, 1970, 1971, 1972, 1973, 1979, 1982 and 1983) (FAO, 2009).

On September 10th, 2011, in the İskenderun port, a team from WWF Turkey conducted an interview with the chairman of Balık İş Su Ürünleri A.Ş., involved in the export of marine turtles from İskenderun to Germany in the 1960s. The said person had a seat on the company's managerial board from 1964 to 1975 and closely followed the historical trajectory of marine turtle hunting (Ferit Buran, pers.comm.).

Upon request by a German firm, marine turtles were being shipped from İskenderun to Germany. In those years, the hunting and collection of marine turtles were legal in Turkey. Marine turtles from Mersin Karaduvar, Adana Yumurtalık and Hatay Samandağ were larger in numbers albeit smaller in size (from Yumurtalik average weight 70-80 kg, from Samandag and Karaduvar 150 kg). Hunting took place generally in summer months, after turtles laid eggs in beaches. Turtles were initially marketed with their shells; however, upon the request of clients, they later came to be sold in skin, bones and meat. Meat separated from the shell was placed in cardboard boxes from Germany and shipped thus.

In 1975, when the buyer in the German company passed away, marine turtle exportation by Balık İş to Germany came to an end.

The hunting and collection of marine turtles were banned in Turkey in 1984.

According to information provided by written resources, the average weight of marine turtles hunted in Turkey's Mediterranean coasts varied between 75-100 kg; hunting lasted until 1984, and was particularly intensive from 1932 until 1975. This data indicates that the turtles hunted or collected were mostly mature animals. As revealed by face-to-face interviews, mostly female animals in the reproductive phase were collected in the years from 1964 to 1975, after laying their eggs in beaches.

In Turkey, studies and documents on marine turtles have figured in the public agenda since 1972, and conservation efforts have geared up since the late 1980s (Oruç et al. 2012).

4. Potantial Feeding and Wintering Sites in Turkey

Historically, more marine turtle monitoring effort has focused on nesting beaches, the number of detailed marine biodiversity studies carries out in Specially Protected Areas (SPA) has been increasing, particularly since 2002 (Oruç *et al.* 2011).

The Kaş-Kekova (Antalya) area appears to serve as a feeding ground for *C. caretta* and *C.mydas,* and principal threats include solid waste (plastic bags etc.), long line fishing and ghost fishing gear (abandoned nets and fishing line stuck on the bottom of the sea) (Tural and Çiçek 2010; Soysal 2015). Speedboats and long line fishing gear are the main causes of injury or death for marine turtles are found in the Kemer (Antalya) area. In the Eastern Mediterranean (Bay of Iskenderun), intensive fishery activities have resulted in incidental catch. Monitoring studies and observations indicate that the green turtle (*C. mydas*), which rarely nests in Turkey's western Mediterranean beaches, has been using this region as a feeding ground. The fact that green turtles are accidentally caught in fishing nets in the Bay of Iskenderun during autumn and winter can be regarded as an indication that part of the population over- winters in this area (Oruç 2001). It is also observed that some satellite tracked green turtles spend the winter in the Bay of Antalya (Türkecan 2010; Godley *et al.* 2002).

From various reports reveal some possible foraging areas such as Kuşadası and Dilek Peninsula-Menderes Delta (Surucu 2007, 2014, 2015, 2016), Datça-Bozburun SPA (Okuş *et al.* 2004), Lycian Coast (Antalya) (Yokeş 2003), Gökçeada and Çanakkale (Ayrıntılı Haber 2016).

Map 1. Nesting, potential wintering and feeding sites of marine turtles in Turkey

5. Conservation Efforts

In the year of 1986, a big tourism investment was cancelled by the efforts of DHKD (The Society for the Protection of Nature), a lot of individuals and organizations both in national and international level in Mugla/Dalyan which made the marine turtles a symbol of all nature conservation efforts.

Under the supervision of the Ministry of Agriculture and Rural Affairs, a range of meetings were held with the attendance of relevant institutions, universities and NGOs in 1989. In those meetings, the universities' and the NGOs works were assessed in the regard of conservation. The Marine Turtles Monitoring and Assessment Commission was found in 1990, including the Ministry of Public Works and Settlement, Environmental Protection Agency for Special Protected Areas, Prime

Ministry of Undersecretaries of Environment, Dokuz Eylul University, Hacettepe University, DHKD/WWF representatives. In 1991, after the foundation of the Ministry of Environment, the commission works had started to progress. Marine Turtles Science Commission has carried out the coordination plans since the beginning of 2000. The commission, in which involves all the experts and organizations that pursue monitoring, research and conservation studies as members, is organized by the Ministry of Forestry and Water Affairs. The committee organizes a meeting in every year to share and discuss the experience, monitoring and conservation surveys about nesting sites and other topics. The National Marine Turtle Symposiums have been held with the support from relative ministries, the commission's members and local authorities since 2003. The main goal of the national symposiums is to associate all the relative parties with each other to share their knowledge and experience in order to make a contribution to all the practices for better conservation.

The monitoring and conservation practices and studies in Turkey have been rapidly growing with the support of many different institutions including the Ministry of Forestry and Water Affairs, the Ministry of Environment and Urbanization, the Ministry of Food, Agriculture and Livestock, the Coast Guard Command, WWF–Turkey, Ecological Research Society (EKAD), Dokuz Eylul University, Hacettepe University, Pamukkale University, Mersin University, Çanakkale University, Adnan Menderes University, Ordu University, DEKAMER, other relative ministries, local authorities, experts of two aquariums, and the local NGOs.

6. New IUCN status of *Caretta caretta*

In the end of 2015, The IUCN Marine Turtle Specialists Group (MTSG) published a research paper that was done for loggerhead, *Caretta caretta* in global scale. According to the consequences of the research, the status of *C.caretta* which used to be ''Endangered'' in the Red List of IUCN in 1996, has become ''Vulnerable'', showing that the level of the danger for the species' population has been reduced. Therefore, the status of the *C. caretta* is now ''Least Concern'' in the scale of the Mediterranean basin because of the increase in population.

The study that contains ten subpopulation of the *C. caretta* has discussed gathered population data and the risks that the species has been facing throughout the time. The consequences of the conducted study since 1996 both globally and regional have been re-evaluated and the statues have been updated.

The consequences of conservation efforts of *C. caretta* that have been held for the last 20 years can be seen in a positive direction. Yet, high-risk level is continuing for the *C. mydas* that nests in eastern Mediterranean beaches in Turkey (Mersin, Adana, Hatay). On the global scales, *C.mydas* is still in endangered (EN) status. However, its status in the Mediterranean subpopulation is Critically Endangered (CR).

The increasing threats have been continually growing for the green turtles which nest through the entire Mediterranean basin, the eastern Mediterranean beaches in Turkey and in Cyprus. The Iskenderun basin where there is also nesting areas of marine turtles was established as Turkey's 'energy passage'. More than 10 proposals were offered for the construction of thermal power stations in that area. As the responsibility is on every institutions for conservation in the Mediterranean basin, unfortunately the nesting and wintering areas of the *C. mydas* are at high risk.

The increase in population as a consequence of the programme developed for conservation of the *C. caretta* within the entire Mediterranean for the last 20 years couldn't guarantee a bright future for nesting areas. The rapid assessment of WWF – Turkey at nesting areas in 2003 and 2013 has shown that 65% of those areas are in poor conditions.

The future of nesting sites are in danger because of several reasons such as the fact that these areas still haven't been included into the "Development Plans" which is organized by the Ministry of Environment and Urbanization, also being in investment areas where there is not enough conservation plans and nonexistence of enough local monitoring units.

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MONITORING AND CONSERVATION OF THE MEDITERRANEAN MONK SEAL IN THE TURKISH PART OF THE MEDITERRANEAN SEA

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The Mediterranean monk seal, *Monachus monachus* (Hermann, 1779) is one of the rarest and most threatened species in the world. It is also Europe's most endangered marine mammal (Johnson and Lavigne 1998). Being the only representative of the genus *Monachus* (Scheel *et al.* 2014), the worldwide abundance of this elusive seal species is estimated to be fewer than 700 individuals (Karamanlidis *et al.* 2016). The International Union for the Conservation of Nature (IUCN) first classified the Mediterranean monk seal as endangered in 1966. The species was listed as "Critically Endangered" in years between 1996 and 2013. Due to the indications of small population increases in the subpopulations, as of 2015, this conservation status has been updated from critically endangered to endangered in keeping with the IUCN's speed-of-decline criteria, with a recommendation for re-assessment in 2020 (Karamanlidis and Dendrinos, 2015). The species is also protected by Bonn (Appendix I and II), Bern (Appendix II), CITES (Appendix I), Barcelona (Fourth protocol species), and Biodiversity (Eligible species) conventions and European Community's Habitats Directive (Annex II and Annex IV).

In general, there are three or four isolated subpopulations in the eastern and western Mediterranean, the archipelago of Madeira and the Cabo Blanco in the northeastern Atlantic Ocean **(Figure 1)**. Turkey is among the very few countries still providing a shelter to the species. The monk seal population size on the Mediterranean coast of Turkey was estimated as 35 individuals at the end of 1970's. Later, in a study carried out between 1987 and 1994 a total of 45 individuals were identified along the entire extent of the Turkish coast, including the Black Sea and the Sea of Marmara. In that study number of seals inhabiting the south coast of Turkey was given as 11 individuals (Öztürk 1994). In early 2000's, Güçlüsoy *et al.* (2004) estimated the monk seal population size utilizing the first hand sighting reports and recent research studies and reported 104 individuals, 37 of them inhabiting the south coast of Turkey. Finally in 2007, the population size estimated for the narrower coastal band between Antalya and Syria was given as 38 (Gucu *et al.* 2009a and 2009b). As can be noted, the number of individuals reported in the literature points out an increase in the survivors rather than a decline. Whatever the actual number is, the size of the monk seal population is low enough to put the Mediterranean monk seal in the list of the most endangered species.

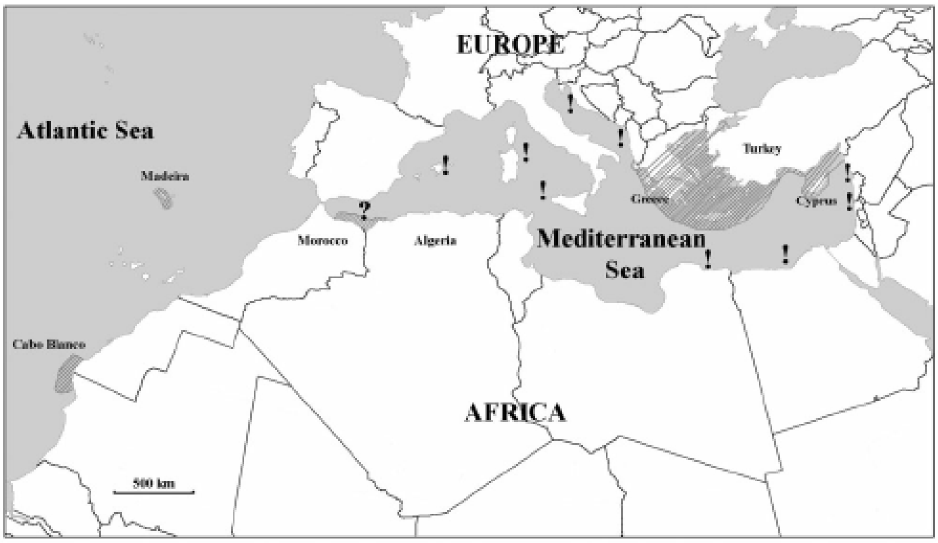

Figure 1. The current distribution of the Mediterranean monk seal. Cross-hatched areas indicate the geographical range of extant monk seal populations; the question mark indicates an area where the fate of the population is unknown; the exclamation marks indicate areas outside the current range where Mediterranean monk seals have recently been seen (taken from Karamanlidis *et al.* 2016).

A detailed study carried out between 1994 and 1996, represented that the largest and the only vital (retaining reproductive ability) colony of monk seals on the Turkish coast inhabits the west coast of Mersin (Gucu *et al.* 2004). In this study, the caves used by the seals for resting or breeding were discovered. Following this study, the importance of Mersin (Cilician) coast for the survival of the species has been recognized and the area has been set aside for conservation in 1997. The surroundings of the identified breeding caves, and the foraging areas has been designated as "No-take-zone" in the sea and on the land as "1st Degree Natural Asset". A follow up study conducted after the conservation remedies were enforced, indicated that the protected area hosted a breeding colony composed of 24 individuals. It was also observed that certain seals were using only certain caves. Therefore the region was subdivided into territories based on the home ranges of the territorial males. The habitat partitioning of the colony is represented in Figure 2. Among these sub-groups the fewest individuals were found in Taşucu and Aydıncık. Moreover, it was realized that the subgroup in this area did not breed throughout the study. In the same study, the ages of the seals were also estimated (Table 1). The demographic structure of the colony at the time of census (Figure 3) reflects an unusual adult dominated structure which indicated a very low reproductive success. Within the period between 1994 and 2000, six dead seals were found. As the locals of the region have reported this number might have been as high as 10 seals. These losses explain the abnormal demography in the colony. In ecological terms, this is a typical case of Allee effect (under-population effect) in which the number of individuals is so low that reproductive (and some social) activities do not take place only because the individuals are not paired. The loss of harem forming dominant males had significant impact on the colony and reproduction has almost ceased. Consequently, despite the conservation efforts and positive response of the colony to the protective measure the sub-group inhabiting the coast especially between Taşucu and Aydıncık is still under high risk due to the increased industrial activities in the region (such as recently constructed marine terminal, cement plant and thermal power plant in the same region). In the same study it was found out that the seals partition the caves and the total number of suitable caves is one of the major factors limiting the size of the colony.

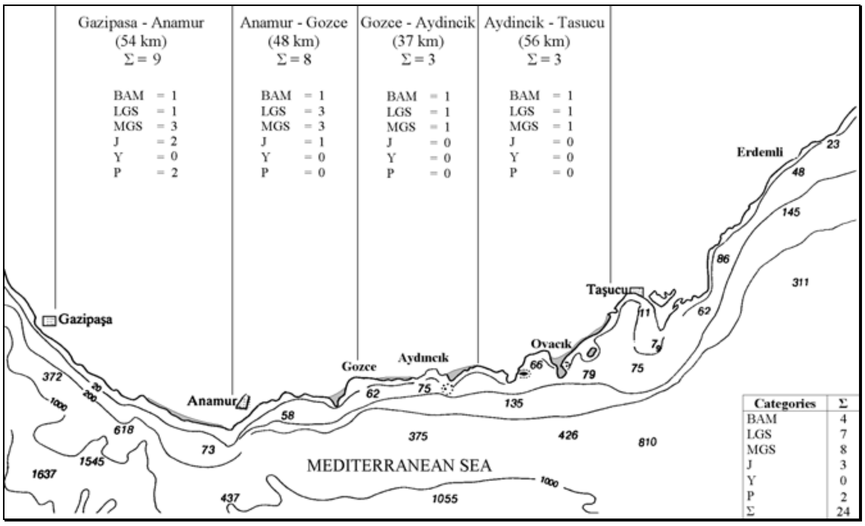

Figure 2. Distribution of the seals along the Cilician Basin with the arbitrary ranges of the sub-regions, the total number of seal individuals using each sub-region and the sub-group category compositions. The data presented on the bottom right corner summarizes the total numbers of seals in each category (taken from Gucu *et al.* 2004)

The further studies carried out right after the enforcement of conservation measures represented that the response of the seals in Mersin has been very positive. The breeding success which had been drastically reduced at the end of 1990's, has significantly increased after 2002 and reached to 5 pups per year (Table 2 and Figure 3) and so that the size of the colony has increased from 24 to 30. Gucu and Ok (2006) and Ok (2006) have analyzed the viability of the population based on population parameters presented by the colony before and after the protection. According to the analysis, the colony would not have survives if the protection had not been established. The risk of extinction within 10 year was almost 100% with the fecundity and mortality rates presented by the colony before the protection. After protection these rates have significantly modifies in favor of the species and as of today, the risk of extinction within the next 50 years is below 30%. However this estimation does not mean that the monk seal population on the west coast of Mersin is in safe. With the increase in the population size, the pup mortality has increased remarkably. The major causes of pup mortality are entanglement in the fishing nets and being born in an unsuitable cave exposed to open sea. The mortality of the pups born in the caves where fishing activities are intense is almost 100%. The pups are entangled in the nets are drowned since they are not strong enough to tear off the fishing nets. Similarly they are not good swimmer during the first few weeks after birth and they can hardly survives if the waves wash them away from the their breeding caves during storms. This clearly indicates the necessity of the protection of the caves.

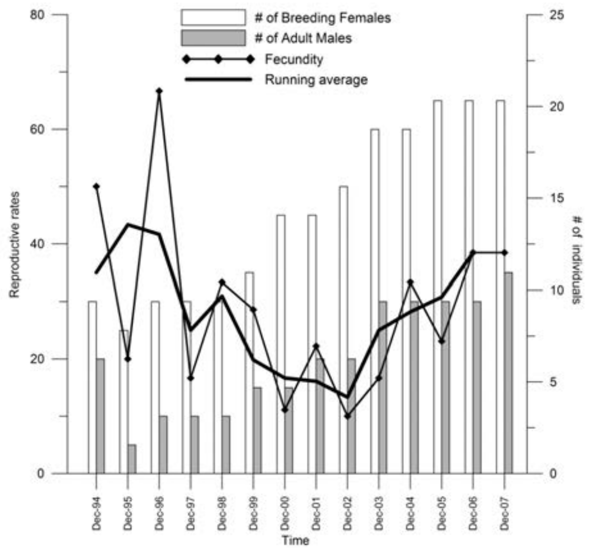

Figure 3. Reproductive activities in P1 (Taken from Gucu *et al.* 2012)

Further studies indicated existence of a small segregated breeding population of seals inhabiting the steep rocky coast at *i*) Turkish/Syrian border (P2), *ii*) north Cyprus (P3) and *iii*) Antalya (P4) (Figure 4). Three years after conservation, a young female was sighted between P1 and P2. The same individual frequented a formerly "abandoned" cave which had not been used by the seals within the previous 25 years (Gucu *et al.*, 2004). Later, a male sighted within P1 moved beyond the anticipated migration limits (Gucu and Ok 2004). Finally a dominant male of P1 sighted in Cyprus (Gucu *et al.* 2009a). All these individual events demonstrated that the P1 tended to further expand with the enlargement of the population size and the sub-region between Taşucu and Aydıncık mentioned above play a crucial role bridging the main colony (P1) with those found in Cyprus (P3) and in the Gulf of Iskenderun (P2).

Estimated overall demographic structures of the populations in the northeastern Mediterranean were given in Table 2 and 3. A total of 69 individuals are involved in the tables and as of year 2008, 50 individuals are believed to survive in four populations.

Table 1. Identified individuals of the Cilician monk seal colony, their sex, category and estimated age. BAM = Black Adult Male; LGS = Large Grey Seal; MGS = Medium Grey Seal; J = Juvenile; Y = Youngster; P = Pup; □ = Deceased; ? = Unknown; ages at September 2001 (Taken from Gucu *et al.* 2004)

Seal ID	**Identified on**	**Sex**	**Categories at first encounter**	**Age (years)**
I - M1	16-Apr-95	M	BAM	14.7
I - F1	23-Jul-95	F	LGS	13.4
I - P1	30-Jul-95	?	Y	6.6
II - M1	19-Aug-98	M	BAM	11.4
II - F1	11-Oct-97	F	LGS	11.2
II - X1	11-Oct-97	?	J	5.2
III - M1	10-May-97	M	BAM	12.6
III - F1	24-Apr-96	F	MGS	8.2
III - F2	04-Aug-96	F	LGS	12.4
III - F3	21-Aug-96	F	LGS	12.4
III - P1	21-Aug-96	F	P	†
III - P2	15-Nov-96	M	J	6.1
III - P3	02-Dec-96	M	Y	5.2
III - P4	09-Nov-97	M	P	4.1
III - P5	24-Oct-99	F	P	2.2
IV - M1	24-Aug-96	M	BAM	13.4
IV - F1	20-Aug-98	F	LGS	10.4
IV - F2	13-Mar-99	F	MGS	5.3
IV - P1	20-Aug-98	F	P	3.4
IV - P2	23-Oct-99	F	P	2.2
IV - P3	09-Nov-00	M	Y	1.3
IV - P4	29-Aug-01	?	P	0.3
IV - P5	29-Aug-01	?	P	0.3
IV - X1	18-Oct-98	?	J	4.2
X - X1	10-Mar-98	?	LGS	10.8

It is very likely that there was one single and large seal population in the past covering the entire extent of the northeastern Mediterranean. Later, because of intensive urbanization and industrialization within their habitat, and also because of deliberate killings, the population became fragmented into smaller isolated populations suggested in Figure 4 by the early 1980s. Today, the seals dispersed to Syria, Cyprus, the Gulf of Iskenderun and all along the northeastern Mediterranean may be the relicts of the same historical population. Depending on the level of disturbance and the size of the fragments, some groups may maintain their biological and social functions, as on the Cilician coast. Due to steep and mountainous topography on the west coast of Mersin, human pressure and, in turn, habitat fragmentation, has not been as severe as on the east coast, as indicated by continued reproductive ability of the colony inhabiting there. However, the fate of the small colony in the Gulf of Iskenderun is uncertain, especially when the genetic bottleneck is considered — i.e. the probability of extinction may increase due to reduced genetic variability.

Table 2. Demography table of the monk seal population (P1) in the northeastern Mediterranean; underlined italic numbers are back-calculated ages, arrows show the movement between populations (Taken from Gucu *et al.* 2012)

Sex	Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
F	Tekin	*21.0*	*22.0*	*23.0*	*24.0*	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0
M	Yula †	8.0	†													
M	Japon †	8.0	†													
M	Cecan †	8.0	†													
M	Bombacı	*7.0*	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	→			
F	Kır †	6.0	†													
F	Dede †	6.0	†													
F	Kokona	*5.0*	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
M	Kamash	*5.0*	*6.0*	*7.0*	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
F	Meryem	*4.0*	*5.0*	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
F	Yasli	*4.0*	*5.0*	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
F	Melek1	*3.0*	*4.0*	*5.0*	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
M	Yagiz	*2.0*	*3.0*	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
F	Anac	*2.0*	*3.0*	*4.0*	*5.0*	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
F	Bozzy †	*0.0*	*1.0*	*2.0*	3.0	†										
F	Charlie †	0.0	†													
M	Yakisikli	*0.0*	*1.0*	*2.0*	*3.0*	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0
F	Ceren	_	0.9	1.9	2.9	3.9	4.9	5.9	6.9	7.9	8.9	9.9	10.9	11.9	12.9	13.9
F	Meltem	_	_	*0.0*	*1.0*	*2.0*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
F	Umit †			0.0	†											
M	Arap			0.3	1.3	2.3	3.3	4.3	5.3	6.3	7.3	→				
M	Ferit Jr.			0.9	1.9	2.9	3.9	4.9	5.9	6.9	7.9	8.9	9.9	10.9	11.9	12.9
F	Charlie				1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
M	Askim				0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
F	Ney					0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
M	Saklikuzu					0.3	1.3	2.3	3.3	4.3	5.3	6.3	7.3	8.3	9.3	10.3
F	Sedef						0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
F	Sanda						0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	†
M	Yalcin							0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
M	Uykucu								0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
F	Amorti								0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
M	Tarcin									0.0	1.0	2.0	3.0	4.0	5.0	6.0
F	Zeynep †										0.3	†				
F	Lal †										0.0	1.2	†			
F	Kay											0.3	1.3	2.3	3.3	4.3

M	Luigi											0.1	1.1	2.1	3.1	4.1
F	Rane											0.1	1.1	2.1	3.1	4.1
M	Afag †											0.3	†			
M	Levant												0.2	1.2	2.2	3.2
M	Tahta												0.1	1.1	2.1	3.1
F	Lamas												0.0	1.0	2.0	3.0
F	Aluna													0.2	1.2	2.2
F	Rüzgar													0.1	1.1	2.1
F	Çöplük													0.1	1.1	2.1
F	Filmi olan													0.1	1.1	2.1
M	Serdar													0.0	1.0	2.0
F	Aluna														0.2	1.2
F	Doğan														0.1	1.1
M	Photo														0.0	1.0
F	M. boncuk														0.3	†
F	Extra														0.1	†

Table 3. Demography table of the monk seal populations in the northeastern Mediterranean; underlined italic numbers are back-calculated ages, horizontal arrows show the dispersed individuals (Taken from Gucu *et al.* 2012)

ex	Code	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
P2 (estimated using the data in Ok (2006))																
M	**Olen-1**	*3.0*	*4.0*	*5.0*	*6.0*	*7.0*	*8.0*	†								
F	**Olen-2**			0.0	1.0	2.0	3.0	4.0	5.0	6.0	†					
F	**Fırtına**							*0.0*	*1.0*	*2.0*	*3.0*	*4.0*	*5.0*	6.0	7.0	8.0
F	**Arap**										→	8.3	9.3	10.3	11.3	12.3
F	**Kınalı**										*0.0*	*1.0*	*2.0*	3.0	4.0	5.0
M	**Rüzgar**													0.1	1.1	2.1
F	**Ali Eksi-1**														0.1	†
M	**Ali Eksi-2**														0.1	†
P3 (estimated using the data in Gucu et al. (2009a))																
M	**Bombacı**												→	19.39	20.39	21.39
F	**YediDalga**							0	1	2	3	4	5	6	7.00	8.00
F	**Karpaz**							0	1	2	3	4	5	6.00	7.00	8.00
F	**Karpaz J**												0.8	1.80	2.80	3.80
F	**Karpaz P**													0.80	1.80	2.80
P4 (estimated using the data in Gucu et al. (2009b))																
F	**Cıralı**	0.20	1.20	2.20	†											
F	**Emine**									*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*5.00*	6.00
M	**IFAW-1**					*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*5.00*	*6.00*	*7.00*	8.00	8.00	9.00
M	**IFAW-2**					*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*5.00*	*6.00*	*7.00*	8.00	8.00	9.00
F	**ÜçAdalar**									*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*5.00*	6.00
F	**Adrasan**													*0.50*	*1.50*	2.50
M	**Erkek**														*0.60*	1.60

The evaluation of survey results, however, reveals that the situation in the Northeastern Mediterranean is not as bad as first feared — and may even be promising. It is evident that the colony on the west coast of Mersin is increasing, and is also following an expanding trend. The caves recently repopulated by the seals are located right in the middle of the two fragmented colonies. At the moment we are not sure if there is sufficient genetic movement between these fragments. However, if the habitat and the caves used by the seals in particular, are kept intact it is very likely that there will certainly be a bridge between isolated populations. In fact, it seems that this is the only chance of the small colony in the Gulf of Iskenderun and Cyprus to survive. On the other hand if only one of the breeding caves in P1 is lost, that would certainly mean a disaster not only for the population in question, but also for the neighboring populations where breeding success depends on migratory individuals originated from P1.

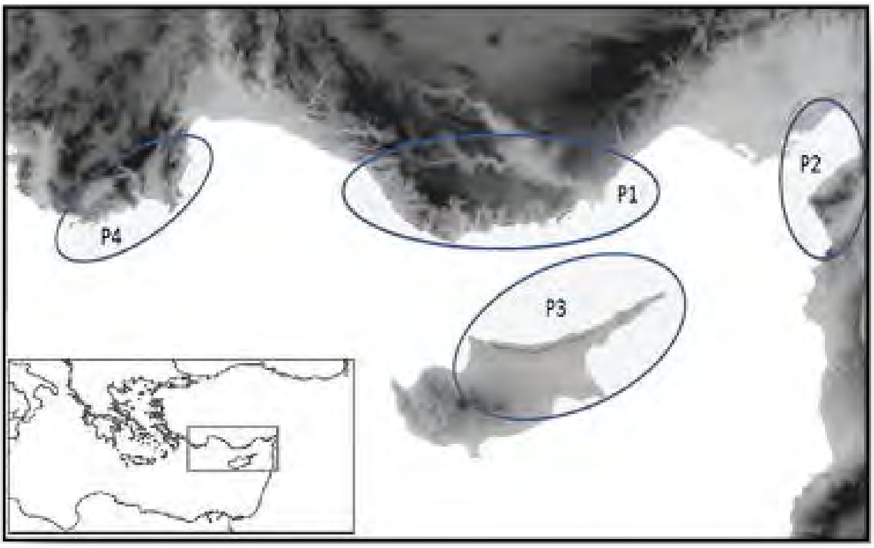

Figure 4. The regions used by the respective seal populations in Northeastern Mediterranean (taken from Gucu *et al.* 2012)

In general, the main accumulation of the seals is observed at the sites where the human interference is minimal, especially at the spots the main road is not in the near proximity. Therefore it would be wrong to conclude that the habitat preferences of the seals are driven by human activities around; the sites with dense human activities are avoided. As given above, the largest and the only viable seal colony inhabiting the east coast of Mersin dwell in a very delicate social structure. The caves that serve to fulfill significant biological requirements, such as resting and breeding play crucial role within this structure. Although karstic morphology on the land permits formation of coastal caves, number of caves bearing certain peculiarities sought by the seals is extremely limited. With this respect the caves has critical importance on the persistence of the colony on this region.

Competition for breeding habitat among Mediterranean monk seal females has never been reported. Moreover, it was observed that two different mothers gave birth in the same cave within the P1 (one month apart) in 2005 and 2006. However it was also observed that two pups died because they were given birth in unfavorable caves (Gucu 2008). Figure 5 shows the relation between number of pups and the pup mortality. In general high pup mortalities were observed when more than 2 pups were born in a harem in a year. Therefore it may be postulated that in addition to the number of suitable breeding caves, the maximum number of pups that can be born in a cave during a whelping season may be a limiting factor determining the reproductive success.

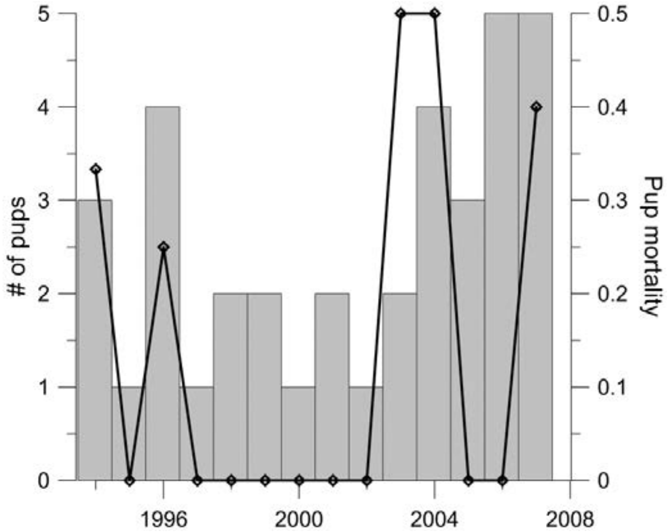

Figure 5. Number of pups (bars) and pup mortality (line) (taken from Gucu *et al.* 2012)

As mentioned above, Turkish part of the Mediterranean Sea hosts one of the last and continuously breeding populations of monk seal in the Mediterranean Sea. The scarcity and importance of breeding caves and the dwindling state of the fish stocks were the main concerns for the survival of the population. In such a situation the best solution seemed be enforcement of a conservation strategy i.e. establishment of a functional network of marine protected areas that will protect critical monk seal habitat and reduces the fishing pressure on main food source of the monk seal. During the last several decades important steps have been made in understanding this elusive species, but more needs to be done to ensure the future of the Mediterranean monk seal.

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