



## Climate Change and Biodiversity Effects in Turkish Seas

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### Abstract

Sea temperature change in the Mediterranean, Marmara and Black Sea coasts of Turkey and its possible biodiversity effects are investigated. The surface sea water temperatures of the Mediterranean, Marmara and Black Sea region of Turkey for last 41 years showed increased trends in Mediterranean Sea (Iskenderun, Mersin and Antalya), Marmara Sea (Istanbul) and Black Sea (Samsun). On the other hand, the number of Indo-Pacific species is getting rapidly increased for the last decade that caused increased invasion of the Indo-Pacific species and significant shift of biodiversity in Turkish Seas. This settlement process is probably accelerated or facilitated by global climate change and overfishing of native species. Nowadays, the occurrence of Atlantic-Mediterranean (*Lithognathus mormyrus*, *Serranus hepatus* and *Callinectes sapidus*) and Indo-Pacific (*Stephanolepis diaspros*, *Lagocephalus spadiceus*) originated species in the Marmara and Black Seas can also be an important indicator of the process of Mediterraneanization of the Marmara and Black Seas.

**Key words:** Climate Change, Sea Surface Temperature, Biodiversity, Turkish Seas.

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### Introduction

The Mediterranean Sea is unique, being a semi-enclosed marginal Sea, with a narrow connection with the Atlantic Ocean through the Strait of Gibraltar, the manmade connection

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to the Red Sea via the Suez Canal, and the narrow Bosphorus Strait connecting it to the smaller enclosed Black Sea (Lascaratos et al., 1999; Turley, 1999). The world's atmosphere and oceans are warming, and the most immediate effects of this on the marine environment include rising sea levels, higher seawater temperatures and acidification, more frequent extreme events and changes in oxygen levels or deoxygenation processes (IPCC Fourth Assessment Report, 2007). Due to these pressures and ecosystem responses, climate change is now considered a major driver of biodiversity change and loss. The Mediterranean will be strongly affected by climate change over the course of this century. The oceanographic and physical aspects of climate change in the Mediterranean have been described in many reports and scientific studies, although uncertainty remains about the degree of physical and chemical change expected at sub-regional and local scales (Lionello, 2012).

Climate change combines with Atlantic influx, lessepsian migration and the introduction of exotic species by humans to favour the occurrence and establishment of warm-water species, whether exotic or native, in 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).

The connection between Mediterranean Sea and Black Sea is re-established 6000 years ago and Mediterranean originated species entered into the Black Sea. At that time, sea level of the Mediterranean was higher than today. This continued process nowadays are called Mediterraneanisation of the Black Sea, which can be more pronounced in forthcoming years.

The present study, surface sea temperature change in the Mediterranean, Marmara and Black Sea coasts of Turkey for last 41 years and composition and distribution of biodiversity based on purse seiner, trawler and trammel net are investigated.

## **Material and Methods**

Surface temperature data of the Mediterranean, Marmara and Black Seas was collected between 1970-2011 years from Turkish State Meteorological Service. Surface sea temperature data for each region were daily taken. The average surface sea temperature were calculated based on weekly, monthly and yearly data.

Catch composition of fish species data were obtained from purse seiner, trawler and trammel net from the Mediterranean Sea between 2009 and 2015 by the project supported the Ministry of Agriculture and Rural Affairs Turkey (TAGEM-09AR-GE11).

A total of 173 hauls were carried out, with bottom trawl net, with a 22 mm cod-end mesh size between 30 and 150 m depth in the Mediterranean Sea. A total of 110 purse seine operations was performed in the Mediterranean, including 52 operations in the Iskenderun Bay, 36 operations in Mersin Bay and 22 operations in Antalya Bay between 2009-2011 yaeras. In trammel nets, a total of 341 operations was carried out of which 118 in the Iskenderun Bay, 118 in the Mersin Bay and 105 in the Antalya Bay.

All operations were carried out for winter, spring, summer and autumn. All fish samples were sorted and scientific nomenclature was arranged according to Eschmeyer (2015). Systematic classification of fish samples was carried out according to Nelson (2006) and Turan (2007).

## Results

Surface sea water temperatures have been increased for all seas, especially for the Mediterranean Sea in which surface sea water temperatures for the Antalya Bay, Mersin Bay and Iskenderun Bay were increased about 1.5°C, 3°C and 2°C (Figure 1, Figure 2 and Figure 3).

The seawater temperature data based on 1970-2011 years increased steadily. In some years, the temperature values compared with the past years were declined slightly. In recent years, the average seawater temperature value was clearly increased that indicates the tropicalization of the Mediterranean Sea.

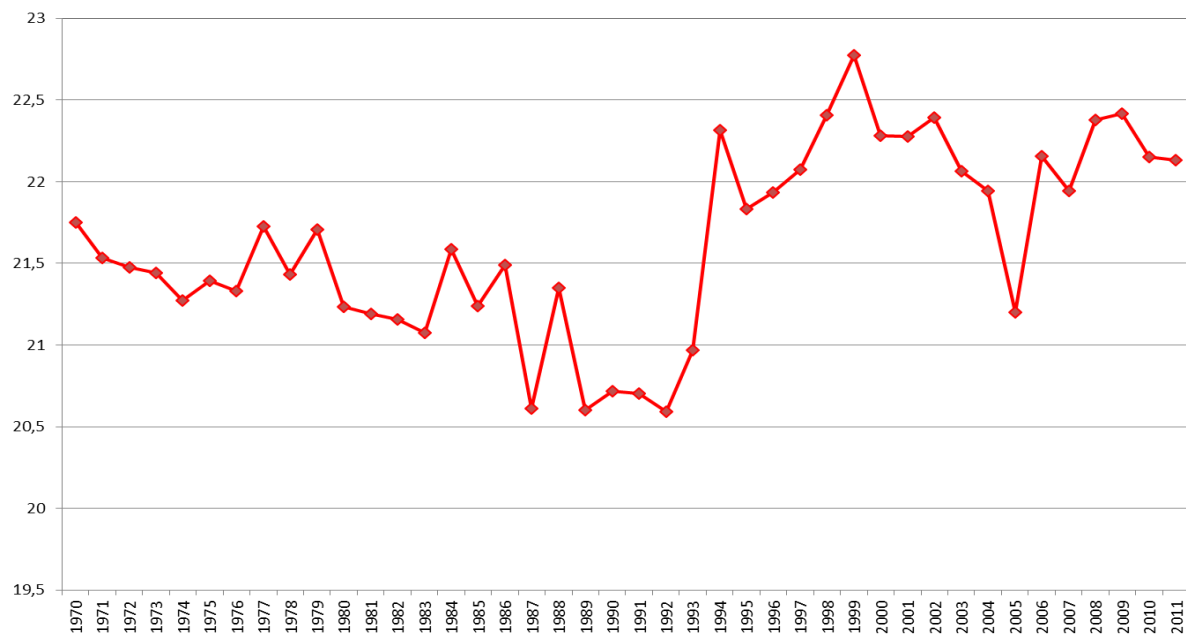


Figure 1. The average surface sea water temperatures at the Gulf of Antalya between 1970-2011.

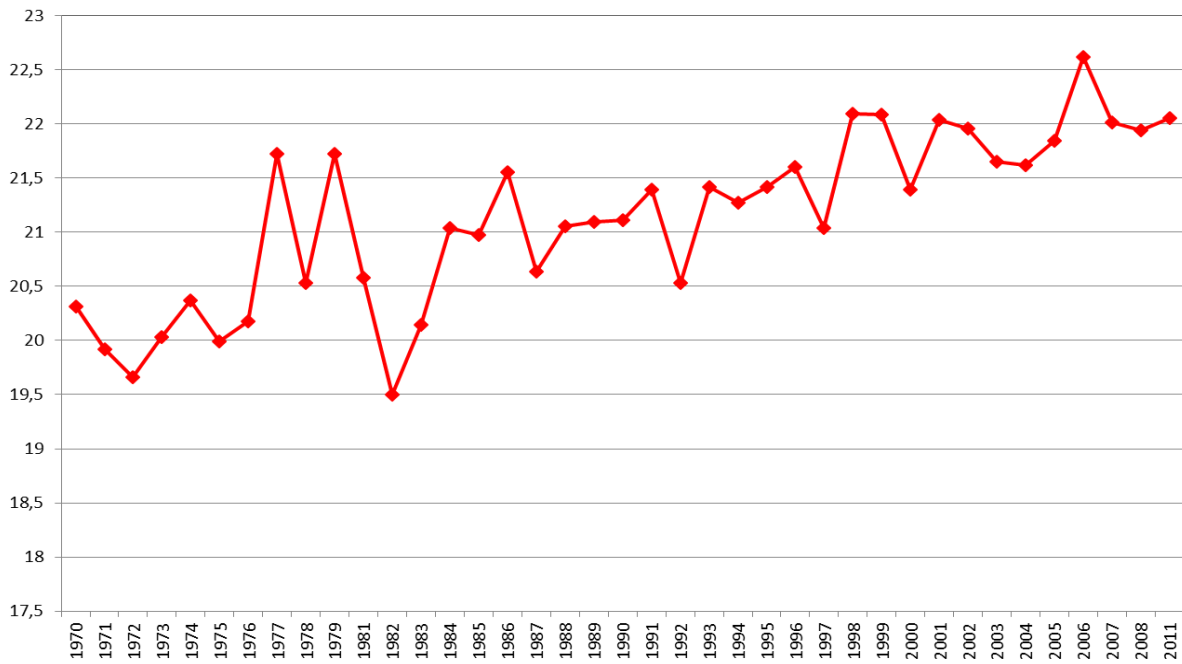


Figure 2. The average surface sea water temperatures at the Mersin Bay between 1970-2011.

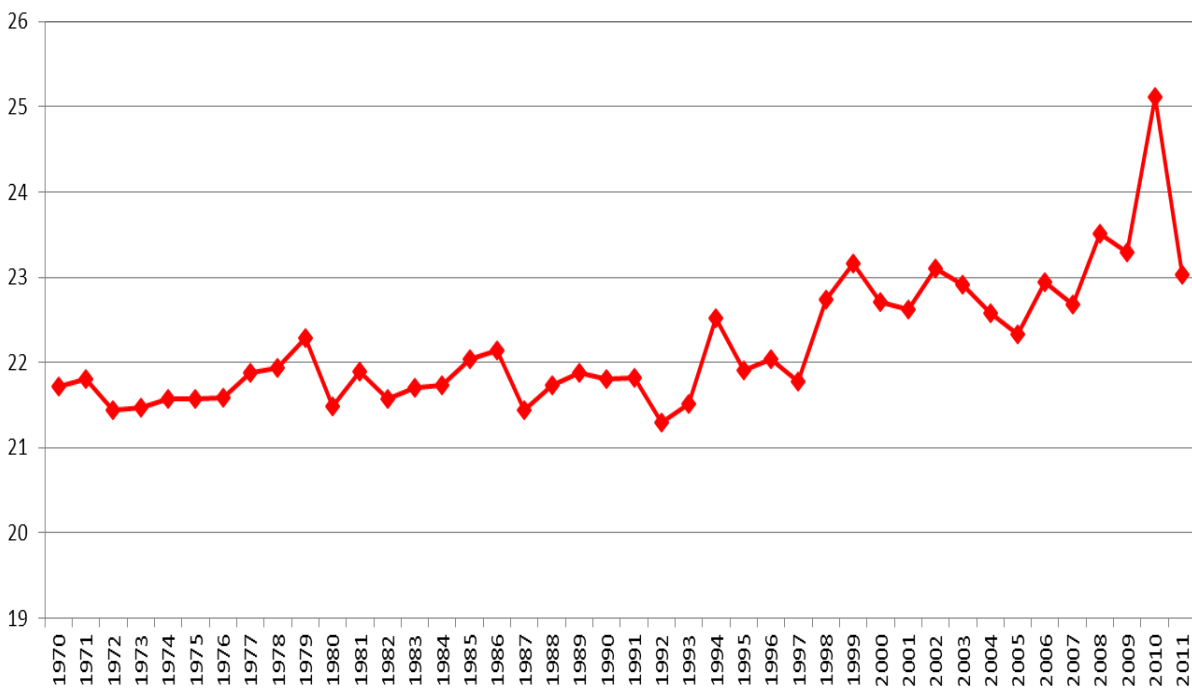


Figure 3. The average surface sea water temperatures at the Iskenderun Bay between 1970-2011.

The surface sea water temperatures of the Marmara and Black Sea region of Turkey showed increase trends for the Marmara Sea (Istanbul) and the middle Black Sea (Samsun), (Figure 4 and Figure 5). A very high sharp decline was observed in 2009 in the middle Black

Sea (Samsun) region. Moreover, a high decline was also observed in 2011 in the Iskenderun Bay region, Northeastern Mediterranean Sea.

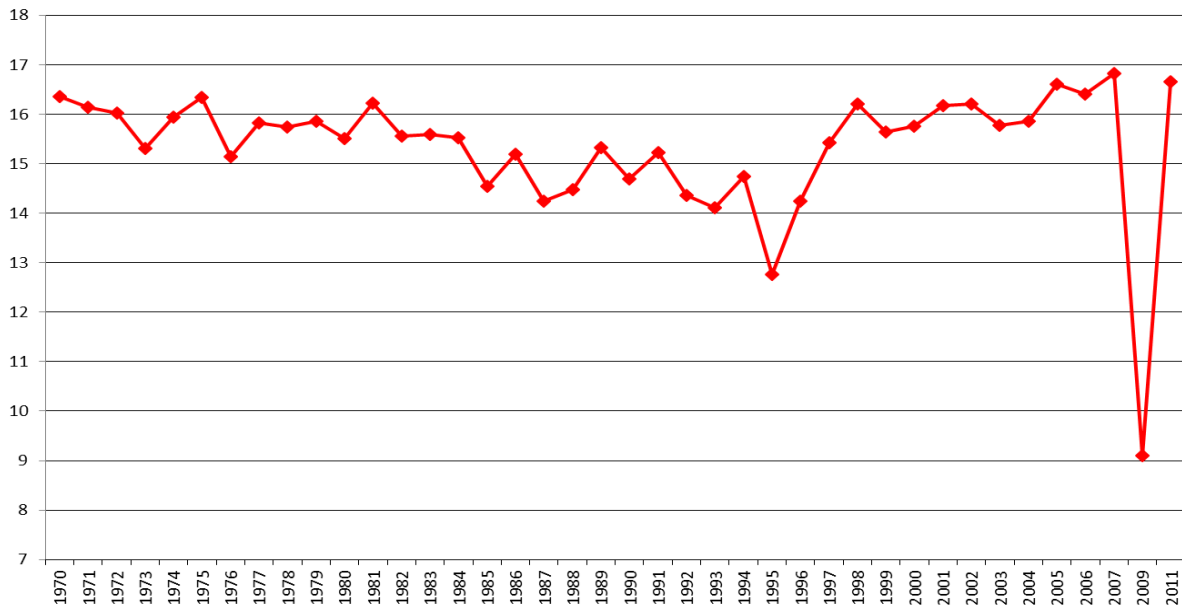


Figure 4. The average surface sea water temperatures at the Middle Black Sea (Samsun) between 1970-2011.

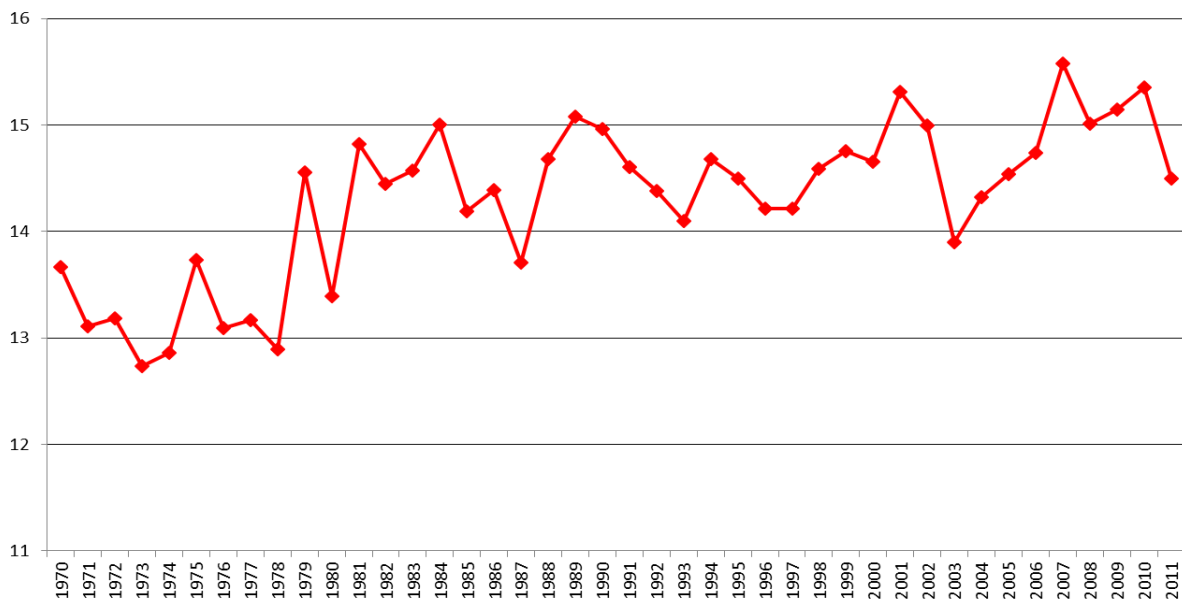


Figure 5. The average surface sea water temperatures at the Marmara Sea (Istanbul) between 1970-2011.

The composition of alien species for trawling purse seiner and trammel net fishery between 2009-2011 years were 27%, 39% and 33% respectively in the eastern Mediterranean

coast of Turkey (the Antalya, Mersin and İskenderun Bays). Highest amount of biomass for alien species were taken by purse seiner fishery.

On the biodiversity aspects, the warming causes an increase in the number of Indo-Pacific species in the Turkish Seas. Up to date there has been 74 alien fish species belonging to 47 families in Turkish marine waters (Figure 6). The number of alien fish species in the Turkish Seas is in highly increasing trend for the last two decades.

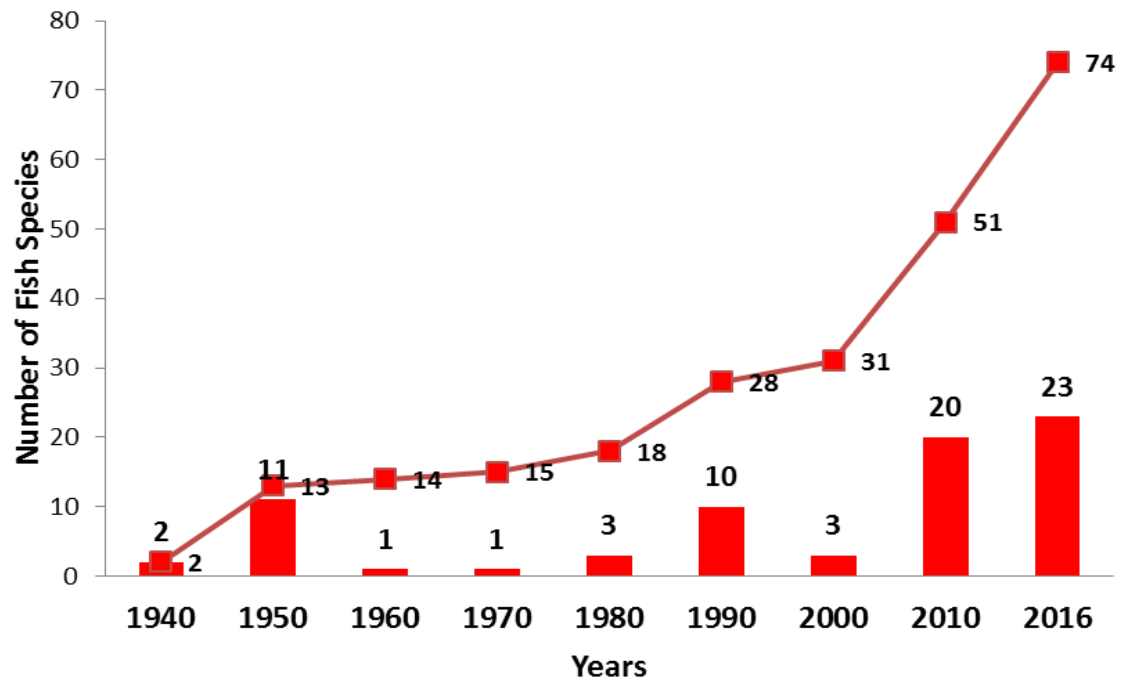


Figure 6. Trends of alien fish species in marine waters of Turkey.

When we consider the distribution of alien species according to families, the highest number of fish species associated were Tetraodontidae (six species) and Apogonidae family (five species), constituting largest alien species in the Turkish marine waters (Figure 7).

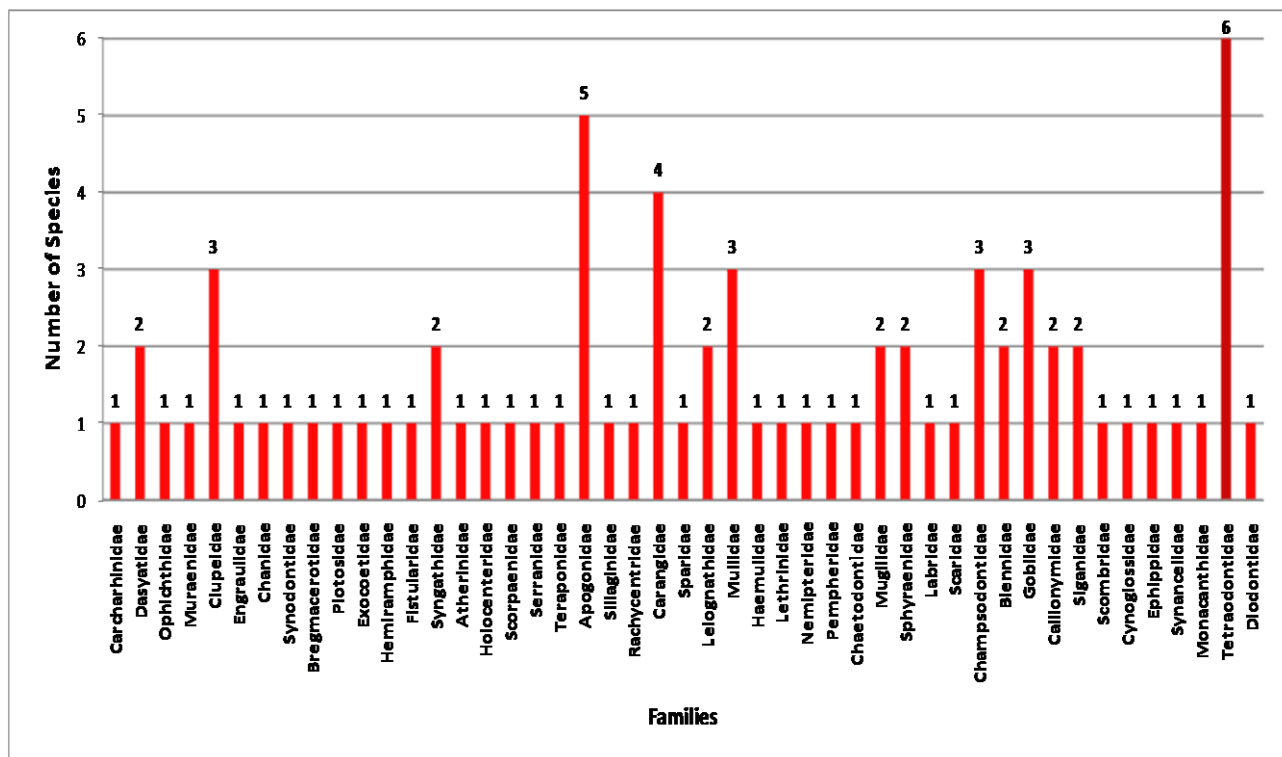


Figure 7. The distribution of alien species according to Families in marine waters of Turkey.

The number of alien fish species according to origin in marine waters of Turkey were 88% Atlanto-Mediterranean, 11% Indo-Pasific and 1% cosmopolitan species (Figure 8).

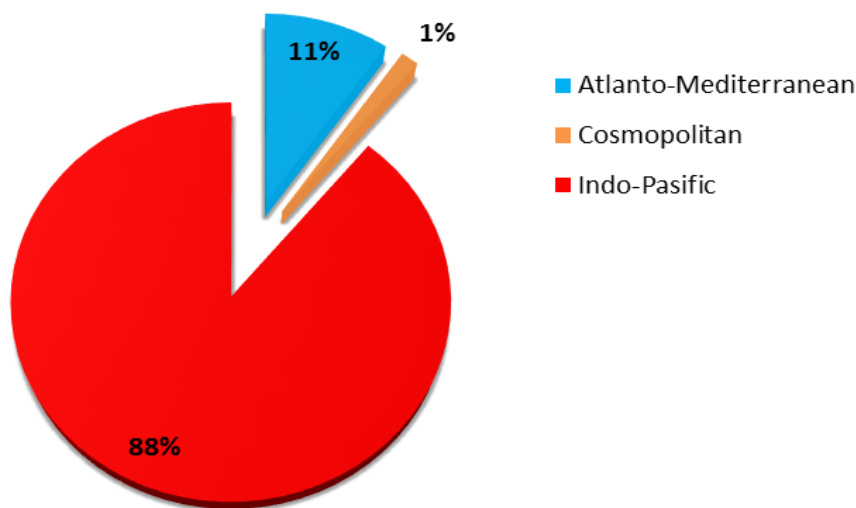


Figure 8. Percentage of composition of alien fish species according to origin in marine waters of Turkey

In Turkish marine waters, the Mediterranean, Aegean, Marmara Sea and Black Seas comprise 61%, 35%, 3% and 1% of the alien fish species, respectively (Figure 9).

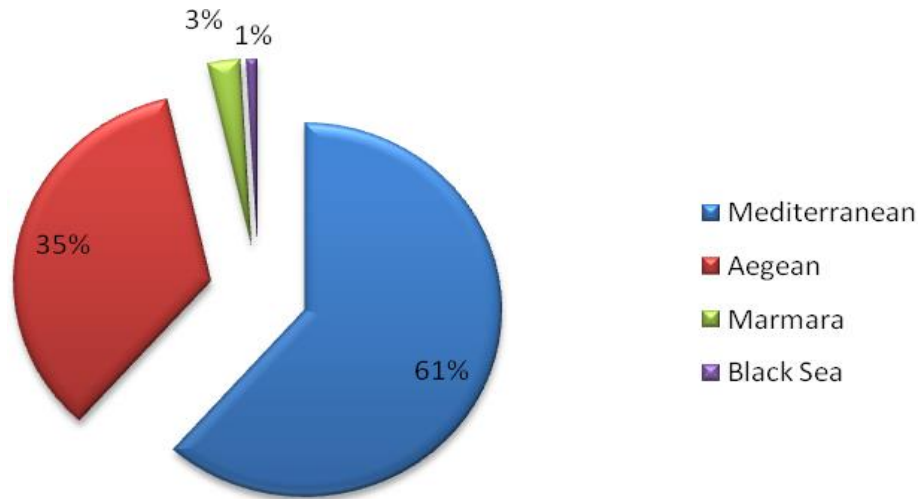


Figure 9. Percentage of composition of alien fish species in marine waters of Turkey.

## Discussion

The average surface sea water temperatures between 1970 and 2011 revealed an increased trend for all Turkish Seas, especially for the eastern Mediterranean part. We related the increase of the sea water temperatures to the biodiversity change in the Turkish marine waters. There seems to be a good relation between the sea water temperatures and the number of migrated Indo-Pacific originated species. The native species are shifting with alien species, especially with indo-Pacific originated species. Nowadays, composition of fishery in the Eastern Mediterranean Sea was about 50 percent lessepsian species. Some of endemic species have been replaced with other Indo-Pacific species. We found that *Decapterus russelli*, *Jaydia queketti*, *Nemipterus randalli*, *Champsodon nudivittis*, *Ostorhinchus fasciatus*, *Cheilodipterus novemstriatus* and *Pomadasys stridens* are having established large communities in Turkish coasts.

The increase of temperatures in the Mediterranean Sea seems to give more favourable conditions for the majority of Indo-Pacific originated migrants. Similarly, Lasram & Mouillot (2009) reported that the successful introductions of indo-Pacific species from the Red Sea and Atlantic species from lower latitudes to the Mediterranean Sea are in correlation with the increasing temperature of the Mediterranean Sea.

In last decades, the rise of sea temperatures in the Mediterranean coast of Turkey allow species such as *Lagocephalus sceleratus*, *Nemipterus randalli* and *Pomadasys stridens* to establish populations in the Mediterranean as the higher temperatures favoured their reproduction compared to the native species. Besides, in recent years, 19 new fish species belonging to 17 families were captured with purse seiner, trawler and trammel net from the Mediterranean Sea (Antalya, Mersin and Iskenderun Bays) between 2009 and 2011 years. According to these results, there will be more invasion of the alien species and more significant change of biodiversity in the Mediterranean. Supporting that three Indo-Pacific origin species, *Argyrops filamentosus*, *Trachurus declivis* (Gurlek et al. 2016a, b) and



*Plotosus lineatus* (Doğdu et al., 2016) have recently been reported from Turkish marine waters in the first half of 2016 year.

The Sea of Marmara exhibits peculiar hydrological conditions, with low salinity waters coming from the Black Sea stratifying over saline waters of Mediterranean origin on the bottom (Unluata et al., 1990). In recent years, climatic change favoured an increase of biotic penetration from the Sea of Marmara into the Black Sea, which therefore has been undergoing a process of 'Mediterranization' (Tokarev & Shulman, 2007; Turan et al. 2010; Yaglioglu et al. 2014).

Today, a major characteristic of species entering the Black sea from the Mediterranean Sea is the fact that they live in its saline and warm waters. For example, the introduction of species like conger, barracuda, johndory, brown comber and striped sea bream in this sea shows that the distribution of thermophilic species is extending. Mediterraneanization, the extension of Mediterranean fauna to the Black Sea, is an ongoing process and new records of Mediterranean-originated fauna for the Black Sea have been given by some scientists in recent years (Engin et al., 2007; Kovacic & Engin, 2009; Yaglioglu et al. 2014). The occurrence of Atlantic-Mediterranean (*Lithognathus mormyrus*, *Serranus hepatus* and *Callinectes sapidus*) and Indo-Pacific (*Stephanolepis diaspros*, *Lagocephalus spadiceus*) originated species in the Marmara and Black Seas (Dalgıç et al., 2013; Bilecenoglu et al. 2014; Yağlıoglu et al. 2014) can be an important indicator of the process of Mediterraneanization of the Marmara and Black Seas.

As a consequence, alien species have found optimal environment for settlement in the Eastern Mediterranean. One of the major reasons of the introduction of these species in the Mediterranean Sea and other Seas (Marmara and Black Sea) of their spread by forming colonies that enter in competition with native species is the rise of the seawater temperature.

### Acknowledgements

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