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Comparatively Evaluation of the Sprat (*Sprattus sprattus*) Fisheries in the Whole of the Black Sea and in the Turkish Coast of the Black Sea

Karadeniz'in Tamamında ve Türkiye Kıyılarında Yapılan Çaça (*Sprattus sprattus*) Balıkçılığının Karşılaştırmalı Olarak Değerlendirilmesi

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ABSTRACT

The purpose of this study was to investigate comparatively the sprat (*Sprattus sprattus*) fisheries in the whole of the Black Sea and in the Turkish coast of the Black Sea. With this aim, the prior studies on the sprat fisheries conducted from 1970 to recent years in the Black Sea and Turkish coast of Turkey were examined. Especially changes in annual catch amounts and on likely reasons were focused. As a result of evaluating the obtained data, necessary precautions for sustainable fisheries were determined and solution proposals have been presented. Sprat is the second most caught fish species in recent years and an important raw material resource for fish flour and fish oil industry. Especially in the Samsun coast of Turkey, this is target species for commercial pelagic trawl fisheries. Sprat has been caught by Georgia, Russia Federation, Ukraine, Romania and Bulgaria from the Black Sea since the beginning of 1970s. In Turkey, the first sprat fishing started in 1993 and increased gradually until 2007. Sprat catch increased rapidly from 2008 to 2011 and reached 87.141 tons in 2011 after which a sharp decline occurred (12.092 tons in 2012 and 9.764 tons in 2013). Then, it increased again and reached 41.648 tons in 2014 and 76.996 tons in 2015. Trend of annual catch values showed that there is no stability in the stock of this species in Turkish waters of the Black Sea.

Keywords: Turkish Black Sea coast, sprat, *Sprattus sprattus*, fishery.

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ÖZET

Bu çalışmanın amacı, Karadeniz'in tamamında ve Türkiye kıyılarında yapılan çaça (*Sprattus sprattus*) balıkçılığını karşılaştırmalı olarak incelemektir. Bu amaçla, 1970 yılından bugüne Karadeniz ve Karadeniz'in Türkiye kıyılarında yürütülmüş çaça balıkçılığına ilişkin önceki çalışmalar incelenmiştir. Özellikle yıllık av miktarlarındaki değişimler ve muhtemel nedenleri üzerinde durulmuştur. Elde edilen verilerin değerlendirilmesi sonucunda, sürdürülebilir balıkçılık için alınması gereken önlemler belirlenmiş ve çözüm önerileri sunulmuştur. Çaça, Karadeniz'deki ikinci en bol balık türüdür ve balık unu ve balık yağı fabrikaları için önemli bir hammadde kaynağıdır. Türkiye'nin özellikle Samsun kıyılarında, orta su trolü balıkçılığı için en önemli hedef türdür. Bu tür, 1970'lerin başından beri Gürcistan, Rusya Federasyonu, Ukrayna, Romanya ve Bulgaristan tarafından Karadeniz'den avlanmaktadır. Türkiye'de ise ilk çaça avcılığı 1993 yılında başlamış ve av miktarı 2007 yılına kadar tedrici olarak artış göstermiştir. Çaça avı 2008'den 2011'e hızla artarak 2011'de 87.141 tona ulaşmış ve ardından 2012'de 12.092 tona ve 2013'de 9.764 tona kadar keskin bir düşüş göstermiştir. Daha sonra tekrar artarak 2014 yılında 41.648 ton, 2015 yılında 76.996 ton seviyesine ulaşmıştır. Yıllık av değerlerinin eğilimi, Karadeniz'deki Türk sularında bu türün stokunda istikrar olmadığını göstermektedir.

Anahtar sözcükler: Karadeniz'in Turkiye kıyıları, çaça, *Sprattus sprattus*, balıkçılık.

1. INTRODUCTION

Fisheries activities in the Black Sea have been sustained since ancient times. In recent years, industrial, semi-industrial and small-scale fisheries coexist using many different fishing gears. With small pelagic species such as anchovies intensively fishing, the catch amount which was around 400 thousand tons in 1970, exceeded 900 thousand tons in 1988. During the period from the end of the 1980s to the today, the total annual landing varied between 300 and 600 thousand tons, mainly due to the rapid collapse of pelagic fish stocks.

Fish stocks in the Black Sea are often shared by fleets from 6 riparian countries. In this sea, 68% of the total catch is fished by Turkey. This country was followed by Ukraine, Russian Federation and Georgia, respectively. More than 90% of the fish caught from the Black Sea consisted of small pelagic fish species (less than 10 species) such as anchovy, horse mackerel (*Trachurus mediterraneus*) and etc. Fisheries in this sea are affected by different threats such as the effects of increased pollution from human activities, habitat degradation, the introduction of alien species, overfishing and the impacts of climate-driven changes in the marine ecosystem (FAO, 2016a).

After the anchovy, the sprat (*Sprattus sprattus*) is the second most abundant, planktivory and pelagic fish species in the Black Sea. For larger fish species, they are an important food source. They are very important for the ecosystem. Because they represent the link between plankton and predator fish. Thus its population level exerts top down control on the lower components of the food web, and bottom-up control on the upper components of the ecosystem of zooplankton and a main food resource for top predators (dolphins, spiny dogfish, mackerel, whiting, turbot etc.). Anchovy and sprat populations show strong fluctuations depending on environmental

conditions. Food supply is one of the most important conditions determining the population size of small pelagic fish (Nikolsky, 1965).

As mentioned above, sprat is an important fish species for Black Sea fishery in terms of both its mission in ecosystem and commercial value. Especially in the last 20 years, the fishing pressure on the sprat stock has increased considerably and it affected negatively the sprat stock. The present study was focused on history and current status of the sprat fisheries in the Black Sea and Turkish waters of the Black Sea.

2. MATERIALS AND METHODS

2.1. Black Sea

The Black Sea is a sea isolated from the World Oceans. It connected to the Oceans via the Mediterranean Sea through Istanbul and Canakkale straits and Gibraltar straits and with the Sea of Azov in the northeast through the Kerch Strait. It lies among Bulgaria, Romania, Ukraine, Russia Federation, Georgia and Turkey. The Black Sea coast lines of Ukraine, Turkey, Russia Federation, Georgia, Bulgaria and Romania are 1.628, 1.400, 475, 310, 300 and 225 km, respectively (European Commission, 2010). The southern of Black Sea is covered by the Turkish Exclusive Economical Zone (EEZ) (172.199 km^2), the northwest and the north-central by the Ukraine EEZ (144.038 km^2), the northeastern by the Russian Federation EEZ (66.854 km^2), the southeast by the Georgian EEZ (22.765 km^2), and the western by the Bulgarian (35.156 km^2) and Romanian EEZ's (20.598 km^2) (Oguz *et al.*, 2012).

Black Sea receives significant fresh water input from rivers such as the Danube, the Dnieper and the Don and its catchment area is over one third of continental Europe. The Black Sea has high river supply, but water output through the İstanbul strait is restricted. That is, water cycling is rather limited. This created a typical stratification in this sea and waters below ca. 150 m are anoxic. With more than 80% of its waters being anoxic with a high content of hydrogen sulfide, the Black Sea contains the largest mass of lifeless water on Earth. Marine organisms are concentrated in the upper oxygenated layer, and the continental shelf situated above the limit of anoxia hosts abundant bottom life. While the continental shelves of the Black Sea are wider in the northwest and southwest regions, does not exceed 20 km in the remaining parts of the sea. The wide north-western shelf in particular is the most important spawning and feeding area for the Black Sea fish species. In the Black Sea, all the waters are under the jurisdiction of the coastal states (European Commission, 2010).

Marine fisheries is an important economic sector in the Black Sea countries, and virtually all the commercial fish stocks in the Black Sea are shared among riparian countries. 48.3% of the total catch obtained from the Black Sea are fished by Turkey. 32.70, 10.08, 4.14, 2.78 and 2.17% of total catch were fished by Ukraine, Russia, Georgia, Romania and Bulgaria, respectively (Ak and Genc, 2012). On the other hand, according to FAO (2016b) Turkey's share in the total catch was 68% and it was followed by Ukraine, Russian Federation and Georgia. The Black Sea is characterized by a relatively low species diversity and high productivity (Knudsen *et al.*, 2010). Over the last 50 years, ichthyofauna in the Black Sea has undergone major changes concerning either its qualitative and quantitative structure and the behaviors of various species.

2.2. Sprat (*Sprattus sprattus)*

Sprat is a small-bodied pelagic fish species that is most abundant in shallow waters. Sprat reaches sexual maturity at age 1. It spawns throughout the year, but the most intense spawning occurs between November and March. In the winter period, eggs are encountered in the surface and deeper waters and in the summer period only at depths below 10 m (Radu *et al.*, 2010). In the summer period, the juvenile and adult sprat leave the upper layer and

thus avoid severe competition for food with other plankton-consumers such as *Mnemiopsis leidyi*. During this period their preferred food consists mainly of the cold-water *Calanus* and *Pseudocalanus* copepods living below the cold intermediate layer of the water column (Totoiu *et al.*, 2016).

Sprat is a relatively short-lived fish species. It is caught predominately age 1 and age 2. Fish that is 4 years or older are rarely caught. This species is widely distributed in the Europe and North Africa, ranging from Morocco to Norway, including the Black Sea and Baltic Sea (Whitehead, 1985 and 1986), but stays largely within the 50 m depth contour and is also common in inshore waters. Its distribution is strongly affected especially by hydrographic conditions. It is known that larvae are the most abundant in the vicinity of tidal mixing fronts (Valenzuela and Vargas, 2002). This species can adapt to salinity changes in a wide range and therefore this species is abundant in estuaries (Araujo *et al.*, 2000).

The Black Sea sprat is an important species for the Black Sea ecosystem. Daytime it is found in deeper waters and nights move closer to the surface. It forms big schools and migrates seasonally between inshore and open sea (Ivanov and Beverton, 1985). But there are no specific spawning or feeding migrations. Mostly adults tend to stay under thermocline, they only go up in the spring and in the autumn. In warm water, the offspring cover a large spreading area on the surface (Radu *et al.*, 2010). It is known that this species is widely distributed in the north-western part of the Black Sea. It is a migratory fish species and has migration routes in the Black Sea basin (Figure 1).

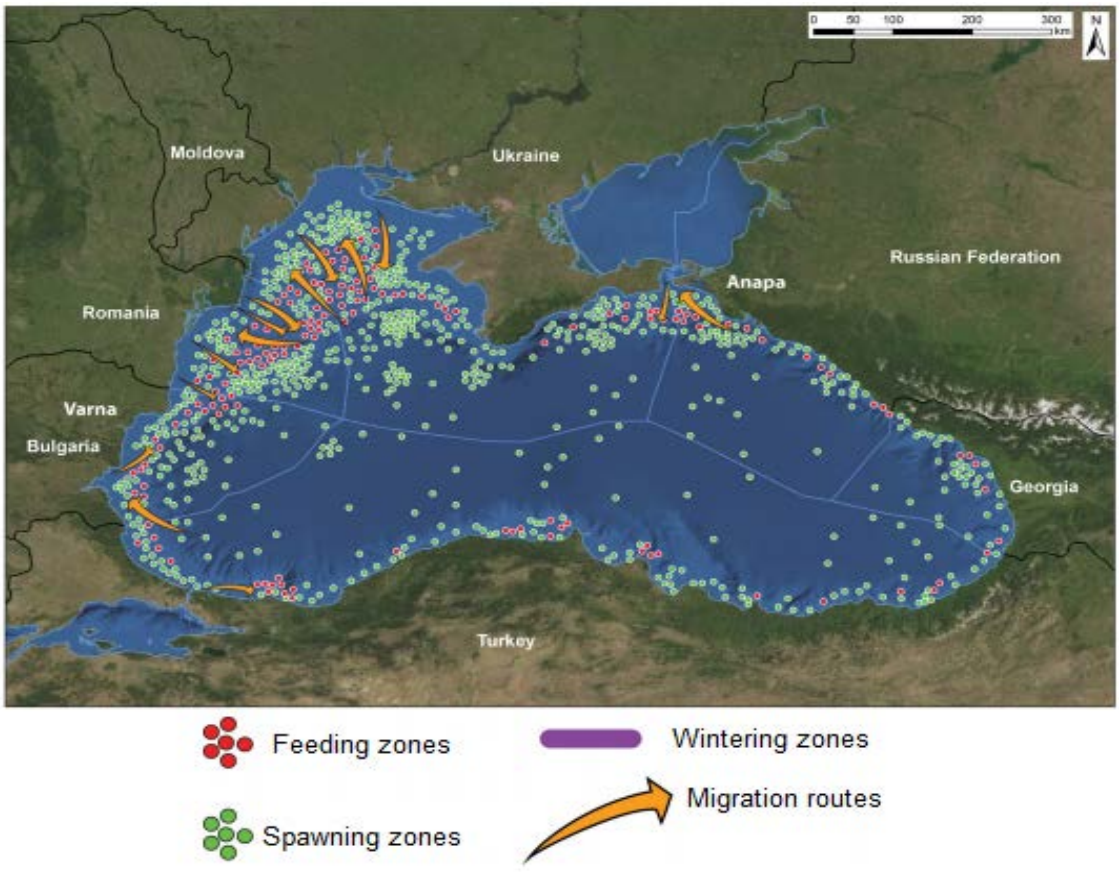

Figure 1. Sprat migration routes in the Black sea basin (European Commission, 2013).

Sprat is one of the most important fish species in the Black Sea that is fished and consumed by the riparian countries. It is the most abundant small pelagic fish species in the this sea together with anchovy and horse mackerel and accounts for most of the landings in the north-western part of the Black Sea. Although there is no target species except of Turkey, whiting is also caught as a bycatch in the sprat fishery (Raykov, 2006). In the Black Sea, sprat fisheries is carried out during daytimes and when they form large schools. This species is generally fished with pelagic pair trawls and purse seine nets.

Sprat lives at depth of 80-100 m during the winter period, approaches the littoral region in April and May, and migrate from the coast to the open sea to avoid high water temperature in the summer period. This species is an important food for many top predators. It is mainly landed for industrial processing, but a small market exists for human consumption. It is not the only raw material for the fishmeal and oil industry, but also fresh food for people (Ceylan and Emir, 2015)

2.3. Data Collection and Analysis

To evaluate the sprat fisheries in the Turkish Black Sea coast were gathered scientific results from previous some studies in this sea (Prodanov *et al.,* 1997; Düzgüneş and Erdoğan, 2008; Radu *et al.,* 2010; Knudsen *et al.,* 2010; Oğuz *et al.,* 2012; Öztürk *et al.,* 2013; FAO, 2016a and etc.), catch data from the FAO (2016b) and TUIK (2016) fishery statistics and information and opinions of fishermen on the sprat fisheries.

3. RESULTS AND DISCUSSION

3.1 Sprat fisheries in the Black Sea

The opportunities of marine fishing in the Black Sea limited by its specific characteristics (Limborg *et al*., 2009). The exploitation of the fish recourses is restricted by the shelf area. Sprat is present over the entire shelf, but the concentration of fishing agglomerations is highly influenced by environmental conditions, especially the direction and intensity of wind and water temperature (Radu *et al.,* 2013). Since the waters below 100-150 m of the Black Sea are anoxic and contain hydrogen sulfide, fishing conducted mostly on the continental shelf (Shlyakhov and Shlyakhova, 2011). The continental shelves are widest in the northwest of this sea. Thus, it is known that this species is widely in the north-western part of the Black Sea.

The sprat stock in the Black Sea were overfished by the former Soviet Union in the 1950s and 1970s (Barros, 2011). According to SAU (2016) statistics, the sprat have been commercially fishing in the Black Sea since the beginning of 1970s (Figure 2). After the 1970s, the fishing pressure on this species has increased rapidly and high exploitation has caused to decline of its stock. It is also suggested that this decrease is due to the increase in the abundance of the predatory ctenophore *Mnemiopsis leydi* in the late 1980s (Daskalov, 1998; Shiganova and Bulgakova, 2000). During 1980-2002, the dramatic reduction and the disappearance of the traditional predators from the Black Sea ecosystem (bluefish, Atlantic mackerel, bonito, dolphins) led to increase in the pelagic fish stocks (sprat, anchovy, horse mackerel) (Daskalov, 2002; Daskalov *et al.,* 2007). After the 1990 stock collapse, recruitment, biomass and catches of sprat began to increase, and the stock reached the previous peak-level recorded in the 1980s by the early 2000s (European Commission, 2010). However, the sprat catch decreased again between 2003 and 2007. Between 2008-2011, the total catch of this species has increased excessively because of intensification of sprat fishing in Black Sea coast of Turkey. This overfishing caused a decrease in the sprat catch again.

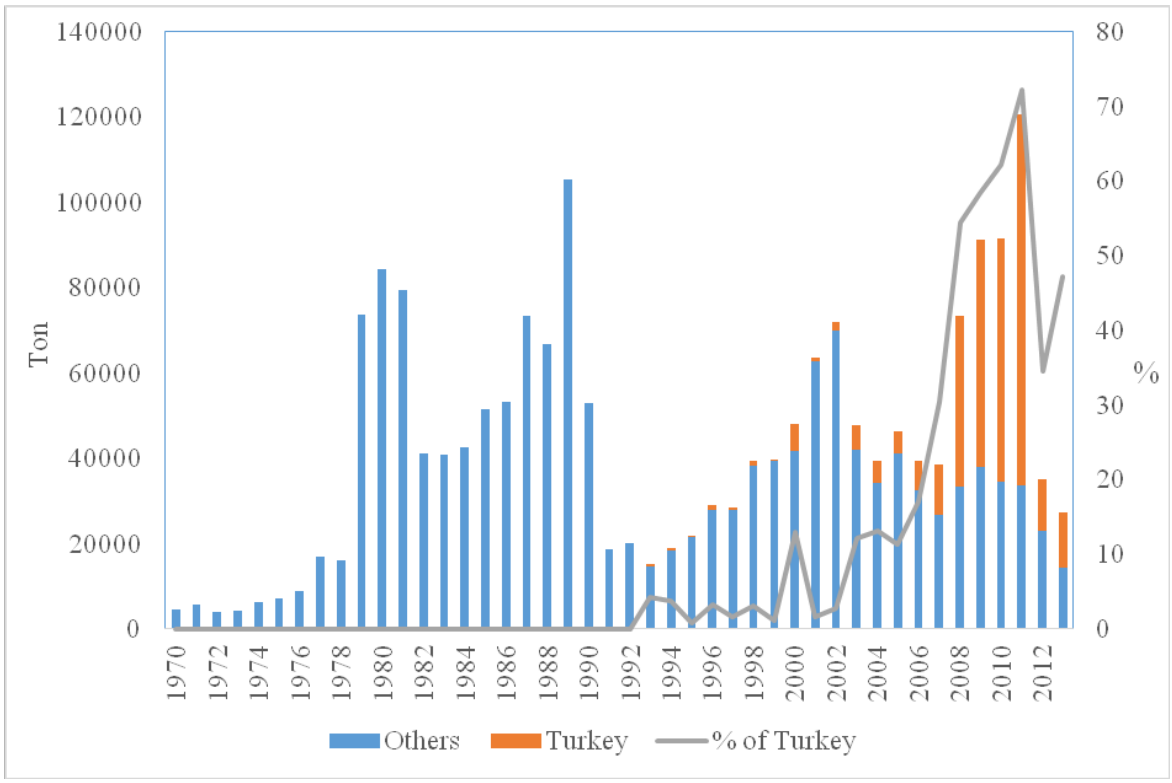

Figure 2. Distribution of the sprat catch captured by Turkey and other Black Sea countries in the Black Sea from 1970 to 2013.

3.2. Sprat fisheries in the Turkish coast of the Black Sea

The sprat is caught only in along Yesilırmak-Kızılırmak shelf area in the Turkish waters of the Black Sea (Figure 3). In recent years, about 40 pairs of vessels have operating to catch sprat in this shelf area. In the Black Sea coast of Turkey, the sprat are caught by pelagic pair trawls. Fishing with these nets can be done at 0-24 m in the spring and 40-80 m in the autumn (European Commission, 2013).

In Turkey, there was only two pelagic trawl vessels between 1993 and 1996. It has reached 8, 30, 70 and 82 in the 2000, 2005, 2010 and 2011 years, respectively. Thus, the catch amount of sprat has steadily increased until 2010, with increasing number of pelagic trawl vessels (Figure 4).

In Turkish waters of the Black Sea, very little sprat was caught until the mid-2000s. After those years, both the vessel number and the catch amount increased sharply and peaked in 2011. Then, the annual catch collapsed in 2012 and 2013, but it started to increase again in 2014 and 2015.

SAU (2016) fishery statistics shows that the sprat has been caught by Turkish fishermen since the early 1990s. But, it has become a target species in the mid-2000s. Because, it had no value as food until that years. In fact, it is still so. However, between 1983 and 1995 a total of 25 fish flour and oil factories were established by the government's credit support (Özdamar and Aral, 1995). Catch amount of the anchovy was not enough to provide food and the raw material of these factories. The sprat was considered as an alternative raw material for these factories. Therefore, it has been used as a raw material in the fish flour and oil factories since the end of 1990s.

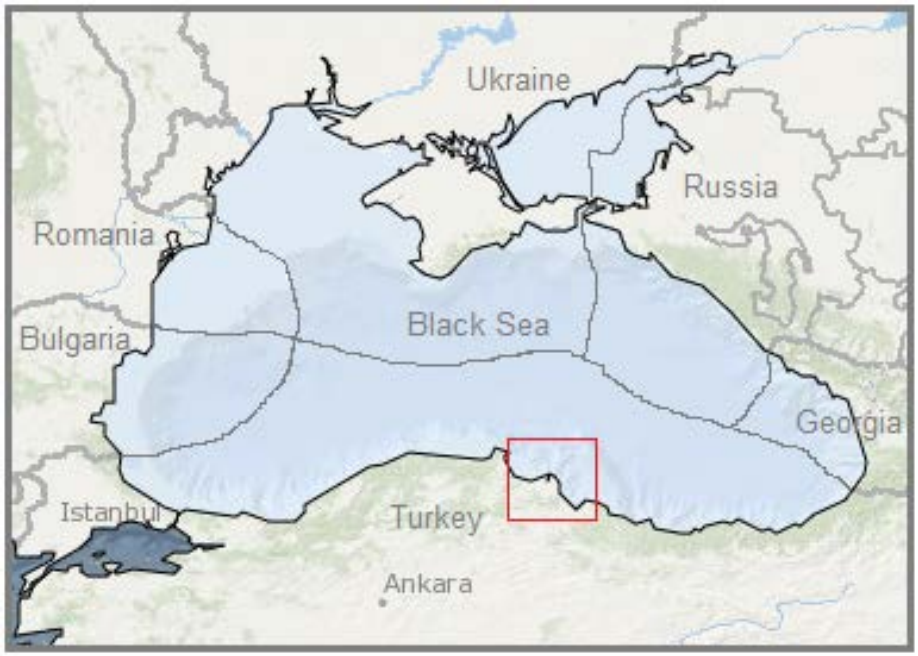

Figure 3. Map showing free area for sprat fishing with pelagic trawl in the Samsun shelf.

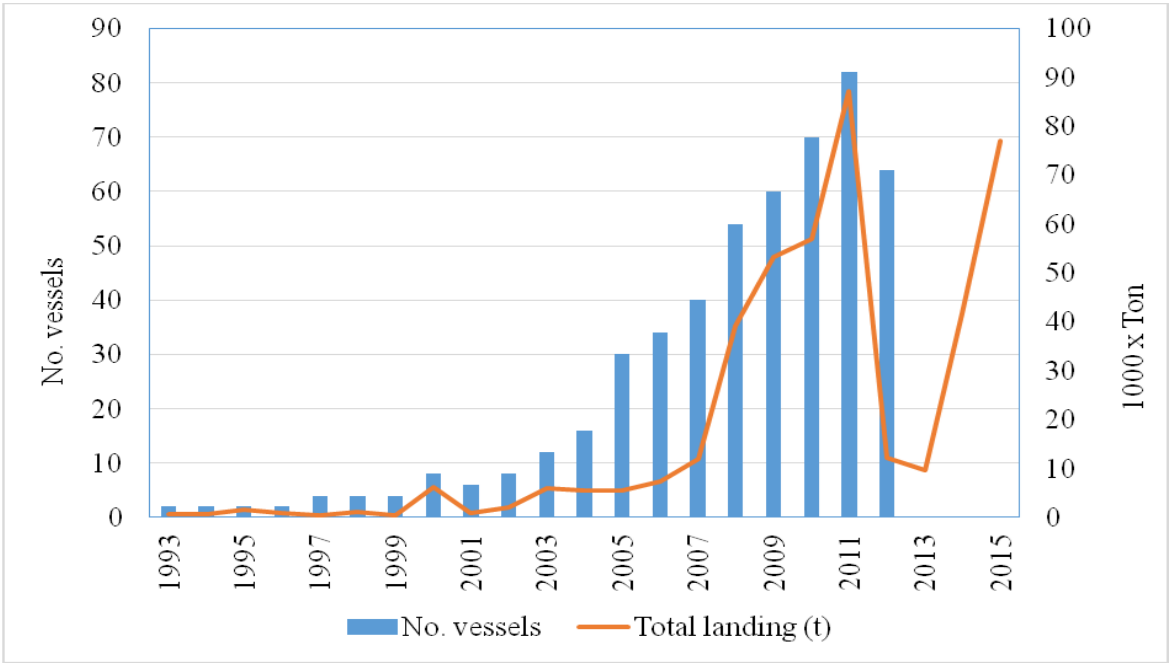

Figure 4. Distributions of the annual sprat cath and vessel number in the Turkish waters of the Black Sea (European Commission, 2013; TSI, 2016).

The sprat was caught with the traps and other fishing nets until the 1970s. In the Black Sea, pelagic trawl was used first time by Bulgaria in 1970 and by Russia Federation after 1976 for fishing sprat (Zengin *et al.*, 2002). At first, pelagic trawl was used to catch the shark (*Mustellus* spp.) in the Turkish waters of the Black Sea in the 1990s (Zengin *et al.*, 2002). During fishing operations, some fishermen observed that anchovy was also caught in this net. In briefly, it has been using for the anchovy, horse mackerel and sprat fishing in the Samsun self since that years.

Zengin *et al.* (2011) reported that the mesh size of pelagic trawls used was 12 mm for sprat fishery in the Samsun shelf. For this mesh size, largely (80%) of the sprat catch were composed of 2 and 3 aged mature individuals having 8 and 9.3 cm average total lengths, respectively. The rate of 1 year old individuals in catch composition was only 9%. It can be concluded that the actual fishery already using 12 mm mesh size do not make any negative impact on immature population and can be defined as confident in the Samsun shelf area. On the other hand, the same study emphasized that the fishery should be more deliberate in the period of new recruitments namely in March, April and May. Because, the ratio of young individuals was found relatively higher in the fall and winter than spring. In fall (September, October and November) almost all of the population was composed of mature individuals. The length range for this period was from 8.0 cm to 9.5 cm. In February, while the spawning considerable decreased, the rate of immature individuals was 30% and new recruits started to be observed. The rate of young individuals in the population was 40.3% in March, 62.3% in April and 55.5% in May.

The sprat catch reaches its maximum value in the spring, especially between March and May. It is suggested that increase in the spring months is possibly related with the vertical migration behavior of sprat depending on season and sea water temperature (Zengin *et al.*, 2002). In addition, the individual experience of the fisherman and the quality of technical equipment on the vessel are factors influencing the amount of daily catch.

The management of population requires in the spring period much more sensitivity than in the fall and winter periods, as the sprat school involving new recruits moves toward the near shore ecosystem. Here, the sprat shares habitat with other bentho-pelagic macro fauna. In the Turkish coast of the Black Sea, the bottom and pelagic trawling are forbidden between 15 April and 31 August. Exceptionally, the sprat fishing is free from the April 15 to May 15 between Samsun Province Yakakent District Çayağzı Cape (41°41.040'N-35°25.193'E) and Ordu Province Unye District Taşkana Cape (41°08.725 'N-37°17.531'E) in the 24 m and deeper waters (RG, 2016). To protect young individuals in this period, the minimum fishing depth should be increased from 24 m to 40 m. This is a reasonable management strategy to conserve the young population. On the other hand, along the waters deeper than 40 m, the mesh size of 12 mm which is already in practice is sufficient to maintain the population which is largely composed of new recruits.

According to Zengin *et al.* (2011), the sprat is not exposed to a significant fishing pressure in the last two decades for the southern coast of Black Sea. At least, the actual landing in 2010 confirms this statement. The sprat fishery started at the beginning of 2000s and increased rapidly in the last decade in the Turkish coast. For this reason, perhaps being the unique population in Turkish coast that has not been previously exploited–or slightly exploited-the sprat population may likely give response to heavy exploitation in future years. The parameters of fishery did not reflect a fishing pressure on the population until 2010, but threatens a steadily increased fishing effort. Another important indicator can be mentioned as the growing demand on sprat by the regional fishing industry producing fish oil and meal.

In fact, fishing of sprat started at the beginning of 2000s and increased rapidly until 2011 in the Turkish waters of the Black Sea. Within this period, the vessel number of the pelagic trawl increased gradually. Therefore, this development probably caused excessive sprat fishing. The response to the steadily increased fishing pressure appeared in 2011 as suddenly decrease in the catch amount. According to Zengin *et al.* (2011), another important indicator can be mentioned as the growing demand on sprat by the regional fishing industry producing fish oil and meal.

4. CONCLUSION

• The total sprat catch was very less at the beginning of the 1970's. It peaked at the beginning and end of the 1990s and 2000s.
• Sprat has been caught in Turkish coast of the Black Sea since the early 1990s and its proportion in the total sprat catch was very low until the mid-2000s. However, in the late 2000s, more than half of the total sprat catch was caught from the coast of Turkey.
• Sprat is an important raw material resource for fish flour and fish oil industry.
• The sprat is caught only in along Yesilırmak-Kızılırmak shelf area in the Turkish waters of the Black Sea.
• The sprat catch in Turkish coast of the Black Sea showed significant fluctuations in the recent years.
• According to regulations of sprat fisheries in Turkey: - Sprat must be fished by pair pelagic trawls during daytime, - Fishing must be conducted at depths of 20-40 m in the spring and in the deeper water (40-80 m) in the autumn.
• In Turkey, pelagic trawls operate as paired vessels. Vessels engaged in the sprat fishery need to receive license eligible only for one fishing period from Samsun City Directorate of Food, Agriculture and Livestock.
• In the Black Sea pelagic trawling starts in 1 September as same as bottom trawling, it lasts until May 15. Bottom trawling ends in April 15.
• Fishing with pelagic trawl is banned in waters shallower of the Black Sea than 24 m between 15 April and 31 August. But, between 15 April and 15 May it is allowed in waters deeper than 24 m limited with offshore of Çayağzı Cape (Samsun-Yakakent) in west and Akçay estuary (Samsun - Ordu city border) in east. The rate of young individuals in the sprat population is larger in the April and May periods than other seasons and they move toward the near shore ecosystem in these months. In order to prevent the fishing of the young individuals, the sprat fishery should not be allowed at least in waters below 40 m depth from 15 April to 15 May.
• There are no regulations on sprat fishing such as quotas, regional prohibit, etc. Current arrangements are not sufficient for sustainable sprat fisheries in the Black Sea.
• As in Romania and Bulgaria which are European Union countries, quota should be applied in other riparian countries for the sprat fisheries.
• For more opening of the mouth of the pelagic trawl, the fishermen add extra weights to the lead line of pelagic trawl. Thus, they catch benthic fish species instead of pelagic species. In order to prevent this illegal fishing, operations of pelagic trawl vessels should be controlled more frequently.

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