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The State of Black Sea Fisheries: Evaluation of the Anchovy, *Engraulis encrasicolus* Fisheries

Karadeniz Balıkçılığının Durumu: Hamsi (*Engraulis encrasicolus*) Balıkçılığının Değerlendirilmesi

Türk Denizcilik ve Deniz Bilimleri Dergisi Cilt: 3 Sayı: 2 (2017) 81-95

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ABSTRACT

In this study, fisheries statistics were investigated in the Black Sea from 1950 to 2014 and the history and current state of especially anchovy, *Engraulis encrasicolus* fishery were evaluated. Catch statistics of countries were taken from "www.seaaroundus.org" and FAO fisheries statistics. As known, fish stocks in the Black Sea are shared among the bordering countries. Results of the study showed that the most annual catch was caught obtained by Turkey with mean 200200 tons yr^{-1} since 1950. This country was followed by Georgia (41900 tons), Russia Federation (40900 tons), Ukraine (23200 tons), Romania (1300 tons) and Bulgaria (100 tons), respectively. Total fish landings in the Black Sea were around 400000 tons yr^{-1} in the 1950s and 600000 tons yr^{-1} in the 1960s and 70s. It reached about 1.4 million tons yr^{-1} in the 1980s, with the development of the small pelagic fishery in the area. Then, they fell sharply to less than 500000 tons yr^{-1} in 1991. Since the beginning of the 1990s, the annual total catch was around 800000 tons yr^{-1}. Anchovy (*Engraulis encrasicolus*) is distributed over the whole the Black Sea and its mean annual catch was average 74500 tons yr^{-1} in the 1950s. Although, anchovy catch rose sharply 586800 tons yr^{-1} in the 1980s, it decreased 346900 tons yr^{-1} in the 1990s and 469200 tons yr^{-1} in the 2000s. During 1950-2010, the proportion of Turkey in the mean anchovy catch was 63.9%. Proportions of the other riparian countries were 14.5, 13.7, 7.4, 0.4 and 0.1% for Georgia, Russia Federation, Ukraine, Romania and Bulgaria, respectively.

Keywords: Black Sea, Anchovy, *Engraulis encrasicolus*, Catch, Evaluation.

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ÖZET

Bu çalışmada, Karadeniz'de 1950 ile 2014 yılları arasındaki avcılık istatistikleri araştırılmış ve özellikle Hamsi, *Engraulis encrasicolus* balıkçılığının geçmişi ve bugünkü durumu değerlendirilmiştir. Ülkelerin avcılık verileri "www.seaaroundus.org" ve FAO balıkçılık istatistiklerinden alınmıştır. Bilindiği üzere, Karadeniz'deki balık stokları kıyısı bulunan ülkeler tarafından paylaşılmaktadır. Araştırma sonuçları, 1950 yılından bu yana ortalama 200.200 ton yıl^{-1} ile Türkiye'nin Karadeniz'den en fazla su ürünleri avcılığı yapan ülke olduğunu göstermiştir. Türkiye'yi sırasıyla Gürcistan (41900 ton), Rusya Federasyonu (40900 ton), Ukrayna (23200 ton), Romanya (1300 ton) ve Bulgaristan (100 ton) izlemiştir. Karadeniz'den elde edilen toplam su ürünleri üretimi 1950'li yıllarda 400000 ton yıl^{-1}, 1960'lı ve 70'li yıllarda 600000 ton yıl^{-1} civarındaydı. Bu miktar, küçük pelajik balıkçılığın gelişmesiyle 1980'lerde yaklaşık 1.4 milyon ton yıl^{-1}'a ulaşmıştır. Ne var ki sonraki dönemlerde ise, 1991'de 500000 ton yıl^{1}'ın altına düşmüştür. 1990'ların başından bu yana yıllık toplam av miktarı yaklaşık 800000 ton yıl^{-1}'dır. Hamsi, Karadeniz'in tamamında dağılım gösteren bir türdür ve 1950'lerdeki yıllık av miktarı ortalama 74500 ton yıl^{-1}'dır. 1980'lerde ise bu miktar 586800 ton yıl^{-1}'a yükselmiş, ancak 1990'larda 346900 ton yıl^{-1}, 2000'lerde 469200 ton yıl^{-1}'a düşmüştür. 1950-2010 döneminde, Türkiye'nin hamsi avındaki payı ortalama %63.9'dur. Diğer kıyıdaş ülkelerden, Gürcistan, Rusya Federasyonu, Ukrayna, Romanya ve Bulgaristan'ın payları ise sırasıyla 14.5, 13.7, 7.4, 0.4 ve % 0.1'dir.

Anahtar sözcükler: Karadeniz, Hamsi, *Engraulis encrasicolus*, Av, Değerlendirme.

1. INTRODUCTION

Many of the largest fisheries today in the world's oceans are based on small pelagic fish species such as anchovy and sardine. Anchovies are small saltwater forage fish belonging to the Engraulidae and Anchoa families. Of those, Anchoveta or the Peruvian anchovy (*Engraulis ringens*), the European pilchard (*Sardina pilchardus*), the Japanese anchovy (*Engraulis japonicus*), and the European anchovy (*Engraulis encrasicolus*) are distinctive in the world's catch and are harvested for human consumption. The European anchovy supports intense fisheries in the Mediterranean Sea (Plounevez and Champalbert, 2000) and the Black Sea (Chashchin, 1996; Daskalov, 2003), where it constitutes the main fisheries resource (Guraslan *et al*., 2014). Particularly the small-sized plankton-eating types, are the most abundant fish species in the Black Sea. Of the fish species, Anchovy (*Engraulis encrasicolus*) is the most important and the main target species of fisheries in the Black Sea which since 1970 constantly represented more than half of the total volume of the landings (European Parliament, 2010). This species plays a crucial role in the Black Sea pelagic food web as a prey of many predators such as bonito, blue fish, horse mackerel, dolphins and others. It is also an important consumer of zooplankton, especially when the stock is large, and thus acts as a competitor of other planktivores (Daskalov *et al.*, 2007).

The summer distribution area of the anchovy covers practically the whole sea. Under the influence of temperature decline the anchovy initiates migration to the southern Black Sea. According to the scheme suggested by Pusanov (1936), the migration sphere usually takes place along the Romanian and Bulgarian coastlines, followed by the approach of the wintering schools to Turkish Anatolia and even Georgia. According to Danilevsky (1964), the anchovy migration takes place from the northwestern Black Sea to the Southern Crimea. Anchovy in the eastern Black Sea spend the winter near the Georgian coast and can also form schools in Turkish waters (European Parliament, 2010).

Anchovy is subject for commercial purse-seines fishery on their wintering grounds. Time-trajectories of abundance, catch and fishing mortality reveal pronounced decadal fluctuations. The increase in biomass and catch during the 1970s and 1980s was promoted by the expansion of powerful trawl and purse seine fishing fleets in Turkey and thus a steady increase in fishing effort (Gucu, 1997). After the 1981/1982 fishing season the limit of fishing mortality for safe stock exploitation has been systematically exceeded, however, the high catches were maintained by the relatively large reproductive stock (European Parliament, 2010).

Massive populations of anchovy display 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 a result of the changes occurring in the Black Sea ecosystem, as well as with respect to biology of sprat (*Sprattus sprattus*) it is exposed to a number of factors. The latter include changes in the environment arising from anthropogenic factors affecting all parts of the plant and animal world. In almost all cases, however there is a change in the natural balance between species in the corresponding ecological niches. Strongest impact has the industrial fishing, which directly destroys part of the populations of some species and in one way or another affects all species in a certain very specific relationship. Anthropogenic pressures related to the economic condition of the Black Sea countries have decreased over the past decade, allowing an improvement in the condition and biodiversity of the ecosystem of the Black Sea (Tokarev and Shulman, 2007). In regard to the fishery and in environmental terms sprat is of paramount importance for the Black Sea. As one of the most numerous species, it traditionally supported the largest commercial fishing in the Black Sea. On the other hand primary and trophic level in the food chain of the sea and important roles to play in the transfer of energy to the higher population units, and therefore exerting a significant influence on the ecosystem as a whole.

Marine fisheries are an important economic sector in the Black Sea countries, and virtually all the commercial fish stocks in the Black Sea are shared among the bordering countries (European Parliament, 2010). Especially in Turkey, anchovy is of great importance for both economic value and vital respects. Besides the food value, anchovy has great importance for feeding of the other some economic fish species.

Especially since 1980s, fishing pressure on the anchovy stock has increased considerably and it was negatively affected by this situation. The present study was focused on the history of economical fish stocks in the Black Sea. With this aim, catch statistics of the economical fish species, especially anchovy caught from the Black Sea from the 1950s to recent years and results of scientific studies were investigated. From the findings obtained, the history and current state of the Black Sea fishery, especially anchovy fishery, were evaluated.

2. MATERIAL AND METHODS

2.1. Black Sea

The Black Sea, called *"Karadeniz"* in Turkish, is one of the youngest seas on the planet. It was an enclosed freshwater lake until sea levels rose around the world (5000-8000 years ago), and water from the Mediterranean Sea inundated the depression that is now the bottom of the Black Sea (Ulman *et al.*, 2013).

Black Sea is the most isolated from the World Ocean-connected to the Oceans via the Mediterranean Sea through Istanbul, Canakkale (Turk Straits) and Gibraltar straits and with the Sea of Azov in the northeast through the Kerch Strait. It lies between Bulgaria, Romania, Ukraine, Russia, Georgia and Turkey. The Black Sea has an area of ca. 423000 km^2, and a maximum depth of 2212 m. The broad

north-western continental shelf (up to 190 km wide) is the submarine prolongation of the flat Russian, Scythian and Moesian Platforms, whereas the very narrow shelf of the southern and eastern basin corresponds to the Balkans, Pontides, Greater Caucasus and Southern Crimea mountain ranges. The shelf break is located at 110-170 m depth in the north-western Black Sea, and to ca. -100 m to the south and east. The slope is steep all around the basin and incised by canyons. The central abyssal plain has depths of 2000- 2200 m. It receives significant fresh water input from major rivers (the Danube, the Dnieper and the Don) and its catchment area extends over one third of continental Europe. High river water supply, together with restricted circulation through the Strait of Bosporus, create the conditions for the peculiar stratification of the Black Sea waters, and for permanent anoxia below ca. 150 m depth. With more than 80% of its waters being anoxic with a high content of hydrogen sulphide, the Black Sea contains the largest mass of lifeless water on Earth (European Parliament, 2010). Only the top 10 percent of the Black Sea is able to support aerobic organisms (Unluata *et al.*, 1990). Marine life is concentrated in the upper oxygenated layer, and the continental shelf situated above the limit of anoxia hosts abundant bottom life. 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 Parliament, 2010).
As seen in Figure 1, Fishery in the Black Sea is conducted by six riparian countries; the southern part is covered by the Turkish EEZ (Exclusive Economical Zone), the northwest and the north-central by the Ukraine EEZ, the northeastern by the Russian Federation EEZ, the southeast by the Georgian EEZ, and the western by the Bulgarian and Romanian EEZ's. The total EEZ of Georgia + Russia + Ukraine (the former Soviet Union countries) amounts that corresponds to 1.3 of the Turkish EEZ (Oguz *et al.*, 2012).

Figure 1. Map of the Black Sea showing the riparian states and their EEZs (Exclusive Economic Zones).

Marine fisheries are an important economic sector in the Black Sea countries, and virtually all the commercial fish stocks in the Black Sea are shared among the bordering countries. However, Turkey has the highest share of fisheries obtained through the catch and aquaculture among the Black Sea countries. In case of Black Sea fish production, Turkey is the lead country (142660 tons) and followed by Russian Federation (32721 tons) and Georgia (11550 tons). Number of fishing vessels is significantly high in Turkey (Table 1). The Black Sea countries had been agreed on EEZ of 200 nm zone and have national sovereignties in their EEZ.

Table 1. Some data of fisheries area of the Black Sea countries.

Data	Turkey	Georgia	Russia Fed.	Ukraine	Romania	Bulgaria	Total
Coastal length (km)[1]	1400	310	475	1628	300	225	4338
EEZ (km^2)[2]	172484	22947	67351	132414	29756	35132	460084
EEZ declaration year[2]	1986	1977	1977	1977	1986	1987	
Shelf area (km^2)[2]	18895	2529	19828	73847	23283	11902	150284
Inshore fishing area (km^2)[2]	18899	2529	18906	59011	10790	11243	121378
Total fish catch in 2014 (t)[3]	142660	11550	32721	3881	229	3709	194750
Number of fishing vessels[4]	4993	43	33	610	488	2557	8724

[1]European Parliament (2010); [2]URL-1, including Azov; [3]FAO (2016), including Azov; [4]Ozturk (2013)

2.2. Anchovy *(Engraulis encrasicolus*)

Many of the largest fisheries today in the world's oceans are based on small pelagic fish species such as anchovy and sardine. Anchovies are small saltwater forage fish belonging to the Engraulidae and Anchoa families (Guraslan *et al.*, 2014). Species of the genus *Engraulis* are typical representatives of pelagic fish communities in all oceans. Among other common ecological features they are characterized by a similar reproductive strategy to other pelagic fishes (Lisovenko and Andrianov, 1996).

According to many authors [for example; (Alexandrov, 1927; Mayorova, 1934, 1951; Pusanov, 1936) from Chaschin (1996)], two different anchovy populations exist in the Black Sea. These are the Black Sea anchovy (*Engraulis encrasicolus ponticus*) and the Azov Sea anchovy (*Engraulis encrasicolus maeoticus*). The latter reproduces and feeds in the Azov Sea and hibernates along the northern Caucasian and Crimean coasts. The Azov anchovy is spawning and foraging all over the Sea of Azov from May through August. In September-October, with the advance of autumn cold the Azov anchovy migrates through the Kerch Strait to the Black Sea. Most authors have considered the sector Novorossiysk-Sochy (the Caucasus) and the region adjacent to the southern coast of the Crimea Peninsula to be the main areas of winter distribution of the Azov anchovy. The wintering area of the Azov anchovy spreads to Sukhumi where its southern border is assumed to lie. The Azov anchovy spring migration back into the Kerch Strait begins in about mid-April and is over by the end of May (Popova, 1954; Kornilova, 1960). The Anchovy is distributed over the whole Black Sea. As seen in Fig. 2, it migrates to the wintering grounds along the Anatolian and Caucasian coasts (October-November to March), forming dense concentrations targeted by intensive commercial fishery. During the rest of the year it occupies its usual spawning and feeding habitats across the sea, with the northwestern shelf being the largest and most productive area (Fashchuk *et al.*, 1991; Daskalov, 1999). The spawning season lasts from mid-May, when water temperature is about 15-16 °C, to the middle or end of August when the temperature is about 25- 26 °C in the Black Sea. Anchovy spawns only in the upper warm layer (0-25 m), above the thermocline (Lisovenko and Andrianov, 1996) and reaches maturity several months after spawning, which takes place during the summer.

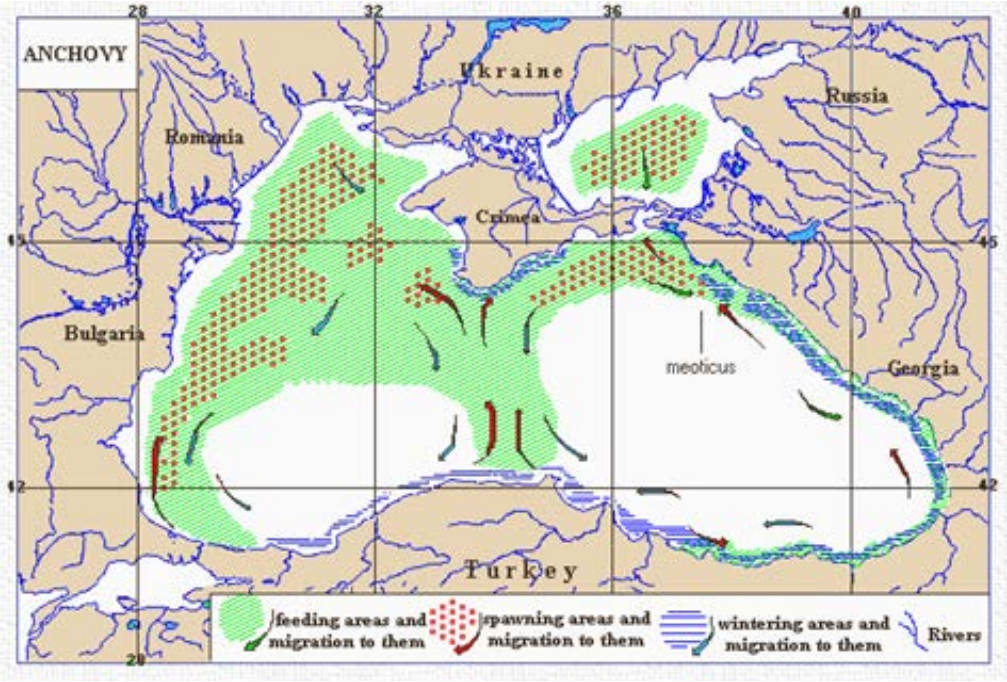

Figure 2. Anchovy migration routes and spawning areas in the Black Sea basin (Ivanov and Beverton, 1985).

2.3. Data Collection and Analysis

In order to evaluate the anchovy fisheries in the Black Sea, previous studies conducted on this sea fisheries (Daskalov, 1999; Daskalov *et al*., 2007; Grishin *et al.*, 2007; Oguz and Gilbert, 2007; Duzgunes and Erdogan, 2008; Knudsen, 2008; Oguz *et al*., 2008, 2012; Knudsen *et al*., 2010; European Parliament, 2010; ICES, 2010; Ozturk, 2013; Sahin and Murtazaoğlu, 2013; Guraslan *et al*., 2014; Gucu *et al*., 2016; and etc.) were reviewed and determined annual catch statistics of fish species given by Sea Around Us (URL-1, 2017) for between 1950 and 2009, and by Food and Agriculture Organization of the United Nations (URL-2, 2017), Turkish Statistical Institute (URL-3, 2017) and General Directorate of Fisheries and Aquaculture (URL-4, 2017) for between 2010 and 2014. Trend of annual anchovy catch from 1950 to 2014 was determined and focused on the possible reasons fluctuations in catch.

3. RESULTS

3.1. Fisheries in the Black Sea

Total fish landings in the Black Sea were around 400000 tons in the 1950s and 600000 tons in the 1960s and 1970s. After a sharp increase from 600000 tons to about 1.4 million tons in six years, they fluctuated around this level from 1983 to 1988, with the development of the small pelagic fishery in the area. Then they fell sharply to less than 500000 tons in 1991 (Figure 3).

As seen in Fig. 3, the most fish from the Black Sea were caught by Russia Federation from the 1950s to the end of 1970s. This country was followed by Turkey and Ukraine. Catch amount of Turkey has increased rapidly in the 1980s and it fluctuated between 300000 and 700000 tons since the beginning of 1980s. Especially at the end of 1980s, the catch amount of Russia Federation declined sharply and it has not changed much since those years. Catch amounts of Turkey and Ukraine were similar from the 1950s to 1960s. After the 1960s, although the catch of Ukraine

decreased little, it has showed a stable development until this time. On the other hand, the most fish were caught by Georgia in the 1970s and 1980s. After those years, catch amount of this country decreased importantly until to the late 2000s. It is understood that Ukraine's catch has increased again since the late 2000s.

Among small pelagic fish species, the anchovy (*Engraulis encrasicolus*) was the most important species landed particularly since the 1970s, with about 50 percent of total (Figure. 4). As seen in Fig. 4, the annual catches of the Black Sea sprat (*Clupeonella cultriventris*) were also relatively high until the end of 1980s. Another fish group was Gobiidae family in the 1950 and 1960s. But after that period it is understood that this fish family has not been caught until recently. One of the most important fish species was Mediterranean horse mackerel (*Trachurus mediterraneus*) in 1980s. Although the sprat has been caught since the 1950's, their catch has increased especially in recent years.

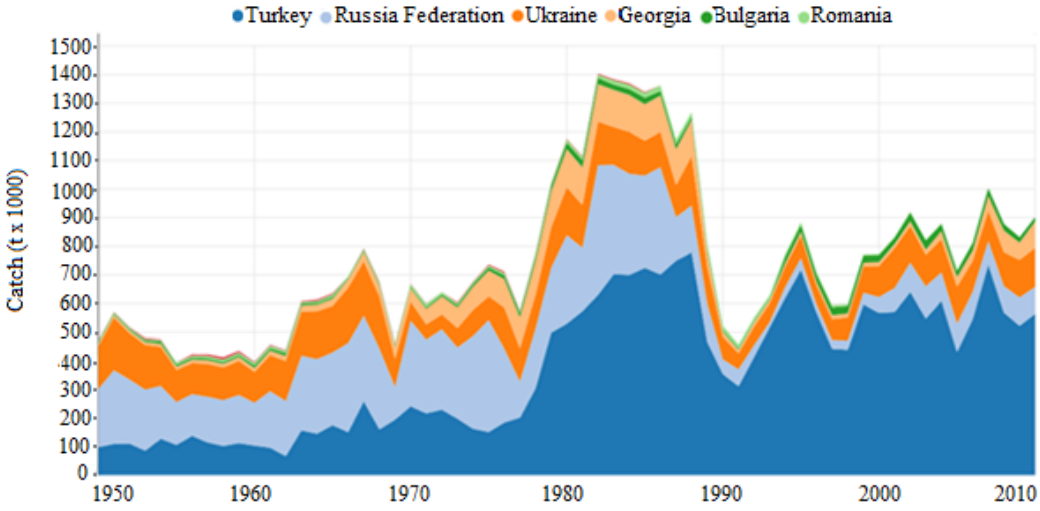

Figure 3. Catches by fishing country in the waters of the Black sea from 1950s to 2010s (URL-1, 2017).

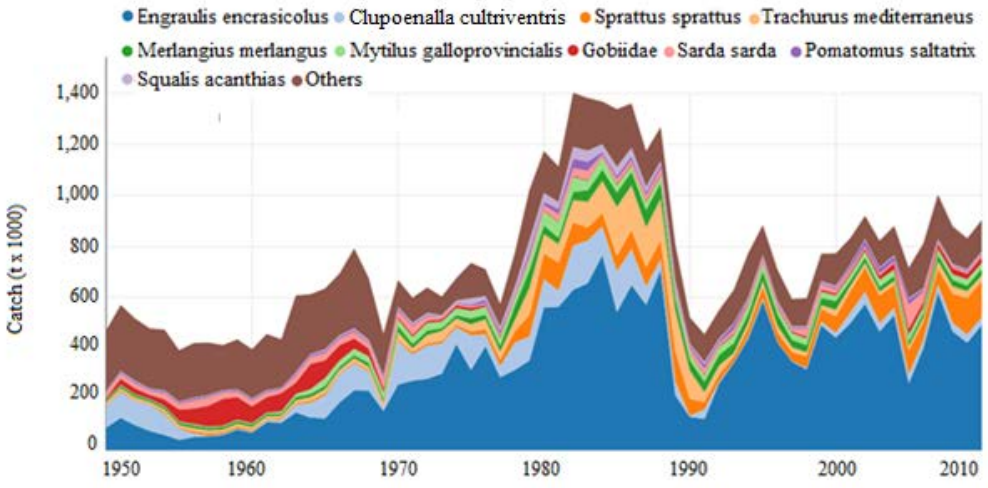

Figure 4. Catches by taxon in the waters of the Black sea from the 1950s to 2000s.

3.2. Anchovy Fisheries

Anchovy is the single largest marine resource in the Black Sea. In the evaluation of annual catch trend of this species given in Figure 5, it was shown that anchovy catch was very few especially until the beginning of 1980s.

In the 1950s, its mean annual anchovy catch was only 74500 tons yr^{-1} (Table 2) and 44.0 and 38.1% of this catch were caught by Turkey and Russia Federation, respectively. These two countries were followed by Ukraine (8.3%) and Georgia (7.4%). The total rate of Romania and Bulgaria was only 2.2%. In the 1960s, the anchovy catch increased twice in 10 years and mean catch was estimated as 150700 tons yr^{-1} (Figure 6). Especially catch amount of Russia Federation, Georgia and Ukraine were importantly increased. Catch increase lasted also in the 1970s and the annual catch was estimated as 321300 tons. In this period, the most anchovy was caught by Turkey with 36.6%. The rates of Russia Federation, Georgia and Ukraine were 26.3, 21.3 and 15.2%, respectively. Total contribution of Romania and Bulgaria to total catch was only 0.7% in this period.

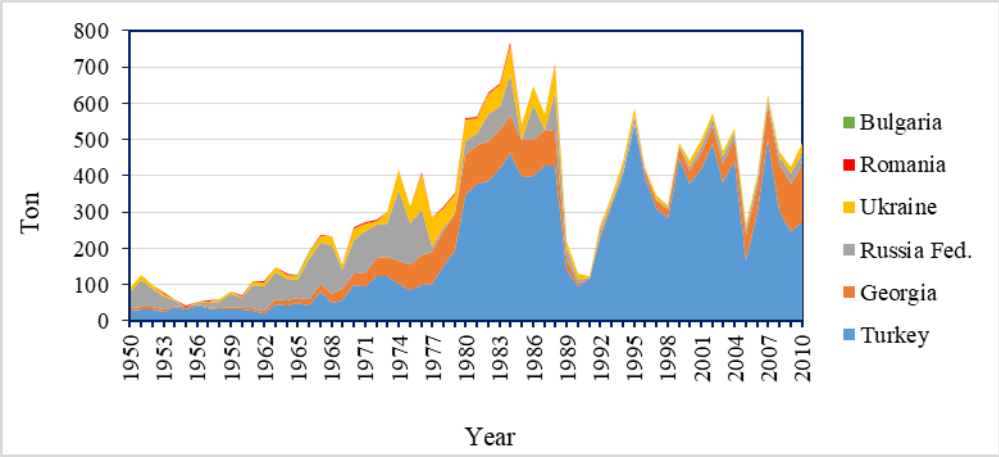

Figure 5. Distribution of anchovy caught by countries in the Black Sea from the 1950s to the 2000s (URL-1, 2017).

Table 2. Mean annual anchovy catches of countries caught from the Black Sea (1000 X Ton).

Years	Turkey	Georgia	Russia	Ukraine	Romania	Bulgaria	Total
1950-59[1]	32.8	5.5	28.4	6.2	1.4	0.2	74.5
1960-69[1]	44.3	16.4	74.4	14.0	1.5	0.2	150.8
1970-79[1]	117.5	68.3	84.4	48.8	2.2	0.1	321.3
1980-89[1]	378.5	96.7	55.3	52.3	3.8	0.2	586.8
1990-99[1]	314.1	12.6	8.7	11.2	0.3	0.0	346.9
2000-09[1]	362.4	73.8	18.9	13.9	0.1	0.1	469.2
2010-14[2]	151.7	19.8	16.0	16.0	0.01	0.1	203.6
Mean	200.2	41.9	40.9	23.2	1.3	0.1	

[1]seaaroundes.org; [2]http://www.fao.org/fishery/statistics/en

As seen in Table 2, in the last five years the anchovy catch decreased importantly. In this period, 74.5% of total catch was caught by Turkey. This country was followed by Georgia, Russia Federation and Ukraine, respectively.

In the 1950s and 60s, while the Russian Federation was the country that caught the most anchovies from the Black sea, Turkey followed this country. After the beginning of 1970s, while Turkey's share in the anchovy production has increased sharply, Russia Federation's share decreased sharply (Figure. 6). Since the 1990s, about 80% of the total anchovy catch was obtained by Turkey.

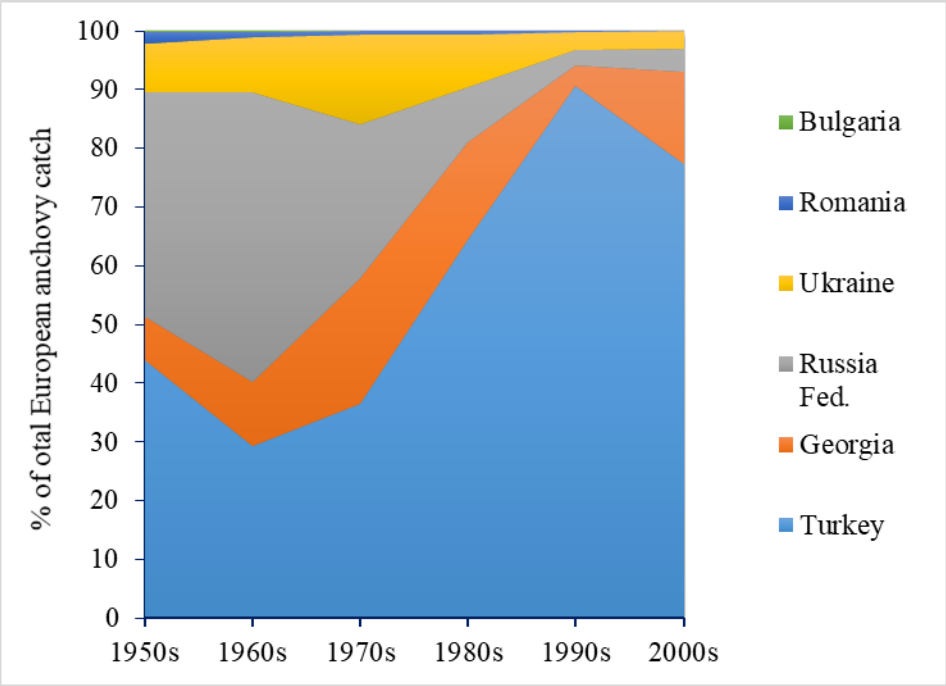

Figure 6. Percent distributions of anchovy catch by 10-years periods and countries.

4. DISCUSSIONS

The Black Sea is characterized by a relatively low species diversity, high productivity and biomass, and anoxic conditions below 150-200 m depth (Knudsen *et al*., 2010). Over the last 50 years, the Black sea ichthyofauna has undergone major changes concerning either its qualitative and quantitative structure and the behaviours of various species. These changes are consequences of human activities, directly through the fishing pressure and indirectly through the deterioration of the environmental conditions, especially in the western part of the Black sea (Maximov and Staicu, 2008). However, it is a very important fishing resource for the six countries located on the coast.

Fish stocks in the Black Sea are shared among the bordering countries. According to catch data given in the URL-1, in the Black Sea most fish had been caught by Russia Federation from the 1950s to the end of 1970s. This country had been followed by Turkey and Ukraine. Catch amount of Turkey increased rapidly in the 1980s and it fluctuated between 300000 and 700000 tons since the beginning of 1980s. Especially at the end of 1980s, the catch amount of Russia Federation declined sharply and it has not changed much since those years. Catch amounts of Turkey and Ukraine were similar from the 1950s to 1960s. After the 1960s, although the catch of Ukraine decreased slightly, it has shown a stable development until this time. On the other hand, most fish were caught by Georgia in the 1970s and 1980s. After those years, catch amount of this country decreased importantly until to the late 2000s. It is

understood that Ukraine's catch has increased again since the late 2000s. Fishing areas of Romania and Bulgaria are limited in the Black Sea, because of shorter the Black Sea coasts than the other countries. Therefore, very few catch has been caught by these two countries from the Black Sea since 1950.

Most of the Black Sea catches concern pelagic fish stocks. Purse seines, mid-water trawls and lampara nets clearly dominate since the late 1960s, and their cumulated effect gave the major peak in landings between 1970 and 1990 (European Parliament, 2010). Significant changes have also occurred in the size of the Black Sea fishing fleets since the late 1980s. The resource crisis and the changed conditions for fisheries in the former communist states have resulted in a dramatic shift in the relative importance of the fishing fleets of the Black Sea countries. Turkish fisheries were just as adversely affected by the resource crisis as the fisheries in the northern Black Sea, but for various reasons they turned out to be more resilient (Knudsen, 2008). In turn, the collapse of the Soviet Union and changes in international relations, state policies and economy triggered overall structural changes in the fisheries of Bulgaria, Romania, Ukraine, Russia and Georgia (Knudsen and Toje, 2008). Meanwhile, investment in the Turkish fleet went forward, and by 1995 the numerical domination of the Turkish fleet was overwhelming - ca. 95% of the total number of fishing vessels in the Black Sea (Caddy, 2008; Knudsen, 2008).

Fisheries in the Azov and Black Seas are characterized mostly by the spectacular increase in catches of small pelagic fish from the 1970s to the mid-1980s and their subsequent collapse by the end of the 1980s. It is now reasonably accepted that the increase in catch was the result of a combination of eutrophication from the rivers draining into the seas and a reduction in predation pressure from heavy exploitation of the more important predators (Daskalov, 2002; Oguz *et al*., 2008). The subsequent collapse has been linked to the invasion by the ctenophore *Mnemiopsis leidyi* coupled with heavy fishing pressure and environmentally unfavourable conditions for fish recruitment (Shiganova and Bulgakova, 2000; Oguz *et al*., 2008).

Top Black Sea predators such as dolphins and porpoises have seriously declined in abundance (Birkun, 2008). Predatory fish, including mackerel (*Scomber scombrus*), blue fish (*Pomatomus saltatrix*) and bonito (*Sarda sarda*) used to enter seasonally from the Sea of Marmara. Now, these species rarely penetrate into the waters to the northwest of the Black Sea (Zengin and Dincer, 2006). The abundance of the stocks of these species can be considered severely reduced, but not necessarily only by fishing. Pollution, especially in the northwest part of the Black Sea, is considered to have played an important part (Mee *et al*., 2005).

Between 1950 and 1955, the anchovy and the Black Sea sprat were caught in almost equal amounts from the Black Sea. The Black and Caspian Sea sprat were caught mostly from the Azov Sea. From the mid- of the 1950s to the mid- of 1960s, annual catches of the Black Sea sprat were very low. But, after those years it increased and showed a steady development until the end of the 1980s. In that period, it was the second fish species most caught in the Black Sea. The Black Sea sprat, a Ponto-Caspian endemic, inhabits the northwestern parts of the Black Sea, in the Sea of Azov Sea and the Caspian Sea, also most rivers of the area, and some lakes in Bulgaria, Romania and Turkey (Whitehead, 1985; Alexandrov *et al*., 2008). But, it was understood that its catch decreased after that years and has been caught in very small quantities since the end of 1980s. The other important small pelagic fish species caught in the region are European sprat, Mediterranean horse mackerel, Atlantic bonito and bluefish (FAO, 2011). European sprat is the second fish species most caught from the Black Sea since the early 2000s. In recent years, unfortunately, this fish species has been over-exploited. Therefore, stock of this

species should be determined and its fishing should be regulated all over the Black Sea. Another important fish species was Mediterranean horse mackerel in the 1980s. In recent years, the catch amount of this fish species was considerably reduced. Atlantic bonito and bluefish are two important fish species of the Black Sea. However, their catches fluctuated from year to year since 1950s. Besides these pelagic species, whiting (*Merlangius merlangus*) is an important benthopelagic fish species caught from the Black Sea since the 1950s. In recent years, especially in the Turkish coast of the Black Sea, it is the most important fish species for small-scale fisheries.

Undoubtedly, the most important fish species for the Black Sea fishery is anchovy since 1960s. Fishing of this species began to gain importance especially since the early 1970s. The highest mean annual catch was obtained in the 1980s (586700 tons yr^{-1}) since 1950. In this period, the anchovy catch of Turkey reached 378500 tons yr^{-1}. The large increase in catches of anchovy until the mid-1980s was probably mainly due to the steady increase in fishing effort. However, it may also have been partly a response to the increasing eutrophication of the Black Sea in this period (Oguz and Gilbert, 2007; Ludwig *et al*., 2009) and a reduction in predators due to fishing (Daskalov *et al*., 2007). Anchovy stocks collapsed in the late 1980s, probably as a result of the combined effect of intensive fishing and increased predation and feeding competition with the ctenophore *Mnemiopsis leidyi* (Oguz *et al*., 2008). The first signs of overfishing appeared after 1984, when anchovy shoals were difficult to be found and the fishery enterprises incurred losses (Shlyakhov *et al*., 1990). However, the real catastrophe occurred after 1986, when the stock shrunk from 1200000 to 500000 tons in two subsequent years. Catches during the 1986/87 and 1987/88 fishing seasons remained high, but in 1988/1989, the catch suddenly dropped to 188000 tons.

Although the annual catch of this species decreased 346900 tons yr^{-1} in the 1990s, the rate of Turkey in this catch reached 90.5%. On the other hand, the rates of Russia Federation, Ukraine and Georgia were decreased importantly. The stock experienced an abrupt decline to less than 300000 tons in 1990, which was the lowest level over the period 1967-1993. The fishing effort and fishing mortality also dropped subsequently because of decreasing profitability of fishing. During the collapse phase, the size/age structure of the catch shifted toward a predominance of small, immature individuals (Prodanov *et al*., 1997; Gucu, 1997). In the 2000s, the annual anchovy catch was 469300 tons yr^{-1}. 77.2% of this catch was caught by Turkey. Catch of Georgia increased importantly with the rate of 15.7%. In 1995-2005, the stock partially recovered and catches increased to 300000-400000 tons, but because the fishing effort and the catches remained relatively high, the exploited biomass could not reach the 1980s levels (European Parliament, 2010). Despite this partial recovery, there is still substantial overcapitalization in anchovy fisheries, especially in the south and southeast of the Black Sea. It is believed that the stock of anchovy is still being exploited above the level of sustainability (FAO, 2011). This may be partly due to the decrease in nutrient input that was a result of both the successful control of fertilizer runoff by the riverine nations and the profound economic changes in the river catchments (Ludwig *et al*., 2009). According to European Parliament (2010), the state of the Anchovy stock has improved after the collapse in 1990s, and in 2000-2005 the catches reached ca. 300000 tons. However, the Anchovy catches dropped substantially in 2006 indicating a distressed stock condition. The other possible cause of the drop in Anchovy stock include climatic effects (higher water temperature may cause a dispersal of fish schools making them less accessible to the fishing gears) and abundant predators (bonito). Given the strong natural variability, transboundary migratory behaviour and sensitivity to various environmental impacts, the protection and

sustainable use of the anchovy resource can be achieved only by coordinated international management and regulation based on sound scientifically grounded stock assessment.

These fluctuations in the fishery as opposed to a status quo, indicate that environmental drivers are equally as important as fisheries in influencing the biomass of a species. As anchovy is a fast-growing, short-lived species, the irregular fluctuations are caused by the survival success of the early life stages. Various factors adversely affecting the survival and in turn, recruitment success have emerged in the Black Sea during the last few decades. A decrease in the trophic state to dystrophy at the spawning grounds (Zaitsev, 1993) and intensified predation and competition pressure incurred by an exotic ctenophore (Vinogradov *et al*., 1989, 2005) are among the most crucial reasons listed. If such non-fishery impacts on recruitment success are disregarded in stock assessment and fisheries management decisions, the ecological and economic consequences would undoubtedly be misleading Scientific, Technical and Economic Committee for Fisheries (STECF) (2013).

Lisovenko and Andrianov (1996) stated that the anchovy in the Black Sea has extremely high reproductive potential and is characterized by high annual fluctuations in abundance and by the ability to rapidly restore biomass. Given these conditions, the danger of overfishing is decreasing for this species in the Black Sea. The anchovy is capable of restoring its abundance under fishery conditions of variable intensity. The most urgent measures for rational fishery include those directed at the preservation of the favourable reproductive conditions of this species (pollution control, river flow regulation, control of food competitors and consumers of eggs and young, making artificial upwellings and so on).

It is stated in BSC (2008) that in the last decade, the amount of nutrients and pollutants entering the Black Sea through the river discharge has been appreciably reduced (BSC, 2008). This in turn has already resulted in a slight improvement in environmental conditions in the Black and Azov Seas in the last decade. This has allowed the recovery of biodiversity and marine living resources despite overfishing, degradation of vital habitats (including spawning and nursery areas) and the disturbance of the ecological balance that continues to occur. On the other hand Gucu (2016) indicated that the anchovy stock estimated to be 1.5 million tons in the 1990s was determined that dropped to half a million tons in recent years. Moreover, almost half of the anchovy stocks falling in recent years due to pollution in the Danube basin constitutes fish in the exclusive economic zone of Turkey. During the migration of anchovy from north to south coast, a significant amount of anchovy was caught by Ukraine, Roman and Bulgaria. But, they haven't caught it since the 1990s. A large portion of the anchovy stock in the Black Sea have been caught by Turkish fishermen. The other hand, contrarily to the other riparian countries, anchovy is the main target fish in Georgia (Ozturk, 2013). But, Georgia and Russia have the fewest fishing boats in the Black Sea. Therefore, anchovy fishing started in Georgian waters in 1996 by Turkish fleet according to mutual agreements between some Turkish and Georgian companies. Ozturk *et al*. (2013) reported that the Turkish anchovy catch in Georgian waters from 2003 to 2009 was estimated as 60968 tons. Turkish catch of anchovy was estimated as 50000 tons in 2011 by 30 fishing boats. In recent years, the establishment of many fish flour factories in Georgia has caused overfishing of small anchovies in the waters of this country.

5. CONCLUSIONS

- Turkish fishing fleet and production is the strongest among all riparian countries since 2013.
- Anchovy is the most abundant fish species in the Black Sea and an important

fisheries resource and prey species for especially some riparian countries.

- Fisheries in the Black Seas are characterized mostly by the spectacular increase in catches of small pelagic fish from the 1970s to the mid-1980s and their subsequent
  collapse by the end of the 1980s. This fluctuation is seen clearly in the distribution of annual anchovy catch.
- It can be evaluated that as a typical catch time series underdeveloped in the 1950s, developing from the beginning of 1960 to the end of 1980, full exploited in the 1980s, and overfished after that time until 2000.
- These main legislative instruments set rules and principles for technical aspects of fishing, such as fishing gear, fishing season, fishing areas, protected areas, limitation on landing size, and prohibition on species to regulate commercial fishing. Turkish fishing fleet and production is the strongest among all riparian countries. However, fishing license have not been issued for the marine vessels since 2002 in order to reduce catch stress on stocks and to maintain sustainable fisheries in Turkey. Additionally, a new support scheme was taken into effect in Turkey for the reduction of the number of fishing vessels over 12 m. Fishing license of 407 vessels over 12 m will be annulled and removed from fleet within 2013. Besides, a total of 413 vessels over 10 m were removed from fishing fleet in 2014. It is known that this application continued in 2015 and will continue in 2016. But, the number of fishing vessels in Turkey is still high. Therefore, the studies started should be continued for the reduction of fishing power.
- Quota should be applicable for anchovy fishing in the Black Sea. Total quota amount should not be more than 300000 tons.
- Georgian waters, fishing over 300 m off the coast, minimum catch size of anchovy is 7 cm. Minimum catch size must be raised to 9 cm as in Turkey.
- More seriously measures should be taken by the riparian countries against organic, biological and chemical pollution for sustainable anchovy fisheries in the Black Sea.

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