



RESEARCH ARTICLE

Is Trawl Fishery on the Verge of Collapse in Foça, Türkiye, Eastern Mediterranean?

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Abstract: In this study, we aimed to examine the status and historical change of trawl fishing fleet in the Foça in the Aegean Sea. The data of the study representing all actively working trawlers in 1998-1999 and 2019 were collected through face-to-face interviews with trawler boat owners in Foça. The questionnaire consisted of questions related to the characteristics of the vessels, fishing activity, socio-demographics of fishers, running costs, annual landings of species and management issues. The study indicated that the annual landings of the main target species significantly decreased over the last two decades. Fishers reported the landings of some species including *Dentex gibbosus*, *Dentex macrophthalmus*, *Homarus gammarus*, *Mustelus mustelus*, *Octopus vulgaris*, *Parapenaeus longirostris*, *Scorpaenopsis scorpaenoides*, *Scorpaena porcus*, *Scorpaena scrofa*, *Spicara smaris*, *Trachurus spp.* and *Zeus faber* decreased considerably over this period. Over the same period, a decrease was found in the mean length of *Merluccius merluccius*, *Lophius piscatorius* and *Zeus faber*. The vessels' fuel tank volume and tow duration showed significant increases from 1999 to 2019. The trawl fleet decreased by ~75% from 1999 to 2019 and 55% of the current fishers reported that they may leave the fishery sector within the next 10 years. A change was also determined in the tradition of the sharing system, which is the number of crews paid in shares rather than a fixed salary, significantly decreased. Moreover, the crew numbers from vessel owners' households significantly decreased. As a result, we discussed the changes, problems, regulations and restrictions related to trawl fishery in Foça, which used to be the most important trawling fishing center of the Aegean twenty years ago. We found dramatic changes in many aspects compared to what it was two decades ago and provided suggestions regarding fisheries management.

Anahtar kelimeler:

Mullidae
Mustelus mustelus
Lophius piscatorius
Balıkçılık yönetimi
Trol balıkçılığı
Akdeniz

Foça'da (Doğu Akdeniz, Türkiye) Trol Balıkçılığı Çöküşün Eşiğinde mi?

Öz: Bu çalışmada, Ege Denizi Foça'daki trol filosunun mevcut durumu ve tarihsel değişimi hakkında bilgi vermeyi amaçladık. 1998-1999 ve 2019 yıllarında aktif olarak çalışan tüm trol teknelerini temsil eden çalışmanın verileri, Foça'da bulunan trol teknesi sahipleri ile yüz yüze görüşülerek toplanmıştır. Anket, gemilerin özellikleri ve balıkçılık faaliyetleri, balıkçıların sosyo-demografik özellikleri, balıkçılık giderleri, türlerin yıllık karaya çıkış miktarları ve yönetim konuları ile ilgili sorulardan oluşmaktadır. Bu çalışma, hedef türlerdeki av miktarının son yirmi yılda önemli ölçüde azaldığını gösterdi. Balıkçılar, *Dentex gibbosus*, *Dentex macrophthalmus*, *Homarus gammarus*, *Mustelus mustelus*, *Octopus vulgaris*, *Parapenaeus longirostris*, *Scorpaenopsis scorpaenoides*, *Scorpaena porcus*, *Scorpaena scrofa*, *Spicara smaris*, *Trachurus spp.* and *Zeus faber* gibi bazı türlerin karaya çıkışlarının bu dönemde dikkate değer bir düşüş gösterdiğini rapor etti. Aynı dönemde *Merluccius merluccius*, *Lophius piscatorius* ve *Zeus faber* gibi bazı türlerin ortalama boylarında da azalma görülmüştür. Gemilerin akaryakıt tanklarının hacmi ve operasyon süreleri 1999'dan 2019'a önemli artışlar gösterdi. Foça'nın trol filosunda 1999'dan 2019'a yaklaşık %75 azalma saptandı. Mevcut balıkçıların %55'i önümüzdeki 10 yıl içinde balıkçılık sektöründen ayrılacaklarını bildirdi. Bu durum trol balıkçılığında payçılık sistemi geleneğini de değiştirmiş; maaş yerine pay olarak ödenen personel (mürettebat) sayısı önemli ölçüde azalmıştır. Ayrıca, tekne sahiplerinin hane halkından gelen mürettebat sayısı son yirmi yılda önemli ölçüde azalmıştır. Sonuç olarak, yirmi yıl evvel Ege'nin en önemli trol merkezi olan Foça'da günümüzde nasıl bir değişim olduğunu, sorunları, balıkçılık düzenlemeleri ve kısıtlamaları tartıştık. Yirmi yıl öncesine kıyasla birçok açıdan çarpıcı değişiklikler bulduk ve balıkçılık yönetimine ilişkin önerilerde bulunduk.

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Introduction

For the last several decades, overfishing and mismanagement of aquatic resources in the Mediterranean has resulted in collapsed stocks, habitat destruction, disturbance of ecological balance, and changes in socio-economic characteristics of fishing fleets. Although the ecological and biological changes in Mediterranean ecosystem have been investigated by many researchers (Tudela, 2004; Osio, 2012; Goffredo and Dubinsky, 2013; Damalas et al., 2015; Tserpes et al., 2016; Colloca et al., 2017; Mannino et al., 2017; Piroddi et al., 2017; Dimarchopoulou et al., 2018; Demirel et al., 2020; Tsikliras et al., 2021), changes in the fishers' behaviours and operational characteristics influenced by decreased stocks have rarely been discussed (Andrews et al., 2021). In addition, the entire fishing fleet operating in the Mediterranean show particular characteristics, and they are managed by different tools and regulations. Therefore, information obtained from local sources may help to clarify the current state of the Mediterranean fishery.

The Mediterranean Sea is not only vital for biodiversity, but it is also important for commercial demersal and pelagic fish resources. It hosts 76 280 fishing vessels and more than 30% of these vessels fish around the Eastern Mediterranean (FAO, 2020). In the Mediterranean, the largest increase (20.4%) in the catch since 2016 was demonstrated by Türkiye (FAO, 2020). The most caught demersal fish species in Türkiye were whiting (8.941t), striped red mullet (2.342t), red mullet (1.761t), European hake (1.270t) and invertebrates including mussel species (36.627t), whelk (11.646t) and shrimp species (5.137t) in 2019 (TÜİK, 2020). The licenced trawl vessel number was 790 in 2019 in Türkiye and among them 63 vessels were registered to Aegean ports (TÜİK, 2020).

It is well known that the trawl net is not selective enough and has a more devastating effect on habitats compared with many other fishing gears (Jenning and Kaiser, 1998; Collie et al., 2000; Lucchetti et al., 2021). To minimise the destructive impacts of trawl fishery, some management tools (e.g., spatial and seasonal closures, quotas, minimum and maximum landing sizes, restrictions in nets and fishing gear) are used by fishery managers and these aforementioned tools show variations depending on the countries or union's regulations (Anon., 2020; EU, 2006). For instance, fishing with trawl nets above the seagrass beds of, in particular, *Posidonia oceanica* or other marine phanerogams is prohibited in the EU waters of the Mediterranean (EU, 2006). There is no doubt that each datum related to the biological, ecological, and socio-economic indicators provided by scientific studies are imperative to develop the current fishery management measures and regulations. Another essential issue is auditing and monitoring the fleets using some tools (e.g., electronic logbooks, vessel monitoring system) and all these characteristics also show regional variations (Anon., 2020).

Previous studies related to trawl fishery in Türkiye mainly focussed on the selectivity of the trawl nets, by-catch issues, and marine debris (Lök et al., 1997; Tokaç et al., 2004; Özbilgin et al., 2007; Tosunoğlu et al., 2008; Zengin & Akyol, 2009; Eryaşar et al., 2014) and discard and catch composition (Gücü, 2012; Gurbet et al., 2013; Çetin et al., 2014; Gökçe et al., 2016; Yıldız & Karakulak, 2017). Ilkyaz et al. (2018) discussed on the spawning season and length and ages at first maturity of demersal fish species in the central Aegean Sea and recommended changing of the closed season for the bottom trawls. The socio-economic characteristics have rarely been documented to date (Ünal and Hoşsucu, 1996; Ünal, 2002; Ünal, 2004). Recently, Dereli et al. (2022) provided the technical measures for single boat bottom otter trawls used in Türkiye and Greece in the Aegean Sea. The authors also review the differences and similarities related to trawl fishing and all other fishing gears and emphasized the importance of harmonization of technical measures and management approaches for the sustainable management of shared stocks. However, trawling, which is a non-substitute fishing segment targeting important commercial fish species, is a type fishery that deserves to be examined in many respects and needs to be performed on a sustainable basis. In this context, in the present study, we reviewed a comparison of trawl fishing in Foça, center of trawlers along the Aegean coast, with its state twenty years ago.

Foça is one of the main regions where trawling is performed in Turkish waters. Trawl fishing began to appear in Foça in the 1940s. By the end of the 1940s, there were five trawlers, the longest of which was 18 meters and the most powerful engine seen was 90 HP, registered to the port of Foça. Although these vessels were far from today's technologies and were working in limited fishing areas, they were catching more fish and earning more than today. With the effect of factors such as the demand for fish, the increasing human population, and the limited employment opportunities especially for those living in the villages and towns of the coastal region, the number of trawlers, which was only five in the past, has increased year by year. As of the 1999-2000 fishing season there were forty licensed vessels, twenty of which were actively working (Ünal, 2002). In 2019, a total of 11 vessels actively fished around Foça (Pers. Comm.; C. Çetin, Head of Foça Fishery Cooperative, 2020). However, in 2021 the Foça trawl fleet showed a decrease, and the actual vessel number was only 5 (Pers. Comm.; N. Turguttekin, former local trawl fisher, 2021).

The main aim of the present study is to compare and highlight the Foça trawl fleets' current characteristics and end of the 1990's characteristics by examining aspects of the vessel, fishing operation, fishing expenditures, fishers' demography, main problems and catch. The findings can support the development of policies, regulations, and restrictions on the management of trawl fishery both in Foça and in other parts of the Aegean Sea.

Material and Methods

Study area

Foça is a fishing and tourism town, with a population of 33 131 inhabitants, located on the coast of Central Turkish Aegean Sea, Eastern Mediterranean (Figure 1). The fishery in Foça is characterised as multi-species and multi-gear fishing area including fishing methods such as trawling, gillnetting, longlining, and trolling. There is a fishery cooperative mainly consisting of small-scale fishers. The total number of shareholders (members) in this cooperative is 138. However, recently, the number of active fishers has decreased to 50 (Pers. Comm.; Ceyhan Çetin, Head of Foça Fishery Cooperative, 2020). The main target species of the small-scale fisheries are *Mullus barbatus*, *Mullus surmuletus*, *Sparus aurata*, *Diplodus sargus*, *Diplodus*

vulgaris, *Boops boops*, *Oblada melanura*, *Dicentrarchus labrax*, *Pomatomus saltatrix*, and *Lithognathus mormyrus* (Tokaç et al., 2010). Foça is one of the most important areas for recreational and charter fisheries and the aforementioned species are targeted by recreational fishers as well (Öndes et al., 2020a). Due to the presence of the Mediterranean monk seal (*Monachus monachus*) and sensitive habitats (e.g., *Posidonia* beds), biodiversity, unique archaeological assets and cultural heritage, a specially protected area (SEPA) was established in 1990 in Foça (Güçlüsoy et al., 2020). However, besides all these characteristics of Foça, the area was also known as the most important trawl fishing location in the Turkish side of the Aegean Sea until today.

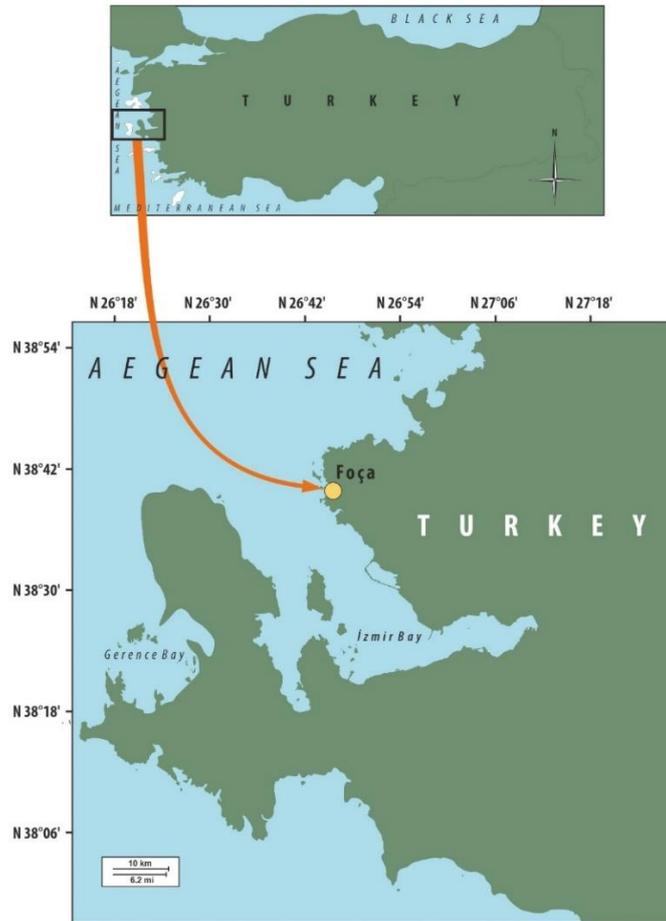


Figure 1. Location of Foça

Data collection

The data of the study representing all actively working trawlers in 1998-1999 and 2019 were collected through face-to-face interviews with trawler boat owners with a time difference of twenty years. Some historical data (e.g. socio-demographic data) are from 1999, while some other data (e.g. catch amount, running costs) are from 1998.

Regarding the data collection, approval was granted by the Ethics Committee of İzmir Katip Çelebi University. Some parts of the data collected in 2000 were published by the first author (Ünal, 2001; 2002; 2004), therefore the given data were used as secondary data in this study to understand historical changes. Both questionnaires conducted in different years gathered 4 types of information: (1) vessel characteristics (e.g. material, vessel type, vessel age, length, engine age, HP, volume of fuel tank and warehouse capacity), (2) socio-demographic features

(e.g. age, gender, education level, marital status, family member number), (3) running costs (4) magnitude and characteristics of fishing activity (annual days at sea, fishing effort, fishing times, maximum fishing hours per trip, vessel owner number, total crew number, crew number from the vessel owners' family and annual catch amounts of species (kg)). In addition to the questionnaire applied in 2019, another questionnaire was performed to fishers who have a minimum of 20 years fisheries experience in order to assess historical changes related to the fishing activity (e.g., tow duration, fishing site, and fishers' behaviours) and current problems. A Likert scale was utilised to evaluate the current problems. The scale consists of 5 categories including 1- strongly disagree, 2- disagree, 3- neither nor, 4- agree, 5- strongly agree.

Data analysis

To test all data for normality and homogeneity of variance, a Kolmogorov-Smirnov K-S test and Levene's tests were used, respectively. In order to compare vessel characteristics, fishers' demographics and fishing activity in 1999 and 2019 a Mann-Whitney U test was used. Similarly, the mean tow duration in different sampling times (1999 and 2019) was tested using the Mann-Whitney U test. The same test was also used to compare the mean annual production of fish and shellfish species by fishing fleets in 1998 and 2018. All analyses were undertaken using the statistical programme SPSS.

Results and Discussion

Comparison of the vessel characteristics, socio-demographics of fishers and fishing activity in 1999 and 2019

Many fishing vessels were wooden in 1999, whilst 54% of vessels were built with iron in 2019 (Figure 2). Regarding the vessel type, 45%, 40% and 15% of the fleet consisted of mirror stern, gullet and liberty, respectively in 1999. There was no liberty vessel in 2019 and 81% of vessels were mirror stern, whilst 19% of vessels were gullet. There was no significant difference in vessel age, vessel size and engine age for the years 1999 and 2019 (Table 1). However, some vessel characteristics including engine power, volume of fuel tank and warehouse capacity showed a significant increase from 1999 to 2019 (Table 1).

It was determined that 85% and 82% of fishers were married in 1999 and 2019, respectively (Figure 2). Fishers who had completed primary school were common in 1999, whereas many fishers (55%) reported that they had at least high school diploma in 2019. While 40% of fishers had no social security in 1999, all fishers had official social security in 2019 (Figure 2). There was no significant difference in some fishers' demographics including age, number of household member and fisheries experience for the fleets in 1999 and 2019 (Table 1). However, it has been observed that a family that has been fishing trawlers in Foça since the 1970s with four different trawlers sold all their trawl vessels and there was not a single fisher from the family left.

The total number of annual fishing days reduced over the last two decades in Foça trawl fishery (Table 1). There was no significant difference in the maximum fishing hours per trip, vessel owner number and total crew number for the years 1999 and 2019 (Table 1). In 1999, 55% of vessel owners declared that they preferred to salary crew members, whereas in 2019 91% of vessels owners paid their crew members a regular salary (Figure 2). Moreover, the crew number from the vessel owners' family showed a significant difference between 1999 and 2019 (Table 1).

Since the 1940's when trawling fishery emerged in Foça, the decrease in CPUE and increased fishing costs, in addition to affecting the fishing income, also caused a change in the income sharing system in trawl fishery. Ünal and Hoşsucu (1996) stated that the sharing system is essential in the distribution of income in Foça trawlers, but a few years later, Ünal (2002) drew attention to the tendency of the crew to switch to fixed but guaranteed salary payments instead of working with the sharing system. In the 1990s, trawlers used to prefer the sharing system in the distribution of fishing income, while in the early 2000s, the proportion of trawlers that distribute income on a share basis decreased to 33% (Ünal, 2002). In addition, only 55% of the interviewed trawlers in Foça could generate a net profit, the remaining vessels created negative economic performance and the Foça trawl fishery was far from viability. Likewise, the fact that the crews were not satisfied with their share and prefer to receive a fixed salary instead of this system, provides information on the economic sustainability of trawl fishery in Foça (Ünal, 2002).

Knowledge of fishers having more than 20 years of experiences

Experienced fishers, who have been fishing for at least 20 years, declared that their mean tow duration was 2.4 ± 0.5 hrs twenty years ago and the mean tow duration was estimated as 3.4 ± 0.5 hrs in 2019. There was a statistically significant difference in tow duration for the compared years ($P= 0.01$, $U=15$). This situation depends on the catch composition and spatial differences of fishing grounds. For example, Can and Demirci (2004) noted that CPUE did not significantly change with tow duration for some species such as *Saurida undosquamis* in bottom trawl fishery in Türkiye. The present study showed that tow duration of trawls increased significantly over the last two decades and this may be related to the decreased CPUE of the target species. Furthermore, Table 2 summarises the temporal changes related to the fishing site, fleet size, overfishing and illegal fishing issues. Although fathers or grandfathers of vessel owners mainly worked directly in fishing, only 18% of vessel owners' children worked in fisheries. Results demonstrated that 55% of fishers considered that they will leave trawl fishery due to reduced income, increased fuel prices and some health problems (Table 2).

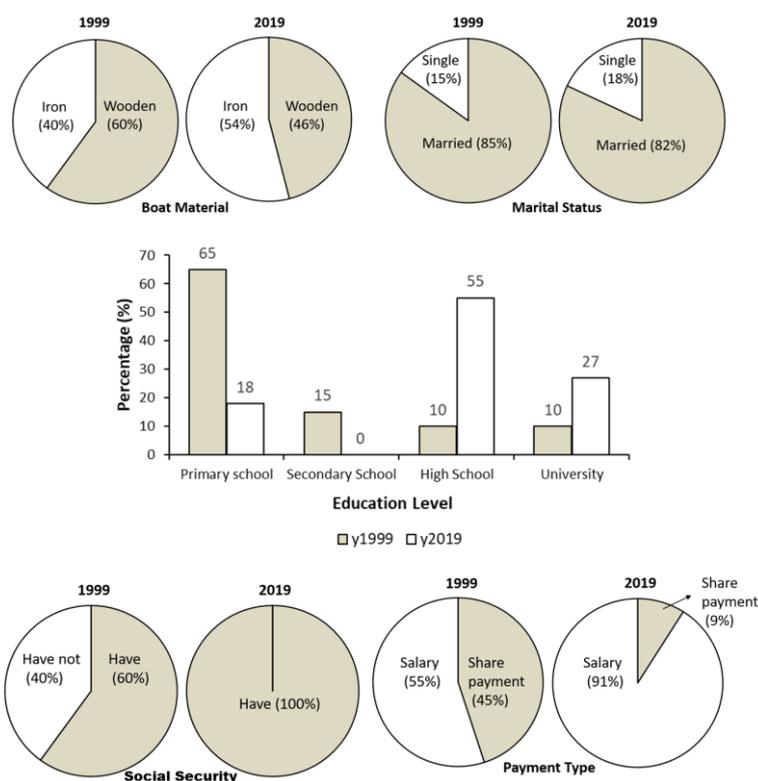


Figure 2. Comparison of some indicators (vessel material, marital status, education level, social security, and payment type) of Foça trawl fleet in 1999 (N = 20) (Ünal 2001, 2002, 2004) and 2019 (N= 11) (this study)

Table 1. Comparative information on vessel, fisher and fishing activity characteristics of Foça trawl fishery based on Ünal (2001, 2004) and this study

Criteria	Ünal (2001, 2004)		P	U-value
	Mean Value (± SD)	This Study		
Vessel characteristics				
Vessel age (year)	17±16	15±8	0.74	102
Length (m)	21±3	21±5	0.96	89
Engine age (year)	11±10	9±7	0.91	102
Engine power (HP)	324±126	463±97	< 0.01*	41
Volume of fuel tank (ton)	7±6	12±8	0.03*	59
Warehouse capacity (c. of safe)	192±126	339±212	0.05*	64
Fisher characteristics				
Age (year)	39±11	42±10	0.41	90
Family member number	3±1.4	4±0.8	0.46	93
Fishing experience (year)	20±10	23±10	0.42	91
Fishing activity characteristics				
Days at sea	182±55	159±26	0.32	86
Max. fishing hours per trip	51±23	55±21	0.56	97
Number of vessels owned	1.3±0.6	1.3±0.5	0.71	104
Total crew number	2.6±0.8	2.9±0.8	0.26	85
Number of crew members from fisher's household	1.8±1.1	0.7±0.9	0.01*	50

Table 2. Percentages related to the responses of trawlers on historical changes and social issues

Question	Yes (%)	No (%)
Have fishing sites been changed for the last two decades?	46	54
Have the trawl vessel number decreased for the last two decades?	91	9
Has overfishing increased for the last two decades?	100	0
Has illegal fishing increased for the last two decades?	100	0
Do you think fisheries have been managed better compared to the last two decades?	46	54
Were your father or grandfather fishermen?	91	9
Do you have a son or daughter who is fisher?	18	82
Do you want to leave trawl fishing within the next 10 years?	55	45

Table 3. Percentage of running costs in 1998 (Ünal, 2002) and 2018 (this study)

Year	Running Costs (%)			
	Fuel	Food	Ice	Transportation
1998	84.1	4.6	4.9	6.4
2018	86.4	3.1	2.8	7.7

Historical changes of running costs

Regarding the ratios of operational costs including fuel, ice, food and transportation, there was no significant difference between the sampling years (Table 3).

The fuel expenses in both 1998 and 2018 accounted for almost the same but the highest fishing expenditures (84.1% and 86.2%) in running costs. However, rates of fuel expenses in total expenditures were 53% and 62%, in 1998 and 2018, respectively. With these rates, fuel costs continued to form the highest cost unit among total expenses. It was observed that the fuel expenses of trawlers declared by fishers after twenty years were again the biggest problem of Foça trawl fishery. This is approximately four-fold more compared to EU countries' trawl fishery operating costs (STECF, 2019). Similarly, Guillen and Maynou (2016) analysed the Spanish trawl fleet for the period between 2000 and 2013 and noticed that not only increased fuel prices but also decreased fish prices together explained the low economic performance of the fleet. Moreover, Samy-Kamal and Sanchez-Lizaso (2014) reported that these two important factors (market prices and fuel prices) mainly influence the fishers' critical decisions in the Mediterranean trawl fishery.

Historical changes in the catch characteristics

The mean annual seafood production of main target species (listed in Table 4) was $29\,989 \pm 22\,150$ kg/vessel in 1998, whilst the mean annual seafood production was 14

$099 \pm 3\,878$ kg/vessel in 2018. There was a statistically significant difference in annual seafood production of the fleet in the two fishing seasons ($P = 0.005$, $U = 36,000$). For many targeted fish and shellfish species the mean annual production (kg/vessel/year) showed significant differences between 1998 and 2018 (Table 4). In particular, some species showed a dramatic decrease in the total production from 1998 to 2018 (Figure 3).

Numerous studies reported that the stocks of some target species in the Mediterranean Sea showed a marked decrease over the last several decades (Osio, 2012; Damalas et al., 2015; Tserpes et al., 2016; Colloca et al., 2017; Piroddi et al., 2017; Dimarchopoulou et al., 2018). Although our results did not directly relate to the abundance or CPUE of species, they showed that the total production of some target species, including deep-water rose shrimp, mackerel species, pickerel, common octopus, John Dory, Large-eyed dentex, pink dentex, Largescaled scorpionfish, common smoothhound and European lobster, decreased significantly from 1998 to 2018. On the other hand, landings of some species including bogue, common cuttlefish and striped prawn showed an increase for the compared years. Similarly, based on fishers' traditional knowledge in the Mediterranean, it was noticed that Atlantic mackerel, poor cod, scorpionfishes, striped seabream, and John Dory showed decreasing trends, whilst the trends of Mediterranean parrotfish, common pandora, cuttlefish, blue and red shrimp, and mullets increased (Damalas et al., 2015). Another study by Ceriola et al. (2008) from the Central Mediterranean reported decreasing trends in the abundance of red mullet, European hake, John Dory, and Norway lobster. On the other hand, not only trawl impact but also increased abundances of alien species have pressured on native demersal species for the last several decades in the Mediterranean. Thus, it was suggested that decision-makers should also focus on these interactions in trawl fishery (Saygu et al., 2020).

Table 4. Mean catch amount of main fish and shellfish species in Foça trawl fishery in 1998 and 2018

Species	Latin Name	Mean Production (kg/vessel/year)		P	U-Value
		1998	2018		
Red mullet	<i>Mullus barbatus</i>	6 730±6 117	3 341±1 835	0.134	66,000
Deep-water rose shrimp	<i>Parapenaeus longirostris</i>	5 695±5 991	515±626	0.005	36,000
European hake	<i>Merluccius merluccius</i>	4 337±4 100	4 233±916	0.159	68,000
Mackerel	<i>Trachurus trachurus</i>				
	<i>Trachurus mediterraneus</i>	3 515±4 476	281±289	<0.001	19,000
	<i>Trachurus picturatus</i>				
Bogue	<i>Boops boops</i>	2 035±2 510	2 167±1 155	0.158	68,000
Pickarel	<i>Spicara smaris</i>	2 016±3 321	370±196	0.032	39,500
Angler fish	<i>Lophius piscatorius</i>	1 405±1 917	465±307	0.582	87,500
	<i>Lophius budegassa</i>				
Musky octopus	<i>Eledone moschata</i>	778±560	693±217	0.842	95,500
Common octopus	<i>Octopus vulgaris</i>	775±1 178	181±135	0.002	30,500
Striped Red Mullet	<i>Mullus surmelatus</i>	785±719	331±146	0.185	70,000
Common squid	<i>Loligo vulgaris</i>	600±744	323±128	0.658	90,000
	<i>Solea solea</i>				
Flat fish	<i>Citharus linguatula</i>	213±308	213±149	0.288	76,000
	<i>Lepidorhombus spp.</i>				
John Dory	<i>Zeus faber</i>	180±234	48±60	0.030	51,000
Common Smoothhound	<i>Mustelus mustelus</i>	195±235	4±3	<0.001	0,000
Chub mackerel	<i>Scomber colias</i>	270±158	8±7	<0.001	0,000
Large-eyed Dentex	<i>Dentex macrophthalmus</i>	192±198	4±3	<0.001	0,000
Black scorpionfish	<i>Scorpaena porcus</i>	151±167	3±2	<0.001	0,000
Common cuttlefish	<i>Sepia officinalis</i>	151±233	329±343	0.070	59,000
Norway lobster	<i>Nephrops norvegicus</i>	145±206	2±4	0.240	75,000
Largescaled scorpionfish	<i>Scorpaena scrofa</i>	92±159	16±21	0.001	28,000
Striped prawn	<i>Penaeus kerathurus</i>	85±195	556±370	<0.001	19,000
Pink dentex	<i>Dentex gibbosus</i>	32±19	1±1	<0.001	0,000
European Lobster	<i>Homarus gammarus</i>	19±11	1±1	<0.001	0,000

*Some fish and shellfish species were recorded as others by fishers; thus the aforementioned species' catch amounts were not presented in table.

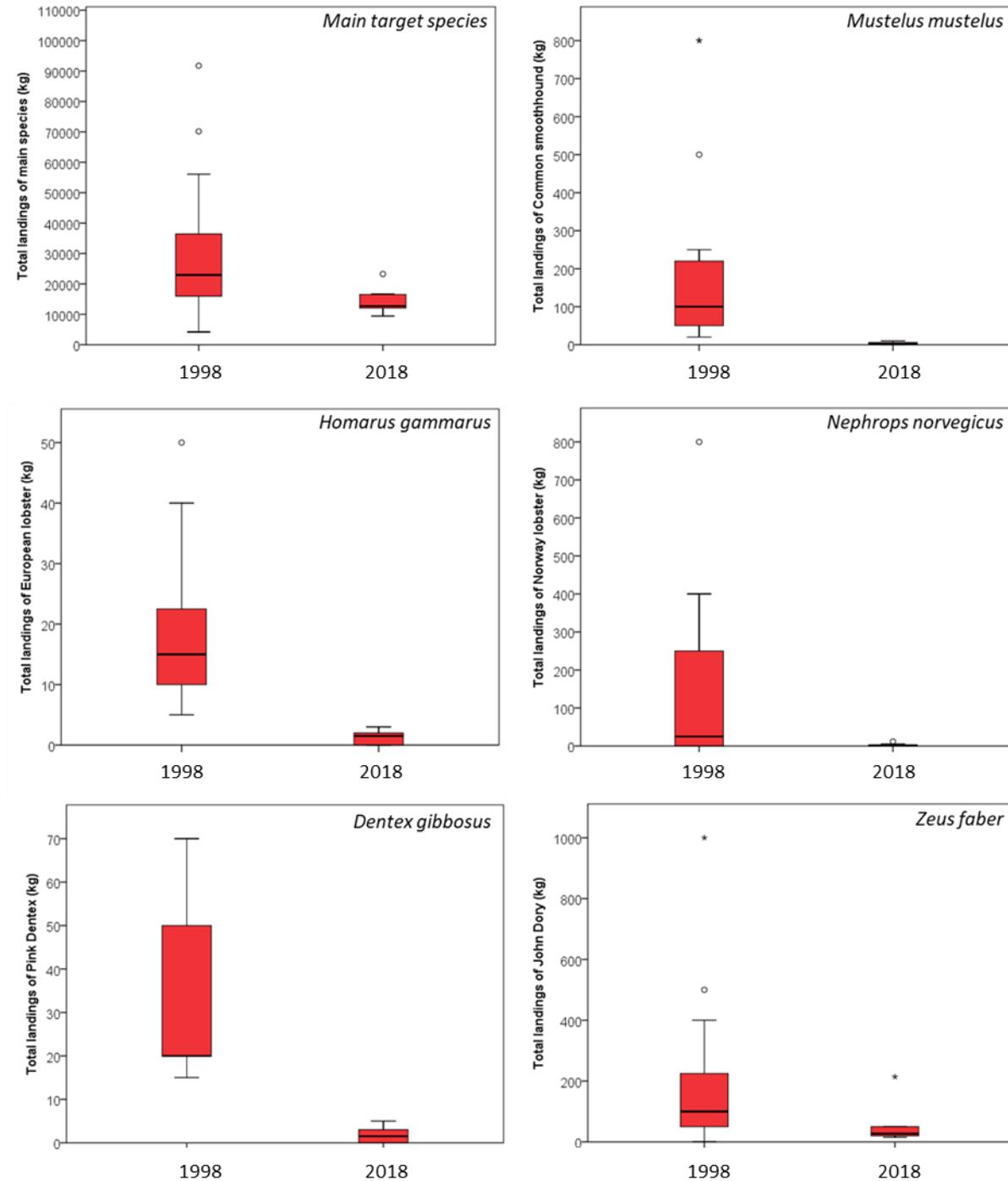


Figure 3. The total annual production values of fishing vessels for main targeted species and some selected species that showed marked decreased catch

Past and present problems in the management of trawl fishery

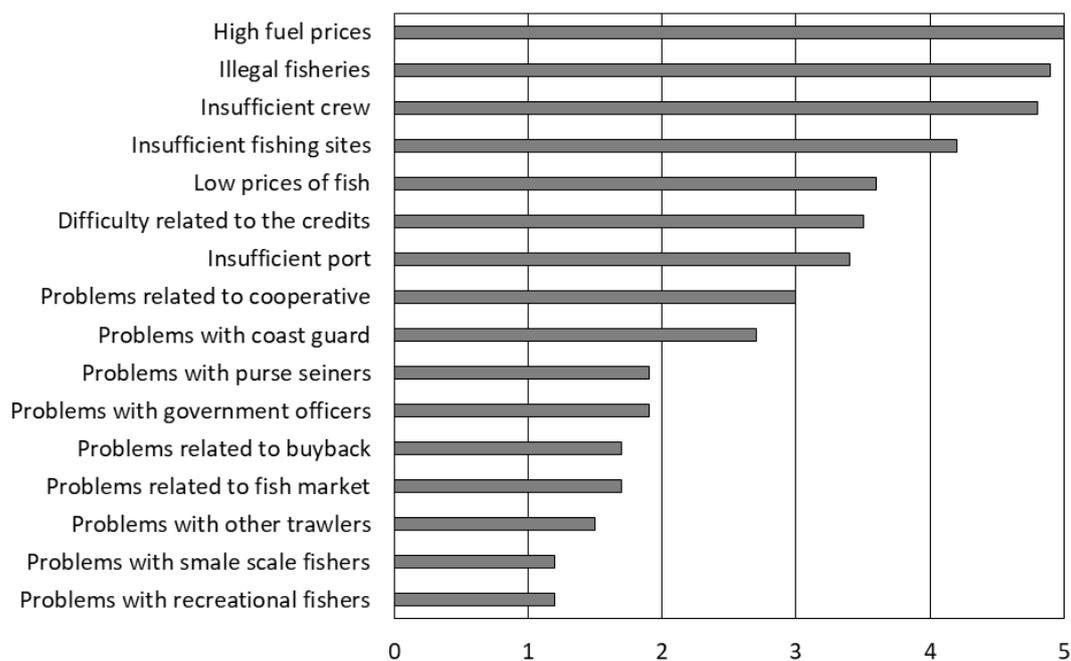
Regarding the previous problems in 1999, all fishers declared that they had problems with high fuel expenses, low prices of fish and the fish market. Moreover, 95% of fishers stated that they faced difficulty acquiring credit, 65%, 60%, 40% and 25% fishers had difficulties with

finding crew, other fishers, coast guard and insufficient port berth, respectively. Only 10% of fishers had problem with the limited fishing sites in 1999.

While in 2019, the biggest problem of Foça trawl fishery was declared as the increased fishing expenditures, in particular fuel expenses. The second biggest problem was illegal trawl fishing with small boats (usually

smaller than 12 meters) in closed areas and even closed seasons which is called “şebeke”. The Likert scale below provides comprehensive information related to the current problems of fishers; in addition to high fuel prices and illegal fishing, fishers specified that difficulties to employ crew, fishing site and port, low prices of fish species, difficulty to obtain credit were other important problems (Figure 4). Another important problem of trawl vessels with a valid work permit that they continue fishing

beyond 6 miles and have a shorter closed season. Furthermore, working permission for 300 days per year seems insufficient by some trawlers and they attempt to violate this regulation in various ways. Those who do not operate the vessel monitoring system, those who start working a few days before the start of the fishing season (they bring the fish to land within the legal time but fish in the closed season), those who fish inside instead of outside 6 miles, have been the subject of complaints by honest fishers for years (Pers. Comm.; N. Turguttekin).



Likert Scale (1-Strongly disagree, 2- Disagree, 3- Neither disagree nor agree, 4- Agree, 5- Strongly agree)

Figure 4. Likert scale on the problems of Foça trawl fleet in 2019

Recommendations on Fisheries Management

In this section, we discussed some recommendations for improvement of the current fisheries communiqué.

Depth closure

In the Mediterranean, littoral zone (up to nearly 50 m) includes vulnerable and sensitive habitats (e.g., Posidonia beds, algae facieses) and species as well high ratio of producer species and therefore, this zone is a critical area for ecosystem completeness. This productive zone is the main fishing ground of small-scale fishers, recreational fishers, and large-scale fishers (e.g., trawlers and purse-seiners) and therefore conflicts among inshore fishers, recreational fishers, and large-scale fishers are not uncommon (Birkan & Öndes, 2020; Öndes et al., 2020a). For example, the results of the present study showed that trawlers who fish in Foça had problems with other trawlers, purse-seiners, small-scale fishers, and recreational fishers. Furthermore, bottom towed gears (e.g., trawls and dredges) damages the fragile species (e.g., critically endangered fan mussel *Pinna nobilis*, some coral and sponge species) and

cause catastrophic impacts on their habitats (Öndes et al., 2020b; Otero et al., 2017). Furthermore, little is known about the survival rates and direct damage rates of by-catch species in trawl fishery in Türkiye (Metin et al., 2004; Düzbastılar et al., 2010), though these issues have been comprehensively evaluated in the Irish Sea, the North Sea and Western Mediterranean (Van Beek et al., 1990; Kaiser & Spencer, 1993, 1995; Depestele et al., 2014; García-De-Vinuesa et al., 2020). To allow the sustainable use of this productive and sensitive zone, we suggest that the ‘depth closure’ should be reconsidered for large-scale fisheries including trawl fishery. Additionally, any kind of large-scale fishing gear including both trawls and purse seines should be prohibited within the Special Environmental Protection Areas (SEPAs) and Marine Protected Areas (MPAs) in Turkish waters. This suggested ban can both minimize the conflicts among fishers and conserve the aforementioned habitats and species (Wang et al., 2021). With this suggested ban, the controlling of illegal fishing activities of fishing fleets (especially ‘şebeke fishing’) can get easier. Subsequently, this suggested restriction can provide a contribution to Türkiye for the harmonization

with the Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (EU, 2006).

Quotas to prevent overfishing

In the present study, all fishers declared that overfishing significantly increased over the last two decades and previous studies related to SSF and recreational fisheries supported this statement (Birkan & Öndes, 2020; Öndes et al., 2020a). Although the overfishing problem is well identified in the literature, few studies have focused on the solutions. One of the most effective management strategy the quota application has never been practiced in the trawl fishery in Türkiye (Anon., 2020). Owing to the nature of the trawl net (its unselective gear characteristic), the quota application includes some challenges. However, instead of applying a species-specific quota, a quota for the total annual catch can be considered. The annual catch quota can be identified by the government. This can contribute to the control of fishing activities, reduce overfishing. In this context, we recommend fisheries managers that stock assessment studies for demersal stocks should be started and carried out regularly at certain time periods. In the meantime, necessary studies should be completed to determine, allocate, control inspection system at sea, landing declaration, bycatch, landing port offices, logbooks and their validations, and monitor quotas very well to establish a system that will work successfully in practice. Solving these issues are the basic conditions for the transition to the quota system. However, one of the challenges is that the application of an output-based fisheries management system is not as easy as it is mentioned in theory. According to the FAO (1985), quotas generally lead to extremely complex procedures which are difficult and costly to implement. The state must systematically monitor its vessels' subject to quota and ensure that directed fishing is stopped as soon as any quota has been reached. FAO (1985) stated the problems of quota management in fisheries:

"In essence, quota management is an exercise in data acquisition. It depends on reliable information about what quantities of quota fish are caught where. Considerable problems are inherent in this requirement, and these lend force to arguments that quotas are in fact unenforceable. Certainly, they are extremely costly in manpower and resource but, requirements in the event can be enforced to some degree, dependent upon circumstances."

Regional fisheries management

One of the most discussed issues by the stakeholders related to fisheries management in recent years is the transition to regional fisheries management. Based on the findings of this study, traditional knowledge of fishers, and two decades of observation, we propose that the regional fisheries management considers an Ecosystem Approach to Fisheries (EAF) in large-scale fisheries including trawl fishery, in not only Foça but also in other regions and fisheries of Türkiye. This means that the same vessels should not fish in the Black Sea, the Sea of Marmara, the

Aegean Sea, and the Mediterranean Sea (Levantine coasts). The fishing borders of each vessel should be identified. With this potential arrangement, high fishing pressure on some areas and species can be prevented. In particular, the stocks of some species which exhibit seasonal migration will be positively influenced thanks to this closure. Moreover, scientific studies on habitat mapping should be urgently applied to understand whether there are additional necessary closed areas or not. EAF should be taken into account for the implementation of these aforementioned recommendations, and fisheries management plans based on EAF should be prepared for each fishery when transitioning to regional fisheries.

Rethinking the fishing season and minimum landing sizes (MLS)

The current bottom trawl fishery season in Türkiye is between the 1st of September and 15th April except for the Levantine coasts (15th Sep-15th Apr). İlkyaz et al. (2018) evaluated the spawning seasons of 21 fish species in the central Aegean Sea, Türkiye and reported that the current closed season protects only 47.1% of species throughout their spawning peak periods. The authors suggested the new closed season which is between March 1st to July 15th and with this potential regulation more species will be protected during their peak spawning seasons. In particular, peak spawning seasons of *B. luteum*, *D. annularis*, *G. niger*, *M. merluccius*, *M. barbatus barbatus*, *P. erythrinus*, *S. cabrilla* and *S. maena* were estimated to be in this period (İlkyaz et al., 2018). In addition, not only spawning periods but also recruitment periods of species should be considered as it also plays an important role in conserving community structure and composition (Demestre et al., 2008). It was also reported that increasing sea temperatures may have a positive or negative effects on crustacean's recruitment periods (Ceriola et al., 2008). However, these management recommendations based on scientific studies have not been considered until now.

The dramatic decrease in the mean size of some target species, such as *M. merluccius*, *L. piscatorius* and *Z. faber* was another remarkable finding of the present study. Similarly, Ceriola et al. (2008) noted great reductions in the size of *M. merluccius* and *Z. faber* in GSA 18. This may be related not only to overfishing of the related species but also to the discovery of new fishing grounds which were full of adult individuals of these species with high spawning capacity and no presence of destructive fishing in these areas (pers. comm.; N.Turgutekin). According to the current communiqué on commercial fisheries, a total of 50 species (fish and invertebrates) has the minimum landing size and one species (common octopus) has the minimum landing weight in Türkiye (Anon., 2020). However, there is no minimum landing size for some species captured by trawls such as *Dentex macrophthalmus*, *Dentex gibbosus*, *Boops boops*, *Pagellus bogaraveo*, *Scorpaena porcus*, and *Spicara smaris*. Similarly, Yıldız & Ulman (2020) noted that 16 taxa still need national studies to determine their maturity sizes and 11 taxa listed in the current notification should have increased MLS values. Furthermore, due to the changes in the climatic factors, the maturity status and

spawning seasons of species may be affected, and we strongly suggest that the current studies should be supported by funds about the size at onset of sexual maturity (SOM) and reproductive ecology of demersal resources should be periodically monitored. The key point is that these future studies should cover large geographical areas; the spatial factors may influence the SOM of species. Therefore, the revisions in MLS of species may be necessary. In addition to all the above-mentioned recommendations, the principles of managing shared stocks should be followed in the Aegean Sea.

Improving the audit fishing activities and monitoring issues

The role of AIS and VMS data in having information on fleet dynamics and developing management measures are well explained (Lambert et al., 2012; Martin et al., 2014; Shepperson et al., 2018). Vessels larger than 15 m in total length have been compulsorily monitored by VMS since 2005 in Europe (Martin et al., 2014). However, the vessels larger than 12 m shall finalize the necessary procedures to be monitored by VMS in Türkiye as of the year 2016 (Official Gazette, 2016).

Although there are published articles on VMS records in European waters (Witt and Godley, 2007; Gerritsen and Lordan, 2011; Martin et al., 2014; Russo et al., 2018), there are no studies on the Turkish fleet. Thus, to understand fleet dynamics and pressures on different fishing grounds, the VMS data and electronic logbook data of the Turkish fleet should be evaluated. Then, according to the results additional closures (e.g., spatial) may be considered.

Conclusion

In conclusion, Foça trawl fishery shows a dramatic change in many aspects compared to what it was two-decades ago. The problem of illegal fishing, which could not be solved for years and is even increasing day by day, increasing fishing costs and low catch amounts seem to be bringing Foça trawler fishing to an end. The total landings of many targeted species and the mean size of some of these species dramatically decreased from 1999 to 2019 in Foça trawl fishery. In two decades, a dramatic decrease has occurred in the trawl fleet.

Today, only 10% of the fishers interviewed twenty years ago continue trawling thanks to their children. A family of trawl fishers came to the region from Bodrum in the 1970s due to the rich fishing grounds, had 5 trawlers over time, and in 2021 they sold their last vessel and left the fishing industry completely (Pers. comm., N. Turguttekin). We hope that the findings which reveal this dramatic change are important for fisheries management and will mobilize any policy-makers left who care about sustainable fisheries in Türkiye.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

Author Contributions

Vahdet Ünal: Designed the study, Data collection and curation, validation, investigation, writing - original draft, supervision, final editing. Fikret Öndes: Data collection and curation, validation, investigation, data analysis, writing - original draft, final editing.

Ethics Approval

Approval was granted by the Ethics Committee of İzmir Katip Çelebi University.

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