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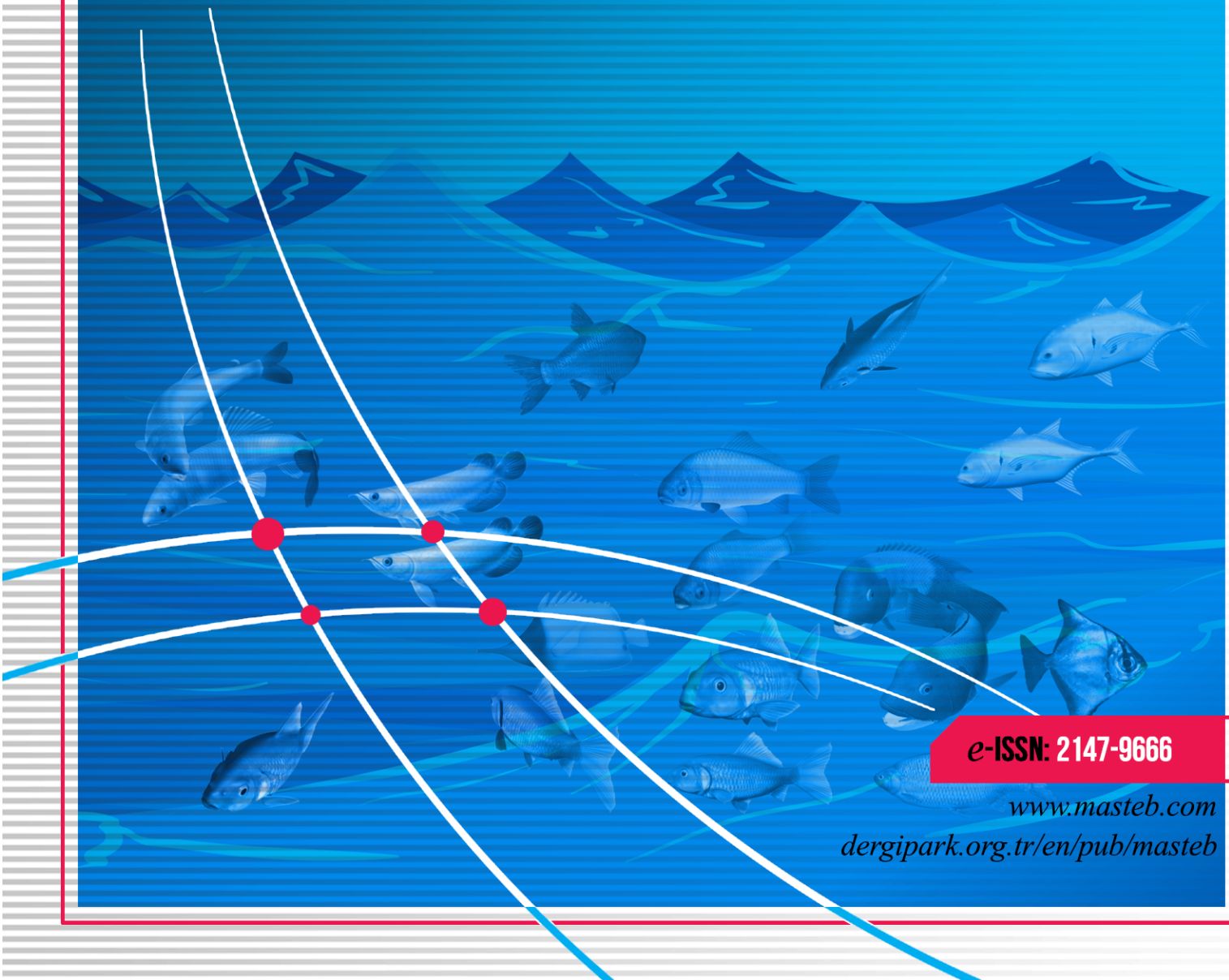

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Marine Science and Technology Bulletin

RESEARCH ARTICLE

First Observation of Loggerhead Sea Turtle *Caretta caretta* (Linnaeus 1758) Around the Shipwreck Used as an Artificial Reef in the Coasts of Gokceada Island, North Aegean Sea

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ABSTRACT

In this study, loggerhead sea turtle *Caretta caretta* (Linnaeus 1758) was observed for the first time around the shipwreck of coast guard boat in Ördek Yalağı located at Gökceada Island, North Aegean Sea. The shipwreck is at a depth of 24.8 m. The loggerhead sea turtle *Caretta caretta* was recorded exactly on the ground and 2 m away from the ship on the shore side of the ship. In this study, *Caretta caretta* was recorded for the first time in this water depth and around a shipwreck that was used as an artificial reef for Turkish waters.

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Introduction

Researches on artificial reef have been carried out for several years in Turkey (Lok et al., 2002; Altınagaç et al., 2010; Gul et al., 2011; Acarli and Ayaz, 2015) and worldwide (Jensen, 2002; Simon et. al., 2010, Honario et al., 2010; Krumholz and Brennan, 2015; Brennan et al., 2015; Jimenez et al., 2016). These studies cover many issues such as construction materials of the reef, species composition around artificial reefs, species-specific artificial reefs, and protection of artificial reef areas. *Caretta caretta* (Linnaeus, 1758) is extensively distributed in tropical and subtropical waters in the Atlantic, Pacific and Indian Oceans, and Mediterranean Sea (Kelez et al., 2003; Özdilek

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et al., 2018).There are a total of eight species of sea turtles in the world. Among them, the species *Dermochelys coriacea*, *Ertmochelys imbricate*, and *Lepidochelys kempii* found in the Mediterranean Sea but not nesting; *Chelonia agassizii*, *Lepidochelys olivace*, and *Natator depressus* species that are not found in the Mediterranean Sea, and *Chelonia mydas* and *Caretta caretta* species prefer coasts of Turkey for laying eggs (DEKAMER, 2009). Würtz (2010) reported that sea turtles were found in 10 countries on the Mediterranean coasts for both feeding and spawning.

Figure 1. Spatial distribution of the *Caretta caretta* (Calim, 2010)

Sandy beaches where the sea turtles nest are slowly disappearing due to the increase in the human activities in the coastal areas (Fig 1). Hence, monitoring projects for sea turtles have increased in Turkish waters (Guzel, 2012; Akdeniz et al., 2012; Ergene et al., 2016; Özdilek et al., 2018; Esinliogulları Mete and Tosunoglu, 2019) as in the worldwide (Lara et al., 2016; Salmon et al., 2016).

Chelonia mydas and *Caretta caretta* are nesting regularly in the coasts of Turkey on the Mediterraean Sea. *Chelonia mydas* is listed as endangered and *Caretta caretta* is listed as vulnerable in the of The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Seminoff, 2004; Casale and Tucker, 2017).This is because the population of sea turtles has decreased and human activities have increased particularly in the coastal areas and therefore their stocks have been significantly damaged (Würtz, 2010). Their populations have decreased due to the pollution of the beaches where they lay eggs and obstacles encountered in these areas, increased sea traffic, human activities, ghost fishing and the selling of their shells as ornaments. Therefore, special efforts are made for the protection of these areas particularly during spawning periods in Turkey and the world.

Gokceada Island which is located in the Aegean Sea is an important fishing area (Esenlioglu Mete and Tosunoglu, 2019) and different fishing gears are used in fisheries in Gokceada Island. Öztekin et al. (2013) reported that sea turtle individuals were caught during longline fishing. On the other hand, sword fishing is one of the most interesting fishing methods since the spear is used. As fishermen travel long distances to catch the swordfish, their chances of seeing sea turtles increase. Therefore, the frequency of seeing sea turtles by fisherman was investigated. In this study, loggerhead sea turtle *Caretta caretta* species was observed for the first time around the shipwreck during underwater observations to determine the species composition on the artificial reef.

Material and Methods

Caretta caretta species is one of the two species that prefer the coasts of Turkey for laying eggs (Würtz, 2010). *Caretta caretta* species was observed the first time around the shipwreck of coast guard boat in Ordek Yalağı located at Gokceada Island, North Aegean Sea (Fig. 2). This shipwreck artificial reef was sunk on October 2016 and found between the depths of 22.6 – 24.8 m parallel to the shore (Fig 3 and Fig 4). The name of the ship was TCSG 132 which scrapped from the coast guard. The length of the ship is 40.3 m and the width is 6.4 m.

Figure 2. The location of the shipwreck

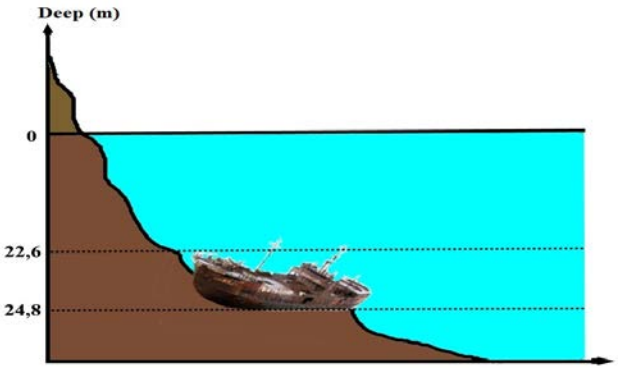

Figure 3. The depth of the shipwreck

Figure 4. Underwater view of the shipwreck

Underwater visual census methods, underwater photograph, and cameras are used to determine the species composition in artificial reefs (Acarli and Ayaz, 2015). In this study, Quadrat methodology which is a method of visual census techniques was used. Underwater camera (GoPro Hero 4) was used in addition to visual census techniques to improve the efficiency of visual census. Data recorded underwater by divers were crosschecked with video records and underwater photographs to improve the reliability of the data.

Results

An adult male *Caretta caretta* species was recorded during underwater observations on January 2019 (Fig 5, Fig 6, and Fig 7). We observed *C. caretta* resting at a depth of 25 m and the water temperature was 13°C. The loggerhead sea turtle was disappeared after 5 minutes of observation. The estimated curve carapace length 60 cm and width 40 cm.

Figure 5. *Caretta caretta* and shipwreck

Figure 6. *Caretta caretta* species around the shipwreck

Figure 7. *Caretta caretta* in the *Posidonia* sp. seagrass

Discussion and Conclusion

In recent years, the deployment of wrecks of ships and planes on the seabed as artificial reef has increased remarkably. In addition, a total of 68 artificial reef projects were conducted in the coasts of Turkey. Özgül and Lök (2017) reported that a total of 14592 concrete blocks, 300 amphorae, 19 ships, 10 trolleybuses, 7 planes, 1 tank, and 8 floating artificial reefs for scientific purposes were deployed on the seabed within the scope of these projects. However, only the shipwreck named TCSG 132 which is located in Gokceada coasts has been scientifically examined for the first time.

According to conversations with fishermen, *Caretta caretta* species are seen as injured and/or dead on the coasts of Gokceada Island by fishermen. Sword fishing starts on March 15 and continues until June 15 in the coasts of Gokceada Island. Fishermen are fishing in the region 40 nautical miles from the shore during the fishing season. They informed that they saw several sea birds and sea turtles during the sword fishing (Y. Tokoglu, personal communication, June 10, 2019). The incidence of the sea turtles in the coasts of Gokceada Island in 2018 was 0.729 individuals/year (This result has been reached as number of sea turtles /number of fishermen).

Biodiversity studies in artificial reefs are among the oldest studied topics (Carlisle et al., 1963). Although there is generally a large majority of fish fauna around artificial reefs, bivalve species, gastropod, and crustacean species are also observed. Until nowadays, there is no report for the observation of *Caretta caretta* species around artificial reefs in Turkey. Therefore, this report has a great importance since it was the first observation.

Fishermen of sword fishing in Gokceada coasts have a long time at sea to find swordfish. Hence, they can see the sea turtles coming to the surface to breathe during this time period. In addition, sea turtle individuals were caught by using longline as discard (Öztekin et al., 2013).

In conclusion, this paper is the first record of loggerhead sea turtle *Caretta caretta* around the shipwreck that was used as an artificial reef in the coasts of Gokceada Island, North Aegean Sea. It is possible to record sea turtles and other rare species by photo-trap to be placed on the artificial reef in future studies.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Marine Science and Technology Bulletin

RESEARCH ARTICLE

Determination of Fish Consuming Habits of Vocational School Students from Different Families

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ABSTRACT

In this study, the fish consuming habits of the university students of Narman Vocational School of Atatürk University in Erzurum city were studied. The data was determined by face-to-face questions asked to the 269 participants and then subjected to statistical analyses by using Chi-square independence test. The data were commended by giving in the form of tables. The results were handed by evaluating the answers given by the participants about their monthly incomes, yearly fish consumption, fish supplying way, fish prices, the kinds of consumed fish, fish cooking form and the seasonal changing of fish consumption. According to results of the study, while people aged less than 21 years consume 60% of their annual fish consumption during the summer months, this rate was determined as 31.1% for people aged between 21 and 30. It was understood that while 29.8% of the participants whose incomes were lower than 300 Turkish Liras (TRY) consumed fish once a month, this rate was 54.3% for the participants whose income levels were more than 1200 TRY. While 41.7% of the participants whose income levels were between 900-1200 TRY were cooking fish by frying method, for the other participants whose income levels were more than 1200 TRY this rate was 62.9%.

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Introduction

It has been thought that nutrition and food shortage will be one of the most important problems of rapidly growing human population. The experts have often explained that the food production and producing will increase twice because of increasing population in 2050. For that reason, aquaculture and fisheries are of great importance (Arslan, 2017).

Nowadays, there are nearly 186,000 different marine and freshwater species all over the world that the majority of them are fishes (21,000 species) and invertebrates (16,000 species). Approximately, five hundred species taking place in mankind's nutrition that the majority of them are also fishes (275-300 species) (Dağtekin and Ak, 2007). Turkey is an important country in terms of aquaculture production potential. In 2016, a totally 170,995,437 tons of fishery products were produced by fisheries and aquaculture (FAO, 2016). This kind of production activity was nearly 588,725 tons in 2016 in Turkey (TurkStat, 2019).

While global fish consumption per capita is about 20.5 kg (FAO, 2017), this is about 5.5 kg in Turkey (TurkStat, 2019), which is

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especially very low in Eastern Anatolia, Southeastern Anatolia and Central Anatolia regions. However, it is quite high in the coastal regions of Turkey (Dağtekin and Ak, 2007). In such a way that the annual fish consumption per capita in the Eastern Black Sea Region is about 20-25 kg, while it is extremely low in Eastern and Southeastern Anatolia (Altay et al., 2000). This situation is caused by many factors such as the lack of adequate introductions of fish in the non-coastal cities (positive relationship between human health and fish consumption, etc.), transportation to the hinterlands with higher coast inability to supply freshly consumed aquaculture in all seasons, food habits, variability in prices and income level (Arık Çolakoğlu et al., 2006; Balık et al., 2013).

Indefinite areas in Turkey, many kind of researches intended for fish consumption have been done, and various results have been obtained by evaluating the distance of the region to the sea, the number of fish farms, the income level of the local people, and their education levels. In the present study, the factors affecting the fish consumption and its affective variables of the students educated in Narman country of Erzurum city having a high altitude and to be 230 kilometers far from the sea coast and 90 kilometers far from the city center were evaluated.

Material and Methods

The study was conducted with a face to face question and answer format with 269 participants, 137 of whom were randomly selected and 132 were men.

The main material of this study consists of gathering the answers to the various questions related to the amount of consumption of aquacultural resources and the causes affecting this amount by making face to face meetings with the students who educate in Narman county of Erzurum city and evaluating them.

The questions as socio-economic status, habits of consumption of aquacultural products, type of consumed fish, amount of consumption, the ways they acquire the fish, causes of their preferences and the baking ways of the participants were asked. The answers were analyzed with the test of Chi-square independence test.

Results

Survey data related the socio-economic and demographic features, consumption habits by season, consumer's opinions about price, frequency of consumers consumption fish, fish consumption habits, consumption rate of consumers, types of seafood consumption determined from the present study are presented in Table 1-8.

The questionnaire was applied to randomly chosen 269 students and 50.9% of the participants were female (137 people) and 49.1% of them were male (132 people) (Table 1). When the number of people in each students' family was inquired, it was understood that they live in such families that 52% of them had 0-5 family members (totally 140), 48% of them had more than 5 family members (totally 129). It was understood that the 72.5% of participant students were under 21 years of age, 27.5% of them were between 21-30 years of age. In addition, when considering the income level which is one of the factors importantly affecting the people's fish consumptions, 34.3% of students had 301-600 Turkish Liras (TRY) income. On the other hand, some other participants with the rate of 31.2% who have 300 TRY of income were following them and the rate of the participant students who had the highest income level was 8.9% and they had 901-1200 TRY of income levels. When it was looked at the students' residences, 76.6% of them were living in different places without Erzurum and 23.4% of them were living in Erzurum city. When it was looked at the fish consumption of the students living in Erzurum, preferred red meat (55.6%), the students living in different cities without Erzurum mostly preferred white meat (58.7%).

Table 1. The socio-economic and demographic features of participants

N = 269	(%)
Male	50.9
Female	49.1
Family members	
0-5	52.0
>5	48.0
Age	
< 21	72.5
21-30	27.5
Income level (TRY)	
<300	31.2
301-600	34.2
601-900	12.6
901-1200	8.9
>1200	13.0
Residence	
Erzurum	23.4
Non-Erzurum	76.6

It was understood that there was a statistically significant difference as a result of the Chi-square independence test ($p<0.05$) among the numbers of family members because of the answers given to the question of "*How do you find the fish prices?*" While 55% of participants (71 persons) who had 5 or more family members found fish prices expensive, this rate was 37.9% (53 participants) for the participants having 5 or lower members in their families (Table 2).

As a result of Chi-square independence test applied to determine whether there is a meaningful difference between the ages in terms of answers given to the question of "*In which season do you consume more water products?*", a significant difference emerged ($p<0.05$). While people aged less than 21 years consume 60% of their annual fish consumption (117 people) during the summer months, this rate was determined as 31.1% for people aged between 21 and 30 (Table 3).

Chi-square independence test, which was applied to define if there was a difference on account of given answers to the question of "*How often do you consume fish?*", revealed that there was an important difference ($p<0.05$). As a result, it was understood that while 29.8% of the participants (25 persons) whose incomes were lower than 300 TRY consumed fish once a month, this rate was 54.3% (19 persons) for the participants whose income levels were more than 1200 TRY.

Table 2. Opinions about fish price of participants from different family members (N=269)

Number of family members	Opinion about fish prices (%)			
	Inexpensive	Reasonable	Expensive	No idea
0-5 (N=140)	1.49	15.61	19.70	15.24
>5	0.00	8.18	26.39	13.38

Note: Pearson Chi-Square is 12.759 (p<0.05)

Table 3. Seasonal consumption rate (%) of participants by age (N=269)

How old are you?	In which season do you consume fish more?			
	Spring	Summer	Autumn	Winter
<21	5	117	8	65
	2.6	60.0	4.1%	33.3
21-30	3	23	5	43
	4.1	31.1	6.8	58.1
Overall	2.97	52.04	4.83	40.15

Note: Pearson Chi-Square is 18.003 (p<0.05)

Table 4. Frequency of fish consumption rate (%) of participant by income levels (N=269)

What is your income level? (TRY)	How often do you consume fish?					N
	Once a week	Once in fifteen days	Once a month	Once a year	I don't consume	
<300	3.6	13.1	29.8	29.8	23.8	84
300-600	7,6	12.0	44.6	17.4	18.5	92
600-900	5.9	14.7	35.3	23.5	20.6	34
900-1200	8.3	0.0	54.2	16.7	20.8	24
>1200	17.1	20.0	54.3	8.6	0.0	35
Overall	7.43	12.63	40.89	20.81	18.21	269

Note: Pearson Chi-Square is 31.242 (p<0.05)

Table 5. Fish consumption rate (%) amounts of participant by income levels (N=269)

What is your income level? (TRY)	How much amount of seafood are you consuming monthly?				N
	1-3 kg	4-6 kg	6-10 kg	>10 kg	
<300	50.0	25.0	10.7	14.3	84
300-600	44.6	28.3	17.4	9.8	92
600-900	52.9	17.6	11.8	17.6	34
900-1200	20.8	12.5	25.0	41.7	24
>1200	40.0	14.3	22.9	22.9	35
Overall	44.6	22.7	15.9	16.8	269

Note: Pearson Chi-Square is 25.196 (p<0.05)

Table 6. Season consumption rate (%) of participant by income levels (N=269)

What is your income level? (TRY)	In which season do you consume more water product?				N
	Spring	Summer	Autumn	Winter	
<300	1.2	58.3	0.0	40.5	84
300-600	5.4	40.2	12.0	42.4	92
600-900	0.0	44.1	5.9	50.0	34
900-1200	8.3	70.8	0.0	20.8	24
>1200	0.0	62.9	0.0	37.1	35
Overall	3.0	52.0	4.9	40.1	269

Note: Pearson Chi-Square is 32.975 (p<0.05)

The answers given with regard to the question of "*How much amount of seafood are you consuming monthly?*" with the purpose of determining if there was a difference among the level of income by applying the results of Chi-square independence test, the results showed that there was a significant difference ($p<0.05$). While the participant students whose income levels were between 600-900 TRY consumed 1-3 kg of fish in a month and their percentage was 52.9% (18 persons) the other participant students whose income levels were between 900-1200 TRY, their percentage rate was 20.8% (5 persons) (Table 5).

Table 6 presents the answers given with regard to the question of "*In which season do you consume more water products?*" with the purpose of determining if there was a difference among the level of income by applying the results of Chi-square independence test and its results showed that there was a significant difference ($p<0.05$). While 50% (17 people) of people with/while income level between 600-900 TRY consumed more fish during the winter months, this rate was determined as 20.8% (5 people) of people with/having income levels between 900 and 1200 TRY.

In Table, the answers given by the participant students to the question of "*What is your fish cooking method?*" were presented and the Chi-square independence test used to understand if there was a significant difference. As a result of the test, it was understood that there was a significant difference among them ($p<0.05$). While 41.7% of the participants whose income levels were between 900-1200 TRY (10 persons) were cooking fish by frying method, for the other participants whose income levels were more than 1200 TRY this rate was 62.9% (22 persons) (Table 7).

With the aim of understanding if there was a significant difference among the participant students living in Erzurum the Chi-square independence test was employed. As a result of this test, it was understood that there was a significant difference ($p<0.05$). While 55.6% of the participants living in Erzurum (35 persons) were consuming red meat more, this rate for the participant students living in different cities was 30.1% (62 persons) (Table 8).

Table 9 presents the answers given by the participant students to the question of "*Where do you buy fish?*" the Chi square independence test was used to understand if there was a significant difference. As a result of the test, it was understood that there was a significant difference among them ($p<0.05$). It is declared that while 66.7% of the participants (42 persons) living in Erzurum define that they buy fish from market places, the rate for the other participant students living in some different countries was 49.5% (102 persons).

As it can be seen in Table 9, the market places have a very important place in the access to finish regardless of where they live. Because fish is a highly perishable foodstuff, the cold chain is of vital importance to its transport and storage. Buying fish from fish market brings many health risks that can be caused by cold chain breaks. Therefore, consumers should be aware of this issue.

Table 7. Consumption rate (%) of participant by income levels

What is your income level? (TRY)	What is your fish cooking method?				N
	Fried	Grilled	Steamed	Others	
<300	71.4	6.0	9.5	13.1	84
300-600	59.8	23.9	10.9	5.4	92
600-900	41.2	17.6	17.6	23.5	34
900-1200	41.7	25.0	16.7	16.7	24
>1200	62.9	28.6	5.7	2.9	35
Overall	59.9	18.2	11.2	10.7	269

Note: Pearson Chi-Square is 32.975 ($p<0.05$)

Table 8. Types of seafood consumption rate (%) of participant

Do you live in Erzurum?	Which type of meat do you consume more?			N
	Fish	Red meat	White meat	
Yes	4.8	55.6	39.7	63
No	11.2	30.1	58.7	206
Overall	9.7	36.1	54.2	269

Note: Pearson Chi-Square is 13.946 ($p<0.05$)

Table 9. Where fisheries are supplied of participant (%)

Do you live in Erzurum?	Where do you buy fish?				N
	Market Place	Fish Sales Room	Fish Market	Peddler	
Yes	66.7	11.1	9.5	12.7	63
No	102	53	31	20	206
Overall	53.5	22.3	13.8	10.4	269

Note: Pearson Chi-Square is 8.758 ($p<0.05$)

Discussion and Conclusion

Many studies that emerged in recent years had focused on the positive effects of n-3 polyunsaturated fatty acids on human health (principally eicosapentaenoic acid and docosahexaenoic acid) (Montaño et al., 2001; Moyad, 2005; Wertz, 2009; Sekikawa et al., 2015; Bellenger et al., 2019). United Kingdom Scientific Advisory Committee on Nutrition (UK SACN, 2004) has reported that almost 300 grams of fish should be consumed per person per week for a healthy life. In Turkey, the fish consumption of per person is both very low and constitutes a significant part of a single species (European anchovy, *Engraulis encrasicolus*, captured from the Black Sea). Therefore, in addition to increasing of the amount of fish consumption per person to have a healthier society, other species should be included in the balance of consumption depending on the only one species. This situation may enlighten the consumer choice in Turkey. The social and state campaigns treated on the effects of fish meat on human health and consumer choice can be gathered on fish meat. At these campaigns, the first target must be the high-income level. Then, with the control of fish prices, this situation should be also reflected in lower income levels.

According to fish consumption of the students living in Erzurum, they preferred red meat (55.6%), the students living in different cities without Erzurum mostly preferred white meat (58.7%). The least consumed meat type is fish meat without depending on where they live. In the study of Oğuzhan et al. (2009) with the aim of defining the consuming habits of aquaculture products, it was defined that the people liked to consume red meat the most (56%), seconded by chicken (37.3%) and fish (6.7%). For that reason, our results show similarities with the findings of Oğuzhan et al. (2009). The most important factors in food consumption are cultural effects, income level and consumer awareness. Turkey's people pay no attention to the fish consumption even if they have financial possibilities. As a result of this study, more emphasis should be made to create social awareness on the positive relationship between fish consumption and human health and the mean fish consuming amount of Turkey (5.6 kg/year) must be increased to higher levels.

The questionnaires are important data resources to have information and estimation about any subject. In this study, the university students educated in Narman county of Erzurum city were asked questions about the fish consumption and the answers given by them were evaluated by using suitable statistical methods. At the end of this study with the aim of evaluating the university students' fish consuming habits following general results were acquired:

- While some of the participant students (some of the people) at the ages of under 21 were carrying out their fish consumption's 60% in summer months, it was found out that this rate was nearly 31% for the remainder of the students whose ages were between 21 and 30. This situation showed that the more the consumers' ages increased the more the consciousness increased equally and a result of this position it was understood that the fish consumption spread over the whole year.
- As income level increases, fish consumption frequently increases. This means that approximately 30% of people with income level less than 300 TRY consume fish once a month, while those with income levels more than 1200 TRY have reacted 54%. As an even more interesting result is the fact that 63% of the group representing the upper-income level has the highest fish consumption in Turkey cause to the production of raw materials during the summer season. Fish consumption frequently increases by about two times as much as income level increases by four times. In addition, there is no one consuming fish at the upper-income level, while the lowest income class is about 24%. This result shows that people do not care much about the content of the food they consume, whereas the benefits of the food consumed with economic prosperity are important in terms of health regardless of the price.
- It was defined that 66.7% and 45.8% of the groups having income levels of 900-1200 TRY and 1200+ TRY consumed 6 kilograms fish per year, respectively. Also, it was defined that the fish consumption amount was increasing with the rise of income level being in a harmony with the frequency of fish consumption. For that reason as the income level increased, either the consumer's consciousness of awareness increased or the price did not have importance to become an obstacle to reach healthy food.
- The most interesting results of this study are the monthly distributions of fish consumption. Specifically, nearly 63% of the participants symbolizing the upper level of income consume fish in summer months in which fish consumption is minimum in Turkey because of the product depending on the European anchovy. Also, it was found out that the groups nearly did not consume fish in spring and autumn. The most caught fish in Turkey is the anchovy, which constitutes 59% of Turkey's total fisheries production in 2017 (TurkStat, 2019). While it is an expected result for the fish consumption to increase in winter months due to the catching of anchovies in the middle of autumn and winter months, it is unexpected result for the consumption of it to be lower in the autumn. This situation may be a unique situation for the students since students that tend to live with their families are fed healthier. But, it is also clear that this study could not give data about the general fish consumption of Turkey.
- It was found out that there was a difference between the fish cooking methods and income. According to the study the people who had low income levels preferred more practical methods. This difference between income level and fish cooking options was due to the costs of fish cooking. People who had low incomes prefer cooking options of less cost. The fish cooking options are related to fish preferences and the climate. Fish cooking option is used more by frying method since the average annual air temperature is low.
- The fish markets have a great importance for the people to reach the fish where they are located. The cold chain has crucial importance for transporting and keeping it fresh because of it going deforming easily. There are many health risks of fish buying from market places because of breaking the cold chain. For that reason, the consumers should be informed and awareness should be raised absolutely.

Conflict of Interest

The author declares that there is no conflict of interest.

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RESEARCH ARTICLE

Occurrence of the rabbitfish (*Chimaera monstrosa* Linnaeus, 1758) in the deep seas of Northern Cyprus, Mediterranean Sea

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ABSTRACT

Rabbitfish (*Chimaera monstrosa*, Linnaeus 1758), which is a deep-sea holocephalan mostly seen between 200-1000 m in depth. The specimen of *C. monstrosa* was caught in the deep-seas of Northern Cyprus by a commercial bottom trawler from Turkey. The depth of sampling area is between 456 and 690 m. Species description fulfilled with the help of morphological features and metric measurements. The specimen was preserved in 4% formaldehyde and deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (Catalogue number: MEUFC-19-11-103).

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Introduction

Cartilaginous fishes are divided morphologically into two classes. The first of which included sharks and rays is the elasmobranchs, and the other one including chimaeras is the holocephalans (Gillis et al., 2011).

Holocephalans, including Chimaeridae family, has two genera; *Chimaera* and *Hydrolagus*. They differ from each other with a distinct morphological difference. Namely, *Hydrolagus* does not have an anal fin, but *Chimaera* has it separated with a kick from the ventral caudal fin (Kemper et al., 2010a).

A deep-sea holocephalan *C. monstrosa*, are mostly seen at depths between 200-1000 meters (Moura et al., 2005). The common name of this fish is rabbitfish, and it belongs to the Chimaeridae family of class Holocephali. Chimaeroid fishes characterized by their large heads and

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long pointed bodies. Adults can found in lengths between 60 cm and 1 m, including the whip-like tail. They have a caudal fin, a pair of pelvic and pectoral fins, and two dorsal fins. The first dorsal fin has a triangular shape and contains a spine in front of it (Didier et al., 2012). Dorsal spine was thought to play a role in the protection of the fish itself. However, the spines of *C. monstrosa* are venomous and can cause painful wounds (Calis et al., 2005). While the skin of adult fish is completely scaleless, the dorsal part of the head and trunk of newborns has fine denticles embedded in the skin. Under the neurocranium, there are gill arches that covered with a thick-walled operculum, supported by cartilage rays extending from the hyoid arch.

Contrary to elasmobranchs, on both sides of the body, there is a little opercular vent positioned from anterior to the pectoral fin base.

Males have frontal tenaculum, paired pelvic claspers, and prepelvic tenacula as sexual structures, while juvenile males do not have tenacula. Using those pelvic claspers, males transfer sperms inside the females' reproductive tract to perform internal fertilization (Didier et al., 2012). Like all chimeras, *C. monstrosa* is oviparous, and during hot seasons, they are laying egg capsules at depths below 100 meters (Calis et al., 2005). *C. monstrosa* has been reported to feed on Bryozoa, Cnidaria, Crustacea, Mollusca, Tunicata, and Teleostei (Eronat, 2016). The reason why chimeras are called rabbitfish is because of their rabbit mouth-like anterior tooth plates and their noses (Didier et al., 2012). The bodies of *C. monstrosa* covered with a distinct brown pattern, which is dorsally brownish and ventrally whitish. There are stripes and blotches on the lateral part of the body. The margins of the fins are more pale or whitish than the body. Brown and silver network patterns are available in some parts of the body (Jordan and Snyder, 2011; Luchetti et al., 2011). At times identification of chimaeroid is challenging. DNA barcoding can be used for identification of species with CO1 gene sequencing (Ward et al., 2008).

C. monstrosa has several records in the Mediterranean region. Some of those are: at Haifa Bay (Goren and Galil, 1997), Italy (Matarrese et al., 1996), North-East North Sea (Bergstad et al., 2003), Northern Tyrrhenian Sea in (Sartor et al., 2003), Syria (Ali, 2003), Balearic Sea (Sion et al., 2004), Sicily (Ragonese et al., 2013), Sea of Marmara (Dalyan, 2010) and the Aegean Sea (Geldiay, 1969).There is no record for *C. monstrosa* in Cyprus, until now. The present study is the first study showing the occurrence of *C. monstrosa* and new data for fish species in Cyprus.

Material and Methods

The deep-sea sampling was carried out on March 7, 2019, by a commercial trawl in the Northern Cyprus, Mediterranean Sea. The depth of sampling area is between 456 and 690 m. The coordinates of the capture zone are 36°07'11.6"N 34°34'14.6"E (Figure 1). The specimen of the rabbitfish (*C. monstrosa*) was preserved in 4% formaldehyde and deposited in the Museum of the Systematic, Faculty of Fisheries, Mersin University, (Catalogue no: MEUFC-19-11-0103) (Figure 2). The identification of the species was made according to Kemper et al. (2010b). All morphometric measurements were done to the nearest 0.01 cm using dial calipers (Table 1). Body length proportions (BDL%) were calculated using the following formula:

$$BDL\% = x\frac{100}{385}$$

In this formula, x is proportioned measurement, BDL is body length and is 385 mm.

Figure 1. Sampling location of the *C. monstrosa* specimen

Figure 2. The specimen of the *C. monstrosa* from the deep seas of Northern Cyprus (A: Top view; B: Lateral view)

Results

In this study, a specimen of *C. monstrosa* has 80.30 cm total length (TL), was caught from the deep seas of Northern Cyprus in March 2019, by bottom trawling operation which is carried out between 456 and 690 m. Morphometric characteristics for this individual were measured, and BDL% values calculated in Table 1.

Table 1. Body length proportions (BDL%) of *C. monstrosa* (female) caught from Northern Cyprus

Measurement	BDL%
TL	208.6
PCL	128.5
SVL	66.2
TRL	46.7
PD2	53.2
PD1	33.7
POB	13.7
POR	15.6
PRN	12.9
D2B	87.01
D2AH	5.5
D2PH	4.7
D1B	19.2
DSA	20.7
D1H	19.2
CDM	23.6
CDH	2.1
CTL	76.6
CVM	24.2
CVH	3.11
HDL	28.6
P1A	37.9
P2A	18.7
IDS	8.6
DCS	0.5
PPS	41.6
PAS	40.5
PCS	63.6
D1P1	18.2
D1P2	44.2
D2P1	31.2
D2P2	27
EYL	8.3
EYH	6.2

Note: Abbreviations used: TL (total length), PCL (precaudal length), BDL (body length), SVL (snout-vent length), TRL (trunk length), PD2 (pre-second dorsal length), PD1 (pre-first dorsal length), POB (pre-orbital length), POR (pre-oral length), PRN (pre-narial length), D2B (second dorsal fin base), D2AH (maximum height of anterior second dorsal fin), D2PH (maximum height of posterior second dorsal fin), D1B (first dorsal fin base), DSA (dorsal spine length), D1H (maximum height of first dorsal fin), CDM (dorsal caudal margin), CTL (total caudal fin length including filament), CVM (ventral caudal margin), HDL (head length), P1A (anterior margin of pectoral fin), P2A (anterior margin of pelvic fin), IDS (interdorsal space), DCS (dorsal-caudal space), PPS (posterior base of pectoral fin to anterior base of pelvic fin), PAS (posterior base of pelvic fin to origin of anal fin), PCS (posterior base of pelvic fin to origin of ventral caudal fin lobe), D1P1 (anterior edge of first dorsal fin base to anterior edge of pectoral fin base), D1P2 (anterior edge of first dorsal fin base to anterior edge of pelvic fin base), D2P1 (anterior edge of second dorsal fin base to anterior edge of pectoral fin base), D2P2 (anterior edge of second dorsal fin base to anterior edge of pelvic fin base), EYL (eye length), EYH (eye height).

Discussion and Conclusion

C. monstrosa inhabits Eastern Atlantic from Northern Norway and Iceland to the Azores and Western Africa. It is less distributed in the western and central parts of the Mediterranean and the northeastern region. There are a limited number of records of this species from the Northeast Mediterranean (Ali, 2003; Bilecenoğlu et al., 2014). The record of *C. monstrosa* from the Turkish coastline only reported in the Sea of Marmara (Dalyan, 2010) and the Aegean Sea (Geldiay, 1969). In the present study, a specimen of *C. monstrosa* reported in Northern Cyprus. The reported maximum total length of this species in literature is 150 cm, and the maturity length is approximately 45.9 cm (Moura et al., 2004). The total length of the specimen captured in this study is 80.3 cm, so it understood that our sample is an adult. Morphometric data of *C. monstrosa* in the previous studies from Levant Basin were not available; therefore, a comparison couldn't make. The morphometric measurements compared with a study from the Bahamas, and the results found 82% similar (Kemper et al., 2010b). The identification of chimaeroid species based on the absence of skeletal elements in dental plates. All chimeras have a total of six dental plates. One pair of these plates located in the lower jaw (mandibular), while the other two pairs located in the upper jaw (two small vomeral and two palatal). (Toscano et al., 2011). In this study, two mandibular plates were found on the lower jaw. This finding was beneficial and supportive in the identification of the species.

Figure 3. A pair of mandibular plates detected in the lower jaw of *C. monstrosa*

C. monstrosa, known to be widely distributed species in the Mediterranean. The reason for the lack of record for the island of Cyprus so far may be that target fishes are living shallow waters when compared with *C. monstrosa* so that fishers do not perform fishing operations in these depths.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

Seasonal Size Composition of Gelatinous Macrozooplankton in the Sinop Peninsula of Black Sea

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ABSTRACT

In this study, size compositions of *Aurelia aurita* (Linnaeus, 1758), *Pleurobrachia pileus* (O. F. Müller, 1776) and *Mnemiopsis leidyi* A. Agassiz, 1865 were presented seasonally between March 2015 and February 2016 at the Sinop Peninsula of Black Sea. Sampling was carried out monthly at the 6 stations by plankton net (50 cm diameter mouth opening, 500 µm mesh size for horizontal tows, 210 µm mesh size for vertical tows). Small sized individuals of *A. aurita*, *M. leidyi* and *P. pileus* were found dominant in summer. Bigger size individuals were observed for *A. aurita* in spring, *M. leidyi* in winter, and *P. pileus* in autumn. *A. aurita* <4 cm was determined as 57%, *M. leidyi* <2 cm was 58% and *P. pileus* < 0.6 was determined as 67%. Maximum and minimum lengths were measured 28 cm and 0.5 cm for *A. aurita*, 2 cm and 0.2 cm for *P. pileus*, 9 cm and 0.2 cm for *M. leidyi,* respectively. The size distribution of *A. aurita, M. leidyi* and *P. pileus* showed significantly different (ANOVA, $p<0.05$) between seasons.

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Introduction

Gelatinous macrozooplankton play a crucial role in the cycle of the food chain in fisheries-based ecosystems. These organisms have controlled whole ecosystem (Oguz et al., 2001, Purcell et al., 1999). Gelatinous populations are opportunistic and can quickly adapt to changes in physical and biological conditions in aquatic systems. When the gelatinous macrozooplankton present in an intensive amount, they saturate to nets during the fishing activity, decrease the fishing efficiency resulting in economic losses in commercial fishing (Özdemir et al., 2014). Increasing abundance of gelatinous due to global climate change, uncontrolled fishing, eutrophication of coastal areas caused negative changes in the Black Sea ecosystem in the last 20-30 years (Kideys, 2002; Bat et al., 2007; Bat et al., 2009). *Aurelia aurita* and invader *Mnemiopsis leidyi* reached high abundances in Black Sea

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ecosystem and negatively impacted on the zooplankton and pelagic fishing in the late 1980s (Kideys and Romanova, 2001; Gucu, 2002). Gelatinous macrozooplankton group mainly feeds on zooplankton, fish eggs and larvae in the Black Sea (Mutlu, 2001; Birinci Özdemir et al., 2018). Nutritional competition over zooplankton, which is the food of pelagic fish, is important in the food chain of the Black Sea. In the Black Sea ecosystem, which is open to changes and responds rapidly to these changes, it is important to monitor the distribution species diversity, population parameters and ecology of gelatinous organisms. *Aurelia aurita, Rhizostoma pulmo, Pleurobrachia pileus* and invasive species *Mnemiopsis leidyi* and *Beroe ovata* commonly found in the Black Sea (Kideys, 2002; Finenko et al., 2003; Birinci Özdemir and Özdemir, 2017; Birinci Özdemir et al., 2018; Dönmez and Bat, 2019). Although there are some studies on the gelatinous macrozooplankton organisms in the Black Sea coast of Turkey (Mutlu and Bingel, 1999; Mutlu, 2001; Mutlu, 2009; Kideys and Romanova, 2001, Bat et al., 2007; Bat et al., 2009; Birinci Özdemir et al., 2018; Ustun and Birinci Özdemir, 2019), these studies are mostly spatial distribution of these species are on the abundance and biomass. In order to contribute to these studies, seasonal size compositions of *A. aurita*, *P. pileus* and *M. leidyi* at Sinop Peninsula of the Black Sea were evaluated.

Material and Methods

In the study, seasonal size compositions of *A. aurita*, *M. leidyi* and *P. pileus* at Sinop Peninsula of the Black Sea were investigated between March 2015 and February 2016. Samplings were conducted by monthly in six stations during the daytime (Figure 1). The coordinates and depths of the stations were given in the Table 1.

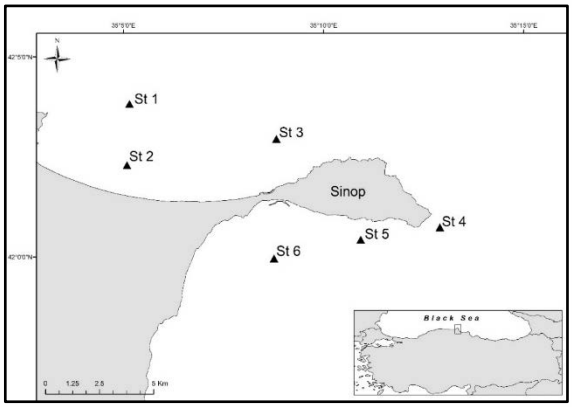

Figure 1. Sampling stations at Sinop Peninsula of the Black Sea

Table 1. Geographic coordinates and depth of sampling station stations

Sampling Stations	Geographic Coordinates	Sampling Depth (m)
St 1	42° 03.826'N- 035° 05.143'E	60
St 2	42° 02.294'N- 035° 05.081'E	20
St 3	42° 02.948'N- 035° 08.813'E	50
St 4	42° 00.739'N- 035° 12.899'E	40
St 5	42° 00.431'N- 035° 10.923'E	50
St 6	41° 59.961'N- 035° 08.757'E	60

Vertical tows were carried out from the bottom to the surface with two replications for each stations. Samples were collected by using plankton nets (50 cm diameter mouth opening, 500 µm mesh size for horizontal tows, and 210 µm mesh size for vertical tows). At the end of each tows, nets were exteriorly washed. Samples in cod-end contents were passed through a 1 mm sieve and the gelatinous macrozooplankton were separated. Disc diameter and length of specimens were measured to the nearest millimeter. Weights were determined respectively according to Birinci Özdemir (2011):

M. leidyi $W=0.7905L^{1.6406}$, R=0.9267

A. aurita $W=0.2895L^{2.1653}$, R= 0.9298

P. pileus $W=0.0757L^{0.7642}$, R=0.7144

One-way ANOVA and post hoc Tukey tests (MINITAB v17.0 statistical package) were used to determine differences in the disc diameters or lengths of gelatinous species between seasons (Zar, 1999).

Results and Discussion

Totally 953 *A. aurita*, 149 *M. leidyi*, and 472 *P. pileus* were evaluated. The mean, minimum and maximum length or disc diameter of species were given as seasonal in Table 2. Also, boxplot of length of gelatinous macrozooplankton according to seasonal changes were given in Figure 2.

Table 2. The mean, minimum and maximum length or disc diameter of gelatinous species collected from different seasons

	Seasons	Mean ±SE	Body length (cm)		
			Min	Max	Number (N)
A. aurita	Spring	8.61 ± 0.27	0.50	28.00	297
	Summer	4.69 ± 0.045	0.80	13.00	43
	Autumn	6.70 ± 0.22	1.00	26.00	381
	Winter	8.02 ± 0.38	0.50	21.00	232
M. leidyi	Spring	4.40 ± 0.67	3.00	7.00	5
	Summer	2.12 ± 0.15	0.20	9.00	100
	Autumn	3.29 ± 0.40	1.00	8.00	28
	Winter	4.02 ± 0.65	0.50	9.00	16
P. pileus	Spring	0.81 ± 0.27	0.40	1.40	79
	Summer	0.57 ± 0.03	0.20	1.50	101
	Autumn	0.70 ± 0.03	0.20	2.00	113
	Winter	0.72 ± 0.03	0.40	1.40	179

Maximum and minimum disc diameters were measured 28 cm and 0.5 cm for *A. aurita*, respectively. The seasonal mean diameters of *A. aurita* were shown in Table 2. In terms of size frequency for *A. aurita* were examined, large individuals were determined in spring season (Figures 2 and 3). In summer, percentage share of small *A. aurita* (< 4 cm) was found higher as 57% (Figure 3). In the Sinop region, mean length and weight of *A. aurita* were 8.3±0.10 cm and 43.2±1.58 g, respectively (Birinci Özdemir et al., 2019). In 2008, it was reported that 4-6 cm *A. aurita* was dominant in spring and summer in

the southern coasts of central Black Sea (Birinci Özdemir, 2011). A maximum diameter of 42 cm has been found in the Western Baltic Sea and the Black Sea (Ishii and Bamstedt, 1998) whereas the maximum diameter was measured 17 cm in the northwestern Black Sea (Weisse and Gomoiu, 2000). Maximum diameter was 28 cm and individuals with a diameter <10 cm were determined to make up 25% of the population in March 1995 in the Black Sea (Mutlu, 2001). Disc diameter of *A. aurita* in open waters ranges from 20 to 30 cm, whereas it reaches from 4 to 10 cm in semi-enclosed/enclosed areas (Ishii and Bamstedt, 1998). In this study, it was found that the dominant diameter varies seasonally, however the diameters between 4 and 10 cm were the dominant size group in general. It was observed that larger individuals were more abundant in open stations.

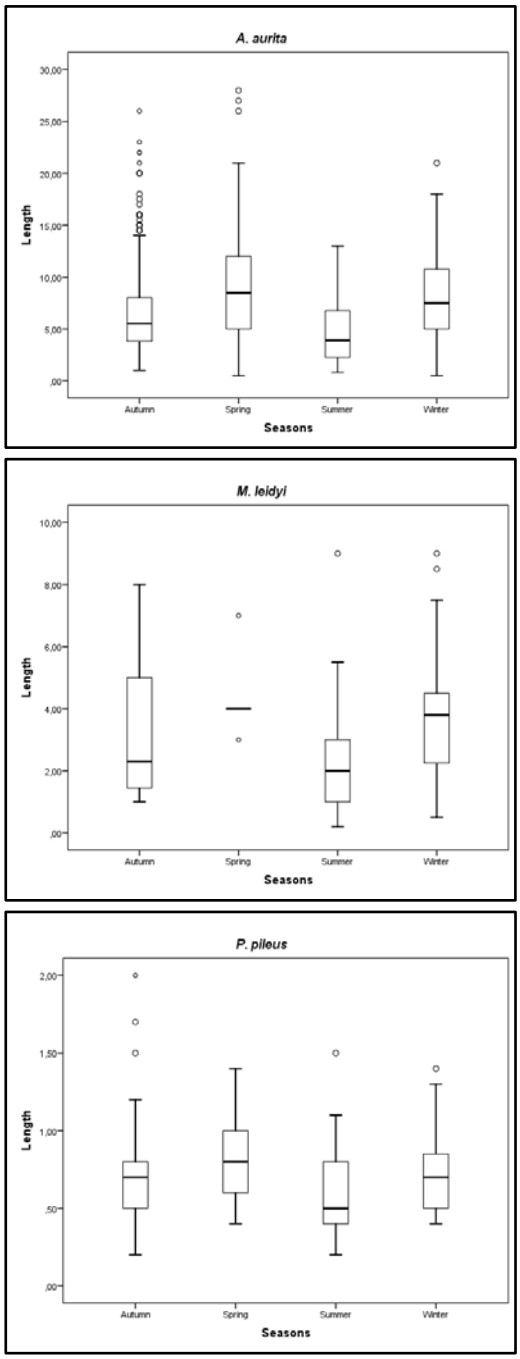

Figure 2. Seasonal length distribution of gelatinous species in Sinop Peninsula during March 2015 and February 2016

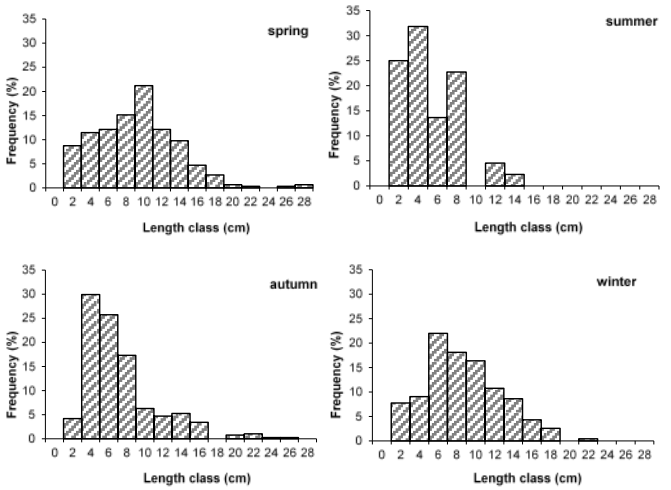

Figure 3. *Aurelia aurita* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

In this study, *M. leidyi* (<2 cm) were determined dominant and percentage share as 58% (Figure 4). It was determined that large individuals were more in spring and autumn (Figures 2 and 4). Maximum and minimum length was measured 9 cm and 0.2 cm, respectively (Table 2). In the northern Black Sea, small *M. leidyi* individuals (1-1.5 cm) predominated in August 1995 (Weisse and Gomoiu, 2000). In 2008, small (<2 cm) *M. leidyi* individuals were determined in summer and maximum individual was 10.8 cm (Birinci Özdemir, 2011). Unal (2002) reported parallel results to the present study. However, researcher found maximum length of *M. leidyi* as 17.3 cm. The largest *M. leidyi* in the Black Sea was determined as 18 cm (Shiganova et al., 2001). Maximum length was measured for *M. leidyi* as 15 cm in the Gulf of Izmit (Isinibilir, 2012). In the present study, the maximum length was found to be lower compared to other studies. It is thought that the dissimilarities between maximum lengths could be resulted from different temperature, sampling area and feeding conditions.

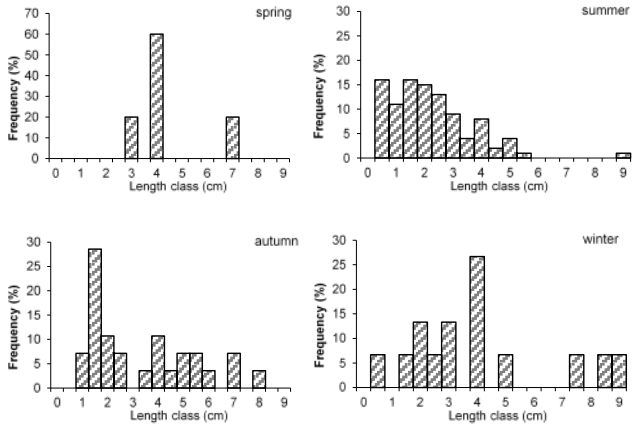

Figure 4. *Mnemiopsis leidyi* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

Small individuals (< 0.6 cm) of *P. pileus* were dense in the summer and it covers 67% (Figure 5). Larger individuals were found in summer (Figure 2). In the present study, the largest and smallest individuals

were detected 2 cm and 0.2 cm, respectively. Mean lowest and highest length was determined in summer 0.57±0.03 cm and spring 0.81±0.27 cm (Table 2). Mazlum et al. (2018) informed that maximum and minimum length of *P. pileus* was 1.5 cm (in winter) and 0.1 cm (in summer) in Southern coasts of the Black Sea. Maximum *P. pileus* was reported as 1.6 cm and an increase were reported in small individuals in autumn and winter in 2008 (Birinci Özdemir, 2011). Mutlu (2009) pointed out that small individuals constitute a large part of the population in spring season in the Black Sea.

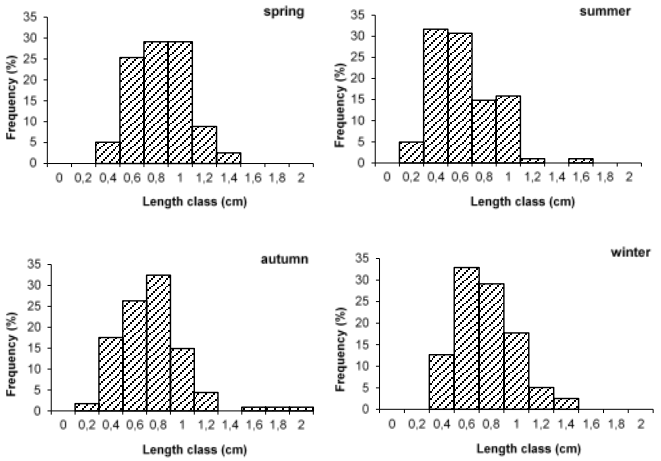

Figure 5. *Pleurobrachia pileus* size composition at Sinop Peninsula of the Black Sea between March 2015 and February 2016

Size distribution of *A. aurita*, *M. leidyi* and *P. pileus* showed significantly differences seasonally (for all species $p<0.05$; $F = 17.34$ for *A. aurita*, $F = 9.13$ for *M. leidyi* and $F = 12.34$ for *P. pileus*). In this study, small-sized individuals of *A. aurita*, *M. leidyi* and *P. pileus* were found dominant in summer. It demonstrated reproduction of gelatinous populations was in this period. Temperature and food availability are really controlling factors for growth of gelatinous in natural environments. Population increase and growth of gelatinous macrozooplankton are parallel to these factors (Finenko et al., 2003; Möller and Riisgard, 2007; Finenko et al., 2014). Consequently, predation pressure of gelatinous macrozooplankton on zooplankton and ichthyoplankton is more intense during this period in the Black Sea.

Conclusion

It is known that climate change, fisheries pressure and the invasions of opportunistic species into the ecosystem have changed the balance in the Black Sea (Gucu, 2002; Kideys, 2002; Oğuz and Gilbert, 2007). With this change in the Black Sea, the negative effects of the gelatinous organisms that exploit the void and become dominant in the pelagic ecosystem on fisheries cannot be doubted. It is necessary to determine the morphological and biological changes of these organisms to monitor the time-dependent species changes and distribution in the system. Considering the possible changes in the ecosystem with the increase in temperature in the future, it is important that these data are recorded regularly in order to observe the effects on the gelatinous, reveal the predictions and determine the differences. Thus, solutions to problems that may be encountered in ecosystem, fisheries, and fishery activities will be presented.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

Maximum Size Record of Sharpsnout Seabream (*Diplodus puntazzo* Walbaum, 1792) for Saros Bay, Northern Aegean Sea

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ABSTRACT

A single specimen of *Diplodus puntazzo* with 34.6 cm in total length and 550.00 g in total weight was caught off İbrice Bight (Saros Bay) with handline (hook (Mustad 496) size 1 and 0.40 mm monofilament line-diameter) by fisherman on May 25, 2016. Its total length and weight were the maximum observed values for the species in the Saros Bay, Northern Aegean Sea.

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Introduction

Sharpsnout seabream (*Diplodus puntazzo* Walbaum, 1792) is a valuable Sparidae species, inhabiting rocky bottoms and sea grass beds and is seldom found at depths greater than 50 m (Macpherson, 1998). This species is a common species throughout the Mediterranean Sea and the Eastern coasts of the Atlantic Ocean from Gibraltar to Sierra Leone, it is rare in the Black Sea and in the North Atlantic (Bay of Biscay) (Bauchot and Hureau, 1986).

Maximum length and weight are important parameters used in life history studies and fishery science. These measurements are applied directly or indirectly in most stock assessment models (Borges, 2001; Cengiz et al., 2019a). Therefore, it is important to regularly update the maximum size of commercially important species (Navarro et al., 2012; Cengiz et al., 2019b). The aim of this paper is to provide data on the maximum observed length and weight of the sharpsnout seabream for Saros Bay in the Northern Aegean Sea.

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Material and Methods

Saros Bay, which is situated in the Northeastern Aegean Sea, is connected to the North Aegean Sea with a depth of approximately 600 m to the west. The shelf extends at a water depth of 90–120 m. The length of the bay is about 61 km and the width at the opening to the Aegean Sea is about 36 km (Eronat and Sayın, 2014; Cengiz et al., 2019c; Cengiz et al., 2019d). As Saros Bay had been closed to bottom trawl fishing since 2000 (Cengiz et al., 2011) and no industrial activity was prevalent in the area (Sarı and Çağatay, 2001), the bay can be considered as a pristine environment (Cengiz et al., 2013; Cengiz et al., 2019e).

A single specimen of *D. puntazzo* was caught off İbrice Bight (Saros Bay) (Figure 1) with handline (hook (Mustad 496) size 1 and 0.40 mm monofilament line-diameter) by fisherman from 15 m depth on May 25, 2016. Total length is defined as the measurement taken from the anterior-most part of the fish to the end of the caudal fin rays when compressed dorso-ventrally (Anderson and Gutreuter, 1983). Hereby, the specimen was subsequently measured to the nearest mm and weighted to the nearest g. Unfortunately, the specimen was not preserved as it was sold by a professional fisherman at the fish market.

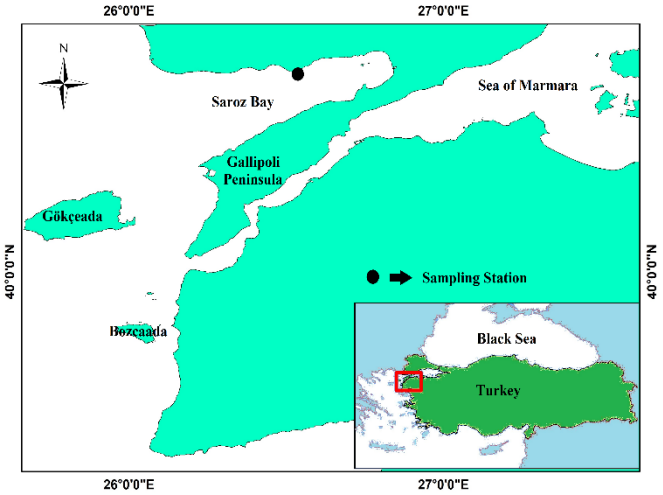

Figure 1. Saros Bay and sampling station

Results and Discussion

The captured sharpsnout seabream was 34.6 cm in total length and 550.00 g in total weight (Figure 2). The comparison of the maximum lengths and weights recorded for *D. puntazzo* in the Aegean Sea (with Northern Aegean Sea) is given in Table 1.

Figure 2. The sharpsnout seabream with 34.6 cm TL and 550.00 g TW

As well known, the individuals in populations exposed to high levels fishing pressure will respond by reproducing at smaller average sizes and ages and so reached maximum lengths may getting smaller. However, the one individual that subjected to no overfishing pressure could be reached that kind of length (Filiz, 2011). On the other hand, any factor that might possibly influence growth has been shown to have an effect, including nutrient availability, feeding, light regime, oxygen, salinity, temperature, pollutants, current speed, nutrient concentration, predator density, intra-specific social interactions and genetics (Helfman et al., 2009; Acarli et al., 2018).

In broad terms, the information on maximum length, weight, age, growth and weight-length relationship are required to estimate the population parameters as asymptotic length and growth coefficient of fish, which are essential for fisheries resource planning and management (Agüero et al., 2010).

Table 1. The comparison of the maximum lengths and weights recorded for *D. puntazzo* in the Aegean Sea (with Northern Aegean Sea)

Authors	Area	N	L_{max} (cm)	W_{max} (g)
Karakulak et al. (2006)	Gökçeada Island, Turkey	7	25.2	-
Özaydın et al. (2007)	İzmir Bay, Turkey	27	21.4	-
Kapiris and Klaoudatos (2011)	Argolikos Gulf, Greece	29	23.9	209.00
Altın et al. (2015)	Gökçeada Island, Turkey	87	24.5	209.80
Kara et al. (2017)	Gediz Estuary, Turkey	61	13.5	41.30
This study	Saros Bay, Turkey	1	34.6	550.00

Conclusion

The present study proves that this species can grow above the previous maximum data reported in the Northern Aegean Sea. The information presented here may be used to compare the similar parameters in ongoing fishery studies all over the world by providing the scientific support to the fisheries scientists.

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Conflict of Interest

The author declares that there is no conflict of interest.

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RESEARCH ARTICLE

The Antimicrobial Activity of *Enteromorpha sp.* Methanolic Extract and Gelatin Film Solution Against on Some Pathogens

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ABSTRACT

Pathogenic microorganisms have been the primary cause of foodborne disease and food poisoning throughout the world for years. The use of natural antimicrobial agents in food coating has been effective in regulating the adverse effects of pathogens in food. Increasing antimicrobial efficacy in these coatings is one of the current issues of the food industry. In the present study, the antimicrobial properties of *Enteromorpha sp.*, which is a marine algae, and gelatin film solution incorporated with *Enteromorpha sp.* methanol extract have been investigated. The contents of *Enteromorpha sp.* methanol extract were determined by Gas chromatography–mass spectrometry (GCMS). The most important components in the extract were methyl palmitoleate, neophytadiene, phytol, methyl linolenate and methyl stearate. The minimum inhibitory concentration (MIC; the lowest concentration of test material which results in 99.9% inhibition of growth) of *Enteromorpha sp.* on *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* were found to be between 10.79 mg/mL and 26.86 mg/mL by spectrophotometric microdilution technique. The antimicrobial effect of gelatin- *Enteromorpha sp.* methanolic extract film solution against the same pathogens was determined by disc diffusion method. The inhibition zone of gelatin- *Enteromorpha sp.* film solution was reported between 0.1 and 5.1 mm against pathogens. After a 24-h incubation, the effectiveness of the film solution was lower (1.3 mm) when compared to the extract on *E. coli* (5.1 mm). As a result, this study clearly showed that *Enteromorpha sp.* could be used as antimicrobial food coating agent, especially, in *E. coli* struggle.

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Introduction

Recently, interest in seaweeds (marine algae) has grown as natural source of pharmaceutical agents. They are rich in polysaccharides, minerals, proteins and vitamins with recorded antioxidant activity that would increase the human diet's quality as food (Yan et al., 1998). Several studies have demonstrated that seaweeds contain active molecules, protective enzymes, phloroglucinol and phenolics, which

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are mostly known as antioxidants (Pavia and Åberg, 1996; Ganesan et al., 2011). Recently, seaweeds are reported to be potentially high bioactive sources that could be useful leads in antimicrobial product development. Their antiviral, antibacterial and antifungal properties are remarkable (Val et al., 2001; Newman et al., 2003). Although marine algae have been traditionally used as important sources of protein, carbohydrate, lipid, vitamin for centuries (Murata and Nakazoe, 2001), currently, their metabolites find out by varieties extraction methods are demonstrated to be unique antimicrobial agents (Lima-Filho et al., 2002; Desbois and Smith, 2015; Kausalya and Rao, 2015).

Food safety and quality in the food industry are major concerns. Food manufacturers are striving to eliminate microorganisms from food products because food surviving microorganisms can lead to food product quality spoilage and cause infection which threatens the public health. Therefore, pathogenic microorganisms are well-considered to be a significant concern for worldwide public health (Nykänen et al., 2000; Srey et al., 2013). In recent years, scientists have focused on edible food coatings containing antimicrobial agents. Synthetic antimicrobial agents can be integrated into edible films and coatings to monitor harmful microorganisms on food surfaces. However, the use chemical preservatives are highly controversial, because they have been shown to cause respiratory or other health problems (Quintavalla and Vicini, 2002). Researches therefore head for alternative strategies to reduce the use of chemical additives in the food industry (Sanchez-Garcia et al., 2010). In this context, the use of natural compounds with antimicrobial properties such as algae which are in rich protein and mineral seems to be an attractive option.

Enteromorpha species, we selected for the study, are cosmopolitan intertidal macroalgae and common edible seaweed species that are abundant in the coastal areas of Asia and Europe around the world (Tan et al., 1999; Callow, 2002). There are hardly any studies on this species spreading in the region of Mersin, Turkey. In the present study, the antimicrobial activity of *Enteromorpha sp.* methanol extract (EME) and gelatin- *Enteromorpha sp.* film solution (EME-F) were firstly researched against *E. coli*, *S. aureus* and *C. albicans* pathogens. Besides, methanolic content were determined as well.

Material and Methods

Plant material and methanolic extraction

Enteromorpha sp. were collected from Viranşehir, Mersin, Turkey in 2019. They were identified and confirmed by comparing them with the specimen located at the Faculty of Fisheries at Mersin University, Turkey. The *Enteromorpha sp.* extraction was performed from approximately 80 g of the dried *Enteromorpha sp.* in 320 mL methanol via shaker incubator for 24 hours at 35°C.

Chemical composition

The qualitative and quantitative composition of *Enteromorpha sp.* analysis was conducted at Giresun University Central Research Laboratories Application and Research Center by GC-MS 7890A-(5975C inert MSD) instrument equipped with an Agilent 19091S-433 column. The chemical composition of *Enteromorpha sp.* methanolic extract was determined by analyzing GC-MS in the scanning range of M+=50-550 m/z. 1 L of the concentrated plant extract was filtered through 0.45 µL syringe filter and injected to GC-MS injection port (250°C) in splitless mode. The extract was eluted using HP5-MS capillary column (30m × 0.25 mm × 0.25 µm) at helium gas (flow rate: 1.75 mL/min) under fixed 21.21 psi of pressure. The study was performed by applying the following sample elution temperature system for a maximum of 70 minutes. The oven temperature was gradually increased after it was kept at 50°C for 2 min. Then, it was increased to 100°C at 5°C min^{-1} and was held for 5 min. Then, it was increased to 150°C at 5°C min^{-1} and performed for 8 min. Finally, the temperature was increased to 250°C at 5°C min^{-1} and it was kept there for 15 min. Characterization of *Enteromorpha sp.* components was based on the library (Wiley and NIST) comparison with the mass spectra of the extract sample (Yabalak, 2018; Sıcak and Eliuz, 2019a).

Antimicrobial activity

The antimicrobial activity of methanol extraction of *Enteromorpha sp.* was researched on several pathogens, namely *E. coli*, *S. aureus* and *C. albicans* using disc diffusion and modified spectrophotometric microdilution technique. Firstly, the inoculums of microorganisms were prepared in 4 mL Tryptic Soy Broth for bacteria, 4 mL Sabouraud Dextrose Broth for yeasts and incubated at 37°C, overnight. After 24 hours, the culture suspensions were adjusted to 0.5 McFarland Standard Turbidity and stored at +4°C until use (Dalynn Biologicals, 2014).

Spectrophotometric microdilution technique

The experiment was performed on 96-well microtiter plates and firstly 50 µL of Mueller Hinton Broth (MHB) medium were added into all wells. Two-fold serial dilutions (50 µL) of EME (286 mg/mL) were made on all x-axis along with ELISA plate. Columns 11 and 12 were used as negative and positive controls. Finally, 5 µL culture of microorganisms was inoculated on all wells except the medium control wells. All of the plates were incubated at 37°C for 24 hours, the growth (turbidity) was measured at 600 nm for bacteria, 415 nm for yeasts. For MIC analysis, the optical density was read both before, T_0 and after 24 hours-incubation, T_{24}. For each plate, MIC was calculated using the following formula: The OD for each replicate at T_0 was subtracted from the OD for each replicate at T_{24}.

$$The\ Percent\ Growth = \frac{OD\ test}{OD\ control} \times 100$$

$$The\ Percent\ Inhibition = 1 - \frac{OD\ test}{OD\ of\ corresponding\ control\ well} \times 100$$

for each row of the 96-well plate. We calculated MIC using the R^2 formula on inhibition curve (Patton et al., 2006; Sıcak and Eliuz, 2019b).

Preparation of coating film solution

The gelatin (Dr. Gusto) and glycerol (Gly) (98% reagent grade) were purchased from Market and Sigma, respectively. The film-forming solution contained 5% (w/w) gelatin, glycerol 3.5% (w/w) and *Enteromorpha sp.* methanolic extract (15%). The pH of the solution was appropriately adjusted to 9-10 with 2 M NaOH. Film solution was

homogenized with a Rotor-Stator homogenizer for 3 min at 23000 rpm in a first step (at about 25°C). The control samples were prepared using the same mentioned-above procedure, except without the addition of the extract. Antimicrobial activities of EME enriched gelatin-based film solutions were determined by disc diffusion method. Antibiotic and EME alone were studied to compare with EME film solution antimicrobial activities. Paper discs (6 mm in diameter) were impregnated on MHA to load 20 µL of ampicillin, EME and EME Film. Then, all samples were incubated at 37°C for 24 hours. The results in the study have recorded the zones of growth inhibition surrounding the disc using digital caliper (Kuppulakshmi et al., 2008). All data on antimicrobial activity were the average of triplicate analyses.

Statistical analysis

All data on antimicrobial activity assay studies were the averages of triplicate analysis. Data were recorded as mean ± SEM (standard error of the mean). Significant differences between means were determined by LSD (SPSS v25; post hoc-one way ANOVA) test and *p* values <0.05 were regarded as significant.

Results and Discussion

Chemical content

The components of the methanolic solution from *Enteromorpha sp.* with their retention time (RT) and area (%) were listed in Table 1**.** In the present study**,** methyl palmitoleate (27.78%), neophytadiene (19.36%), phytol (14.98%), methyl linolenate (14.46%), and methyl stearate (5.40%) were the major components in the methanolic extract of *Enteromorpha sp.* followed by other components such as cyclomethicone 7, heptadec-8-ene, leinoleic acid, palmitin, 1-vinyl silatrane, 9-octadecenamide.

Antimicrobial activity

The 24-hour incubation of *Enteromorpha sp.* with microorganisms was found to be statistically significant in terms of MIC (p<0.05) (Table 2). All microorganisms were found to be sensitive to *Enteromorpha sp.* methanolic extract in broth media. **T**he MICs of EME were 26.86 mg/mL for *E. coli*, 12.04 mg/mL for *S. aureus* and 10.79 mg/mL for *C. albicans* (p<0.05). The antibiotic results were 64 µg/mL, 8 µg/mL and 128 µg/mL for *E. coli, S. aureus* and *C. albicans*, respectively.

As shown in Figure 1, EME revealed different inhibition activities towards the three microorganism cells investigated. Inactivation of *E. coli, S. aureus* and *C. albicans* by increased doses of the methanolic extract was similar in that they cause an increased in cell death rate. In general, a dose-dependent decrease in the survival of the microorganisms was observed. The applied EME at doses of 4 g/mL led to inhibition maximum 65.71% for *E. coli*, 86.17% for *S. aureus*, and 87.65% for *C. albicans* (p<0.05).

Table 2. MICs of EME against tested microbial strains by microdilution method (For positive control: ampicillin (for bacteria) and fluconazole (for yeast) were used as positive control (128 µg/mL))

Microorganism/MIC	EME (mg/mL)	Antibiotics (µg/mL)
E. coli (-)	26.86^{a}±3.2	64^{c}±3.9
S. aureus (+)	12.04^{ad}±0.1	8^{bd}±2.8
C. albicans	10.79^{ad}±1.2	128^{c}±4.8

Note: "±" indicates standard error of the mean. The values shown in different superscript letters are statistically different (ANOVA, p < 0.05, LSD test).

The antimicrobial property of gelatin film solution incorporated with Enteromorpha sp.

According to the antimicrobial property of gelatin film solution incorporated with *Enteromorpha sp.* methanol extract investigated in our study, EME and EME-F were determined to clear inhibition zone by disc diffusion method. The antimicrobial performance of EME was presented stronger than EME-F on *E. coli* (p<0.05). The highest inhibition zone was noted as 5.1 mm for *E. coli* in EME, although the lowest zone was 0.1 mm on *S. aureus* and *C. albicans* in EME and EME-F. The antibiotic results were 4.9 mm, 4.5 mm and 2.4 mm for *E. coli, S. aureus* and *C. albicans*, respectively (Table 3).

Table 1. Chemical composition (C) of *Enteromorpha sp.* methanolic extract

			***Enteromorpha* sp.**		
RT	**C**	**%**	**RT**	**C**	**%**
26.800	cyclomethicone 7	1.01	**41.151**	meinoleic acid	2.19
27.201	2,4-Di-tert-butylphenol	0.76	**41.277**	methyl linolenate	14.46
32.053	meptadec-8-ene	2.77	**41.512**	phytol	14.98
33.272	methyl tetradecanoate	0.68	**41.752**	methyl stearate	5.40
36.099	benzyl (dideuterated)methyl ether	1.04	**41.906**	1-vinyl Silatrane	0.84
36.505	neophytadiene	19.36	**42.049**	2-eicosanol	2.32
37.386	methyl palmitoleate	27.78	**43.949**	palmitin	0.81
40.630	2-Norpinanol, 3,6,6-trimethyl-	0.89	**45.837**	9-Octadecenamide	1.83
40.968	*E,E,E*-1,4,8-cyclododecatriene	2.46	**Total**		**96.58**

Note: RT is retention time; quantity (%) is more than 0.01.

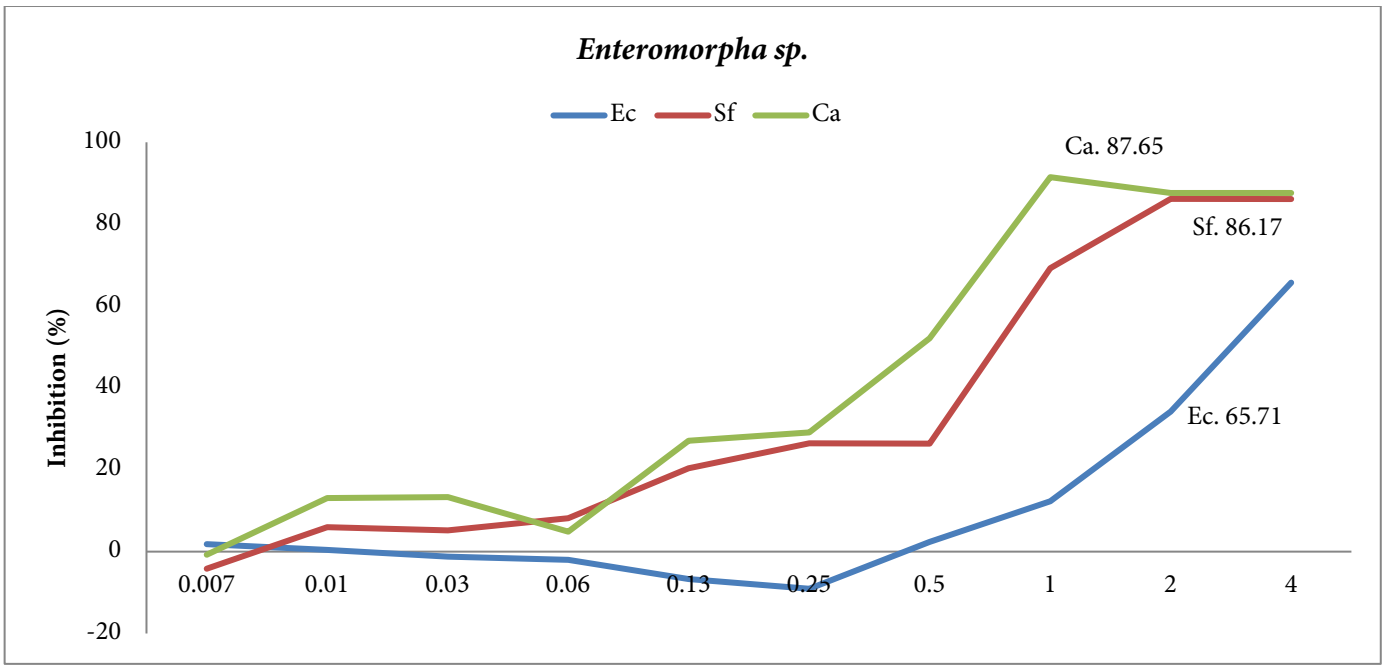

Figure 1. The graph of inhibition (%) – *Enteromorpha sp.* methanolic extract (between 0.007 and 4 g/mL) on *E. coli*, *S. aureus* and *C. albicans*

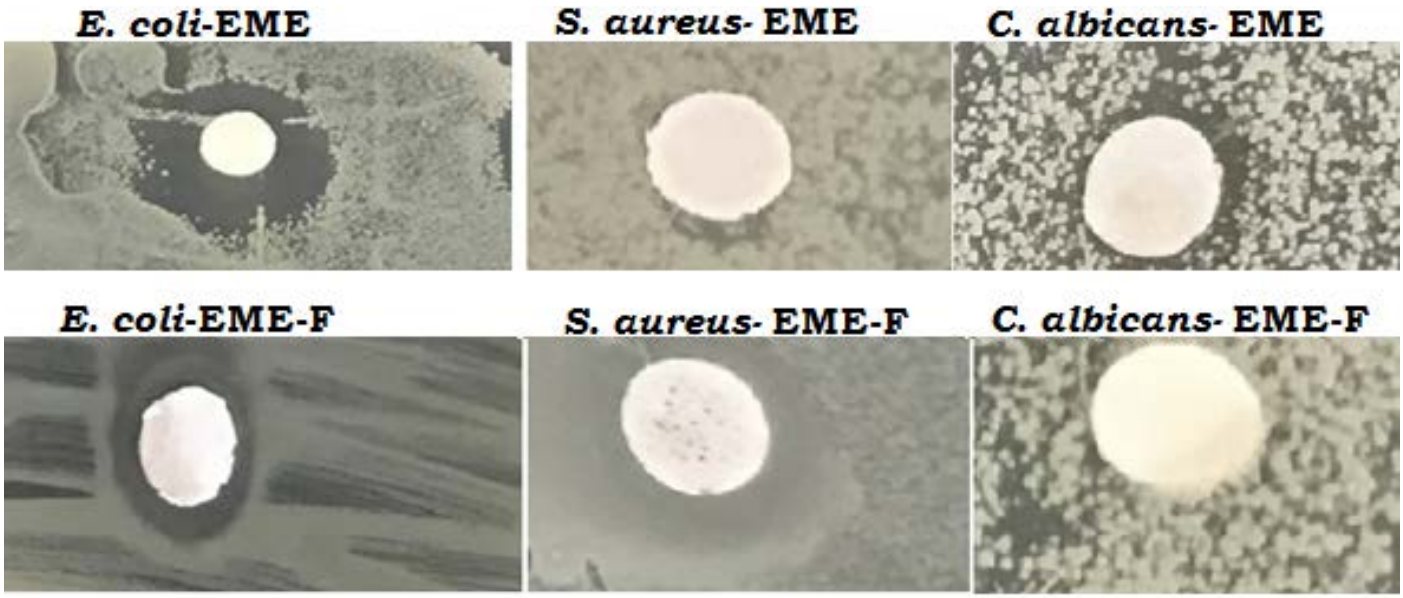

Figure 2. Images of *E. coli*, *S. aureus* and *C. albicans* responses to EME and EME-F extracts

Table 3. The comparing of inhibition zones (mm) of the EME and EME-F against tested microbial strains (For positive control: ampicillin (for bacteria) and fluconazole (for yeast) were used as positive control. IZ: inhibition zone)

Microorganisms		EME	EME Film	Antibiotics
E. coli (-)	IZ	$5.1^{c}\pm1.6$	$1.3^{b}\pm0.6$	$4.9^{c}\pm0.9$
S. aureus (+)	IZ	$0.1^{a}\pm0.1$	$0.1^{a}\pm0.1$	$4.5^{c}\pm1.2$
C. albicans	IZ	$0.1^{a}\pm0.1$	$0.1^{a}\pm0.1$	$2.4^{bc}\pm1.2$

The inhibition zones of *Enteromorpha sp.* methanolic extract and gelatin-based film solution of *Enteromorpha sp.* on microorganisms were photographed in Figure 2. In the photograph, both EME and EME-F solution clearly inhibited *E. coli*.

The present study showed that *Enteromorpha sp.* is highly effective against *E. coli* (5.1 mm) compared to *S. aureus* and *C. albicans* (0.1 mm) in disc diffusion method. In contrast, in the liquid culture, the MIC values were close for to all three microorganisms. The highest MIC value was found in *C. albicans* and then *S. aureus* and then *E. coli* between 10.79 and 12.04 and 26.86 mg/mL by microdilution method. The antimicrobial property of the macroalgae is due to its compounds. The inhibition effect on all pathogens of major components such as phytol (Pejin et al., 2014), methyl stearate, methyl nonadecanoate (Oliveira et al., 2013) of *Enteromorpha sp.* was reported previously. The neophytadiene and phytol components, found in *Enteromorpha sp.* abundantly in this study, were also determined in *Dunaliella salina* Microalga by Herrero et al. (2006) and they had antimicrobial potential.

Previous studies showed the different extracts of *Enteromorpha sp.* species are widely effective against the growth of a wide range of pathogens, particularly, *E. coli*, *S. aureus* and *C. albicans*. For instance, Patra et al. (2015) reported that the inhibition zone as between 10.00 mm and 13.33 mm and the MIC value as 12.5 mg/mL against *E. coli*. Senthilkumar et al. (2015) found that methanolic extract of *Enteromorpha flexuosa* exhibited antibacterial activity against both *E. coli* and *S. aureus*. It was found that the aqueous extract of *Enteromorpha* sp. had an inhibition effect at a value of MIC (200 mg/mL) against *E. coli* and *S. aureus* strains (Alghazeer et al., 2013). The antimicrobial activity of *E. intestinalis* methanolic extract was shown in the study of Ibrahim et al. (2015), among the tested microorganisms, *Staphylococcus aureus* (MRSA) were susceptible to the extract and inhibited with the MIC value of above 6.25 mg/mL (Ibrahim et al., 2015).

Pathogenic bacteria have been known throughout the world for years as the prime cause of foodborne disease and food poisoning (Kim et al., 1995). The use of natural antimicrobial agents in food production and food safety has been instrumental in regulating the adverse effects of bacteria in food. The natural antibacterial agents commonly used as preservatives, however, are first of all effective against gram positive foodborne pathogens, whereas they are not very effective on gram negative foodborne pathogens (Trombetta et al., 2005; Bassole and Juliani, 2012; Sfeir et al., 2013; Nazzaro et al., 2013). Based on this topic, the best result of this study is the efficacy of *Enteromorpha sp.* against *E. coli*, a gram negative bacterium. Because, the toxic species of *E. coli*, especially O157: H7, are gram-negative bacteria that can easily multiply in foods such as cheeses, yoghurts, juices, salads, salad dressings, sandwiches, freshly squeezed fruit juices and cause poisoning (Tosun and Gönül, 2003).

Gelatin-based antimicrobial films and coatings used in food products serve a barrier to oxidative and physical stress and extend the shelf life of foods (Cha and Chinnan, 2004; Silva-Weiss et al., 2013). Also, it was reported that the use of films or coatings incorporated with antimicrobial agents were more efficient than adding additives directly to the food. Therefore, they will spread slowly into the environment and will be effective for longer (Ouattar et al., 2000). Especially when we examined *E. coli*, inhibition zone of gelatin solution combined with *Enteromorpha* was less (1.3 mm) than alone *Enteromorpha sp.* (5.1 mm). This shows that the biological agent trapped in the film will retain its effect for a longer time.

Conclusion

In this study, methanolic extract of *Enteromorpha sp.* exhibited inhibition zones on *E. coli* and lower on tested *S. aureus* and *C. albicans*. Conclusively data demonstrates the anti-*E. coli* potential of methanolic extract from *Enteromorpha sp.* It may also be suggested that there is scope for *E. coli* medical therapy. On the basis of this study, further purification of the active compounds and their individual study of antibacterial activity may be suggested. Another important result is that we showed for the first time that the *Enteromorpha* was an antimicrobial coating agent against *E. coli*.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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Marine Science and Technology Bulletin

RESEARCH ARTICLE

The Behaviour of Turkish Bluefin Tuna (*Thunnus thynnus*) Fishing Fleet in the Mediterranean Sea

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ABSTRACT

The main purpose of this study is to contribute to Turkish tuna fishing fleet management. In this context; The Turkish Bluefin Tuna (*Thunnus thynnus* Linnaeus, 1785) fishing fleet in our territorial waters and international waters in the Eastern Mediterranean were monitored on a spatio-temporal basis and a continuous monitoring model for BFT stock was established. Archival data sets of Bluefin Tuna (BFT) 2010-2016 spatial-temporal migration and remote sensing data sets of traces of fishing vessels and environmental factors (SST and Chl-*a*) were included in the model. Statistical analysis of the model was performed using Geographical Information System (GIS) based-approach and the results were presented on thematic maps. On the other hand, the importance of the announcement of The Exclusive Economic Zone (EEZ) for BFT fishing in Eastern Mediterranean was addressed in the study. Accordingly, the possibility of 'Turkey's Exclusive Economic Zone' announcement in Mediterranean Sea and its borders were discussed.

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Introduction

The main large pelagic fishes commercially exploited in the Mediterranean Atlantic Bluefin Tuna (*Thunnus thynnus* Linnaeus, 1785) (Perciformes: Scombridae). Bluefin Tuna (BFT) fishing has been the subject of the international law and the European Union (EU) law. Turkey became a member of the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 2003 and currently continues BFT fishing with quotas in the framework of ICCAT rules. Within the scope of the ICCAT quota limitation, they are caught in our territorial and international waters in the Mediterranean, are farming of wild-caught fishes, and exported to the Japanese market when they reach the sufficient size.

The current fishing pattern in the Mediterranean Sea is the result of a long history of exploitation of marine resources that started several thousands of years ago (Farrugio et al., 1993). The fishing has been performed in the eastern Mediterranean since at least the 7th millennium BC (Desse and Desse-Berset, 1994; Damalas and Megalofonou, 2012). Aristotle in his work History of Animals written in 350 BC explained the migratory and reproductive habits of BFT in

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the Aegean and Black Sea (D'Arcy Wentworth Thompson, 1910; Damalas and Megalofonou, 2012). Turkey is a peninsula surrounded by sea on three sides with a total of 8333 km of coastal line and BFT fishing in Anatolia dates back to ancient times (Karakulak, 2007). BFT is also a highly migratory species that seems to display a homing behaviour and spawning site fidelity in both the Mediterranean Sea and Gulf of Mexico (Figure 1) (Fromentin and Powers, 2005; Karakulak and Yıldız, 2016).

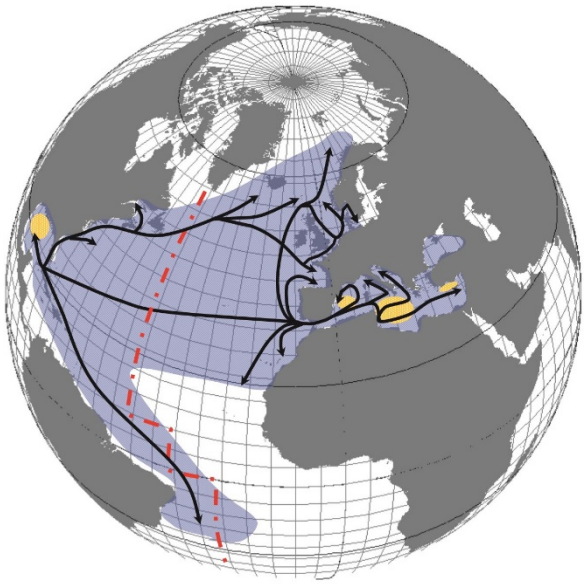

Figure 1. Map of the spatial distribution of BFT (blue), main migration routes (black arrows) and main spawning grounds (yellow areas) (Fromentin and Powers, 2005; Karakulak and Yıldız, 2016)

Temperature triggers spawning and determines the presence of BFT and due to their migration behaviour; distribution is significantly affected by spatial and temporal variations of environmental parameters. During their seasonal migrations, they follow changes in water temperature and currents, foraging along strong thermal fronts (Block and Stevens, 2001; Schick et al., 2004; Royer et al., 2004; Damalas and Megalofonou, 2012). Probability of encountering a school peaked in late spring months, eastwards at water temperatures above 22°C and around the full moon. It is known that BFT's tendency to migrate across borders due to its own biological characteristics is affected by environmental variables and it prefers areas with high chlorophyll-a (Chl-*a*) concentration for feeding and lowest Sea Surface Temperature (SST) value for spawning (Druon et al., 2011). It was reported that they tend to spend more than 50% of their time in ambient temperatures of 15 to 23 °C (Wilson et al., 2005) and 14 to 26 °C in autumn and from 18 to 24 °C in winter (Stokesbury et al., 2004). BFT can sustain cold (down to 3°C) as well as warm (up to 30°C) temperatures, while maintaining stable internal body temperature (Block et al., 2001; Karakulak and Yıldız, 2016). On the other hand, mesotrophic conditions, moderate and low Chl-*a* content were determined in the range of ~0.05 to 0.15 mg m^{-3} (Druon, 2009). Finally, BFT distribution is significantly affected by spatio-temporal variations of environmental conditions (Fromentin et al., 2014). Mediterranean Sea is the primary spawning and fishing area for the BFT and one of these critical areas has been reported to be the Northeast Mediterranean (Karakulak et. al., 2004; Karakulak and Oray, 2009).

Spatio-temporal analysis by Geographical Information System (GIS) technology provides the tools to model species-habitat relationships and their variability and identify essential habitat areas. Overviews of predictive habitat modelling approaches have been presented for various species in Mediterranean Sea (Valavanis et al., 2004; Valavanis et al., 2005; Valavanis et al., 2008).

Monitoring, control and surveillance (MCS) activities of fishing fleet at the national and international level are of national concept, but it is also one of the key activities especially within the scope of management and regulation of fish stocks that have wide areas and migrate in between and across the territorial waters of countries. Due to the lack of scientific knowledge, it is difficult to evaluate the stocks in nature and in this context; scientific studies should be completed for sustainable management. There are international efforts and decisions in stock sharing in order to prevent the destruction of fish stocks, which are significant economically, and are decreasing in Mediterranean Sea. In this context, countries' need reliable data archives and numerical values obtained from analysis results based on scientific studies. In countries lacking scientific studies on the subject, it is inevitable to experience problems regarding fish stock sharing, especially in international regulations. Fields of competence are of pivotal importance for international commissions covering the Mediterranean. The main ones are International Commission for the Scientific Exploration of the Mediterranean (CIESM) created in 1916, the General Fisheries Council for the Mediterranean (GFCM) created in 1949 by The Food and Agriculture Organization (FAO), and the ICCAT in 1966. ICCAT developed a management plan until 2022 after the decline in BFT stocks as a result of overfishing activities in 2002, decided to apply a fishing quota to stakeholder countries and started fishing and cage fattening activities under its control (ICCAT, 2013). Turkey became a member of ICCAT in 2003. Before 2003 when the membership was started, Turkey participated in meetings as an observer and other countries benefited from BFT quota share jointly with some Mediterranean countries. Following the membership, as a result of the initiatives made with ICCAT, a special BFT fishing quota has been allocated to our country since 2004. Pilot study of the quota implementation began in our country; Turkey's quota in 2010 was determined to be 419 tons. Over the years, the success of the application was reflected on the ICCAT reports and quota of Turkey for 2019 is determined as 1880 tons, and 2305 tons for the year 2020 (ICCAT, 2018).

The legal and juristic arrangements related to the issue in order to place BFT fisheries on a legal basis at international level are included in both international law (under ICCAT precautions) and European Union (EU) laws. EU is legally obliged to submit precautionary approaches with scientific evidence and take preventive actions to protect the BFT. On 25 October 2010, the legal requirements for the protection of BFT were discussed at the legislative information meeting under EU law. According to the legal requirements discussed at the meeting, it was stated that the action plans prepared in accordance with the decisions adopted by ICCAT in 2010 to protect the BFT stocks must be realized and thus the Maximum Sustainable Yield (MSY) must be obtained until 2022 (ICCAT, 2013). According

to the figures in the Standing Committee on Research and Statistics (SCRS) 2010 report under the Marine Strategy Framework Directive (MSFD; 2008/56/EC) developed by the EU due to the uncertain and critical situations of BFT in the East Atlantic and Mediterranean; member states are obliged to take the necessary measures to improve or protect their current environmental situation in order to maintain sustainable levels. With respect to BFT, all member states that own Sustainable Stock Biomass associated with Maximum Sustainable Yield (SSBMSY) or have stock on the stock biomass for up to 2020, according to the MSFD requirements, must guarantee and protect the EEZ in which BFT is are required. Each Member State is responsible for extending the EEZ border to the outmost maritime border as possible. Member states are obliged to have SSBMSY of all species in their waters, including BFT, by 2020, and to ensure healthy population distribution with little or no risk of compromising the genetic diversity of the stock.

Material and Methods

The study area covers Levant (Division 37.3.2) under FAO Major Fishing Area 37 and geographical areas coded 24 (North Levant), 25 (Cyprus Island) and 27 (Eastern Levant Sea) under GFCM geographical sub areas (GSAs). Within the framework of ICCAT rules, BFT fleet is tracked via satellite with Vessel Monitoring Systems (VMS) and automatic data recording is performed. However, VMS data is not legally available for use. For this reason, the data sets for the tracking of the fishing vessels used in the study were obtained through the Automatic Identification System (AIS) with the permission of the relevant ministry. AIS is a hardware and software system that allows the identification and positioning of marine vessels in marine traffic to be monitored automatically by providing almost real-time information flow from vessels. All fishing vessels, which have full length of 15 m and over, in Turkey tripping to a port and / or sequential ports have been equipped with AIS Class-B CS tool. All vessels in the BFT fleet are over 15 m long and AIS devices are available.

The archival records of each fishing vessel track and fishing marks indicated on the satellite navigation map of the vessels were obtained within the scope of the Turkish fishing vessel captains' volunteerism principle. Since dataset of the present study was derived from a fishing fleet-dependent survey, it was limited only to the fishing period (between 25th May and 25th June) within the scope of the ICCAT quota limitation. Fishing fleet was monitored by AIS (in coverage area) on a spatio-temporal basis and a total of 424 (present/absent) operating marks were obtained from 32 Turkish BFT fishing vessels from 2010 to 2016.

Surface variables raw data (SST and Chl-*a*) were used at a daily and nighttime scale from the Moderate resolution Imaging Spectroradiometer/Aqua (MODIS/Aqua) ocean color sensor (https://modis.gsfc.nasa.gov/). Real-time images were obtained by rendering with The SeaWiFS Data Analysis System (SeaDAS) algorithm (https://seadas.gsfc.nasa.gov/) and finally mapped in ArcGIS 10.4.

Preferred GIS methods in the study allow the identification of unexpected relationships between multiple data sets and quantification of relationships for resource evaluation. Log normalization by statistical analysis was found to yield comparable definition of anomalies. In the study, ArcGIS Spatial Analyst Tools module, which is widely preferred in spatial-temporal data modelling is used. This module has a wide range of usage with powerful spatial modelling and analyses features such as mapping, cell-based raster data analysis, and interpolation of existing data in the database, querying multiple data between layers. In addition, Mapping Clusters analyses within the scope of Spatial Statistics Tools module were used in the study. To be a statistically significant hot spot, a feature must have a high value, surrounded by other features with high values as well. This tool identifies statistically significant spatial clusters of high values.

Results and Discussion

In the study, archive data sets of BFT's 2010-2016 spatial-temporal distribution and remote sensing data sets of environmental factors (SST and Chl-*a*) were included in the model and a continuous monitoring model of BFT stock was created with a GIS-based approach, then it was presented on thematic maps. Archival fishing coordinates of the model and accessible vessel traces (by AIS), BFT stock of probable fishing areas explored by fishing vessels and spatio-temporal migration path maps are submitted. Starting from May 25, BFT, coming from the south of Eastern Levant Sea and migrating to the Turkey's coasts at the north have been caught densely. Between 5th and 20th June when the temperature of air and sea rises, they migrate to the west between Turkey and TRNC and between 10th and 25th June they are mostly observed at the coasts of Turkey and caught mostly in Gulf of Antalya (Figure 2 and Figure 3).

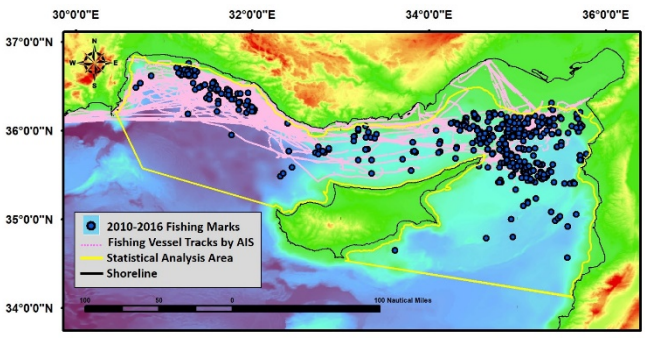

Figure 2. Archives fishing coordinates and fishing vessel tracks (by AIS) in the ArcGIS-based BFT stock continuous monitoring model

Composite maps of remote sensing archive data sets for SST and Chl-*a*, which are known to have significant impacts on BFT migration, suitable fishing area based on SST and suitable fishing area based on Chl-*a* hot spot maps are submitted while this data is put to statistical analysis with fishery data sets (Figure 4 and Figure 5).

When the thematic maps are examined, the importance of the region in terms of BFT, which is one of the most valuable species of living marine resources, becomes obvious.

BFT fisheries in Turkey is one of the most strictly regulated and monitored fishing activity. Turkish BFT fleet is very active in Northeastern Mediterranean and continues to be profitable. Therefore, it is important to carry out proprietary activities in the seas,

to observe the rights in the marine areas and to carry out such activities in accordance with the rules of international law.

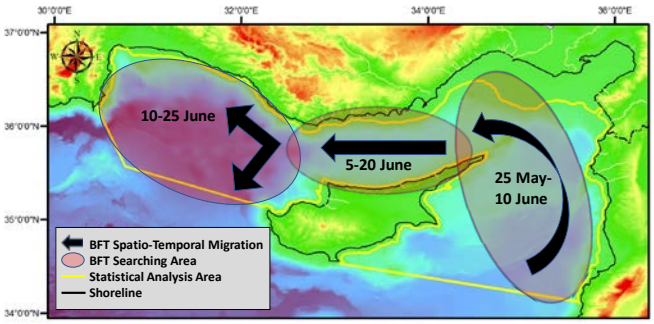

Figure 3. Spatio-temporal migration path of BFT stock in the Eastern Mediterranean and possible fishing areas explored by fishing vessels

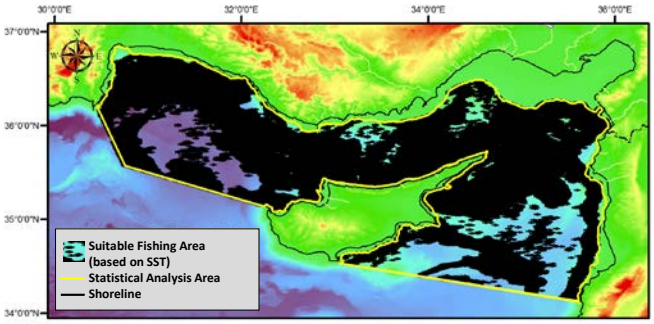

Figure 4. Statistical analysis results of suitable BFT fishing area based on SST

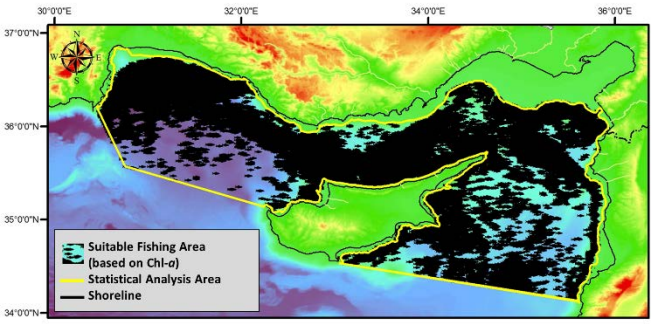

Figure 5. Statistical analysis results of suitable BFT fishing area based on Chl-*a*

Because spatio-temporal variability manages the definition of management units, stocks and boundaries, understanding the dynamics and spatio-temporal distribution of species is crucial for management (Fromentin and Powers, 2005). One way to accomplish such a task is by monitoring commercial BFT fleet, such as those undertaken here. Based on the relationships between environmental preferences and fisheries coordinates with time, an indirect determination of potential fishing area can be achieved. Therefore, current results may provide useful information for fisheries management authorities.

The extremely statistical significance of spatial determinants confirmed that BFT were not randomly received with the same probability; they tend to congregate in certain marine areas following a seasonal pattern. With a high probability of encountering a school increase to the Levantine, where the BFT mostly existed in spring and summer. This was reported argue that the surface water temperatures of the region contain a favorable spawning habitat in early May, as they reached the desired thresholds much earlier than other Mediterranean regions. Meanwhile the outcomes of this study supplement the recent study undertaken on the potential habitats of BFT, which suffered from a verification of estimates in the eastern Mediterranean region (Druon, 2010; Druon et al., 2011; Damalas and Megalofonou, 2012). Since dataset of the present study was derived from a fishery-dependent survey, it was limited only to the fishing period (between 25th May and 25th June) within the scope of the ICCAT quota limitation. Inferences regarding of principal environmental effects on BFT spatio-temporal distribution and abundance in Northeastern Mediterranean region will be the main subject of next scientific paper.

On the other hand, although Turkey has been one of the active participants, they did not sign and approve 1982 United Nations Convention on the Law of the Sea (UNCLOS) text. The reason Turkey did not approve the agreement was not about the provisions concerning the protection of the marine environment; but mainly because of the regulations for the compulsory jurisdiction of the width of the territorial sea and maritime law disputes. In terms of international maritime law, fishing areas and their usage rights are of great importance. Turkey do not have an EEZ announcement yet in the Mediterranean, but it is likely that in the near future, there will be a boundary agreement between the coastal states in the Eastern Mediterranean, and the Turkish EEZ announcement will become obligatory. According to Article 61 of the United Nations Convention on the Law of the Sea (UNCLOS), under the heading of Conservation of the Living Resources; the coastal state has the exclusive right to determine the amount of living marine resources in EEZ, and shall determine the fishing capacity in its own EEZ. According to Article 62 under the heading Utilization of the Living Resources; the coastal state must aim to ensure the maximum exploitation of living resources, and will determine its ability to catch its own marine resources in EEZ.

Turkey should make an effort for protection and investigation of the marine environment, and most importantly, the operation of living resources in the Eastern Mediterranean. In addition, Turkey need to put forward strengths and weaknesses, develop new strategies and scientific projects, and urgently develop marine research policies and prepare action plans accordingly.

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Conflict of Interest

The author declares that there is no conflict of interest.

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RESEARCH ARTICLE

Investigation of Heavy Metal Content of Tellina (*Donax trunculus* Linnaeus, 1758) in Black Sea Region (Kefken)

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ABSTRACT

In this study, monthly change of the heavy metal composition of tellina (*Donax trunculus* Linnaeus, 1758) from Kefken territory on the Black Sea coast between 2013 and 2014 was investigated. Heavy metal analysis was determined by ICP-OES. Mercury (Hg) and tin (Sn) were not detected during the period of 12 months. Lead (Pb) was detected in November, December, January, February, and March and it was calculated as 12.97 µg/g on average. The highest amount of lead was detected in December as 16.08±0.82 µg/g. The amounts of cadmium (Cd), cobalt (Co) and nickel (Ni) were determined between November and April and it was seen that they had average values such as 0.45 µg/g Cd, 0.91 µg/g Co and 4.46 µg/g Ni. Chrome was detected during the 12 months and it was calculated as 4.19 µg/g on average. The highest and the lowest amounts of chrome were detected in January as 16.71±2.11 and August as 0.70±0.05, respectively. In addition, it was seen that during the period this study was held, between 2013 and 2014, there were dramatic temperature changes and the instant temperature changes positively affected the accumulation of heavy metal in the species. Despite the fact that the instant temperature changes positively affect the accumulation of heavy metals in the live metabolism, it is better to handle the subject regarding the effects of global warming on living things. It is possible to say that tellina can be consumed as food in convenient times. In respect of the detections in this study, it can be said that tellina can be conveniently consumed between April and October depending on the territory.

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Introduction

Due to the population growth worldwide, the increase of need for protein results in the increase of consumption of food from animal origin. Therefore, seafood stands out as a way of providing animal source foods of high quality. Within seafood, bivalve emerges as an important food resource with its recently increasing consumption in our country. United Nations and World Food Programme declared that seafood is going to have an important role in food supply in future due to the population growth which is estimated to increase up to 9 billion in 2050. So, it is assumed that the growth in the industry of seafood is going to continue in an accelerating way (FAO, 2015).

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Unlike the other countries, the production of seafood in Turkey relies on fish production especially in aquaculture. Even though our country, which is surrounded on three sides by the sea, has so many economic bivalve species such as Mediterranean mussel (*Mytilus galloprovincialis* Lamarck, 1819), flat osyter (*Ostrea edulis* Linnaeus, 1758), sand mussel (*Ruditapes decussatus* Linnaeus, 1758), white clam (*Chamelea gallina* Linnaeus, 1758), sea scallop (*Pecten maximus* Linnaeus, 1758) and tellina (*Donax trunculus* Linnaeus, 1758); the production of these species, which are rich in essential amino acids, unsaturated fatty acids, vitamins, minerals and antioxidant materials, is lower than its real potential. Especially the aquaculture production is so low that it is limited with Mediterranean mussel solely (Karayücel et al., 2010; Acarlı et al., 2011). However; it is essential to ascend the production and hunting rate of these species and to show their nutritious capacity and meat yield. Pouring the sewage and transmission of pesticides to sea, industrial and domestic waste, acid rains, heavy seaway and the harmful waste left from ships result in the increase of heavy metals such as cadmium, lead, copper, zinc, mercury, arsenic and seafood takes in all these heavy metals. However, consumption of these foods harm human health (Hu, 2000; Otchere, 2004; Guidi et al., 2010; Kayhan et al., 2009; Le et al., 2011). In the related studies, bivalve species is preferred both because of its common consumption and its being indicator species in sea pollution (Sericano, 2000; Conti and Cecchetti, 2003; Casas et al., 2008; Başçınar, 2009). A study based on the heavy metal content of Mediterranean mussels taken from 10 different parts of Ionian Sea shows that the samples involve 1.19 mg/lt lead, 0.31 mg/lt chrome, 0.15 mg/lt mercury, 0.64 mg/lt cadmium, 0.54 mg/lt tin and 5.15 mg/lt zinc (Storelli et al., 2000). In another study on mussels taken from Annaba Bay, Algeria shows that the mussels taken from four different stations involve 0.35 mg/kg cadmium, 0.81 mg/kg chrome, 9.52 mg/kg copper, 0.198 mg/kg silver, 7.73 mg/kg manganese, 2.01 mg/kg lead, and 83.33 mg/kg zinc respectively but iron and nickel were not detected (Belabed et al., 2013). Usero et al. (2005) declared that their study upon the heavy metal concentration of tellina and white clam taken from Atlantic shores of South Spain showed that tellina involved high amounts of chrome, copper, lead, zinc, arsenic and silver and white clam also involved high amounts of nickel and cadmium. Maanan (2008) studied cadmium, chrome, lead, and manganese concentration of Mediterranean mussel, pacific oyster (*Crassostrea gigas* Thunberg, 1973) and grooved carpet shell (*Venerupis decussatus* Linnaeus, 1758) taken from Atlantic shores of Morocco and declared that these elements arose in spring and summer but they declined in winter and these results coincide with the results of Mubiana et al. (2005). Conti and Cecchetti (2003) declared that Mediterranean mussels taken from Sicily shores of Italy did not pose danger in respect of the elements cadmium, chrome, copper, silver and zinc and they were suitable for consumption. Yildiz et al. (2011) investigated seasonal variation in the condition index, meat yield and biochemical composition of the flat oyster *Ostrea edulis* collected from the Dardanelles. De Souza et al. (2016) studied arsenic, lead, nickel, and cadmium content of pacific oyster and mussels taken from 28 aquaculture plants in the north and south bays of Santa Catarina, Brazil and declared that the samples of plants in the south bay involved arsenic and the samples of plants in the north bay involved nickel highly; yet, both of them involved low amounts lead and cadmium.

In this study, the convenient consumption time of tellina from Kefken, and its heavy metal accumulation change due to seasonal temperatures were examined.

Material and Methods

Collection of the Samples

Tellina (*Donax trunculus* Linnaeus, 1758) were collected from the Kefken station (Figure 1) between November 2013 and October 2014, monthly. 50 samples of the species were provided every month.

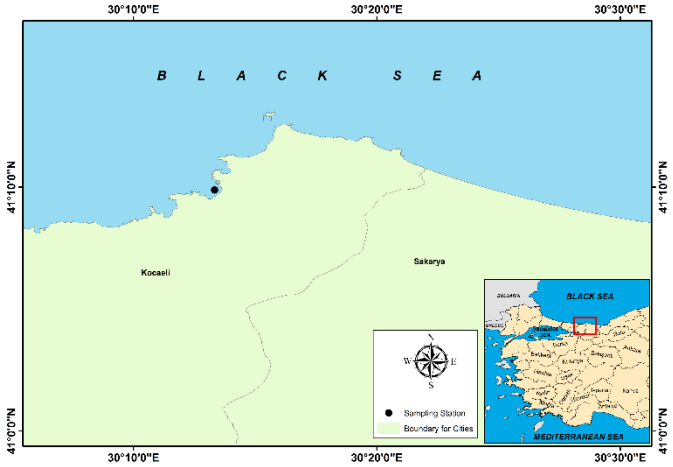

Figure 1. Sampling area of tellina and Kefken station

Determination of Heavy Metal Content

The samples were homogenized and dried for 72 hours at 105°C. All analyzes in this study were performed on dry samples. The analysis of heavy metal contents was made in Tekirdağ Namık Kemal University Central Laboratory (NABİLTEM). Spectro Blue brand ICP-OES was used for element determination and Novawave SA brand was used for the preparation of the samples in NABİLTEM.

Digestion Procedure for Heavy Metal Analysis of Donax trunculus by ICP-OES

In order to determine heavy metal contents of the samples, a digestion procedure and solubilization of the samples were chosen and used Aydın (2008). Therefore, microwave digestion was used and performed with nitric acid in NABİLTEM. Firstly, the samples were dissolved by microwave digestion with acid. The samples were then allowed to cool and made ready for ICP-OES by filtration with distilled water. This procedure was repeated twice for each sample. The minerals (Pb, Cd, Cr, Co, Ni, Hg and Sn) were measured with ICP-OES and then concentrations were calculated based on the standards.

Monitoring of Environmental Parameters

Temperature and salinity of the sea water taken from the research area between November 2013 and October 2014 were measured with YSI probe.

Results and Discussion

The heavy metal contents of *Donax trunculus* between November and October are given in Table 1. The temperature and salinity parameters of sea water in Kefken region are shown in Figure 2. In Figure 3, the average air temperatures in Turkey on climate assessment reports that were prepared by T.C. the General Directorate of Meteorology of the Ministry of Forestry and Water Affairs for 2013 and 2014 are given (OSİB1 2013; OSİB1 2014). The amount of lead was found between November and March, but was not determined in other months. The highest lead was found to be as 16.08 ± 0.82 µg / g in December. It is observed that the most suitable months of consumption of the species in respect of lead content are between April and October. The fact that the determination of lead was not determined after April does not mean that the lead and heavy metals do not exist. This is related to the detection limit of the ICP-OES instrument. In other words, the results from ICP-OES instrument can be obtained if the heavy metals in the samples are at a level that can be detected. The samples are diluted at a concentration at which the instrument can read all the elements during the sample preparation and microwave digestion. When the dilution is made during sample preparation, some elements can be measured or not by ICP-OES instrument if the samples are at a level concentration in liquid phase. Therefore, the fact that the detection of some elements in the samples was not determined in some months does not mean that these heavy metals do not exist. The limit of detection of the lead which depends on the dilution factor of 100 times is about 4 µg / g on dry weight. In other words, the reason why the amount of lead and other heavy metals cannot be determined in some samples or months by ICP-OES, can be explained as the detection limit of the instrument for Pb is about 4 ng / mL (0.04 µg / mL) in the dissolved liquid phase. Then, the amount determined in the liquid phase by instrument is regulated by the dilution coefficient to detect the actual amount of heavy metal in the dry sample. Therefore, some elements in the samples could not be determined in some months due to the digestion procedure, liquid dilution and detection limit. Figure 2 shows that the temperatures of seawater in the sample area have increased since March 2014. The temperatures were high in August 2014, and also it was seen that the temperature in September and October 2014 was approximately 5 ° C warmer than the previous November 2013. As shown in Figure 3, the climate assessment report of 2013 and 2014 prepared by T.C. the General Directorate of Meteorology of the Ministry of Forestry and Water Affairs shows that the temperature changes between October and November in 2014 were higher than the same months of 2013. In other words, it is seen that there was a change of 6.5 ºC in the same months of 2014 while there was a change of about 3 ºC between October and November in 2013. It can be said that these snap temperature changes between seasons also affected the heavy metal accumulation of the species. The amount of lead and other heavy metal was not determined since April in 2014. It is thought to be related to the differences in the nutrients and components in marine environment due to the temperature changes between 2014 and 2013. Cadmium was detected between November and May and was not determined in the other months. Cobalt and nickel like cadmium were also determined in the same months. The chromium amount of the species showed that it was high between November and May but decreased in the following months. The detection limit of chromium by ICP-OES is lower than the other elements and therefore it can be said that it is easily determined. The results of chromium indicate that the other metals decreased in April and October. The reason why the other heavy metals cannot be determined during these months has been explained in detail above. It is known that these species feed filtration of sea water. Therefore, the changes in the temperature and the related components in the sea water can lead to differences in the accumulation of heavy metals. It can be said that studies like this clearly present the effects of global warming on environmental conditions and living things.

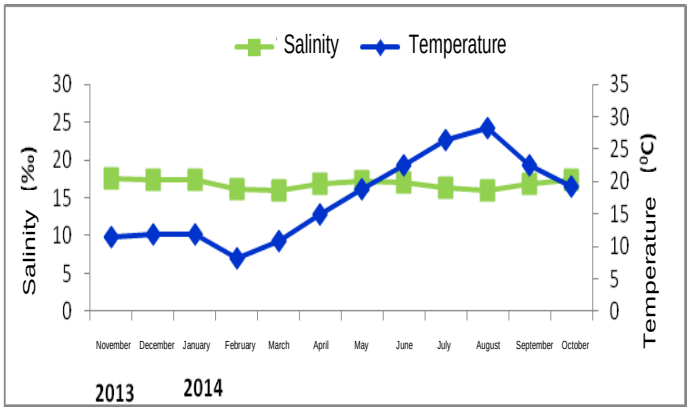

Figure 2. Sea water temperature and salinity parameters between November 2013 and October 2014 in Kefken region

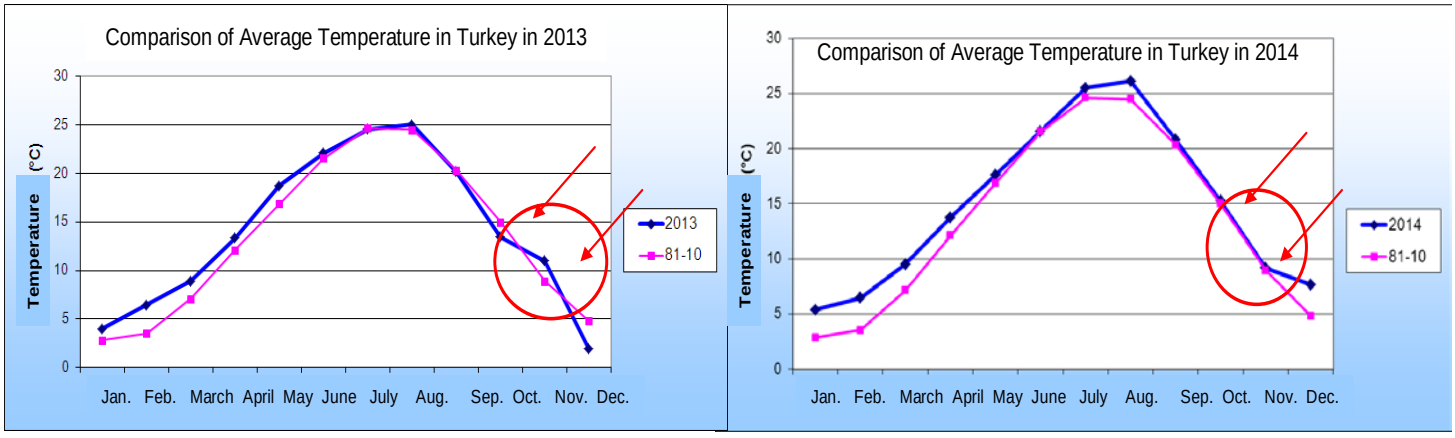

Figure 3. Change of average temperatures in Turkey between 2013 and 2014 (OSİB1 2013; OSİB1 2014)

Table 1. Monthly heavy metal contents of tellina (*Donax trunculus* Linnaeus, 1758) on dry weight

Heavy Metals	November	December	January	February	March	April
Pb (µg/g)	12.59±3.55	16.08±0.82	8.27±0.71	14.06±2.61	13.83±0.63	N.D.
Cd (µg/g)	0.31±0.02	0.33±0.01	1.07±0.06	0.25±0.11	0.32±0.00	0.52±0.15
Cr (µg/g)	3.12±0.24	6.84±0.72	16.71±2.11	3.64±0.89	9.91±0.96	2.46±1.44
Co (µg/g)	0.61±0.03	0.81±0.11	1.68±0.19	0.84±0.05	1.03±0.05	0.46±0.08
Ni (µg/g)	2.66±0.30	3.97±0.02	14.92±0.95	3.16±0.01	5.36±0.51	0.62±0.72
Hg (ng/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn (ng/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Heavy Metals	**May**	**June**	**July**	**August**	**September**	**October**
Pb (µg/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd (µg/g)	0,38±0,07	N.D.	N.D.	N.D.	N.D.	N.D.
Cr (µg/g)	2,54±0,06	1,44±0,05	1,38±0,01	0,70±0,05	0,80±0,05	0,71±0,00
Co (µg/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ni (µg/g)	0,51±0,00	N.D.	N.D.	N.D.	N.D.	N.D.
Hg (ng/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn (ng/g)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Note: *N.D. indicates that the measurements with ICP-OES are below the detection limit

Table 2. Heavy metal research in different bivalve

Sample Type	Elements	Location of Sample	Digestion Method	Instrument	Reference
D. trunculus *C. gallina*	Cr, Ni, Cu, Cd, Pb, Zn, As, Hg	Southern Spain, Atlantic coast	Microwave digestion	AAS	Usero et al.(2005)
C. gallina	Zn, Cd, Cu, Pb, Fe, Ni, Cr, Mn, As, Hg	Southern Spain, Atlantic coast	Microwave digestion	AAS, GFAAS	Usero et al.(2008)
D. trunculus *C. gallina*	Hg, Cd, Pb, Cu, Zn, As, Fe, Co, Al, Mn, Ni, Sn, Cr	Tekirdağ, North Marmara	Microwave digestion	ICP-MS	Özden et al. (2009)
R. decussatus *R. philippinarum*	Cr, Ni, Cu, Zn, As, Cd, Pb, Hg	Northwest Portugal	Wet digestion	ICP-MS	Figueria and Freitas (2013)
M. galloprovincialis *C. glabra*	Cd, Cu, As, Hg, Pb	Ionian Sea Mar Piccolo, Taranto, Navy Arsenal	Microwave digestion	ICP-MS	Giandomenico et al. (2015)
C.grayanus *C. gigas*	Zn, Cu, Cd, Pb, Ni	Japan Amurskiy and Ussuriyskiy Gulfs	Wet digestion	FAAS	Shulkin et al. (2003)
C. gigas *M. edulis*	Cd, Pb, Cu, Zn	South West England, Kent, Shell Ness, Long Rock, Epple Blind-Fez, Nayland Rock, Foreness Point, Pegwell	Microwave digestion	ICP-OES	Bray et al. (2015)
D. trunculus	Fe, Mn, Zn, Cu, Pb and Cd	Nile River Delta	Wet digestion	AAS	El-Serehy et al. (2012)
M. galloprovincialis	Ag, Al, As, Cd, Co, Cr, Cu, Fe, K, Mn, Ni, Pb, Sn, V, and Zn	Black Sea, Marmara Sea, Turkish Straits, Aegean Sea	Microwave digestion	ICP-MS	Belivermiş et al. (2016)
M. galloprovincialis	Cr, Mn, Ni, Mg, Fe, Cu, Zn, Se	North Adriatic Sea	Microwave digestion	ICP-MS	Bongiorno et.al. (2015)
Ostrea edulis	Hg, Cd, Cu, Zn, Pb, Mn, As, Se, Cr	A local fish market in İstanbul	Microwave digestion	ICP-MS	Erkan et.al. (2011)

Discussion

Tellina lives in fine sand with tidal traffic and heavy wave actions without precipitate segregation (Brown and McLachlan, 1990; Gaspar et al., 1999). In addition; among the other bivalves, tellina is one of the most dominant species worldwide and they live under 15 – 20 cm of the sand surface (Ansell, 1983). It generally prefers 0-2 meters of depth (Ansell and Lagardère, 1980); however, it is possible to see up to 6 meters of depth (Gaspar et al., 1999). *D. trunculus* has a smooth surface with radial vessels and its shell is either yellowish or light brown. Inside of the shell, there is coloration of blue-purple or brownish and orange depending on the territory. Its length is generally 30mm; yet, it may reach up to 45mm (Poppe and Goto, 1993; Öztürk et al., 2014).

The changes of element content may take place because of metabolic activities due to the season and seasonal differences in the chemical properties of sea water (Karayakar et al., 2007); studies of

Astorga-Espana et al. (2007) and Li et al. (2010) showed that lead (0.14-0.18 mg/kg) and cadmium (0.25-0.48 mg/kg) content of the thick-shelled mussels were below the maximum limits of European Union (1.5 mg/kg for lead; 1 mg/kg for cadmium) and Cr (0.13-0.19 mg/kg) and Cu (1.3-3.8 mg/kg) were below the maximum limits too. Lead and Cd concentration of *Mytilus edulis* was 162 and 0.82 mg/kg respectively (Olafsson, 1986), 21 and 4 mg/kg in *Mytilus galloprovincialis* in Çam Bay of East Black Sea (Cevik et al., 2008) and 15.7, and 0.168 mg/kg in *Mytilus chilensis* (Astorga-Espana et al., 2007). Nickel and cadmium concentration of *Mytilus galloprovincialis* in Çam Bay was 6 and 3 mg/kg respectively (Cevik et al., 2008). These kind of samples are collected from sea, dried by lyophilisation or stove (generally in 110°C) and stabilized, and solubilized with acid or acid mixtures by the methods of wet decomposition, dry-ashing, or microwave methods. Heavy metals solubilized in the samples are assessed by spectroscopic methods such as flame atomic absorption (FAAS), graphite furnace atomic absorption (GFAAS), inductively coupled plasma atomic emission (ICP-AES), inductively coupled plasma-mass emission (ICP-MS), and inductively coupled plasma-optic emission (ICP-OES). Some studies related to these samples are given in Table 2.

According to the declaration (2008-29) of Ministry of Agriculture and Forestry on the standards of quality of shell fishes; the amounts must be lower than 1.2 mg/lt for tin and tin compounds, 0.1 mg/lt for nickel and nickel compounds, 0.1 mg/lt for lead and lead compounds, 3 mg/lt for boron, 0.1 mg/lt for chrome, 0.7 mg/lt for iron, 0.003 mg/lt for zinc, 0.1 mg/lt for arsenic, 0.07 mg/lt for aluminium, 1 mg/lt for bromine, 0.01 mg/lt for copper, 5 mg/lt barium, 0.015 mg/lt for beryllium, and 1 mg/lt for cobalt.

Conclusion

In this study, monthly changes of heavy metal composition of tellina (*Donax trunculus* Linnaeus, 1758) in Kefken region of Kocaeli and the effects of seasonal temperatures on accumulation were investigated. Hg and Sn were not detected as heavy metal pollutant, but Pb was determined in November, December, January, February and March and the average amount was determined as 12.97 µg/g. The average amount of Cd, Cr, Co and Ni was determined as 45 µg/g, 4.19 µg/g, 0.91 µg/g and 4.46 µg/g, respectively. It was seen that the temperature changes between 2014 and 2013 were approximately 3.5°C. It was determined that these snap temperature changes between seasons had an effect on the metal accumulation of the living species. Although the snap temperature difference seems to have a positive effect on living metabolism, it would be more appropriate to evaluate the effect of this situation on all natural organisms. This study presents important results such as other literature. Therefore, it can be said that *D. trunculus* is a suitable species for human consumption. It is thought that *D. trunculus* species will be suitable for consumption between April and October.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

Using of Quinoa Based Film to Extend the Shelf Life of Rainbow Trout Fillets under Cold Storage (4±1°C) Condition

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ABSTRACT

In this study, the structural features (thickness and light transmittance) of edible films that obtained from quinoa starch were analyzed, and the films were applied to rainbow trout fillets. These fillets were classified under two different groups without quinoa starch film (control) and coated with quinoa starch film (QSBF).Thereafter, these fillets were storage in the refrigerator at (4±1°C) for 12 days. Analyzes were performed on days 0, 3, 9, and 12 during storage to detect chemical and microbial changes in both groups**.** The film thickness was 0.195 ± 0.010 mm, and the light transmittance values were between 10–37%. At the end of storage, the highest values of chemical analysis were found in the control group 20.35±0.49 mg/100g in (TVB-N), 3.87±0.10 µmol MA/kg in (TBARS) and 6.27±0.00 in (pH), respectively. The highest values of microbial analysis were found in the control group 5.35±0.22 log cfu/g in (TAMB), 3.32±0.48 log cfu/g in (LAB), Pseudomonas 5.72±0.28 log cfu/g and *Enterobacteriaceae* 4.38±0.68 log cfu/g in the control group respectively, although (TPC) was found 6.84±0.11 log cfu/g in the QSBF group. The results of chemical and microbial analysis showed that statistical difference between control and treatment groups was significant ($p<0.05$). Quinoa starch-based biofilms (QSBF) had a chemically and microbiologically protective effect on trout fillets that were stored. Further studies are needed to optimize the use of (QSBF) as microbiological and chemical barriers for fish fillet packaging.

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Introduction

Rainbow trout (*Oncorhynchus mykiss*) is one of the most common aquaculture fish species in the world. In recent years, the rainbow trout breeding industry has become highly developed, and its production efficiency has increased due to newly designed technological systems (Crawford and Muir, 2008). Fish and fishery-related products have been recognized as important sources of human nutrition (Masniyom, 2011). Fish-related products provide nutritional benefits due to their valuable protein content and are a significant source of polyunsaturated fatty acids. However, the quality of spoilable products, like fish meat, must be protected to ensure a long term shelf life (Dursun and Erkan, 2009). Traditional preservation methods, such as vacuum and modified atmospheric packaging, have typically been used to extend fish shelf life, although these methods require large capital investments. As an economical alternative, research has

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focused on the development of antimicrobial packaging systems, such as edible films or coatings that can be combined with active ingredients. Edible films and coatings can be produced from different sources including proteins, lipids and polysaccharides (Sayanjali et al., 2011). The shelf life of fish fillets has reportedly been extended from 6 to 13 days, depending on the species to which these active packaging materials have been applied (Socaciu et al., 2018). Quinoa (*Chenopodium quinoa*) was selected by FAO (2014) as a food safety crop for the 21st century because it is tolerant to salinity and drought stresses and can grow in marginal regions. Quinoa's high antioxidant levels and protein content make it an excellent nutrient source. However, quinoa has rarely been studied as a substrate for edible coating materials. Quinoa protein is a good biopolymer for edible films due to its excellent elongation and adhesive properties, which can be achieved without the use of plasticizers (Abugoch et al., 2011). To the best of our knowledge, the application of edible film derived from quinoa seed has not been previously reported, particularly to extend the shelf life of rainbow trout fillets. Therefore, this study aimed to evaluate the efficacy of quinoa-based edible films for increasing the shelf life of rainbow trout fillets.

Material and Methods

Materials

Rainbow trout (*Oncorhynchus mykiss* L., 1758) that were obtained from the Atatürk University Faculty of Fisheries, Inland Fisheries Research and Production Center were used in this study. The trout had an average weight of 300 ± 15 g. White quinoa *(Chenopodium quinoa)* from a commercial company (Damietta Gold (500 g), Turkey) was used as the film base material.

Methods

Obtaining of Quinoa Starch and Films

Quinoa seeds were soaked in a 1:2 ratio in pure water for 8 hours and then milled using a blender. The supernatants were removed by passing the milled portions through fine mesh sieves. The remaining material was placed in centrifuge tubes and centrifuged three times at 1000 g for 15 minutes at 4°C, with the supernatants removed after each centrifuge. At the end of the process, the solution pH was adjusted to 10.5 with 0.20% aqueous NaOH to dissolve the remaining proteins. Then, 1 mol L^{-1} HCL was added to neutralize the solution. After neutralization, the remaining material was washed five times with distilled water to remove the protein and salts from the solution, leaving the starch (Araujo-Farro et al., 2010). The films were prepared using the method reported by Araujo-Farro et al., (2010), with minor changes. The quinoa starch obtained in the sterile cabinet was placed in glassware at a concentration of 4 g/100 mL to form film solutions. After stirring for 5–10 minutes in the magnetic stirrer to achieve saturation, the solution was left in a water bath at 82°C for 30 minutes until the solution achieved a plastic consistency. After standing, 1% glycerol (glycerol approx. 87%) was added to the solution, and it was remixed with a magnetic stirrer, followed by incubation at 35°C for 16 hours to obtain films.

2.2.2. Preparation and Wrapping of Fillets with Film and Trial Plan

The fish were prepared in the laboratory using sterile scalpels to open and remove the internal organs and to clean the dorsal and abdominal muscles from the gill caps to the tail fins. The process was repeated by inverting the fish; the fillets were obtained by separating the bones, tail and gills together with their heads. For wrapping of fillets, care was taken to cover the entire surface of the fillets with films prepared under sterile conditions (Ahmad et al., 2012). Trout fillets coated under vacuum aspirator in sterile environment were placed on aluminum foils. Edible films were prepared from starches (4% quinoa-100 mL distilled water-1% glycerol) from Quinoa (*C. quinoa*) seeds. The prepared films were subjected to some structural (film thickness and light transmittance) analyzes. Fillets (120 pieces) are extracted from 60 trout, around 18 kg, 60 fillets were covered with films and the rest of them were accepted as control group without any treatment and the experiment was designed repetition. The treatment and control group fillets were subjected to chemical and microbiological analyzes on certain days (0, 3, 6, 9 and 12 days) of storage at 4±1 °C.

Structural Analysis of Quinoa Films

Thickness measurements of edible films

The film thickness was measured with a micrometer (Tronıc, model 1131-150/Japan) with sensitivity of 0.001 mm. Measurements were made from 10 different regions of the films and the overall average was calculated.

UV-VIS absorption spectroscopy of edible films

Light absorption measurement of edible film coatings was carried out with a UV-VIS spectrophotometer (Perkin-Elmer, model Lamda 35/USA) having wavelength range of 200-1100 nm. In our study, quinoa starch edible film sample was placed into solid sample chamber and absorption spectra between 200-1100 wavelengths were taken. Light absorption values were then calculated using the equation given below.

$$Absorbance\ (A) = log\frac{I_0}{I}$$

In this formula, A; absorbance, I_0; intensity of light on the sample, I; the intensity of the light leaving the sample, ε; molar absorption coefficient (L/mol, cm), b; thickness of the sample cup (cm), c; and the concentration (mol/L). The ratio between light and light intensities entering the sample cup is expressed as transmittance (T) and calculated by the following formula (Arık et al., 2005).

$$Transmittance\ (T) = \frac{I_0}{I} = 10^{-\varepsilon bc}$$

Chemical Analysis

Total volatile basic nitrogen (TVB-N) analysis

TVB-N analysis of the samples was performed using the method reported by Malle and Tao (1987). The TVB-N value was determined by calculating formula by considering the spent H_2SO_4 solution (n) in the titration.

Thiobarbituric acid reactive substance (TBARS) analysis

The method given by Lemon (1978) was used to determine the TBARS value. TBARS value (µmol MA/kg) was calculated by substituting the absorbance values based on the square and the standard curve prepared with TEP (1, 1, 3, 3 tetraethoxypropane) in the following formula (Aras Hisar et al., 2004).

pH analysis

In order to measure the pH values, 10 g of paralleled samples were taken into small pieces and 100 mL of purified water was added. The obtained suspensions were homogenized in Ultra-Turrax for 1-2 minutes and then measured with pH meter (Schott, Lab Star) (Gökalp et al. 2001).

Microbiological Analysis

Microbial analysis was carried out from cold-stored fillets were done for each bacteria group (total aerobic mesophilic, psychrotrophic, lactic acid, *Pseudomonas* and *Enterobacteriaceae*). 10 g fillet samples was taken and diluted in 99 mL of 0.85% (w/v) sterile saline solution. To homogenise, a Stomacher (Lab. Stomacher Blander 400 BA 7021, Sward medical) was used the samples in a sterile polyethylene bag for 1.5 min and sterile 9 mL 0.85% (w/v) NaCl solution for dilution. The number of total aerobic mesophilic bacteria (TAMB; Merck, at 30±1°C for 48 h; Harrigan, 1998); lactic acid bacteria (in MRS; Merck, at 30°C for 48 h in anaerobic conditions; Papamanoli et al., 2003), Pseudomonas counts were determined using Pseudomonas agar base (Oxoid) supplemented with C-FC (Cetrimide-Fucidin-Cephloridine) selective supplement (Oxoid) incubated at 25°C for 48 h. PCA plates were then incubated for 7 days at 10°C for psychrotorophic bacteria count (González-Fandos et al. 2005). *Enterobacteriaceae* (Violet Red Bile Agar, Oxoid and Violet Red Bile Dextrose Agar, Merck 1.10275.0500, at 37°C for 24 h; Harrigan, 1998) were counted, respectively.

Statistical Analysis

The data obtained as a result of the experiments were subjected to variance analysis using SPSS package program (SPSS 20 Software, USA) and Duncan multiple comparison test was applied for the applications that were found to be significantly different according to the results of this analysis. Logarithmic transformation was applied to microbiological values.

Results

Structural Results of Quinoa Films

The thickness of the films obtained from the quinoa starch we used in our study was determined as 0.195±0.010 mm. The light transmittance values of the films obtained from the quinoa starch at different wavelengths were given in Figure 1. The light transmittance of the quinoa starch edible films was 10% at 220 nm, 26% at 400 nm, 30% at 600 nm, 34% at 800 nm and 37% at 1000 nm, respectively.

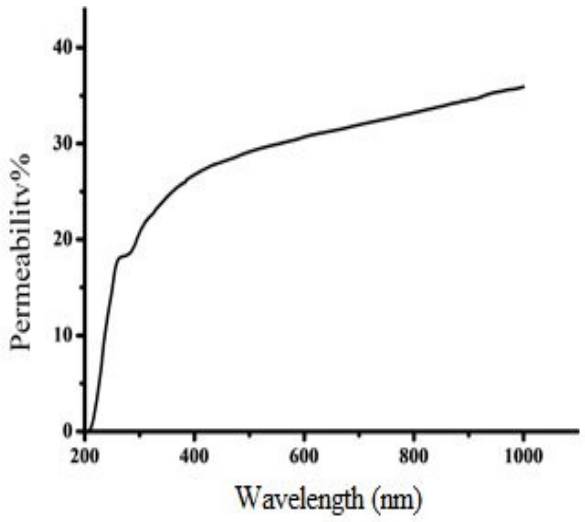

Figure1. Light transmittance values of quinoa starch edible films in different wavelength (nm)

Chemical Analysis

Total volatile basic nitrogen (TVB-N)

TVB-N content of rainbow trout fillets coated with quinoa starch film (QSBF) and without quinoa starch film (control) during storage is shown in Figure 2A. At the beginning of storage, TVB-N results in the control and film coating groups were 13.85±0.63 mg/100g. Increases were recorded in both groups up to the end of storage depending on storage time and the highest value was found 20.35±0.49 mg / 100g in the control group and 18.65±0.21 mg / 100g in the QSBF group. In statistical analysis, day and group, which is one of the main sources of variation, were found very important at $p<0.01$ level, while the effect of group x day interaction was found significant at $p<0.05$ level.

Thiobarbituric acid reactive substance (TBARS)

TBARS results during the storage days are shown in Figure 2B. In the control and film coating groups at the beginning of storage were determined as 2.46±0.08 and 2.76±0.28 µmol MA/kg, respectively. Increases were observed in both groups until the end of storage period, and the highest value was found to 3.87±0.10 µmol MA/kg in the control group at the end of storage period. According to the analysis of variance, the effect of group and day, which are the main sources of variation on TBARS value, was very important ($p <0.01$), and the effect of group x day interaction was insignificant ($p<0.05$).

pH

pH values of treatment and control group is shown Figure 2C. At the beginning of storage, pH values of control and QSBF groups were determined as 6.27±0.00 and 6.28±0.02, respectively. Increases were observed in both groups until the end of the storage period. At the end of the storage period, the lowest value was found to 7.66±0.22 in the film coated group. According to the analysis of variance, it was determined that the day was very important ($p<0.01$), the groups were insignificant ($p<0.05$) and the effect of group x day interaction was significant ($p<0.05$).

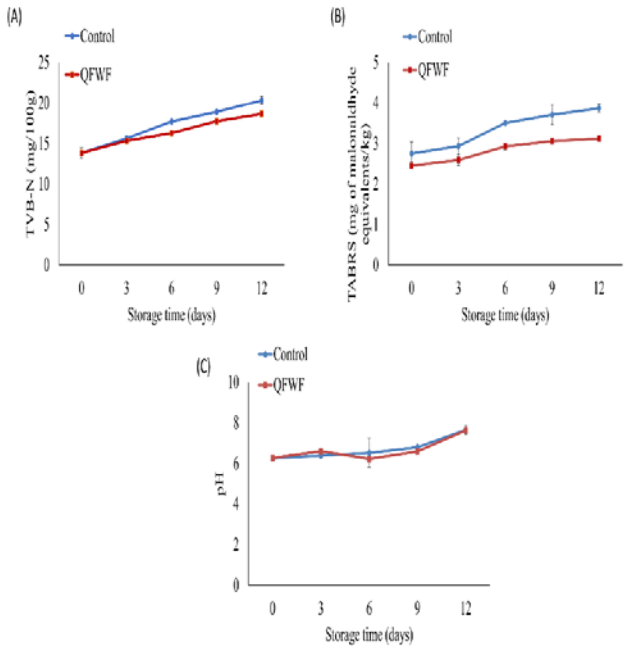

Figure 2. The effect of edible coating with on (A); *Total volatile basic nitrogen (TVB-N),* (B); *Thiobarbituric acid reactive substance (TBARS),* (C); *pH* values of trout fillets during storage (12 day) at 4 ± 1ºC. Mean ± standard deviation of the values (three replicates) are presented

Microbiological load of filmed trout fillets

The results of the number of bacteria determined during storage (12 days) were given in Figure 3. The total number of aerobic mesophilic bacteria (TAMB) was 2.55±0.07 log cfu/g and 2.52±0.06 log cfu/g in the control and QSBF groups at the beginning of storage, respectively. Increases in the number of TAMB were observed in parallel with storage period and the highest value was found to 5.35±0.22 log cfu/g in the control group at the end of storage period. The results showed that the effect of group and day on the TAMB was statistically very significant ($p<0.01$) and that group x day interaction was significant ($p <0.05$). The total number of psychrotrophic bacteria (TPC) was found to 4.19±0.71 log cfu/g in both groups at the beginning of storage in Figure 3. Continuous increase in these values was observed during storage and the highest value was found to 6.84±0.11 log cfu/g in QSBF group at the end of storage period. The results showed that the effect of group and day on the number of psychrotrophic bacteria was statistically significant ($p <0.01$), and that the interaction of group x days was insignificant ($p<0.05$). The number of LAB at the first day of storage was found 2.00±0.00 log cfu / g in the control and QSBF group in Figure 3. During the storage period, no change was observed in both groups and the highest value at the end of storage period was found 3.32± 0.48 and 2.66±0.28 in the control and QSBF group, respectively. After the statistical analysis, it was determined that the effect of groups ($p <0.05$) and the effect of days and group x days interaction on lactic acid bacteria number ($p <0.01$) was significant. At the beginning of storage, the number of *Pseudomonas* in the control and film coating group was 2.00±0.00 log cfu/g in Figure 3. Increases were observed in both groups until the end of storage period, the highest value at the end of storage period was 5.72±0.28 log cfu/g in the control group and 5.23±0.22 log cfu/g in QSBF group. In statistical analysis, the difference between storage days was significant for both groups ($p<0.05$). According to the analysis of variance, the effect of group x day interaction was significant ($p<0.05$) and days were very significant ($p <0.01$). The number of *Enterobacterieacea* at the beginning of storage was found to same value 2.00±0.00 log cfu/g in the control and film coating group in Figure 3. Increases were observed in both groups until the end of storage period. On the last day of storage, the highest values (4.38±0.68 log cfu/g) were observed in the control group and 4.07±0.54 log cfu/g in the QSBF group. According to the analysis of variance, the effect of group and group x day interaction on the number of *Enterobacterieacea* was insignificant ($p<0.05$) and the difference between days was significant ($p <0.01$).

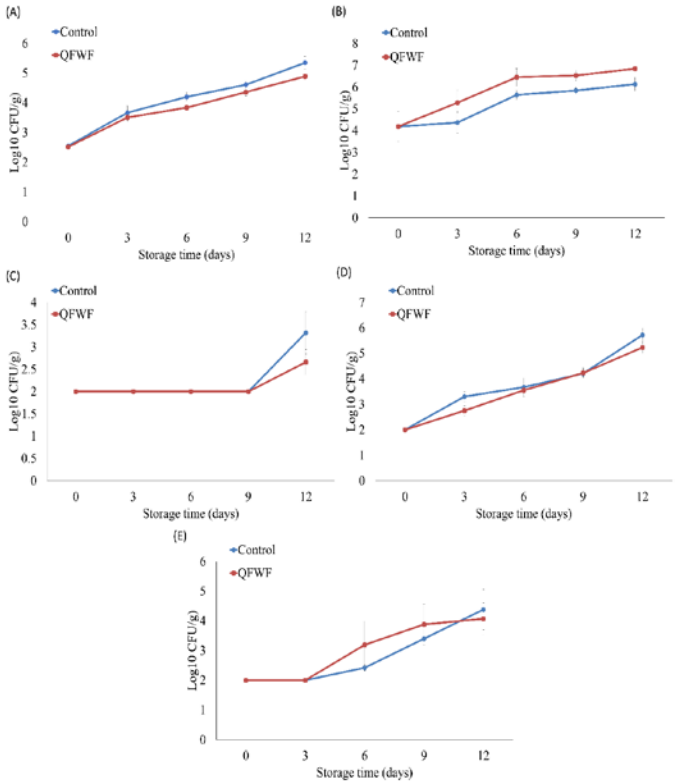

Figure 3. The effect of edible coating with on (A); The total number of aerobic mesophilic bacteria (TAMB) (B); Total psychrotrophic bacteria (TPB), (C); Lactic acid bacteria (LAB), (D); *Pseudomonas*, (E); *Enterobacterieacea* values of trout fillets during storage (12 day) at 4 ± 1ºC. Mean ± standard deviation of the values (five replicates) are presented

Discussion

Structural Properties of Quinoa (Chenopodium quinoa) Films

In our study, we measured the thickness of films as 0.195±0.010 mm. The difference in film thickness may vary depending on the bulk thickness, the difference of the main material used in the production of the film, the amount of use of the materials and the mixing ratios. Therefore, it is clear that other studies do not show similarity. In a study, which investigated the properties of gelatin films with seaweed extract, it was reported that the average thickness of films containing

gelatin film and gelatin-seaweed extract was 0.295 mm (Rattaya et al., 2009). Valenzuela et al., (2013) reported the film thicknesses as 0.051±0.001, 0.110±0.009, 0.111±0.010 and 0.126±0.008 mm in a study in which they determined the characterization and structure of edible biofilms consisting of a mixture of quinoa protein–chitosan–sunflower oil. In another study, the characterization of edible biofilms with quinoa protein-chitosan mixture was investigated and the thicknesses of the films were reported as 0.142±0.017, 0.125±0.017 and 0.054±0.003 mm (Abugoch et al., 2011). Araujo-Farro et al., (2010) have identified the thickness of films containing quinoa starch as 0.080±0.020 mm. UV-VIS Absorption Spectroscopy has been found that % light transmittance increases parallel to the increase of light wavelength. Gomez-Guillen et al., (2007) and (Al-Hassan and Norziah 2012) reported that the transparency of the films is very important on the light transmittance of the edible films, and that this transparency may be related to the addition of any material to the main materials used. Similarly, in our study, it was found that the quinoa starch used in the film production was quite light and therefore the light transmittance values differed from other studies due to the transparent color of the films obtained.

Chemical Changes of Filmed Trout Fillets

The TVB-N is very usually used in the assignation of spoilage of seafood (Ruiz-Capillas and Moral, 2001). It describes the sum of ammonia, methylamine, dimethylamine, trimethylamine, and other basic nitrogenous volatile compounds resulted from fish degradation (Sikorski, 1990; Ruiz-Capillas et al., 2015). As a result of endogenous enzyme and bacterial activities in fish, the amount of volatile basic nitrogenous substances increases. The acceptable limit values (25 mg/100 g) of TVB-N (Aras Hisar et al., 2004) vary according to the fish species, but the data obtained in our study are among the mentioned limit values (Nowzari et al., 2013; Volpe et al., 2015). The daily consumable limit value determined for trout was reported as 20 mg/100g by Aras Hisar et al., (2004) and Alak, (2012). At the beginning, TVB-N value was found as 13.85±0.63 mg/100g in our study. Parallel results were also published by another researchers in different works about on ice stored *S. aurata* (Tejada and Huidobro, 2002; Grigorakis et al., 2003; Kılınc et al., 2007). In our study, TVB-N values obtained from the control and QFW fillets remained below the daily consumable limit value during the storage period. Morover, the lowest value was found 18.65±0.21 mg/100g in the QSBF group at the end of storage. That value suggested that coating with QSBF may cause delaying the increase of the TVB-N value. This result can shows that the TVB-N results are related to microbiological findings. Similar results were also published by different researchers (Fan et al., 2009; Gómez-Estaca et al., 2010; Ojagh et al., 2010; Alak et al., 2010; Li et al., 2013). Morover, Ucak (2019) was reported that the TVB-N values reached 42.70, 39.90, 34.30 and 30.10 mg N/100 g in control, G0 (samples wrapped with gelatin film), G4 (samples wrapped with gelatin film incorporated with 4% garlic peel extract) and G8 groups (samples wrapped with gelatin film incorporated 8% with garlic peel extract), respectively at the end of the storage. When the results of our study are compared with other studies, it is seen that fish species, storage conditions, processing technologies, additives and packaging are effective in TVB-N value used as freshness criteria (Alak, 2012; Aras Hisar et al., 2004). Lipid oxidation is an important issue for quality of food. Because of TBARS is generally a significant parameter used as lipid oxidation index (Fan et al., 2009; Jeon et al., 2002; Jongjareonrak et al., 2008; Ojagh et al., 2010). Some researchers (Ojagh et al., 2010; Jouki et al., 2014; Shokri and Ehsani 2017), were published that values <3 mg MDA/kg for perfect quality material, <5 for good quality material, and 5≤ MDA/kg< 8 for suitable for human consumption. It has been reported that edible biofilms can be an important barrier in preventing light-effect lipid oxidation on foods (Gómez-Estaca et al., 2009). Furthermore, it is thought to be effective in decreasing oxidation level in the coated fillets by preventing the contact between food and oxygen due to the barrier properties of the films. In addition, fish species, preservative application, storage conditions and packaging may have an impact on TBARS values (Araujo-Farro et al., 2010). In our current study results, it was also determined that quinoa film coating applied during storage period had inhibitory effect on lipid oxidation. Because of the highest value was found 3.87±0.10 µmol MA/kg in the control group at the end of storage day. Similarly, (Sathivel et al., 2007) reported that chitosan and soy protein concentrate delays lipid oxidation in skinless pink salmon fillets. Ucak (2019) sum up lipid oxidation was also delayed in the samples wrapped with gelatin films incorporated with garlic acid extract, especially in concentration of 8%. In parallel with, (Socaciu et al., 2018), were published data reviewed in the theirs paper that TBARS values ranged from 0.2 to 0.9 mg MDA/kg for rainbow trout fillets, 1.1 to 1.8 mg MDA/kg for salmon fillets, 1.0 to 2.5 mg MDA/kg for pike-perch fillets, 0.06 to 0.12 mg MDA/kg for beluga sturgeon fillets, 3.0 to 4.0 mg MDA/kg for silver carp fillets, 0.9 to 1.2 mg MDA/kg for grass carp fillets,0.2 to 2.0 mg MDA/kg for Japanese sea bass fillets, and 0.8 to 1.8 mg MDA/kg for red drum fillets. Owing to accumulation of alkaline compounds indicating fish spoilage, pH of trout fillets increased slowly during our study (Utami et al., 2014). Fan et al., (2009) investigated the effect of chitosan coating on the quality and shelf life of silver carp and found that the pH value of chitosan coated products was lower than the control group. In different studies with biofilm coating, it was also reported that the pH value was low (Gómez-Estaca et al., 2009; Volpe et al., 2015). The initial low level of pH in fish is due to the conversion of glycogen to lactic acid during the post mortem glycolysis phase (Sengor et al., 2000). In the next stage, the oxidation-reduction equilibrium, the change in the concentration of free hydrogen and hydroxyl ions occur due to the increase of storage time and the effect of enzyme-microorganisms and thus the pH value increases. In addition, decomposition of nitrogenous compounds in meat due to post-mortem changes leads to an increase in pH (Hernández et al., 2009). In our study, pH was determined that the day was very important ($p<0.01$), the groups were insignificant ($p>0.05$). Similarly, (Dogan and Izci, 2015) were published that the pH values were observed as increase, although chitosan film coated fillets was lower than the control group ($P< 0.05$). It was observed that the data obtained in our study was consistent with the researches mentioned above.

Microbiological Load of Filmed Trout Fillets

There are many studies on the storage of fish and other aquaculture products with antimicrobial properties of edible coatings

in the literature. Because of microbiological analysis is very important for determining the quality of the food products. In the literature, the values of TAMB in fresh fish have been reported by different researchers as 2-7 log cfu/g (Sallam, 2007; Song et al., 2011). In our study, we found that the number of bacteria in all groups increased during storage. But the limit value (7 log cfu/g) was not exceeded in control and QFW groups at the end of on storage. Our data, which is in parallel with the results of a lot studies where the same storage process and different film techniques are applied, is thought to have a significant inhibitory effect of coating solution and coating technique on the TAMB. Some researchers also informed these coatings have antimicrobial effect (Vásconez et al., 2009; Alak et al., 2010; Zhou et al., 2011; Qiu et al., 2014; Bahram et al., 2016; Yıldız and Yangılar, 2016; Shokri and Ehsani, 2017). Ahmad et al., (2012) documented that gelatin film integrated with lemongrass essential oil may reduced microbial counts of sea bass slices. Similarly, (Lu et al., 2010) reported that TAMB of coated sample was 5.27 log cfu/g on the contrary that of control sample reached 8.10 log cfu/g on fresh northern snakehead fish fillets during refrigeration storage. Edible coatings (Souza et al., 2010), was applied to salmon fillets and (Feng et al., 2016) golden pomfret fillets respectively, showed an antimicrobial impact compared to uncoated groups. In paralled with salmon fillets without any coating surpassed the critic level (7 log cfu/g) on the 12 day, (Souza et al., 2010). TPB results obtained at the end of storage period is not consistent with the results reported by (Ojagh et al., 2010; Jiang et al., 2011; Ahmad et al., 2012; Huang et al., 2012; Cardoso et al., 2017) . It is thought that the variation of the film materials used is effective in this change. Similarly, Dursun (2012) stated that protein film coating may cause a decrease or increase in the number of psychrotrophic bacteria. This situation is in parallel with our study data. In addition, the difference of fish material can be effective in the determined mismatch. Alak (2011) reported that there may be an increase in the number of psychrotrophic bacteria in cold water fish. Facultative anaerobic LAB are the main cause of meat spoilage. Particular species of LAB (such as *Lactobacillus* spp., *Carnobacterium* spp. and *Leuconostoc* spp.) have been reported as the most effective bacteria in meat spoilage (Giatrakou et al., 2010). The highest values were found 3.32±0.48 and 2.66±0.28 in the control and QSBF group, respectively, at the end of storage period on LAB. Similar results were obtained in different film-coating studies (No et al., 2002; Viuda and Martos et al., 2008; Volpe et al., 2015; Carrión-Granda et al., 2018). In particular, it is known that solvent material and biofilm additives are effective in inhibiting lactic acid bacteria (Volpe et al., 2015; Yıldız and Yangılar 2016; Carrión-Granda et al., 2018). Kazemi and Rezaei (2015), the lowest amounts of LAB count published in the samples coated at first and last days of storage, respectively. In the present study, when the lactic acid bacteria numbers of the control and film coating groups were examined on the last day of storage, these numbers were found that the application had an inhibitory effect on the bacteria. Gram negative psychrotrophic bacteria are the major group of microorganisms responsible for aerobically spoilage of fresh fish at low temperatures and Pseudomonas spp. are the main bacteria in this group (Wei et al., 2006). Different solvents and films are known to be effective in inhibiting *Pseudomonas* (Alak, 2012; Shokri and Ehsani 2017; Yu et al., 2017). Gómez-Estaca et al., (2009) determined that antimicrobial effect of clove essential oil added, fish gelatin and chitosan composite films on *Lactobacillus acidophilus*, *Pseudomonas fluorescens*, *Listeria innocua* and *Escherichia coli* bacteria. We also obtained similar result that was 5.72±0.28 log cfu/g in the control group and 5.23±0.22 log cfu/g in QSBF group in our study. Similarly, (Raeisi et al., 2015) report that the increasing in control samples was significantly higher than that of coated ones as reached to 7.4 log cfu/g at day 10. Nirmal et al., (2009) reported that the application of sodium metabisulfite and catesin is effective on *Enterobacterieacea* in shrimps and that sodium metabisulfite shows low inhibition properties. Lee and Yoon (2001) reported that acids released by lactic acid bacteria in materials applied may inhibit *Enterobacterieacea* bacteria. Edible coating with 8% whey protein concentrate/glycerol, 2:1 has also shown to be effective against Enterobacteriaceae in rainbow trout fillets as compared with the other formulations tested in the study (Yıldız and Yangılar 2016). The most effective edible films/coatings against Enterobacteriaceae were those incorporated with 2% thyme esential oil (Jouki et al., 2014) 1.5% oregano (Kazemi and Rezaei 2015) and 1% lemon (Volpe et al., 2015) that were applied on rainbow trout fillet. The data obtained in our study show similarity with the results of the researchers.

Conclusion

Studies on the effects of edible biofilms obtained from starch extracts from Quinoa seeds on food shelf life have been found to be quite limited. In the literature review, studies related to this substance have not been found, especially in seafood processing technology. However, in recent years, there has been a growing interest in the use of quinoa, a dietary food, as an edible film. In this study, the structural properties (thickness and light transmittance) of the obtained quinoa biofilms and chemical and microbiological changes during cold storage in film coated fillets were investigated in order to determine the possibilities or suitability of use in rainbow trout fillets. In our study, it was determined that quinoa starch film coating applied to trout fillets had a significant effect especially on chemical parameters in cold storage and had inhibitory effect on bacterial growth. It is also thought that this application has a positive effect on trout fillet quality parameters in terms of shelf life and can be used as an alternative source of biofilm for the protection of aquatic products. In particular, it is considered that these products, which do not have a negative health effect on the seafood processing industry and which contribute positively to the nutritional content of the product, should be supported with further studies to be developed and enriched with the use of appropriate technical-technology.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

A New Maximum Length with Length–Weight Relationship of Tub Gurnard (*Chelidonichthys lucerna* Linnaeus, 1758) from Central Black Sea Coasts of Turkey

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ABSTRACT

The study was carried out in the 2012-2016 fishing seasons in the Central Black Sea coasts of Turkey. Tub gurnard (*Chelidonichthys lucerna* L., 1758) were examined in the commercial fishery (trawls, trammel nets and gillnets). A total of 56.104 kg tub gurnard was caught during the study period. Total length and weight of 117 tub gurnard individuals were measured. Minimum, maximum and average total lengths were calculated as 12.8 cm, 74.2 cm and 33.28±1.28 cm, respectively. The maximum length is the second maximum length for the Black Sea coasts however first maximum length for the Central Black Sea coasts of Turkey. Length-weight relationship (LWR) of tub gurnard were determined as $W=0.0103L^{2.9876}$ in the study. The value of the parameter 'b' was found to be 2.9876 and the growth was isometric (b = 3) for tub gurnard ($P > 0.05$).

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Introduction

The Black Sea, an almost closed basin between Europe and the Anatolian peninsula, is one of the youngest seas in the world and connected to the Aegean Sea via the narrow Bosphorus and Dardanelles. The Black Sea is a prototypic anoxic sea due to the lack of oxygen in the water, which has existed in the deep for a long time. Eukaryotic life occurs in only 10% of the total depth of the Black Sea (Balkas et al., 1990; Bat et al., 2007; Talley et al., 2011; Bat, 2017).

Tub gurnard (*Chelidonichthys lucerna*) is one of the three species belong Triglidae family living in the Black Sea (Bat et al., 2008; Bilecenoğlu et al., 2014; Yankova et al., 2014). It is a nectobenthic fish distributed in the eastern Atlantic from Norway to Senegal, Mediterranean and Black Sea (Serena et al., 1998) and mainly habits sand or gravel bottoms up to 320 m depth (Mytilineou et al., 2005).

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They feed mainly on fish, crustacean and molluscs (Bat et al., 2008). It has been reported that tub gurnard spawn between May and September with 100 000-300 000 pelagic eggs in Georgian coasts of the Black Sea (Komakhidze et al., 2003). This species was classified as least concern in IUCN Red List (Nunoo et al., 2015).

Tub gurnard is mainly caught as by-catch by gill nets and trawls in mixed demersal fisheries for flatfish and round fish (ICES, 2010; Kasapoğlu and Düzgüneş, 2017) and have high commercial value (Bat et al., 2008). Set nets have been used in the Black Sea coastal fishery (Özdemir et al., 2017; Erdem et al., 2018). Target species of these fishing gears are red mullet, whiting, bluefish, horse mackerel and pontic shad (Kalaycı and Yeşilçiçek, 2014; Aydın and Hacıoğlu, 2017). However, some species can be caught by set nets and demersal trawl as economical by-catch for example, tub gurnard, sea bass, sea bream, shi drum, brown meagre and European flounder (Erdem, 2000; Erdem et al., 2007).

Although some biological parameters of tub gurnard have been well-studied in coasts of Sea of Marmara, Aegean Sea, Mediterranean and contiguous Atlantic area (Papaconstantinou, 1984; Colloca et al., 1994; Abdallah, 2002; Santos et al., 2002; Borges et al., 2003; Mendes et al., 2004; İşmen et al., 2004; Eryılmaz and Meriç, 2005; İlhan and Toğulga, 2007; Deval et al., 2007; Boudaya et al., 2008; Çiçek et al., 2008; Vallisneri et al., 2011; Stagioni et al., 2012; Demirel and Dalkara, 2012; Akyol, 2013) the studies in the Black Sea coasts of Turkey are very limited (Ceylan et al., 2014; Haşimoğlu et al., 2016).

Scientific studies are most important for approaching ecosystems sustainable fisheries and success of the fisheries management. It is very essential research on biology, population parameters and length-weight relationships (LWRs) of all fishes (target, discard and bycatch) in the seas and oceans of the world. Maximum length and weight are important parameters used in life history studies and fishery science. These measurements are applied directly or indirectly in most stock assessment models (Borges 2001; Cengiz et al., 2019a). Therefore, it is important to regularly update the maximum size of commercially important species (Navarro et al., 2012; Cengiz et al., 2019b). LWRs are useful for life history and morphological comparisons of population from different location (Gonçalves et al., 1997; Moutopoulos and Stergiou, 2002).

The aim of the present study is to supply new data on maximum length, length weight relationship (LWR) and fishery of tub gurnard caught in the Central Black Sea coastal fisheries of Turkey.

Material and Methods

The study was carried out in the Central Black Sea coasts of Turkey at monthly basis by using a commercial demersal trawl (September 2014 - April 2015), trammel nets and gill nets (September 2012 - August 2016). The sampling area is Central Black Sea coasts (Sinop inner harbour, Sinop Peninsula and İnceburun off shore) this area is an important migration route of pelagic and demersal school fishes in the Black Sea coasts of Turkey. Samples were collected with demersal trawl at depths ranging from 70 m to 120 m. Sampling area is shown in Figure 1.

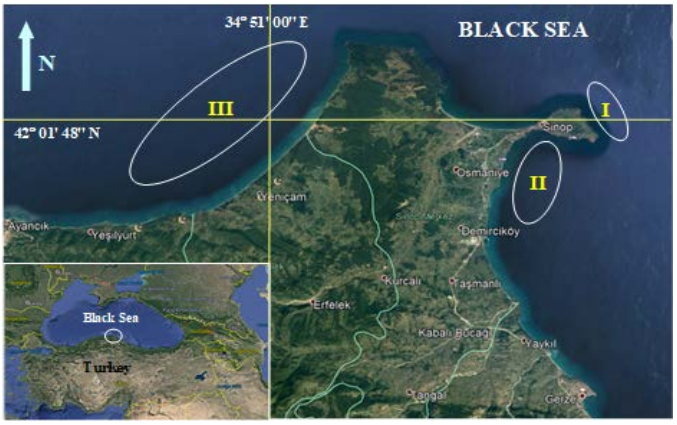

Figure 1. The study areas (I-II: surveys with trammel nets and gill nets, III: surveys with demersal trawls)

Fishes were caught by using a typical otter bottom trawl with 40 mm codend mesh size; tow duration was restricted to 60-120 min. Also, a total of 18 trammel nets were used with 32 mm, 36 mm, 40 mm, 44 mm, 48 mm and 52 mm mesh sizes. Gill nets had 36 mm, 44 mm, 48 mm, and 320 mm mesh size. The fishing gears were used between 15 m and 60 m depth.

A total of 22 hauls for trawl and 36 fishing operations for trammel and gill nets were conducted during the study period. Fish were measured to the nearest 0.1 cm (total length) and weighted to the nearest 0.01 g (wet weight) (Figure 2).

Figure 2. Tub gurnard (*Chelidonichthys lucerna* L., 1758) captured by demersal trawl net (Maximum length: 74.2 cm)

Length-weight relationships were estimated by fitting an exponential curve ($W = aL^b$) to the data (Ricker, 1975; Pauly, 1984).

Parameters a and b of the exponential curve were estimated by linear regression analysis over log-transformed data:

$$\log W = \log a + b \log L$$

where W is the total weight (g), L is the total length (cm), a is the intercept and b is the slope, using the least-squares method. The association-degree between variables of W and L was calculated by the determination coefficient (R). Additionally, 95% confidence limits of the parameter b were estimated. The Student's *t test* was used for comparison of the slopes (Zar, 1996).

$$t = \frac{Sd_{\log TL}}{Sd_{\log W}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2}$$

In this formula, $Sd_{\log TL}$ is the standard deviation of the $\log TL$ values, $Sd_{\log W}$ is the standard deviation of the $\log W$ values, n is the number of specimens used in the computation. The value of b is different from $b = 3$ if calculated t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984).

When the parameter 'b' is statistically equal to 3, the growth is called isometric, but the growth is positive allometric when the 'b' value is more than 3 and negative allometric when the 'b' value is less than 3 (Dutta et al., 2012).

Results

A total of 56.104 kg tub gurnard was caught during the study period. Total length and weight of 117 tub gurnard individuals were measured in the study. A total 39 fishes captured by the trawl nets and 78 fishes caught by the trammel nets (55 specimens) and gillnets (23 specimens).

Minimum, maximum and average total length was calculated as 12.8 cm, 74.2 cm and 33.28±1.28 cm, respectively. Minimum, maximum and average weight of the fish was recorded as 24.4 g, 3983.5 g and 532.12±63.85 g, respectively (Table 1). The largest size fish (74.2 cm) captured by the trawl nets in İnceburun off shores (region III) and the smallest fish (12.8 cm) caught by the trammel nets in Sinop inner harbor region (region II).

Table 1. Length parameters of tub gurnard for the fishing gears (cm)

Parameters	Trammel nets	Gill nets	Trawl nets	All
Specimens	55	23	39	117
Minimum	12.8	44.2	23.5	12.8
Maximum	55.2	68.5	74.2	74.2
Average	30.1±1.37	49.6±1.44	38.4±1.32	33.3±1.28

Table 2. Length-weight relationship (LWR) parameters for tub gurnard

Parameters	
N	117
a	0.0103
a (SE)	0.0647
95 % Confident of a	0.0089 – 0.0142
b	2.9876
b (SE)	0.0431
95 % Confident of b	2.89102 – 3.0721
R	0.9884
Growth	Isometric (b=3)
t test	p>0.05

Note: N is number of specimens; *a* is intercept of the relationship; *b* is slope of the relationship; *R is* coefficient of determination; *b (SE)* is the standard error of *b*; *a (SE)* is the standard error of *a*.

The fish between the 25 cm and 35 cm length group represented the majority of all fish with 59.83%. When the most of fishes were captured in the 35 cm (31.62 %) length group, the least fish were caught in the 75 cm (3.42 %) length group. Length-weight relationship (LWR) of tub gurnard was determined as $W=0.0103L^{2.9876}$. Length-weight frequency distributions and graphic of LWR are shown in Figure 3.

Descriptive statistics on the length and sample size (n), regression parameters a and b of the length-weight relationship (LWR), 95% confidence intervals of a and b, the coefficient of determination (R) of analyzed species are shown in Table 2.

These results displayed that there was significant relationship between length and weight for tub gurnard. The value of the parameter b was 2.9876 for tub gurnard in the study. The a value of tub gurnard was 0.0143 and coefficient of determination (R) was 0.9884. The growth was isometric (b = 3) for tub gurnard.

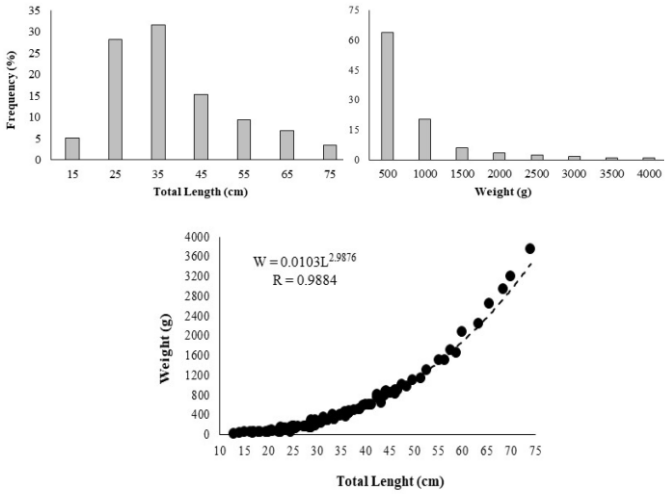

Figure 3. Length-weight frequency distribution and LWR of tub gurnard

Discussion

The tub gurnard has an important economic value and is important by-catch species in Turkish seas. Many scientists expressed that tub gurnard was captured by trammel nets, gill nets and demersal trawl nets (Özdemir et al., 2003; Çiçek et al., 2006; Ceylan et al., 2014; Kasapoğlu and Düzgüneş, 2017; McCartey and Marriott, 2018).

The present study determined that the mean length and weight are 33.28±1.28 cm and 532.12±63.85 g, respectively. The maximum, minimum total length and weight measured for fishes were 74.2 cm, 12.8 cm, and 24.4 g, 3983.5 g, respectively. Minimum and maximum total lengths were reported as 2.2 cm (Eastern Mediterranean Sea) and 88.2 cm (Eastern Black Sea) in Turkish seas (Çiçek et al., 2006; Haşimoğlu et al., 2016).

As well known, the individuals in populations exposed to high levels fishing pressure will respond by reproducing at smaller average sizes and ages and so reached maximum lengths may getting and getting smaller. However, the one individual that subjected to no overfishing pressure could be reached that kind of length (Filiz, 2011). On the other hand, any factor that might possibly influence growth has been shown to have an effect, including nutrient availability, feeding, light regime, oxygen, salinity, temperature, pollutants, current speed, nutrient concentration, predator density, intra-specific social interactions and genetics (Helfman et al., 2009; Acarlı et al., 2018).

Table 3. Studies on parameters of length-weight relationship (LWR) of tub gurnard

Authors	N	Sex	L_{Max}-L_{Min}	a	b	R	Growth
[a]Papacostantinou, 1984*	153	M	13.5-76.7	0.007014	3.146	0.99	+A
	122	F	13.2-32.7	0.007729	3.110	0.99	+A
[a]Papacostantinou et al. 1994	563	M+F	6.0-35.0	0.009846	3.011	0.93	-A
[a]Serena et al. 1998	538	M+F	11.7-45.5	0.013900	2.859	0.99	-A
[a]Abdallah, 2002	196	M+F	4.7-24.9	0.029000	2.630	0.97	-A
[a]Santos et al. 2002	75	M+F	14.0-34.4	0.018000	2.978	0.98	-A
[a]Borges et al. 2003	10	M+F	13.6-29.2	0.001296	2.956	0.99	I
[a]İşmen et al. 2004	143	M	8.3-21.2	0.089000	3.010	0.99	I
	199	F	8.0-30.3	0.095000	3.010	0.98	I
	342	M+F	8.0-30.3	0.009300	2.990	0.98	I
[c]Eryılmaz and Meriç, 2005	224	M+F	12.3-41.5	0.009200	3.019	0.98	I
[a]Çiçek et al. 2006	137	M+F	2.2-30.3	0.013500	2.851	0.99	-A
[a]Olim and Borges, 2006	21	M+F	7.5-27.7	0.011000	2.720	0.99	-A
[b]İşmen et al. 2007	829	M+F	12.5-76.0	0.009600	2.928	0.99	-A
[b]İlhan and Toğulga, 2007*	186	M	14.1-29.9	0.005300	3.237	0.98	+A
	360	F	12.7-34.4	0.005100	3.245	0.98	+A
	546	M+F	12.7-34.4	0.005200	3.240	0.98	+A
[a]Sangun et al. 2007	474	M+F	6.7-24.5	0.016600	2.743	0.97	-A
[a]Boudaya et al. 2008	126	M	17.0-26.0	0.007300	3.037	0.93	I
	160	F	16.0-36.0	0.015500	2.826	0.95	-A
[b]İlkyaz et al. 2008	121	M+F	12.1-42.3	0.004300	3.240	0.97	+A
[a]Çiçek et al. 2008	106	M	6.5-29.3	0.009400	2.988	0.99	I
	113	F	6.1-30.3	0.011400	2.918	0.99	-A
	228	M+F	2.2-30.3	0.012900	2.874	0.99	-A
[c]Keskin and Gaygusuz, 2010	17	M+F	6.3-15.1	0.011300	2.902	0.98	I
[c]Bök et al. 2011	90	M+F	8.0-64.0	0.010000	2.982	0.98	I
[a]Vallisneri et al. 2011	396	M	12.8-34.2	0.000001	2.952	0.97	I
	484	F	11.3-41.5	0.000001	3.038	0.98	I
[c]Demirel and Dalkıran, 2012	352	M+F	10.5-56.0	0.009000	3.000	0.98	I
[b]Bilge et al. 2014	81	M+F	16.6-40.7	0.005200	3.222	0.98	+A
[a]El-Serafy et al. 2015	315	M	12.6-23.3	0.004300	3.264	0.97	+A
	511	F	11.8-28.2	0.004200	3.265	0.98	+A
[c]İşmen et al. 2018	204	M+F	9.2-37.0	0.027000	2.676	0.98	-A
[d]McCarty and Marriot, 2018	804	M+F	10.4-57.5	0.067000	3.103	0.98	+A
[e]Present study	117	M+F	12.8-74.2	0.010300	2.988	0.98	I

Note: a: Mediterranean Sea, *b*: Aegean Sea, *c*: Marmara Sea, *d*: North Sea, *e*: Black Sea, * indicates fork length, *M*: male, *F*: female, *M+F*: male and female, *Max*: maximum, *Min*: minimum, *I*: isometric, *+A*: positive allometric; *-A*: negative allometric,

The second maximum size for tub gurnard was measured as 74.2 cm for Black Sea coasts of Turkey. Moreover, this length was the maximum size for this species in the Central Black Sea coasts of Turkey. Maximum lengths were determined as 76 cm in Aegean Sea,

30.3 cm in Eastern Mediterranean Sea and 64 cm in Marmara Sea in other studies for Turkish seas (İşmen et al., 2007; Çiçek et al., 2008; Bök et al., 2011). The minimum and maximum lengths were measured in the different countries 6.0 cm and 57.5 cm, respectively (Papacostantinou et al. 1994; McCartey and Marriot, 2018).

Length-weight relationship was found as $W=0.0103L^{2.9876}$ (R=0.989) for tub gurnard (Isometric growth, *b=3* (p>0.05)). In the present study, the *b* value was estimated to be 2.987 for tub gurnard. It was identified that *b* values of tub gurnard varied from 2.630 to 3.265 by other authors (Table 1). The variations in *b*-values may be ascribed to one or more factors: the seasons and effects of different areas, differences in salinity, temperature and pollution of aquatic environment, gender, nutrient quality and availability, differences in the quantity of fish analyzed, as well as in the observed size ranges of the sampled species (Gonçalves et al., 1997; Froese et al., 2011).

Seventeen of twenty-four studies had significantly different *b*-values, which reported negative allometric growth (Papacostantinou et al., 1994; Serena et al., 1998; Abdallah, 2002; Santos et al., 2002; Çiçek et al., 2006; Olim and Borges, 2006; İşmen et al., 2007; Sangun et al. 2007; Çiçek et al., 2008; Boudaya et al., 2008; İşmen et al., 2018) and positive allometric growth (Papacostantinou, 1984; İlhan and Toğulga, 2007; İlkyaz et al., 2008; Bilge et al., 2014; El-Serafy et al., 2015; McCarty and Marriott, 2018) for tub gurnard. Also, the present study showed that the *b*-values have generally been in agreement with similar results (isometric growth) in seven studies (Table 1).

On the other hand, tub gurnard were generally captured in small sizes. First maturity size of female and male are 19-20 cm and 17-18 cm for Turkish seas, respectively (İşmen et al., 2004; Eryılmaz and Meriç, 2005; İlhan and Toğulga, 2007). The sizes ranged between 25 cm and 40 cm in some studies carried out in other Mediterranean countries (Papacostantinou, 1984; Baron, 1985; McCarty and Marriott, 2018). The minimum landing size (MLS) is 18 cm for tub gurnard in Turkish seas (Anonymous, 2016). However, it is not enough once for reproductive of fish. The MLS has to be raise for the sustainability of tub gurnard fish stocks in Turkish seas.

Conclusion

These important data and results are usually used by authorities of fisheries management, scientific institutions and academic studies. Therefore, the relevant studies on fishery, biology, populations and stocks of fish species captured in the Black Sea should be improved and appraised in the future.

Consequently, the tub gurnard is an economic fish for the coastal fishermen, although the fish is captured as by-catch in small scale fisheries in Turkey. Tub gurnard fishery has been decreasing in the Turkish seas for last decade (TurkStat, 2019). For this reason, tub gurnard should not be caught by the fishermen before they reach the first reproduction length (19 cm). Captured small fishes must be released to the sea once for reproduction. Also, minimum fishing size measure for tub gurnard should be reviewed and the MLS must be raised to more than 18 cm.

Conflict of Interest

The authors declare that there is no conflict of interest.

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RESEARCH ARTICLE

New Alternative Fishing Gear Suggestions for Trap Fisheries from the Waste Recycle Materials: Case Study for Muricidae (Mollusca: Gastropoda)

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ABSTRACT

Small-scale fisheries have a high socioeconomic importance for local communities. Therefore, ensuring the sustainability of fisheries resources would contribute to the socioeconomic development of fisheries communities. In this study, traps produced from plastic waste recycle materials which can be used in fishing of economically valued whelks (*Hexaplex trunculus* and *Bolinus brandaris*) that are used as natural bait in angling and longline fishing were investigated. These traps in different sizes were examined at the depths of 3-8 m in the Urla coasts of Izmir Bay, Turkey. The soaking times of traps were between 10-48 hours. The same amounts of baits (*Sardina pilchardus*) were equally placed in all traps. Catch per unit efforts (CPUE) of traps were calculated between 7-34 individuals/trap per day. The experimented traps were found successful for whelks fishing. Traps yield high quality and economically valued catches, related to restricted bycatch and low impact on habitat. Therefore, these traps can be suggested as alternative fishing gears designed for trap fisheries for whelks. This paper provides valuable knowledge for fisheries managers and decision makers to ensure the sustainability of local fisheries resources and small-scale fisheries.

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Introduction

Marine and freshwater fish species are not only caught for supplying food and raw components, but they are also used in recreational fisheries, ornamental aquariums and aquaculture facilities across the globe (Engelhard et al., 2019). Recreational fisheries is described as "*fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets*" by FAO (2012). The economic importance of the recreational fisheries has promptly increased globally. Recreational fisheries is targeting several different fish species and engaging at least

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220 million participants in both marine and freshwater habitats (Cooke et al., 2018). In addition, recreational fisheries can support rural livelihoods in developing countries (Smith et al., 2005) besides small-scale fisheries have a high socioeconomic importance for local communities. Ensuring the sustainability of fisheries resources would contribute to the socioeconomic development of fisheries communities.

Muricid gastropods possibly will play an important role in the population dynamics of benthic organisms due to predation behaviours could lead to several variations on the amount and diversity of other benthic communities (Güler and Lök, 2019). The purple dye murex (*Bolinus brandaris* Linnaeus, 1758) and the banded murex (*Hexaplex trunculus* Linnaeus, 1758) are widely distributed species of the Muricidae family throughout the Mediterranean Sea (Gaillard, 1987; Houart, 2001). Both species have extended their distribution areas, possibly due to accidental introduction of juveniles among bivalves imported for shellfish culture (Vasconcelos et al., 2016). The purple dye murex (*Bolinus brandaris*) generally occurs in the sublittoral zone (Dalla Via and Tappeiner, 1981) although the occurring was reported at 200 m (Macedo et al., 1999). The species prefers sandy, muddy, and sandy-muddy habitats (Muzavor and Morenito, 1999). The banded murex (*Hexaplex trunculus*) usually occurs between intertidal and infralittoral zones until the depth of 200 m (Dalla Via and Tappeiner, 1981; Macedo et al., 1999). Houart (2001) reported that this species is frequently occurring between the depths of 0.3 m and 30 m. The banded murex prefers both soft and hard habitats such as sandy, muddy, rocky, and sandy-muddy substrates (Macedo et al., 1999; Muzavor and Morenito, 1999; Houart, 2001). These species are used as baits for small-scale and recreational fisheries (particularly for fishing of Sparidae species, i.e., *Sparus aurata, Diplodus vulgaris, Diplodus sargus, Pagellus erythrinus, Pagellus bogaraveo*, *Pagellus acarne*). Hence, they have an important economic value in commercial fish feed market. Morphometric relationships should be determined to contribute significant information for fisheries biology, population dynamics and fisheries management. Several researchers studied morphometric relationships and relative growth of *H. trunculus* and *B. brandaris* (Trigui El Menif et al., 2006; Lahbib et al., 2009, 2010; Abidli et al., 2012; Mutlu, 2013; Vasconcelos et al., 2012; 2016), reproductive cycle (Vasconcelos et al., 2008a; 2008b; 2008c; 2009; Gharsallah et al., 2010; Elhasni et al., 2010; 2013; Lahbib et al., 2011), embryonic development (Güler and Lök, 2014) and foraging behaviours of juvenile Muricid species (Güler and Lök, 2019) in the Mediterranean coasts. The aim of this paper is to develop new alternative fishing gears for trap fisheries and to investigate alternative materials to be used as traps for the whelk fishing. In addition, the length-weight relationship findings for collected individuals from these traps will also be provided.

Material and Methods

Materials

Seven fishing gears to be used for trap fisheries produced from plastic materials were experimented to recommend as alternative fishing gears for small-scale and recreational fisheries. The entrance hole of designed plastic fishing gears was constructed by net rigging. In addition, groundropes were attached to the underside of fishing gears in order to sink of fishing gears because they were floating plastic materials and had a lower specific gravity according to the sea water. The characteristics of these alternative fishing gears were given in Table 1.

Study Area

Modified fishing gears were investigated in the coasts of Urla in İzmir Bay. Experimental studies were carried out in two locations and repeated three times (Figure 1). The sediment of studied locations was directly observed by SCUBA divers and described as gravelly, gravelly loam, sandy, and muddy in addition to seagrass meadows (*Posidonia oceanica*).

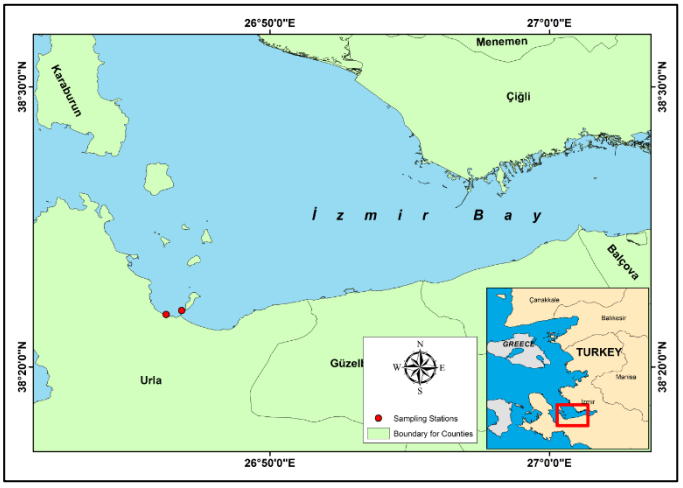

Figure 1. Sampling locations in the coast of Urla, İzmir Bay

Methods

Modified fishing gears at different shapes, sizes, and colours were deployed at the sea bottom between 3-8 m water depths. All fishing gears were attached to a rope with each other such as a longline. The soaking times of fishing gears were 24 hours. Splintered fresh sardine (*Sardina pilchardus*) individuals placed in a feedbag (produced by a net) were used as bait in order to attract the Muricidae species. Feedbag positioned in the centre of the fishing gears.

The morphometric measurements of the caught species were carried out by digital calliper and precision scales. Shell length (SL) and total weight of individuals were measured. Catch per unit effort (CPUE) were calculated by using equation 1 given below:

$$CPUE = \frac{N}{T \times S} \quad (1)$$

In this equation, N is the number of total caught individuals, T is the number of traps, and S is the soaking time of traps.

Table 1. Characteristics of alternative fishing gears for trap fisheries

Fishing Gears	Base Diameter (cm)	Entry Diameter (cm)	Height (cm)	Shape	Colour
#1	40	10	15	Circle	White
#2	45	10	35	Circle, Perforated	Pink
#3	40	10	35	Circle	Yellow
#4	40	10	25	Circle	Red
#5	40	10	20	Circle	Magenta
#6	40	10	40	Circle	White
#7	40	10	15	Square	Transparent

Results

Seven alternative fishing gears to be used in trap fisheries of Muricidae species were developed and the usability of these models was investigated. A total of 313 Muricid species were collected during the experiment. The total catch amount of each model was presented in Table 2. However, the only individuals that introduced into these fishing gears have been considered to calculate the amount of the total catch. The individuals that climbed to gears have not been taken into account to compute the number of the total catch. The most yielded model was found as model #2. This model had a pink coloured material and the highest size. The base diameter and the height of model #2 are bigger than other ones. The least individuals were collected from model #6. The model #6 is the second biggest model regarding base diameter and height. Although it was the second largest model, it was the least abundant model. Unexpectedly, the abundance varied between models even though the sizes were approximately equal.

Table 2. Total catch amount of each model

Fishing Gears	Catch Amount
#1	66
#2	71
#3	39
#4	45
#5	26
#6	14
#7	52

Moreover, length-weight relationships (LWRs) of Muricid species were computed for each model. LWRs for each model were presented in Figure 2.

Discussion

Modern fisheries management is intensely influenced by the ecosystem theory nevertheless concentrated principally on fishing activities and target fish resources (Garcia et al., 2003) due to fishing activities usually target one or several species, known to provide food for consumers and livelihood to the fisheries communities (FAO, 2003). Overexploitation of fish stocks, changes in ecosystems, and global skirmishes on fisheries management and trade of fishes still intimidate the long term sustainability of fisheries and the role of fisheries in supplying food (FAO, 2012). Ecosystem approach to fisheries management signifies the mere opportunity for fisheries to become sustainable and responsible (Garcia and Cochrane, 2005). Muricid species have already been caught by several fishing gears such as shrimp trawl (Elhasni et al., 2017), wallet-line (Vasconcelos et al., 2008d), collecting by divers (Güler and Lök, 2019), fishing nets (Abidli et al., 2012). Several and unstandardized fishing gears that used in whelk fishing and trap fisheries may cause significant damages on the marine habitat and ecosystem. Furthermore, fisheries required to be managed in an ecosystem context since fisheries play a significant role in the ecosystem besides human activities.

The limitation of the present study may be the unavailability of physicochemical characteristics of the study area. Environmental factors have possible impacts on the physiology of animals and trap fisheries. Similarly, Yee and Murray (2004) indicated that the temperature of water could affect the physiology of ectothermic animals containing gastropods. Güler and Lök (2019) stated that higher water temperature could impact the consumption rates of Muricid species. These species could feed a wide size range of mussels (Güler and Lök, 2016; 2019). However, the present study was carried out at the same time by using all fishing models, and then replicated two times again. Therefore, environmental conditions were maintained during the study period. Hence, environmental factors (water temperature, depth, current) are not considered in the calculations since the study assumes that all the fishing gears equally have been affected by environmental conditions. In addition, the baits were equally distributed in each model (50 g per model).

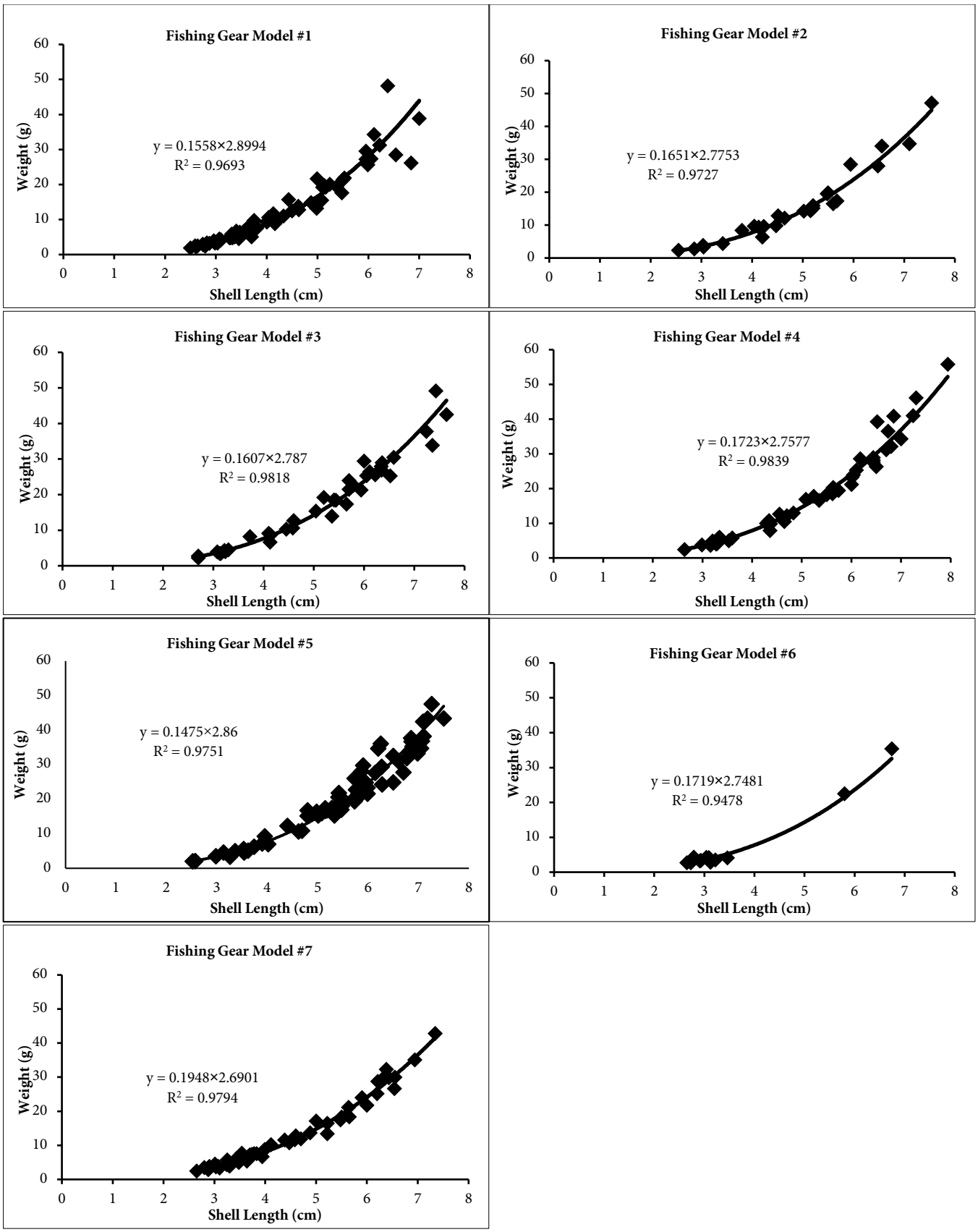

Figure 2. LWRs of Muricid species collected from fishing gear models

The differences in colour were not found to have a significant effect on catch efficiency. When the catch efficiencies of the two white models were compared, more individuals were collected in the shorter model than the higher model. Therefore, it can be said that Muricid species prefer shorter models rather than climbing high. On the other hand, although the height of the pink model is higher than the other models, the odour of the baits is spread over a larger area due to the perforated sides. Therefore, although it is perforated and the height of the model is high, the smell of the baits attracted the animals. As a matter of fact, most individuals are also observed in this model.

Conclusion

In conclusion, it was determined that the height and catch efficiency are inversely correlated. The higher model was favoured by less individuals. This study reveals effective fishing gears for trap fisheries that could be applied to compare different materials and models. Muricid species preferred the model that shorter and having perforated sides. Therefore, in future studies, it is considered that the catch efficiency will be higher if the height is low and the models have perforated sides are used. In the following researches, it is suggested to investigate the effect of feed amount on catch efficiency by using models developed with the present study.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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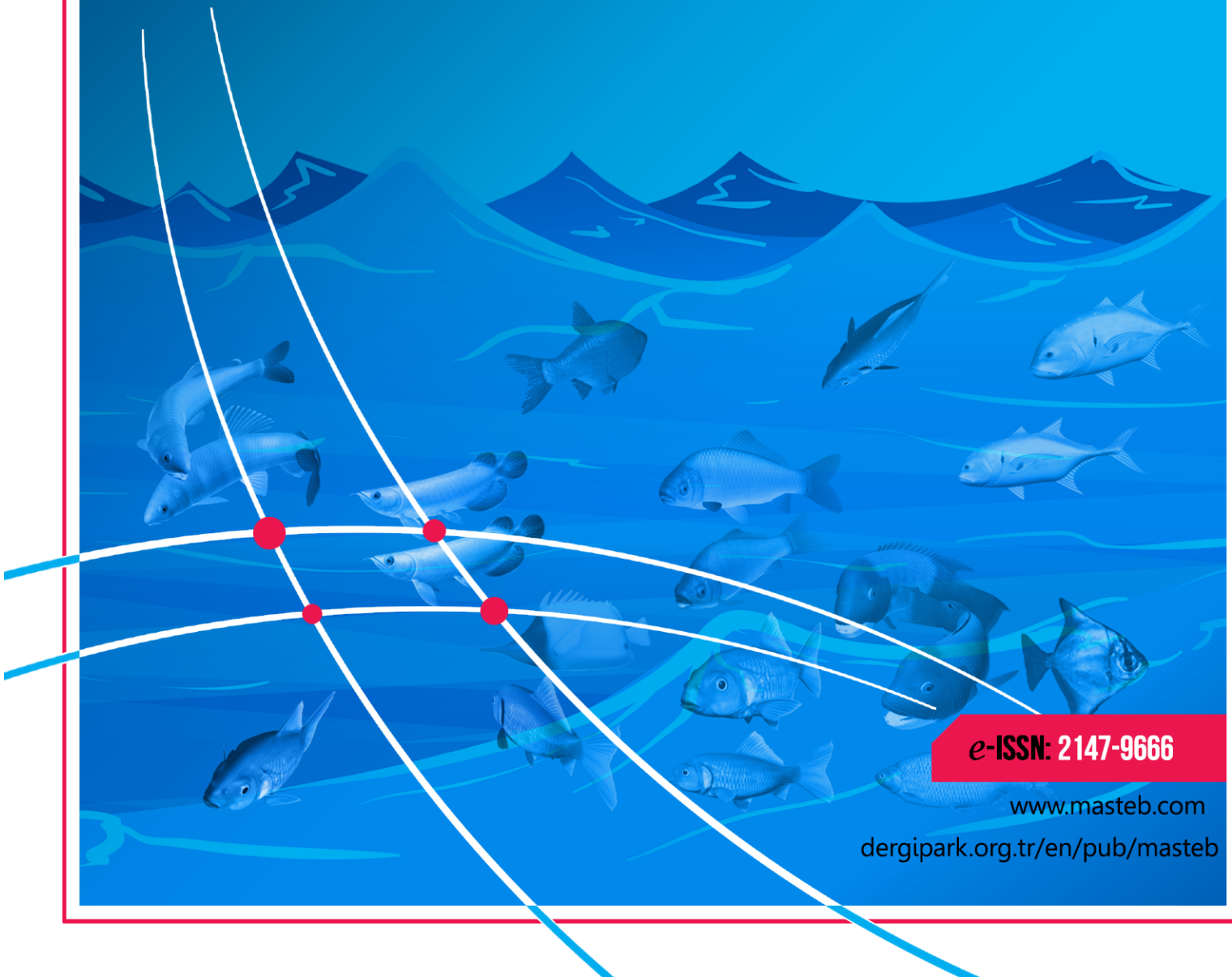

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