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Trends of white grouper landings in the Northeastern Mediterranean: reliability and potential use for monitoring

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Abstract

As a consequence of national fishery statistics showing a sharp decline in the landings of white groupers (WG) – *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817) – after 2010, the decision to ban any further fishing of the species was taken by the Turkish management authority in 2016. Stakeholders have since strongly objected to this decision claiming that the trends of landing statistics are unreliable. Here, this assertion is questioned using multiple sources of data comprising the catch per unit effort (CPUE) from the fishery independent bottom trawl survey (2004-2018), officially reported landing statistics (2002-2017) and the microdata set of landings (2012-2016) gathered by the Turkish Statistical Institute (TUIK). Based on the results of this study, there were clear correlations among the datasets. Landing records and the CPUE time series revealed unimodal non-linear patterns over time (p<0.001). Landings increased until 2010 and decreased thereafter, whereas CPUE values started to decrease after 2009. In the segmented time series, there were no statistically significant differences between the direction and magnitude of slopes calculated from landings and fishery independent data. Cross-correlations between landings and CPUE were statistically significant with one and two-year time lags. This was because the earlier age groups were sampled with coastal bottom trawl operations. Combined with further efforts, these findings may help to develop a monitoring program for the status of white grouper populations in the northeastern Mediterranean and contribute to a better management strategy.

Keywords: *Epinephelus aeneus*; False cod; Levant Basin; fishery statistics; fishery management.

Introduction

The white grouper (WG), *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817), is one of the most commercially valuable fish for coastal fisheries all along its distribution range from the eastern Atlantic to the southern and eastern Mediterranean (Heemstra & Randall, 1993). In addition, the WG is a predator species with considerable ecological importance to the structure and functioning of the coastal ecosystems (Sadovy de Mitcheson et al., 2013). According to records of the International Union for Conservation of Nature (IUCN), its conservation status is “Near Threatened” (Pollard et al., 2018) meaning that it may be allocated to one of the threatened categories in the near future (IUCN, 2012).

White groupers inhabit the Mediterranean and Aegean coasts of Turkey (Bilecenoglu et al., 2014); however, the major part of their catch is recorded as coming from the Mediterranean (TUIK, 2019). By virtue of having extensive soft bottoms (Avsar, 1999), Iskenderun Bay is the main fishery ground (Mavruk et al., 2018) providing an appropriate habitat for WG populations (Heemstra & Randall, 1993).

In spite of its huge economic importance for the local community (Ünal et al., 2009), a scientific baseline has not yet been established to regulate WG fishery. Our current knowledge about its inter-annual variability is only based on the fishery landing statistics that have been collected since 2002. After 2010, these records revealed a sharp decline in the amounts of WG catches around the Mediterranean coasts of Turkey (TUIK, 2019). Based on this information, WG fishing was completely banned in 2016 (Official Gazette, 2016), causing strong protests from the fishers’ community (Mavruk et al., 2018). The main assertion of this opposition was that “the fishery landing records do not reliably represent the total catch or the population status of WGs”. This assertion seems plausible scientifically, as recent studies have clearly revealed that a significant amount of the total landings are not recorded in the landing statistics (Pauly et al., 2014; Pauly & Zeller, 2016). Thus, these records underestimate actual catch amounts around the world as well as in Turkey. According to Ulman et al. (2013), 37% of total landings are not recorded in the fishery statistics of Turkey, and unreported amounts are particularly apparent in artisanal fishery, which puts the highest pressure on the grouper populations (Mavruk et al., 2018).

Nonetheless, fishery management authorities are
aware of this bias and assume that it is constant throughout time (Sullivan, 2003), thereby suggesting that fishery statistics provide reliable indications of both regional and local trends in populations (Garibaldi, 2012). Based on this assumption, catch-based stock assessment (CBSA) methods are developed (Froese & Kesner-Reyes, 2002) and employed (Pauly, 2007; Zeller et al., 2009; Tsikliras et al., 2013).

CBSA methods obviously require reliable estimates of catch trends rather than the actual catch amounts. The aforementioned controversy between the fishery community and the management authority; therefore, turns into the simple and testable question: “do official landing records reliably represent the trend of abundance in WG populations?” In order to find an answer to this question, we compared the trends of WGs from two fishery dependent and one fishery independent sources of data. The fishery dependent datasets included: (1) the officially reported national fishery landing statistics and (2) its microdata set gathered by the Turkish Statistical Institute (TUIK). The fishery independent data was (3) the catch per unit effort (CPUE) values of WGs that were provided from a scientific bottom trawl survey seasonally performed between 2004 and 2018 in the northeastern Mediterranean. Additionally, the use of coastal bottom trawl operations for the monitoring of WG populations was investigated.

Material and Methods

Description of Fishery Landing Data

Fishery landing data is gathered by the Turkish Statistical Institute (TUIK) by way of conducting face-to-face structured interviews with a representative sample of small-scale fishers (boat size < 10m) and all of the large-scale fishers (boat size > 10m) in each fishery port all over Turkey. The raw data is called microdata, which is not accessible. TUIK makes the data publicly available via the Biruni database (TUIK, 2019) after it is aggregated by years and by the main fishery areas (Mediterranean, Aegean Sea, the Marmara Sea and Black Sea) (TUIK, 2019). These records are also shared with the United Nations Food and Agriculture Organization (FAO) with some taxonomic deformities, which are explained in detail by Avsar et al. (2016). TUIK recorded white grouper (TUIK code: 741-Lahoz) landings after 2002 as a separate species (Avsar et al., 2016). Its total annual landing data (tonnes/year) spanning from 2002 to 2016 from the Mediterranean coasts of Turkey (TUIK code: TR6, Fig. 1) were accessed using the publicly available Biruni database (TUIK, 2019).

The microdata set of national fishery statistics recorded from 2012 to 2016 were accessed at the Data Research Center in the Regional Office of TUIK in Adana, with a bilateral protocol declaring that “all responsibility arising from the analyzing and interpreting of the data belongs to the author of the study”. In accordance with data confidentiality requirements, all personal details of informants were deleted by TUIK before being accessed. In the microdata set, species level information on the total landings (kg) of fishing vessels were recorded seasonally (April, July, October and December) between summer 2004 and autumn 2018 at two transects located at 10 and 20 m depth contours in Iskenderun Bay in the northeastern Mediterranean (Fig. 1). Within the context of 56 fieldworks, a total of 112 operations were performed in the morning over a one-hour period at an average speed of 2.5 knots. The vessel length was 19.2 m and was powered by a 422 hp engine. A Mediterranean type bottom trawl net with a 10 m head rope and a mesh size of 44 mm was used in these operations.
Statistical analyses

Because the landing (tonnes/year) and CPUE (gr/hour) time series were in different units, both were standardized in order for comparable measures to be obtained (Sokal & Rohlf, 2012). The standard Z scores were calculated using the following formula:

\[ Z = \frac{x - \bar{x}}{sd} \]  

Here, \( x \) denotes the original value, \( \bar{x} \) and \( sd \) denote the overall average and standard deviation of CPUE or landing data (Table 1).

General linear mixed models (lmm) and additive mixed models (gams) were fitted to analyze linear and non-linear trends in the Z scores (Wood, 2006). Before the models were fitted, data exploration procedures were applied by using the protocol suggested by Zuur et al. (2010) to avoid common statistical problems. Then, the lmm's were fitted using the restricted maximum likelihood estimation with Gaussian distribution, identity link function and autoregressive error structures. Based on likelihood ratio tests, autocorrelated error structures did not improve the models. Thus, the final model was refitted using the ordinary least square approximation. The effect of seasons and depth contours were investigated for CPUE data. Both variables were not found to be significant and dropped from the models based on Akaike Information Criteria (AIC). Model validation was then performed by checking the residuals against normality, homoscedasticity, autocorrelation and independence from the dropped variables (Zuur et al., 2009). The final equation for the lmm was as follows:

\[ Z_i = \alpha + \beta_1 Y_i + \alpha_2 D + \beta_2 D Y_i + \epsilon_i \ldots \]  

Here, \( Y \) refers to the \( i \)th year. \( D \) is a dummy variable which is zero for CPUE and one for landings. The terms \( \alpha \) and \( \beta \) are the intercept and slope for the CPUE, respectively. The terms \( \alpha \) and \( \beta \) are the differences for intercept and slope for landings, respectively. The term \( \epsilon \) indicates normally distributed residuals with zero mean and \( \sigma^2 \) variance. The final equation for the gam was as follows:

\[ Z_i = \alpha + cr(Y_i) + \epsilon_i \ldots \]  

Where \( \alpha \) is the intercept and \( cr(Y) \) is the cubic regression spline function. The linear and additive models were fitted using R libraries nlm and mgcv (Wood, 2001; Pinheiro et al., 2015).

The non-linear trend of standardized catch per unit effort values (\( Z_{\text{CPUE}} \)) was then predicted from equation 3. The parallelism between fluctuations of non-linear trends of standardized landing (\( Z_L \)) and CPUE (\( Z_{\text{CPUE}} \)) time series were evaluated by using cross-correlation coefficients (Zuur et al., 2007) with time lags of up to five years. Based on cross-correlation analyses, the one-year lag values of the standard scores for CPUE (\( Z_{\text{CPUE}_{t-1}} \)) were used in segmented linear models (slm).

To determine the segments, a hierarchical clustering algorithm-based change point detection analysis was employed using R library cpc (James & Matteson, 2014). This analysis revealed that the directions of the common trend of both time series changed in 2010. Then, by way of adding a dummy variable (S) to the models’ design matrix, both time series were divided into two tangential periods, which were from 2004 to 2010 (S=0) and from 2010 to 2016 (S=1). Then the segmented linear model (Taljaard et al., 2014) was fitted using the same modeling and validation procedures with equations 2 and 3 (Zuur et al., 2009). The final equation for the segmented linear model was as follows:

\[ Z_i = \alpha + \alpha_2 S + \alpha_3 D + \alpha_4 D S + \beta_1 Y_i + \beta_2 S Y_i + \beta_3 D Y_i + \beta_4 S D Y_i + \epsilon_i \ldots \]  

Here, \( j = i \) for \( D=1 \) and \( j=i-1 \) for \( D=0 \). \( \alpha \) and \( \beta \) are the intercept and slope of the regression line for CPUE values in the first segment (2004 to 2010), \( \epsilon_{2,3,4} \) and \( \beta_{2,3,4} \) are regression parameters for the differences of intercept and slope for the second segment (2010 to 2016) and landing data, respectively.

Table 1. Overall mean \( \bar{x} \), standard deviation (sd), number of observations (n), 0.95 confidence intervals (0.95 ci), minimum and maximum values of white grouper (Epinephelus aeneus) landings, catch per unit effort (CPUE) and area (CPUA) in weight (W) and in numbers of individuals (N).

|            | Landings (t) | CPUE-W (kg/h) | CPUE-N (ind/h) | CPUA-W (kg/km²) | CPUA-N (ind/km²) |
|------------|---------------|---------------|-----------------|-----------------|-----------------|
| \( \bar{x} \) | 262.39        | 2.66          | 8.00            | 93.53           | 281.03          |
| sd         | 127.41        | 4.51          | 11.42           | 158.50          | 401.27          |
| n          | 15            | 112           | 112             | 112             | 112             |
| 0.95 ci    | 70.56         | 0.84          | 2.12            | 29.35           | 74.32           |
| min        | 119.50        | 0.00          | 0.00            | 0.00            | 0.00            |
| max        | 583.00        | 23.57         | 55.00           | 827.98          | 1932.06         |
Results

Between 2002 and 2016, officially reported landings ranged from 119.5 (2015) to 583 (2010) tonnes/year with an overall average of 262±70.56 (±0.95 confidence intervals-ci) tonnes/year (Fig. 2 a). Based on the microdata set, 94±4% (± standard deviation) of the catch was reported from the cities around the Iskenderun and Mersin Bay. Longline fishing was the primary source of fishery pressure. The inter-annual changes of spatially fractioned data were consistent among cities (Fig. 3).

In the bottom trawl survey conducted between 2004 and 2018, WGs were caught in 80 out of 112 tows (71%). Seasonal ($\chi^2 = 3.70$, df = 3, p = 0.30) and depth-related ($\chi^2 = 0$, df = 1, p = 1) variations in frequency of occurrence were not significant. A total of 896 WG individuals were sampled during the survey. Overall average CPUE values were found to be 8.00±2.12 (±0.95 ci) individuals per hour and 2.66±0.84 kg per hour, and CPUA values were found to be 281.03±74.32 individuals per km$^2$ and 93.53±29.35 kg per km$^2$ (Table 1). In 2009 and 2010, CPUE values reached 6.20±2.52 kg/h (Fig 2 b). In the bottom trawl survey, the overall mean and median of the total length of individuals caught were 27.84±2.85 (±0.95 ci) cm and 24.58 cm (23.7 to 30.6; 95% confidence intervals based on the Wilcoxon test), respectively.

Seasonal- and depth-related variations of CPUE were not significant, and both variables were dropped from the linear and additive models. Based on the gam results,
non-linear trends of both CPUE and landings were significant (Table 2; p<0.001). Moreover, non-linear trends of $Z_{\text{CPUE}}$ and $Z_t$ showed significant correlation with each other for one- and two-year lags (Fig. 2 c). The highest cross-correlation between two-time series was observed with a one-year lag ($r = 0.77$, p<0.01) indicating that the landings were strongly correlated with the CPUE of the previous year.

Ordinary linear regressions fitted to the unsegmented time series revealed that the monotonic decrement was statistically significant for the CPUE (p<0.05; −0.36 ± 0.28 kg/hour per year; ±0.95 ci), whereas no significant change was detected in landings (Table 3). Based on segmented linear models (slms), CPUE increased 1.52 ± 0.81 kg/hour per year from 2004 to 2010 (p<0.001). It then decreased by 0.86 ± 0.47 kg/hour per year (p<0.001). Total landings of WGs also revealed the same pattern. Annual landings increased by 62.71 ± 45.57 tonnes per year from 2004 to 2010 (p<0.01) and decreased at the same rate afterwards (p<0.01). Slopes of regression lines of CPUE and landing time series were not significantly different from each other in the segmented linear models (Fig. 2 d).

Discussion

Reliable knowledge on the temporal changes in fish populations is important in order to advance successful conservation and management strategies. However, fishery independent estimations of trends are only available in a few areas and stocks in the eastern Mediterranean (Gucu et al., 2010; Gucu & Bingel, 2011; Mavruk et al., 2017). Landing statistics are therefore the only source of information on decision making – as throughout the world (Pauly et al., 2013). On the other hand, it is well documented that landing statistics underestimate the actual landings particularly in grouper fishery because of the excessive illegal, unreported or under-reported catches (Sadovy de Mitcheson et al., 2013; Ulman et al., 2013; Pauly et al., 2014). Nevertheless, this data can be utilized in stock assessment procedures, if the mentioned bias is stable throughout the years. Based on the results of this study, fluctuations of fishery landing records were in accordance with the fishery independent data. These two datasets were collected using different approaches and provided different kinds of information on the fish populations (Pennino et al., 2016). Fishery independent data used in this study was collected for the purpose of monitoring the abundance of the coastal fish populations (Mavruk et al., 2017), whereas the fishery dependent data (landing records) was collected to document the total catch amounts of commercial fish species (TUİK, 2019). Therefore, the parallelism between the two datasets is considered as a strong indication that the trend of landings reliably represents the trend of the white grouper population in the eastern Mediterranean coasts of Turkey. In accordance with this, there are other instances showing that the trends calculated from grouper landing statistics are validated by fishery independent data sources in the west African coasts (Thiao et al., 2012; Ndiaye et al., 2013).

This inference can be criticized in some respects. First of all, the catch is not just dependent on the status of the population but is also influenced by fishery related factors such as changes in effort and fishing behavior (Carruthers et al., 2012; Pauly et al., 2013). But, between 2002 and 2016, no apparent change occurred in the fishery fleet size operating throughout the Mediterranean coasts of Turkey (TUİK, 2019). Another concern about the reliability of making comparisons between two different data sources is that the spatial extents of landing (all along the Mediterranean coasts of Turkey) and fishery independent data-sets (for the northwestern coasts of Iskenderun Bay) are quite different. Nonetheless, it is clear from the analysis of the microdata set that the largest fraction of landings was recorded from the ports around Iskenderun Bay, from which the fishery independent data was collected. As the assessment of Mavruk et al. (2018) revealed, this area is the major fishing ground for WGs along the Mediterranean coasts of Turkey.

The microdata set revealed that the trends of landings were consistent among cities along the Mediterranean coasts of Turkey. This can be considered as an indication that fluctuations in the grouper catches reflect large-scale variations in grouper populations because fishery related factors, such as gear types, are not different among cities (Demir, 2018). It is also important to note the decrease in grouper populations (from fishery independent data) and catches started in 2009 and 2010. In 2009, the annual average sea surface temperature (sst) was 0.7°C higher than the decade average in Iskenderun Bay (Mavruk et al., 2017). Moreover, for the eastern Mediterranean, the

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Table 3. Details of linear regressions for overall and segmented time series of standard scores for catch per unit effort ($Z_{\text{CPUE} \pm 1}$) and landing data ($Z_{\text{L}}$).

| Parameters | Overall | Segmented |
|------------|---------|-----------|
| $a_1$      | 0.739±0.487** | -1.125±0.902* |
| $a_2$      | -0.127±1.358** | 3.096±1.430*** |
| $a_3$      | -0.079±0.061* | 0.337±0.179*** |
| $a_4$      | -3.331±4.231** |
| $\beta_1$  | 0.025±0.172** | -0.528±0.207** |
| $\beta_2$  | -1.125±0.902* | 0.155±0.400** |
| $\beta_3$  | -3.331±4.231** |
| $\beta_4$  | -0.457±0.546* |

Adj. R$^2$: 0.03 0.267
AIC: 368.67 339.25
RSE: 1.097 0.955
df = 116 112

Significance codes: ns: not significant, * p<0.05, ** p<0.01, *** p<0.001. ± values show 0.95 confidence intervals of parameters. AIC: Akaike information criteria, RSE: residual standard error, df: degrees of freedom of the model. $\alpha_{1,2,3,4}$ and $\beta_{1,2,3,4}$ denotes the regression coefficients of Equation 2 for overall model and Equation 4 for segmented model.
highest maximum SST value for the last 30 years was recorded in August of 2010 (Bengil & Mavruk, 2019). In the following years, these climatic anomalies resulted in drastic changes to the fish communities of Iskenderun Bay in favor of invasive species (Mavruk et al., 2017). In this regard, climate-related changes in the abiotic and/or biotic environment could have been major drivers of the observed fluctuations in the grouper populations. Further studies will inevitably be required in order to fully establish these connections.

Despite the potential errors in the magnitude and/or trends of grouper landing records, such as under-reported catch amounts (Pauly & Zeller, 2016) or presentist bias (Zeller & Pauly, 2018), the decline in WG landings apparently reflects the actual situation in the grouper populations of the northeastern Mediterranean. Therefore, from a statistical perspective, the official landing data for WG fishing can be considered as accurate for policymaking. However, this does not mean it provides enough information on policymaking from conservation and managerial perspectives. Catch-only stock assessment methods can give overprotective and misleading results (Carruthers et al., 2012), particularly with short time series. The WG fishery ban in Turkey provides a good example of this. Based on the decrease in landing records, WG fishery was completely banned in 2016 (Official Gazette, 2016), and this measure was widely rejected by the fishers’ community. Moreover, the regulation caused additional concerns about the other grouper species (Mavruk et al., 2018), some of which are classed under data deficient or endangered categories in respect of their conservation status (IUCN, 2017). The ban was finally revoked in October 2018. In the new statute, the minimum landing size was declared to be 50 cm in total length, and WG fishing is seasonally closed from the 1st of June to the 31st of August (Official Gazette, 2018). Despite the frequent changes in legislations, the scientific baseline to manage WG populations is still lacking, and a better data collection and monitoring strategy is required.

Based on the results of this study, a monitoring program can be developed in Iskenderun Bay using scientific bottom trawl operations in the shallow coastal zone. In the fishery independent data, the abundance of WGs over the previous two years was strongly correlated with the total landings. However, this data was collected using bottom trawl operations, whereas the primary source of fishing pressure on WGs was from longline fishing instead (Mavruk et al., 2018). In accordance with this, the majority of total landings were reported by longliners as a result of analysis of TUIKs’ microdata set. Actually, these two types of fishing catch different length/age classes. Mavruk et al. (2018) report that the median length of WGs caught by trawlers is 32 cm. This value was close to that of the present study, which was from 23.7 to 30.6 cm (95% CI). On the other hand, the median length caught by longliners was reported to be 50 cm (Mavruk et al., 2018), which is considerably larger than those of bottom trawlers. Using von Bertalanffy growth parameters given by Turan et al. (2017) for Iskenderun Bay, WGs caught by bottom trawlers are around three years old, whereas longliners mainly catch five-year old fish. This may explain why the highest correlation coefficients were found using one and two-year time lags between the bottom trawl survey and landing records. One implication of this could be that the status of WG cohorts can be monitored by using bottom trawl surveys one or two years before the pressure of longline fishing impacts the WGs.

The northwestern coast of Iskenderun Bay is a shallow area with prevailing soft bottoms (Avşar, 1999) that provide a proper habitat for juvenile WGs (Özbek et al., 2013). In comparison with the adjacent areas, WG biomass was found to be at least twofold higher than the 0 to 30 m depth contours of Mersin Bay (Gucu & Bingel, 1994; Salihoglu & Mutlu, 2000) and Antalya Bay (Özbek et al., 2013). In this study, the overall average WG biomass was 2.66 kg/h at 10 and 20 m depth contours, whereas Gucu & Bingel (1994) reported 1.19 kg/h at 7 to 17 m depth contours in Mersin Bay. In the same area, Salihoglu & Mutlu (2000) reported that the WG biomass ranged from 0.32 to 1.2 kg/h at 0 to 25 m depth contours. Moreover, both studies (Gucu & Bingel, 1994; Salihoglu & Mutlu, 2000) reported higher biomass values from Iskenderun Bay. Özbek et al. (2013) found that the white grouper biomass was 3.09 kg/h at the 25 m depth contour in Antalya Bay. Although this value is higher than the overall average of the present study, the study by Özbek et al. (2013) was performed between 2009 and 2010 when the average white grouper biomass was 6.20 kg/h in Iskenderun Bay.

In conclusion, the northwestern coast of Iskenderun Bay appears to be a good candidate for a regular monitoring program on juvenile WGs, with the resulting data possibly providing a useful precautionary management tool for WG fishery. Data currently available does not provide enough information to accomplish this objective, because it does not cover the necessary parameters on the biology of white groupers. Further efforts should therefore be focused on points such as inter-annual changes of age classes, maturity stages and reproduction parameters.

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References

Avsar, D., 1999. Yeni Bir Skifomedüz (Rhopilema nomadicum)‘ün Dağılımı ile İlgili Olarak Doğu Akdeniz’in Fizi-Kimyasal Özellikleri. Turkish Journal of Zoology, 23 (2), 605-16.

Avsar, D., Mavruk, S., Saygu, İ., Ozgur Ozbek, E., 2016. An evaluation of the fishery landings statistics of the Mediterranean coast of Turkey: statistics of which species? p. 275-304. In: The Turkish Part of the Mediterranean Sea. Marine Biodiversity, Fisheries, Conservation and Governance. Turan, C., Salihoglu, B., Ozbek Ozgur, E., Ozturk, B. (Eds). Turkish Marine Research Foundation. Istanbul.

Bengil, F., Mavruk, S., 2019. Warming in Turkish seas: comparative multidecadal assessment. Turkish Journal of Fisheries and Aquatic Sciences, 19 (1), 51-57.

Bilecenoglu, M., Kaya, M., Cihangir, B., Cicek, E., 2014. An updated checklist of the marine fishes of Turkey. Turkish Journal of Zoology, 38, 901-929.

Brandt, A., 1969. Die Fischerei der Maltesischen Inseln. Protokolle zur Fischereitechnik, 10, 166-212.

Carruthers, T.R., Walters, C.J., McAllister, M.K., 2012. Evaluating methods that classify fisheries stock status using only fisheries catch data. Fisheries Research, 119-120, 66-79.

Demir, Ö., 2018. Researches on artisanal longline fishery and release of the unwanted catch in the Northeast Mediterranean. PhD Thesis. Mersin University. 107 pp.

Froese, R., Kesner-Reyes, K., 2002. Impact of fishing on the abundance of marine species. Journal of Marine Science, 12, 1-12.

Garibaldi, L., 2012. The FAO global capture production database: A six-decade effort to catch the trend. Marine Policy, 36 (3), 760-768.

Gucu, A.C., Bingel, F., 1994. Trawllable species assemblages on the continental shelf of the Northeastern Levant Sea (Mediterranean) with an emphasis on Lessepsian migration. Acta Adriatica, 35 (1-2), 83-100.

Gucu, A.C., Bingel, F., 2011. Hake, Merluccius merluccius L., in the northeastern Mediterranean Sea: a case of disappearance. Journal of Applied Ichthyology, 27 (4), 1001-1012.

Gucu, A.C., Ok, M., Sakinan, S., 2010. Past and present of fish fauna in the NE Levant Sea and factor facilitating the colonization by lessepsian fishery. p. 88-108. In: Report of the Technical Meeting on the Lessepsian Migration and Its Impact on Eastern Mediterranean Fishery. EastMed Technical Documents 4. FAO Rome.

Heemstra, P., Randall, J., 1993. FAO Species Catalogue: Groupers of the World (Family Serranidae, Subfamily Epinephelinae). FAO Fisheries Synopsis, 16 (125), 1-10.

IUCN., 2012. IUCN Red List Categories and Criteria. Version 3.1. Switzerland and Cambridge: IUCN Gland. 2nd ed.

IUCN., 2017. The IUCN Red List of Threatened Species. Version 2017-3. <www.iucnredlist.org>.

James, N.A., Mattes, D.S., 2014. ecp: An R Package for Nonparametric Multiple Change Point Analysis of Multivariate Data. Journal of Statistical Software, 62 (7), 1-25.

Mavruk, S., Bengil, F., Yeldan, H., Manasirli, M., Avsar, D., 2017. The trend of lessepsian fish populations with an emphasis on temperature variations in Iskenderun Bay, the Northeastern Mediterranean. Fisheries Oceanography, 26 (5), 542-554.

Mavruk, S., Saygu, İ., Bengil, F., Alan, V., Azzurro, E., 2018. Grouper fishery in the Northeastern Mediterranean: an assessment based on interviews on resource users. Marine Policy, 87, 141-148.

Ndiaye, W., Thiaw, M., Diouf, K., Ndiaye, P., Thiaw, O. et al., 2013. Changes in population structure of the white grouper Epinephelus aeneus as a result of long-term overexploitation in Senegalese waters. African Journal of Marine Science, 35 (4), 465-472.

Official Gazette, 2016. Commercial Fishery Regulation Rescripts of Republic of Turkey (No: 2016/35). Official Gazette of the Republic of Turkey.

Official Gazette, 2018. Rescript (No: 2018/19) of Changes in the Commercial Fishery Regulation Rescripts (No:2016/35) of Republic of Turkey. Official Gazette of the Republic of Turkey.

Özbek, E.O., Kebaçtu, Ç., Çardak, M., 2013. Spatio-temporal patterns of abundance, biomass and length-weight relationship of white grouper, Epinephelus aeneus (Geoffroy Saint-Hilaire, 1817) (Pisces: Serranidae) in the Gulf of Antalya, Turkey (Levantine Sea). Journal of Blacksea and Mediterranean Environment, 19 (1), 23-45.

Pauly, D., 1980. A Selection of Simple Methods for the Assessment of Tropical Fish Stocks. FAO, Rome. 54 pp.

Pauly, D., 2007. The Sea Around Us Project: documenting and communicating global fisheries impacts on marine ecosystems. Ambio, 34 (4), 290-295.

Pauly, D., Hilborn, R., Branch, T.A., 2013. Does catch reflect abundance. Nature, 494, 3-6.

Pauly, D., Ulman, A., Pirrodi, C., Bultel, E., Coll, M., 2014. ‘Reported’ versus ‘likely’ fisheries catches of four Mediterranean countries. Scientia Marina, 78 (S1), 11-17.

Pauly, D., Zeller, D., 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nature Communications, 7, 1-9.

Pennino, M.G., Conesa, D., López-Quilez, A., Muñoz, F., Fernández, A. et al., 2016. Fishery-dependent and -independent data lead to consistent estimations of essential habitats. ICES Journal of Marine Science, 73 (9), 2302-2310.

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., R Development Core Team, R., 2015. nlme: linear and nonlinear mixed effects models. R package version 3.1-122.

Pollard, D.A., Francour, P., Fennessy, S., 2018. Epinephelus aeneus. The IUCN Red List of Threatened Species 2018: e.T132722A100459597. IUCN Red List. <https://www.iucnredlist.org/species/132722/100459597>.

Sadovy de Mitcheson, Y., Craig, M.T., Bertoneini, A.A., Carpenter, K.E., Cheung, W.W.L. et al., 2013. Fishing groupers towards extinction: A global assessment of threats and extinction risks in a billion dollar fishery. Fish and Fisheries, 14 (2), 119-36.

Salihoglu, I., Mutlu, E., 2000. National marine research and monitoring programme, Mediterranean, Marmara Sea, Turkish Straits System, Black Sea and atmosphere sub-projects. 1995-1999 Period Synthesis Report. Ankara-Turkey. 499 pp.

Sokal, R.R., Rohlf, F.J., 2012. Biometry: The Principles and Practice of Statistics in Biological Research, Vol. 4. W.H. Freeman and Company. New York, NY: 915 pp.
Sparre, P., Venema, C.S., 1998. Introduction to tropical fish stock assessment. Part I: Manual. FAO Technical Papers. No: 306. 407 pp.

Sullivan, M.G., 2003. Exaggeration of Walleye Catches by Alberta Anglers. North American Journal of Fisheries Management, 23 (2), 573-580.

Taljaard, M., McKenzie, J.E., Ramsay, C.R., Grimshaw, J.M., 2014. The use of segmented regression in analysing interrupted time series studies: An example in pre-hospital ambulance care. Implementation Science, 9 (1), 1-4.

Thiao, D., Chaboud, C., Samba, A., Laloë, F., Cury, P., 2012. Economic dimension of the collapse of the ‘false cod’ Epinephelus aeneus in a context of ineffective management of the small-scale fisheries in Senegal. African Journal of Marine Science, 34 (3), 305-311.

Tsikliras, A.C., Tsirgos, V.Z., Stergiou, K.I., 2013. Assessing the state of Greek marine fisheries resources. Fisheries Management and Ecology, 20 (1), 34-41.

TUIK, 2018. Turkish Statistical Institute, Micro-Data Set for White Grouper Fishery from 2012 to 2016. Ankara-Türkiye.

TUIK, 2019. Fishery Production Statistics of Turkey. Turkish Statistical Institute. www.tuik.gov.tr (Accessed 1 September 2019).

Turán, C., Gürlek, M., Uyan, A., Doğdu, S., 2017. Some Biological Characteristics of the White Grouper. p. 239. 3rd International Symposium on Euro-Asian Biodiversity, 05-08 July 2017, Minsk, Belarus.

Ulman, A., Bekişoğlu, S., Zengin, M., Knudsen, S., Unal, V. et al., 2013. From bonito to anchovy: a reconstruction of Turkey’s marine fisheries catches (1950-2010). Mediterranean Marine Science, 14 (2), 309-342.

Ünal, V., Erdem, M., Göncüoğlu, H., Güçlüsoy, H., Tosunoğlu, Z., 2009. Management paradox of groupers (Epinephelinae) fishing in the Gökova Bay (Eastern Mediterranean), Turkey. Journal of Food, Agriculture and Environment, 7 (3-4), 904-907.

Wood, S.N., 2001. R Package mgcv: GAMs and generalized ridge regression for R.

Wood, S.N., 2006. Generalized additive models: an introduction with R. CRC Press. New York. 476 pp.

Zeller, D., Cheung, W.W.L., Close, C., Pauly, D., 2009. Trends in global marine fisheries - a critical review. Fisheries, Trade and Development. Royal Swedish Academy of Agriculture and Forestry, Stockholm, 55-77.

Zeller, D., Pauly, D., 2018. The ‘presentist bias’ in time-series data: Implications for fisheries science and policy. Marine Policy, 90, 14-19.

Zuur, A.F., Ieno, E.N., Elphick, C.S., 2010. A protocol for data exploration to avoid common statistical problems. Methods in Ecology and Evolution, 1 (1), 3-14.

Zuur, A.F., Ieno, E.N., Smith, G.M., 2007. Analyzing Ecological Data. New York: Springer. 672 pp.

Zuur, A.F., Ieno, E.N., Walker, N., Saveliev, A.A., Smith, G.M., 2009. Mixed Effects Models and Extensions in Ecology with R. Springer New York. 574 pp.