Grouper fishery in the Northeastern Mediterranean: An assessment based on interviews on resource users

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ABSTRACT

Groupers are important components of coastal ecosystems as well as a valuable resource for fisheries. Their populations are known to be decreasing throughout the world primarily due to over-exploitation. However, even the basic data for an effective management strategy is lacking. Interviews of a representative sample of 113 fishers in Turkey in the northeastern Mediterranean were conducted with specific questions regarding fishing gears, periods and areas as well as best day's catch and the sizes of fishes caught. Fishermen recognized *Epinephelus marginatus, E. aeneus, E. costae, Hyporthodus haifensis, Mycteroperca rubra* and *Polyprion americanus* distributed in the area. "Endangered" *E. marginatus* and "Near Threatened" *E. aeneus* were the dominant species of the grouper fishery. Based on best days' catch values and reported lengths of fish caught, the northern coasts of Iskenderun Bay were found to be important for both species. Demersal longliners, spearguns, traps, anglers and demersal trawlers were reported catching groupers in the study area. Artisanal fishermen, especially demersal longliners contributed the most to the grouper fishery. Fishing pressure were subject to seasonal fluctuations, with decreasing reported catches during summer when threatened groupers spawn. Finally, some critical aspects of fishery pressure were related to the removal of juveniles which may lead to reproduction loss.

1. Introduction

The specific knowledge retained by fishermen regarding their resources, environment and fishing practices can provide valuable information to fishery scientists [1]. This knowledge can be extremely useful in order to gather information on behavior [2], diseases [3], population abundance [4], fishing practices [5], spawning grounds [6], nursery- habitats [7] and arguably many other factors that are applicable to the understanding and management of fisheries. In this study, the local knowledge of fishermen was used to acquire information related to the status of grouper populations and to their fishery in the Gulf of Iskenderun and Mersin (northeastern Mediterranean). In the past, participatory approaches have been successfully employed for groupers (Serranidae-Epinephelinae) e.g. [4,9]. However, despite a growing use of Local Ecological Knowledge (LEK) by Mediterranean scientists [10–14], no LEK-related investigations are currently available for Mediterranean groupers.

Groupers are valuable commercial fish [15] that generally inhabit shelf waters with a clear length-related depth distribution in many of their species [16–19]. As well as their economic importance, they have been well documented with regards to their key structural role and functions within the food web in coastal areas [20].

Their life history traits are generally characterized by long life span, slow growth, late maturation and protogynous hermaphroditism; which render these species more susceptible to fishing pressure than gonochoristic fishes [21]. These attributes make the groupers particularly vulnerable to anthropogenic factors, such as habitat loss, pollution, climate change, introduction of alien species, and particularly fisheries, resulting in low resilience to exploitation [22–24]. Therefore, the implementation of effective management and conservation policies are essential for the sustainability of the grouper fisheries.

The Gulfs of Iskenderun and Mersin are both important fishing grounds for groupers [28], because of the wide continental shelf [25,26] and high diversity of habitats [29]. Small scale fishing is dominant in this area [30], and groupers provide an important source of income for the local fishery.

To date, 13 grouper species have been listed as present in the eastern Mediterranean Sea [31,32]. This number includes six native

species (*Epinephelus marginatus*, *E. aeneus*, *E. costae*, *E. caninus*, *Hyporthodus haifensis* and *Mycteroperca rubra*) and seven exotic species (*Cephalopholis taeniops*, *E. areolatus*, *E. coioides*, *E. fasciatus*, *E. geoffroyi*, *E. malabaricus* and *M. fusca*). All native groupers inhabit the Mediterranean coasts of Turkey [33], and *E. coioides* were once reported from the Gulf of Antalya [34].

According to the IUCN's Red List, the conservation status of these groupers varies among species: the dusky grouper, *E. marginatus*, is currently classified as Endangered (EN), whilst the white grouper, *E. aeneus*, is assigned to the Near Threatened (NT) category. The conservation status of other groupers inhabiting the study area are: Least Concern (LC) for *M. rubra*, and Data Deficient (DD) for the other three species (*E. caninus*, *E. costae*, *H. haifensis*) [35]. Additionally, *Polyprion americanus* (DD) is often caught together with groupers [36], and is thus considered in the context of this study even though it belongs to a different taxon: Polyprionidae [37].

Until 2016, the landing size in Turkey was restricted to a minimum 45 cm for *E. aeneus* and *E. marginatus* [38]. Following catch statistics [39] highlighted abrupt declines in populations of *E. aeneus*, policymakers introduced a regulation providing for the permanent prohibition of the catch of these two species until 2020 [40]. This regulation has resulted in much dispute, and major objections have arisen from the fishermen exploiting the study area.

So far, data on Turkish groupers have been mostly gathered through experimental trawl catches [16,41,42], and national fishery statistics [39], which are often hampered by taxonomic uncertainties [43] and underreported catch amounts [44]. Unal et al. investigated the catch records of fishery cooperatives around a special marine protected area in Gökova Bay located in the southern Aegean Sea [9]. However, such data are spatially limited. The improvement of management strategies for effective conservation would ideally require information regarding the status of grouper populations, their spatial distribution, and the characteristics of these fisheries on the large spatial scale.

Here, information on grouper populations and their small-scale fishery in the Gulfs of Iskenderun and Mersin was collected by interviews with local fishermen. Our aims were to: (1) provide a general appraisal on the diversity and abundance of the groupers targeted in the area; (2) document the diversity of fishing practices and their seasonality; and (3) use this information as a complementary tool to develop a general understanding on the status of grouper populations and the effects of both the professional and recreational fisheries.

2. Material and methods

Interviews were carried out by the authors (SM, IS, VA) between October 2016 and February 2017. Prior to the interviews being conducted, the fishermen were given a short introductory explanation about the data gaps and how they could contribute to an effective management strategy. After building upon the trust factor with the fishermen, questions were directed to both professional and recreational fishermen operating in the areas of the Gulf of Iskenderun and Mersin (36.0–37.0°N; 34.5–36.5°E). Interviews with professional fishermen mainly took place during either their land activities or break times across ten major fishery ports within the study area (Table 1, Fig. 2). Recreational fishermen were mostly met at diving clubs and at sports fishing stores. In both cases, the purpose of the interview was explained to the fishermen before the questions were asked. Interviews were based on a structured questionnaire (Appendix A), which consisted of their age, experience, type of fishing activity (professional or recreational), and the type of fishing gear used.

In order to assist with the correct identification of species, pictures of 13 grouper species (including the non-indigenous ones) were shown to the fishermen before they were asked whether they had ever caught any of these fishes. For each of the recognized species, and in relation to the last fishing season, a number of questions were asked: the fishing gears used, the depth and bottom type of the fishing area, the best day's

catch in weight (BDC), and the minimum, maximum and usual sizes of the catch. Fishermen were also asked to define the fishing period for each species caught.

The frequency of occurrence (FO%) and the best days' catch values were used as proxies for the abundance of groupers. FO% was calculated based on the number of reports, using the following equation:

$$FO\%_i = 100*(F_i/N), \tag{1}$$

where F_i is the number of interviews reporting the presence of species i, and N is the total number of interviews.

Differences in the best day's catch and minimum, usual and maximum sizes, were tested among species, fishery ports and fishing gears by using the Kruskal-Wallis test (KW) [45]. A pairwise test was used for multiple comparisons of mean rank sums (Nemenyi Test) by using the R library "PMCMR" [46]. Confidence intervals of medians were calculated by using rank statistics based on the Wilcoxon rank sum test [47]. The frequency of occurrence was analyzed by using Chi-square test [45] after the frequency table was transformed to proportions, since the number of interviews varied among ports. The null hypothesis was that the frequency of each group was proportionally equal. Figures and maps were created by using R library "ggplot2" [48].

3. Results

Overall, a total of 113 interviews were carried out in the study area (Table 1; Fig. 2). Four of the interviews were excluded from the analyses due to insufficient answers being received. The median fishery experience of respondents was 27 years, with an inter-quartile range (iqr) of 17–35 years. Most of the respondents were professional, small-scale fishermen (96; 88%), whilst 10 respondents (9%) were recreational fishermen. According to our results, groupers are targeted with six different gears: longliners (72; 59%), spearguns (18; 15%), anglers (14; 12%), nets (7; 6%), bottom trawls (7; 6%) and traps (3; 2%).

3.1. Distribution of groupers in the study area

Overall, a total of 6 grouper species were unmistakably recognized by Turkish fishermen plus *P. americanus*. The FO% values were found to be significantly different among species ($\chi^2 = 51.43$; df = 6; p < 0.001). Two species, *E. aeneus* and *E. marginatus* were more frequently caught than the other groupers. Regarding levels of abundance, median BDC values were also significantly different amongst the species (KW $\chi^2 = 41.00$; df = 6; p < 0.001) and the highest BDC was reported in *E. aeneus* (31.5 kg). This species was followed by *E. caninus* (12.5 kg), *P. americanus* (12 kg), *E. marginatus* (11 kg) and *H. haifensis* (10 kg) (Fig. 1).

The spatial variations of frequency were not significant in *E. aeneus* (med = 100%), *E. marginatus* (med = 98%) and *E. costae* (med = 85%). Whilst the frequency of *M. rubra* significantly varied among ports ($\chi^2 = 34.44$; df = 9; p < 0.001), the frequency of *H. haifensis* ($\chi^2 = 118.92$; df = 9; p < 0.001), *P. americanus* ($\chi^2 = 127.42$; df = 9; p < 0.001) and *E. caninus* ($\chi^2 = 107.86$; df = 9; p < 0.001) were reported as being lower in the Yumurtalik and Golovasi fishery ports located around the western coasts of the Gulf of Iskenderun (Fig. 2). With a continued focus on abundance, the reported BDC of *E. aeneus* was significantly higher (KW $\chi^2 = 19.05$; df = 9; p < 0.05) in the fishery ports located around the northern coasts of the Gulf of Iskenderun (Fig. 3), whereas there were no significant changes found in the other species.

Three descriptors provided information on the size structure of the grouper populations: Minimum, average and maximum size of the targeted species (Fig. 4). There were also significant spatial variations in the reported sizes of fish. The median values of the MaxL were significantly higher towards the Gulf of Iskenderun for *E. aeneus* (KW $\chi^2 = 26.21$; df = 9; p < 0.001) and *E. marginatus* (KW $\chi^2 = 17.57$; df = 7; p < 0.05) (Fig. 3) and the MinL was detected as being significantly