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Catch per unit effort, maximum sustainable yield and exploitation of demersal fish of Omani artisanal fishery

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ABSTRACT

Objective: To evaluate exploitation status of the stocks of demersal fishes in Omani artisanal fisheries.
Methods: Time-series data between 2005 and 2014 on catches and effort represented by the number of fishing boats were used to estimate catch per unit effort and maximum sustainable yields applying Schaefer surplus production model. Regression analyses were made online using GraphPad software.
Results: The study revealed that increasing the number of boats on the fishery caused a decrease of catch per unit effort of some species. Maximum sustainable yields and exploitation status were estimated for these species applying.
Conclusions: Some demersal fish species were found to be caught in quantities exceeding maximum sustainable yields during some fishing seasons indicating overexploitation of their stocks.

1. Introduction

The artisanal fishery in Oman contributes over 90% of the total marine catch. The fish stocks in this fishery suffer from an increase of exploitation pressure due to open access system[1,2]. In that fishery, small fiberglass boats powered with engine dominate the fleets constituting about 99%[2]. The boats are less than 12 m length fishing with gears such as traps, bottom gill nets and hand lines. These boats obviously increased in the fishery during the last decade[3]. This is expected to have direct effect on the fish stocks and exploitation status.

The production of artisanal fishery composed of some different categories of fish groups classified as large pelagic fish, small pelagic fish, demersal fish, sharks and rays, mollusks and crustaceans. Demersal fish category includes some important fish species which are selected for the present study. These fish include emperors (*Lethrinus lentjan* and *Lethrinus nebulosus*, family Lethrinidae), groupers (*Epinephelus areolatus*, *Epinephelus chlorostigma* and *Epinephelus tauvina*, family Serranidae), sea breams [*Acanthopagrus bifasciatus* (*A. bifasciatus*) and *Argyrops filamentosus* (*A. filamentosus*), family Sparidae], rabbit fish (*Siganus canaliculatus*, *Siganus rivulatus*, *Siganus spinus* and *Siganus javus*, family Siganidae), croakers [*Atractoscion aequidens* (*A. aequidens*), family Sciaenidae], sweet lips (*Plectorhinchus pictus* and *Plectorhinchus schotaf,* family Haemulidae), snappers (*Lutjanus ehrenbergii* and *Lutjanus malabaricus,* family Lutjanidae), jobfish [*Pristipomoides typus* (*P. typus*), family Lutjanidae], ribbonfish [*Chirocentrus dorab* (*C. dorab*) and *Trichiurus lepturus* (*T. lepturus*), family Trichuridae] and catfish [*Arius polystaphylodon* (*A. polystaphylodon*), family Ariidae]. Because of their importance, the exploitation of these species should be well managed.

Generally to manage human exploitation of resources, it is necessary to know how much can be safely taken without depleting them, and without otherwise negatively impacting the environment. In case of fishing when discussing the limits of exploitation of the fish stocks, the concept of maximum sustainable yield (MSY) should be considered as a key tool for fisheries management. MSY for a given fish stock means the highest possible annual catch that can be sustained over time, by keeping the stock at the level producing maximum growth[4]. The MSY refers to a hypothetical equilibrium state between the exploited population and the fishing activity.

MSY as a tool for stock evaluation being easily adopted when data on fishing effort and catch are available from which catch per unit effort (CPUE) could be analysed over a range of fishing season[4]. In Oman, data on catches in weights and number of fishing boats (fishing effort) are available in statistical fishery book issued annually by ministry of agriculture and Fishery Wealth. MSY and surplus production models were discussed and adopted in fishery management in many previous studies[5-20].

One objective of the present study is to investigate the effect of the increase of fishing boats in artisanal fishery on the catch of demesral fishes per boat. Another objective is to estimate the MSY of these fishes. Then it is possible to have an evaluation of their exploitation status.

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2. Materials and methods

Data on catch and effort (number of fishing boats) for demersal fishes of artisanal fishery between 2005 and 2014 were obtained from the compilation of fishery statistics[3]. These data were used to analyse the CPUE. Then CPUE and effort were inserted in Schaefer surplus model as explained by Sparre and Venema to estimate MSY according to following equation[4]:

$c/f = a + bf$

where, c/f was the CPUE; f was the fishing effort; a was the intercept;

b was the slope.

The slope showed negative value indicating the decrease of CPUE with the increase of fishing effort. In such condition, MSY was estimated via surplus production models, otherwise the model was not applicable[4]. Here, the trends of CPUE against effort were analysed for different species. When CPUE decreased with the increase of effort, species were selected for the estimation of MSY and maximum rate of fishing mortality (FMSY) and evaluation of stock exploitation status. For statistical analysis, linear regression analysis was made using online software[21].

3. Results

This study revealed that the catch per boat (CPUE) of croaker (*A. aequidens*), sweet lips (*Plectorhinchus* sp.), snappers (*Lutjanus* sp.), jobfish (*P. typus*), ribbonfish (*C. dorab* and *T. lepturus*), and catfish (*A. polystaphylodon*) increased with increasing the number of fishing boats (Figures 1–6).

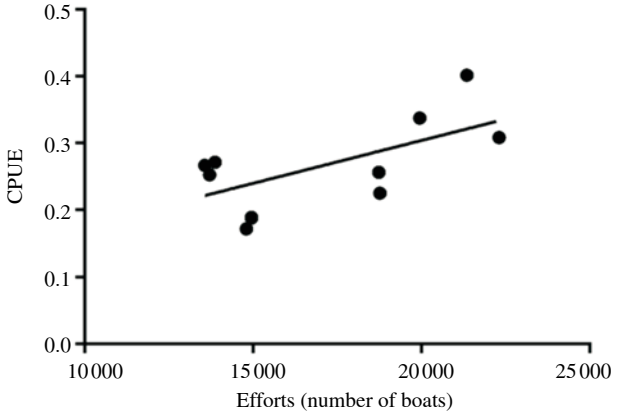

Figure 1. Change of CPUE of croaker fish species (*A. aequidens*) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

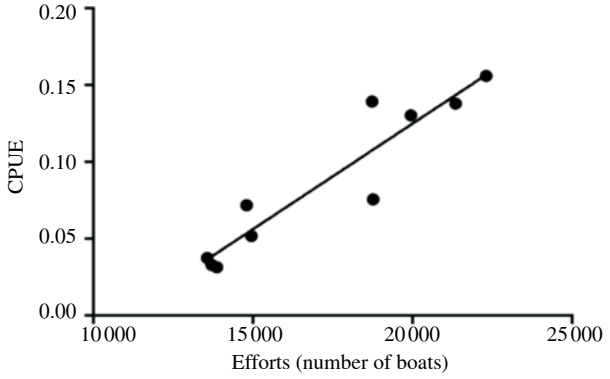

Figure 2. Change of CPUE of sweet lips fish species (*Plectorhinchus* sp.) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

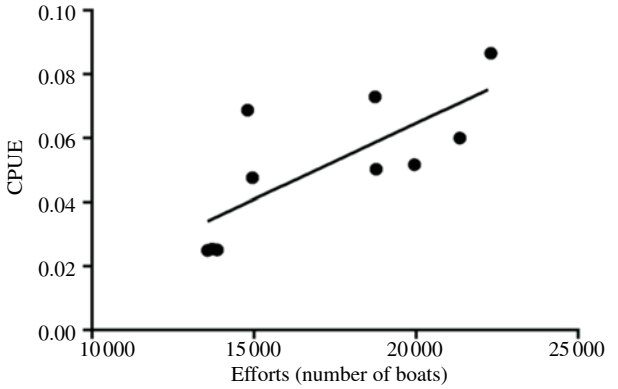

Figure 3. Change of CPUE of snapper fish species (*Lutjanus* sp.) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

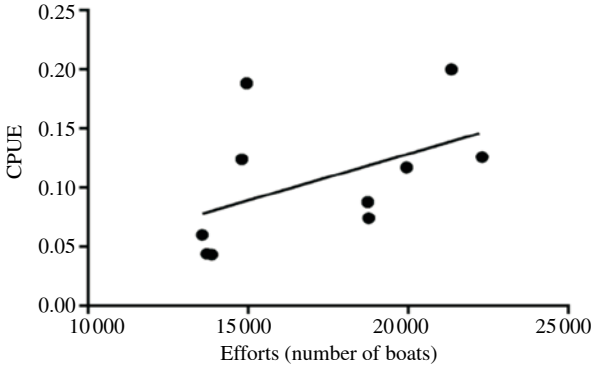

Figure 4. Change of CPUE of jobfish species (*P. typus*) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

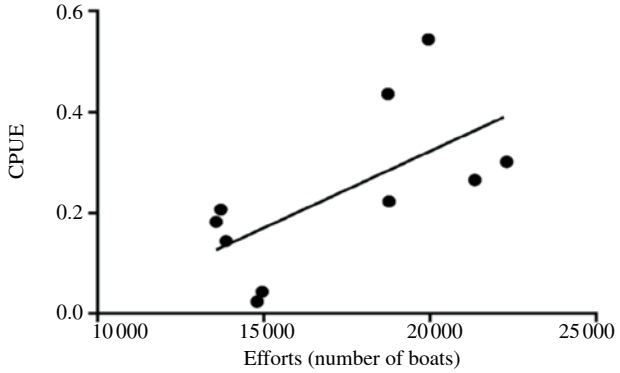

Figure 5. Change of CPUE of ribbonfish species (*C. dorab* and *T. lepturus*) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

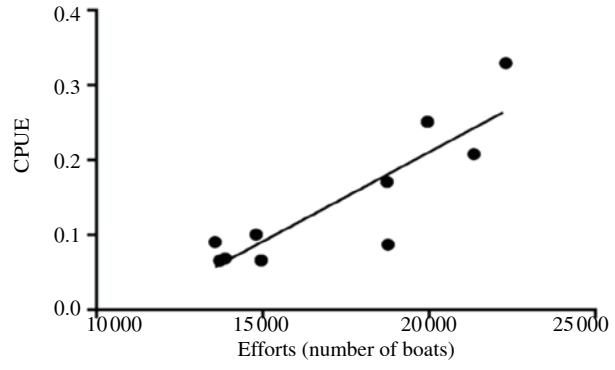

Figure 6. Change of CPUE of catfish species (*A. polystaphylodon*) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

Figures 7–10 demonstrate that the increase in the number of fishing boats which resulted in a decrease of the catch per boat (CPUE) of emperors (*Lethrinus* sp.), sea breams (*A. bifasciatus* and *A. filamentosus*), groupers (*Epinephelus* sp.) and rabbit fish (*Siganus* sp.).

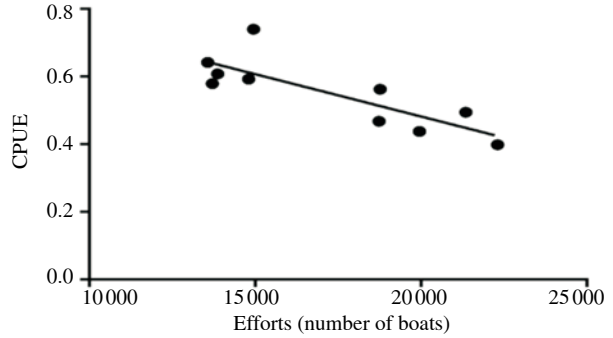

Figure 7. Change of CPUE of emperor fish species (*Lethrinus* sp.) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

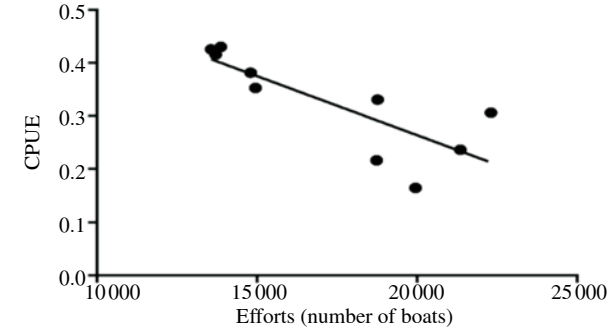

Figure 8. Change of CPUE of sea bream fish species (*A. bifasciatus* and *A. filamentosus*) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

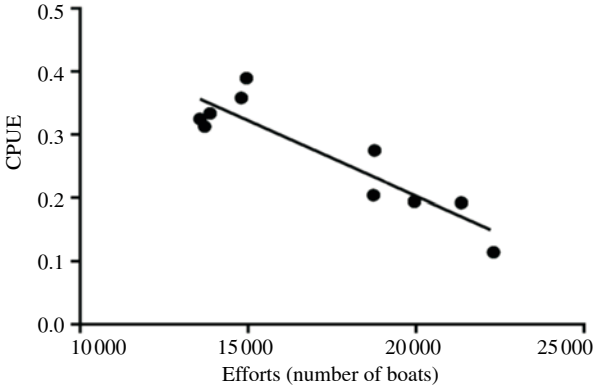

Figure 9. Change of CPUE of grouper fish species (*Epinephelus* sp.) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

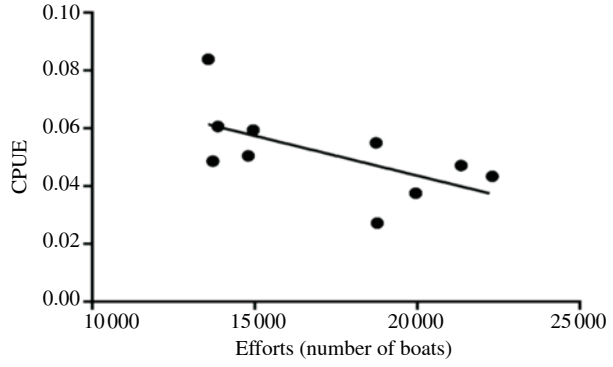

Figure 10. Change of CPUE of rabbit fish species (*Siganus* sp.) with the increase of efforts (number of fishing boats) in artisanal fishery in Oman (2005–2014).

The results of surplus production analysis clarified that catches of emperors, groupers, sea breams and rabbit fish exceeded the MSY during some fishing seasons (Table 1). Number of fishing boats also exceeded the number needed to obtain the MSY (FMSY) of these fishes. This indicated an overexploitation of the stocks of these species, which could be related to the increase of fishing pressure on the stocks.

Table 1

Catches by species (tonnes), efforts in number of boats and MSYs and corresponding efforts.

Fishing season	Efforts (No. of boats)	Catches in tonnes by species groups			
		Emperors	Sea breams	Groupers	Rabbit fish
2005	13560	8710	5779	4410	1138
2006	13706	7943	5703	4289	668
2007	13862	8429	5970	4630	842
2008	14796	8770	5648	5308	748
2009	14942	11061	5279	5825	888
2010	18759	10557	6212	5160	512
2011	18731	8776	4051	3827	1031
2012	19943	8737	3301	3885	751
2013	21342	10561	5044	4109	1008
2014	22307	8897	6834	2562	970
MSY		9651.4866	5648.0675	4853.1933	885.4609
FMSY		19640.3680	15917.9450	14253.7510	17929.0190

4. Discussion

The present study aims to estimate the MSY of demersal fish species (emperors, groupers, sea breams, rabbit fish, croakers, sweet lips, snappers, jobfish, ribbonfish and catfish) caught from Omani Fisheries using surplus production analysis. Schaefer model was selected for its simplicity of data requirement. It needs only time series data on effort and catches which are easily available. Schafer model conforms to assumption that CPUE declines as with the increase of effort[4]. Thus, the MSY was estimated for only four groups of species (emperors, groupers, sea breams and rabbit fish) because their catch per boat decreased by increasing the number of fishing boats. The CPUE of the other species (croakers, sweet lips, snappers, jobfish, ribbonfish and catfish) increased with the increasing effort, so they were excluded from surplus production analysis.

Statistical data of artisanal fishery in Oman did not give catches in details for individual species but the data were collected for the aggregated species of the same family[3]. For this type of multispecies assemblage, surplus production models of single species could be used as data are insufficient to perform single species assessment[22]. Single-species surplus production models have been applied to many multispecies assemblages, including tropical fishes, sharks and demersal fishes[22-26].

Few previous studies on exploitation status of demersal fish caught from artisanal fisheries in Omani are used to compare with our results. Food and Agriculture Organization (FAO) clarified that the capacity of data collection, stock assessment and fishery management in the Western Indian Ocean is generally poor in comparison with other regions, but Oman made a progress in last decade in terms of data collection and stock assessment for some species such as kingfish, yellowfin tuna and the sea bream species, *Argyrops spinifer*[1,27-30]. The present study indicated overexploitation of emperors, groupers, sea bream and rabbit fish as their catches exceeded their MSYs in many fishing seasons. Also the numbers of boats needed to obtain the MSYs were exceeded in many fishing seasons (Table 1) indicating the increase of fishing pressure on their stocks. In contrary to this result, Al-Mamry *et al.* stated that the level of exploitation of sea bream species, *Argyrops*

spinifer was optimal and stock was in a healthy status, depending on data collected in the period between 2001 and 2002 applying yield per recruit analysis[30]. There was obvious increase in the number of fishing boats since 2005 as shown in the present work. FAO pointed out that groupers may deserve special attention in terms of management because their catches have declined dramatically since 2000[27]. Another FAO report mentioned that some demersal fish stocks such as breams have come under increasing fishing pressure and are considered fully exploited[2]. The report revealed that 99% of the vessels fishing in the artisanal fishery are small boats having length less than 12 m and powered with engines. From the above discussion and according to the result, it is clear that the numbers of fishing boats that work in artisanal fisheries in Oman are too many and cause a pressure on fish stocks and it is expected to cause over exploitation of other species. So rules must be established to control the fishing effort and the catches exploited.

The increase of fishing boats in Omani artisanal fishery caused a decrease in the catch per boat of some demersal fish species (emperors, groupers, sea breams and rabbit fish). These species are obviously overexploited as they are caught above their MSYs. Thus, the number of fishing boats of Omani artisanal fisheries should be declined to diminish the fishing pressure on demersal fish stock and to solve the problem of overexploitation.

Conflict of interest statement

I declare that I have no conflict of interest.

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