Gulf of Suez Fisheries: Current Status, Assessment and Management

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Abstract. The Gulf of Suez is the most productive fishing ground along the Egyptian sector of Red Sea, where more than 64% of Egyptian Red Sea fish production was harvested from it. The current status of the Gulf fisheries was evaluated and an assessment of the different fishing gears operated inside it was done. Fishery statistics of the different fishing gears over 25 years (1979-2004) were collected and analyzed. The biomass-based model of Schaefer was applied to the catch per unit of fishing effort (CPUE) indices. The maximum sustainable yield (MSY) and the relevant level of fishing effort (f_{MSY}) for trawl, purse-seine and artisanal fisheries in the Gulf were estimated. Also, $2/3 f_{MSY}$, as a target reference point was calculated. The obtained results revealed that, the fish stocks under the current fishing effort for the three fishing methods are overexploited and the estimated precautionary target reference points advised the reduction of fishing effort by about 44.5%, 43.3% and 50% for trawl, purse-seine and artisanal fisheries, respectively. As the reduction of fishing effort seems to be unrealistic, considering socio-economic dimension, regulating mesh size and defining closed area on the light of developing a geographical information system for fishing grounds in the Gulf of Suez could be advised.

Keywords: Red Sea, Gulf of Suez, trawl, purse-seine, artisanal fisheries, biomass-based models, reference points, management.

Introduction

Although Egypt has a vast marine shoreline (1100 km on Mediterranean and 1080 km on Red Sea), the mean annual fish production from this vast

area does not exceed 85 thousand ton (1980-2004). Many challenges are facing Egyptian marine fisheries such as; over-fishing, destructive fishing methods, illegal mesh sizes of nets used, increasing of tourism, industrial expansion and pollution from land-based sources. All these factors led to declining productivity and yields from our marine fisheries, so it is urgent to identify and design long-term plan to manage, sustain and enhance the development benefits from these fisheries.

The Gulf of Suez extends about 250 km from Suez in the north (Lat. $29^{\circ}56'$ N) to Shadwan Island in the south (Lat. $27^{\circ}36'$ N). Its width varies between 20 and 40 km, and its depth throughout its axis is fairly constant with a mean depth of 45 m (Fig. 1). The Gulf is the most productive area along the Egyptian sector of Red Sea where more than 64% of Egyptian Red Sea fish production was harvested. Three main fishing methods are operated in the Gulf; trawl, purse-seine and artisanal fisheries specially long and hand lines.

Fig. 1. Gulf of Suez.

Many studies have been done to evaluate the fishery status in the Gulf (Sanders and Kedidi, 1984 a, b & c; Mehanna, 1999 a, b & c; El-Gammal and Mehanna, 1999 & 2002). The present study was made to update the data concerning catch, effort and catch per unit of fishing effort of trawl, purse-seine and artisanal fisheries in the Gulf of Suez and to evaluate the current status of fish stocks exploited by the three fishing methods in the Gulf. It aimed also at suggesting some management measures to conserve this valuable fishery resource.

Materials and Methods

Fishing effort represented by the number of landing and the number of fishing boats, the annual total catch and the catch by species during the period from 1979/80 to 1981/82 were obtained from Sanders and Kedidi (1984 a, b & c), while the same data of the period from 1982/83 to 1997/98 were obtained from Mehanna (1999c) and El-Gammal and Mehanna (1999 & 2002). Those of the period from 1998/99 to 2003/04 were obtained from the fisheries office of the General Authority for Fish Resources Development at Suez city. The data collection included the vessel characteristics, type and size of fishing gear, number of fishing days, number of crews and the fishing locations with species caught. These data were analyzed to estimate the catch per unit of fishing effort which was considered as a function of stock biomass. The gross revenue for each fishing technique was calculated using the annual mean prices of fish species.

The logistic model of Schaefer (1954 & 1957) was applied to assess the fishery status in the Gulf of Suez. The essential equations used in MSY and CPUE at f_{MSY} ($CPUE_{MSY}$) estimation were as follows:

$$CPUE = a + bf$$

where CPUE = equilibrium catch per unit effort, f = equilibrium effort and a & b are constants whose values can be estimated by least square method. Schaefer model has $MSY = a^2 / 4 (-b)$, $f_{MSY} = a / 2 (-b)$ and $CPUE_{MSY} = a/2$. Subsequently, $2/3 f_{MSY}$ have been calculated as a precautionary reference point.

Results and Discussion

Description of the Fishery

Trawl Fishery

The number of vessels operated in the Gulf of Suez ranged between 72 and 78 vessels during the period from 1979/80 to 2003/04. The vessel length varied between 20 and 30 m. Each vessel is powered by main engine of 200 to 600 hp with the majority (68 vessel) of 400-600 hp. All vessels are provided with mechanized winches. Some of them are equipped with echo-sounders. Trawl net is of the Mediterranean type, its length ranged between 20 and 30 m with an average mesh size of 1.5 cm in the cod-end. The sweep length varied between 200 and 250 m. The fishing trip is about 5 to 10 days and the number of crew is about 10 to 15 persons. The trawl fishery is seasonal, generally from October to May. The number of fishing days during the first three months of the fishing season constitutes 42.4% of the seasonal total effort.

The trawl fishery contributed about 19.85% of the total fish production from the Gulf. This being about 56% of the gross revenue of the Gulf due to the high price of large shrimp and cephalopod in the local markets.

Purse-Seine Fishery

The number of fishing boats varied between 56 and 83 vessel operated inside the Gulf. The vessel's length ranged between 12.5 and 30 m. They are powered by engines of 150 to 600 hp with the majority (63 vessel) of 400-600 hp. The purse-seiners are operated at night using lighted dinghies. This illumination leads to concentrate the fish before setting the net. All fishing ceases during an approximately ten days during each month when the moon is full. The net's length is between 200 and 300 m and its depth ranged from 50 to 80 m. The nets are hauled manually. The crew number ranged between 25 and 30 persons.

The purse-seine fishery is seasonal generally from October through May. At the beginning of each season, the fishing trip takes two to five days duration because most fishing is undertaken relatively close to the landing site of Ataka at Suez city. Later in season, fishing trip takes more days. The purse-seine fishery contributed about 77.9% of the total fish

production from the Gulf. This constitutes about 32% of the gross revenue of the Gulf.

Artisanal Fishery

The number of fishing boats varied between 93 and 178 boats. The length of the fishing boat ranges between 10 to 15 m in length and powered by inboard engines of about 50 to 200 hp. The fishing trip takes about 10 days. The number of crew ranged between 2 to 10 person. The fishermen on these boats use several fishing gears such as long-line, hand-line, gill net, trammel net and beach-seine. The artisanal fishery in the Gulf were all over the year, until the fishing season 1996/97 where it became seasonal, generally from September to June.

The artisanal fishery contributed about 2.25% of the total fish production from the Gulf. This is being about 12% of the gross revenue of the Gulf fishery due to the high price of the fish species caught by the artisanal fishery.

Catch Composition

The most economically important fish categories represented in the catch of the trawl, purse-seine and artisanal fisheries in the Gulf were given in Fig. 2.

Trawl Fishery

The lizard fish (family: Synodontidae) came in the first degree where it contributed about 29.9% of the total trawl catch followed by the stripped snapper (family: Lutjanidae) where it constituted about 14.9% then the large shrimp (family: Penaeidae) which contributed about 11%, then threadfin bream (family: Nemipteridae) (6.7%), red mullet (family: Mullidae) (6.9%), horse mackerel and scads (6%), cuttlefish (4.8%) and small shrimp (1.6%). In addition, the “others” group that contains the unsorted species or those of lesser importance and represented 18.2% of the trawl catch. The large shrimp is considered as the most economic important category in the trawl fishery where it forms about 40% of the gross revenue from the trawl fishery.

Fig. 2. Catch composition of different fishing gears in the Gulf of Suez during the period 1979/80 – 2003/04.

Purse-Seine Fishery

The dominant species groups in purse-seine catch were, the horse mackerel and scads (family: Carangidae) which were considered as the most abundant group in the catch (39.2%), followed by the round herring (family: Clupeidae) (21.1%). Sardines (family: Clupeidae) came in the third degree in the catch (10.2%) followed by slimy mackerel (7.3%) then the indian mackerel (2.5%) and little tuna (1.1%) (family: Scombridae). In addition, the species groups of lesser importance or unsorted species were grouped in the “others” category (18.6%).

Artisanal Fishery

The dominant fish groups were, the groupers (family: Serranidae) which were considered as the most abundant group in the catch (29.1%), followed by the Emperor (family: Lethrinidae) (15%). Long spine bream (family: Sparidae) came in the third degree in the catch (4.4%) followed by the little tuna (4%) then the spanish mackerel (1.2%) (family: Scombridae). In addition, more than 100 fish species belonging to about 20 families were unsorted and grouped in the “others” category (Mehanna, 1999c). This category represented 46.3% of the total artisanal catch.

Catch Statistics

The annual fish production from trawl, purse-seine and artisanal fisheries from the Gulf of Suez was given in Fig. 3.

The total trawl catch showed a fluctuation from season to another with a maximum of 5377.1 ton (1981/82) and a minimum of 2669.6 ton (1993/94) with a mean of 3691.33 ton during the investigated seasons. On the other hand, the total purse-seine catch shows a great variation from season to another with a maximum value of 26153.7 ton (92/93) and a minimum value of 6803.8 ton (82/83) with a mean of 14319.6 ton. While, the total artisanal catch fluctuated between a maximum of 821.2 ton (89/90) and a minimum of 108.5 ton (99/00) with a mean of 403.9 ton.

Fishing Effort

Fishing effort represented by the number of landings for the three fishing methods during the fishing seasons from 1979/80 to 2003/04 was shown in Fig. (3). Number of landings of trawl fishery varied between a

Fig. 3. Total catch and fishing effort (no. of landing) of different fishing gears in the Gulf of Suez during the period 1979/80 – 2003/04.

minimum of 1251 (1979/80) and a maximum of 2284 (1996/97) with a mean of 1640 landings (± 111.385). For purse-seine fishery, number of landings fluctuated between a minimum of 1369 (1982/83) and a maximum of 3881 (2000/01) with a mean of 2819 landings (± 735.051). While the number of landing for artisanal fishery varied between a minimum of 1260 (1980/81) and a maximum of 2300 (2001/02) with a mean of 1775 landings (± 121.012).

Catch Per Unit of Fishing Effort (CPUE)

The catch per unit fishing effort gives the first sight about the relative abundance of the different fish stocks and consequently the status of the fishery. The values of total trawl catch per unit of fishing effort varied between a maximum of 4.2 ton/landing during 1980/81 and a minimum of 1.4 ton/landing during 1997/98. The total purse-seine catch per unit of fishing effort ranged between a maximum of 8.3 ton/landing during 1983/84 and a minimum of 2.6 ton/landing during the 2002/03. The catch per unit of fishing effort of artisanal fishery (ton/landing) varied from a maximum of 0.53 (1979/80) to a minimum of 0.06 (1999/00).

It is noticed that, there is a serious decline in relative abundance of different fish stocks exploited by different fishing gears in the Gulf during the last five years (Fig. 4). This can be clearly seen by comparing data concerning catch, effort and CPUE during the period 1979/80-1983/84 with those recorded for last five years (Tables 1, 2 & 3).

Fig. 4. Catch per unit of fishing effort (t/landing) for different fishing gears in the Gulf of Suez.

Table 1. Percent of change in relative abundance of different fish stocks exploited by trawl fishery.

Fishing period species	1979/80 – 1983/84		1999/00 – 2003/04		% of change	
	Mean effort landing no.	CPUE t/landing	Mean effort landing no.	CPUE t/landing	Effort increasing	CPUE decreasing
Total catch	1368	3.37	1971	1.77	44	47.3
Lizard Fish		1.32		0.51		61.5
Stripped snapper		0.38		0.24		37.6
Large shrimp		0.39		0.12		69.4
Threadfin bream		0.21		0.19		0.9
Red mullet		0.09		0.17		98*
Cephalopod		0.12		0.08		33.1
Horse mackerel		0.20		0.10		46.8

*underestimated red mullet catch due to that the majority of catch in the first period was added to “others” group.

Table 2. Percent of change in relative abundance of different fish stocks exploited by purse-seine fishery.

Fishing period species	1979/80 – 1983/84		1999/00 – 2003/04		% of change	
	Mean effort landing no.	CPUE t/landing	Mean effort landing no.	CPUE t/landing	Effort increasing	CPUE decreasing
Total catch	1907	6.54	3657	3.29	91.8	49.7
Horse mackerel		2.67		1.96		26.7
Round herring		1.84		0.49		73.1
Sardines		0.23		0.17		25.9
Slimy mackerel		0.08		0.27		0.9*
Indian mackerel		0.14		0.19		2.18*
Little tuna		0.03		0.04		0.33*

*The reliable fishery statistics for these three fish groups were recorded late after the first period (at 89/90).

Table 3. Percent of change in relative abundance of different fish stocks exploited by artisanal fishery.

Fishing period species	1979/80 – 1983/84		1999/00 – 2003/04		% of change	
	Mean effort landing no.	CPUE t/landing	Mean effort landing no.	CPUE t/landing	Effort increasing	CPUE decreasing
Total catch	1382	0.42	2078	0.076	50.4	81.7
Grouper		0.15		0.035		77.5
Emperor		0.10		0.011		89.0
Longspine bream		0.02		0.0007		96.8
Spanish mackerel		0.01		0.0002		97.9
Little tuna		0.04		0.0004		99.0

Surplus Production Models

Biomass-based models are amongst the simplest used for fisheries stock assessment. They are often termed delay-difference models, and in their simplest form as production or surplus production models. The surplus production models had been developed to determine the equilibrium or sustainable yield that may be harvested from a fishery for a given level of effort. They provide a first assumption about the fishery and detect the preliminary status of it. A large family of surplus production models exists now (e.g. Pella, 1967; Pella and Tomlinson, 1969; Fletcher, 1978; Prager 1994), but all of them are similar to the classical Schaefer (1954 & 1957) and Fox (1970 & 1975) models. The effort and catch per unit of fishing effort statistics are essential in the stock assessment studies, as they constitute the basic input for the surplus production models. The surplus production models allow to estimate the optimum level of effort f_{MSY} that produces the maximum sustainable yield MSY without affecting the long term productivity of the stock.

Classically, MSY and the corresponding f_{MSY} were estimated as target reference points for management. But, for the high risk in orienting fishing policy to achieve such points which includes different kinds of uncertainties, a number of precautionary target points were proposed. Those points reduce the effect of uncertainty in estimated parameters, variations in parameters owing to external causes, changes induced through interspecies interactions as well as limiting the risk of possible reproductive failure (Sissenwine and Shepherd, 1987; Clarke, 1991, Booth, 2004). Recently, a new family of Target Reference Points have been proposed as a conservative or precautionary reference points, such as $F_{40\%}$, $F_{25\%}$, $F_{0.1}$, $2/3$ MSY and $2/3 f_{MSY}$, (Gulland and Boerema, 1973; Garcia, 1994 & 1996; Caddy and Mahon, 1995; Caddy and McGarvey, 1996 and Schnute and Richards, 1998).

To evaluate the effect of fishing effort on the stocks exploited by the different fishing gears in the Gulf of Suez, the surplus production model of Schaefer was applied to estimate MSY and f_{MSY} as limiting or threshold reference points for each gear. Also, $2/3$ MSY and $2/3 f_{MSY}$ as precautionary target reference points was calculated. The obtained results are represented in Fig. 5.

Fig. 5. MSY and f_{MSY} as limited reference points and $2/3 MSY$ & $2/3 f_{MSY}$ as target reference points for different fishing gears in the Gulf of Suez.

For trawl fishery, a maximum sustainable yield of 4062 tons could be obtained at fishing effort f_{MSY} of 1462 landing. This means that the present level of fishing effort (1756 landing during the fishing season 2003/04) is higher than that produces MSY by about 16.7%. In respect to purse-seine fishery, a maximum sustainable yield of 14053 tons could be obtained at fishing effort of 3287 landing, *i.e.* the present level of fishing effort should be reduced by about 15%. For artisanal fishery, a maximum sustainable yield of 525.9 tons could be obtained at an effort of 1546 landing, *i.e.* maximum yield achieved through reduction of fishing effort by 24.9% (from 2060 to 1546 landings).

The target control is more conservative than threshold, and defines a desired rate of fishing and acceptable levels of stock biomass. So, the use of $2/3 f_{MSY}$ as a target reference point is safer than the use of the limiting or threshold reference point (f_{MSY}). The use of $2/3 f_{MSY}$ criteria revealed that the present level of fishing effort must be reduced by about 44.5%, 43.3% and 50% for trawl, purse-seine and artisanal fisheries, respectively. This reduction in fishing effort will be associated with an increase in fish abundance indices by 84.1%, 83.3% and 523% for trawl, purse-seine and artisanal fisheries, respectively.

This study confirmed all the previous studies concerning fisheries management in Gulf of Suez. El-Gammal and Mehanna (1999) found that, the stocks exploited by trawling in the Gulf of Suez are overexploited and the fishing effort should be reduced by about 26% to obtain the maximum sustainable yield. Mehanna (1993, 1997, 1999, 2000, 2001, 2002, 2003 and 2005) based on per-recruit analysis studied the fishery status and proposed some precautionary management measures for the majority of fish stocks exploited by the three fishing gears in the Gulf of Suez. She concluded that, for all investigated fish stocks the fishing mortality coefficient should be reduced and the length at first capture must be increased to maintain these stocks. El-Gammal and Mehanna (2002) estimated the maximum sustainable yield and the corresponding level of fishing effort for total purse-seine fishery and found that the fish stocks exploited by the purse-seine fishery in the Gulf of Suez are overexploited and to obtain the maximum sustainable yield, the present level of fishing effort should be reduced by about 27%. Based on these previous studies, some regulatory measurements were proposed to reduce the fishing effort in the Gulf. These measurements were: forbidding any new licenses or any improvements on the fishing boats

and the closed season for three months each year. The present study proved that much effort is still needed to ensure the protection and management of the Gulf fisheries.

It is worth mentioning that, the over-fishing is not the only challenge facing the development and management of Gulf of Suez fisheries, but a number of other problems were identified such as: illegal mesh sizes, destructive fishing methods, increasing of tourism and industrial expansion, which cause damages in coastal ecosystem and pollution. So it could be suggested that, regulation of mesh sizes and defining closed areas on the light of developing a geographical information system for the fishing grounds in the Gulf. Setting of a total allowable catch could be applied, but this requires a great deal of knowledge about the stocks and fishery of the Gulf, before such a measure could be implemented.

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مسايد خليج السويس: دراسة تحليلية تقييمية وتنظيمية

سحر فهمي مهنا و فهمي إبراهيم الجمال

المعهد القومي لعلوم البحار والمسايد - فرع خليجي السويس والعقبة

ص.ب. ١٨٢ السويس - مصر

المستخلص. يعتبر خليج السويس من أهم مناطق الصيد على طول الساحل المصري للبحر الأحمر، حيث يصل إنتاجه السنوي من الأسماك حوالي ثلثي إنتاج مصر من البحر الأحمر. تم تجميع جميع الإحصائيات الخاصة بالإنتاج الكلي لحرف الصيد المختلفة العاملة بالخليج، وهي حرفة الجر والشانشولا، بجانب الحرف الصغيرة وأهمها السنار. كما تم تجميع إحصائيات الإنتاج لأنواع المصايد بكل حرفة، وجهد الصيد الواقع عليها، على مدار ٢٥ عاماً ابتداء من ١٩٧٩/١٩٨٠م إلى ٢٠٠٣/٢٠٠٤م. تم تحليل هذه البيانات، واستقراء ما حدث من تدهور للوفرة النسبية لجميع المجاميع السمكية بالخليج، وعليه تم استخدام أحد نماذج فائض الإنتاج، وهو نموذج شيفر لتعيين أقصى إنتاج مستمر لكل حرفة على حدة، وتحديد جهد الصيد المؤدى لهذا الإنتاج، كما تم حساب ثلثي هذا الإنتاج، وثلثي جهد الصيد الأمثل، كنقاط مرجعية تنظيمية، وقد أثبتت الدراسة أن مجاميع الأسماك المصايد بحرفة الجر، والشانشولا، والحرف الصغيرة تتعرض لجهد صيد جائر، وللوصول إلى الإنتاج الذى يضمن الحفاظ على الكتلة البيولوجية لهذه المجاميع مع تحقيق أقل نسبة مخاطرة، يجب خفض جهد الصيد بنسب ٤٤,٥ و ٤٣,٣ و ٥٠٪ لحرفة الجر والشانشولا والسنار على التوالي.