An evaluation for the exploitation level of Egyptian Marine Fisheries

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ABSTRACT

Egyptian marine fisheries contribute to the economy of the country where it provides an important source for food and employment. There are many challenges that affected the sustainability of marine fish stocks from which overfishing due to the increasing fishing effort. In the present study, annual catch and effort data were analyzed to estimate the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}) for both the Mediterranean & Red seas, Egypt. According to the Schaefer model (1954), the value of MSY was estimated at $73.0*10^3$ tons for Mediterranean sea fisheries, and at $63.1*10^3$ tons for Red sea fisheries. These values of MSY were obtained at fishing effort (f_{max}) of $3.5*10^3$ & $1.6*10^3$ standard boats in Mediterranean & Red seas respectively. The results indicated that the optimum exploitation in Egyptian marine fisheries required an urgent reduction in fishing effort. These results confirmed the overexploitation situation of the marine fish stocks in Egypt.

INTRODUCTION

The marine fishery resource provides important source for food and has been traditionally exploited for centuries in Egypt. With the rapid increase in the human population over the years, the demand for fish has increased considerably. During the last years there has been a growing awareness among the users about the need to conserve and manage marine fisheries resources based on data collected in a scientific manner so as to ensure proper utilization and maximum sustainable yield (MSY). Egypt has a long coastline on both Mediterranea (1100 Km) and Red seas (1080 Km). Egyptian marine fisheries (Fig. 1) has a rich and diverse commercial species varied from demersals, semipelagics, benthopelagics and pelagics. Over exploitation on the Egyptian coastal resources has caused decline of many fish, mollusc and crustacean stocks. Stock assessment of fishery is important for its effective management and the effective management strategy which based on a sound scientific basis can help to obtain sustainable yield every year (Mehanna and El-Gammal, 2007; Osman, 2015; El-Mahdy, 2017; Ali, 2017; Hassanein, 2017; Mehanna, 2020; Mohamed *et al.,* 2020). The state of a

fishery can be assessed by many mathematical models. Catch and effort statistics constitute the minimum requirements for the assessment of a fishery. Effort and catch per-unit effort statistics provide indices that are related to important quantities, such as the fishing mortality and the density of the exploited stock (Gulland, 1983). Surplus production models (SPMs) also known as biomass dynamics models (BDMs) are frequently used to evaluate MSY and to study the harvested population. These models need catch and effort data which is valued when age structured data are absent (Haddon, 2011). Surplus production models are used to determine the optimum level of effort which produces the maximum yield that can be sustained without affecting the long-term productivity of the stock, the so-called maximum sustainable yield (MSY). A number of studies were undertaken to estimate MSY of the marine fishery resources in Egypt based on SPMs (Mehanna, 2002, 2005, 2009; Mehanna and El-Gammal, 2007; Mehanna and Haggag, 2010; Mehanna _et al.,_ 2020).

The present study analysed the catch and effort data of Mediterranean and Red seas fish stocks to estimate the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}) using Schaefer model (1954). The results of Schaefer (1954) model provide baseline information on maximum sustainable yield for the Egyptian marine waters, which could be useful for any future fishery assessment.

MATERIALS AND METHODS

A time series of catch and effort data for the period from 1995 to 2016 (22 years) were collected from two sources; the Central Agency of Public Mobilization and Fisheries Statistics (CAPMS) and General Authority for Fish Resources Development (GAFRD). Fishing effort is expressed by the number of operational fishing boats in the Egyptian marine waters of both Mediterranean and Red Sea. As the Egyptian marine fisheries is of multi-fleet nature, the fishing boats of different characteristics were standardized.

The surplus production model of Schaefer (1954) was applied in this study to the per annum total catch in tons and standardized number of fishing units. This model considered the stock as one big unit of biomass.

Schaefer model (**1954**) is one of Surplus production models, which can be used to estimate the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}), expresses the catch per unit effort (CPUE) as a function of effort as follows:

$$\mathbf{Y\,/f = a + b\,f}$$

Where: Y: yield (catch in weight),
         f: effort,

and Y/f: yield (weighted catch) per unit of effort.

By fitting the effort against catch per unit effort via ordinary least square method (OLS), the obtained parameters a and b can used to estimate the MSY and f_{MSY} using the following formulae:

$$\mathbf{MSY = -\,a^2\,/\,4b}$$
$$\mathbf{f_{msy} = -\,a\,/\,2b}$$

The slope (b) will be negative if the catch per unit effort (Y/f) decrease with the increase of effort (f) and vise versa.

Fig.1. Egyptian Marine fisheries (Mediterranean and Red Seas coasts)

RESULTS AND DISCUSSION

1. Egyptian marine fisheries

Egypt drives its fish production from two resources; natural resources (marine and inland waters), and artificial resources or aquaculture. Egyptian Marine fisheries include two seas, Mediterranean sea in the north and Red sea in east of Egypt (Figs. 1&2).

Egyptian Marine fisheries one of the most important sources for fish production in Egypt, and represented the largest area compared to other fish resources. The actual area of these fisheries are approximately about $11.2*10^6$ acre during the period of study (1995-2016), which represented about 84.8% of natural fisheries area and 80.5% of Egyptian fisheries area. While exploitable area of these fisheries is only about 31.8%, 30.2% from natural fisheries area and Egyptian fisheries area consequently (Table 1).

The Mediterranean Sea fisheries area varies between actual and exploitable areas which are about $6.8*10^6$ and $3.3*10^6$ acre, whereas the Red Sea fisheries these areas are $4.4*10^6$ acre and $0.9*10^6$ acre for actual and exploitable areas respectively. As the area of Mediterranean Sea fisheries is greater than that of Red Sea fisheries, its contribution to the Egyptian natural fisheries is higher (Fig. 2). On the other hand, the coast length of Egyptian Marine fisheries is approximately about $2.4*10^3$ Km, divided to about $1.1*10^3$

Km (46%) for Mediterranean Sea fisheries and up to $1.3*10^3$ Km (54%) for Red sea fisheries with its two Gulfs (Table 1).

Table 1. Relative actual and exploitable area of Egyptian marine fisheries during 1995-2016.

Items	Egyptian Marine fisheries						Natural fisheries	Egyptian fisheries
	Mediterranean Sea		Red Sea		The total			
	A	E	A	E	A	E		
Area (acre*10^6)	6.8	3.3	4.4	0.9	11.2	4.2	13.2	13.9
Egyptian marine fisheries area (%)	60.7	78.6	39.3	21.4	100.0	100.0	——	——
Natural fisheries area (%)	51.5	25.0	33.3	6.8	84.8	31.8	100.0	——
Egyptian fisheries area (%)	48.9	23.7	31.6	6.5	80.5	30.2	——	100.0
Coast length (Km)	1100		1300		2400		——	——
Egyptian marine fisheries coast length (%)	46		54		100.0		——	——

A: Actual area for fishing
E: Exploitable area for catching.
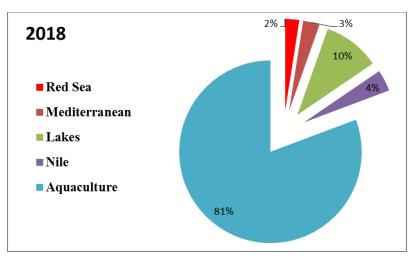**Source:** Maiyza, 2015 and Google Earth program.

Fig. 2. Contribution of Egyptian marine fisheries in fish production during 2018

From the above illustrated table and graph, Red Sea fisheries is longer in coast length and smaller in its area than in Mediterranean Sea fisheries because of Red Sea coast has many meanders compared to Mediterranean Sea. Consequently, the contribution of Mediterranean fisheries to the fish production in Egypt is more than the contribution of Red Sea fisheries.

It is worth mentioning that the marine fisheries in Egypt were contributed by 25% of total fish production in 80's, severly decreased to only 5% in 2018 (Mehanna, 2020; GAFRD, 2018).

2. Catch and effort statistics

The total fish catch in the Egyptian Marine fisheries during the period of the study is about $119.3*10^3$ tons, which represents about 31.37%, 13.3%, from Natural fisheries production, and total Egyptian fish production consequently, (Table 2). The relative importance of the Mediterranean Sea fisheries is higher than The Red Sea fisheries in its contribution to the Egyptian Marine fisheries, natural fisheries and Egyptian fisheries in its fish production and area.

Table 2. Catch in Egyptian marine fisheries during 1995-2016.

Marine fisheries (seas)	Average Production (tons*10^3)	% from Egyptian Marine fisheries	% from Natural fisheries production	% from total Egyptian fish production
Mediterranean Sea	64.4	54.0	16.9	7.2
Red Sea	54.9	46.0	14.4	6.1
Egyptian marine fisheries	119.3	100.0	31.3	13.3
Natural fisheries	380.2	——	100.0	42.4
Total Egyptian fish production (tons*10^3)	897.1	——	——	100.0

Source: CAPMAS, 2016 and GAFRD, 2016.

There are 10 governorates shared the Egyptian marine fisheries, 7 governorates are lie on Mediterranean Sea and shared its fisheries; arranged according to its productivity as Damietta, Beheira, Port Said, Alexandria, Kafr El-shiekh, North Sinai and Matrouh. Whereas three governorates are shared the Red Sea fisheries, which are Suez, Red Sea and South Sinai (Table 3).

Table 3. Catch and effort of different governorates shared the Egyptian marine fisheries during 1995 – 2016.

Egyptian Marine fisheries		Production		Effort			
				Motor boat	Sailing boat	Total	
		(tons*10^3)	%			(boat)	%
Mediterranean Sea	Damietta	19.5	30.0	830	242	1072	22.9
	Beheira	13.0	19.8	617	293	910	19.5
	Port Said	12.2	18.6	408	494	902	19.3
	Alexandria	11.6	17.7	702	395	1097	23.4
	Kafr El-shiekh	5.8	8.9	199	216	415	8.9
	North Sinai	2.9	4.4	175	54	229	4.9
	Matrouh	0.4	0.6	10	41	51	1.1
	Total	65.4	100.0	2941	1735	4676	100.0
	% of Totals	53.8%		70.5%	66.7%	69.0%	
Red Sea	Suez	29.1	51.8	550	341	891	42.5
	Red Sea	26.1	46.4	602	456	1058	50.5
	South Sinai	1.0	1.8	79	68	147	7.0
	total	56.2	100.0	1231	865	2096	100.0
	% of Totals	46.2%		29.5%	33.3%	31.0%	
Totals		121.6		4172	2600	6772	

Source: CAPMAS, 2016 and GAFRD, 2016.

Fish catch of Egyptian marine fisheries during 1995-2016 is about $119.3*10^3$ tons with percentage contribution of 54% for Mediterranean fisheries and 46% from Egyptian marine fisheries. Generally there is a decreasing trend in the catch of marine fisheries during the period of study reflecting the decreasing of productivity and relative abundance of these fisheries (Fig. 3).
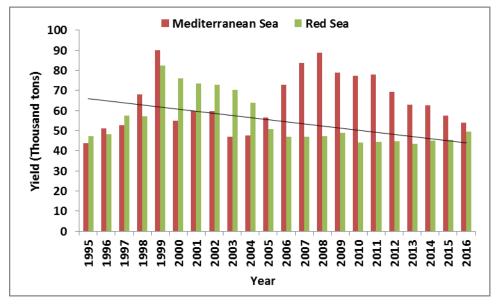

Fig. 3. Trend of fish production from Egyptian marine fisheries during 1995–2016

The fishing effort in Mediterranean and Red Sea fisheries represented by fishing boats are contributed about 69% and 31% of fishing effort in Egyptian marine fisheries respectively, which is estimated at about $6.8*10^3$ boats during the period of the study.

It is noted that the fishing effort represented by the number of fishing vessels in Mediterranean Sea fisheries is higher than Red Sea fisheries; also motor boats are bigger than sailing boats in Egyptian marine fisheries in general (Table 3).

3. Egyptian marine fisheries management

Fish stock assessment is very important process because it determines: (1) fisheries productivity, (2) the impact of fishing process on fisheries, (3) the effect of changing fishing rates. So it is essential to ensure the fisheries management and optimum exploitation **(Musick & Bonfil, 2005)** by:
- Identify the level of exploitation that gives maximum weighted production in the long term from under study fisheries.
- Fish stocks assessment studies must be direct to fishermen and decision-makers in fisheries management, because these studies answer to number of questions: when and where? What catch? , as well as what is size supposed to catch? and how to fish (fishing methods and tools).

To manage Egyptian marine fisheries and to evaluate its current exploitation situation, the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}) for catch are estimated using the surplus production models. These models deal with the entire stock, the entire fishing effort and the total yield obtained from the

stock, without details about growth and mortality parameters or the effect of mesh size on the age of fish capture .

   To apply **Schaefer model** on Egyptian marine fisheries, the catch and catch per unit fishing effort expressed as ton/standard fishing unit during 22 years (1995-2016) are used.

3.1. MSY and f_{max} for Mediterranean Sea fisheries

   Schaefer model has been applied on Mediterranean sea fisheries during the period from 1995 to 2016 to estimate the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}) for fish catch (Figs.4 & 5). The estimated MSY was $73.0*10^3$ ton at fishing effort of $3.5*10^3$ standard boats. These results confirmed the over exploitation situation in the Egyptian Mediterranean fisheries (Table 4) and coincide with the previous studies dealing with the assessing the fish stocks in Mediterranean (eg. Mehanna, 2009, 2014, 2019a&b; Mehanna and Haggag, 2010&2011; Mehanna *et al.,* 2011; El-Serafy *et al.,* 2015; Hassanein, 2017).
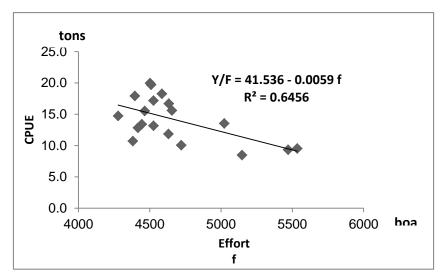

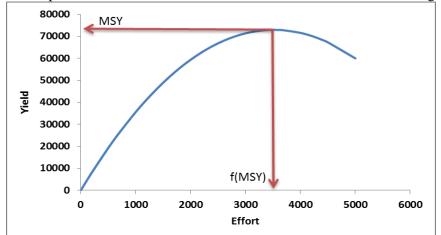**Fig. 4.** Relationship between CPUE and effort in Mediterranean Sea fisheries during 1995-2016

Fig. 5. Yield Curve of Mediterranean Sea fisheries according to Schaefer Model

Table 4. MSY and f_{max} estimated via Schaefer model of Egyptian Marine fisheries during 1995-2016.

Egyptian marine fisheries	Items	Results
Mediterranean Sea	Schaefer Model	$Y = 41.536\,f \pm 0.0059\,f^2$
	MSY * (tons*10^3)	73.0
	f_{max} ** (boats)	3500
	Overproduction %increasing	13.6
	Effort %drcreasing	25.1
Red Sea	Schaefer Model	$Y = 76.21 \pm 0.0234\,f^2$
	MSY* (tons*10^3)	63.1
	F_{max} ** (boats)	1628
	Overproduction %increasing	14.9
	Effort %drcreasing	22.3

3.2. MSY and f_{max} for Red Sea fisheries

Schaefer model has been applied on Red Sea fisheries also to estimate the maximum sustainable yield (MSY) and the corresponding level of fishing effort (f_{max}) (Figs. 6 & 7). It is obvious that the value of MSY is $63.1*10^3$ ton, whereas the value of f_{max} is $1.6*10^3$ boats. The overfishing situation was observed (Table 4) and agreed with all previous studies dealing with tstock assessment of Red Sea fisheries (eg. Mehanna and El-Gammal, 2007; Mehanna, 2005 to 2020; Tesfamichael and Mehanna, 2012; Osman, 2015; Mohamed, 2016; El-Mahdy, 2017; Mehanna _et al.,_ 2016, 2017, 2018, 2019; Mohamed _et al.,_ 2020).
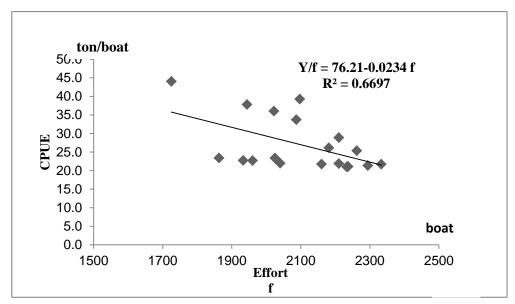

Fig. 6. Relationship between CPUE and effort in Red sea fisheries during 1995-2016.
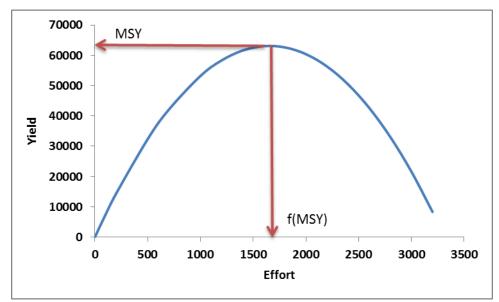
Fig. 7. Yield Curve of Red sea fisheries according to Schaefer Model

In spite of the large area of marine fisheries in Egypt, these fisheries are not exploited rationally due to the decrease of relative abundance of its fish stocks as a result of different reasons such as pollution (domestic and industrial sewages), over fishing and illegal fishing, habitat degradation, human activities on coastal areas, in addition to climate changes. These challenges especially the increasing of fishing effort had affected the sustainability of fish production from Egyptian marine fisheries (Mediterranean Sea & Red Sea fisheries). This situation was proved by applying **Schaefer model (1954)** where the estimated optimum effort was less than the actual one in both seas.

The results (Figs. 5 & 7; Table 4) showed that a maximum sustainable yield of about 73.0 and 63.1 thousand ton could be obtained from Mediterranean and Red seas fisheries, respectively. The estimated optimum fishing effort was 3500 and 1656 standard fishing unit for Mediterranean and Red seas fisheries, respectively. This means that, the present level of fishing effort of the two seas fisheries should be decreased to obtain MSY, while for the catch it will be increased by about 13.6% and 14.9% of its current value by applying the optimum number of vessels.

CONCLUSION

In conclusion, based on the obtained results, the Egyptian marine fisheries are in situation of over fishing. Although, there are some regulatory measures to manage these fisheries like closed season for three months in Red Sea and 45 days in Mediterranean, prohibition any new fishing licenses and any improvements on the fishing boats but these regulations not enforced and not sufficient to conserve our fisheries. So, further studies based on the analytical models to assess and manage the different fish stocks exploited by different fishing gears are required. Also, make a data base about the Egyptian fisheries containing good records for fishery statistics to facilitate the evaluation and managing

these resources is urgent need. As well as, a multi fleet-multi species assessment models should be used in the case of our marine fisheries.

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