Thesis for the Degree of Master of Fisheries Science

Bioeconomic Analysis on the Egyptian Coastal Fisheries in the Mediterranean and Red Seas

by

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KOICA-PKNU International Graduate Program of Fisheries Science

Graduate School of Global Fisheries

Pukyong National University

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지중해와 홍해의 이집트 연안어업에 관한 생물경제학적 분석

Advisor: Prof. Jongoh NAM

by

Marwa Mamdouh Lotfy

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A dissertation

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List of Acronyms

CAPMS	:	Central Agency for Public Mobilization and Statistics
PKNU	:	Pukyong National University
GAFRD	:	General Authority for Fish Resources Development
MALR	:	Ministry of Agriculture and Land Reclamation, Egypt
EAF	:	Ecosystem Approach of Fisheries.
NIOF	:	The National Institute of Oceanography and Fisheries.
IUU	:	Illegal, Unreported and Unregulated fishing
SD	:	Standard Deviation
CPUE	:	Catch Per Unit Effort
CY&P	:	Clarke, Yoshimoto, & Pooley
MSY	:	Maximum Sustainable Yield
MEY	:	Maximum Economic Yield
FFA	:	Forum Fisheries Agency
EPRS	:	European Parliamentary Research Service
MSE	:	Mean Square Error
KOICA	:	Korea International Cooperation Agency
NP	:	Net Profit

OAE	:	Open Access Equilibrium
OLS	:	Ordinary Least Square
NIOF	:	Regional Fisheries Management Organizations
SY	:	Sustainable Yield
STR	:	Sustainable Total Revenue
TC	:	Total Cost
FY	:	Fiscal Year

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Abstract

Fish landing in the Egyptian water has declined substantially on both of the Mediterranean Sea and the Red Sea from 89.943 metric tonnes (MT) and 82.400 metric tonnes in the 1999 to 53.964 metric tonnes and 49.690 MT in the 2016 owing to overfishing. This declined in fisheries is provoked by several factors. The most important of them is the number of fishing vessels used. The aim of this research is to provide current stock and economic situations of marine fisheries in Egypt. The analysis employs catch and effort data of total production to determine biological parameters using surplus production models. The CY&P suitable to estimate maximum sustainable yield (MSY) and fishing effort in MSY (E_{MSY}) is selected, because it appears the model is the finest to

estimate MSY. In addition, bio-economic model based on the CY&P model is developed by the price and fishing cost of all species caught by all fishing gears in the both seas.

The result shows that the main reasons of depletion of the catch cause to the present overfishing efforts due to the reduction of fisheries resources. To achieve the maximum economic rent, the present effort level should be diminished from current overfished fishing efforts to the level of E_{MEY} by implementing taxing fishing effort, reducing trawler fishing gear, and activation of monitoring & inspection systems. In addition, to reduce fishing efforts of the both seas, this research recommends the TAC where every species should be subjected to quota regulation, controlling the mesh size of fishing net to prohibition overfishing and protecting fish juveniles, implementing of Ecosystem Approach Fisheries according to recommended of GFCM, improving the fishery statistics recording system, and introducing the new technologies in recording system to ensure transparency.

Keywords Mediterranean Sea, Red Sea, surplus production model, multiple species and multiple gears, CY&P model, MSY, MEY, OAE.

Chapter I. Introduction

1.1. Background

Egypt is found in the eastern district of the North African continent. It is bordered by the Mediterranean Sea between Libya and the Gaza Strip, from the East of the Red Sea, North of Sudan (Samy, 2015). The country is surrounded by two seas, thereby endowed with much freshwater as opposed to the other North African countries (Fig. 1.1.).

Fishing has being carried out in antiquity and is still a major ongoing exploit. Egypt has a land mass of 1,001.450 km^2 with a water body surface area of 6,000 km^2.

Fishery resources are divided into three main sectors namely marine fisheries, inland fisheries and aquaculture. The marine fisheries cover an extended coastline of about 2,450 km^2 along the Mediterranean and Red Seas.

Inland fisheries includes the river nile, lakes and lagoons. The Nile is the longest river in the country, alongside the Northern lakes of Burullus, Mariut, Manzala and Edku as well as the coastal lagoons cover a distance of 1,532 km^2 and is divided into two major branches, the Rosetta and Damietta. This area is known as the Lower Egypt or Nile Delta. The area is endowed with wealthy inland water and coastal lakes with huge fishery catch and aquaculture potential through numerous irrigation canals and coastal lagoons of Bardawil and Port Fouad. In addition, there are inland lakes like Timsah & Bitter lakes, the closed lakes of Qarun 1, 2, 3 and Wadi Al Raiyan. Also the great reservoir behind the Aswan high dam (Lake Nasser) in

Upper Egypt and some minor water bodies in the western desert have been improved for fisheries production (Toshka and New Valley water bodies). Finely, the third sector, aquaculture, is made up of government farms, private farms, semi intensive, intensive, cages and rice paddy and is currently the major sector in the country.

Table 1.1. Marine and inland water in Egypt

Fisheries	Coastline (Km) or surface area (Km²)
Seas	
Mediterranean Sea	950 Km (Bird 2010)
Red Sea	1500 Km (Bird 2010)
Northern lakes	
Mariout	250 Km²(Ahmed and Ha"der 2011)
Edku	70 Km² (Magdy et al.2008)
Burullus	410 Km² (Shaltout and Al-Sodany 2008)
Manzala	700 Km² (Ramdani et.al.2009)
Coastal Lagoons	
Port Fouad	60 Km² (Mehanna 2007)
Bardawil	650 km² (Mehanna 2007)
Inland Lakes	
Bitter and Temsah	250 and 15Km²
Suea Canal	'(Hamed et al. 2012)
Qarun	235 Km²
Rayan	703 Km² (Sayed and Abdel- Satar 2009)
Nasser	5238 Km² (El-Shabrawy 2009)
Nile Riever	1532 Km (Shawki et al.2005')

Source: (Samy, 2015).

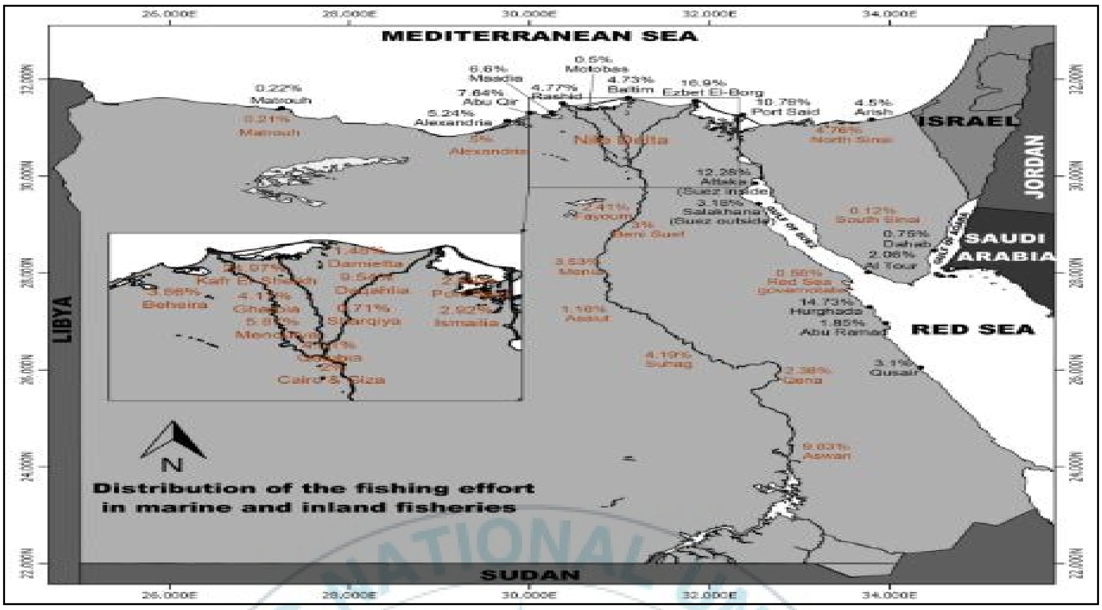

Fig. 1.1. Map of Egypt.

1.2 Global status of fish production of Egypt.

Egypt is a unique country in Africa with a remarkable improvement in development during last ten years. The country's aquaculture sector was nominated by FAO in 2018 as the best in Africa (Table 1.2). The Egyptian aquaculture has expanded rapidly and greatly outpaced traditional fishing activities. As a result of this rapid growth of aquaculture was ranked number ten Worldwide in terms of overall production and number two in Tilapia production. In addition, inland production has improved according last statistics of FAO 2018.

Table 1.2. Aquaculture quantity and percentage of world total production FAO 2018

Region/selected countries	1995	2000	2005	2010	2015	2016
Africa	110	400	646	1 286	1 772	1 982
	0.5%	1.2%	1.5%	2.2%	2.3%	2.5%
Egypt	72	340	540	920	1 175	1 371
	0.3%	1.1%	1.2%	1.6%	1.5%	1.7%
Northern Africa, excluding Egypt	4	5	7	10	21	23
	0%	0%	0%	0%	0%	0%
Nigeria	17	26	56	201	317	307
	0.1%	0.1%	0.1%	0.3%	0.4%	0.4%
Sub-Saharan Africa, excluding Nigeria	17	29	43	156	259	281
	0.1%	0.1%	0.1%	0.3%	0.3%	0.4%

Egyptian fishing fleet is economically profiting of subsidy fuel price significantly which is beneficial not only to the fishing sector but to the country at large. Internationally, Egypt was ranked the eighth country in terms of consumption of subsidies fuel (Eastmed. 2014). Recently the government increase the price of fuel for some industries by 50 percent indicating a likely increase in fuel price in the future (Eastmed 2014).

In 2030, globally the percentage of the world production will increase by 36.7% (from 170,941 to 200,955 MT) and the capture fisheries is expected to reach about 91MT, slightly higher (by 1%) than in 2016. The major growth is expected to originate from aquaculture which is projected at 109 MT.

In Africa, the fisheries production will increase by 20.4% (from 11,260 to 13,556 MT) in general. As result of estimate will be an increase of fish production in Egypt by 55.7% which is expected to come from aquaculture (from 1,706 to 2, 657 MT) but fisheries will increase by

1% hence the fisheries sector is non-redundant in growth evidence of weakness in fisheries management approach (FAO. 2018).

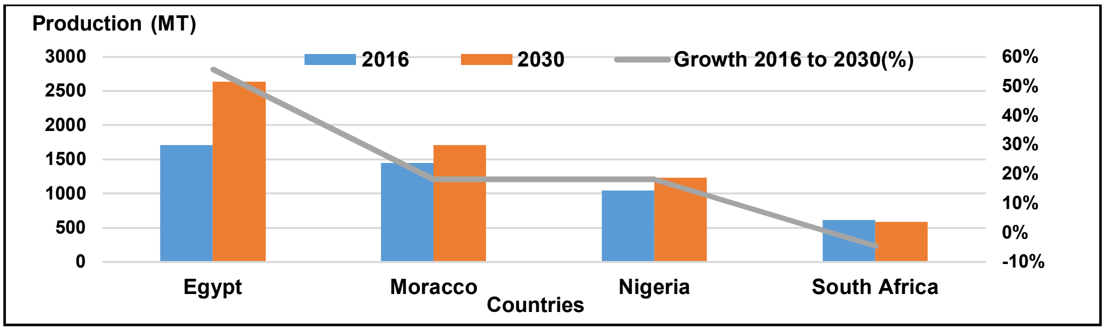

Fig. 1.2. Projected fish production, 2030 (live weight equivalent), (Source: FAO 2018 P: 185).

1.3 Status of fish production in Egypt

Fresh fish is an integral part of traditional Egyptian cuisine and the main source of cheap animal protein source for the lower income population.

Quantity of fisheries consumed in the country is a little bit more than half a million tonnes above the quantity produced locally (FY 2014, 2016). In 2015, the fishery sector contributed 21,179 million of the net national agriculture income EGP (9.47%) while plants and land food animals generated 151,117 million EGP (67.55%) and 51,405 million EGP (22.98%), respectively (GAFRD, 2016).

Fisheries sector has a large working population which has 101 fishermen cooperative associations all over the country according to statistic 2016. The fishermen associations have

88 fisheries associated by 94,347 members of fishermen and stakeholders. They contribute about 184,731 of capital EGP.

Conferring to the statistics recorded in 2016, the overall fish production was 1,706.273 MT (Fig .1.4) according to sectors of marine fisheries including (53,964T by Mediterranean Sea and 49,690T by Red Sea) both seas representing 6.07% of total fish production. Inland waters include northern lakes (8,561T by Maryout, 50,83T by Edku, 67,577T by Burullus and 42,305T by Manzala), coastal lagoons (4,093T by Port Foad & Bardaweel), Nile river & branches by 73,484T and inland lakes (18,352T by Nasser lake, 3,056T by Bitter temsah & Suez canal, 5,966T by Rayan, 2,439T by Water bodies in new valley and 878kg by Qaruon). Marine and inland fisheries production except for aquaculture was 335,613MT made up 20% of total fish production. Finally, aquaculture production (13,078T by government farms, 1,166.147 MT by private farms, 2,268T by semi-intensive & intensive, 175,632T by cages and 13,535T by rice paddy) was 1,370.660 MT, made up 80% of total fish production (Fig 1.3.).

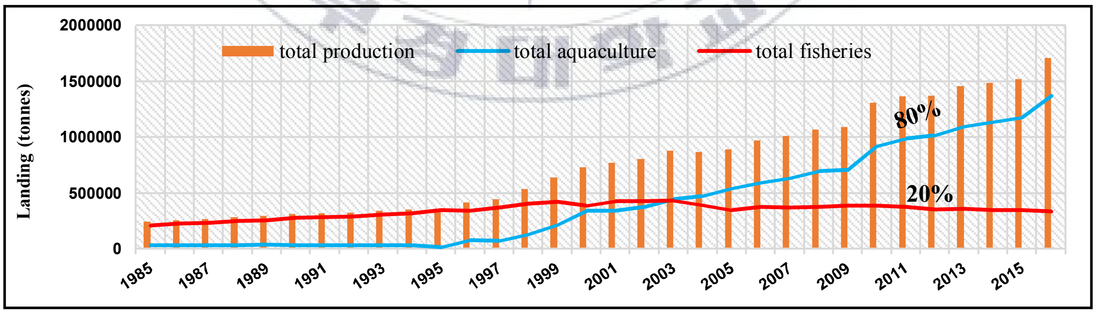

Fig. 1.3. Fish production in Egypt 2016.

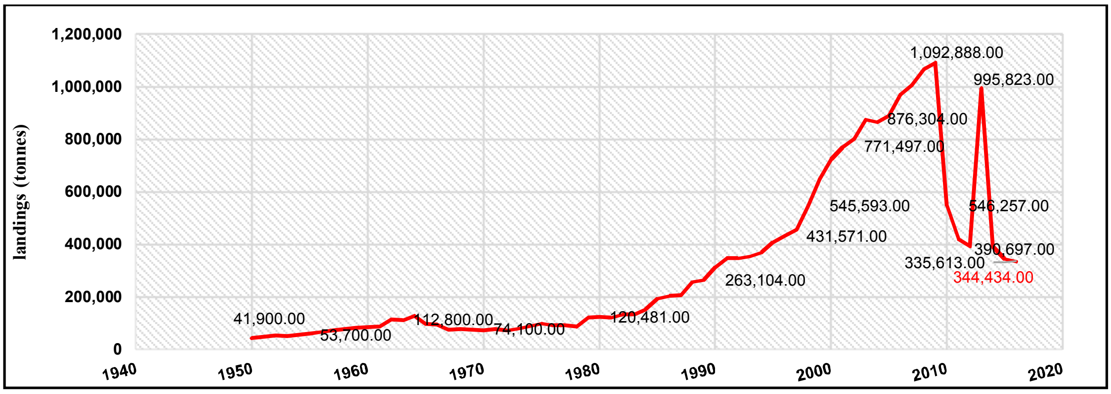

Fig. 1.4. Trend of total fisheries in Egypt over 1950~2016. (FishstatJ).

1.4 Trade of imports and exports

In middle-east countries, fish production has been gradually increasing at a growth rate of 16%. Egypt is the biggest producer in both capture fisheries and aquaculture, supplying 40% of total production. This is followed by The Islamic Republic of Iran (21%) and Turkey (19%). Presently, there are eight countries in Middle East exporting fish products to the EU, including Egypt. Egypt motivated this trade relationship as shown in Fig. 1.5. (FAO fisheries balance sheet 2011).

Egypt, upgraded the fishery trade in 2016 with a domestic output of 1,706.000MT and worth of 32,307.727 EGP, showing an increase of 69% as compared with statistics recorded ten years ago.

The mean per capita consumption 21.64% (1,970.000 MT) with population of 91,023.000 people increases the self-reliance by 8.50%.

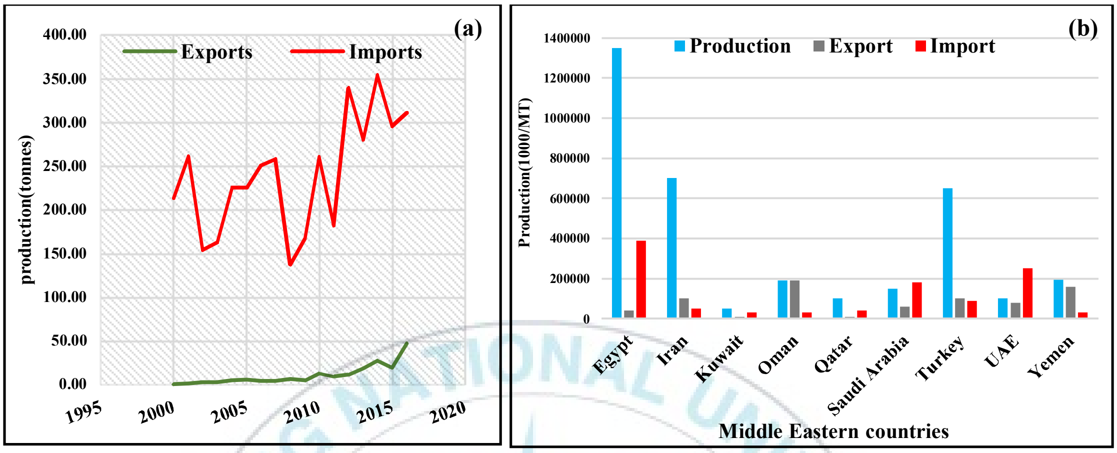

Fig. 1.5. Trend of import & export (a) in Egypt 2000~2016, (b) in Middle Eastern countries.

1.5 Management of fisheries

Egypt started implementing Ecosystem Approach to Fisheries in 2014 (EAF) collaboration with different ministries and organization undertake FAO to enhance fisheries sector. The situations of economic and social objectives will be in need of a broader consideration for ecological values and constraints. This will necessitate broader stakeholders and more research. Recently, the government of Egypt believes that the fish sector (fisheries and aquaculture) is a significant asset which has generated employment prospects for numerous persons, alleviating poverty and encouraging investment projects that will increase revenue which lead to the inevitable enactment of an organized and committed fisheries sector laws. Like the fisheries law No. 124/1983 decree on fishing of aquaculture products and the organization of fish farms) outlining where and how aquaculture is carried out in Nile water and permits the using of water from drainage channels or lakes. Law No. 190/1983 decree formation of the General Authority for Fish Resources Development (GAFRD) aims are to advance the national economy in the fishery sector and institute schemes lead to vertical-extension and horizontal-extension in this sector.

1.6 Purpose of research.

For the past ten years the Egyptian fisheries products have faced a radical evolution. (Mohammed, 2015) but the fisheries sector continued to decline to the tune of 20% which is proof of flaw in the control of maritime fisheries assets. Hence, there is the need to focus on viable fisheries control, using appropriate management plan to reduce the exhaustion of fish stocks and curb overfishing (Mohammed, 2015). Consequently, the Mediterranean Sea and Red Sea are preferred research site for the domineering role they play contributing to fish production in the country. In addition, the geometrical increase in population increases the pressure on fisheries sector as demand for fish increases (Mahmoud *et al*., 2017). The estimate of both the biological and economical parameters can be realised using a bio-economic model, according to the results of Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and Open Access Equilibrium (OAE) level.

This research will supplementary explicate in detail as follows:

1. Define the preferable appropriate surplus production models, which can be workable fisheries of Mediterranean Sea and Red Sea.
2. Determine the effort and catch at MSY is analyzed biological parameters to discern the effort levels at MEY that gives the maximum rent and at OAE using the economic parameters, price and cost (Marezo, 2018).
3. Identify possible management implications of the fisheries ecological and economic conditions in the research area.

The objective of the research is to confront the main challenges facing the Egyptian fishery resources and how to overwhelm them.

Chapter II. Status of Marine Fisheries in Egypt

2.1 Fisheries of Mediterranean Sea

2.1.1 Description of the catch

Fishing is one of the utmost universal anthropogenic activities affecting the marine environment. The fishing surroundings along the Egyptian Mediterranean coast are divided into four regions which are assisted by 10 fishing ports (Damietta (Izbet El-Borg), Madaaia, Arish, Abu Qir, Alexandria (Anfoshi), Baltim, Matrouh, Motobas (Burullus), Port Said and Rashid). The amount catch was 53,964 tonnes.

Table 2.1. Total catch per ports in Mediterranean Sea / MT- 2016

Region	Catch (tonnes)
Western	
Matrouh	339
Alexandria (Alexandria,Abo qir)	4985
Beheira (Rashed,Miaddiyah)	10000
Middle Delta	
Kafr El-shiekh (Baltim, Mtobas)	11883
Damietta	
Damietta	10859
Eastern	
Port said	14426
North Sinai (Arish)	1472
Total Catch	53964

It has a wide biodiversity (FishBase and the Global Biodiversity Information Facility). The marine ichthyofaunal of the Mediterranean comprises >700 species (Froese and Pauly, 2016)

Overall, 956 fish species (71 Elasmobranchii, 2 Holocephali and 883 Actinopteri) have been recorded to date from the Egyptian marine waters. Of these, 263 species are present only in the Mediterranean Sea.

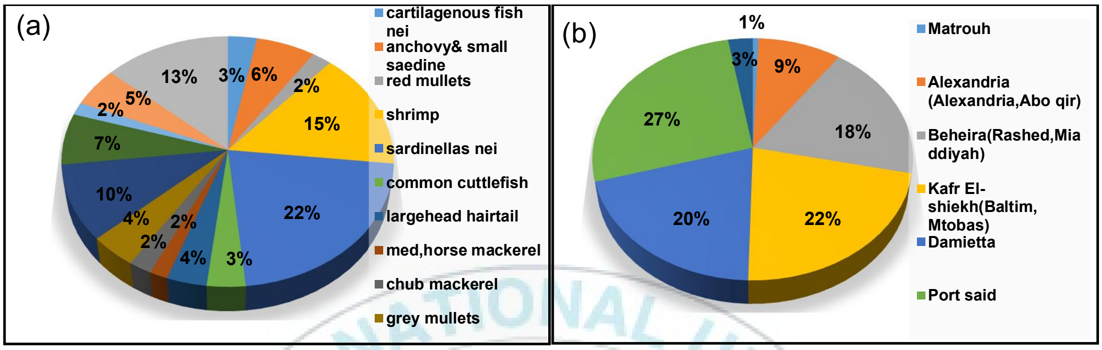

Fig. 2.1. Species composition percentage target species (a), catch per ports (b) in Mediterranean Sea 2016.

The target species are Sardines, Sardinella aurita and Sardina pilchardus which are the most landed species (15.34 %) followed by shrimps including Penaeus japonicus, Metapenaeus stebingi, Penaeus semisulcatus & Trachypenaeus curvirostris (9.57 %), molluscs (5.78 %), bogue Boops boops (5.23 %), grey mullets Mugil cephalus, Liza aurata, Liza ramada (5.22 %) and anchovy Engraulis encrasicolus (4.19 %). Almost landings from trawler and purse seine fishery (Mohamed, 2015).

In 1999, the total fish production was 89,943 tonnes whereas in 2016 the total fish production was 53,964 tonnes showing a decreased by 35.97 %. In addition, Egypt has IUU catch from all sectors including industrial, artisanal, subsistence, recreational fishing, by-catch and discards are a waste of our stock. This is the main problem in Egyptian fishery sector causing the decrease in the quantity of the landing.

2.1.2 Description of the fishery

The total numbers of the registered motorized vessels in the Mediterranean were about 3,110 vessels and the non-motorized vessels were about 1,157 vessels. The motorized fleet employed about 15,281 fishers and most of the fishing boats are hoary vessels which fish close to the coast with traditional fishing gears. The motorized vessels include four main gears namely trawler 24%, purse seines 6%, polyvalent 15% and long line 28%. Non-motorized are 27%.

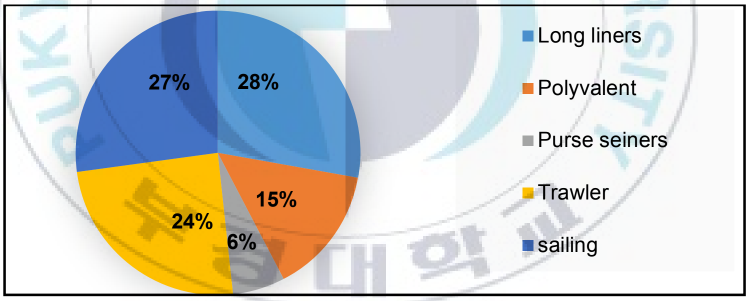

Fig. 2.2. Gears composition of the Mediterranean Sea.

a) Trawl fishery

Trawl systems are playing a main role in the commercial fishery. Most of the landing is carrying out by trawls. In particular, 65% of total Egyptian landing is upcoming from trawl fishery and the uppermost fishing effort was recorded in Ezbet El-Borg port with almost 17 % of the total motorized vessels according to engine power between 50 more than 800 HP (Mohammed, 2015).

Trawls can be distributed into three categories constructed on the place of fishing: surface (Beam trawlers), midwater (pelagic trawlers) and bottom (trawlers). Bottom trawler has a negative impact on seabed which is an important problem in Egypt. Trawls can be divided into three length categories (LOA) of fleet by GFCM. First, trawlers (>24 meters): the total number of vessels was 39 operating far from the coast and in depths of more than 500 meters. Secondly, trawlers (18-24 meters): this is the most important sector of production, encompassing half of production and employing about 1/3 of fishers. There are more than 800 vessels working 195 days per year targeting mainly species like, shrimp, lizardfish, red mullets and cuttlefish. Thirdly, trawlers (12-18 meters): the total number is 210 vessels and employment is about 1,715 fishers, they operate in coastal and shallow water targeting mainly red mullets and lizard fish.

b) Long line fishery

Long line is a fishing gear that is comprise of a main line with subordinate lines attached and hooks placed on the end of them (Canterla, 1989). Long line is a very old gear, derived from "volantín" or "three hook line", which is utilized by the Egyptians in the Mediterranean Sea (Canterla, 1989). The pelagic long line is designed to catch widely distributed pelagic and semi-pelagic fish. This gear is very efficient in catching tunas, billfish, and others. This can be on the surface or at the bottom. Lines can moreover be set by means of an anchor or left to drift. Hundreds or even thousands of baited hooks can hang from a single line. Long liners can be set to hang near the surface (pelagic long liner) to catch fish such as tuna and swordfish or along the sea floor (demersal long liner) for ground fish such as halibut or cod (Wikipedia, 2018). There is a total of 1,185 vessels, comprising 28% of the fleet capacity and employing 27% of fishers. The average length is between 12~24 meters, with average engine power range 10~120 HP. The highest of fishing effort was registered in Said port and Baltim port respectively (Wikipedia, 2018).

c) Purse seines

Purse seines is second commercial fishing gear represent 66% of total catch and it is a favoured technique for capturing fish species which aggregate nearby to the surface such as : mackerel, sardines, herring, anchovies, certain species of salmon and tuna soon. Light is used at night to attract and capture offshore pelagic fishes at depths further than 40 meters. The total number of vessels used is 253 with average length between 12~24 meters with average engine power range of 30~500 HP. The height of fishing effort was registered in Port Said, Arish and Madaaia. Purse seine made up 20% of total motorized vessels.

d) Polyvalent and other non-motorized vessels.

Polyvalent and small-scale vessels with engine realise 19% of the total catch and represent 15% of total motorized vessels. The foremost gears utilized were the trammel net and gill nets. The average engine power ranged from 10~150 HP and the height of fishing effort of motorized vessels registered in ports of Arish 26%, Abu qir 24% and Madaaia 19% respectively. Non-motorized vessels were about 1,157 which made up 27% of the total vessels but landing was not reported.

2.2 Fisheries of Red Sea

2.2.1 Description of the catch

The Red Sea fisheries production was contributed by 15% (49,690) tonnes of the total natural fisheries production in 2016 (GAFRD 2016). Worth mentioning that the total catch was a decline from 12.94% (in 1999) to 2.91% (in 2016) of the total production of the Red Sea.

There are three main regions on the Red Sea coast including Gulf of Suez, Red Sea and South sinai. They are represented by 21%, 63% and 10% of the total catch, respectively. Those regions include fishing ports: Gulf of Suez (Attaka, Salakhana, Ras gharib and El-Tor), Red Sea (Hurghada, Safaga and Abu Ramad) and South Sinai (Table 2.2).

Table 2.2. Total catch of ports in Red Sea / MT-2016

Region	Catch (tonnes)
Suez	10611
Red Sea	34229
South sinai	4850
Total	49690

The marine fisheries capture has a diversity of species. The furthermost landed species in 2016 were presented as anchovy 6%, horse mackerel 20%, sardinellas 14%, lizasrfish 9%, groupers 6%, jacks 4%, threadin bream 5%, japonicas 7.4%, branded barracuda 3% and indan mackerel 6% of total catch (Fig. 2.3.).

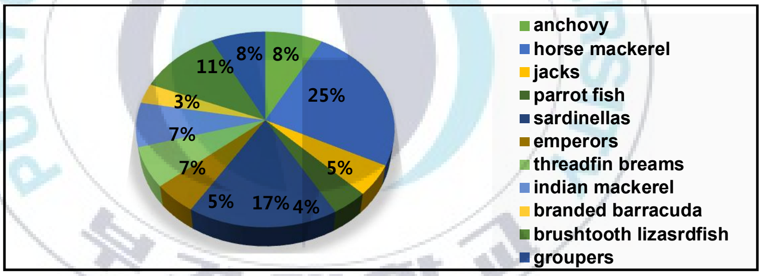

Fig. 2.3. Species composition percentage of the most commercial species in Red Sea 2016.

2.2.2 Description of the fishery

The total numbers of the Egyptian registered motorized vessels were 1,845 vessels, while the non-motorized vessels were 67 vessels. About 3,239 fishers were employed in the motorized fleet and most fishing vessels were old according to 2016. Some fishers fish nearby the coast with traditional fishing gears. The main problem in Red Sea is recreational activities. The Red Sea is one of famous areas where recreational activities are practiced. The activities are diving, snorkeling and water sports. Moreover, its distinct marine environment with coral reefs, mangroves and sea grass beds are attractive to touristic activity. It is of considered economic benefit but it has consequences as unreported catch leads to uncontrolled fishing. According to registered data the number of recreational vessels summed up to 3,465.

a) Trawl fishery

Trawl systems are occupying a main role in the commercial fisheries and the maximum fishing effort was registered in Suez port with 126 vessels from the total trawler motorized vessels, the average engine power ranged 400 to more than 800 HP. The total trawler catch in Red Sea was 13,536 MT (27 %).

b) Long line fishery

The long line gear is very efficient in catching tunas, billfish, groupers 33%, emperors 22%, parrot fish 18% and others. The total catch was 9,008 MT (15 %). The total number of vessels was 948, which is 50 % of the fleet capacity and the average length vessels was between 12~24 meters and the average of engine power range 10~120 HP. The height of fishing effort by long liner was registered at all ports of Red Sea.

c) Purse seines

Purse seines affected 42 % of total catch and it is a favourable technique for capturing fish species which are close the surface including sardines 27%, mackerel 39%, anchovies and herring. The total number of vessels was 117 vessels, it represented 6% of total vessels and the height of fishing effort was registered especially in Suez port.

d) Karkaba & Crab net, Polyvalent and other non-motorized vessels.

The gear called crab net, has the length range 30~40 m and width range 75~100 cm. The total number of vessels was 318 vessels and working in Suez port. The trammel net was modified into Tammded and Karkaba nets. This modification is to increase catch ability of the net. The polyvalent vessels was 336 and the height of fishing effort were registered in the Red Sea port and South Sinai port. The main target species were grey mullet 72%, stripes piggy 26% and rabbit fish 47%. The average engine power range 10~150 HP. Non-motorized vessels were 67 (4%) of total vessels but landing is not reported.

Chapter Ⅲ. Materials and Methods

3.1. Method of models

3.1.1. Surplus production models

The Surplus production models is usually utilized in fisheries analysis to discovery biological parameters (Pascoe.1995). These models are derived from catch and effort data.

The Schaefer, Schunte and Walter & Hilborn models have logistic yield-effort relationship. While, the Fox and CY&P models are following exponential yield-effort relationship or a Gompertz curve (Richard, 1959).

The Schaefer, Schnute, WH, Fox, and CY&P models showing the equation for estimating surplus production in Table 3.1.

Table 3.1. Estimating equation for surplus production models

Model		Equation
Logistic Growth Models		
1	**Schaefer**	$(U_{n+1} - U_{n-1}/(2U_n) = r - (r/qK)(U_n) - q(E_n)$
2	**Schnute**	$\ln(U_{n+1}/U_n) = r - (r/qK)((U_n + U_{n+1})/2) - q((E_n+E_{n+1})/2)$
3	**Walter & Hilborn (WH)**	$(U_{n+1} - U_{n-1}) - 1 = r - (r/qK) U_n - qE_n$
Exponential Growth Models		
4	**Fox**	$(U_{n+1} - U_{n-1})/(2U_n) = r \ln(qK) - r \ln(U_n) - q(E_n)$
5	**CY&P**	$\ln(U_{n+1}) = (2r/(2+r)) \ln(qK)] + ((2-r)/(2+r)) \ln(U_n) - (q/(2+r))(E_n+E_{n+1})$

Source: CY&P, 1992 (p. 119-120).

Toward defining the parameter r, q and K, ordinary least squares (OLS) regression with time series data of catch and effort was utilized. The analyzed function can be predestined applying the P-Value, coefficient of determination (R^2) and the validation of the insignia of each coefficient. The population will embed the natural carrying capacity of environment (K) cause natural variability at this level and the population growth halts and growth ratio of individual fish slows down. Intrinsic growth rate (r) rises in the number of organisms per unit of time and it is will be highest at intermediate levels (Cochrane, K.L. 2002).

Logistic growth model with maximum sustainable yield (MSY)

The level of MSY able to sustain for indeterminate period of time, due to its large harvest and this happens at the level where the natural yearly net growth of the fisheries stock is maximized (Marezo, 2018).

The base on the Schaefer model, as all subsequent the surplus production models, it is presumption that the biomass of next year (B_{y+1}), it is define by biomass of this year (B_y) the growth in biomass meantime the year, G_y, and the level of the catch, C_y:

$$B_{y+1} = B_y + G_y - C_y \quad (1)$$

The surplus growth of the population was presumed by Schaefer to be logistic, given by:

$$G = r B (1 - B / K) \quad (2)$$

Wherever K is the carrying capacity of environment, r is the intrinsic growth rate (both constant). Hence, when B = K, growth is equal zero.

Additional key assumption of the Schaefer model is (CPUE) which commensurate to the stock biomass, by:

$$U = q\,B \qquad (3)$$

Wherever U is CPUE and q is the catchability coefficient. The catch is equal to the (U) times the level of effort, by:

$$C = q\,B\,E \qquad (4)$$

Wherever E is the level of fishing effort.

At the equilibrium condition, the catch is equal to the growth rate, therefore, that $B_{y+1} = B_y$, equating equation 2, 4, by:

$$qEB = rB\left(1 - \frac{B}{K}\right)$$

$$B = K\left(1 - \frac{q}{r}E\right) \qquad (5)$$

Replacing equation 5 into equation 4, an idiom can be resulting relating to the sustainable level of catch to the effort.

$$C = \alpha E - \beta E^2 \qquad (6)$$

That $\alpha = q\,K$, while, $\beta = q^2K / r$

The effort level is give rise to in the maximum sustainable yield (MSY), that E_{MSY}, it might be attained by setting the first order derived, dC/dE, to zero:

$$\frac{dC}{dE} = \alpha - 2\beta E = 0$$

$$E_{MSY} = \frac{r}{2q} \qquad (7)$$

By attention of the (C_{MSY}), this one is determined by substituting equation 7 into the catch equation 6, by:

$$C_{MSY} = q\left(\frac{r}{2q}\right)K\left(1 - \frac{q}{r} \cdot \frac{r}{2q}\right)$$

$$C_{MSY} = \frac{rK}{2}\left(\frac{1}{2}\right)$$

$$C_{MSY} = \frac{rK}{4} \quad (8)$$

Maximum sustainable yield (MSY) in the exponential growth model

The exponential growth models, based on the Gompertz growth function, they are the logistic growth curve presumed in the Schaefer model by:

$$G = r\ B \ln (K / B) \quad (9)$$

Different the logistic growth curve that is parabolic with maximum growth occupying at K/2, an exponential growth curve is deviated.

The surplus production models, founded such a growth assumption was adjusted by Fox (1970). By way, per the Schaefer model, the sustainable yield (SY) is tantamount to the growth of the population, by

$$C = r\ B \ln (K/B) \quad (10)$$

Foreseeable, that CPUE, is evidence to the percentage of the biomass, by equation 10 can be define as:

$$C = \frac{rU}{q}\left[\ln \frac{U_\infty}{q} - \ln \frac{U}{q}\right] \quad (11)$$

Wherever U□ is (CPUE), that would be happen, if the stock was not exploited (U□ = q k). Intensifying out the right hand side outcomes in the cancellation of the ln (q). Hence, that equation 11 can be simply as

$$C = \frac{rU}{q}[\ln U_{\infty} - \ln U] \tag{12}$$

Separating the equation 12, by U result as:

$$E = \frac{r}{q}(LnU_{\infty} - LnU) \tag{13}$$

That E is the level of effort depleted in the fishery. This can be resign to generate:

$$LnU = LnU_{\infty} - (q/r)\,E \tag{14}$$

Through equation 14, in the Fox model that the mean of CPUE, can be approved as

$$U = U\ \ e^{-\left(\frac{q}{r}\right)E}$$

Hence, the catch can be conveyed by:

$$C = U\ \ E\,e^{-\left(\frac{q}{r}\right)E} \quad \text{or}$$

$$C = \ qkE\ e^{-\left(\frac{q}{r}\right)E} \tag{15}$$

The effort level of the maximum catch is acquired in the Fox model, by:

$$\frac{dC}{dE} = qke^{-\left(\frac{q}{r}\right)E}\left(1 - \frac{q}{r}E\right) = 0$$

Distributing both side by $qke^{-\left(\frac{q}{r}\right)E}$ and resolving the resultant equation for E, by:

$$E_{MSY} = \frac{r}{q} \tag{16}$$

3.1.2. Bio-economic model

Fundamental bio-economic model is a valuable structure to present various biological and economic concepts. Its integrate both of biological and economic parameters for a fishery through the models (Thunberg *et a.,* 1998). At any time, the yield is a purpose of fishing effort and bulk of the fish stock.

The logistic growth model with maximum economic yield (MEY)

The portion of the logistic growth model utilized by Schaefer model, the resulting effort and catch relationship was absolutely by Gordon (1954), who created it to improve the first bio-economic models of fishery as giving:

$$Max\,\pi = TR - TC$$

$$\pi = P.Q - c.E$$

$$\pi = P(\alpha E - \beta E^2) - c.E$$

$$\pi = P.\alpha E - P\beta E^2 - c.E \qquad (17)$$

Henceforth, E, at the maximum economic yield, E_{MEY}, it can be observed using the first order condition by:

$$\frac{d\pi}{dE} = P\alpha - 2P\beta E - c = 0$$

$$2P\beta E = P\alpha - c$$

$$E_{MEY} = \frac{P\alpha - c}{2P\beta}$$

$$E_{MEY} = \frac{P\alpha}{2P\beta} - \frac{c}{2P\beta}$$

$$E_{MEY} = \frac{\alpha - \frac{c}{P}}{2\beta} \quad (18)$$

Fishing in open access equilibrium (OAE)

The open access equilibrium (OAE), arises that when wholly rentals have been squandered, like that P=0. While that, the effort level at OAE can be predestined by setting equation 17 to zero, as:

$$TR - TC = 0$$

$$P.\alpha E - P\beta E^2 - c.E = 0$$

$$P.\alpha - P\beta E - c = 0$$

$$P\beta E_{OAE} = P.\alpha - c$$

$$E_{OAE} = \frac{\alpha - \frac{c}{P}}{\beta} \quad (19)$$

Maximum economic yield (MEY) with the exponential growth model

Likewise, in the Gordon-Schaefer bio-economic model, the total revenue (TR) in the Fox model can be defined as a fishing effort function by reproducing equation 15 by adding price, p: $R = pqkE\ e^{-\left(\frac{q}{r}\right)E}$ (20)

That the total cost (TC) is still derivative as a function of effort

$$C = cE \quad (21)$$

Thus the total rent (P) in the fishery is assumed by subtracting equation 21 to equation 20

$$P = pqkE\, e^{-\left(\frac{q}{r}\right)E} - cE \tag{22}$$

Henceforth, the level of effort that turn out the maximum economic yield, E_{MEY}, it able to found using the first order condition for profit maximization (Marezo, 2018).

$$\frac{dP}{dE} = pqke^{-\left(\frac{q}{r}\right)E}\left(1 - \frac{q}{r}E\right) - c \tag{23}$$

That E_{MEY}, cannot basically be explicated as a function of the model parameters, for the exponential function as compare to the associated equation in the Gordon-Schafer model (Marezo, 2018). The relation can be foremost expressed as:

$$E_{MEY} = \frac{r}{q}\left[1 - \frac{c}{pqk}e^{\left(\frac{q}{r}\right)E_{mey}}\right] \tag{24}$$

Fishing in open access equilibrium (OAE)

The open access equilibrium, through the Gordon-Schaefer model, the effort level in open access equilibrium possibly be appraised by setting equation 22 to 0, as:

$$pqke^{-\left(\frac{q}{r}\right)E} = c \tag{25}$$

Also, the left-portal side of equation 25 is the average revenue per unit of effort (R/E), but the right-portal side is the average cost per unit of effort, (C/E) (Marezo, 2018). Resolving equation for E as:

$$E_{OAE} = \frac{r}{q}[\ln(pqk) - \ln(c)] \tag{26}$$

Equations for logistic and exponential growth models, are summarized in Table 3.2.These equations include effort, catch, biomass and net rent of each MSY, MEY and OAE (Marezo, 2018).

Table 3.2. Statistic and dynamic equation at bioeconomic models

Level	Parameter	Logistic Growth Mode	Exponential Growth Model
Catch	Equation	$qkE(1-qE/r)$	$qkE\ e^{-(q/r)\ E}$
MSY	Effort(E_{MSY})	$r/2q$	r/q
	Catch (C_{MSY})	$Kr/4$	$qKE_{MSY}\ e^{-(q/r)\ Emsy}$
	Biomass (B_{MSY})	$k(1-qE_{MSY}/r)$	$k\ e-(q/r)\ E_{MSY}$
	Net.rent (π_{MSY})	$pC_{MSY}-vE_{MSY}$	$pC_{MSY}-vE_{MSY}$
MEY	E_{MEY}	$r(1-v/(pqK))/(2q)$	$r/q[1-(v/pqK)e^{(q/r)E}{}_{MEY}]$
	C_{MEY}	$(Kr/4)\ [1-(v/(pqK))2]$	$qkE_{MEY}/\ exp\ (E_{MEY}\ q/r)$
	B_{MEY}	$C_{MEY}/(qE_{MEY})$	$C_{MEY}/(qE_{MEY})$
	π_{MEY}	$pC_{MEY}-vE_{MEY}$	$pC_{MEY} – vE_{MEY}$
OAE	E_{OAE}	$r(1-v/(pqk))/q$	$r/q[LN(pqK)-LN(v)]$
	C_{OAE}	$qkE_{OAE}\ (1-qE_{OAE}/r)$	$qkE_{OAE}\ e^{-(q/r)Eoae}$
	B_{OAE}	$Ke^{-(q/r)Eoae}$	$K(1-qE_{OAE}/r)$
	π_{OAE}	$p\ C_{OAE}\ v\ E_{OAE}$	$p\ C_{OAE}\ v\ E_{OAE}$

3.1.3. Economic data price, fishing cost and production value rate

The fish prices (price received by the operator), the fishing cost and the harvest ratio are considered 3 essential keys that can determinant of economic conditions in a fishery. The change in per capita can have insignificant impact on the financial capability of vessels operating in a fishery and the return from the utilization of fisheries stocks. These (P, c) are stated in real term (USD) (Marezo, 2018).

Price

Egypt is improving the macroeconomic performance throughout the last decade, by following IMF advice on fiscal, monetary and the structural reform policies. As a result, it is managed to tame inflation, slash budget deficits and attract more foreign investment. Egypt has devalued the pound several times in the past year (US government, 2004). In addition, in 2016, currency to float freely reduced its value by almost **50%** against the dollar.

The annual average prices of all species caught by all fishing gears in 2014, 2015 and 2016 in the Mediterranean Sea, calculated by catch ratio of individual species caught by individual fishing gears, were 26.65 EGP, 33.478 EGP and 38.752 EGP, respectively. The average price of the last three years was calculated as 32.96 EGP (4.7US$) based on Table 3.3. In particular, the trawler had higher price more than the other gears. The price of the trawler was 53% on the average for the above three years. In addition, the proportion of the average prices for the above three years of other fishing gears were 27% of purse seine, 9% of long liners, 11 % of polyvalent in Mediterranean Sea, respectively.

Table 3.3. Average price 2014~2016 in Mediterranean Sea

	Gears of Mediterranean Sea											
Gear	Trawler			Purse seiners			Polyvalent			long liners		
Year	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
Weight price	36.4	43.8	53.2	16.8	24.8	26.9	23.5	25.3	28.6	32.1	39.1	40.7
Price	13.9	17.4	21.7	6.3	10	10.9	3.7	3.2	3.4	2.8	2.8	2.8

The annual average prices of all species caught by five fishing gears in the Red Sea in 2014, 2015 and 2016 were 28.19 EGP, 36.13 EGP and 39.861 EGP, respectively. The average price of the last three years was calculated as 34.73 EGP (4.96 US$) based on Table 3.4. In particular, the purse seiners have higher price more than that of other gears. The price of the purse seiners represented 40% of the average price for the recent three years. In addition, the proportion of the average price for the recent three years of other fishing gears is 31% of trawler, 25% of long liners, 4 % of polyvalent and karkaba in the Red Sea, respectively.

Table 3.4. Average price 2014~2016 in Red Sea

Gear of Red Sea															
Gear	Trawler			Purse seiners			Polyvalent			Long liners			Karkaba		
year	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
weight price	29.08	39.34	9.29	22.7	30.5	37.	28.34	32.21	41.4	39.35	41.8	48.3	23.3	30.1	36.7
Price(EGP)	9.25	11.9	10.7	9.9	13.	18.9	0.2	0.16	0.18	7.95	9.2	8.7	0.87	1.2	1.2

Fishing cost

In the short term, recital analysis was shown to all the segments with available data. The data were estimated through an Eastmed project by FAO in cooperation with GAFRD. The survey of this study includes the socioeconomic situation in Mediterranean Sea. In Red Sea, the data were collected by GAFRD in the same format for the Eastmed project for improving on short term performance our fleet. Fishing cost is composed of unit cost, fishing efforts, and catch ratio by individual fishing gear. Unit cost implies that all costs involved in fishing such as energy costs, maintenance costs, operational costs, commercial costs and fixed costs.

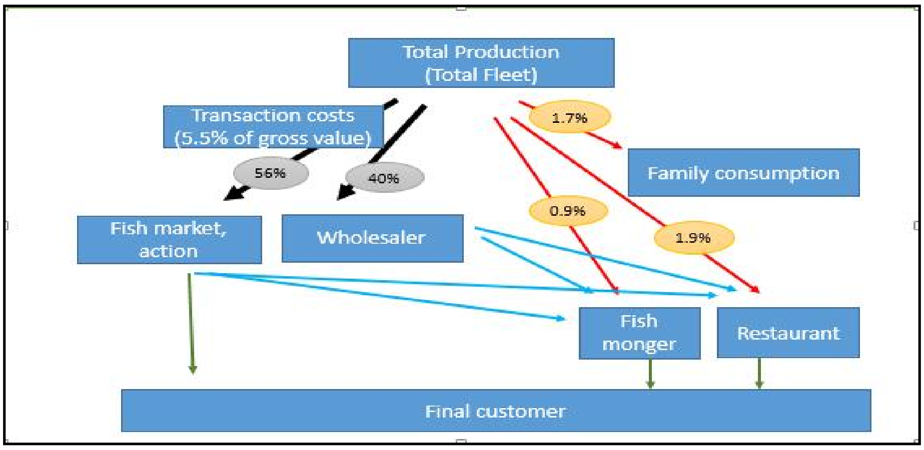

Fig. 3.1. Main fish sale market by the motorized vessels. (Source: Eastmed, a-as944e).

The labor costs occupied 40% of the total revenue based on that most vessels are depended on the manpower than equipment. The important point is that energy costs are 38% and 35% of Mediterranean Sea and Red Sea, respectively based on Fig. 3.2. With an increased fuel cost or a smaller amount of subsidies, the sector will be affected negatively and increasing of the costing.

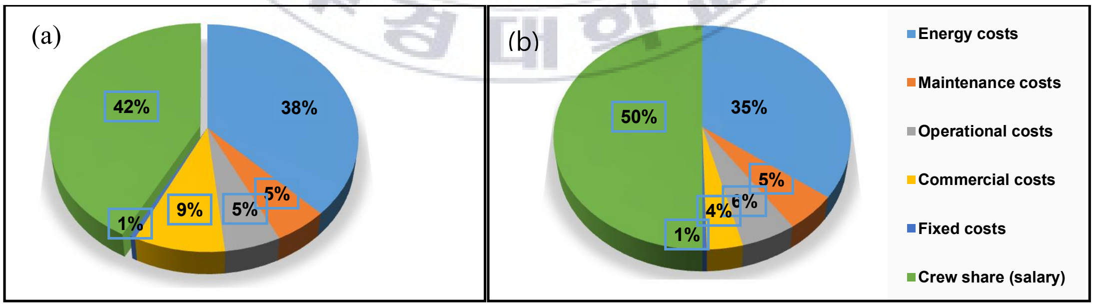

Fig. 3.2. The cost structure in Mediterranean Sea (a) and Red Sea (b).

The unit cost of Mediterranean Sea was 375.15 EGP (4.9US$) by four fishing gears as shown in Table 3.5. and the unit cost of Red Sea was 250 EGP (4.7 US$) as shown in Table 3.6. by five fishing gears.

Table 3.5. The Unit Cost of Mediterranean Sea

Year/ Gear	**Trawler**	**Purse seiners**	**Polyvalent**	**Long liners**
Total Cost EGP				
2015	48,066.510	13,430.779	19,897.694	43,217.634
2016	98,633.080	14,222.387	24,524.856	38,273.173
Unit Cost				
2015	192	218	1,110	539
2016	361	218	1,166	480
Average	277	218	1,138	510
Weighted2015	76	88	142	39
Weighted2016	148	89	137	32
Weighted	112	88	140	36
Unit cost (HP)	375 EGP			

Table 3.6. The unit cost of Red Sea

Year/Gear	**Trawler**	**Purse seiners**	**Polyvalent**	**Long liners**	**Karkaba & crab net**
Total cost EGP					
2015	6,684.746	6,608.796	12,083.327	35,860.654	4,739.966
2016	11,847.253	6,577.151	13,226.889	30,618.538	6,373.378
Unit cost					
2015	80	98	952	783	365
2016	164	105	1,029	691	481
Average	122	102	990	737	423
Weighted2015	23	44	5	174	14
Weighted2016	45	53	5	125	16
Weighted	34	48	5	148	15
Unit cost (HP)	250 EGP				

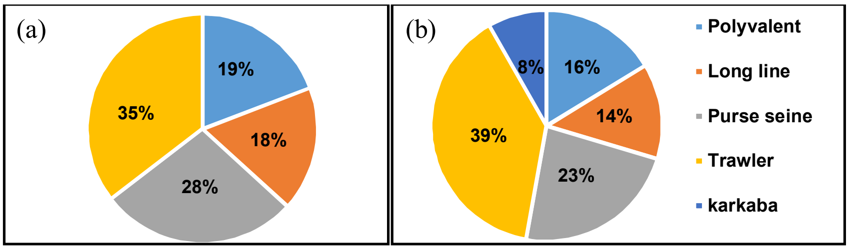

Fig. 3.3. The percentage of the cost per gears in Mediterranean Sea (a) and Red Sea (b).

Production value rate

The distribution of production of Mediterranean Sea and Red Sea compared to the identical distribution of the values differ significantly with different fishing gears based on Fig 3.4.

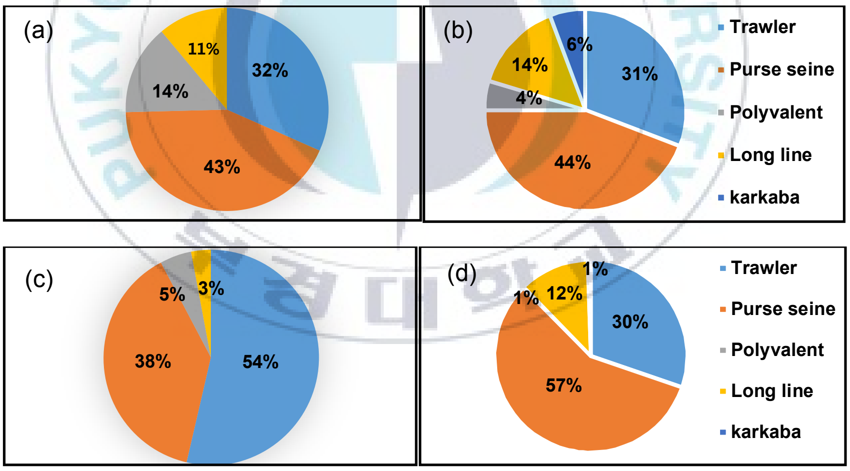

Fig. 3.4.The distribution of production (a) in Mediterranean Sea, (b) in Red Sea and production value of (c) Mediterranean Sea, (d) in Red Sea.

During the period 1985~2016 the contribution of production according to fishing gears in Mediterranean Sea was highest 43% by purse seiners then 32% by trawler and the average of production value was highest 54% by trawler then 38% by purse seine. In Red Sea, in the same period the contribution of production shown the highest of 44% purse seine then 31 % of trawler and the average of production value shown the highest of 57% purse seiners then 30% of trawler and other gears based on Fig. 3.4.

3.2 Data source.

Fishery sector falls under the authority of the General Authority for Fish Resources Development (GAFRD). The GAFRD collects the statistics data annually from all ports and additionally undertake research from specialized researchers are from within the GAFRD or from the cooperation of organizations. Fisheries statistics are collected but require more accuracy of quality (FAO 2010).

To analysis stock assessment in this research the catch of both were expressed of the total production in weight, while the efforts were expressed the number of vessels contributing in the fleet using motorized vessels (HP). Catch and effort data on marine fisheries grasped by different gears through 1985~2016 period were shown in Table 3.7.

The annual catch of Mediterranean Sea was collected by four fishing gears including 67% of trawler, 66% of purse seine, 19% of polyvalent and 11% of long liners and it was represented 16% of total catch of inland water. The annual catch of Red Sea was collected by five fishing gears including 51% of purse seiners, 27% of trawler, 18% of long liners and 3% of polyvalent & karkaba, which was represented 15% of total catch of inland water.

Table 3.7. Catch and effort data of Mediterranean (a) and Red Seas (b), 1985~2016

(a) Year	Total Catch	Effort per Horse power(HP)
1985	33,000	245,480
1986	33,000	217,104
1987	33,000	217,104
1988	36,000	336,940
1989	36,000	336,940
1990	35,500	336,940
1991	40,000	245,480
1992	44,000	336,940
1993	45,000	217,104
1994	45,600	217,104
1995	43,700	238,315
1996	51,089	269,137
1997	52,748	279,614
1998	68,000	259,785
1999	89,943	144,337
2000	59,000	280,032
2001	59,624	288,013
2002	59,619	301,858
2003	46,973	324,090
2004	47,481	313,496
2005	56,721	314,466
2006	72,666	327,233
2007	83,762	322,088
2008	88,882	335,078
2009	78,790	325,853
2010	77,388	385,353
2011	77,799	352,761
2012	69,332	369,959
2013	63,030	392,077
2014	62,746	409,581
2015	57,602	438,691
2016	53,964	449,903

(b) Year	Total Catch	Effort per Horse power(HP)
1985	22,000	134,150
1986	22,000	134,150
1987	23,000	153,360
1988	28,000	300,240
1989	44,000	189,041
1990	39,900	300,240
1991	42,000	300,240
1992	43,288	134,150
1993	51,000	153,360
1994	48,352	153,360
1995	47,300	183,608
1996	48,434	183,325
1997	57,418	189,041
1998	57,063	171,671
1999	82,503	164,084
2000	75,972	178,670
2001	73,549	204,913
2002	72,889	235,890
2003	70,408	210,541
2004	63,914	206,059
2005	50,732	233,636
2006	46,940	203,852
2007	46,986	309,145
2008	47,361	215,012
2009	49,031	203,836
2010	43,974	208,261
2011	44,504	210,920
2012	44,866	243,137
2013	43,634	221,084
2014	45,053	221,248
2015	45,331	221,936
2016	49,690	205,764

Chapter IV. Result and Discussion

4.1 Mediterranean Sea

4.1.1 Catch per unit effort

According to the data registered during the period of time from 1985~2016. In 1999 and in 2008, the data registered highest catch were 89.943 tonnes, 88.882 tonnes, respectively. The number of motorized vessels was 2661 vessels, 3130 vessels with fishing effort 144.337HP, 335.078HP, respectively. While, in 2016 the total catch was abruptly decreased to 53.964 tonnes with efforts 3110 vessels, the CPUE was also decreased from 283 Kg/HP to 108 Kg/HP, despite the number of vessels has not changed since 2008 until now but the production was decreased by 34 % in Fig. 4.1.

Fishing effort data by a standardization that to minimize partiality due to the confounding of apparent abundance patterns with fishing power of four different fishing gears were estimated. These approaches offer some protection against bias to confounding. In the absence of formal criteria for classifying the best model (Bishop. 2006).

The time series of catch and CPUE in Mediterranean Sea by effort from four fishing gears include trawler, purse seiners, polyvalent and long liner. Initially, in 1999 the catch rate was increased, but after that it was starting to decline year by year because all fishermen concentrate about the financial benefit, without looking at the negative impact of overfishing in the long term, until 2007. By 2008, the catch rate rose again lead to the implementation of the close season.

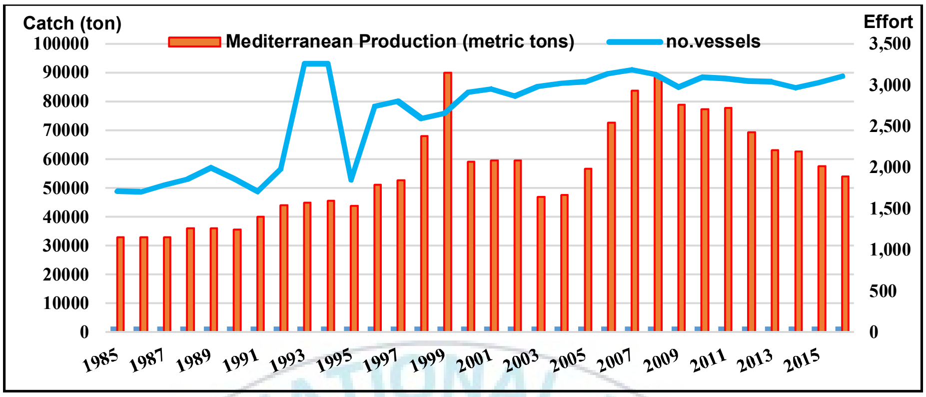

Fig. 4.1. Trend of catch and effort in Mediterranean Sea 1985-2016.

Fishing and some policy in this time, which gave the opportunity to conserve the stock assessment. Then, the catch began to deplete again year by year to become a half quantity previous catch in 2016. Whilst, the CPUE gives the first sight about the relative plenty of the different fish stocks and consequently the status of the fishery in Fig. 4.2.

In 1999, the CPUE was reached to the maximum level that was 999kg/HP, by individual gears 463kg /HP, 3,069kg/HP, 1,214kg/HP and 515kg/HP, respectively. In 2016, the minimum level of that was 108kg/HP, by individual gears 62kg/HP, 413kg/HP, 163kg/HP and 69kg/HP according to fishing gears including trawler, purse seiners, polyvalent and long liner, respectively. It was noticed that CPUE has been in serious decreased in relative abundance of different fish stocks exploited by different fishing gears in Fig. 4.3.

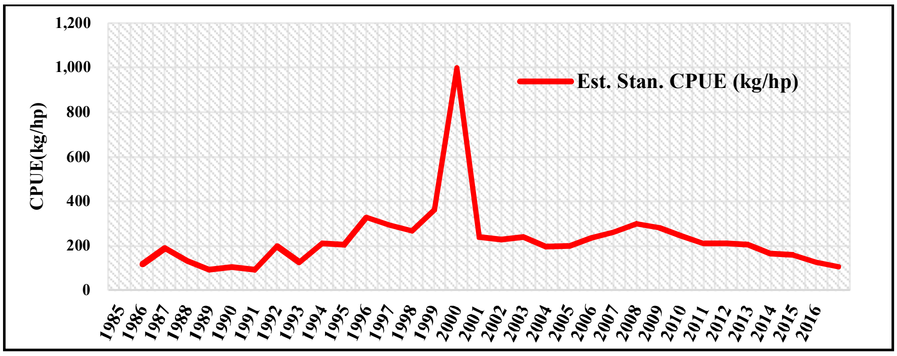

Fig. 4.2. Trend of CPUE over 1985~2016.

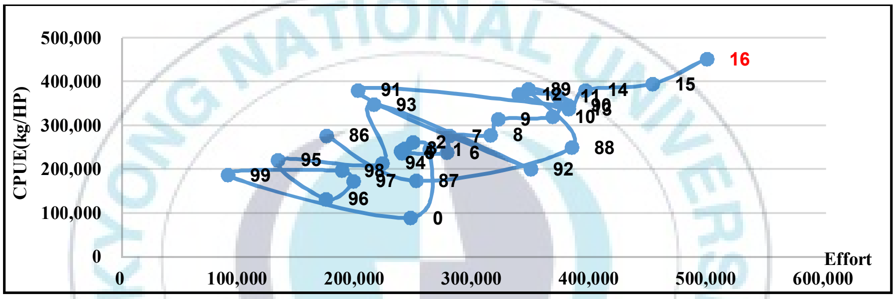

Fig. 4.3. Trend of effort and CPUE of Mediterranean Sea over 1985~2016.

The correlation coefficient between the 2 variable (catch and effort) was estimated to be -0.60261(CORREL function). The correlation is negative refer to there are some values decreases as the other increases.

4.1.2 Estimates of surplus production model.

The surplus production models were useful to the Mediterranean Sea of the total catch by four motorized vessels as fishing effort over 1985~2016. The data of catch and effort utilized to define the biological coefficients in the assessment.

The models were estimated by using ordinary least squares (OLS) regression in excel. The regression analysis results of five models are shown in Table 4.1.

Table 4.1. The statistical value of five for Mediterranean Sea

Parameter	Schaefer	Schnute	WH	Fox	CY&P
R^2	0.018271691	0.041845265	0.08141021	0.019408679	0.518952961
Adj. R^2	-0.054448925	-0.026594359	0.015796654	-0.053227715	0.484592458
P-value	0.779619595	0.549666287	0.30458085	0.767518071	3.55325E-05
Obs.	30	31	31	30	31
Intercept	0.626854773	0.292504006	0.287195822	0.734576709	0.000221058
X1 (CPUE)	0.861901259	0.421908475	0.143751808	0.804962244	0.034915636
X2 (Effort)	0.520350773	0.284195083	0.595344985	0.512721808	0.005203235

The Schaefer, Schunte, Fox, WH and CY&P can estimate biological coefficients and economic results from Mediterranean Sea by different fishing gears. In Statistical, the CY&P model was the superlative appropriate model to describe the biological coefficients with the data, an $R^2 = 0.5189$ and P-value = 0.3358022, with 31 observations and 30 degrees of freedom ($p<0.05$) compared to the results of other models. The Mean square Error (MSE) was examined, which measures whether or not the model is well defined. This was estimated as the average of the squared difference between the observed and estimated values (Gujarati, 1995). MSE were estimated for each model from the estimated and actual catch series in Fig. 4.4. MSE are equation form calculate of SSE as:

SSE = ∑(y-y^) ² Sum Squares Error (1)

MSE = SSE/ (n-(k+1)) Mean Squares Error (2)

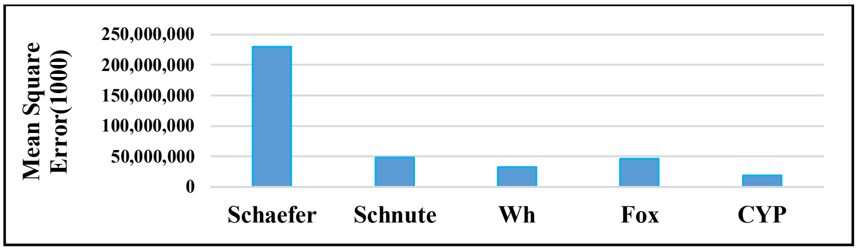

Fig. 4.4. Mean Square Error of the models in the Mediterranean Sea.

In a case of Mediterranean Sea, MSE of CY&P model was best as the lowest one, on average. In the statistic criteria, the CY&P model was found to get the uppermost R^2 with significant at the 5% level on T-test distribution, the lowest relative standard error and the lowest MSE. Given this, CY&P model was the best fitted model among surplus production models to explain the fisheries status of Mediterranean Sea by different fishing gears. As the next step, the biological coefficients, r, q and K, are estimated by surplus production models. The results of the regression analysis of all models are evaluated as r, q and K, respectively. The CY&P model estimated r, q, and K as shown in Table 4.2.

The five models determined the coefficients r, q, and K. The coefficients, r, q, and K estimated CY&P model, the best model among analyzed models, are r=0.9662867, q=3.96396E-06, K=162,825.922, respectively.

Table 4.2. Biological parameters in Mediterranean Sea

Parameter	Schaefer	Schnute	WH	Fox	CY& P
r	0.197208665	0.505861574	0.501897137	0.056421024	0.966286706
q	6.94182E-07	1.29687E-06	6.66122E-07	7.8893E-07	3.96396E-06
k	2,755,945,866	619,467,251	740,375,473	9,039,907,5	162,825,9
E_{MSY}	142,044	195,032	376,731	71,516	243,768
C_{MSY}	135,874.101	78,341.170	92,898.083	187,633.539	57,880.873

The yield-effort relationship for the surplus production models with genuine catch and effort for the Mediterranean Sea during 1985~2016 is shown in Fig. 4.5. Shown the curves comparison of five models, two models (Schnute and CY&P) are comparatively close to actual catch.

The CY&P model was utilized to explain the fisheries status of the Mediterranean Sea by four fishing motorized gears, as seen on the yield-effort relationship of CY&P model in Fig. 4.6. The real catch lies around the level of MSY in 2016. At E_{MSY}, fishing efforts at the maximum sustainable yield level were estimated to be 243.768 HP. The catch at maximum sustainable yield, C_{MSY}, was 57,880.87 metric tonnes under the biomass in MSY level estimated to be 59,900.309 MT. Further, the MSY estimated by fishing gear at effort ratio and catch ratio is shown in Table 4.3. Based on biological coefficients by CY&P model, the relation between effort and catch was finding that the effort was increased during last three years around 448.339 HP and it was exceeded the level of MSY (243.768 HP). Especially trawler efforts were 310.066 HP but the levels of MSY were 168.140 HP at the effort ratio, that the effort should be reduced to 96.585HP. Hence, it has negatively impacted production.

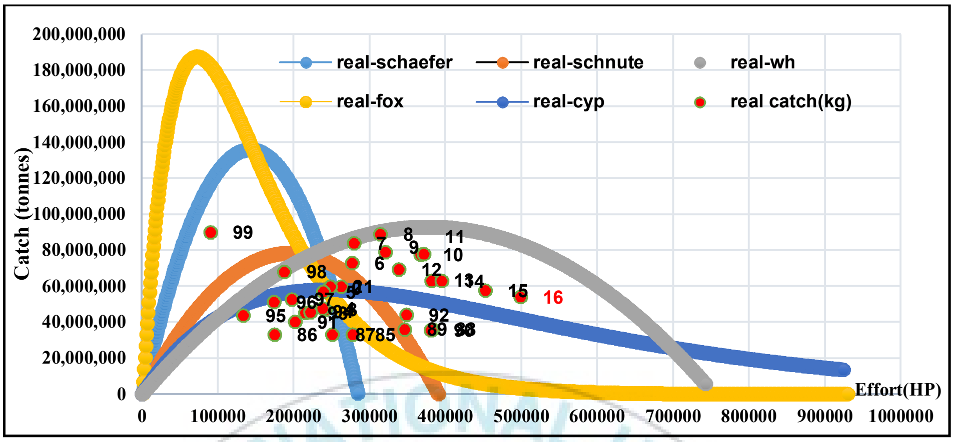

Fig. 4.5. Curves of Yield-effort relationship comparison for the five models.

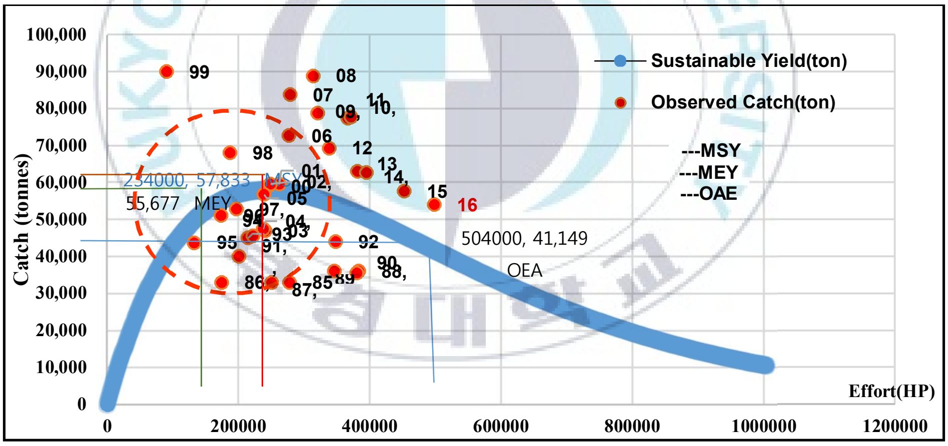

Fig. 4.6. Curve of CY&P Yield-effort relationship with MSY, MEY and OAE level.

The average of fishing production over current three years was reached to 58,104 MT, which exceeded MSY level, (C_{MSY}: 57,880.873 MT).

Table 4.3. Effort ratio, catch ratio at level of MSY to four gears

(Unit: HP, kg)

Fishing gear	E_{MSY} (Effort ratio)	C_{MSY} (Effort ratio)
Trawler	168,140	39,923.539
Purse seine	25,220	5,988.214
Polyvalent	21,773	5,169.750
Long liners	28,636	6,799.370

Fishing gear	E_{MSY} (Catch ratio)	C_{MSY} (Catch ratio)
Trawler	96,585	22,933.359
Purse seine	96,075	22,812.199
Polyvalent	32,806	7,789.609
Long liners	18,302	4,345.706

In the fisheries, the first relation between catch and effort is expressed as CPUE. The recent three-years' the average of CPUE over last three years obtained was 131.57 Kg/HP that was greater than CPUE at MSY level 237.44 kg/HP. This CPUE, which means the comparative plenty in fish stock year by year, was decreased due to increasing fishing efforts. In order to manage the fisheries of the Mediterranean Sea by GFCM, FAO through the Eastmed project, has to consider the management actions to reduce fishing efforts.

4.1.3 Analysis of bioeconomic model

The price and the cost can be combined relatively easily in the surplus production models to derive an equilibrium bio-economic model. The maximum economic yield (MEY) and fishing efforts of the level can be estimated through these models.

For attaining US$ 194,232.298 of maximum rent (π) or Maximum Net Profit (NP), the fishing efforts at the level (E_{MEY}) have to be maintain nearby 180,716 HP, with an estimated C_{MEY} (55,576.044 tonnes) of Mediterranean Sea. The results come from the total revenue (TR) 262,000.798 US$ subtracted from the total cost (TC) 67,768.500 US$. Hypothetically, the maximum rent at MEY level should be greater than MSY level.

Table 4.4. The condition of fisheries economic at MSY, MEY and OAE level

Fisheries level	Effort (HP)	Catch (ton)	TR (US$)	TC (US$)	NP (US$)
MEY	180,716	55,576.044	262,000.798	67,768.500	194,232.298
MSY	243,768	57,880.873	272,866.397	91,413.000	181,453.397
OAE	510,352	40,596.241	191,381.876	191,381.876	0

In 2016, the quantity of the catch has reached the lowest level of net profit around 67,492.497 US$, due to utilized the higher fishing efforts with 498,423 HP. Hence, that led to a negative impact on the total cost without any additional benefit. The results showed the extent of economic loss incurred through last three years (Table 4.5.).

Table 4.5. The condition of fish economic 2014~2016

Year	Effort(HP)	Catch(ton)	TR(US$)	TC(US$)	NP(US$)
2014	394,574	62,746.000	295,801.949	147,965.300	147,836.649

2015	452,020	57,602.000	271,551.715	169,507.437	102,044.277
2016	498,423	53,964.000	254,401.179	186,908.683	67,492.497

By increasing the effort level to 510.352 HP, at OAE, the operation of total cost also will increase to 191,381.876 US$. Applying the equation TR – TC, the net profit was found to be zero. This was constant with the open access condition, TR – TC = 0, as clarified in Fig. 4.7.

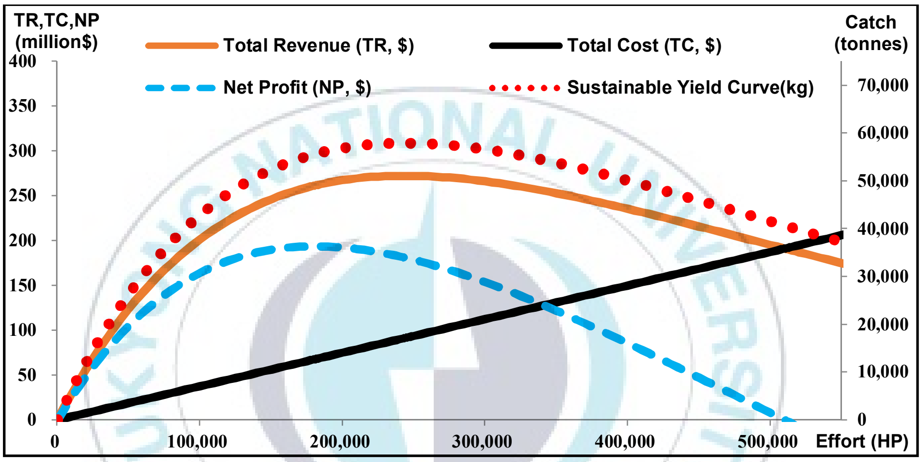

Fig. 4.7. Curves of SY, STR, TC and NP of Mediterranean Sea by CY&P model.

4.2 Red Sea

4.2.1 CPUE

According to the data during the period of time from 1985~2016, in 1999, the data registered the highest catch was 82,400 tonnes and the number of vessels was 597 motorized vessels with effort 164,084HP. While, in 2016, the total catch was abruptly decreased to 49,690 tonnes by

1,845 of motorized vessels (effort 205,764 HP). During these years the quantity of the catch was clearly decreased 39.69 % at the end of the analysis frame time (Fig. 4.8.).

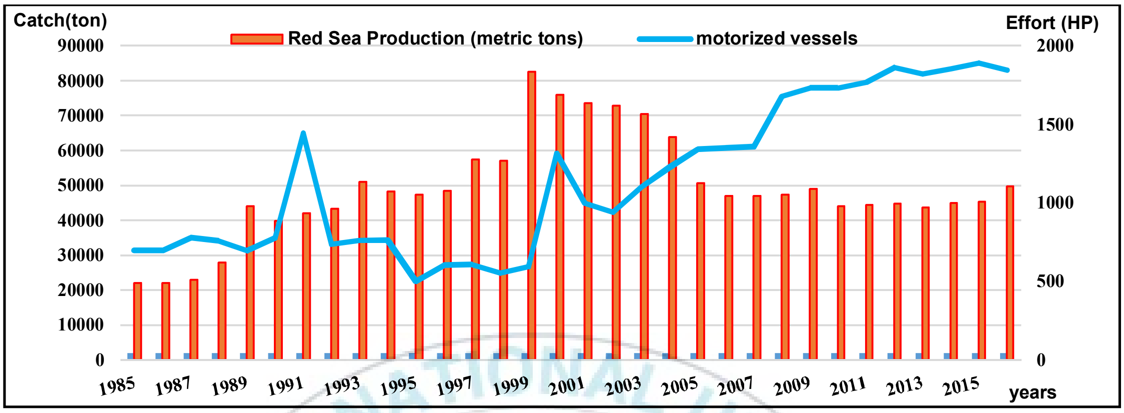

Fig. 4.8. Trend of catch and effort in Red Sea over 1985~2016.

The time series of catch and CPUE in the Red Sea by effort from five fishing gears include trawler, purse seiners, polyvalent, long liner, and karkaba & crab net. In 1999, the catch proportion represented 32%, 30%, 12%, 14%, and 11% by each fishing gear, respectively. In 2016 the catch proportion represented 27%, 51%, 1%, 17%, and 3%, respectively. The results showed that fisheries structures have been changed in the Red Sea since 1999. However, the changes in the catch proportion by each gear have clearly effected in the production. The CPUE gives the first sight about the comparative profusion of the different fish stocks and subsequently the status of the fishery. Catch per unit effort (CPUE) was different by fishing gears.

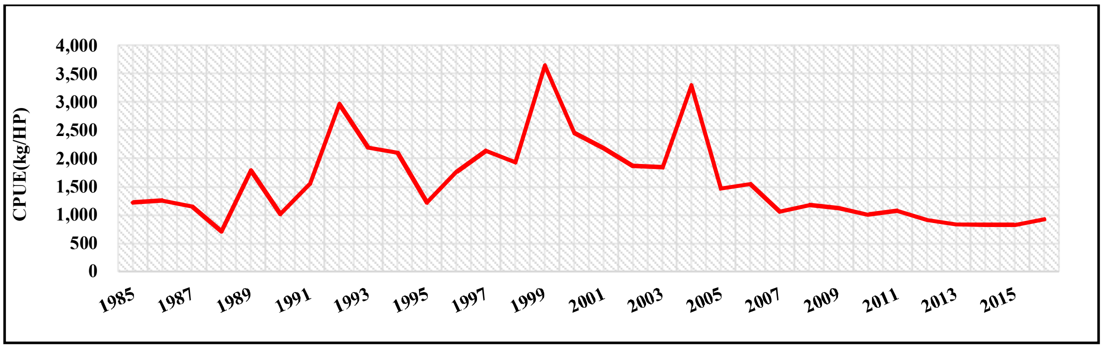

Fig. 4.9. Trend of CPUE over 1985~2016.

In 2016, the CPUE was reached to the minimum level, that was 187kg/HP, 402kg/HP, 17 kg/HP, 203 kg/HP, 125kg/HP. (average 157,907 kg/HP) according to the fishing gears: trawler, purse seiners, polyvalent, long liner, and Karkaba, respectively. It was noticed that CPUE has been in serious decline in relative abundance of different fish stocks exploited by different fishing gears. The correlation coefficient between (catch and effort) was - 0.665909.

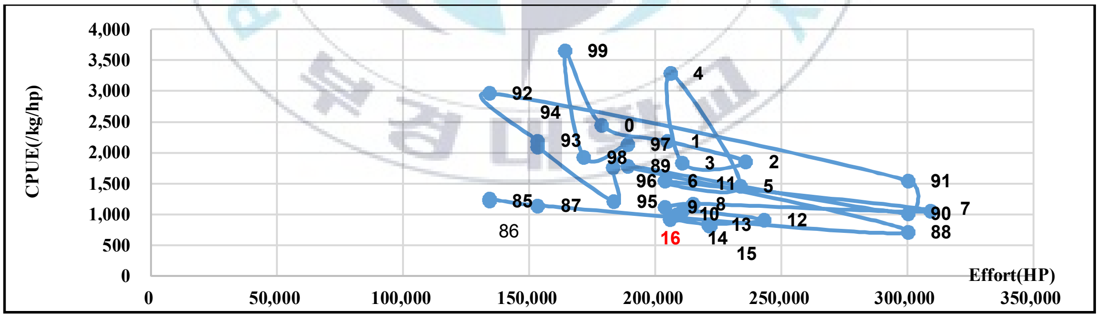

Fig. 4.10. Relation between catch and CPUE of Red Sea over 1985~2016.

4.2.2 Assessments of surplus production model.

The surplus production models were useful to the Red Sea of the total catch by five motorized vessels as fishing effort over 1985~2016. The data of catch and effort utilized to define the biological coefficients in the assessment.

The models were estimated by using ordinary least squares (OLS) regression in excel. The regression analysis results of five models are shown in Table 4.6.

Table 4.6. The Statistical value of the models in Red Sea

Parameter	Schaefer	Schnute	WH	Fox	CY&P
R^2	0.005436386	0.001438428	0.23751556	0.006310474	0.568974812
Adj. R^2	-0.068234993	-0.069887399	0.183052385	-0.067296158	0.538187299
P-value	0.929051203	0.980049222	0.022450902	0.918088644	7.63901E-06
Obs.	30	31	31	30	31
Intercept	-0.077318593	-0.104223061	-0.574076478	0.126340016	3.29166086
X1 (CPUE)	4.74005E-05	0.000132991	-7.45486E-05	-0.026146145	0.504671099
X2 (Effort)	3.31931E-07	3.35299E-07	3.30515E-06	1.0084E-07	-1.40761E-06

The Schaefer, Schunte, Fox, WH and CY&P can estimate biological coefficients and economic results from the Red Sea by different fish gears. In Statistical, the CY&P model was the superlative appropriate model to describe the biological coefficients with the data, an R^2 = 0.56897 and P-value = 7.639E-06, with 31 observations, 30 degrees of freedom ($p<0.05$) compared to the results of other models. The Mean square Error (MSE) was examined. MSE measures whether or not the model is well defined (Fig. 4.11).

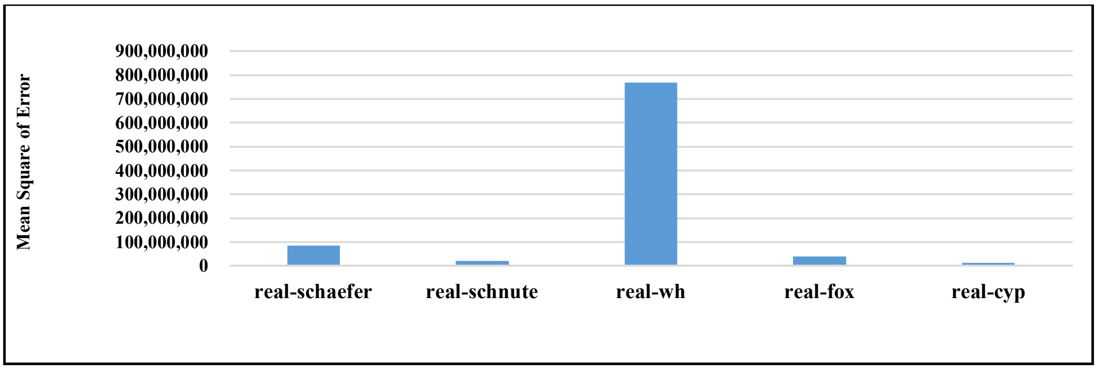

Fig. 4.11. Mean Square Error of the models in Red Sea.

In a case of the Red Sea, MSE of CY&P model was best as the lowest one, on average. In the statistic criteria, the CY&P model was found to get the uppermost R^2 with significant at the 5% level on T-test distribution, the lowest relative standard error and the lowest MSE. Given this, CY&P model was the best fitted model among surplus production models to explain the fisheries status of the Red Sea by different fishing gears. As the next step, the biological coefficients, r, q and K, are estimated by surplus production models. The results of the regression of all models are evaluated as r, q and K, respectively. The CY&P model estimated r, q, and K as shown in Table 4.7.

The coefficients, r, q and K estimated CY&P model, the best model among analyzed models, are r=0.658388, q=3,963.96E-06 and K=205,571.183, respectively.

Table 4.7. Estimated of biological parameters by five models in the Red Sea

Parameter	Schaefer	Schnute	WH	Fox	CY&P\
r	-0.0773186	-0.104223061	3.30515E-06	0.026146145	0.658388271
q	-3.31931E-6	-3.35299E-6	-3.30515E-06	-1.0084E-07	3.74197E-6
k	-4,914.215	-2,337.272	2,329.912.352	-1,244.257.135	205,571.183
E_{MSY}	116,468.04	155,417.94	86,845.83	-259,284.30	175,947.00
C_{MSY}	94,990.064	60,899.418	-334,386.969.06	-11,968.047.88	49,790.884

The yield-effort relationship of the five surplus production models with genuine catch and effort for Red Sea over 1985~2016 was shown in (Fig. 4.12.), as of the yield-effort curve evaluation of five models, two models (Schnute and CY&P) were relatively close to actual catch. As shown in the yield-effort relationship of CY&P model (Fig. 4.13), the genuine catch lies about the MSY. E_{MSY} was 175,947HP. C_{MSY} was estimated to be 49,790.884 metric tonnes and the biomass at MSY level was evaluated to be 75,625.412 metric tonnes.

The level of MSY was estimated with individual each gear with effort ratio and catch ratio, as shown in (Table 4.8). Based on biological parameters by CY&P model, this results generally indicated that the fishing efforts were biologically overfished. Namely, current fishing efforts, 295,855 HP, exceeded the fishing efforts level of MSY, 175,947HP. Especially trawler effort was 72,420HP with catch 13,535.600 MT. It shows that the efforts should be reduced to 51,595 HP at this quantity of catch. Hence, it has negatively impacted production.

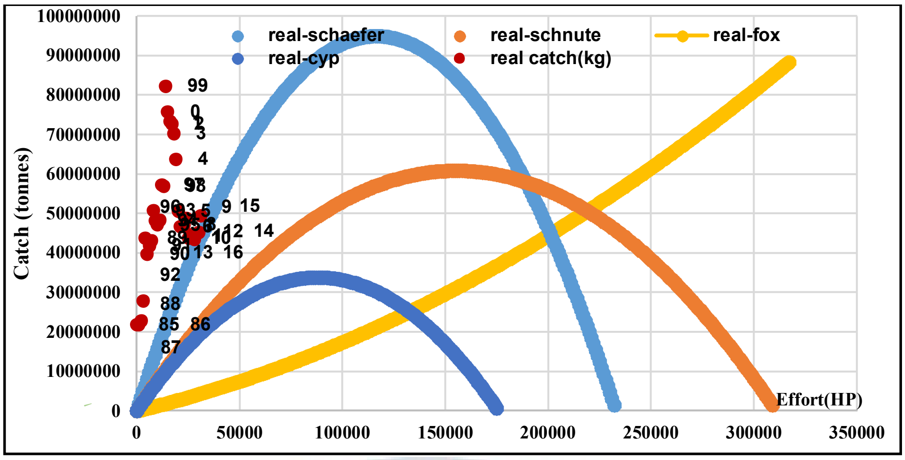

Fig. 4.12. Curves of Yield-effort relationship comparison for the models.

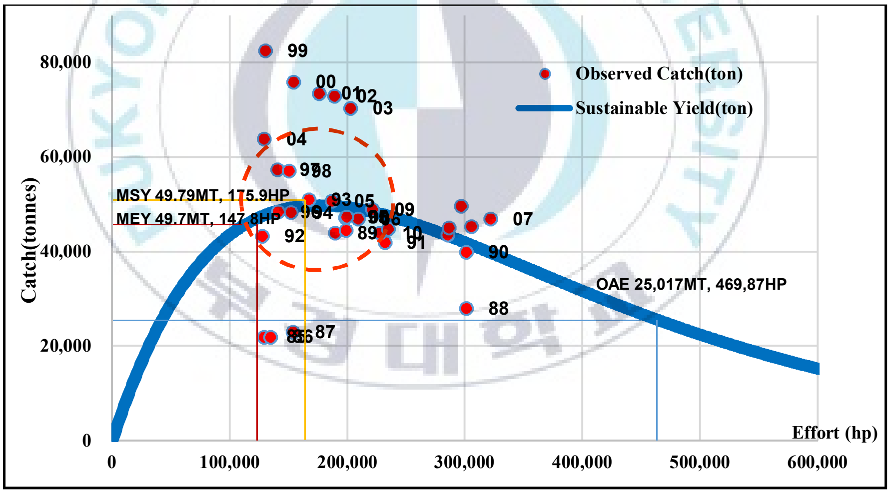

Fig. 4.13. Curve of CY&P in relationship of Yield-effort with MSY, MEY and OAE level.

Table 4.8. Effort ratio, catch ratio at MSY to five gears

(Unit: HP, kg)

Effort ratio	E_{MSY}	C_{MSY}
1. Trawler	75,497	21,364.724
2. Purse seine	34,744	9,832.117
3. Polyvalent	2,972	841,099
4. Long liners	55,966	15,837.750
5.karkaba	6,768	1,915.194
Catch ratio	E_{MSY}	C_{MSY}
1. Trawler	51,595	14,600.729
2. Purse seine	81,565	23,081.840
3. Polyvalent	990	280,294
4. Long liners	35,499	10,045.664
5. karkaba	6,298	1,782.358

In the fisheries, the first relation between catch and effort is expressed as CPUE. The recent three-years' the average of CPUE obtained was 157,907Kg/HP that was smaller than CPUE at MSY level, 282,988 kg /HP. This CPUE, which means the comparative plenty in fish stock year by year, was decreased due to increasing fishing efforts. Around the period of 2000~2010, the average of CPUE was 336 Kg/HP, but from 2010~2016 it was 177 kg/HP. That can explain increasing of fishing efforts.

4.2.3 Results of bio-economic model

The price and the cost can be combined relatively easily in the surplus production models to derive an equilibrium bioeconomic model. The maximum economic yield (MEY) and fishing efforts of the level can be estimated through these models.

Moreover, the amount of effort which goes to maximized rent under MEY can be estimated. The maximum rent (π) or NP acquires around US$ 194,286.231. At that point, the effort level (E_{MEY}) has to maintain nearby 147,746 HP, with an estimated C_{MEY} of the Red Sea of metric 49,078.689 tonnes. The results come from the total revenue (TR), 231,370.478US$ subtracted from the total cost (TC), 37,084.246 US$. Hypothetically, the maximum rent at MEY level should be greater than MSY level.

Table 4.9. The condition of fisheries economic at MSY, MEY and OAE level

Fisheries level	Effort (HP)	Catch (ton)	TR (US$)	TC (US$)	NP (US$)
MEY	147,746	49,078.689	231,370.478	37,084.246	194,286.232
MSY	175,947	49,790.884	234,727.961	44,162.697	190,565.264
OAE	469,875	25,017.320	117,938.547	117,938.547	0

In addition, there were studies, in a part of Red Sea in Gulf of Suez, which confirmed all the previous studies concerning fisheries management in the Gulf of Suez. El-Gammal and Mehanna (1999, 2007) found that the stock was exploited by purse seine. Especially, trawler fishing gear was overexploited. They recommended that the fishing efforts should be diminished by 26 % to obtain the maximum sustainable yield.

However, in 2016 catches have reached the lower level of net profits around US$159,858.273, when the 296,391 HP was exceeded E_{MSY} and E_{MEY} over the last three years (table 4.10).

Table 4.10. The condition of fish economic 2014~2016

Year	Effort (HP)	Catch (ton)	TR (US$)	TC (US$)	NP (US$)
2014	285,930	45,053.000	212,392.268	71,768.327	140,623.941
2015	305,245	45,331.000	213,702.836	76,616.604	137,086.232
2016	296,391	49,690.000	234,252.365	74,394.091	159,858.273

By intensifying the effort level to around 469,875 HP at OAE, the processing cost also increasing to US$ 117,938.547. Applying the equation TR – TC, the net profit was found to be zero. This was steady with the open access condition TR – TC = 0, as illustrated in Fig. 4.14.

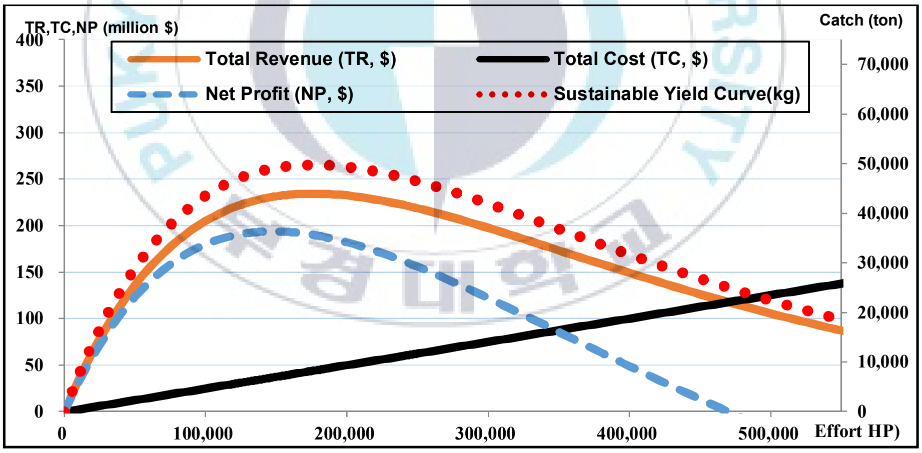

Fig. 4.14. Sustainable Yield (SY) Curve, STR, TC and NP of Red Sea by different fisheries gears are estimated by CY&P model.

Chapter V. Conclusion

The fisheries situation in the Egypt is considered as an important sector which requires large-scale improvements. This research takes the main natural resources of fishing as a research area (the Mediterranean Sea and the Red Sea). Due to its wide impact of the area which represents 31% of the total catch in inland fishery, it has made contributions towards the labour market. The research employed catch and effort data over 1985~2016 and the data have shown increased fishing efforts resulting in a continuous decrease in the catch due to the depleting fisheries resources.

Biomass-based models are unpretentious one used for fisheries stock assessment. They are often termed as surplus production models and discussion related to the fisheries management are usually governed by the stock assessment results. Hence, it is necessary for scientists to enhance reliable description of stock dynamics and stock status to managers. The present study was designed to estimate the MSY of both Egyptian seas by motorized fishing efforts using surplus production models.

The surplus production models were developed to determine the equilibrium or sustainable yield, which may be harvested from a fishery for a given level of effort. The effort and catch per unit of fishing effort (CPUE) statistics are essential in the stock assessment studies, which consider the reference point indicator to trend of population size. 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, given an assumption about the rate of growth. The five models were explored to determine one of them suitable to biological and economic circumstances of marine fisheries in Egypt. Based on the statistical results, the CY&P model developed by Clarke, Yoshimoto, and Pooley in 1992 was selected for explaining the condition of this fishery.

The price and cost data can be combined relatively easily in the surplus production models to derive a simple equilibrium bioeconomic model. This model estimates MEY and the fishing efforts at that point. Likewise, the model produces the catch and the effort which is likely to goes to zero profits under open access (OAE).

The results of the analysis clearly indicate that current fishing efforts (E) were greater than maximum sustainable yield of fishing efforts (E_{MSY}), in Mediterranean Sea E was 498 HP and E_{MSY} was 243 HP while E was 296.39 HP and E_{MSY} was 175.94 HP in Red Sea in 2016. The catch was also around the MSY levels. Hence, the total cost (TC) increased by 51% and 63% comparing the level of MSY, MEY in the Mediterranean Sea, respectively. While in the Red Sea the (TC) increased by 40% and 50% comparing the level of MSY and MEY, respectively. That has negatively impacted the economic benefit as shown in the results.

Consequently, it is strongly recommended to implement fisheries management policies for decreasing the fishing effort of the Mediterranean Sea and the Red Sea to 45.6% and 40.5%, respectively. Especially in Trawler fishing gear, that can increase our net profit by 168% and

19.20%, respectively. Our models have led to many important suggestions and conclusions regarding fishing circumstances of the both seas.

As the model indicates that our stocks are depleting rapidly, to make all these fishing efforts a sustainable one, our study suggests some recommendations. For examples, there are taxing fishing effort, reducing trawler fishing gear, activation of monitoring & inspection systems, deciding the TAC where every species should be subjected to quota regulation, controlling the mesh size of fishing net to prohibition overfishing and protecting fish juveniles, implementing of Ecosystem Approach Fisheries (EAF) according to recommended of GFCM, improving the fishery statistics recording system, and introducing the new technologies in recording system to ensure transparency.

References

Advani S. 2015. Distance from a fishing community explains fish abundance in a no-take zone with weak compliance. Plos one 10(5):10.1371/journal.pone.0126098.

Ahmed W and Ron V. 2016. The Status and Development of Aquaculture in Egypt, USDA, Foreign Agricultural Service, Global Agriculture Information Network.

Ashraf I and H El-Karamany. 2015. Marine Science Department, Faculty of Science, Suez Canal University, 41522. Ismailia, Egypt, Status of fisheries resources of bitter lakes, Suez Canal, Egypt.

Bailey S and xing Z. 2010. Modelling of a Fish Population and the Effects of overfishing, math 201 group project final report.

C. Papaconstantinou and H. Farrugio. 2000. Íational Centre for Marine Research, Institute of Marine Biological Resources IFREMER, 1 rue Jean Vilar, 34200 Sete, France ,Fisheries in the Mediterranean, Mediterranean marine science,Vol1/1, 5-18.

Canterla M. 1989. Actividades pesqueras en los puertos del suroeste andaluz en la segunda mitad del siglo XV, Actas: IX Jornadas de Andalucía y América, España.

Daniel G and J.Rothschild. 2012. Reconsidering Historical Definitions of Overfishing and the Balance between Sustainable use and Overexploitation, ICES CM, L: 25

EPRS. 2015**.** Understanding Fisheries technical rules, an illustrated guide for non-experts, in – depth analysis, PE 571.313

FAO. 2011. FAO Fisheries and Aquaculture Report No. 974.

FAO. Eastmed Project., 2014. HQ, Androu 1,112 57 Athens, Greece, socio-economic analysis of Egyptian fisheries: options for improvement, Eastmed technical documents 19, GCP/INT/041/EC-GRE-ITL.

FAO. Eastmed Project., 2016. A Sub-regional Analysis of the Socio-Economic situation of the Eastern Mediterranean FisheriesGCP/INT/250/EC-IT/TD-22.

FAO. 2016. 2018 the Status of the Mediterranean and Black Sea Fisheries. General Fisheries Commission for the Mediterranean. Rome, Italy.

Forcada A and Corsi F. 2010. Structure and Spatio-Temporal Dynamics of Artisanal fisheries Around a Mediterranean Marine Protected Area. ICES J Mar Sci 67(2):191–203.

Fox W. 1970. An exponential surplus yield model for optimizing exploited fish populations. Transaction of American Fisheries Society 99:80-88.

GAFRD. 1997-2012. Status of fisheries in Egypt: reflections on past trends and management challenges.

GAFRD. 2015, 2014, 2016 Statistical Yearbook. General Authority for Fish Resources Development. Ministry of Agriculture Publications. Egypt.

Gianluigi. 1998. A Surplus Production Model with a Nonlinear Catch-Effort Relationship, Marine Resource Economics, Volume 13, 37–50.

Gordon, H. S. 1954. The economic theory of a common property resource: the fishery. Journal of Political Economy 62: 124-142.

Hatem Hanafy Mahmoud, Lydia TM K and Daniel P. 2015. Reconstruction of marine fisheries statistics in the Egyptian Mediterranean Sea, 1950-2010. Fisheries Centre, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.

J. Bishop. 2006. Standardizing fishery-dependent catch and effort data in complex fisheries with technology change, Rev Fish Biol Fisheries 16:21–38, DO10.1007/11160-006-0004-9.

Mahmoud S, Abdelazim N, Moheb I, and Mohamed El-Tarabily. 2017. Analysis of Egyptian Red Sea Fishing Ports, Vol. 9, No. 2.

Marezo Alfathoni Putasa. 2018. Bioeconomic Analysis of the Yellowfin Tuna (Thunnus albacares) Longline Fishery in Western and Central Pacific Ocean. master thesis, Pukyong National University.

Markets in the Middle East: market, trade and consumption, http://www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338542/

McGraw-Hill/Irwin. 2015. Statistical Techniques in Business & Economics, a business unit of the McGraw-Hill companies, Inc., 1221avenue of the Americas, New York, NY, 10020.

Mohamed Samy-Kamal. 2015. Status of fisheries in Egypt: reflections on past trends and management challenges, Rev Fish Biol Fisheries, DOI 10.1007/s11160-015-9404-z.

Mohammed Abdelaty Mahdy. 2015. Ecosystem-based resource assessment and management system for Red Sea fisheries off Egypt. Master thesis, Pukyong National University.

Najah Mistafa Kalmar. 2005. The Red Sea and Gulf of Aden. Global International Waters Assessment, GIWA Regional Assessment, Sub-regions 48, 49.

Ratneesh Suri. 2008. Optimal Harvesting Strategies for Fisheries: A Differential Equations Approach. Massey UN, and Albany, New Zealand.

Sahar Fahmy Mehanna and Fahmy I. El-Gammal. 2007. Gulf of Suez Fisheries: Current Status, Assessment and Management, JKAU: Mar. Sci., Vol.18, pp: 3-18 (2007 A.D./1428 A.H.).

Samy, M., Sánchez Lizaso, J. L. & Forcada, A. 2011. Status of marine protected areas in Egypt. Animal Biodiversity and Conservation, 34.1: 165–177.

Schaefer, M.B.1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Bull. Inter-Am. Trop, Tuna Comm, 1(2): 26-56.

Schaefer, M.B. 1957. Some consideration of population dynamics and economics in relation to the management of the commercial marine fisheries. Journal of Fisheries Research Board of Canada 14(5):669-681.

Seham, F.A. and A.M. Salem. 2004. The present status of fishery and information system in Egypt, GCP/INT/918/EC. MedFisis Technical Document No. 4.3: 31pp.

US Government. 2004. The 2002 CIA World Factbook.

Wikipedia, https://en.wikipedia.org/wiki/Longline_fishing connected at 24, Dec. 2018

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