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Original Article

An economic study of Egyptian fish production with a special focus on cartilaginous fish

Aliaa Midhat A. El-Kasheif[1], Medhat Helmy Hashem[2], Alaa Mahmoud El-Far[3], and Yaseen Eid Abdul-Tawab[4]

[1]National Food Safety Authority (NFSA), Egypt.
[2] Animal Biotechnology Dep., Genetic Engineering and Biotechnology Research Institute, Sadat City Univ., Egypt.
[3] Fish Biology and Fisheries lab., National Institute of Oceanography and Fisheries (NIOF), Egypt .
[4] Economic Lab., National Institute of Oceanography and Fisheries (NIOF), Egypt.

ABSTRACT: The seafood sector in Egypt is considered one of the most important economic sectors due to its importance for food security and economic development. To achieve its objectives, the research relied on the use of descriptive and quantitative economic analysis methods in a manner appropriate to the subject of study in interpreting and describing variables. The research relied mainly on secondary data from statistical bulletins. The published annual publications of the Ministry of Agriculture and Land Reclamation are included in the records of the General Authority for the Development of Fish Resources and the Central Agency for Public Mobilization and Statistics, in addition to some references, theses and scientific research on this subject of research. The focus is on examining the evolution of the quantity and value of the annual cartilaginous fish catch from the Egyptian marine fishery. The aim of the research is to analyze the economics of Egyptian fish production with a focus on cartilaginous fish. We have made several recommendations to achieve the development and advancement of Egypt's natural resources, lakes and fish farming sector, which will contribute to solving the issues raised in this research.

Key word: Egyptian fishery sector, economic analysis methods, food security, fish economic
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1.INTRODUCTION

The seafood sector in Egypt is one of the most important economic sectors due to its importance for food security and economic development. In addition to its high content of animal protein, fish is also considered one of the main food sources that helps the Egyptian population meet part of their nutritional needs for vitamins, salts and minerals. In terms of nutritional value and relative utility as well as price competitiveness, fish is the most preferred form of animal protein in Egypt. Fish is followed by poultry and bird meat, eggs and dairy products and finally red meat. Therefore, in order to keep pace with population growth and increased health and nutrition awareness, Egyptian nutrition policy aims to increase the nutritional level of the population by increasing protein content in general and animal protein in particular, among which fish is considered one of the most important Sources.

Correspondence :
Aliaa Midhat A. El-Kasheif
National Food Safety Authority (NFSA), Egypt
Mail: aliaa.elkasheif@yahoo.com

In Egypt there are large areas of water rich in fish; These regions vary greatly depending on their location and the type of water they contain. Together, they account for approximately 13.9 million acres, which is 1.5 times the country's current agricultural land. Egyptian fishing waters come from a variety of natural and man-made sources, including pond farming, intensive farming, semi-intensive farming, fish cages and rice field farming. Natural sources include marine fisheries (Mediterranean, Red Sea), marine fisheries (Egyptian lakes) and inland freshwater fisheries (Nile and its tributaries). Nevertheless, there is a fish feed gap of around 385,000 tonnes in 2021, which will be covered by importing fish and fishery products from abroad.

An estimated 66.4 billion pounds (billion pounds) of fish wealth would be generated in agriculture in 2021, making it a significant part of the national economy. According to statistics, Egypt's fish production has increased significantly, rising from approximately 771.8 thousand tons in 2001 to 2.002 million tons in 2021. Capture fisheries account for approximately 21.25% of Egypt's total fish production, while fish farming accounts for approximately 78.75% of the year's total fish production. In spite of this, there is still a difference between the amount produced and the amount consumed; fish imports were almost 385 thousand tons, or more than 13 billion pounds, but they did not surpass with a cash value of approximately 0.9 billion pounds, the number of shipments is approximately 28,000 tons. Fish self-sufficiency reached 84.86% in 2021, and the average per capita share of fisheries products climbed from roughly 15.8 kg in 2001 to nearly 23.2 kg in 2021. Which suggests that in order to achieve the highest level of productive and economic efficiency as well as being a productive activity that contributes to diversification, it is necessary to develop a logical scientific management plan for the optimal exploitation of natural fisheries. This plan should aim to achieve optimal productivity in light of sustainable development with the expansion of fish farming to confront and narrow the food gap in general and fisheries in particular. Sources of income for agriculture, supplying employment and drawing laborers.

This is evident from the above-mentioned importance of fish to Egyptian society as a source of animal proteins among some other nutrients. The wealth of fish in Egypt is considered one of the sources of Egypt’s national income, on which some processing industries depend and which, in addition to its importance as a source of protein, also offers great employment and investment opportunities. Livestock farming provides part of the food needs of members of society, and it is worth noting that the state is currently increasing its interest in this vital production sector, but the rate of increase in fish production still cannot keep up with the continuous increase in consumption, creating the problem of the gap between production and consumption, which requires several measures. Studies aimed at addressing the various problems suffered by the fish production sector in Egypt in order to fill this gap, especially in view of the extinction of some important fish species that are of relative importance for export, such as cartilaginous fish, as their average production reached about 1.93 in the period (2001-2021) and does not exceed this. Its contribution to fish production is about 0.1% and it has a high manufacturing value, which allows fish products to be exported in a manufactured form, which generates a higher return than exporting them in their raw form. Therefore, it is necessary to investigate ways to further develop and advance them .

The research aims to analyze the economics of Egyptian fish production with a focus on cartilaginous fish by achieving the following sub-objectives:

1. To determine the current situation of Egyptian fish production, capture fisheries and fish farming in the period (2001-2021).
2. Examine the evolution of Egyptian sources of fish production from capture fisheries.
3. Examine the evolution of sources of fish production from marine fisheries.
4. Examine the evolution of fish production from fish species originating from Egyptian fisheries.
5. Estimate the relative importance of Egyptian fish production by fish group.
6. Examine the evolution of the quantity and value of the annual cartilaginous fish catch from the Egyptian marine fishery.

1. METHOD AND DATA SOURCES

To achieve its objectives, the research relied on the use of descriptive and quantitative economic analysis methods in a manner appropriate to the subject of study in interpreting and describing economic variables. This description was based on the use of simple statistical methods such as percentages and arithmetic averages, and the simple regression method was used to estimate the general time trend equations for economic variables. The research relied mainly on secondary data obtained from the published annual statistical bulletins of the Ministry of Agriculture and Land Reclamation, the records of the General Authority for Fisheries Development and the Central Agency for Public Mobilization and Statistics, in addition to some references, theses and related scientific research to the research subject.

3.RESULTS AND DISCUSSION

First, research the state of fish farming, capture fisheries, and fish output in Egypt from 2001 to 2021.

Based on an analysis of Table (1) & Fig (1) Data, it can be shown that the total fish output in Egypt from 2001 to 2021 increased, ranging from a low of around 771.5 thousand tons in 2001 to a high of 2.02 million tons in 2021. With an average fish output of almost 1.35 million tons for the aforementioned period, and by assuming the general time trend equation for the development of total Egyptian fish production during the study period, the figure for 2001 is equivalent to about 161.83%.

According to Equation (1) in Table (2), production at a statistically significant yearly rate of around 69.49 thousand tons, or roughly 5.14% of the overall production average, it followed a generally rising trend. The time component accounts for 97% of the production changes, as indicated by the value of the coefficient of determination, or "R2."

The data in the same table, when examining the fish production capacity of Egyptian capture fisheries from 2001 to 2021, showed that the capacity ranged from a minimum of approximately 336 thousand tons in 2016 to a most of approximately 431.12 thousand tons in 2003, or a rise of approximately 28.31%. Equation (2), which is contained in Table (2), shows the general time trend equation for the evolution of Egyptian capture fisheries production during the study period. For the year 2016, with an average fish production of approximately 381.80 thousand tons during the aforementioned period, contributing 28.28% of the total Egyptian fish production: 2) Production has been generally declining at an annual pace that is statistically negligible. From the above, it is evident that the output from catch fisheries has declined, and that the production quantity is out of proportion to the fish produced in these fisheries' natural capacities and the available capital and human resources. Furthermore, it is not in line with the yearly population growth in Egypt, which is correlated with a rise in fish consumption, as seen by the ongoing rise in the import of fish in all forms fresh, frozen, canned, and processed.

An analysis of the data in the same table revealed that the fish production capacity for fish farming during the period of 2001–2021 ranged from a minimum of approximately 343.1 thousand tons in 2001 to a maximum of approximately 1641.9 thousand tons in 219, indicating an increase of approximately 378.54 tons percent for the year 2001. The average fish production during the aforementioned period was approximately 968.23 thousand tons, accounting for 71.72% of Egypt's total fish production. Equation (3) in Table (2) was used to estimate the general time trend equation for the growth of fish farming production over the research period. This showed that production followed a generally growing trend at a statistically significant yearly rate of around (70.38). Second: The development of Egyptian fish production sources from capture fisheries .

Captured fisheries in Egypt occupy vast areas amounting to about 13 million acres. These fisheries vary according to their nature. The first is marine (the Mediterranean Sea and the Red Sea), and the second is lake and includes Lakes Manzala, Burullus, Bardawil, Edku, Qarun, Mariout, the Bitter Lakes, and the Port Fouad Navigation. The third is freshwater fisheries in the Nile River. With its branches, Rasheed and Damietta, canals and drains, in addition to artificial lakes such as Lake Nasser in Aswan and Wadi El Rayan lakes in Fayoum.

The data in Table (3) & Fig (2) made it evident that the marine fish production capacity studied during the period (2001–2021) ranged between a minimum of approximately 95.1 thousand tons in 2021 and a maximum of approximately 133.2 thousand tons in 2001, i.e., an increase equivalent to approximately 40 thousand tons. 1% in 2021, with an average fish output of around 114.53 thousand tons throughout that time frame, making up 30% of the total fish produced by catch fisheries. Equation (1), which estimates the overall time trend equation for the evolution of marine fisheries output throughout the research period, according to Table (4), output followed a general downward trend at a statistically significant yearly rate of around 1.514 thousand tons, or 1.32% of the overall production average. The time factor's influence accounts for 58% of the production changes, as indicated by the value of the coefficient of determination, or "R2".

Examining the lakes' ability to produce fish between 2001 and 2021, the data in the same table showed that the capacity varied from a minimum of roughly 144 thousand tons in 2007 to a maximum of approximately 255.6 thousand tons in 2021 an increase of roughly 77.5%. Contributing 47.46% of the overall fish output from capture fisheries in 2007 was the year with an average fish production of around 181.21 thousand tons during the aforementioned timeframe. Equation (2) in Table (4), which estimates the general time trend equation for the development of lake production during the study period, shows that production increased generally until it reached a statistically significant annual rate of about 2,560 thousand tons, or roughly 1.41% of the general average of production. The time component accounts for 33% of the production changes, as indicated by the value of the coefficient of determination, or "R2."

An analysis of the data in the same table revealed that the freshwater fish production capacity for the period of 2001–2021 ranged from a minimum of approximately 66.1 thousand tons in 2014 to a maximum of approximately 120.8 thousand tons in 2002. This represents an increase of approximately 82.75% over the previous year, with an average fish production of approximately 109.9 thousand tons during the aforementioned period accounting for 22.55% of the total fish production from capture fisheries. Equation (3) in the table shows that (4) & Fig (3) indicated that production took a general decreasing trend at a statistically significant annual rate of about 2.178 thousand tons, which represents about 1.98% of the general average of production. This was determined by estimating the general time trend equation for the development of fish farming production during the study period. Sixty-four percent of output fluctuations may be attributed to the time component, as shown by the coefficient of determination (R2) value.

Table 1. Quantity of fish production from capture fisheries, fish farming, and total Egyptian fish production during the period (2001-2021). Quantity (in thousand tons)

Years/statement	Natural Fisheries		Fish Farming		Total Egyptian Fish Production
	Production Quantity	% Relative importance	Production Quantity	% Relative importance	
2001	428.7	55.54	343.1	44.46	771.75
2002	425.4	53.06	376.3	46.94	801.7
2003	431.1	49.21	444.9	50.79	876.02
2004	393.5	45.49	471.5	54.51	864.99
2005	349.5	39.30	539.7	60.70	889.25
2006	375.9	38.72	595.0	61.28	970.89
2007	372.5	36.95	635.5	63.05	1007.99
2008	373.8	35.01	693.8	64.99	1067.62
2009	387.4	35.45	705.5	64.55	1092.9
2010	385.3	29.51	919.6	70.49	1304.6
2011	375.2	27.54	986.8	72.46	1361.8
2012	354.2	25.81	1017.7	74.19	1371.7
2013	356.9	24.54	1097.5	75.46	1454.5
2014	344.8	23.26	1137.1	76.74	1482.1
2015	344.1	22.65	1174.8	77.35	1518.8
2016	335.7	19.67	1370.7	80.33	1706.7
2017	370.8	20.34	1451.8	79.66	1822.8
2018	373.4	19.30	1561.5	80.72	1934.5
2019	397	19.47	1641.9	80.53	2038.9
2020	418.7	20.83	1591.9	79.17	2009.9
2021	425.2	21.25	1576.2	78.75	2001.2
Average	381.84	28.28	968.23	71.72	1350.03

Source: Collected and calculated from data from the General Authority for Fish Resources Development, Fish Production Statistics Bulletin, various issues.

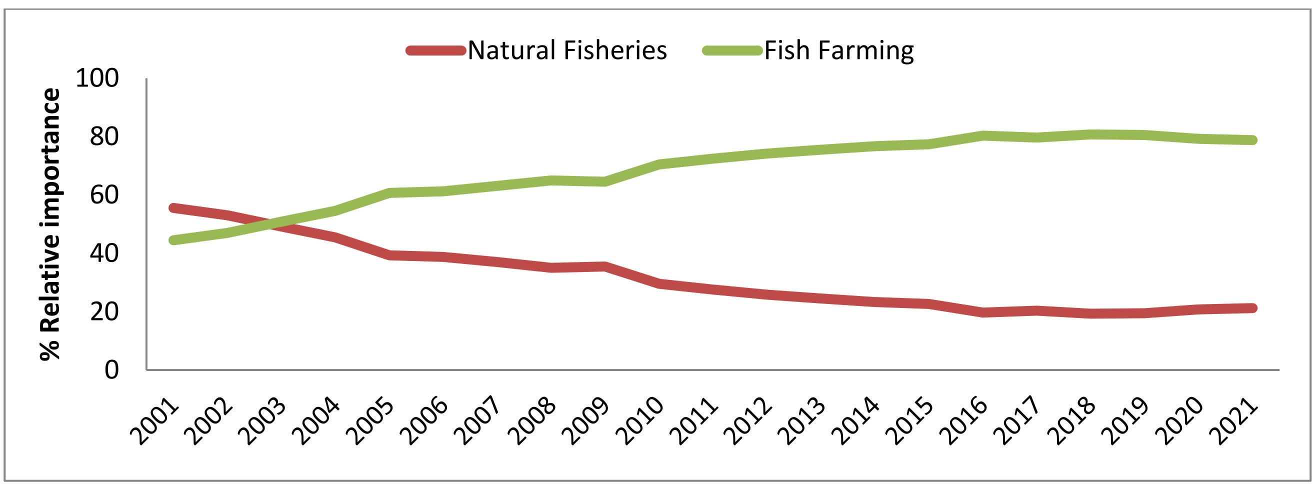

Fig. 1. Quantity of fish production from capture fisheries, fish farming, and total Egyptian fish production during the period (2001-2021). Quantity (in thousand tons)

Table 2. General time trend equations for the development of Egyptian fish production, capture fisheries, and fish farming during the period (2001-2021).

variable	Equation number	General time trend equation	R2	F	Annual rate of change %
General time trend equation	1	$\hat{Y}i$ =138393.9 + 69.490 Xi (25.69)**	0.97	**660.11	5.14
Egyptian capture fisheries	2	$\hat{Y}i$ =2686.51 - 1.146 Xi (-1.06)	0.06	1.14	-
Fish farming	3	$\hat{Y}i$ =140579.2 + 70.38 Xi (30.43)**	0.98	**926.30	7.26

whereas:

- Yi = the estimated value of the dependent variables (capture fisheries, fish farming, Egyptian fish production) in year t.
- xi=time factor in years as an independent variable in year t, where i=(21,....,3,2,1).
    - The numbers in parentheses below the estimates indicate the calculated (t) value.
- (**) indicates significance at the level of (0.01), (*) indicates significance at the level of (0.05), (-) is not significant.
- Source: Collected and calculated from the data presented in Table (1).

Table 3. Development of Egyptian fish production sources from capture fisheries during the period (2001-2021) Quantity (in thousand tons)

Years	**Egyptian nature fisheries**						**Total fish production from capture fisheries**
	Marine water *	**%**	**Lakes****	**%**	**Fresh water*****	**%**	
2001	133.2	31.07	185.6	43.29	109.9	25.64	428.7
2002	132.5	31.15	172	40.43	120.8	28.40	425.4
2003	117.3	27.22	195.4	45.33	118.3	27.44	431.1
2004	111.4	28.32	177	44.98	105	26.68	393.5
2005	107.4	30.73	158.3	45.29	83.8	23.98	349.5
2006	119.6	31.82	151.3	40.25	105	27.93	375.9
2007	130.7	35.10	144	38.66	97.7	26.23	372.5
2008	136.2	36.44	157.9	42.24	79.7	21.32	373.8
2009	127.8	33.00	172.2	44.45	87.3	22.53	387.4
2010	121.4	31.51	179.2	46.51	84.7	21.98	385.3
2011	122.3	32.60	163.2	43.50	89.7	23.91	375.2
2012	114.2	32.24	173.4	48.96	66.6	18.80	354.2
2013	106.7	29.90	182.5	51.13	67.7	18.97	356.9
2014	107.8	31.26	170.9	49.56	66.1	19.17	344.8
2015	102.9	29.90	171.5	49.84	69.7	20.26	344.1
2016	103.7	30.89	158.5	47.21	73.5	21.89	335.7
2017	109.8	29.61	183.5	49.49	77.5	20.90	370.8
2018	104.77	28.06	194.9	52.20	73.7	19.74	373.4
2019	98.9	24.91	220.7	55.59	77.4	19.50	397
2020	101.4	24.22	237.8	56.79	79.5	18.99	418.7
2021	95.1	22.37	255.6	60.11	74.5	17.52	425.2
Average	114.53	29.99	181.21	47.46	109.9	22.55	381.84

*Maritime (including the Mediterranean and the Red Sea)

**The lakes (Al-Manzala, Burullus, Bardawil, Idku, Qarun, Mariout, Bitter Lakes, Port Fouad Nasser, Nasser, and Wadi Al-Rayan).

***Fresh water (including the Nile River and its branches)

Source: Collected and calculated from data from the General Authority for Fish Resources Development, Fish Production Statistics Bulletin, various issues.

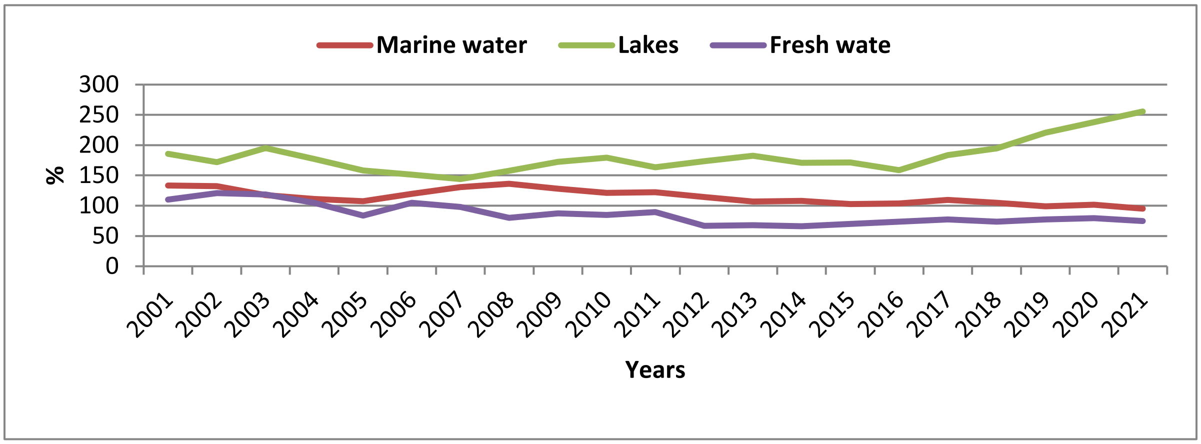

Fig. 2. Development of Egyptian fish production sources from capture fisheries during the period (2001-2021) Quantity (in thousand tons)

Table 4. General time trend equations for the development of fish production sources from capture fisheries during the period (2001-2021).

Variable	Equation number	General time trend equation	R^2	F	Annual rate of change %
Marine water	1	$\hat{Y}i$ =3158.2 – 1.514 Xi (-5.10)**	0.58	**26.03	-1.32
Lakes	2	$\hat{Y}i$ =4966.2 + 2.560 Xi (3.05)**	0.33	*9.30	1.41
Fresh water	3	$\hat{Y}i$ =4466.9 – 2.178 Xi (-5.76)**	0.64	**33.2	-1.98

whereas:

- Yi = the estimated value of the dependent variables (marine, lakes, freshwater) in year t.
- xi=time factor in years as an independent variable in year t, where i=(21,....,3,2,1).
- -The numbers in parentheses below the estimates indicate the calculated (t) value.
- (**) indicates significance at the level of (0.01), (*) indicates significance at the level of (0.05), (-) is not significant.
- Source: Collected and calculated from the data presented in Table (3).

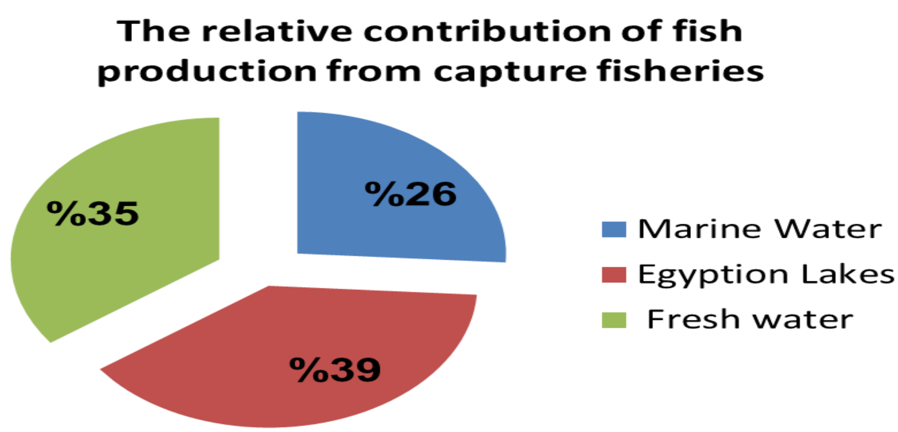

Figure 3. shows the relative contribution to fish production from capture fisheries during the study period (2001).

Third: The development of sources of fish production from marine fisheries. Egypt's natural marine fisheries include both the Mediterranean and the Red Sea. These fisheries extend along the Egyptian coast and within its territorial waters (12 nautical miles) in addition to exclusive economic waters (may reach 200 nautical miles). The total area of Bahrain's fisheries in which fishing is carried out is about 11.2 million acres, or about 6.8 and 4.4 million acres, for the Mediterranean and Red Seas, respectively, representing 83% of the total area of Egyptian fisheries.

The data presented in Table (5) indicates that the fish production capacity from the Mediterranean ranged from a minimum of approximately 47 thousand tons in 2003 to a maximum of approximately 88.9 thousand tons in 2008. This was determined by analyzing the fish production capacity from the Mediterranean and Red Seas during the period (2001-2021). With an average fish output of around 49.4 thousand tons throughout the aforementioned period, contributing 43.13%, 12.94%, and 3.66% to the total fish production from marine and natural fisheries, that is, an increase comparable to roughly 89.15% over the year 2003. and the overall fish output in Egypt, accordingly, together with an approximate equation representing the overall temporal pattern in the growth of Mediterranean production during the research period. According to Equation (1) in Table (6), output followed a general downward trend at an annual rate that was statistically insignificant. Furthermore, the data in the same table makes it evident that the Red Sea's fish capacity varied from a minimum of approximately 40 thousand tons in 2018 to a maximum of approximately 73.5 thousand tons in 2001. This represents an increase of approximately 83.75% over the year 2018 and an average fish production of approximately 49.2 thousand tons during the aforementioned period, contributing, respectively, 42.96%, 12.88%, and 3.64% to the total fish production from marine and natural fisheries and the total fish production in Egypt. Equation (2), which estimates the general time trend equation for the development of Red Sea production during the study period, shows that production took a general decreasing trend at a statistically significant annual rate of about 1,049 thousand tons, or roughly 2.13% of the overall production average. This information is contained in Table (6). The coefficient of determination, or "R2," indicates that 43% of the variations in production may be attributed to the influence of the time component. The average production of Bahrain together is about 114.53 thousand tons, representing about 4.91% of the total Egyptian fish production, which amounts to about 1.35 million tons during the aforementioned period. This decrease in fish production from Bahrain is due to the concentration of fishing operations in places near the coast with primitive ships. Fishing and its weak capabilities, which led to the deterioration of fish fertility and the weakness of fish stocks in this area, in addition to the change in hydrological conditions on the Egyptian coast after the construction of the High Dam. And overfishing, which has exceeded the level of optimal biological exploitation (Al-Kreoni and Abdel-Hafez, 2008).

In addition to pollution in its various forms. The majority of these obstacles are caused by the human factor, in addition to other natural and environmental factors, including the narrow continental shelf and the unsuitable nature of the bottom of the fisheries of the western region, west of Marsa Matrouh, and even Salloum, due to the abundance of rocks in most of its parts (Abu El-Enein, 2003). The lack of necessary studies and information for fishermen regarding the breeding season and fish movements. The surface waters of the Red Sea are poor in various types of nutrient salts. It derives its needs from the sea currents that reach it through Bab al-Mandab (Fahmy, 2002).

Table 5. Evolution of the relative importance of fish production sources from marine fisheries during the period (2001-2021)

Years/ statement	Mediterranean sea				The Red Sea				Total marine fisheries	% of total fish production	Total natural fisheries	Total Egyptian fish production
	production quantity	% of total marine fisheries	% of total natural fisheries	% of total fish production	production quantity	% of total marine fisheries	% of total natural fisheries	% of total fish production				
2001	59.6	44.74	13.90	7.72	73.5	55.18	17.14	9.52	133.2	17.2	428.7	771.75
2002	59.6	44.98	14.01	7.43	72.9	55.02	17.14	9.09	132.5	16.5	425.4	801.7
2003	47	40.07	10.90	5.37	70.4	60.02	16.33	8.04	117.3	13.4	431.1	876.02
2004	47.5	42.64	12.07	5.49	63.9	57.36	16.24	7.39	111.4	12.9	393.5	864.99
2005	56.7	52.79	16.22	6.38	50.7	47.21	14.51	5.70	107.4	12.1	349.5	889.25
2006	72.7	60.79	19.34	7.49	46.9	39.21	12.48	4.83	119.6	12.3	375.9	970.89
2007	83.8	64.12	22.50	8.31	47	35.96	12.62	4.66	130.7	13.0	372.5	1007.99
2008	88.9	65.27	23.78	8.33	47.4	34.80	12.68	4.44	136.2	12.8	373.8	1067.62
2009	78.8	61.66	20.34	7.21	49	38.34	12.65	4.48	127.8	11.7	387.4	1092.9
2010	77.4	63.76	20.09	5.93	44	36.24	11.42	3.37	121.4	9.3	385.3	1304.6
2011	77.8	63.61	20.74	5.71	44.5	36.39	11.86	3.27	122.3	9.0	375.2	1361.8
2012	69.3	60.68	19.57	5.05	44.9	39.32	12.68	3.27	114.2	8.3	354.2	1371.7
2013	63	59.04	17.65	4.33	43.6	40.86	12.22	3.00	106.7	7.3	356.9	1454.5
2014	62.7	58.16	18.18	4.23	45.1	41.84	13.08	3.04	107.8	7.3	344.8	1482.1
2015	57.6	55.98	16.74	3.79	45.3	44.02	13.16	2.98	102.9	6.8	344.1	1518.8
2016	54	52.07	16.09	3.16	49.7	47.93	14.80	2.91	103.7	6.1	335.7	1706.7
2017	59	53.73	15.91	3.24	50.8	46.27	13.70	2.79	109.8	6.0	370.8	1822.8
2018	56.7	54.10	15.18	2.93	40	38.17	10.71	2.07	104.8	5.4	373.4	1934.5
2019	48	48.53	12.09	2.35	50.9	51.47	12.82	2.50	98.9	4.8	397	2038.9
2020	49.9	49.21	11.92	2.48	51.5	50.79	12.30	2.56	101.4	5.04	418.7	2009.9
2021	50.4	53.00	11.85	2.52	45.2	47.53	10.63	2.26	95.1	4.8	425.2	2001.2
Average	49.4	43.13	12.94	3.66	49.2	42.96	12.88	3.64	114.53	4.91	381.84	1350.03

Source: Collected and calculated from data from the General Authority for Fish Resources Development, Fish Production Statistics Bulletin, various issues.

Table 6. General time trend equations for the development of fish production sources from marine fisheries during the period (2001-2021).

Variable	Equation number	Annual rate of change %	R^2	F	Annual rate of change %
Mediterranean sea	1	$\hat{Y}i$ =1132.9 - 0.532 Xi (-1.18)	0.07	1.39	-
Red Sea	2	$\hat{Y}i$ =2161.3 – 1.049 Xi (-3.76)**	0.43	14.17	-2.13

whereas:

- Yi = the estimated value of the dependent variables (Mediterranean Sea, Red Sea) in year t.
- xi=time factor in years as an independent variable in year t, where i=(21,....,3,2,1).
    - The numbers in parentheses below the estimates indicate the calculated (t) value.
- (**) indicates significance at the level of (0.01), (*) indicates significance at the level of (0.05), (-) is not significant.
- Source: Collected and calculated from the data presented in Table (5).

Fourth: The development of fish production from fish species produced from Egyptian fisheries. The data in Table (7) made it evident that the production capacity of bony fish during the study period (2001–2021) ranged from a minimum of approximately 1010.1 thousand tons in 2008 to a maximum of approximately 9248.3 thousand tons in 2006, indicating an increase equivalent to approximately 815.6% for the year 2008. The average fish production during the aforementioned period was approximately 3815.40 thousand tons. Additionally, by estimating the general time trend equation for the development of bony fish production during the study period.

The output took a trend year, according to Equation (1) in Table (8), declining at a statistically significant yearly rate of around 397.6 thousand tons, or roughly 10.42% of the overall average production. The time component accounts for 54% of the production changes, as indicated by the magnitude of the coefficient of determination, or "R2".

Examining the cartilaginous fish production capacity from 2001 to 2021, it was evident from the data in the same table that the fish capacity varied from a minimum of approximately 0.60 thousand tons in 2005 to a maximum of approximately 3.4 thousand tons in 2011, indicating an increase of approximately 466.7 tons percent for the year 2005. The average fish production during the aforementioned period was approximately 1.93 thousand tons, and the general time trend equation was estimated. Equation (2) in Table (8) for the development of cartilaginous fish production during the study period shows that production took a general decreasing trend at a rate of approximately 0.061 thousand tons annually, or roughly 3.16% of the general average production. This amount is statistically significant. Twenty percent of the variations in output may be attributed to the influence of the time component, as indicated by the value of the coefficient of determination (R2).

An analysis of the data in the same table revealed that the production capacity of crustacean fish for the years 2001–2021 varied from a minimum of approximately 11.8 thousand tons in 2001 and 2003 to a maximum of approximately 25.9 thousand tons in 2021, indicating an increase of approximately 119 thousand tons. 5% of the fish production occurred in the years 2001–2003, with an average of 18.36 thousand tons during the aforementioned period. Throughout the research period, the general temporal trend equation for the growth of crustacean fish production was estimated. According to Equation (3) in Table (8), output followed a generally growing trend at a statistically significant yearly rate of around 0.311 thousand tons, or 1.7% of the overall production average. Twenty percent of the variations in output may be attributed to the influence of the time component, as indicated by the value of the coefficient of determination (R2).

Examining the mollusk production capacity from 2001 to 2021, the data in the same table showed that the fish capacity varied from a minimum of approximately 1.9 thousand tons in 2015 and 2016 to a maximum of approximately 4.8 thousand tons in 2008, which is an increase of approximately 152 thousand tons. 6% for the years 2015 and 2016, averaging around 2.92 thousand tons of fish output over that time, and calculating the general time trend equation for the evolution of shellfish production during the research period.

Table (8)'s Equation (4) shows that production required a generally declining trend with an annual statistically significant rate of around 0.078 thousand tons, or 2.67% of the average output overall. Forty percent of the production variations may be attributed to the time component, as shown by the value of the coefficient of determination (R2).

Lungfish production capacity was examined from 2001 to 2021, and the data in the same table showed that the fish capacity increased by approximately 742.86%, from a minimum of approximately 0.70 thousand tons in 2001 to a maximum of approximately 5.9 thousand tons in 2015. By computing the general time trend equation for the development of lungfish production over the research period and using the average fish output of 4.69 thousand tons for the year 2001, Production increased generally at an annual rate, according to Equation (5) as shown in Table (8).

It was statistically significant and amounted to around 0.125 thousand tons, or 2.7% of the typical production. The time component accounts for 33% of the production changes, as indicated by the value of the coefficient of determination, or "R2".

An analysis of the data in the same table revealed that the production capacity of other fish species during the period (2001–2021) ranged from a minimum of approximately 10.1 thousand tons in 2021 to a maximum of approximately 27.3 thousand tons in 2001. This indicates an increase of approximately 170. 3% for the year 2021, with an average fish production of approximately 19.32 thousand tons during the aforementioned period. Additionally, by estimating the general time trend equation for the development of fish production of other types during the study period, Production followed a general pattern, according to Equation (6) in Table (8). declining at a yearly rate of around 0.403 thousand tons, or 2.1% of the average production, and this decline is statistically significant. The time component accounts for 37% of the production changes, as indicated by the value of the coefficient of determination, or "R2".

Fifth: The relative importance of Egyptian fish production according to fish groups. There are many and different types of fish, as well as their quantities produced from Egyptian fisheries, so the groups of fish caught from different fisheries have been identified into several groups, as the data contained in Table (9) shows the relative importance of fish production from fish species produced from Egyptian fisheries during the period (2017-2021).

It was found that the production of bony fish occupies first place, with a fish production of about 1.92 million tons, with a percentage of about 97.81% of the fish production, which amounts to about 1.96 million tons, and in second place come the types of crustacean fish, with a fish output of about 18.18 thousand tons, with a percentage of About 0.96%, then other species come in third place with a fish yield of about 15.3 thousand tons, with a rate of about 0.78%, then come in fourth place are species of pneumonic fish with a fish yield of about 5.12 thousand tons, with a rate of about 0.26%, then they come in fifth place. Types of mollusc fish with a fish yield of about 2.38 thousand tons, at a rate of about 0.12%. Then in sixth and last place come the types of cartilaginous fish, with a fish yield of about 1.16 thousand tons, with a rate of about 0.07%. This explains the low productivity of cartilaginous fish as a result of their extinction from the Egyptian coast, which prompted a study of the development of their production and the most important problems facing their production, given their economic, manufacturing and export importance. (Abdel Tawab and Qarni, 2023).

Sixth: Development of the quantity and value of the annual catch of cartilaginous fish from Egyptian marine fisheries.

1. ***Quantity of fish production.***

The data in Table (10) made it evident that the amount of cartilaginous fish caught by Egyptian marine fisheries between 2001 and 2021 ranged from a minimum of approximately 628 tons in 2005 to a maximum of approximately 3,578 tons in 2006, indicating an increase of approximately 469.74 tons percentage for the year 2005.

Table 7. Development of fish production of fish species produced from Egyptian fisheries during the period (2017-2021). Quantity (thousand tons)

Years	Bony fish	Cartilaginous fish	Crustaceans	Mollusca	Plumonata	Other items
2001	7161	2.4	11.8	3.00	0.70	27.3
2002	7580.7	2.2	13.7	2.8	1.00	24.00
2003	8338	1.6	11.8	4.2	5.4	19.1
2004	8276.4	1.4	13.9	3.3	4.7	14.00
2005	8409.5	0.60	17.5	3.00	4.1	23.00
2006	9248.3	3.6	15.4	3.4	5.1	18.5
2007	9620	2.5	17.00	4.2	4.6	17.7
2008	1010.1	3.00	23.4	4.8	4.9	21.4
2009	1034.2	2.5	24.9	3.2	5.00	23.1
2010	1251.1	3.00	21.3	3.3	5.00	21.00
2011	1304	3.4	21.4	2.9	5.00	25.6
2012	1323.6	2.3	16.1	2.7	4.8	22.3
2013	1404.5	2.1	21.4	2.3	5.6	18.4
2014	1426.8	1.8	25.8	2.5	5.5	19.4
2015	1473.7	1.1	18.6	1.9	5.9	17.7
2016	1663.8	1.3	17.1	1.9	5.6	16.8
2017	1772.9	1.4	20.8	2.1	5.8	19.7
2018	1897.6	1.3	14.3	2.6	4.9	17.00
2019	1998.1	1.00	16.9	2.4	5.00	15.7
2020	1971.3	1.00	16.5	2.4	5.3	14.00
2021	1957.9	1.1	25.9	2.4	4.6	10.1
Average	3815.40	1.93	18.36	2.92	4.69	19.32

Source: Collected and calculated from data from the General Authority for Fish Resources Development, Fish Production Statistics Bulletin, various issues.

The average fish production during the aforementioned period was estimated to be 1941.76 tons, and the general time trend equation for the development of the quantity of production during the study period was also estimated. Equation (1), which is shown in Table (11) shows that production declined overall at a noteworthy yearly pace. According to statistics, it came to 62.97 tons, or around 3.24% of the whole output average. Twenty percent of the variations in output may be attributed to the influence of the time component, as indicated by the value of the coefficient of determination (R2).

Table 8. General time trend equations for the development of fish production from fish species produced from Egyptian fisheries during the period (2001-2021).

Variable	Equation number	General time trend equation	R^2	F	Annual rate of change %
Bony fish	1	$\hat{Y}i$ =803385.1 – 397.6 Xi (-4.74)**	0.54	**22.53	-10.42
Cartilaginous fish	2	$\hat{Y}i$ =123.9 – 0.061 Xi (-2.13) *	0.20	*4.53	-3.16
Crustaceans	3	$\hat{Y}i$ =607.1 + 0.311 Xi (2.15) *	0.20	*4.61	1.7
Mollusca	4	$\hat{Y}i$ =160.4 – 0.078 Xi (-3.58)**	0.40	**12.83	-2.67
Plumonata	5	$\hat{Y}i$ =247.6 + 0.125 Xi (3.1)**	0.33	**9.46	2.7
Other items	6	$\hat{Y}i$ =830.5 – 0.403 Xi (-3.31)**	0.37	**10.97	-2.1

whereas:

- Yi = the estimated value of the dependent variables (bony fishes, cartilaginous fishes, crustaceans, mollusks, lungworts, other classes) in year t.
- xi=time factor in years as an independent variable in year t, where i=(21,....,3,2,1).
  - The numbers in parentheses below the estimates indicate the calculated (t) value.
- (**) indicates significance at the level of (0.01), (*) indicates significance at the level of (0.05), (-) is not significant.
- Source: Collected and calculated from the data presented in Table (7).

Table 9. The relative importance of fish production from fish species produced from Egyptian fisheries during the period (2017 - 2021). Quantity (thousand tons)

Years/statement	2017	2018	2019	2020	2021	Average	% of the total
Bony fish	1772.9	1897.6	1998.1	1971.3	1957.9	1919.56	97.81
Cartilaginous fish	1.4	1.3	1	1	1.1	1.16	0.07
Crustaceans	20.8	14.3	16.9	16.5	25.9	18.88	0.96
Mollusca	2.1	2.6	2.4	2.4	2.4	2.38	0.12
Plumonata	5.8	4.9	5	5.3	4.6	5.12	0.26
Other items	19.7	17	15.7	14	10.1	15.3	0.78
Total	1822.7	1937.7	2039.1	2010.5	2002	1962.4	100

whereas:

- Bony fish: include tilapia, mullet family, carp, catfish, sea bream, sea bass, sardines, whiting, whiting, gourd, basaria, dafas, musa, coral, bagha, macaroni, lute... And others.
- Crustaceans: include shrimp and crab.
- Lungs: include snails and shellfish.
- Molluscs: include octopus and squid.
- Cartilaginous fish: include sharks, oysters, and oysters
- Source: Collected and calculated from data from the Central Agency for Public Mobilization and Statistics, Annual Bulletin of Fish Production Statistics, various issues.

2.The value of fish production.

Upon examining the production value of cartilaginous fish caught in Egyptian marine fisheries between 2001 and 2021, it was evident from the data in the same table that the value of production varied from a minimum of approximately 5,338 thousand pounds in 2005 to a maximum of approximately 49,995 thousand pounds in 2011, indicating an increase of approximately 836.6 thousand pounds for the year 2005. The average production value during the mentioned period was approximately 24,250.8 thousand pounds. Additionally, by estimating the general time trend equation for the development of production value during the study period, Equation (2) in Table (11) shows that the production value increased generally at a pace of a yearly total of around 978.33 thousand pounds, or 4.03% of the whole output value average, that is statistically significant. The time component accounts for 28% of the variations in output value, as indicated by the magnitude of the coefficient of determination, or "R2".

Table 10. Evolution of the quantity and value of the annual catch of cartilaginous fish during the period (2001-2021)

Statement/years	Total production (tons)	Production value (in thousand pounds)
2001	2406	9624
2002	2222	8888
2003	1604	6416
2004	1378	11534
2005	628	5338
2006	3578	30754
2007	2503	25030
2008	3119	32282
2009	2549	18914
2010	3079	31898
2011	3333	49995
2012	2338	36381
2013	2112	32862
2014	1843	30410
2015	1141	17195
2016	1300	22100
2017	1375	25190
2018	1293	25343
2019	1040	25927
2020	883	26331
2021	1053	36855
Average	1941.76	24250.81

Source: Collected and calculated from data from the General Authority for Fish Resources Development, Fish Production Statistics Bulletin, various issues.

Table 11. General time trend equations for the development of the quantity and value of the annual catch of cartilaginous fish during the period (2001-2021).

Variable	Equation number	General time trend equation	R^2	F	Annual rate of change %
Production Quantity	1	$\hat{Y}i$ =128574.6 – 62.97 Xi (-2.2) *	0.20	*4.8	-3.24
Production value	2	$\hat{Y}i$ =1943167.9 + 978.33 Xi (2.72)**	0.28	*7.41	4.03

whereas:
Yi = the estimated value of the dependent variables (production quantity, production value) in year t.
xi=time factor in years as an independent variable in year t, where i=(21,....,3,2,1).
- The numbers in parentheses below the estimates indicate the calculated (t) value.
(**) indicates significance at the level of (0.01), (*) indicates significance at the level of (0.05), (-) is not significant.
Source: Collected and calculated from the data presented in Table (10).

In contrast to many Mediterranean nations, cartilaginous fish bycatch makes up the majority of Egypt's fishing harvest. Target species including *C. plumbeus* and *Mustelus spp*. are subject to seasonal commercial fishing, with maxima occurring in the spring and summer when the species migrate to shallower waters, according to Saad and Alkusairy (2023). Regular seasonal migration toward the beach was seen in the research (Alkusairy, 2019; Alkusairy and Saad, 2018), which may be related to the seasonal reproductive cycle. Sharks and rays of all sizes are taken; however, in coastal fisheries, the juveniles are primarily collected as bycatch.

Aetomylaeus bovinus, Dasyatids, Triakids, and the little juvenile Carcharhinid individuals make up the majority of these groups. Many sharks, including *Scyliorhinus canicula*, *Galeus melastomus*, *Squalus plainvillei*, *Centrophorus granulosus*, *Mustelus spp.* and some rays, are taken in deep fisheries (trawl nets and longlines). After 2012, all chondrichthyans, including rajids, are landed for marketing because to the decrease in fuel and the high cost of bony fish.

Numerous investigations conducted in the Eastern Mediterranean have reported the existence of chondrichthyans in a number of locations. Research pertaining to the Aegean Sea and Turkey's southern coast (Kaya, 1993; Papaconstantinou *et al.*, 1994; Kabasakal, 2001; Kabasakal, 2002; Filiz and Bilge, 2004; Kabasakal, 2004; Kabasakal, 2014; Yapici and Filiz, 2014; Yigin and Ismen, 2014) primarily focused on chondrichthyans in its northeastern region. A handful (Ali and Saad, 2003; Ali *et al.*, 2010; Ali *et al.*, 2012; 2013) were conducted in Syria. Conversely, research conducted from Egypt's northern shore to Israel's coast revealed the presence of chondrichthyans in the southeast of the Eastern Mediterranean.

According to the United Nations Food and Agriculture Organization, the Eastern Mediterranean is made up of all waters that stretch from the Aegean Sea, which follows the coasts of Turkey and Greece, eastward towards the Levantine basin, crossing the northern entrance to the Suez Canal, and traveling along the coast of Egypt (FAO, 2004). Compared to the Western Mediterranean, the Eastern Mediterranean has less species variety and inadequate nutrition (Martin *et al.*, 2006). According to Azov (1991), it is the Mediterranean's most oligotrophic region.

A more recent update on the makeup of sharks in Alexandria's Egyptian Mediterranean waters, utilizing DNA barcoding in addition to traditional taxonomical methods, was published by Moftah *et al.* (2011). The aforementioned investigation verified the existence of many species in the Mediterranean seas of Egypt, including *Squalus acanthias*, *Oxynotus centrina*, *Squatina squatina*, *Scyliorhinus canicula*, *Scyliorhinus stellaris*, *Mustelus mustelus*, *Mustelus punctulatus*, and *Carcharhinus altimus*.

Studies on the common guitarfish are uncommon in the eastern Mediterranean and nonexistent in the coastal waters of Lebanon. The majority of research on biological and aging features was conducted in the seas of Alexandria, Egypt, which is in the southeast of the Mediterranean (Abdel-Aziz *et al.*, 1993). According to Azab *et al*, 2019 report, the seven shark species that were gathered from the Mediterranean Sea near Alexandria are members of the Carcharhinidae family, which is represented by the names *Carcharhinus altimus*, *C. brachyurus*, *C. brevipinna*, *C. falciformis*, *C. obscurus*, *C. plumbeus*, and *Prionace glauca*. Four of them *C. brachyurus*, *C. falciformis*, *C. obscurus*, and *Prionace glauca* are regarded as the first records in the Egyptian Mediterranean waters (Moftah *et al.*, 2011; Akel and Karachle, 2017).

Roy *et al.* (2015) reported that only 10 to 20% of shark body parts are exported through legal channels; the remainder is smuggled to countries such as Myanmar, India, Singapore, Thailand, Hong Kong, China, USA, and others. The main shark goods used in commerce are fins and fin rays, flesh, liver oil, liver and fishmeal, cartilage, skin, and jaws (Hanfee, 1997). Smaller sharks are utilized to generate fish meal and fertilizer if markets for human consumption are unavailable (Compagno, 1990), which was shown to be consistent with the current experiment. Shark items that make up a significant portion of global trade include fresh, chilled, frozen, and unidentified shark flesh (Anon, 2003). Sharks are mostly exploited for their flesh, fins, skin, cartilage, and liver (Musick, 2005).

Shark flesh was largely consumed locally since it quickly spoiled without refrigeration (Musick, 2005). Sharks' main method of osmoregulation involves the retention of urea in their blood and tissues, which gives flesh a strong flavor and odor and is harmful at greater amounts (Vannuccini, 1999). Bleeding recently trapped animals is one way to tackle this issue. Urea concentrations differ from species to species; hammerhead sharks have the greatest quantities while spiny dogfish have the lowest (Gordievskaya, 1973). In addition to being consumed fresh, shark flesh may also be processed into the popular shark food surimi, dried, salted, or smoked (Musick, 2005).

The current study is supported by Haroon's (2010) observation that shark flesh is packaged fresh, frozen, or salted dry depending on the needs of the consumer .

The most expensive shark items are the fins, which are used to prepare the traditional Chinese delicacy known as shark fin soup (Clarke *et al.* 2006). The biggest and most expensive fins in most shark species are the first dorsal, pectorals, and lower lobe of the caudal, which are often sold as a set and were taken into account in the current study. A variety of shark species' smaller second dorsal, anal, and pelvic fins are combined and marketed.

Only the upper portion of the tiny cartilaginous ceratotrichia (needles) fin is utilized to produce the soup (Musick, 2005). Shark fins are cleanly removed from the body to avoid the meaty lower portion. They are subsequently packaged and dried for selling . Once processed in China, Hong Kong Special Administrative Region, or on mainland China, the majority of fins are sold to both domestic and foreign traders. Shark fin soup is an expensive shark product, and demand for it has increased significantly recently (Clarke *et al.,* 2006). (Cook *et al,* 1968). Shark fins, fin rays, and dorsal skin are shipped to China, Singapore, Hong Kong, and the United States, as reported by Roy *et al.* (2007); this is also included in the current study.

Several nations in Asia and Oceania consume shark skin after boiling and removing the fins. Shark skin has mostly been used to create beautiful, incredibly durable leather. Skins from bigger sharks are favored for the tanning business.

CONCLUSION

Based on the results obtained so far, the research recommends the following to achieve the development and advancement of the Egyptian fishing sector, the most important of which are:

1- Regarding natural fishing:

A - The seas:

-Development of the Egyptian fishing fleet in line with modern methods marine fisheries in international waters and expansion of fish farming on Egyptian coasts.

- Establishment of infrastructure projects for local production near fishing ports, such as: For example, the establishment of factories for the production of fishing nets and ice, the construction of complexes for the transportation, packaging, processing and wrapping of fish, and the use of solar energy in their operation.

B- Lakes: - Taking into account scientific research and scientific innovations in the areas of breeding, nutrition and reproduction in order to conserve natural fish resources.

C- Increasing the fish stocks of the lakes by adding juvenile fish through lake management to increase fish production.

2- Regarding fish farming:

- The need for expansion of fish farming due to its importance in bridging the fish nutritional gap through:

A- Development of current production systems and transfer of technology for this activity from developed countries.

B- Expanding the establishment of hatcheries to supply fish farms with the species they need.

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