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Fishing Effort, Catch per unit Fishing Effort and Relative Abundance of the Common Fish Species in Bardawil Lagoon, Egypt

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ABSTRACT

Bardawil Lagoon, situated in the Mediterranean coastal lands of Sinai, holds significant ecological importance as one of the least polluted wetlands not only in Egypt but also within the entire Mediterranean region. It is home to a diverse array of economically significant fish species such as seabream, sole, seabass, grey mullet, eel, meager, and grouper. Covering an average area of approximately 650 square kilometers, the lagoon supports the livelihoods of over 4,000 fishermen. Fishing activities in the lagoon are seasonal, typically spanning from early April to the end of December. This seasonal closure is a crucial conservation measure aimed at protecting the spawning populations of commercial species, ensuring their sustainability. Over the past 19 years, total annual commercial landings in Bardawil Lagoon have fluctuated between 1241.7 and 5410 tons, as reported in the Annual Statistical Report of 2021. In 2021 alone, 4206.7 tons were landed, translating to a substantial economic value of more than 400 million Egyptian pounds. Various fishing methods are employed in the lagoon, including Dabba or trammel nets, Dubdeiba, El-Bouss, Crab nets, Lines or Sinnar, and Dahbana nets. This study aimed to shed light on the fishing effort and the characteristics of fishing gear utilized in Bardawil Lagoon. Additionally, the study assessed the relative abundance of commercial species, expressed as catch per unit fishing effort (ton/standardized fishing boat), to evaluate the current status of these species in the lagoon. Furthermore, the study explored the governmental development projects undertaken in the lagoon area, providing a comprehensive overview of the ongoing initiatives.

INTRODUCTION

Fishery statistics, including catch and effort data, play a crucial role in stock assessment studies. These data serve as fundamental inputs for surplus production models, which are developed to determine the equilibrium or sustainable yield that can be harvested from a fishery for a specific level of effort (**Mehanna, 2006**). An understanding of the fishing effort is fundamental for assessing and managing fish stocks. Most management measures include deciding directly or indirectly upon the amount of

fishing effort (f) that should be applied to the stock to obtain a certain amount of catch (C) that is sustainable over time (**Rothchild, 1977**). Furthermore, the most commonly used method up-to-date of estimating the relative abundance of an exploited fish stock is by using the catch per unit effort (C/f) as an index of relative abundance of fish stocks.

Fishing gears are fundamentally associated with selectivity, a vital aspect of fisheries management. Selectivity, which assesses the impact of fishing on an ecosystem, constitutes an essential component of management plans. By understanding and addressing selectivity, fisheries can sustainably manage their impact on marine ecosystems, ensuring ecological balance and biodiversity. Mesh size and gear restrictions are among the most easily applied and widely used management regulations. Consequently, most countries have forced legislation that prohibits certain gears and mesh-sizes in order to protect the fishery resources (**Gulland, 1982**).

Bardawil Lagoon (Fig. 1) is one of the northern lakes in Egypt, and it is a part of the Mediterranean coastal lands of Sinai. Moreover, it is an important source of local and economic fish in North Sinai, and it plays an essential role in the fish production in Egypt, where it produces very economically important species of fish such as seabass, seabream, sole, grey mullet, eel, meager and white grouper. Bardawil Lagoon is a shallow hyper-saline lagoon; it extend to about 85km in length with a maximum width of 22km, and ranges in depth from 0.3 to 3m. The Bardawil Lagoon, stretching along much of the Mediterranean coast of Sinai, is separated from the sea by a sandbar that varies in width between 100m and 1km. This lagoon stands out as the least polluted wetland in Egypt and is among the least polluted in the entire Mediterranean region. Covering an average area of about 650 square kilometers, it provides livelihoods for approximately 4,000 fishermen. The fishery in Bardawil Lagoon is generally seasonal from April to the end of December; all fishing activities are prohibited in winter from January to the end of March. A number of fishing methods are used in the lagoon including Dabba or trammel nets, Dubdeiba, El-Bouss, Dahbana nets, Lines or Sinnar and crab nets (**Mehanna, 2006a, b; Mehanna, 2013; Farouk, 2014; Salman 2014; Mehanna *et al.*, 2020**).

Recognizing the significance of the lagoon, the government initiated a development project aiming at enhancing fish production from the Bardawil Lagoon. The project, commenced this year, comprises three phases. The first phase involves digging a longitudinal canal parallel to the sandbar, spanning a length of 73km. The second phase focuses on excavating several branching canals totaling 57km in length. Lastly, the third phase involves the creation of coast guard canals, covering a distance of 7.5km. These strategic developments are intended to optimize the lagoon's potential and foster sustainable fisheries in the region (Fig. 2). The present study has concentrated on examining the characteristics of fishing gears employed in the Bardawil Lagoon, analyzing the fishing effort exerted within the lagoon, and assessing the relative abundance of commercial fish species over the course of the last 19 years.

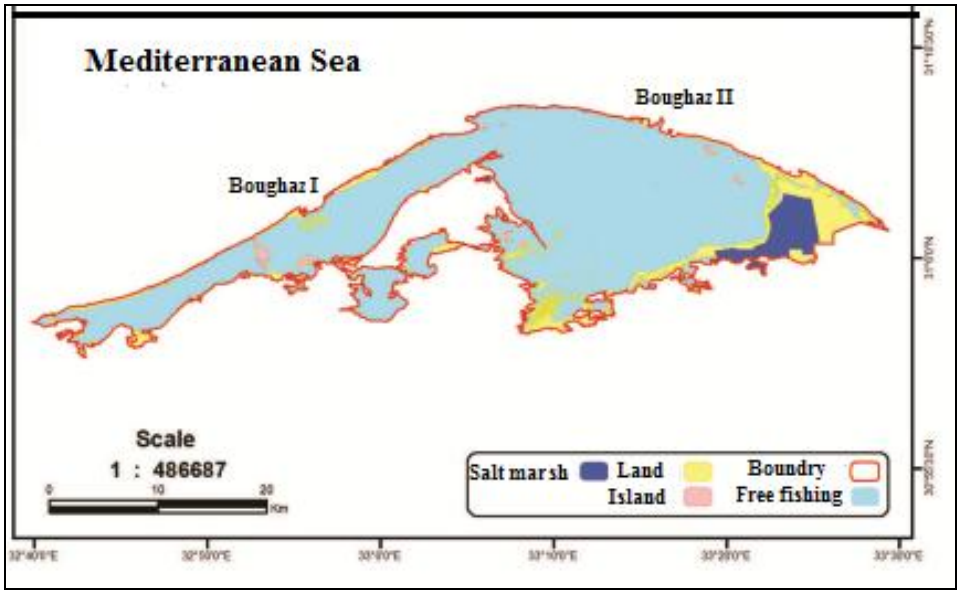


Fig. 1. Bardawil Lagoon

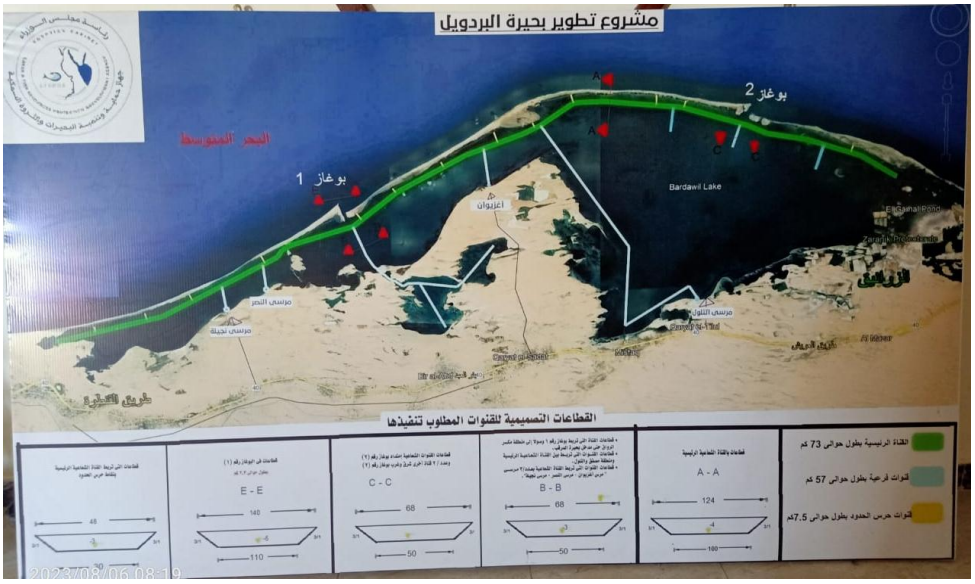


Fig. 2. Development project stages for Bardawil Lagoon development (source: LFRPDA office in Bir Elabd)

MATERIALS AND METHODS

1. Collection of fishery statistics

Data concerning the monthly and annual catch of different fish species and fishing effort of Bardawil lagoon were obtained from the General authority for Fish Resources Development office in Bir El-Abd, North Sinai.

2. Catch composition and fishing gears

The catch composition of the different fishing gears and the gears' characteristics were recorded during the field trips to three landing sites in the lagoon fishery (Fig. 3),

El-Tulul, Aghzwan and El-Nasr. During the field visits, the fishermen were interviewed to collect all data about the fishing gears used and how they operated, their characteristics, their catch composition, and the real fishing effort exerted into the lagoon. Additionally, interviews were conducted with administrative individuals to gather data regarding the progress and impact of the governmental development project in the lagoon.

Fig. 3. Bardawil Lagoon and conducting interviews with the fishermen and the director of the lagoon

3. Catch per unit fishing effort

The fishing effort in the study was quantified using the number of fishing boats, standardized across various fleet segments. The method proposed by **Robson (1966)** and elaborated upon by **Gulland (1983)** was employed for standardization. The Dabba boats unit was selected as the standard fishing effort unit, with all other types of fishing boats converted into equivalent standard units. The collected catch and estimated effort data were analyzed to calculate the catch per unit of fishing effort (CPUE), serving as an indicator of stock biomass and relative abundance of stocks.

RESULTS AND DISCUSSION

1. Fishing effort and fishing gears

The fishing boats utilized in the Bardawil Lagoon are small wooden vessels, measuring approximately 6- 7 meters in length and with an average width of 1.8 meters. These boats are powered by outboard motors ranging from 8 to 10 horsepower, with the majority equipped with 9.9hp engines for Dabba fishing method. For El-Bouss fishing techniques, the boats are powered by outboards with higher capacities, typically ranging from 15 to 30 horsepower.The number of fishing boats during the last 20 fishing seasons fluctuated between 1120 and 1150 boats working with Dabba and varied between 84 and 108 working with El-Bouss fishing method. The average number of fishermen was three persons for each Dabba boat, while the number varied between 14 and 20 persons for each unit Bouss fishing technique (four boats: two motorized and two un-motorized). Fig. (4) shows that the Dabba fishing gear predominates in Bardawil Lagoon, contributing to 89% of the total production from the lagoon between 2003 and 2021.

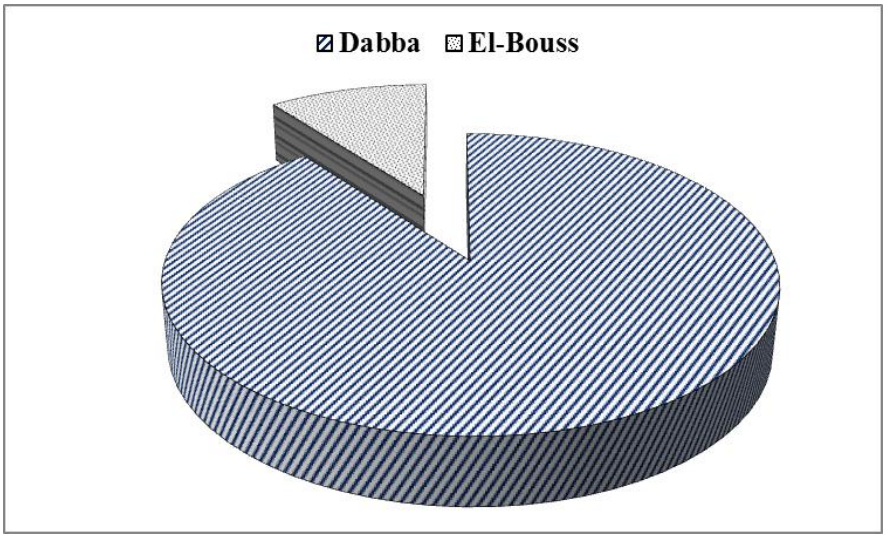


Fig. 4. Contribution of each fishing method in the Bardawil Lagoon production (2015-2021)

Dabba fishing gear (Fig. 5) is trammel nets of 750m average length for each boat, the two outer layers of the net have 4-5 maga (number of openings in 50cm) and 1-2m in depth, while the middle layer has smaller mesh size of about 14 maga and about 1.5 - 3m in depth. The net is supported by an upper rope of 4mm thickness and floating units, separated from each other by about 40cm, and it has a lower rope of 3mm thickness loaded by parts of lead with an average weight of 30g and separated from each other by about 20cm (Bardawil Lagoon report, Statistics Department, 2023). The fishing by trammel nets was daily undertaken from the sun set to the early morning of the next day.

The Dubdeiba fishing gear functions as a trammel net, with each boat equipped with a net measuring 400 meters in length. The outer layers of the net feature 4-5 maga (floats) and reach depths of 1-2 meters, while the middle layer has a smaller mesh size, approximately 17 maga, and depths ranging from 1.5 to 3 meters. Structurally similar to Dabba, the Dubdeiba net is not set in the water directly; instead, fishermen spread the nets in a circular shape and collect them in a repeating manner.

Catch of Dabba and Dubdeiba is composed of all commercial species in the lagoon like seabream, seabass, soles, meager, grey mullet, shrimp, crab, striped piggy and rabbitfish.

Fig. 5. Dabba fishing gear in Bardawil Lagoon

El-Bouss fishing gear (Fig. 6) provides about 11% of the total fish production in Bardawil lagoon. This fishing technique depends on the aggregation of 4 boats together; two of them motorized and the other two are un-motorized and used for carrying nets. Bouss fishing nets consist of two parts, one horizontal and the other vertical with length not exceeding 800m and depth of 5m with 26 maga. The net is kept vertically in water by floating parts or rubber of 50cm at equal distances and loaded from the bottom by parts of lead in 55cm equal distances. The horizontal part of the Dubdeiba net comprises three layers, supported by units made of bamboo, allowing it to spread effectively in the water. The outer two layers have 4-5 maga, while the middle one has 26 maga. The Dubdeiba fishing gear is exclusively employed for catching grey mullets, with all other species in the lagoon being caught as bycatch. Each fishing operation takes about 2 hours and repeated for 4-5 times per day.

Fig. 6. El-Bouss fishing gear in Bardawil Lagoon

The dahbana net, also known as purse-seine or chancholla, as shown in Fig. (7), is a trammel net used by Dabba fishing boats to capture mullets and other pelagic species. Each net has a length of 400 meters per boat. The outer layers feature a depth of 2 meters and 4-5 maga, while the middle layer is divided into two parts: the upper section has a depth of 1 meter with 26 maga, and the lower part also has a depth of 1 meter with 14 maga. The net is spread in a circular shape and collected without standing in the water. It operates primarily at night to catch *Liza ramada* and *L. aurata*, as well as shrimp. However, it is considered a destructive gear for sea bream juveniles.

Fig. 7. Dahbana fishing gear (chancholla) in Bardawil Lagoon

Crab nets in Bardawil Lagoon consist of single-layer nets with a depth not exceeding 1 meter and featuring 10 maga. These nets are primarily used to catch crabs in the lagoon. Fishermen spread the nets in the water from sunset to sunrise on the next day.

Lines gears, known as Sinnar, are predominantly long and hand lines made of nylon, with a length of up to 300 meters. Branches are attached to the main line at equal distances. Each branch line is equipped with a hook at its end. This fishing method is specifically employed to catch nocturnal fishes without artificial lights. The main catches using this method include *Dicentrarchus labrax, D. punctatus, Epinephelus aeneus, Anguilla anguilla* and *Argyrosomus regius.*

Additionally, there are illegal fishing gears used in the lagoon, varying according to the appearance and abundance of different species. For instance, the Madad gear is utilized for catching groupers and meagers, along with crab nets. The Sphinx nets, a type

of trammel net, are kept vertically in the water using floating parts or rubber and are weighted from the bottom with lead parts. These nets are inexpensive and do not require boats for use. Although they are prohibited in the lagoon, fishermen employ them to catch sole fingerlings. Trawl nets, despite being banned, are still illegally used to catch shrimp, inadvertently capturing a significant portion of young and small-sized commercial fish species (**Mehanna *et al.*, 2011; Mehanna *et al.*, 2020**).

2. Catch statistics

In Bardawil Lagoon, the catch is classified into two main categories based on their value and size. The high-valued category includes species such as gilthead seabream, seabass, flathead grey mullet, meager, grouper, soles, European eel, crabs and large shrimp (Fig. 8). In contrast, the low-valued category (Fig. 9) comprises less significant species and small-sized commercial fishes like *Crenidens crenidens, Atherina boyeri, Hemiramphus far, Siganus rivulatus, Terapon puta, Tilapia zillii, Tylosurus* spp*., Aphanius dispar, A. fasciatus, Pomatoschistus marrmoratus* and *Syngnathus abaster, Metapenaeus stebbingi* in addition to *M. monoceros.* Many of these species are immigrants from the Red Sea, finding Bardawil Lagoon to be a suitable habitat due to its decreased water salinity. The lagoon provides a safe shelter and abundant feeding grounds for these species. Furthermore, these immigrants exploit unoccupied trophic levels in the lagoon, leading to a decline in euryhaline native species (**Mehanna *et al.*, 2020**).

Between 2003 and 2021, crustaceans, including five shrimp species and three crab species, dominated the catch in Bardawil Lagoon, accounting for 54% of the total catch (21.5% for shrimp and 32.4% for crabs). Among fish species, grey mullet was the most significant, constituting 28.7% of the lagoon catch. It was primarily composed of flathead grey mullet *Mugil cephalus* (67% of the mullet catch), followed by *Liza ramada* (31%), *L. aurata* (0.7%), *Chelon labrosus* and *L. carinata*. Other notable fish species included gilthead seabream (9.9%), soles (4.7%), seabass (2.3%), meager (0.43%) and grouper (0.18%) (Fig. 8).

In 2021, there were some notable changes in the species composition of the lagoon catch. Seabream (Sparus aurata) experienced a sudden increase from 487.6 tons in 2020 to 1185.5 tons in 2021, constituting 29.4% of the total catch. This increase was unexpected, especially since other fish species did not show similar trends. Seabream catches ranged between 208 and 487.6 tons in the last 20 years and they never exceeded this value until 2021. Grey mullet contributed to 24.7% of the total catch in 2021, followed by seabass (5.9%), soles (2.9%), meager (0.89%) and grouper (0.23%). Crab populations remained stable, accounting for 26.9% of the lagoon catch, while shrimp's contribution decreased to only 9.1% (Fig. 10)

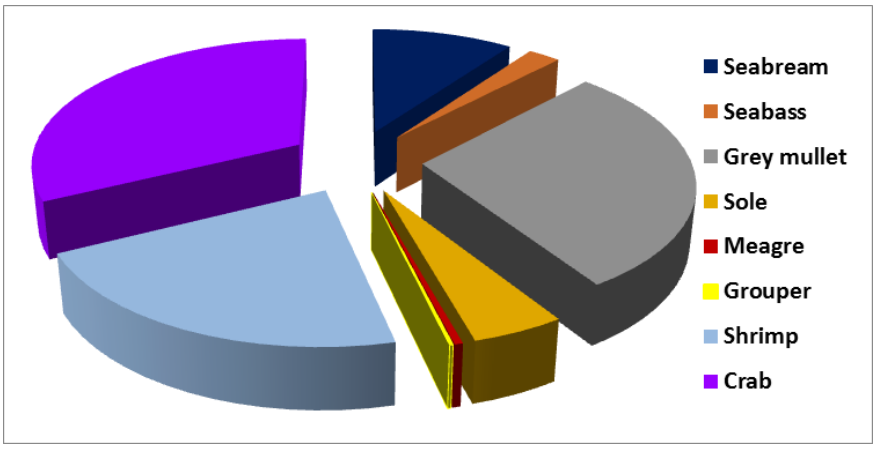


Fig. 8. Catch composition in Bardawil Lagoon during 2003-2021

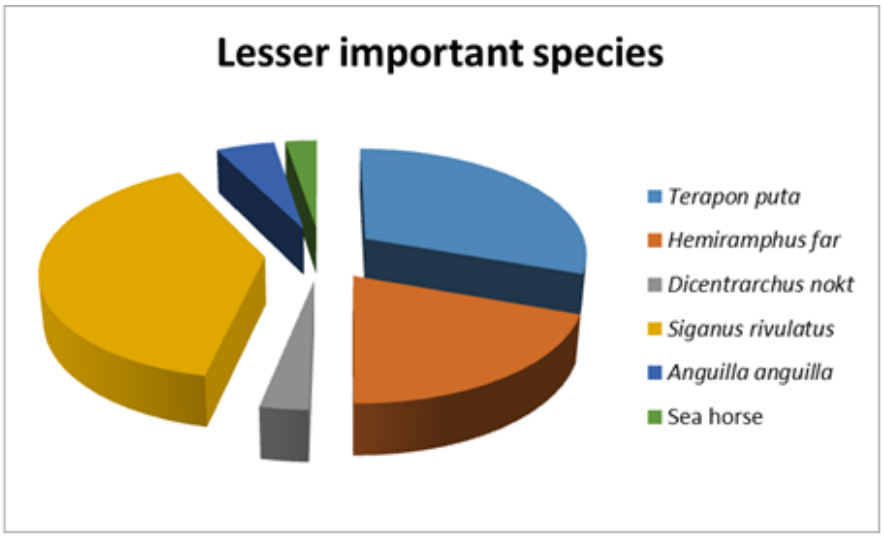


Fig. (9). Catch composition of lesser importance fish species in Bardawil lagoon

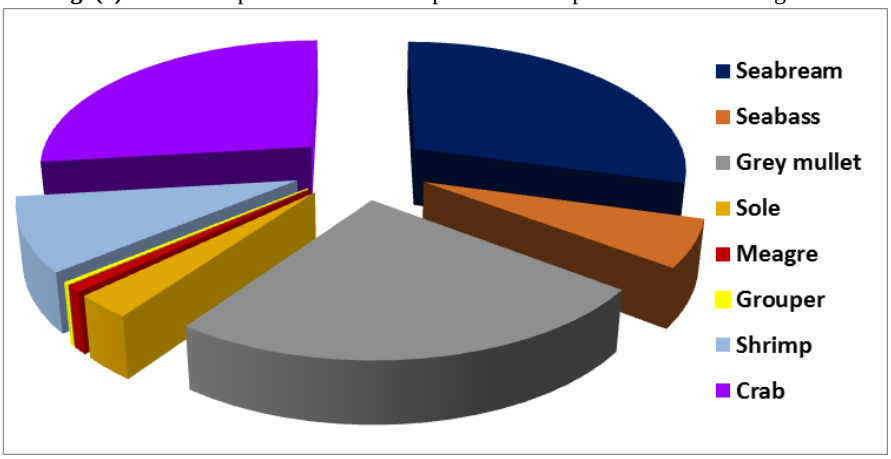
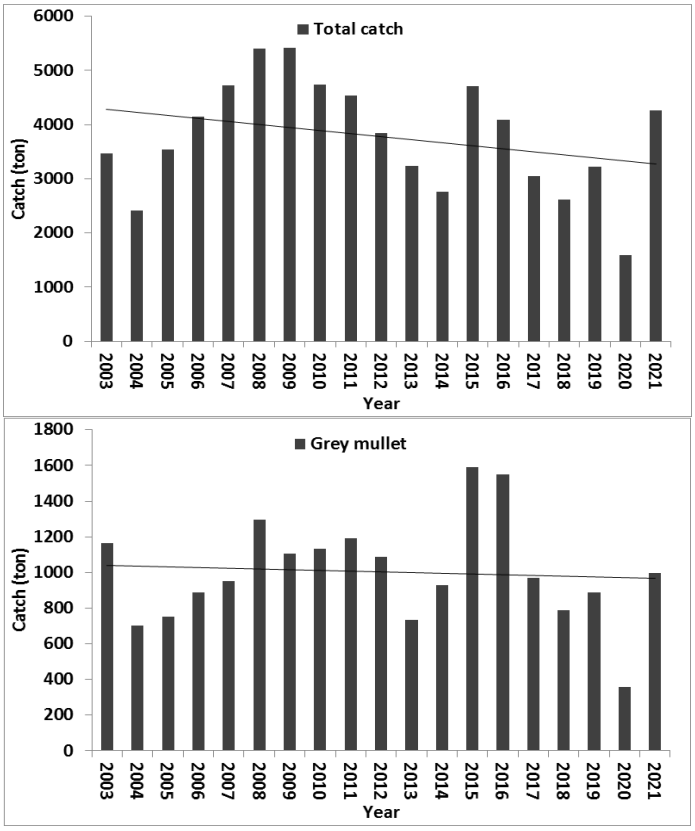
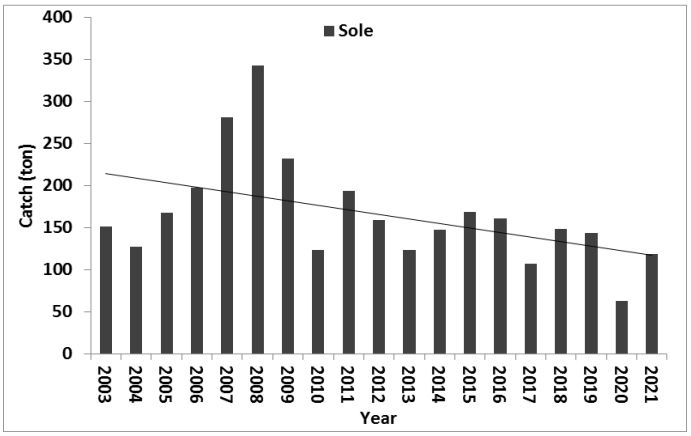
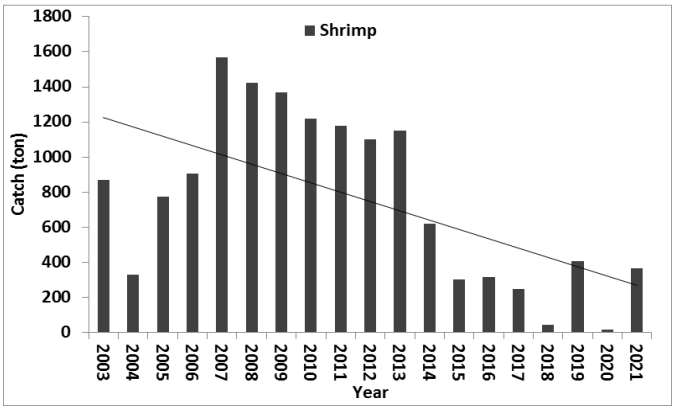


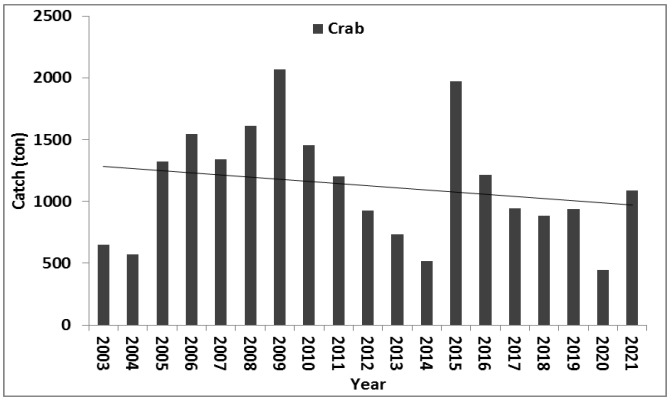
Fig. 10. Catch composition in Bardawil Lagoon during 2021

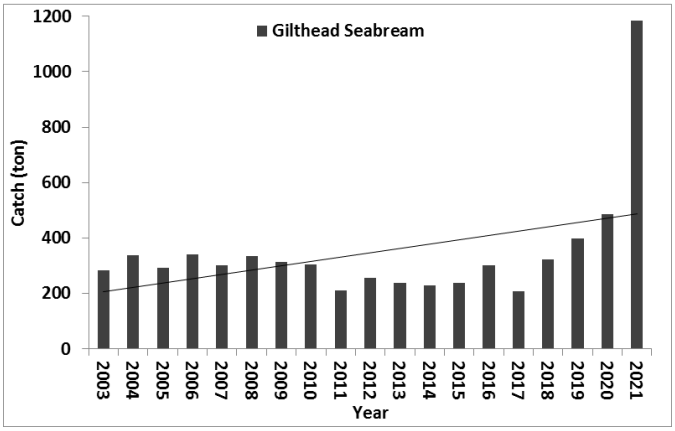
The data presented in Fig. (11) indicate a general decreasing trend in the annual total fish production from Bardawil Lagoon between 2003 and 2021. This declining pattern is consistent with grey mullet, soles, shrimp, and crab catches during the same period. However, there were notable exceptions in the cases of gilthead seabream and European seabass, where a sudden increase in catch was observed in 2021. The unexpected surge in gilthead seabream and European seabass catches in 2021 poses a puzzling scenario, especially given the consistent catch levels over the previous 18 years. This increase is even more perplexing considering that the development project only commenced in 2023. The reasons behind this abrupt rise in seabream and seabass catches in 2021 remain unexplained and require further investigation to understand the underlying factors contributing to this anomaly.




Sole
Catch (ton)
Year


Shrimp
Catch (ton)
Year


Crab
Catch (ton)
Year


Gilthead Seabream
Catch (ton)
Year

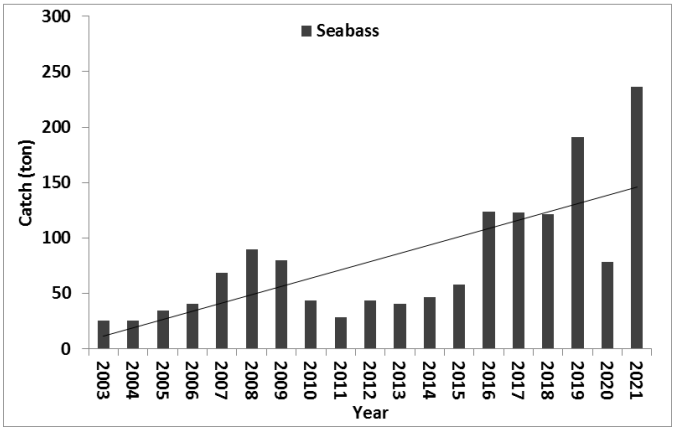


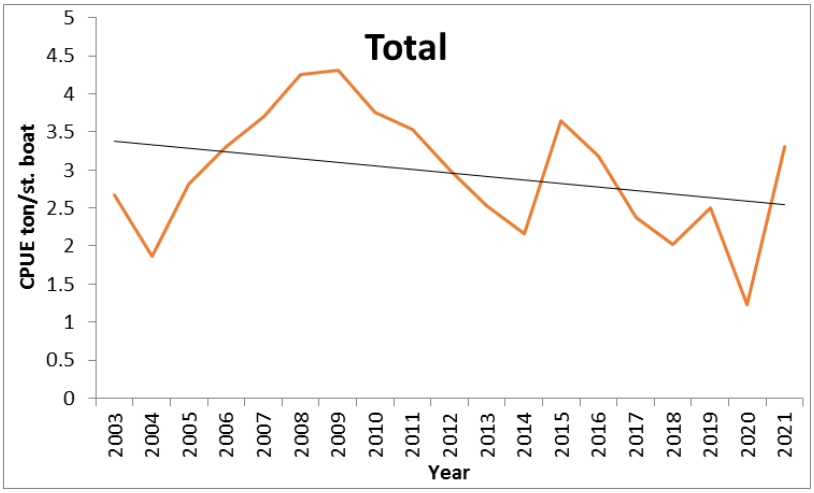
Fig. 11. Catch trend for total and commercial species in Bardawil Lagoon

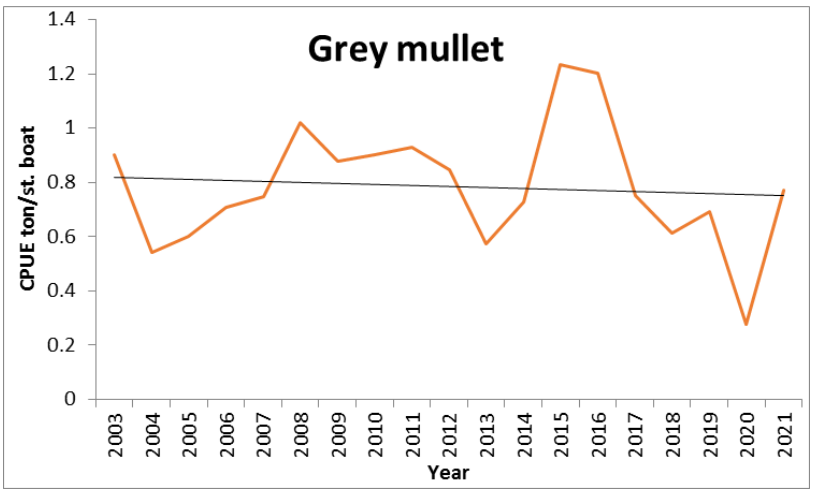
4. Fishing effort and catch per unit fishing effort (CPUE)

The fishing effort (standardized number of fishing boats operated in Bardawil lagoon) during the fishing seasons from 2003 to 2021 fluctuates from season to another from a minimum of 1254 fishing boat to a maximum of 1294 fishing boat, while the number of fishing days ranged between 112 and 196 days during the period 2003-2021.

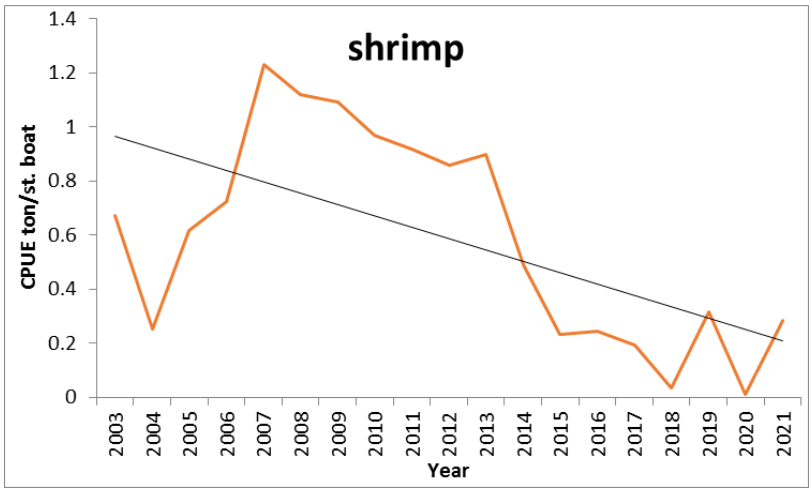
The catch per unit fishing effort has been extensively used to measure changes in the abundance of fish population. The annual catch per unit of fishing effort (expressed as the ton per standard number of fishing boat "C/f") for the total and common species catch during the fishing seasons from 2003 to 2021 are estimated and represented in Fig. (12).

The total annual catch per boat fluctuated between a maximum value of 4.3 (ton / boat) during 2009 and a minimum value of 1.2 (ton/boat) during the fishing season 2020, with a decline trend in the relative abundance of fish stocks in the lagoon.




Grey mullet
CPUE ton/st. boat
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Year


Sole
CPUE ton/st. boat
0.3
0.25
0.2
0.15
0.1
0.05
0
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Year


shrimp
CPUE ton/st. boat
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Year

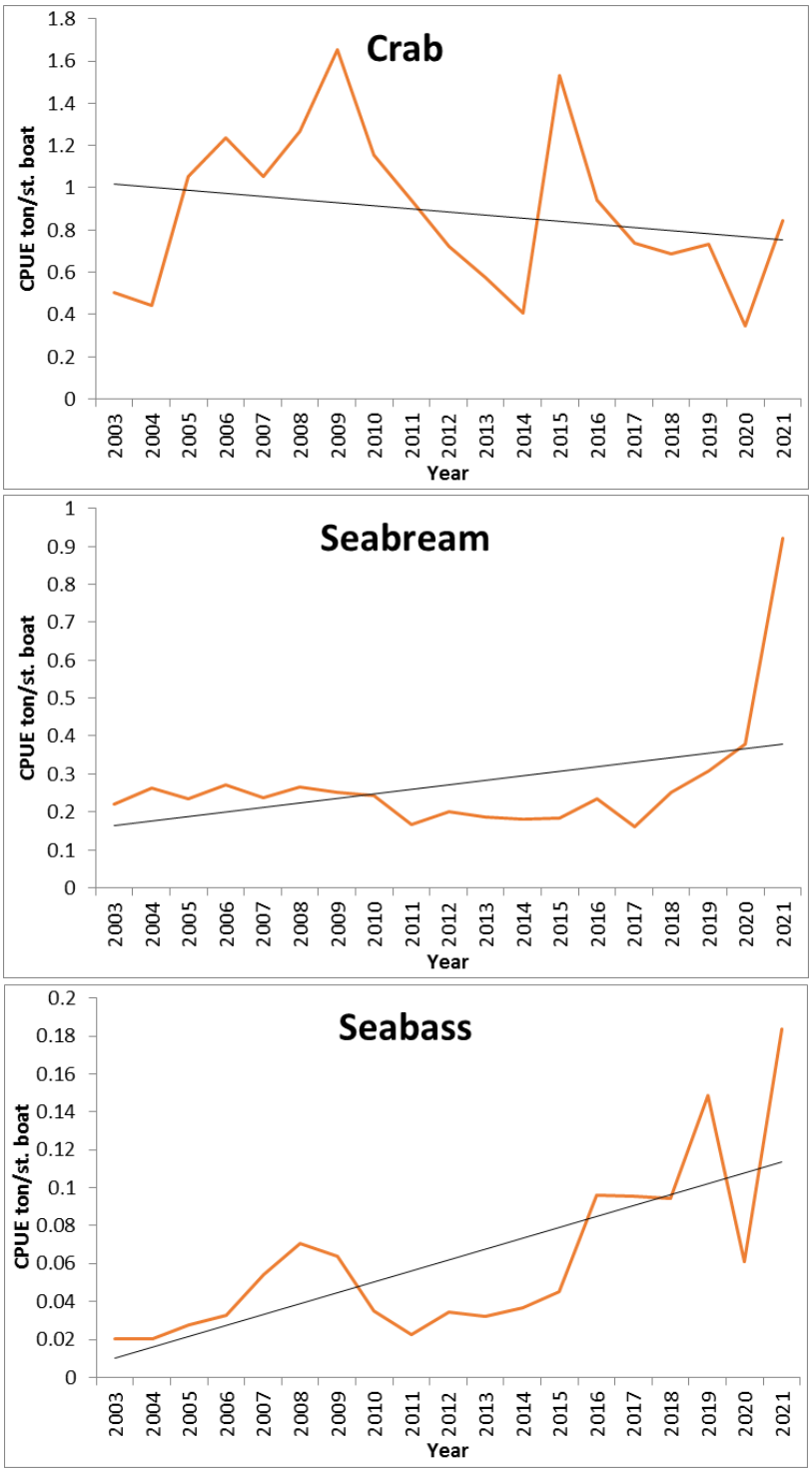


Fig. 12. Relative abundance of total fish production and common species in Bardawil Lagoon during 2003-2021

The CPUE for the grey mullet, soles, shrimp and crab in Bardawil Lagoon showed a decreasing trend in the last 19 years, reflecting the decline of relative abundance of these stocks. Grey mullet catch/effort fluctuated between a maximum value

of 1.23 ton/ boat during 2015 to a minimum value of 0.28 ton/ fishing boat during the fishing season 2020. The CPUE of soles fluctuated between a maximum value of 0.27 ton/ boat during 2008 and a minimum value of 0.05 ton/ boat during 2020. Shrimp catch per unit effort was fluctuated between 1.23 (2007) and 0.01 (2020) ton/ boat, while crab catch per unit effort was varied from 1.65 (2009) to 0.35 (2020) ton/ boat. The catch per unit fishing effort (CPUE) for seabream in the lagoon showed an increasing trend, reaching a very high value in 2021 at 0.92 ton per boat. Similarly, seabass catch also exhibited a rising trend, with a recorded CPUE of 0.18 ton per boat in 2021. These trends suggest an improvement in the efficiency of fishing for these specific species in Bardawil Lagoon, leading to higher catches per unit of fishing effort (Fig. 12).

The decrease in the relative abundance of the total catch and commercial species from Bardawil Lagoon suggests an overexploitation situation in the lagoon. Previous studies on seabream and seabass in Bardawil Lagoon have consistently indicated heavy exploitation of these species exploited (**Hegazy & Sabry, 2001; Khalifa, 2005; Mehanna *et al.*, 2010; Ahmed, 2011; Mehanna *et al.*, 2011; Mehanna *et al.*, 2014; Al-Zahaby *et al.*, 2018; El-Aiq *et al.*, 2021; El-Desoki *et al.*, 2021**). Therefore, the sudden increase in the catch of both species, as reported in the annual statistical book of GAFRD, appears illogical and warrants a careful review of the catch statistics to ensure accurate representation of the situation.

CONCLUSION

Fishery-dependent monitoring relies on the collection of two crucial parameters: catch (C) and fishing effort (f). These parameters are essential for determining the catch rate (C/f), which represents the relative abundance of fish stocks. The catch rate is directly linked to stock abundance and serves as an index of stock size. Therefore, the quality and reliability of fishery statistics are of utmost importance for effective fishery management and evaluating the fishery status.The current recording system requires urgent improvements to enhance its accuracy and reliability. Additionally, evaluating fishing gears and their selectivity is a vital component of any fisheries management plan. Re-evaluating these gears to improve their selectivity and prohibiting the use of destructive ones is necessary. Based on the results obtained, an overfishing status is observed in the Bardawil Lagoon fishery. To address this situation, efforts should be directed towards improving the accuracy of fishery statistics. Detailed studies based on biological, dynamical, and ecological parameters are essential to achieve the sustainability of lagoon fisheries. These studies will provide valuable insights into the ecosystem, enabling information for decision-making to attain sustainable fisheries management in Bardawil Lagoon.

REFERENCES

Al-Zahaby, A. S.; El-drawany, M. A.; Mahmoud, H. H. and Abdsalla, M. A. F. (2018). Some biological aspects and population dynamics of the Gilthead Sea bream from Bardawil lagoon, Sinai, Egypt. Egypt. J. Aqu. Biol. Fish., 22: 295- 308.

Ahmed, M. S. (2011). Population dynamics and fisheries management of Gilthead seabream, *Sparus aurata* (Sparidae) from Bardawil lagoon, North Sinai, Egypt, Egypt. J. Aqu. Biol. Fish., 15: 57- 69.

El-Aiq, A.; Raaft, M.; Youssef, E. A.; Ahmed, S. M.; Al-Beak, A. M. and Kassem, S. A. (2021). Assessment of *Sparus aurata* (Gilthead Seabream) stock in Bardawil lagoon, southeast Mediterranean Sea. Int. J. Aquac. Fish. Sci., 7(3): 30-34. DOI: https://dx.doi.org/10.17352/2455-8400.000070

El-Desoki, M. O.; Younis, Y. M.; Youssef, E. D.; Ahmed, M. S.; Kassem, S. A. and Al-Beak, A. M. (2021). Age, growth and mortality of the European Seabass, (*Dicentrarchus Labrax*) in Bardawil lagoon, North Sinai, Egypt. Int. J. Aquac. Fish. Sci., 7(4): 042-046. DOI: https://dx.doi.org/10.17352/2455-8400.000072

El-Gammal, F. I.; Al-Zahabi, A. S. and Mehanna, S. F. (1994). Preliminary analysis of the status of trawl fishery in the Gulf of Suez, with special reference to shrimp fishery. Bull. Inst. Oceanogr. Fish., ARE, 20 (2): 157-174.

Eid, N. M. (2019). Comparative study on stock assessment of family Mugilidae between Timsah and Bitter lakes, PhD Thesis, Suez Canal University.

Farouk, A. (2014). Impact of Some Environmental Condition on Water Quality and Some Heavy metals in Water and common fish species in Bardawil Lake. PhD Thesis, Al-Azhar University.

GAFRD (2020). Annual statistical report of General Authority for Fish Resources Development GAFRD, 2020.

Gulland, J.A. (1982). The management of tropical multispecies fisheries, in Theory and management of Tropical Fisheries, Pauly D. & Murphy G.I. (eds), ICLARM Conf. Proc. No. 9, Manila, ICLARM: 287-298.

Gulland, J. A. (1983). Fish stock assessment: a manual of basic methods. Chichester, U. K., Wiley Interscience, FAO/Wiley series on food and agriculture, 1: 223p.

Hegazy, M. R. and Sabry, E. A. (2001). Stock assessment for the seabass (*Dicentrarchus labrax* L., 1758) - piscs: Moronidae in Bardawil lagoon, Egypt. J. Egypt. Ger. Soc. Zool., 34: 41-55.

Khalifa, U. S. (2005). Population characteristics and fisheries management of European seabass *Dicentrarchus labrax* L., in Bardawil lagoon, Egypt. Afr. J. Biol. Sci., 1: 69-78.

Mehanna, S. F. (2006a). Lake Bardawil fisheries: current status and future sight. J. Egyp. Ger. Soc. Zool., 51(D): 91-105.

Mehanna, S. F. (2006b). Fisheries regulations based on yield per recruit analysis for the spotted seabass *Dicentrarchus punctatus* (Moronidae) at Bardawil lagoon,

Mediterranean coast of Sinai, Egypt. Egyp. J. Aquat. Biol. & Fish., 11 (4): 129-145.

Mehanna, S. F. (2013). Sustainable development of Bardawil lagoon fisheries. First Regional Symposium on Sustainable Small-Scale Fisheries 27 – 30 November 2013, St. Julian‟s Malta.

Mehanna, S. F. (2020). Challenges faced the small scale fisheries and its sustainable development. ICAR- Central Marine Fisheries Research Institute, Research Centre Mangalore, 7-10 January 2020.

Mehanna, S. F. (2021). Egyptian Marine Fisheries and its sustainability, pp. 111-140. In: Sustainable Fish Production and Processing (Ed. Galanakis, Ch. M.). Academic Press, Elsevier, 325 pp.

Mehanna, S. F.; El-Aiatt, A. A.; Ameran, M. and Salem, M. (2010). Population dynamics and fisheries regulations for the European seabass Dicentrarchus labrax (moronidae) at Bardawil lagoon, Egypt. 3rd International conference on Fisheries and Aquaculture, 29 November-1 December, Cairo, Egypt. www.cabdirect.com

Mehanna, S. F.; El-Aiatt, A. A. and Salem, M. (2011). An investigation of the impacts of shrimp bottom trawling on the Bardawil lagoon fisheries, Egypt. Egyp. J. Aquat. Biol. & Fish., 15 (3): 369-378.

Mehanna, S. F.; Shaker, I. M. and Farouk, A. (2014). Population dynamics of gilthead seabream *Sparus aurata* in the Bardawil lagoon, North Sinai, Egypt. 4th scientific conference “Fisheries resources between science and application”, Abbasa, 11-13 March 2014.

Mehanna, S. F.; Eid, A. M.S.; Ali, B. A. and Aabed, M. S. (2020). Fishing gears, catch composition and length at first capture of the common fish species in Bardawil lagoon, Egypt. Egyptian Journal of Aquatic Biology & Fisheries, 24(5): 523 – 538.

Robson, D. S. (1966). Estimation of relative fishing power of individual ships. ICNAF Res. Bull., 2: 5-14.

Rothchild, B. J. (1977). Fishing effort, in Fish Population Dynamics, J.A. Gulland (ed.), London, John Wiley & Sons: 96-115.

Salman, Sh. (2014). Fisheries characteristics and population dynamics of commercial species of family Soleidae at Bardawil Lagoon, North Sinai, Egypt, MSc Thesis, Suez Canal University.