



## The Effect Of Hook Size On Size Selectivity In Bardawil Lagoon Artisanal Longline Fishery, Eastern Mediterranean, Egypt

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### ABSTRACT

The size selectivity and fish species of longline fishery using small hooks were studied in Bardawil lagoon using hooks of different sizes (numbers 10, 12, and current 13) baited with small shrimp. Hook numbers 10 and 12 are 67 and 32% larger respectively than number 13 hooks in terms of maximum width and 24 and 15% larger respectively in terms of maximum length. A total of 12600 hooks were fished in 18 sets targeted European eel that fished during three months October, November, and December during 2019 and repeated in 2020. As a bycatch, seabass, sea bream, sand flathead fish, and grouper are dominated in the catch along with undersized eel. The distribution of catch size according to the different hook sizes was, in general, highly overlapped for all caught species and the hook size had clear effect on maximum and minimum length at capture. All experimental hooks fished a wide range of lengths per species, but the catch rate (number of fish per 100 hooks) was significantly lower for the largest hook except for seabass. The capture of illegally sized or immature fish was high in all hooks but much higher in the smallest hook except for seabass. Clear increases in average size with hook size were evident for target and bycatch species. The results of selectivity experiments in terms of the 50% retention length ( $L_c$ , the fish length corresponding to 50% chance of capture) were presented reflecting the increase of  $L_c$  with the increase of hook size.

### INTRODUCTION

Fisheries have a significant role in poverty alleviation, food security, nutrition supply, sources of income, employment opportunities, foreign exchange earnings and overall on the socio-economic development of Egypt. Sound fisheries management needs that fishing gears should catch the large mature fish while immature and small juveniles are allowed to escape (Armstrong *et al.*, 1990). This suggests that the gear's capture efficiency should be modified with the size or age of the fish. The capture efficiency is defined as the proportion of fish encountering the gear which are retained in the catch.

Thus the gear should 'select' the older fish from the population which is being exploited. In practice, the catch selection be subject to the size rather than the age of the encountered fish, because the size (e.g. length or girth) determines the possibility of escape through the mesh or by swimming away from the gear.

Bardawil lagoon is one of the most key lakes in the northeastern Egypt, eastern Mediterranean Sea. It is a salty coastal depression free of pollution because it is far from any sources of pollution. The catch of the Bardawil lagoon composed mainly of the high-value saltwater fish species like seabream, soles and seabass. One of the main challenges that facing the lagoon development is the fishing gears used. There are many legal and illegal fishing activities in the lagoon which operated on a small scale basis, utilizing small boats and limited technology.

Despite the great socio-economic importance of small-scale fisheries in Egypt, there is a huge gap of information on size selectivity of hook and line gear, catch composition, catch rates and factors which affect these, and gear overlap and competition. Little is known concerning the amount of long-line gear in use.

Fishing techniques and gears can impacted the biomasses and harvested yields of stocks, ecological interactions among species and the productivity and functioning of ecosystems, where this impact may be direct or/and indirect (Millar and Fryer, 1999; Hall, 1999; Campos *et al.*, 2003; Mehanna *et al.*, 2010&2011; Aabed, 2020; Mehanna *et al.*, 2020). For the vital role of fishing gears in fisheries management, there are a continuous improvements and development of fishing gears worldwide. The re-evaluation of current fishing methods and application of new technologies could help small scale fisheries increase their outcomes by increase their catch, but improving of the current fishing technologies or introducing of any new ones always demands good rational management and regulation based on good scientific research.

In Bardawil lagoon, different longline types are traditionally used to target European seabass, grouper, meager and recently the European eel. Each type is characterized by differences in the gear's components (e.g. mainline material, hook shape and size, bait type and size, etc.) which affect the selectivity and the impact on the potential bycatch species. This longline fishery operates mainly in the lagoon between October and December. The number of hooks deployed is 300 hooks per set and the soaking time from sunset to just before sunrise, is less than 10 h.

Very rare investigations based on scientific research were found on fishing gears and its selectivity in Bardawil lagoon particularly (Salem, 2018; Mehanna *et al.*, 2020) and in Egyptian marine fisheries in general. Because the effective fishery management requires a good knowledge on fishing gears, the present work was done to evaluate the impact of hook size on size selectivity in Bardawil lagoon artisanal longline fishery, eastern Mediterranean, Egypt.

## MATERIALS AND METHODS

### 1. Study area

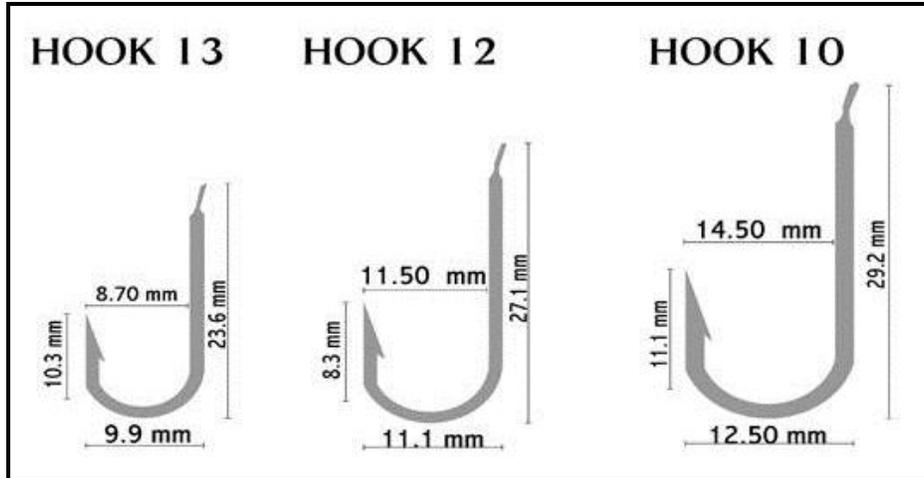
The study was carried out in Bardawil lagoon (Fig. 1) during two fishing seasons 2019 and 2020, covering three months from October to the end of December (the traditional fishing season for the hook gear). The lagoon is considered as a natural depression covering an area of 650 km<sup>2</sup>, in an arid area in the northern part of Sinai Peninsula, Egypt. It extends to about 90 km length with a maximum width of 22 km. It is a shallow hyper-saline lagoon where its depth ranged from 0.3 to 3 m (Mehanna, 2006a&b; Salman, 2014). It is separated from the Mediterranean Sea by along narrow sandbar that varies in width between 100 m and 1 km. The lagoon is connected to the Mediterranean Sea by two artificial channels (Boughaz I and II) and one natural narrow channel (Boughaz Zaranik).



**Fig. 1. Bardawill lagoon**

### 2. Gear design

Three long-line selectivity trials have been carried out during two fishing seasons (2019 and 2020). The local fishermen were consulted prior to the design of the experimental fishing gear used in the selectivity studies. The study was conducted using the current hook style that used by fishers along with two different sizes. They use the strong “J” style hooks size No. 13 (with a bend width of 9.9 mm and a total length of 23.6 mm) to target the eels and basses species. Moreover, we used two different J-style hooks: 12 (with a bend width of 11.1 mm) and 10 (with a bend width of 12.5 mm) (Fig. 2). The longlines used in this study consisted of monofilament mainline 60 mm and 30 mm leaders. The leaders inbetween spaces were approximately 3 m each and each longline contains 100 hooks.



**Fig. 2. J style hooks of different sizes**

### **3. Field collection**

Field work was conducted by choosing two commercial fishing boats using longlines and operating in Bardawil lagoon. Longlines targeted European eel and seabass were rigged with the hook type commonly used by the fleet (J hook style: size 13). Hooks were baited with small shrimp. Six baskets were prepared (Fig. 3) each with 350 hooks and two sets for each hook size and deployed twice a month for three months (fishing season of line fishery) from October to December, 2019 and repeated in 2020. Line setting started in the evening and completed before sunset whereas the hauling began at dawn and took 7-9 hours which is the usual style of commercial shallow set longline fishing boats working in the lagoon. The six baskets are of 2100 hooks with a total of 12600 hooks during each season of the experiment. Samples were taken directly to the laboratory. The species, number, length by individual and weight were recorded and measured. The catch data (number of fish per 100 hooks) of the 18 trips were analyzed and the catch rate for the target and bycatch species was analyzed for the three hook sizes.

### **4. Biological measurements**

Length measurements made on total body length (TL) for each specimen to the nearest millimeter and sorted afterwards in sequential length groups of one centimeter interval.

### **5. Length frequency distribution**

Length frequency distribution for the most three common species in Bardawil lagoon was determined and the percentage of occurrence of each length class was obtained according to Gayanilo *et al.* (1997&2003).

### **6. Length at first capture ( $L_c$ )**

The length at first capture, the length at which 50% of the fish retained in the gear, of the target and bycatch species was estimated for each hook size by the analysis of

probability curve using the method of Pauly (1984). This length was compared with the length at first maturity for those species reported in the same area.



Fig. 3. Longline baskets

## RESULTS and DISCUSSION

### 1. Line fishery description

The lines methods including the trolling hand line and long line have become widely used for catching seabass, grouper, meagre and recently European eel in Bardawil lagoon. The principle is to use baited hooks on lines. For longline in Bardawil lagoon, the mainline is of 300 to 450 m length to which 250 to 300 branch lines are attached. Each branch line has a hook of about 2 to 5 cm length and about 0.8 to 1.5 cm width. The baits used in this method are small shrimps and grey mullets and the catch is mainly composed of eels and groupers. In the hand-line, hooks are used individually to catch a single fish, while light is used to attract fishes. This method of fishing is operated only to catch the nocturnal fishes and its main catch is *Dicentrarchus labrax* and *D. punctatus*. The boats are using the two techniques, where each boat has one to three fishermen (Fig. 4).



Fig. 4. Line fishery in Bardawil lagoon

## 2. Catch composition and catch trend

In 2018, only 2610 ton was landed corresponding to a value of almost 130 million Egyptian pounds. The annual total fish production from Bardawil lagoon during the period from 2009 to 2018 (Fig. 5) fluctuated between a minimum of 2610 ton during 2018 and a maximum value of 5410 ton during 2009 with an average of 4055 ton. In 2018, crustaceans represented 39.2%, while mullet constituted about 33.5%, sole 6.3%, Gilthead seabream represented 13.7%, European seabass formed 5.2%, meagre (0.3%) and grouper (0.6%) (Fig. 6). In addition, the “others” group that contains the unsorted species or those of lesser importance and contributed by 10% of total lagoon production. Generally, the fish production in Bardawil lagoon showed a decreasing trend during the period of study and the same trend is noticed for all the commercial species except for European seabass and grey mullet (GAFRD, 2018). For shrimp, a sharp decreasing trend was observed since 2015 this coincide with banning the kalsa fishing gear (bottom trawl net) (Mehanna, 2006a & 2013; GAFRD, 2018; Salem, 2018&2019; Mehanna *et al.*, 2020; Aabed, 2020).

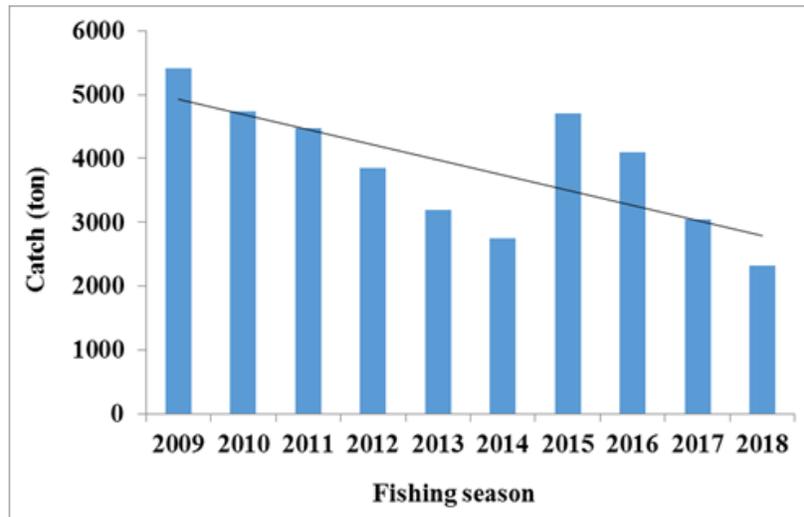


Fig. 5. Catch trend in Bardawil lagoon during 2009-2018 (GAFRD, 2018)

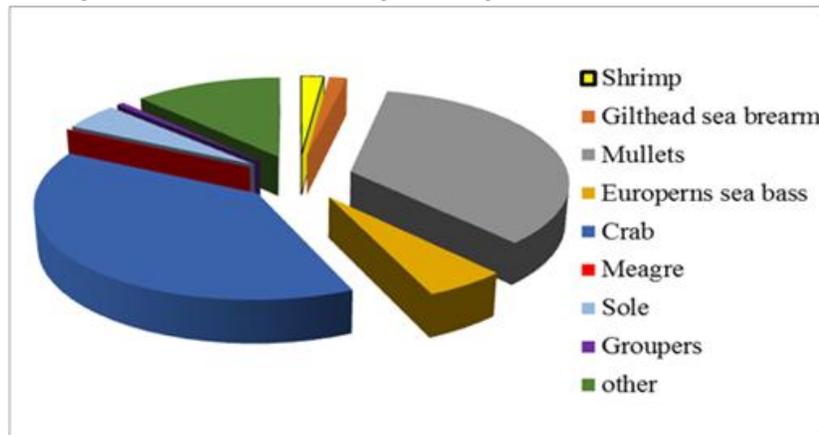


Fig. 6. Catch composition during 2018 (GAFRD, 2018)

### 3. Longline selectivity and catch rate

One of the main challenges in marine fisheries is the bycatch and discards, where the captured species and sizes are outdoor the size range of those targeted. In the present work, the assessment of hook size was done by using two different sizes (10 and 12) of J-style along with that used by fishers (No. 13). Hook numbers 10 and 12 are 67 and 32% larger respectively than number 13 hooks in terms of maximum width and 24 and 15% larger respectively in terms of maximum length. The results obtained indicated that the catch was composed of the target species (European eel) and a number of secondary species, or bycatch species. The catch per different hook sizes was recorded and compared for both the target species and the bycatch species.

The target species, European eel was the dominant species, representing 54.6% of the total biomass and 52.9% of the total number in all hook sizes, followed by the seabass (25.7% of the total biomass and 17.3% of the total number), then Flathead fishes *Platycephalus* spp. representing 13.3% of the total biomass and 18.6% of the total number and the seabream formed 6% of the total catch in weight and 10.2% of the total catch in number. Groupers are appeared but in very low percentages (0.5% of the total weight and 1% of the total number).

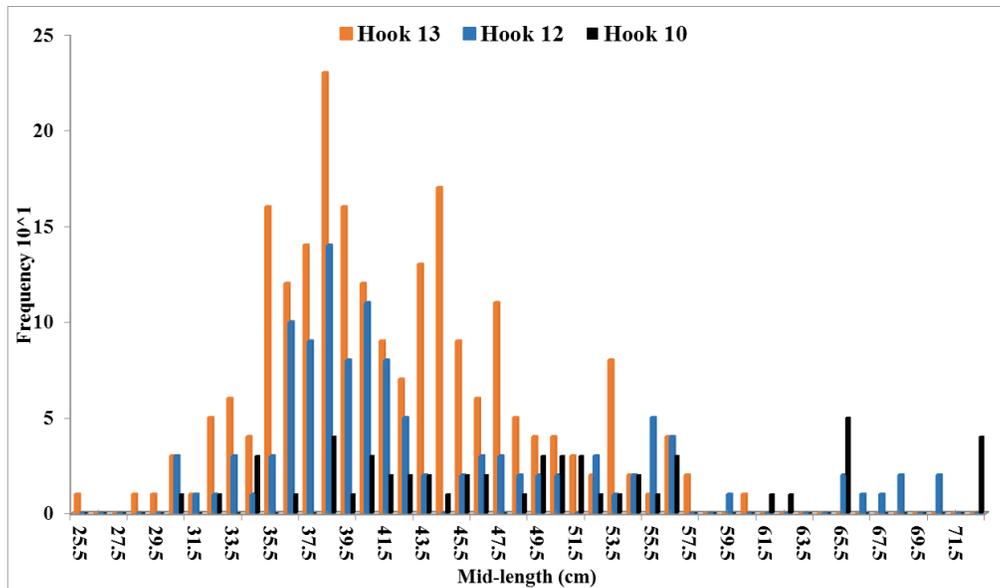
#### 3.1 European eel

European eel (*Anguilla anguilla*) length composition was varied in relation to the J-style hooks of different sizes (Fig. 7). In total, 812 European eel were caught with J-style longline gear during the three months of experiment; these fish ranged in size from 25 to 73 cm TL. Evaluation of the European eel length frequency histograms (TL) showed wide distributions (range of TL) for each hook size and indicated that TL increased with increasing hook size (25-61, 30-71 and 30-73 cm TL for hooks 13, 12 and 10 respectively). It is also noticed that the hook size 13 that used by fishermen in the lagoon catch more number and less length than the other two hook sizes (Fig. 7). The estimated average lengths for the three different hook sizes were 40.7, 43.8 and 49.7 cm TL for hook 13, 12 and 10 respectively reflecting the increasing of average length with the increasing of hook size.

Also, catch rates were significantly different among hook sizes during the experiment forming 4.5, 2.5 and 1.4 individual/100 hooks for the three sizes respectively. The hook No. 13 showed the highest catch rate followed by 12 then 10 hooks. The selective properties of the hooks No. 10 are well evident when compared to the two others, allowing for almost total escapement of eel smaller than 30 cm.

Although the mean TL showed a significant differences among different hook sizes for the studied species, the distributions of length frequency covered wide ranges with considerable overlapping among hook sizes, which resulted in broad selectivity curves. These results suggest that hook size regulations could potentially be a useful management strategy to more effectively target desired size-classes of the European eel in Bardawil lagoon. These results coincide with that of Salem (2018) where he used three

different hook sizes 13, 12 and 11. The length range in his study was wider from 32 to 83 cm for all hooks with means of 43.9, 45.1 and 51.2 cm for hook size No. 13, 12 and 11, respectively in Bardawil lagoon.



**Fig. 7.** Length distribution and catch in number of European eel according to the hook size

### 3.2 European seabass

In respect to the European seabass *Dicentrarchus labrax*, it was caught during the experiment with significant difference in length and size composition between the different hook sizes (Fig. 8). The length range was from 11 to 52 cm TL and in contrast to European eel, the larger hook caught the smallest individuals (13-33, 12-47 and 11-52 cm TL for hooks 13, 12 and 10, respectively). The average length was estimated at 23.6, 24.6 and 26.7 cm TL for hook size 13, 12 and 10, respectively. The hook 10 caught more fish and larger ones than the hook 13 and hook 12 with the highest average length. Generally, most seabasses caught by these different hook sizes were very young and didn't reach its maturation. Mehanna (2006b) and Mehanna and Khalil (2006) mentioned that seabasses are exploited by two fishing methods in the Bardawil lagoon; trammel nets and lines. The seabass length frequency observed by lines was larger than that by trammel nets, where the length range of the European seabass caught by hooks and lines was varied between 26 and 71 cm TL, while that caught by trammel nets varied from 16 to 30 cm TL. They concluded that the fishes of lengths greater than 60 cm of European seabass were rarely reported in the catch. Salem (2011a&2019) mentioned that European seabass is an important species in the Egyptian coasts of Mediterranean Sea especially in Bardawil lagoon and it is the main demersal target of hand lines, long lines and trolling fisheries. Moreover, it is an economically important species, in the Egyptian Mediterranean coasts especially in Bardawil lagoon, that reaches high prices in the

market and are much appreciated nationally. He observed the total length of *D. labrax* ranged from 18.2 to 64.7 cm TL. Abed (2020) and Mehanna *et al.* (2020) found that European seabass *D. labrax* length were ranged in his study from 20.0 to 55.7 cm total length. The catch rates of European seabass were significantly different among hook sizes during the experiment forming 2.9, 4.3 and 3.4 individual/100 hooks for the three sizes respectively. The hook No. 12 showed the highest catch rate followed by 10 then 13 hooks. Although the hook 12 showed the highest catch rate, the selective properties of the hooks No. 10 are better based on the value of average size and maximum observed length.

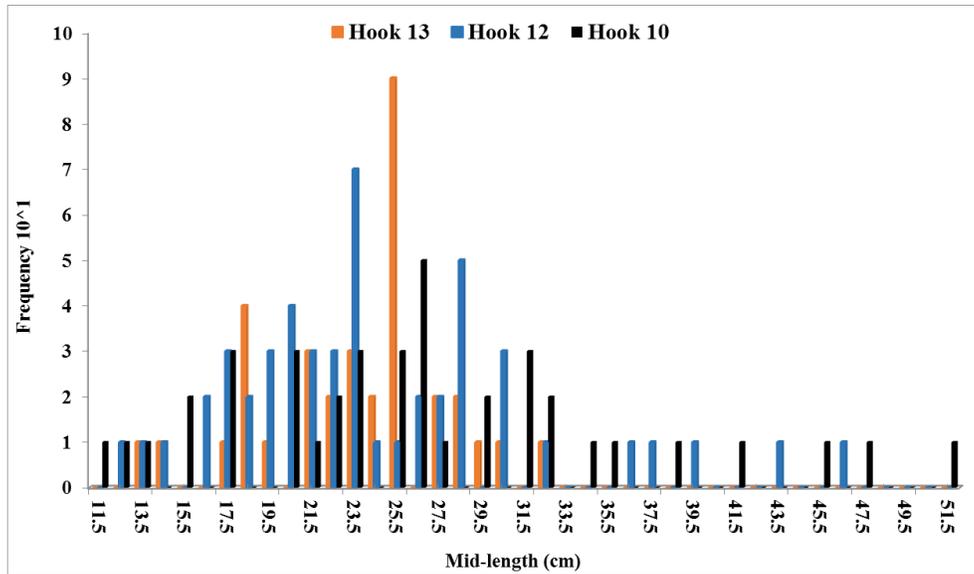


Fig. 8. Length distribution and catch in number of the European seabass according to the hook size

### 3.3 Gilthead seabream

For Gilthead seabream *Sparus aurata* as bycatch, it was caught during the experiment with significant difference in length and size composition between the different hook sizes (Fig. 9). The length frequency distribution covered lengths of 12-26, 13-24 and 13-21 cm TL for hooks 13, 12 and 10, respectively. The average length was estimated at 18.4, 19.5 and 17cm TL for hook size 13, 12 and 10 indicating that although the hook 13 caught more fish and larger ones, the hook 12 has the highest average length. Generally, most seabreams caught by these different hook sizes were young and didn't reach its maturation (Mehanna, 2007; Salem, 2011b; Mehanna *et al.*, 2014).

The catch rates of Gilthead seabream were estimated as 3.4, 1.4 and 0.3 individual/100 hooks for the hook 13, 12 and 10 respectively. The hook No. 13 showed the highest catch rate followed by 12 then 10 hooks. Although the hook 13 showed the highest catch rate, the selective properties of the three hooks sizes are not conservative for seabream in Bardawil lagoon based on the value of average size and maximum observed length.

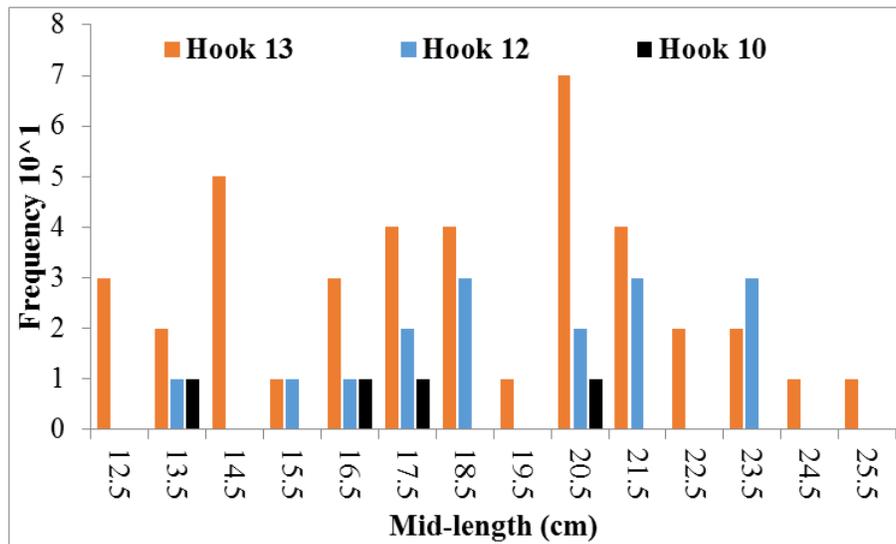


Fig. 9. Length distribution and catch in number of seabream according to the hook size

#### 4. Length at first capture

Length at first capture is an important factor where it is a function of mesh size and gear selectivity (Beverton and Holt, 1957). Also, the length at first capture ( $L_c$ ) is proxy of mesh and hook size and use to compare the effectiveness of capture. The length at first capture for the hook 13 was 39.5 for *Anguilla anguilla*, 18.8 cm for *Sparus aurata*, and 24.2 cm for *Dicentrarchus labrax*. There is no significant difference between  $L_c$  values among different hook sizes (43.1 for *A. anguilla*, 18.9 cm for *S. aurata*, and 25.1 cm for *D. labrax* for hook No. 10). In all cases, it is clear that the length at first capture is smaller than the length at first sexual maturity reported for these species in the previous studies (Table 1) indicating the overexploitation situation due to the unsuitable hook sizes used in Bardawil lagoon (Mehanna and Khalil, 2006; Mehanna, 2007; Salem, 2011a&b, 2018, 2019; Mehanna *et al.*, 2010; Al-Zahaby *et al.*, 2018; Mehanna *et al.*, 2020).

Table (1). Length at first capture and Length at first sexual maturity ( $L_m$ ) for the three studied species in Bardawil lagoon.

Fish species	Lc (cm)			Lm cm	Reference
	H13	H12	H10		
<i>Sparus aurata</i>	18.8	18.3	18.9	20.0 20.5 20.5♂ 22.8♀ 20.8	Tharwat <i>et al.</i> (1998) Abdalla (2000) Salem (2011) Al-Zahaby <i>et al.</i> (2018)
<i>Anguilla anguilla</i>	39.5	40.4	43.1	≥ 50	Salem (2019)
<i>Dicentrarchus labrax</i>	24.2	24.6	25.1	29.2♂ 30.8♀	Shallouf <i>et al.</i> (2019)

## CONCLUSION

In conclusion, catch rates, species composition and size selectivity in hook-and-line fisheries are influenced by a number of variables including hook size and design. In our study we have focused on hook size because of its implications for management strategies. The results indicated that the target species catch rate and size increased by increasing the hook size. At the same time the small J-style hooks had a negative impacts on the bycatch species as most of fish caught were undersized and didn't reach its maturation. Also, the length at first capture estimated in this study was less than the length at first sexual maturity for the three studied species reflecting the overexploitation of these species. Generally, longlines have a number of characteristics that are highly favourable in terms of the rational use and management of living resources. These include the minimal capture of undersized fish, essentially no harmful effects in terms of the environment, low energy costs, low discard rates, and the capture of a high quality product. These characteristics need to be tested to determine the best hook size that protect the young fishes and juveniles and reduce the bycatch. This study is part of PhD research on the selectivity of line fisheries in Bardawil lagoon for the first time, which will hopefully contribute to the improved management and utilization of commercially important species in the lagoon. So, we recommend that government and Fisheries research institutions along with different agencies and interested bodies must take immediate action to protect the marine ecosystem and commercial fish stocks from destruction and overexploitation through more detailed studies on fishing gears and how to improve its selectivity in the Egyptian fisheries.

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