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Population biology of Red Sea bream *diplodus noct*, Valenciennes, 1830 (family: Sparidae) from the northern part of the Gulf of Suez

Manal M. Sabrah, Aly Yousif and Amal M. Amin

National Institute of Oceanography and Fisheries (NIOF)
P.O. Box 182, Suez, Egypt
E. mail: manal_sabrah@yahoo.co.uk

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Abstract

Age, growth, mortality and the reproductive biology for Red Sea breams, *Diplodus noct*, were analyzed. Samples were collected from the northern part of the Gulf of Suez (Suez Bay) during the seasonal experimental fishing survey using the trammel nets from 2003 to 2005. The study revealed that there is insignificant difference between males and females in length, age and weight ($P > 0.05$). The age of *D. noct* was estimated by reading otoliths and it was found that the fish maximum age was IV years. The estimated length weight relationship was $W= 0.0127L^{3.073}$. The von Bertalanffy growth parameters were estimated as K = 0.46 yr^{-1} (SE = 0.065), $L\infty$ = 28.5cm (SE = 0.18) and t_0 = - 0.029 yr^{-1}. The overall sex ratio males to females were 1: 1.6 in favor of females. Estimated total, natural and fishing mortality rates were Z= 2.0yr^{-1} (SE=0.343), M= 0.99 yr^{-1} and F= 1.01 yr^{-1} respectively. Exploitation ratio was estimated as E = 0.51. The study of the gonad maturation and gonado-somatic index revealed that, *D. noct* is a winter spawner. Length at first sexual maturity for males and females were 11.55±cm.The study revealed that *D. noct* fishery is relatively overexploited and any increase in the fishing effort will expose the fishery ground to stress.

Key words: Red sea, Gulf of Suez, Diplodus noct, age, growth, mortality, population, reproductive biology

1. Introduction

Family Sparidae, commonly known as Sea breams, inhabit both tropical and temperate coastal waters. Some species of the family have been shown to be hermaphroditic, some have both male and female gonads developing simultaneously (Smale, 1988) whilst others change sex from male to female (protandrous) or from female to male (protogynous), but in case of the red sea bream *Diplodus noct*, the hermaphroditic didn't appear (Buxton & Garratt 1990; and Randall 1995). Most Sea breams are excellent fish food and are of notable importance to both commercial and recreational fisheries throughout their range (Smale & Buxton, 1985; and Sommer *et al*., 1996). Red Sea bream, *Diplodus noct* is distributed in the Western Indian Ocean from the Red Sea and Arabian Gulf to Natal in South Africa. It is found in sandy bottoms, around coral reefs in shallow coastal waters and bays (2-8 m depth) (Hardy, 2003 and Sommer *et al*., 1996). They are caught by trammel net, gill net, traps and lines. Sparids in the Suez Bay, northern Gulf of Suez contributing three species, *Diplodus noct* or the red sea bream, *Rhabdosargus haffara* and *Rhabdosargus sarba*, which dominat the catch of the Bay. They are heavily invertebrates' consumers. The age, growth, mortality, sex ratio, spawning season, size at maturity and fisheries aspects of the common red sea bream have a little studies thoroughly in various areas of its distribution. Different authors around the world have been studied the genus *Diplodus*, (Stoner and Livingston, 1984; Pike and Lindquist, 1994; Laurent Vigliola, *et al*, 2000; Pajuelo, *et al*., 2008; Bailly, 2010; Richardson, 2010 & 2011 and Dulc, *et al.*, 2011). Few studies on the biology of *D. noct* in the Red Sea were done (Ahmad, 1999; El-Ghrabawy, *et al*, 2004; Kamal, 2004 and EL-Mor & El-Maremie, 2007 and 2008).

Studies on fisheries biology of *D. noct*, which are crucial for stock assessment, have not yet been undertaken in the northern part of the Gulf of Suez. This work is considered to be the first attempted study to provide an insight into fisheries and the reproductive biology information which are important input parameters for stock assessment techniques.

2. Material and methods

2.1. Data collection

The area of investigation includes the most northern part of the Gulf of Suez. It extends from the tip of the Gulf to Ras Abo El-Darag on the Western side, and to Ras Matamer on the Eastern side (Figure 1). The area is the artisanal fishing region for the small boats that land in Salakhana small landing port. Drifting trammel net surveys were conducted in both sides of the Gulf in

depth range of 1.5m – 10m. All the valid fishing zones in both sides were surveyed, especially off the coastal cities, shown in figure (1), and around. The surveys extend through 2003 – 2005 over different geographic areas. The three common fishing techniques used in the survey were Karkaba, Sunset and Sunrise. Survey time duration ranged between 3-5 days, fishing cover different bottom habitats namely; sandy, stony, reef and sea grasses.

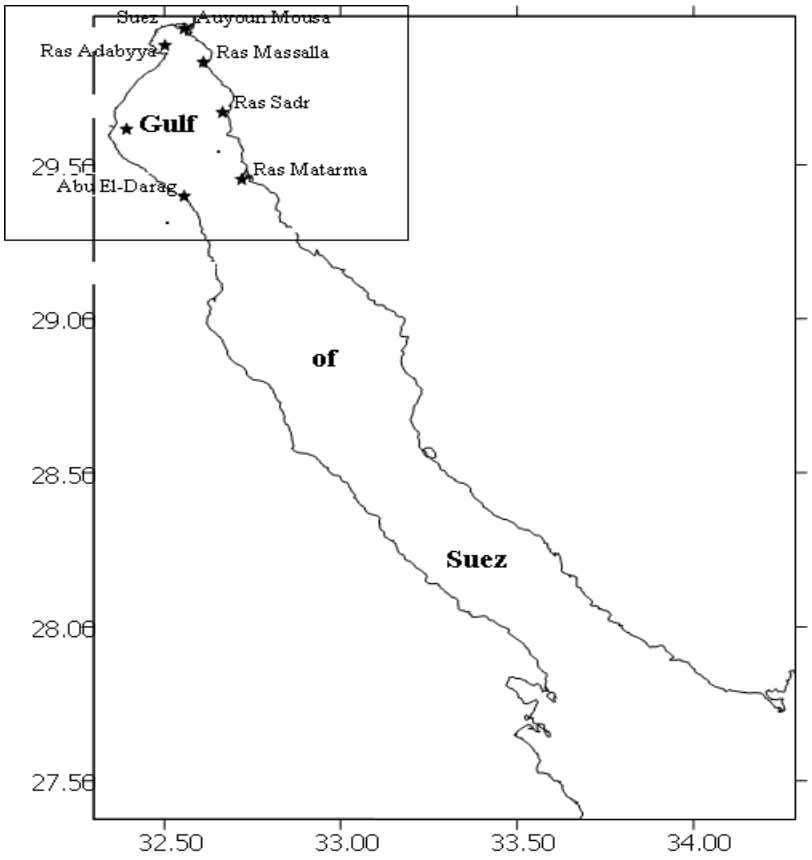

Figure 1. Area of investigation

Seasonal catch from the Suez Bay was separated into different species. A total of 610 individuals of *D. noct* ranged length in length between 8.0±0.15 and 25.9±0.95 cm. TL with average of 14.5±0.9 cm and weight ranged between 8.5±0.26 and 289 ±2.88 gm with an average of 63.4±1.33 gm, were analyzed for age, growth and mortality rates. For the reproductive biology, 294 of females and 184 males were used, the rest of the samples were unsexed.

2.2. Data analysis

2.2.1. Age and growth

Total length (TL) was measured to the nearest 0.1cm and total weigh to the nearest 1 g for all fishes. Sexes and the maturity stages were recorded. Gonad weight was measured to the nearest 0.01 gm. The length frequency distributions were estimated at 1.0 cm length intervals for each season. Otoliths were removed from each fish, cleaned, and stored dry for age determination from 610 fish. Growth parameters were investigated by fitting the von Bertalanffy (1938) growth constants to size at age data, which is defined as follows: $\mathbf{l_t = L\infty(1-e^{-k(t-t_o)})}$, where, l_t is length at time t, L_∞ is the asymptotic length, k the growth coefficient and t_o the hypothetical time at which length would be equal to zero**.** Length-weight relationship was determined, using the equation: $\boldsymbol{W=a\,L^b}$ (Ricker, 1975). Where W is defined as the total weight in grams, L is the total length of the fish in cm, and the parameters (a) and (b) are constants. Length-weight relationship isometric or allometric was tested statistically by the chi-square test.

2.2.2. Mortality

The annual instantaneous rate of total mortality (*Z*) was obtained using length converted catch curves adapted to incorporate seasonal growth patterns (Gayanilo and Pauly, 1997). The annual instantaneous rate of natural mortality (*M*) was estimated using the empirical equation derived by (Pauly, 1980), Log M= -

0.0066 – 0.279 log L∞ + 0.6543 log K + 0.4634 log T. where, T is the mean annual water temperature.

The instantaneous rate of fishing mortality (F) was estimated by subtracting the value of M from Z. The exploitation rate (E) was determined according to Gulland (1971): ***E = F / Z***.

The length at first capture (L_c) was estimated from the ascending left part of the catch curve according to the method of Pauly (1984) and incorporated in FISAT soft ware.

2.2.3. Reproductive biology

The spawning season was determined by estimating the average seasonal gonado-somatic index (GSI) of both males and females as a percentage of the gonad weight to the total weight of the fish. ***GSI = g. wt/ T wt x 100.*** The seasonal variation of different maturity stages was determined for each individual and classified into six maturity stages according to the scale of Gunderson's (1993) with some modifications. Stage I "immature", stage II "mature", stage III "maturing", stage IV "ripe", stage V "running" and stage VI "spent". The length at first sexual maturity L_{m50} was estimated according to King (1995) for each length group.

3. Results

3.1. Age and growth

The numbers of age groups estimated for *Diplodus noct* were four groups from the pooled data. No statistical difference in growth rates between males and females (***p***=0.186>0.05) were found. The identified mean lengths were 10.37, 17.0, 21.5 and 23.96 (Table, 1). It was noticed that the fish maximum growth rate was at its first year of life, where the fish attained over 43% of its maximum size. (Figure 2) shows that, age group I is dominating the catch and constituting 51.15%, this means that the red sea bream in the eastern Suez Bay is fully recruited to the fishery at age group I. The von Bertalanffy growth parameters that described the growth in length were L_∞ =28.5 cm TL (SE = 0.18), K = 0.46 $year^{-1}$(SE = 0.065) and t_o = -0.029 years (SE = 0.126).

Table 1. Age-length data of *Diplosus noct* from northern of the Gulf of Suez

Items	Age group				
	0	I	II	III	IV
Fish No.	55	312	210	20	13
S.D.	±0.89	±1.362	±2.10	±0.56	±0.99
Age groups %	9.02	51.15	34.40	3.30	2.13
Mean lengths (cm)	**9.05±0.11**	**10.37±0.57**	**17.00±1.30**	**21.50±2.15**	**23.96±2.94**
S.I.	0.00	0.00	2.16	4.31	2.96

S.D.: Stander deviation S.I.: Separation index

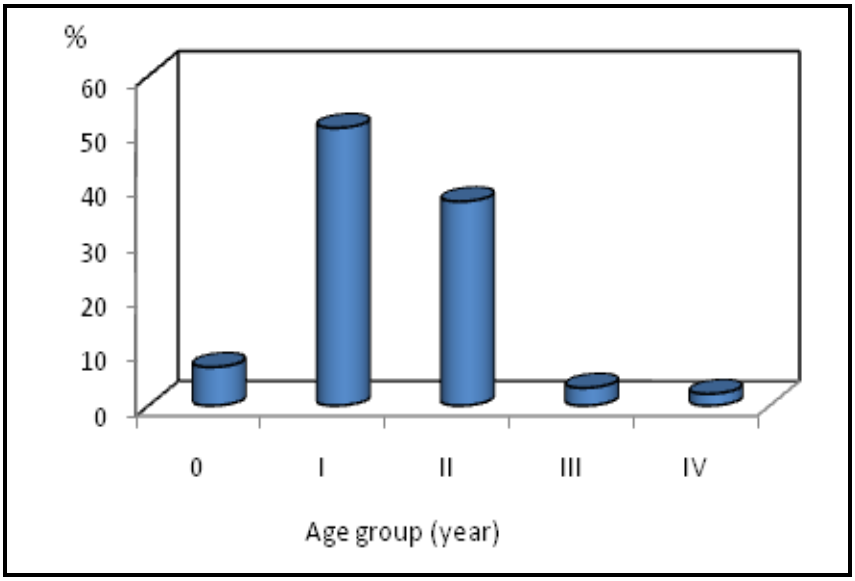

Figure 2. Age composition of *D. noct* from the northern part of the Gulf of Suez.

3.2. Length weight relationship

Because there was insignificant statistical difference in lengths and weights between males and females (*t*-test, $P > 0.05$), the length-weight regression was calculated for all samples. The length weight relationship was based on samples that ranged in length between 8±0.15 to 25.9±0.95 cm, while the total weight ranged from 8.5±0.26 to 289±2.88 gm. The following equation describes this relationship: $W = 0.13\ L^{3.073}$ $r^2 = 0.991$. It is clear that b is around 3 it means that this relationship is isometric ($X^2 = 5.021$ $P > 0.05$).

3.3. Mortality, exploitation rates and probability of capture

The annual total mortality rate Z based on the length converted catch curve (figure 6) gave a value of 2.0 yr^{-1} with (intercept: $a = 9.03$, slope: $b = -2.0$, $r = 0.953$ and confidence interval of Z: 1.48–2.53 yr^{-1}). The annual natural mortality rate according to Pauly (1980) with annual average temperature T 22.5° was found to be $M = 0.99$ yr^{-1} and have the fishing mortality $F = 1.01 yr^{-1}$. These results indicate that the fishing mortality is higher than the natural mortality and the current exploitation ratio estimated to be $E_{cur} = 0.51$. According to Gulland (1971), the yield is considered optimum when the exploitation ratio $E_{opt}=0.50$ or when F=M. It was observed that F > M by 0.02%. This result implies that the stock of *D. noct* in the Suez Bay is slightly at the over-exploited state. Figure 7, shows the probability of capture L_c, which is closely related to the mesh size. L_c for *D. noct*, found to be 10.57cm at 50% probability. It was noticed that L_c at 50% is nearly equal to the first year of life 10.37cm and smaller than the length at 1st sexual maturity $L_{m=}$ 11.5cm (fig.5).

3.4. Reproductive biology

3.4.1. Sex ratio

The results indicated that the overall sex ratio of males to females of *D. noct* was 1:1.6 in favor to females. The Chi-square test revealed that the difference between number of females and males have insignificant difference throughout the sampling period, as ($X^2 = 5.412$ and $P = 0.144$). Seasonal variation in sex ratio (Table, 2 and Fig. 3), showed that the number of females exceed males in all seasons, except in summer. Chi-square test shows insignificant differences in all seasons and in the whole population.

Table 2. Seasonal variations in sex ratio of *D. noct* from northern of the Gulf of Suez.

Season	Female no.	Male no.	Sex ratio	% female	%male	X^2	*P*
Autumn	181	100	1.80 : 1	64.40	35.60	1.563	0.118
Winter	47	28	1.70 : 1	62.67	37.33	1.981	0.169
Spring	24	16	1.50 : 1	60.00	40.00	0.226	0.085
Summer	46	40	1.15 : 1	53.49	46.51	0.195	0.102
Total no.	298	184	482	61.83	38.17		
Mean sex ratio	**1.6 : 1**					5.412	0.144

X^2: Chi-square

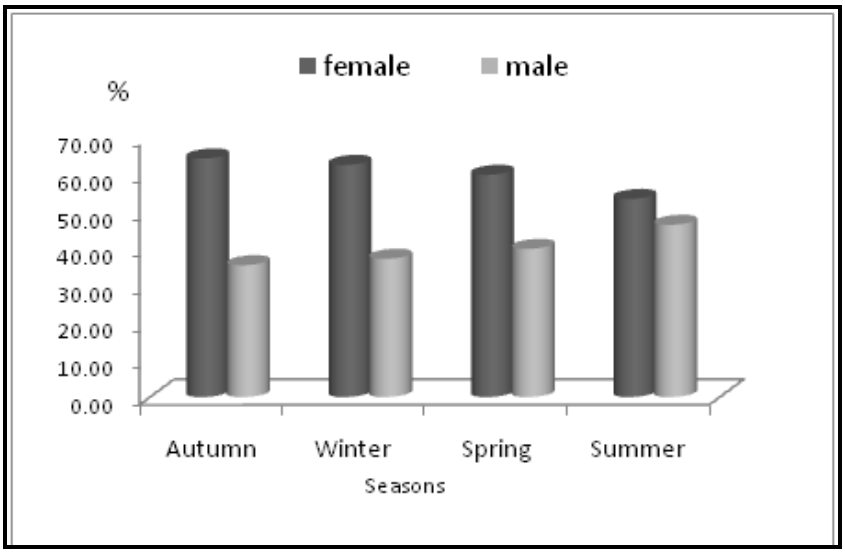

Figure 3. Seasonal variations in percent abundance of males and females of D. noct from northern part of the Gulf of Suez.

3.4.2. Gonado-somatic index

Seasonal average gonado -somatic index (*GSI*) values of females and males are given in Figure 4. Based on the gonado-somatic index values, it can be said that the species under study has a relatively short spawning period. In both sexes, gonads start to mature in early autumn. Maximum gonado-somatic index value was recorded in winter for females and males with mean values 5.95±1.1 and 4.57±1.33 respectively. This shows that the spawning period of the *Diplodus noct* from the northern Gulf of Suez occurs at winter. On the other hand, by chasing the variations in the different maturity stages of *D. noct*, it was observed that the ripe stage first appeared by very low percentage in the late summer, and then it increased gradually till reached its highest values in autumn. The spent stage appeared for the first time in winter reached its highest value in spring. From the last observations, it is clear that the collateral peak of the gonado-somatic index with the increase of the full ripe stage percentages throughout autumn and winter suggested that this species is a winter spawner.

3.4.3. Length and age at first sexual maturity

In the present study, the smallest mature males and females of *D. noct* was 9.0 cm. There was no mature fishes could be observed before this length. From the maturation curve (figure 5) the estimated mean size at which 50% of males and females were mature occurred between 11.0 and 12.0cm (mean11.55cm ±0.06) for both males and females, which is corresponding to T_m= 1.1 yr., as age at first sexual maturity.

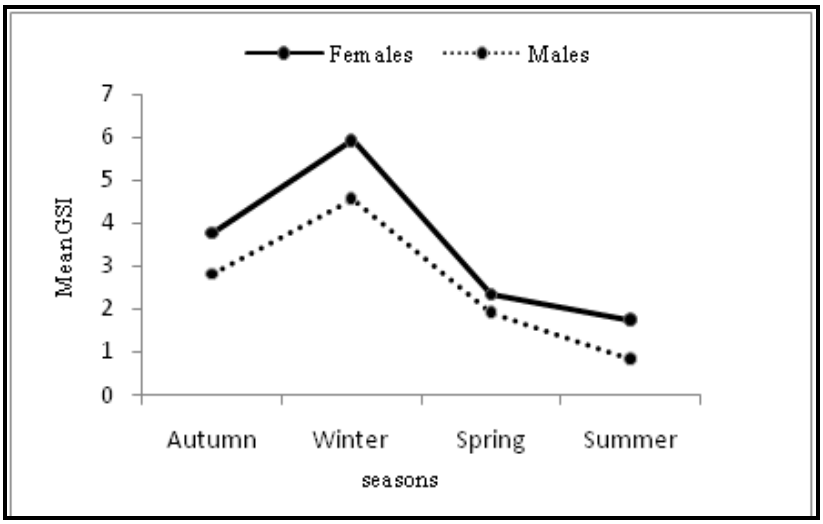

Figure 4. Seasonal variation in gonado somatic index of *D. noct*

from northern part of the Gulf of Suez

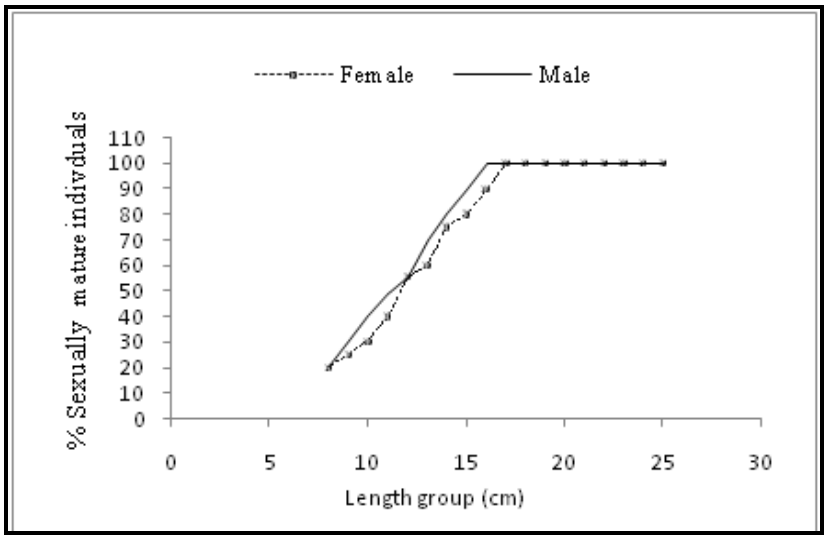

Figure 5. Length at first sexual maturity of *D. noct* from eastern Suez Bay, Gulf of Suez

4. Discussion

Suez Bay is an important area in the northern part of the Gulf of Suez as it is considered to be a suitable nursery ground for the most species endemic in the Gulf of Suez and the Red Sea. These surveys were done to evaluate the status of this fishery ground and its species. Sparidae fishes inhabit tropical and temperate coastal waters. They are found near the shore in shallow inlet and bays less often at moderate depths (1-8m) (Chaves and Mesegur, 2005). Catch composition of the family sparidae dominating the Suez Bay are *Diplodus noct, Rhabdosargus haffara and Rhabdosargus sarba.* Bauchot & Smith (1984) and Lieske & Myers (1994) recorded that the maximum length of *D. noct* 25 cm with a common length 15 cm. These recorded results are in a good agreement with the present findings. *D. noct* is the most abundant species in Suez Bay with maximum age 4yrs with a highly separation indices over 2 (Table, 2), which well discriminated the age groups according to Rosenberg and Beddington (1988).The results showed a slow growth rate except in the first year of life. Many studies have been published on age, growth and length weight relationship of *D. noct* in different regions around the world. Table (3), shows these studies which are reasonable and in accordance with the parameters estimated in the present study.

The annual total, natural and fishing mortality rates of *D. noct* were estimated as, 2.0, 0.99 and 1.01yr^{-1} respectively, while exploitation rate E = 0.51 yr^{-1}. The values of both fishing mortality and exploitation rate were relatively high indicating a relatively high exploitation.

The length at 1st capture was estimated as L_c = 10.57cm. It was observed that L_c is nearly equal to its length at the first year of life and at the same time it was smaller than the length at first maturity 11.5cm. This indicates that the fish are caught before they spawn for the first time, so it will be affecting the recruitment at the long run. So, we can say that the fish must be caught at least at 12 cm total length to get the chance to spawn even once.

Successful exploitation of any fish stock should be based on knowledge of its reproductive characteristics as maturity stages, spawning period and the length and age at first sexual maturity for a good management of its fishery ground.

The study of the seasonal variations of maturity stages and gonado-somatic index of *D. noct* revealed that, this species is a winter spawner. According to the present data, it clears that recruits appear in spring. Table (3) shows the investigated results by some authors in different regions, which have good agreements with the current study. On the other hand, the study of length at first sexual maturity indicates that males and females of *D. noct* have the same maturity length lies between 11-12 cm, while Table (3) indicated some differences in other regions. These may be attributed to difference in regional temperatures or in the food availability among various areas.

Table 3. Growth and reproductive parameters of *Diplodus noct* recorded by several authors in different regions.

Growth and length weight relationship parameters					
Authors	L∞	K	a	b	Regions
Ahmad, 1999	28.07	0.226	0.0173	2.934	Red Sea
Lorenzo, 2001	25.00	0.268	-	-	Canary island
Goncalves, *et al.*, 2003	27.7	0.40	0.0172	3.0	Portugal
Present work	28.5	0.46	0.0127	3.073	Suez Bay
Reproductive biology parameters					
	Spawning period		Length in cm at 1st sexual maturity		
Ahmad, 1999	Nov. to Jan.		12.5 M and 13.5 F		Red Sea
Lorenzo, 2001	Jan. to May		10.3 M and 12.8 F		Canary island
Goncalves, *et. al*.2003	Sep. to Apr.		-		Portugal
El-Mor and El-Maremie, 2007	Peak in Jan.		-		Red Sea, south Sinai
Present work	Nov. to Feb.		11-12cm male & female		Suez Bay

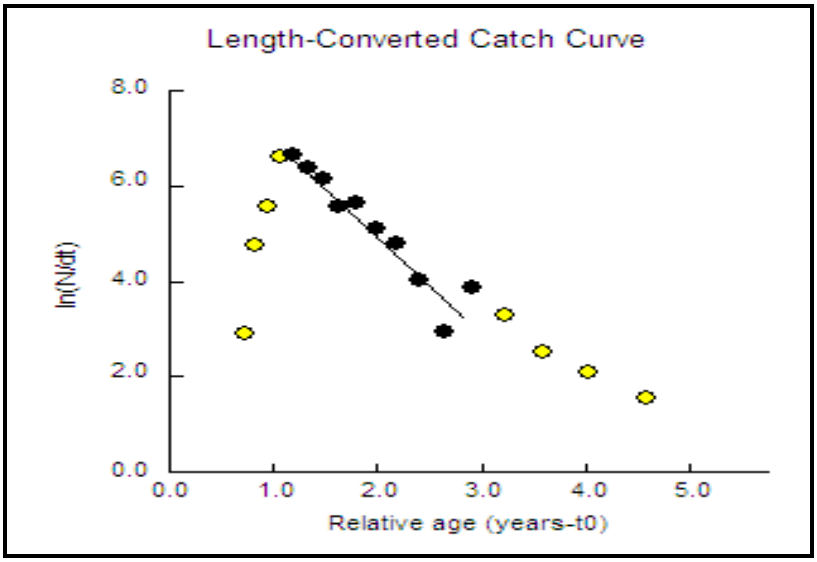

Figure 6. Length converted catch curve of *D. noct* from northern part of the Gulf of Suez

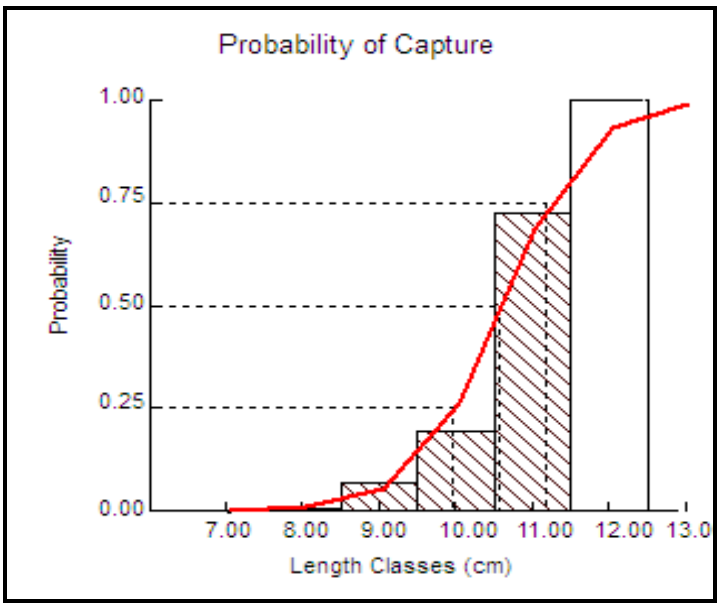

Figure 7. Length at first capture probability of *D. noct* from northern part of the Gulf of Suez

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