

## MATURITY AND GONADOSOMATIC INDEX OF EUROPEAN HAKE *MERLUCCIIUS MERLUCCIIUS* (LINNAEUS, 1758) FROM THE EGYPTIAN MEDITERRANEAN WATER

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**ABSTRACT:** Looking at the Mediterranean in particular, we find that its production decreased during the ten years from 77,799 tonnes in 2011 to 49,896 tonnes in 2020, and the quantities produced by some common fish families of economic and nutritional importance also decreased. Especially benthic fish, which are of great importance, especially for residents of coastal cities in the Egyptian country, such as bourbon fish, whose production decreased from 4,124 tonnes in 2011 to only 549 tonnes in 2020, and shrimp production, whose production decreased from 10799 tonnes in 2011 to 5460 in 2020, which is equal to a decrease of 50 % roughly.

A total of 572 European hake individuals were collected from commercial demersal trawl fisheries and analyzed to estimate the reproductive biology. The sex ratio M/F was 1:2.16, which means that females dominate the catch. European hake spawns all year round. However, the peak of the gonadosomatic index was in the winter season from November to March, which indicates the peak of the spawning season. Length at the first sexual maturity was estimated at 34.4 cm for females. All of the fish sampled were in the third and fourth stages of maturity. The total length ranged from 17 cm to 69 cm, with an average length of 32.7 cm for all samples.

**Key words:** European hake, reproduction, gonadosomatic index, Egyptian Mediterranean water.

### INTRODUCTION

The catch of European hake, *Merluccius merluccius* (Linnaeus, 1758) from the Egyptian Mediterranean Sea was an insignificant amount (Philips, 2014). In 2017 European hake was recorded for the first time in the national catch statistics documents (GAFRD, 2020), and that's may be due to exploring new fishing grounds for valuable demersal species like *Aristaeomorpha spp.* Furthermore, the biological information about this species in the Egyptian Mediterranean Sea waters are limited (Abd El-Aziz, 1976; Soliman, 1992). Lloris *et al.* (2005) revealed that the genus *Merluccius* is widely distributed geographically. Consequently, high commercial value of Hake faces a particularly high fishing pressure, with catches mainly focused on young individuals (Leonart *et al.*, 2003; Recasens *et al.*,

1998). The reproductive study plays a significant role in fishery prediction, creation of management strategies. The success of the fishery is precisely related to the proportion of reproduction and survival of the fishes. Reproduction and recruitment are the two most important events in a fish's life history, as well as the primary determinants of fish yield (King, 1995). Gonadosomatic index (GSI) is used to indicate the sexual cycle of fish species. Consequently, we can determine the time of spawning (El-Sayed, 1996; Plaza *et al.*, 2007). Knowledge of the spawning patterns of fish could help to develop a better management plan to maintain this fishery (El Ganainy, 1992). So, the objective of this study was to recognize the spawning season and maturity of European hake from the Egyptian Mediterranean water.

## MATERIALS AND METHODS

The official statistics of General Authority for Fish Resources Development, shows the total landing of European Hake (Local name: Nazilli) from the Egyptian Mediterranean Sea for the first time in 2017. A pilot survey was carried out during the same year in order to find out the main fishing ports that receive the majority of the landings of European Hake. A total number of 572 random monthly samples of *M. merluccius* was collected throughout the period from January to December 2017 from onboard commercial deep-water trawl fishing vessels as well as from the landings of Damietta, Rasheed and Alexandria fishing ports (Figure 1).

The sex ratio is defined as the number of males to the number of females (M: F) by total length class using the formula; total number of males/total number of females. The chi-square test ( $\chi^2$ ) was used to justify the probability of the existence of significant differences between the sex ratio of the species under this study and the expected 1:1 sex ratio (Sokal and Jamesrohlf, 1987). Nikolsky (1963) with some modifications was used to determine the different maturity stages of European Hake according to color and size in relation to the body cavity. It is divided into

six maturity stages as follows: Stage I (immature): young individuals that have not yet engaged in reproduction. Testis are very small size, transparent, and thread-like. Ovaries are transparent, pale rose in color, and about 1/3 of the body cavity. At Stage II, sexual products have not developed yet, and smaller gonads and eggs are not distinguishable to the naked eye. The ovaries take up about half the body cavity; they are transparent and pale rose in color. In Stage III (maturing – pre-spawning), the testis change from transparent to a cream or pale-yellow color. The pre-spawning ovary is yellow to orange color, oocytes are visible, and the ovary fills more than 2/3 of the body cavity. When slight pressure is applied to the fish belly, the sexual products become ripe; the gonads have reached their maximum weight, but the sexual products are still not extruded. In Stage V (running), the gonads swell and reach their maximum weight. Sexual products are extruded in response to slight pressure on the fish's belly. Stage VI (spent condition), the sexual products have been discharged; genital aperture pressure. Gonads have the appearance of deflated sacs. The ovaries are dark violet in color. They may contain a few eggs left-over, and the testis have a dirty white color and have some residual sperms.



Figure (1): Sampling ports in the Egyptian Mediterranean Sea.

The Gonadosomatic index (GSI) was calculated according to Sokal and Rohlf (1969) using this formula  $GSI = (GW / W) * 100$  Where GW is the gonadal weight in g, W is the gutted body weight in g. Monthly variations in the value of GSI were estimated for males and females to determine the spawning season. Moreover, a Chi-square test ( $\chi^2$ ) for independence was used to test for a significant association between gonads development in females and males during sampling time.

Condition factor for females were used to justify the spawning period calculated using the this equation  $K = (W / L^3) \times 100$  (Hile, 1936)

The length at first sexual maturity ( $L_{m50}$ ) was deduced by fitting a logistic curve to the sexually matured individuals' proportion by length using the following formula  $Ln((1-P)/P) = r_1 L_m - r_2 L$

Where (P) is the proportion of a sexually matured individual,  $r_1$  is the slope of the curve.  $r_2$ , is the intercept. L is the total length of the fish in cm.  $L_m$ : is length at sexual maturity ( $L_{50}$ ).

## RESULTS

The total length (TL) of individuals ranged from 17 cm to 69 cm, with a mean length of 32.7 cm for all samples. The total weight ranged from 33.34 to 2940 g. Furthermore, the TL of females was in between 17 cm to 69 cm with a mean length of 28.2 cm, while for males ranged from 17 to 54 cm with a mean length of 25.8 cm (Figure 2). Moreover, an independent sample *t*-test clarified that there was a significant difference ( $P < 0.05$ ) between males and females in the average length.

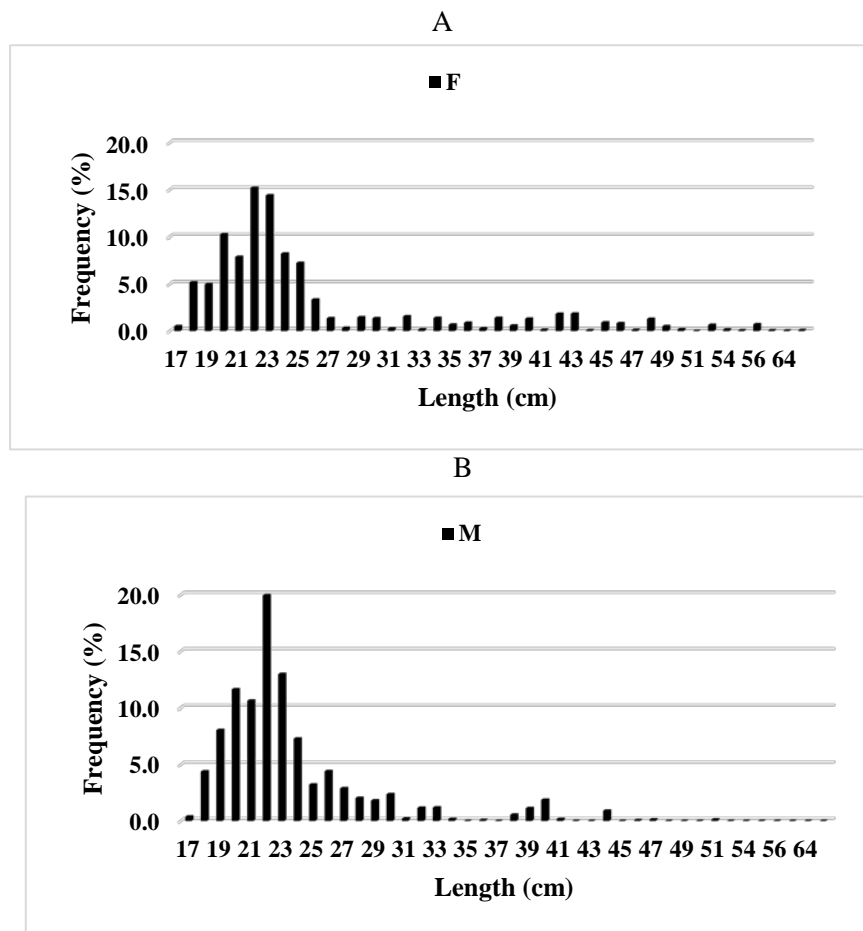


Figure (2): Length frequency distribution of *M. merluccius* for females (A) and males (B)

Out of a total of 572 specimens ranging from 17 to 69 cm TL, 67.9% were females and 31.4% were males. The sex ratio (M: F) for *M. merluccius* was 1:2.16 (Figure 3). In addition, chi-square test ( $\chi^2$ ) was applied to compare the sex proportions with contingency in the length interval [17 to 47] and it shows a significant difference from a ratio of 1:1 at  $P < 0.05$ . All of the specimens with a TL greater than 53 cm, however, were females. The gonadosomatic index (GSI) was computed monthly during the period from January to December 2017 for both sexes (Figure 4). It is clear that the average monthly values of GSI in females began to rise gradually in December and reached their peak in February. Then, it gradually decreased in May and reached its lowest value in October. The condition factor (K) values calculated monthly for females is shown in Figure (5). Analyzing jointly the both Figures (4 and 5) it was found an increase of the GSI values, while the K values are showed decreased notably in the Winter time from December till April.

In this study, we revealed that there were 6 different developmental stages of gonads (Figure 6). Out of the 381 females, 77 specimens were in stage 1, 74 specimens in stage 2, 55 specimens in stage 3, 45 specimens in stage 4, 57 specimens in stage 5, and 5 specimens in stage 6. In addition, 68 samples were unidentified stage (U), as shown

in Table 1. Based on visual observation, it was found that maturing stage 3 is present all around the year, while mature stages 4 and 5 are present in the winter months of December to April, with a peak of spawning activity occurring during February and March. On the other hand, immature stages 1 and 2 were the most common all year. Furthermore, the length at first sexual maturity (Lm) was determined as 34.4 cm for females.

## DISCUSSION

The sex ratio evolution in the length class from 17 to 53 cm. shows that the sex ratio M: F was 1:2.16 females are dominating the catch. It was found that lengths over 53 cm TL were 100% female. In the same geographical area, Philips and Ragheb (2013) observed a different result, as did Pieiro and Sanza (2003) in Iberian Atlantic waters where males dominate the catch. This difference could be due to several factors related to different growth rates; time and method of sampling; adaptation to the reproductive behaviour of the population; environmental conditions and food availability (Nikolsky, 1963; Vandeputte, 2012). Moreover, a recent study of European hake growth depending on a tagging technique introduced by Mellon-Duval *et al.* (2009) shows that females have a faster growth rate than males from the age of two years.

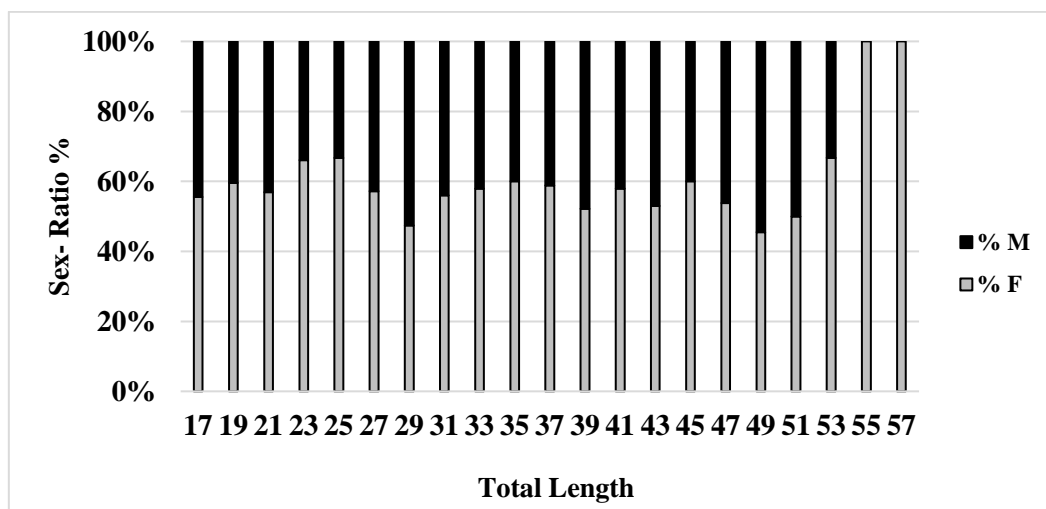


Figure (3): Sex ratio of males and females of *M. merluccius* at length class from the Egyptian Mediterranean waters.

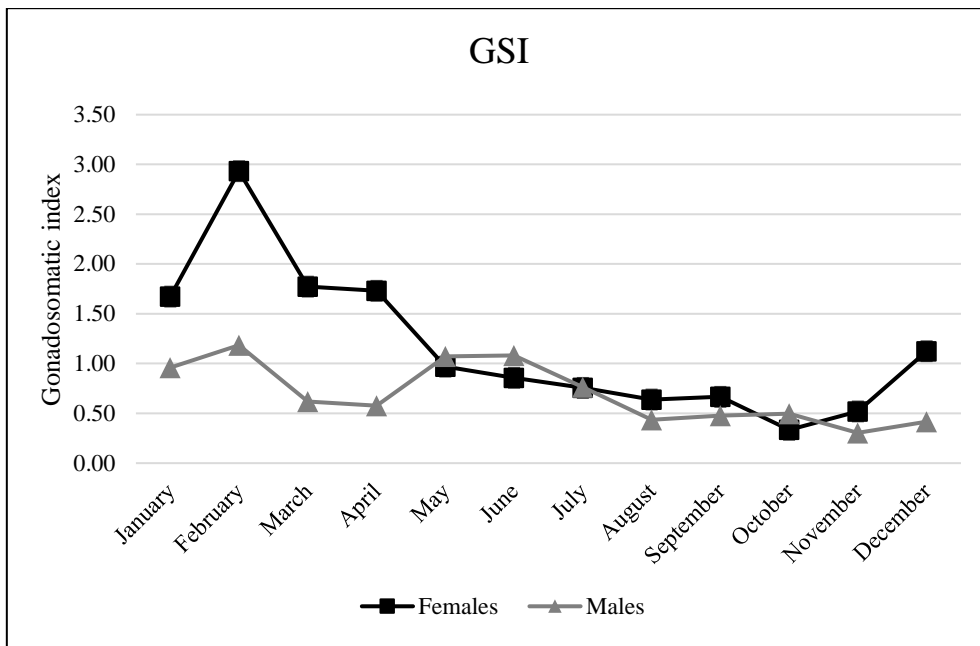


Figure (4): Monthly variation of the gonadosomatic index (GSI) for *M. merluccius* from the Egyptian Mediterranean water (2017).

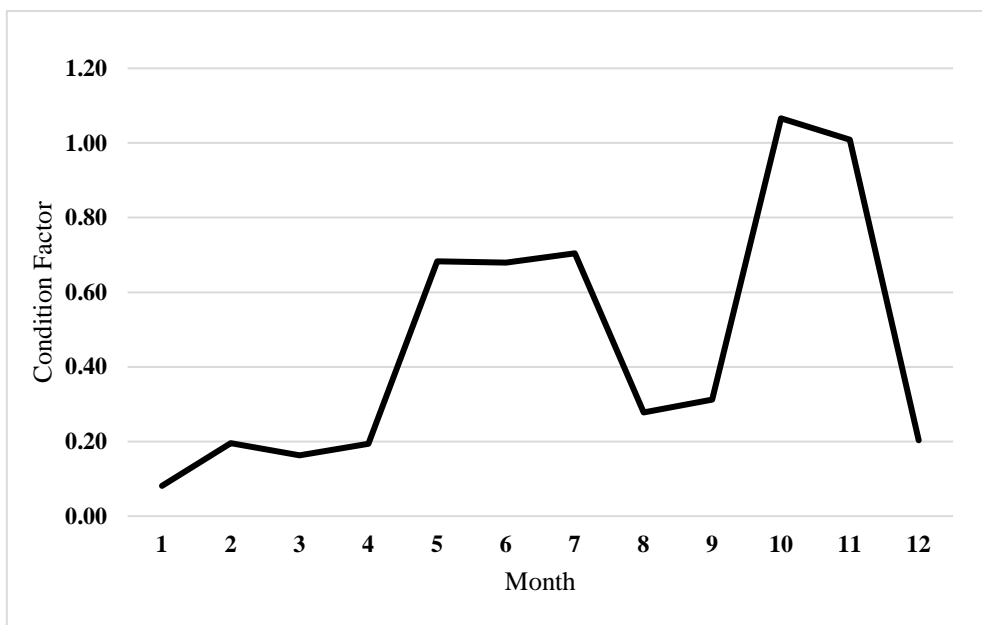


Figure (5): Monthly variations in the condition factor (K) average for *M. merluccius* female from the Egyptian Mediterranean waters.

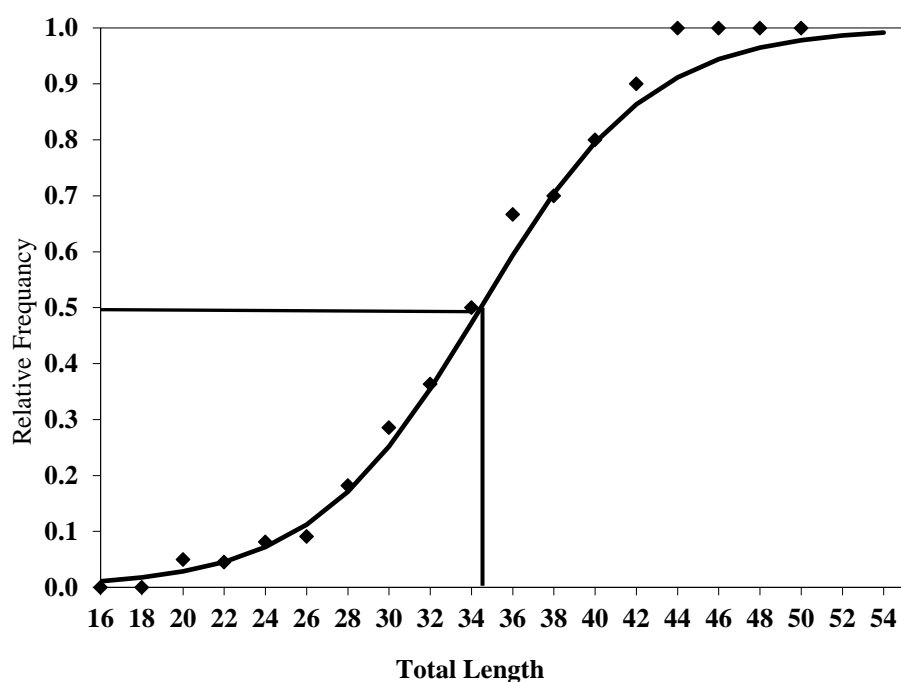


Figure (6): Length at first sexual maturity of *M. merluccius* females from the Egyptian Mediterranean waters.

Table 1. Number of female individuals of *Merluccius merluccius* in each maturity stages; U refers to un- identified stage.

Month	Maturity stages						
	1	2	3	4	5	6	U
January	6	12	8	4	2	1	8
February	2	5	2	6	5	1	0
March	2	2	2	7	3	0	1
April	4	9	4	4	3	1	0
May	8	3	2	2	5	0	9
June	12	2	4	3	3	0	36
July	5	9	26	17	2	1	12
August	13	2	1	1	8	0	0
September	1	1	2	0	6	1	0
October	10	12	0	0	9	0	0
November	11	15	0	0	5	0	0
December	3	2	4	1	6	0	2
Total	77	74	55	45	57	5	68

The spawning cycle of the European hake was studied during the period from January to December 2017 according to the bimonthly evolution of the gonadosomatic index (GSI). The Gonadosomatic index is an indicator of the spawning season (Nikolsky, 1963). High GSI values show that the gonads are developing, and when GSI values are low, this indicates the end of the spawning period (Lahaye, 1972).

The reproductive behaviour of European hake is almost all year round, with certain interannual variability (Recasens *et al.*, 1998). In this study, the monthly trend of GSI seems to define a sole reproductive event during the year that extended from November to March with a peak in February. The spawning season here estimated for the Egyptian Mediterranean Sea, including the period between November and March, is also reported by (Al-Absawy, 2008; Philips and Ragheb, 2013) in Egyptian Mediterranean water, as well as in the central and western Mediterranean Sea (Carbonara *et al.*, 2019), the eastern central Atlantic Moroccan coast (Habouz *et al.*, 2011) and in the Sea of Marmara, Turkey (Kahraman *et al.*, 2017). Other authors identified a different period of the spawning season. Michela *et al.* (2017) in the Adriatic Sea showed that the peak of GSI occurred in June. In addition, a Chi-square test for independence indicated no significant association between the average GSI in males and females during sampling months, with  $p$  value = 0.99.

In the current study, the length at first maturity was estimated at 34.4 cm for the females (Figure 6). Al-Absawy (2010) has reported for the Egyptian Mediterranean Sea an estimated L50 compatible with those found in this study. Carbonara *et al.*, (2019) reported for the Western and Central Mediterranean Sea a L50 value of 33.03 cm and Habouz *et al.*, (2011) findings for the eastern central Atlantic a L50 value of 33.8 cm. These results were slightly less than those estimated in this work.

Recasens *et al.*, (2008) reported the L50 value as 35.8 cm in the western Mediterranean. Moreover, the values reported in this study are higher than those reported for the Tunisian coast

(Khoufi *et al.*, 2014), and lower than those reported for Iberian Atlantic waters (Piñeiro and Saínza, 2003) and the Gulf of Lions (Mellon-Duval *et al.*, 2009). These differences may be explained by the phenotypical response to some environmental changes or by the evolutionary consequence of some selective pressures such as fishery efforts (Barot *et al.*, 2004). Additionally, by the different estimation techniques applied (ICES, 2008), the age at first sexual maturity was estimated by using the Von Bertalanffy growth equation to convert the length at first sexual maturity to an age at first sexual maturity, and we found that *M. merluccius* reaches first sexual maturity at age group two.

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## النضج الجنسي ومعامل المناسل لأسماك الهيك الأوروبي من المياه المصرية للبحر المتوسط

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### الملخص العربي

النظر إلى البحر المتوسط على وجه الخصوص، نجد أن إنتاجه تناقص خلال عشر سنوات من 77799 طن عام ٢٠١١ إلى ٤٩٨٩٦ طن عام ٢٠٢٠، كما تناقصت أيضاً الكميات المنتجة من بعض عائلات الأسماك الشائعة ذات الأهمية الإقتصادية والغذائية. وخاصة الأسماك القاعية التي لها أهمية كبيرة خاصة لقاطنى المدن الساحلية بالقطر المصرى مثل أسماك البربونى التي تناقص إنتاجها من ٤١٢٤ طن عام ٢٠١١ إلى ٥٤٩ طن فقط عام ٢٠٢٠ وأيضاً إنتاج الجمبري الذي تناقص إنتاجه من ١٠٧٩٩ طن عام ٢٠١١ إلى ٥٤٦٠ عام ٢٠٢٠ أى مايساوى إنخفاض بنسبة ٥٠٪ تقريباً.

تم تجميع عدد ٥٧٢ من أسماك الهيك الأوروبي من المصايد التجارية لحرقة الجر فى البحر المتوسط فى مصر من أجل التعرف على السمات البيولوجية الخاصة بالتناسل فى تلك الأسماك. تراوح طول الأسماك فى العينة من ١٧ سم الى ٦٩ سم بمتوسط طول بلغ ٣٢,٧ سم. بلغت نسبة الجنس بين الذكور و الإناث ١:٢,١٦ مما يدل على ان الإناث تستحوذ على النسبة الأكبر فى المصيد. من خلال الدراسة تبين ان أسماك الهيك الأوروبى تقوم بالتفريخ على دفعات طوال العام مع زيادة فى معدل التفريخ فى فصل الشتاء من نوفمبر وحتى مارس بناء على حسابات مؤشر المناسل GSI، كما أن درجة النضج الجنسي رقم ٣ و ٤ لمناسل إناث أسماك الهيك الأوروبى كانت ذات التكرار الأعلى فى العينة مما يدل على قدرتها على التفريخ. بلغ متوسط الطول الذي يصل عنده نصف القطيع من الإناث إلى النضج الجنسي ٣٤,٤ سم.