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Deep Sea Shrimp Resources in the South Eastern Mediterranean Waters of Egypt

Mohamed A. Ibrahim*, Mohamed W. A. Hasan, Alaa M. M. El-Far, El-Sayed F. E. Farrag and Mahmoud M. S. Farrag

National Institute of Oceanography and Fisheries (NIOF), Alexandria, Egypt
** Corresponding Author: National Institute of Oceanography and Fisheries, Anfoushy, Alexandria, Egypt.*
Email address; drmohamedamin@hotmail.com

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Abstract

The data of four deep-water shrimp trawlers from the Mediterranean waters of Egypt using standard Italian trawl of 40mm codend was used to evaluate the resources of *Aristaeomorpha foliacea* and *A. antennateus.* Results showed that the average total catch per (five-hours-hauls) is about 62 kg. The by-catch constitutes about 16 - 22% of the landed catch comprising 21 species, with *Merluccius merluccius as* the dominant species. Hauls from east off the Nile Delta give about 33% more by-catch/haul than west. On the contrary, the western water gave about 7% more shrimp than the eastern one. *A. antennatus* was found with *A. foliacea* in 45% of the hauls and never was found alone. The former contributed about 0 – 14% of the shrimp catch in each haul. Shrimp catch rate is relatively higher during sunrise and day time operations than those of sunset and night ones. The density of the major species ranges between 95 and 101 kg/km^2*;* of which 55 – 74kg/km^2 are deep water shrimp. This suggests a good shrimp potential in the 500–700 m depth stratum. The best prospects for the Egyptian marine fisheries are to introduce more modern vessels, equipment and fishing methods (e.g. Mid-Water Trawl) and Deep-Water Trawl to add this new target species to the fishery.

Keywords: *Aristeus antennatus, A. foliacea*, red shrimp, fisheries, CPUE, CPUA, deep water shrimp, South Eastern Mediterranean, Egypt.

1. Introduction

The Northern Coast of Egypt extends for about 1050 km from Rafah in the East on Sinai Peninsula to Sallum in the West on the Egyptian-Libyan border. It is one of the longest Mediterranean shores in North Africa. The main fishing ground is the continental shelf off the Nile Delta which mainly extends to the eastern side of Port Said more than to the western side of the Nile Delta to Sallum. The continental shelf is narrow in the East and West of the Nile Delta as compared with the wider central Delta region. The seabed is flat, mostly muddy to sandy along the middle and eastern side. According to Said *et al*. (2007) and as based on data taken from the joint Soviet-Egyptian expeditions carried out along the Egyptian Mediterranean sector during December 20-27 1988 aboard RV Academic Levrentyev, and March 7-15, 1990 aboard RV professor Bogorov; there are four water masses observed during winter; (i) the surface water mass of temperature 17-19 °C, salinity maximum 39.0-39.2 ‰ occupies the upper 200 m layer, (ii) the Levantine intermediate water mass of temperature 15-17 °C and salinity 38.8-39.0 ‰ occupies depths between 200 and 400m,(iii) a mid depth water mass lies between 400 and 800 m of temperature 14-15 °C and salinity range 38.75-38 ‰ and (iv) the deep water mass of potential temperature range 13.3-13.5 °C, salinity 38.6-38.75 ‰ and density ~29.1σ_t. Limited grounds for trawling are available on the western side. Fish landing from the shelf is 78,790 tons which constitutes about 20.3% of the total Egyptian catch 38,7398 tons (GAFRD, 2009). The licensed motorized fleet during the year 2009 was 2,977 vessels; of which 106 are bottom trawlers; 1,186 are boats using long lines; 498 boats using trammel nets and 232 are purse-seiners. A total of about 20,000 licensed fishermen are working in the fisheries field. The engine power capacity of the commercial trawlers range from 50 to more than 800 horse power (hp), but the majority of them range from 100 to 250 hp. Most of the trawlers operate on 50m depth stratum using the Italian-designed trawl nets. In order to discover and explore additional new fishing grounds for Egypt; the General Authority of Fisheries Resources Development (GAFRD) contracted with some Italian shrimp trawlers to exploit the Egyptian Mediterranean fishing grounds deeper than 400 meters (which are not exploited by the traditional commercial trawlers) to explore their potentials. The obtained data by these trawlers was

2. Materials and methods

The primary purpose of the methodology employed in this study was more to manipulate the reliable quantitative catch data to view the distribution and potential of the unexploited shrimp stock in the deep Egyptian Mediterranean water.

Samples were collected by several commercial Italian shrimp trawlers ranging in length from 32 to 37 meters and from 1,050 to 1,200 hp engines. They were using Italian designed nets of 60–70m long and 8m width, 30 - 40m wing with a height of 1–6 m. and cod-end mesh size of 40mm stretched with 300-350 kg otter board. Trawling was going all the time during November and December 2009 on both west and east off the Nile Delta. Haul duration was about five hours with 4 casts a day during sun rise, day time, sun set and night.

The basic data collected was catch (weight) of target species (deep sea shrimp) and any other encountered major fish species, fishing effort and species composition. Depth contours were compiled from ships data and GEODAS Grid Translator Data and were accomplished by means of the Surfer Computer Program (V.9). No attempt was made to standardize the catch effort data in relation to ship length or horse power or net variations as most of these variables are relatively minor among ships. Adjustments were performed only for haul duration equals five hours. Catch percentages were used in the calculations to overcome variability in the landed catch among ships and time.

For estimation of biomass; the catch per unit area (CPUA) was used according to (Sparre and Venema, 1998). As the exact positions of the start and the end of the haul were available; the distance covered was estimated in units of nautical miles as:

$$D = 60 * \sqrt{(Lat1 - Lat2)^2 + (Lon1 - Lon2)^2 * \cos^2(0.5 * (Lat1 + Lat2))} \quad (1)$$

$$D = V * t \quad (2)$$

$$(a) = D * hr * 0.5 \quad (3)$$

Where;

D = distance covered, Lat1 = latitude at start of haul (degrees), Lat2 = latitude at end of haul (in degrees), Lon1 = longitude at start of haul (degrees), Lon2 = longitude at end of haul (degrees), V = velocity, t = trawling duration, (a) = swept area, hr = head rope length (Floating rope) and 0.5 = constant (wing spread according to Pauly, 1980).

3. Results and discussion

Data of 201 successful bottom trawl hauls were obtained from 4 shrimp trawlers. Among these hauls; 123 were in the West off the Nile Delta at depth range of 576 - 722m (average 680m) and 78 ones on the Eastern side at a depths range of 640 – 700m (average 670m). Hauls in the West covered a rectangular trawling area (31.326N, 29.235E), (31.407N, 29.438E), (31.213N, 29.319E) and (31.326N, 29.235E), while those in the East covered an almost triangular area (31.904N, 33.904), (31.974N, 33.303E) and (31.838N, 33.514). The effective duration of a haul ranged between 4 – 6 hours with an average of 5 hours and the trawling speed varied between 2.5 and 3.0 knots (average 2.8 knots); depending on the depth and the nature of the substratum. Figure 1; represents the location map, the depth contours in meters and position of the fishing grounds.

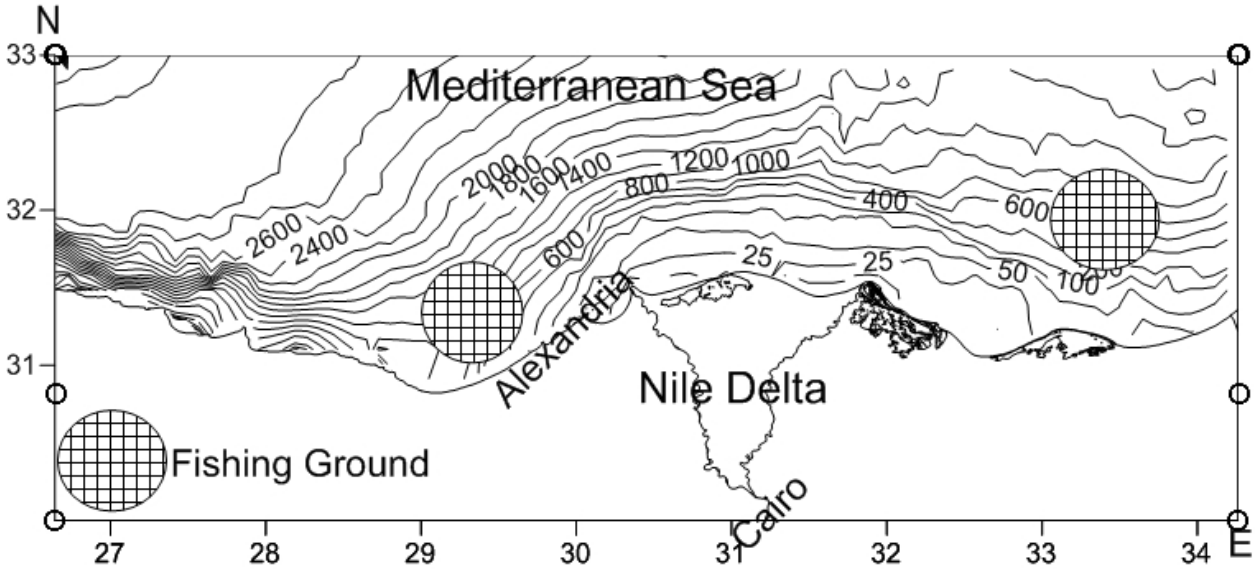

Figure 1. Location map showing the depth contours (m) and position of the fishing grounds.

3.1. Landed catch

As the fishing activity of the trawlers was devoted to deep water shrimp; any other catch was considered as by-catch. Collectively, results showed that the mean total catch per 5 hour/haul in the Western water was 59.9kg\haul, while it was 61.7 kg for the Eastern one. The by-catch constitutes about 16.47% of the landed catch from the West side, while it was 21.96% for the East as represented in Table 1. Even though statistics in Table 2 proved that there is no significant statistical difference between the average total catch/haul at 95% confidence level between the West and the East of delta waters (t) = -0.331 at 199 degrees of freedom; yet the Eastern water gave about 33% more by-catch/haul than the Western one at a 95% confidence level and 199 degrees of freedom (t) = -2.3608. On the contrary, the Western water gives about 7% more shrimp than the Eastern water at the same level of confidence. This could be attributed to the fact that the Eastern water has higher faunal biodiversity than the West one due to more food supply in the East (Champalbert, 1996). In general, the average five-hours haul landed 51 kg of shrimp and 11 kg of by-catch.

3.2. The By-catch

The by-catch of 66 successful hauls from the Western water and 42 ones from the Eastern were analyzed for species composition. 21 species were identified Table 3. Cephalopods were represented by two species namely; *Illex coindetii* (Verany, 1839) and *Todaropsis eblanae* (Ball, 1841). Elasmobranchs were represented by 8 species. The sharks *Galeus atlanticus, Echinorhinus brucus* and *Hexanchus griseus* are common in the fishing grounds. In addition, 11 bony fish species were encountered. Among them; *Merluccius merluccius* was the dominant fish species in the by-catch both by number and weight. It is represented by 5.36% of the total catch in the West and by 9.13% in the East with an average of 6.9% Table 4 with length range between 26 and 63cm.

Table 1: Percent (by weight) of shrimp and by-catch relative to total catch/haul*.

	Shrimp		By catch	
	West of Nile Delta Water	East of Nile Delta Water	West of Nile Delta Water	East of Nile Delta Water
Number of hauls	123	78	123	78
Mean %	83.53	78.04	16.47	21.96
Minimum %	6.452	20	0.00	8.54
Maximum %	93.55	91.46	93.55	80.00
St Dev	17.73	12.96	17.73	12.96

* haul duration = five hours.

Table 2: Statistics of % shrimp and % by-catch (kg) relative to catch/haul*.

	Mean (West)	Mean (East)	t-value	Degrees of freedom	p	Valid No treatments (West)	Valid No treatments (East)	Std. Dev. (West)	Std. Dev. (East)	F-Ratio	p
By-Catch											
West vs. East	16.47	21.96	-2.3608	199	<0.05	123	78	17.729	12.957	1.872	0.003
Shrimp											
West vs. East	83.53	78.04	2.361	199	<0.05	123	78	17.729	12.957	1.872	0.003
Catch/haul											
West vs. East	59.9	61.7	-0.331	199	>0.05	123	78	37.081	37.809	1.040	0.838

* haul duration = five hours.

Table 3: By-catch in the deep trawling grounds of the Mediterranean waters of Egypt.

Group or Family	Scientific Name	Common English Name
	(I) Cephalopods	
F. Ommastrephidae	*Illex coindetii* (Verany, 1839)	na
F. Ommastrephidae	*Todaropsis eblanae* (Ball, 1841)	na
	(II) Sharks and Rays	
F. Dasyatidae	*Dasyatis pastinaca* (Linnaeus, 1758)	Common stingray
F. Rajidae	*Dipterus oxyrinchus* (Linnaeus, 1758)	Long nosed skate
F. Rajidae	*Raja asterias* Delaroche, 1809	Starry ray
F. Rajidae	*Rostroraja alba* (Lacepède, 1803)	Bottle nosed skate
F. Torpedinidae	*Torpedo tokionis* (Tanaka, 1908)	Trapezoid torpedo
F. Echinorhinidae	*Echinorhinus brucus* (Bonnaterre, 1788)	Bramble shark
F. Hexanchidae	*Hexanchus griseus* (Bonnaterre, 1788)	Blunt nose six gill shark
F. Scyliorhinidae	*Galeus melastomus* Rafinesque, 1810	Black mouth cat shark
	(III) Bony Fishes	
F. Bothidae	*Arnoglossus thori* Kyle, 1913	Thor's scald fish
F. Congridae	*Conger conger* (Linnaeus, 1758)	European conger
F. Macrouridae	*Nezumia aequalis* (Günther, 1878)	Common Atlantic grenadier
F. Merlucciidae	*Merluccius merluccius* (Linnaeus, 1758)	European hake
F. Myctophidae	*Ceratoscopelus maderensis* (Lowe, 1839)	Lantern fish
F. Ophichthidae	*Ophisurus serpens* (Linnaeus, 1758)	Serpent eel
F. Phycidae	*Phycis blennoides* (Brünnich, 1768)	Greater fork beard
F. Scophthalmidae	*Lepidorhombus boscii* (Risso, 1810)	Four spotted megrim
F. Sebastidae	*Helicolenus dactylopterus dactylopterus* (Delaroche, 1809)	Black belly rosefish
F. Trachichthyidae	*Hoplostethus mediterraneus mediterraneus* Cuvier, 1829	Mediterranean slime head
F. Trichiuridae	*Lepidopus caudatus* (Euphrasen, 1788)	Silver scabbard fish

Table 4: Species composition and their percentage (by weight) in an average haul*.

Fishing ground	West Side	East Side	Average
No. successful hauls	66	42	108
Deep Sea Shrimp			
Aristeomorpha folicea	67.14	63.32	65.57
Aristeus antennatus	5.12	0.24	3.12
Sub Total % shrimp	72.25	63.56	68.69
Cephalopods			
Illex coindetii	0.23	0.02	0.14
Todaropsis eblanae	0.41	0.43	0.42
Sub Total % Cephalopods	0.64	0.45	0.56
Sharks and Rays			
Galeus atlanticus	2.12	2.96	2.46
Echinorhinus brucus	1.49	6.00	3.33
Hexanchus griseus	11.41	0.62	7.00
Rostroraja alba	0.61	0.55	0.59
Dasyatis pastinaca	0.16	0.01	0.10
Raja asterias	0.04	0.07	0.05
Sub Total % Cartilaginous F.	15.83	10.21	13.53
Bony Fishes			
Merluccius merluccius	5.36	9.13	6.90
Helicolenus dactylopterus dactylopterus	0.43	7.22	3.20
Phycis blennoides	0.60	3.18	1.66
Ophisurus serpens	0.99	0.73	0.88
Lepidopus caudatus	0.18	0.02	0.11
Arnoglossus thori (Kyle, 1913)	0.86	0.01	0.51
Dibranchus spp.	0.17	2.58	1.16
Sub Total of Bony Fishes	8.59	22.87	14.42
Others	2.69	2.91	2.8
Total %	100%	100%	100%

* haul duration = five hours.

3.3. Shrimp Catch

Two highly commercial deep sea shrimp species, extensively exploited in the Western and central Mediterranean Sea related to Order Decapoda; Suborder Dendrobranchiata and Family Aristeidae were caught during the present study. They are the red shrimp or the Giant Gamba Prawn *Aristaeomorpha foliacea* (Risso, 1827), and the rose shrimp *Aristeus antennatus* (Risso, 1816). The former is characterized by: Long rostrum in females and juvenile males, shorter in adult males; more than 3 dorsal rostral teeth, no ventral teeth; strong hepatic spine; telson with 4 pairs of movable lateral spines in posterior half. It looks

a bit like *A. antennateus* but is a bit darker red and has a few more edges on the "sword on the head". They feed on small benthic invertebrates mainly euphausiids and other species of crustaceans namely Natantia and polychaetes (Fisher *et al*., 1981).

They are widespread decapod crustacean in the eastern and western Atlantic, western Pacific, the Indian Ocean and the Mediterranean Sea (Holthuis, 1980). They are found at depths ranging between 300 and 750m over a large part of the continental slope (Bianchini and Ragonese, 1994). As a whole; *A. antennatus* was found with *A. foliacea* in 45% of the hauls and never found alone. The former contributes about 0 – 14% of the shrimp catch in each haul. Statistics showed no correlation between landed catch and depth (r^2 = -0.198 for the West) and (r^2 = -0.3 for the East). Belcari *et al*., (2003), mentioned that in the Western Mediterranean, *A. foliacea* was much more abundant than the companion species *A. antennatus*, with percentages ranging from 72 to 99% of the total red shrimp catch. In other areas of the western Mediterranean the opposite trend was observed. In the eastern basin of the Mediterranean in the Greek waters also a significantly higher abundance was notice According to (Belcari et al., 2003); data on the eastern side of the Mediterranean confirm the general assumption that the abundance of *A. foliacea* seems to follow longitudinal and latitudinal gradients. Thus the species is scarce or absent in the Catalan Sea, in the Gulf of Lions and in the Ligurian Sea, abundant in Tunisia, outnumbers *A. antennatus* in the northern Tyrrhenian Sea and in the Sicilian channel it is present in almost equal proportions in the southeastern Tyrrhenian Sea and again less abundant in the Ionian Sea.

3.3.1 Diurnal shrimp catch

Table 5 and Figure 2; represent the catch rate (kg/h) for a standard five-hours haul as well as the percentage contribution of shrimp and by-catch. It is evident from the table that shrimp catch rate is relatively higher during sunrise and day time operations than those of sunset and night ones in both east and west waters. This could be explained on the fact that even though sun light does not reach depths beyond 200m in the water column causing darkness all the time there; it appears that these crustaceans probably burry them selves in the bottom sediment during the apparent day light period as an inherited behavior as in the shallow-water crustaceans and hence becomes vulnerable to the bottom trawl.

3.3.2 Shrimp and by-catch density

Applying equations (1-3) on the relevant mentioned tables to calculate the density of the landed catch; results are presented in Table 6. From the table it could be concluded that the density of the major species ranges between 95 and 101 kg/km^{2,} of which 55 – 74kg/km^2 are deep water shrimp. This suggests a good shrimp potential for this 500–700 m depth stratum.

Table 5: Catch rates and percentage contribution of shrimp and by-catch (by weight) relative to average haul* and to a four-haul working day.

	West Side					East Side				
	sun rise	day time	sun set	night	Total	sun rise	day time	sun set	night	Total
Shrimp Catch rate (kg/h)	15.9	13.8	6.2	6.1		12.9	15.8	6.5	7.7	
By-Catch rate (kg/h)	3	5	5	4		8	8	5	3	
(A): % Relative to 4 hauls per day:										
%shrimp catch/haul*	37.86	32.86	14.76	14.52	100.0	30.07	36.83	15.15	17.95	100.0
%by-catch/haul*	17.65	29.41	29.41	23.53	100.0	33.33	33.33	20.83	12.50	100.0
%Total catch/haul*	32.12	32.33	18.77	16.79	100.0	31.24	35.50	16.72	16.54	100.0
(B): % Relative to catch/haul*										
%Shrimp	84.13	73.40	55.36	60.40		61.72	66.39	56.52	71.96	
%By-catch	15.87	26.60	44.64	39.60		38.28	33.61	43.48	28.04	
%Total catch	100.0	100.0	100.0	100.0		100.0	100.0	100.0	100.0	

* haul duration = five hours.

Table 6: Catch density (kg/km^2) in the depth stratum (600 -700m) in the Egyptian Mediterranean Waters.

Density (kg/km2)	West of Delta			East of Delta		
	shrimp	By-catch	Total	shrimp	By-catch	Total
Maximum	193	206	245	174	52	204
Minimum	14	0	17	4	4	18
Average	74	21	95	83	18	101
St. Dev.	51	40	64	55	11	62
No. hauls	108	108	108	77	77	77

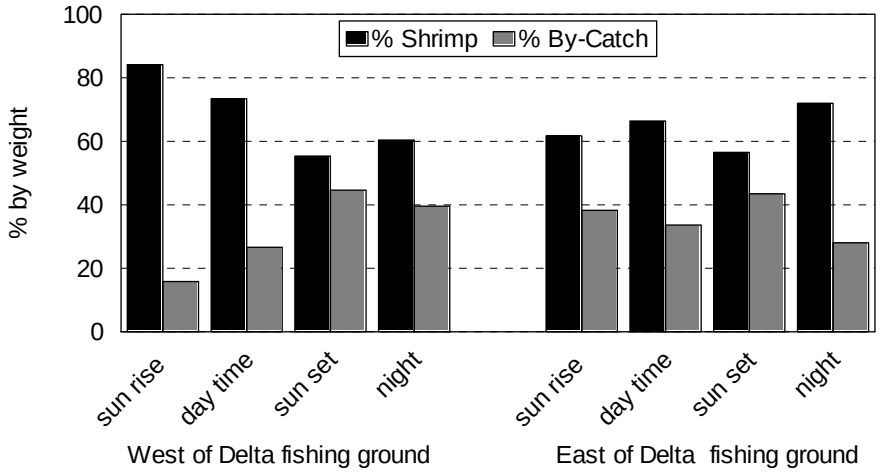

Figure 2. Percentage contribution (weight) of shrimp and by-catch according to time.

4. Conclusions

The depth stratum 500–700 m of the Egyptian Mediterranean water hosts appreciably large quantities of deep sea shrimp and other fishes. The deep sea shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus* represent 78-84% (as biomass) of the total trawl catch, corresponding to a high economic income. It is evident from the results that shrimp catch rate is relatively higher during sunrise and day time hauls than sunset and night ones in both the East and the West waters. The density of shrimps and several other commercial fish species were found in a density range between 95 and 100kg/km^2. The present results suggest the possibility of developing a deep-water shrimp fishery. Yet, it should be kept in mind that low information exists on the reproductive biology and larval life and recruitment of those deep sea shrimps in the Egyptian water; which calls for further studies. In such a case, attention should be paid to avoid overfishing because of the high vulnerability of the shrimp to the fishing pressure. Carlucci *et al*. (2006) mentioned that a larger mesh than 40-mm stretched should be adopted in the fishery of the deep-water shrimp in order to reduce mortality in juveniles. The 60-mm codend mostly reduces the capture of specimens smaller than 30 mm Carapace Length. In conclusion; the best prospects for the Egyptian marine fisheries are to introduce more modern vessels, equipment and fishing methods (e.g. mid water trawl) and deep water trawl in order to introduce this new target species for the Egyptian fishery.

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مخزون جمبري المياه العميقة في مياه البحر المتوسط المصرية

محمد أمين إبراهيم* ـ محمد وجيه أحمد حسن ـ علاء محمود محمد الفار ـ السيد فراج السيد فراج ـ محمود محروس سيد فراج

*المعهد القومي لعلوم البحار والمصايد ـ الأنفوشي ـ الإسكندرية

تم في هذا البحث الاستفادة من بيانات أربعة سفن صيد أجنبية خلال نوفمبر – ديسمبر 2009، وهي تصيد بشباك الجر الإيطالية لصيد جمبري المياه العميقة على عمق 600 - 700 متر في مياه البحر المتوسط المصرية أمام شرق وغرب الدلتا، حيث أن هذه الأعماق لا تستغل بأسطول الصيد المصري الحالي. ويتراوح طول السفن الأربع بين 32 – 37 مترا وقوة محركاتها تتراوح بين 1050 – 1200 حصان وطول شباكها يتراوح بين 60 – 70 متر وجناح الشبكة فيها 30 – 40 متر وسعة ماجة (عين) كيس الشبكة 40مم. وهي تصيد على مدار اليوم على أربعة فترات (جرات) كل منها حوالي 5 – 6 ساعات.

وأوضحت النتائج أن الجرة الواحدة تنتج حوالي 62 كيلوجرام من محصول الصيد في المتوسط. والمحصول يحتوي على 21 نوعا مختلفا من الأسماك نسبتها 16 – 22% من المصيد، وأهم مكوناتها أسماك النازلي. أما الجمبري فيمثل النسبة الباقية. فالجمبري كان ممثلا بنوعين اثنين ذوي قيمة تسويقية عالية في أوروبا هما الجمبري الأحمر والجمبري الوردي الذي يمثل نسبة (1 – 14%) من نسبة الجمبري المصاد. وهو متواجد بنسبة 45% من الجمبري في مواقع الصيد.

وقد وجد أن المنطقة شرق الدلتا تعطي نسبة 33% من الأسماك ضمن المصيد أكثر من منطقة غرب الدلتا، بينما المنطقة الأخيرة فتعطي 7% زيادة في نسبة الجمبري عن المنطقة الشرقية. وقد وجد أن كمية الجمبري المصادة خلال فترتي شروق الشمس ووسط النهار أكبر من فترتي غروب الشمس والليل بالرغم من أن هذه الأعماق مظلمة على مدار اليوم لأن ضوء الشمس لا يخترق عمود المياه إلى تلك الأعماق لأنه يمتص في الأمتار العليا من المياه.

وقد قدرت كثافة الأسماك والجمبري المصيدة بشباك الجر للجمبري في المياه المصرية عند الأعماق 600 – 700 متر بحوالي من 95 إلى 101 كيلوجرام في الكيلومتر المربع الواحد. منها 55 – 74 كيلوجرام جمبري والباقي عبارة عن أسماك غضروفية أو عظمية أو لافقاريات من مجموعة الرأسقدميات وأهمها الكاليماريا . ولضمان استدامة كفاءة مصايد الجمبري في هذه الأعماق يقترح أن لا تقل فتحات عيون كيس الشبكة وهى مشدودة عن 60مم.

مما سبق يتضح أنه لتنمية المصايد البحرية المصرية يجب تعزيزها بالسفن الحديثة والآلات القوية والشباك المتطورة كشباك الجر في وسط عمود الماء وفي قاع المياه العميقة لتضمن التوسع إلى مواقع صيد جديدة تهدف إلى صيد أنواع أخرى غير متاحة لها حاليا.