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IMPROVEMENT OF CATCHES BY SHRIMP TRAWL GEAR, IN BARDAWIL LAGOON, NORTH SINAI, EGYPT

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ABSTRACT

Four types of shrimp trawl nets 4, 5, 7.5 and 10 mm mesh sizes were used to assess the efficiency of various shrimp trawl nets modification to select and reduce the catch. The catches were affected by different meshes. After five months (Fifteen fishing trips) average catches was calculated per mesh size as follows: 11.11, 10.83, 7 and 6.24 kg for 4, 5, 7.5 and 10 mm, respectively. Average weights of targeted and non-targeted catches were calculated as follows: 1.39, 1.64, 1.4 and 1.31 kg and 9.72, 9.19, 5.6 and 4.93 kg for the same models, respectively. Discarded fish were reducing significantly ($P \leq 0.5$) with increasing of mesh sizes, where increasing mesh size up to 7.5 and10 mm in a trawl end was limited for discards and shrimp No.3. Results indicate that substantial improvement in size-fish for shrimp is achieved by switching from the conventional 4 mm-mesh sizes to a 10 mm-mesh size. The minimum mesh size of the shrimp trawl especially used in shrimp fishery must be 7.5 mm in order to protect fish stocks and optimum catch efficiency for the future. On the economic level, the study showed that the use of 7.5 mm as a mesh size will slightly decrease the total income on a short term but will protect fish stock and secure a profitable on long term. Hence, there is a need to identify the potential long and short-term benefits by lagoon management.

Key words: Shrimp trawl net, by-catch, discards, Bardawil lagoon, Egypt.

INTRODUCTION

Shrimp trawl is a known to be poor selective gear as widely used in Bardawil lagoon fishery. Bottom trawls are use in a multi-species and multi-size ecosystem induces catches of non-targeted fishes or unwanted length grades of the targeted species, much of this catch is often discards with high mortality rates **(Alverson *et al.*, 1994).** Shrimp species, *Metapenaeus stbbing, Penaeus japonicus, Metapenaeus monoceros, Penaeus semisulcatus* are the main target species of catches in shrimp trawl fishing. Shrimp trawl gear which work in Bardawil fishery is illegal net where it bring in large quantities of by-catch which it often includes juveniles of economic fishes, small individual of crabs. **Machias *et al.* (2001)** mentioned that the main problem in the Mediterranean is the absence of monitoring of the discarded fraction of the catches.

The selectivity studies and the effects of mesh size changes are considered of great importance for the management of fisheries **(Pestana and Riberio-Cascalho, 1991; Sobrino *et al.*, 2000; Campos *et al.*, 2002).** Poor data on by-catch and discarding rates can lead to biased estimates of fishing effort and mortalities. In order to manage marine fisheries effectively, we must assess and manage by-catch **(Alverson *et al.*, 1994).** The main reasons for discarding commercialized species are: (a) undersized fish that usually have low or negligible market value; (b) regulation demands on minimum landing sizes and (c) the market value of species caught **(Machias *et al.*, 2004).**

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Overfishing of many species in many areas is widely documented **(Myers and Worm 2003 and Clark, 2006).** Studies on by-catch and discards in the Bardawil lagoon are scarce. Therefore, this study is among the first ones related to by-catch and discards fish were caught by different mesh sizes of shrimp trawl in Bardawil lagoon, aiming to assess the efficacy of different mesh size intended to reduce the catches of small shrimp and the discards fish.

MATERIALS AND METHODS

Study Area

Data was collected from three important fishing areas in the Bardawil lagoon, $Bughaz_2$, $Bughaz_1$ and southern lagoon (Fig. 1).

The lagoon covers an area of 693 km^2, in an arid area in the northern part of Sinai Peninsula, Egypt and separated from the Mediterranean Sea by along narrow sandbar that varies in width between 100 m and 1 km. The lagoon is connected with the Mediterranean Sea by two artificial and one natural narrow channel. The lagoon is considered as a natural depression with a depth of 0.5-3 m.

Nets Design

The shrimp trawl gear, locally name "kalsa" was used to catch during the study period. The design trawl is a cone shape with two wings and ended bag. Four of the experimental of trawl nets were investigated, different only in ended bag meshes size (4, 5, 7.5 and 10 mm). The bag net is about 10 m in length.

The length of each wing and height was 8 m and 1.75 m respectively. The head rope of the cone is fitted with floats to keep the bag open, while the footrope is fitted with sinkers to keep the bag creeping on the bottom.

Fishing Experiment and Sampling Collection

Fifteen fishing trips from May to September during the fishing season, 2013, were done, using two commercial small vessels (which length of 6 m and was powered by 9.9 horsepower outboard engine) and equipped with four models of mesh sizes. Nets were set to touch the bottom by weights and dragged horizontally in the water by tow rubbers.

Ten haul for each mesh size were randomly sampled during the study, where two hauls for each mesh size per month (nets were dragged for ≈ 45 minutes during the night).

Catch Recording and Data Analysis

Every month, researcher was joined a trawling trip to observe and recorded the catch, where, the catch fish of each mesh size were washed, sorted and important species of fishes were identified. The samples of shrimp (target catch) was sorted to two grades, shrimp No.1 (25 g per one and more) and shrimp No.2 (24-5 g per one) addition to shrimp No.3 (less than 5 g) as a discards. All grades were weighted (kg). Also, untargeted species (crab, by-catch and discards fish) were weighted (kg). The catch per haul was weighted of each mesh size to the nearest one gram. Monthly, the target and by-catches of each mesh size to 614 boats to estimate the total annual weight of target and by-catch from the lagoon.

Economic Analysis

The catch was sorted in grades. For each one, average prices per kg were determined. Income differences between the meshes were calculated. The losses were estimated at fishing season.

Statistical Analysis

Analysis of variance (ANOVA) was used to test differences of the catches among net mesh sizes. F-test was applied for comparison of the mean catch and income of mesh sizes models **(SAS Institute, Cary, NC, USA, 2004).**

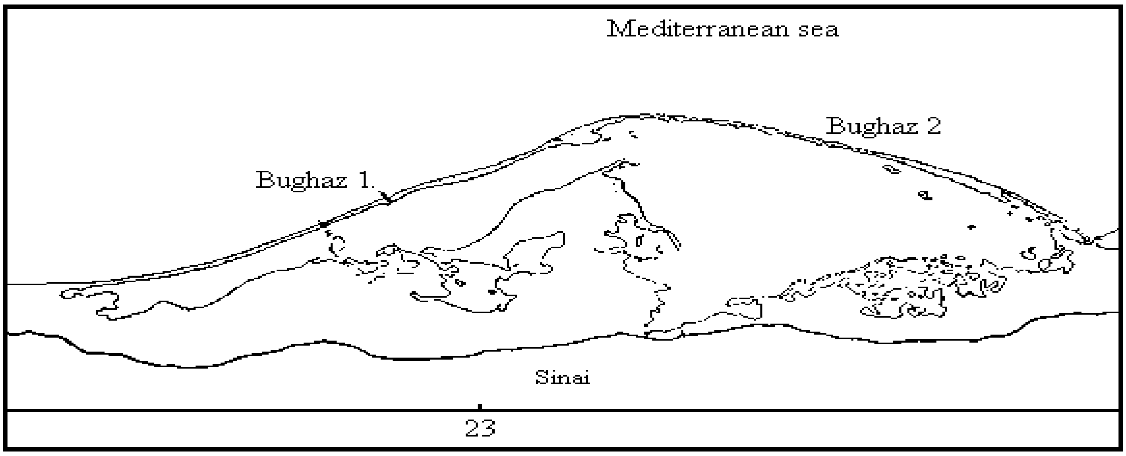

Fig. (1): Bardawill lagoon

RESULTS AND DISCUSSION

The Samples of Experiment

The stock in Bardawil lagoon is heavily exploited **(Khalifa, 2005 and Mehanna, 2006)** and their catch showed a serious decline. Few previous studies were carried out in Bardawill lagoon to reduce the by-catch and discards fish such as **Mehanna *et al.* (2011) and Salem and El-Aiatt (2013)**. In the present study, the average catch composition per haul as a weighted was illustrated in Fig. 2. The catch rates, weight per haul (kg) obtained from four different meshes of shrimp trawl gear tested shows that, small mesh netting (4 and 5 mm) had the higher catch and small size of fish than large mesh netting. The crab and shrimp No.3 were dominated of a samples followed by discards fish; indicating that, the shrimp trawl net is illegal fishing gear. Bottom trawls are known to be poor selective gears.

Their use in a multi-species and multi-size ecosystem induces catch of non-targeted fishes or unwanted length grades of the targeted species; much of this catch is often discards **(Alverson *et al.*, 1994).** Among the different fishing gears the trawl is responsible for the bulk of discards **(Stergiou *et al.,* 1998 ; Hall, 1999).**

Catch and Mesh Sizes

Knowledge of the size-selectivity of commercial fishing gears is crucial to fishery management for maximizing yield purposes and protecting juvenile fish **(Gulland, 1983; Wileman *et al.*, 1996)**.

Average catch was calculated for each mesh size as illustrated in Figure 3. The total catch of the four meshes differ significantly between small mesh size (4 and 5 mm) and large mesh size (7.5 and 10 mm).

The highest of catch was represented with 4 and 5mm mesh size of trawl net without any significant differences. Mesh size 7.5 and 10 mm which offer the lowest catch per haul values. The results indicated that, the increase in mesh size from 4 to 10 mm caused a greater reduction in catches weighted. The composition of catch per different meshes for shrimp and crab addition by-catch and discards are presented in Table 1. Crab was dominated with different mesh size, where represented by 34.65, 35.23, 52 and 57.10% of the weight for mesh size 4, 5, 7.5 and 10 mm respectively.

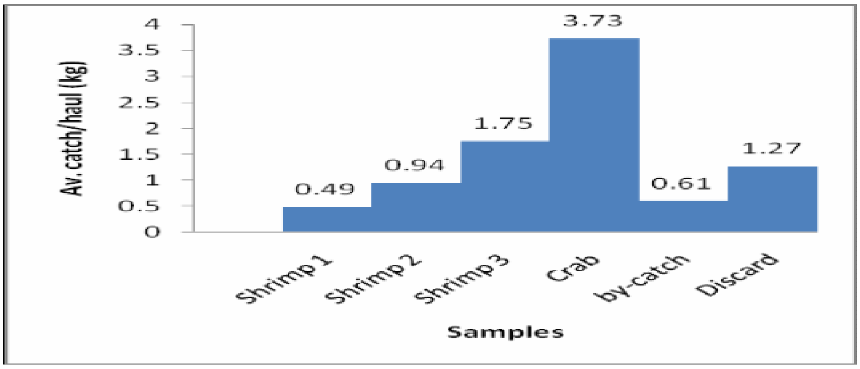

Fig. (2): Average catch composition (kg) per haul

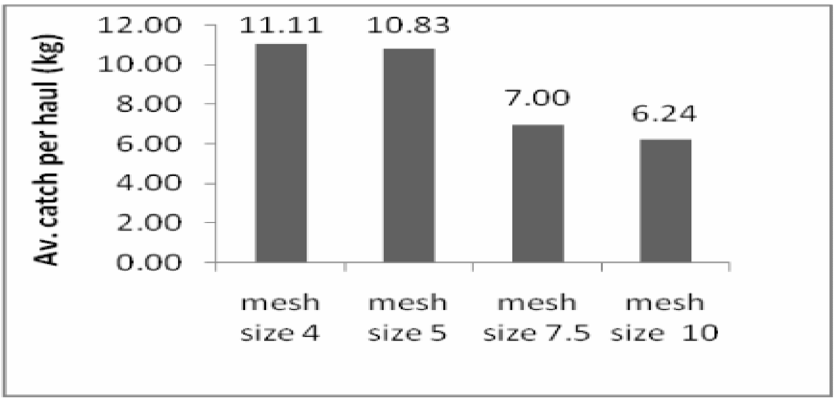

Fig. (3): Average catch (Kg) per haul each mesh size

Shrimp No.3 was dominated with small mesh netting size (4 and 5 mm) and down as increasing of the meshes size from 7.5 to 10 mm respectively. By-catch and discards of juvenile fish species in shrimp trawl fishery is a well-recognized problem, where, about of 6 finfish groups (commercially important), were identified as by-catch and discards with different mesh sizes (gilthead seabream, soles, seabass, groupers, glass eel, terapon and rabitfish) addition to unwanted others like jelly fish. This result agree with **Mehanna *et al.* (2011)**, where recorded that, the major species in Kalsa (trawl) by-catches were gilthead seabream juveniles, soles juveniles, groupers, glass eel, *Terapon puta*, *Sardinella aurita*, and others like shells, gastropods, jelly fish, squilla, small crabs and small sized non targeted fish. Smaller mesh size have been shown to suffer higher discards (dead juvenile of fish, crustacean, mollusk, vertebrate and other unwanted catch) than larger mesh size.

The higher discards were recorded with smaller meshes size. Also, she recorded that, globally, there is now an emphasis on reducing the by-catch through increasing the cod end size to the recommended 40 mm and use of square mesh cod ends. This will help in conserving the fishery resources, particularly the commercially important species.

Although the total catch were significantly higher ($P \leq 0.5$) from small meshes size, (4 and 5 mm) than large meshes size (7.5 and 10 mm), most of catches below the legal size. The target shrimp were the most important groups represented by just two grade, shrimp No.1 and No.2, comprising 1.39 and 1.64 kg per haul (2.51 and 14.96% by weight of catches) were caught by small mesh netting size, 4 and 5 mm respectively.

Other catches of small meshes comprising 2.08 and 1.89 kg per haul of discards fish (18.76 and 17.25% by weight of catch), 3.85 and 3.86 kg crab per haul (34.65 and 35.25% by weight of catch) and 0.56 and 0.5 kg per haul of by-catch (4.05 and 4.6% by weight of catch) addition to 3.23 and 2.94 kg per haul (29.04 and 26.84% by weight of catch) of shrimp No.3 for meshes 4 and 5mm respectively (Fig. 4 and 5).

The positive relationship we observed between mesh size 4 and 5 mm and discards fish, where this meshes caught significantly more discards than 7.5 and 10 mm mesh size. This results indicated then, the major catch of this net (mesh size 4 and 5 mm) is incidental catch of non-target species and discards fish.

The percentages of discards usually reflect the illegal of fishing nets and the fisherman's behavior. The discarding of large quantities of small shrimp is a feature of these fisheries **(Graham, 1997; van Marlen *et al.*, 1998)**.

This study shows that, the large mesh size, 7.5 and 10 mm caught significantly ($P \leq 0.5$) lower quantitative of catches than smaller meshes size, 4 and 5 mm (Fig. 6 and Fig. 7). Increasing mesh size to 7.5 and 10 mm in a trawl end was limited for discards and shrimp No.3, where, caught 80% less as a weighted of small shrimp (shrimp No.3) and about 69% less discards fish on average than mesh size 4 mm. Also, mesh size 10 mm was caught 93% less small shrimp (shrimp No.3) and about 75% less discards fish on average than mesh size 5 mm without significant losses of the larger size shrimp (shrimp No.1 and 2). The large meshes had effect on the catch composition, with a higher catches of the economically important groups such as shrimp No.1 and 2, sea bream, sole fish, sea bass and groupers fish. When sieve nets are fitted to standard shrimp trawls, reduce the capture of small shrimps **(Revill and Holst, 2004).**

Length at First Capture and Mesh Sizes

Length at first capture is an important factor where it is a function of mesh size and gear selectivity **(Beverton and Holt, 1966)**. Also, the length at first capture (L_{c50}) is proxy of mesh size and use to compare the effectiveness of capture. *Penaeus semisulcatus* making one of the target species of trawl operators in Bardawil lagoon, where, it has a high price in the local market.

Thus, the study of length at first capture and mesh sizes focused on the light of *P. semisulcatus* to introduce the length capture about the major contributor in shrimp catches of trawl gear from the Bardawil lagoon. This study indicated that, the sizes of catch were affected by different meshes (Fig. 8). The comparison between the investigated meshes was showed the lowest L_{c50} values of the smaller mesh size, where, the L_{c50} were very low and equal to 4.9 and 5.7 cm TL for mesh size 4 mm (smallest mesh size) and 5 mesh sizes respectively.

The estimated L_{c50} values were 7.9 cm and 8.1cm for 7.5 and 10 mm (largest mesh size) respectively. The present study indicated that, L_{c50} was about 4.9 cm an average weight of 1.7 g and 5.7 cm an average weight of 2.3 g caught with 4 and 5 mesh size respectively.

The catches of these meshes are illegal lengths. L_{c50} of 7.5 and 10-meshes are 7.9 and 8.1cm corresponding with 4.5 and 4.7 gram respectively. **Crocos (1987)** recorded that, female of *P. semisulcatus* reaches sexual maturity at a length of 13.4 cm and the total length at 50% maturity is 17.2 cm. Also, Khorshidian, 2002 found that the size at mass maturity L_{c50} of *P. semisulcatus* was ranged of 13.3 to 15.9 cm. Therefore, the most of catch is immature individuals, where the nets are harmful since in this way they do not first spawning.

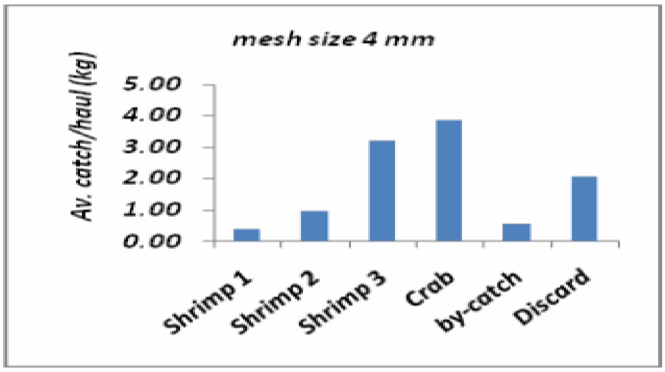

Fig. (4): The catch composition of shrimp trawl (mesh size 4 mm) in Bardawil lagoon, 2013

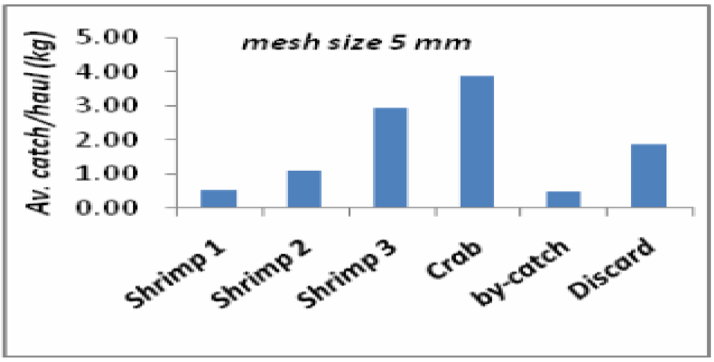

Fig. (5): The catch composition of shrimp trawl (mesh size 5 mm) in Bardawil lagoon, 2013

Table (1): Weight (kg) and percentage of target and untargeted catches for different meshes

Species	Mesh size (mm)							
	4		5		7.5		10	
Target	Weight (kg)	%	Weight (kg)	%	Weight (kg)	%	Weight (kg)	%
Shrimp 1	0.42	3.78	0.53	4.85	0.50	7.13	0.51	8.14
Shrimp 2	0.97	8.73	1.11	10.12	0.90	12.89	0.80	12.78
Total	1.39	12.51	1.64	14.96	1.40	20.02	1.31	20.92
Non-targeted								
Shrimp 3	3.23	29.04	2.94	26.84	0.66	9.43	0.18	2.96
Crab	3.85	34.65	3.86	35.23	3.64	52.00	3.56	57.10
by-catch	0.56	5.04	0.50	4.60	0.65	9.29	0.71	11.32
Discard	2.08	18.76	1.89	17.25	0.65	9.29	0.48	7.64
Total	9.72	87.49	9.19	83.91	5.6		4.93	
Av. catch/ haul (kg)	11.11		10.83		8.40		7.54	

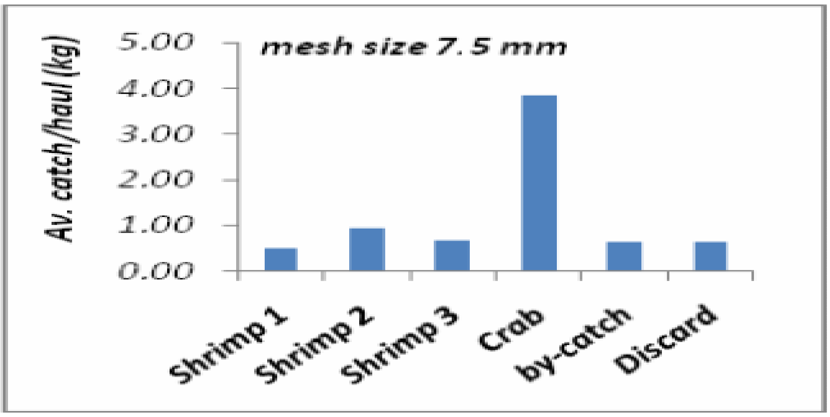

Fig. (6): The catch composition of shrimp trawl (mesh size 7.5 mm) in Bardawil lagoon, 2013

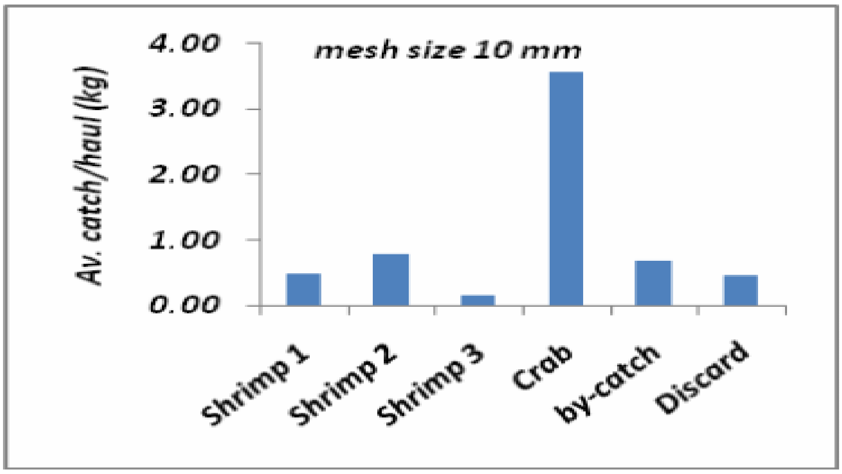

Fig. (7): The catch composition of shrimp trawl (mesh size 10 mm) in Bardawil lagoon, 2013

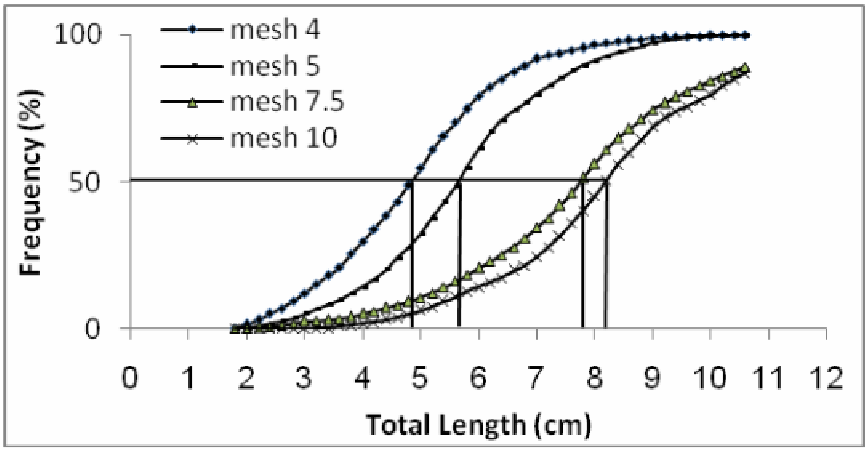

Fig. (8): Length at first capture, L_{c50} with different mesh size in Bardawil lagoon, 2013

Income and Economic Losses

In Bardawil lagoon, fishermen believe that, the juvenile of fish becoming unavailable to catch again by them as they would migrate outside the lagoon. Therefore, fishermen will not readily accept large mesh size, which results in too high a loss of shrimp No.3.

For example; large mesh size resulted in higher losses of shrimp No.3 more than 80% as a weight from total catch, therefore, this meshes was unacceptable by fishermen in Bardawil lagoon. So, the present estimated the average income of catch per haul for different mesh size to fill the gap between total catch and total income (Fig. 9). The study was found that, mesh size 5 is the highest in average cash income 112 L.E. followed by mesh size 4 with an average 104.8 L.E. Mesh size 7.5 and 10 mm, the lowest cash income 92.9 L.E. and 88.5 L.E. respectively. From the point of view economic, the smaller mesh size of shrimp trawl gear had the highest income, but the discards fish with this meshes about 2 kg per haul.

A total of 1228 fishing boats were used the trawl nets, each net is dragged by two boats **(Mehanna *et al.*, 2011),** meaning that, 612 hauls per hour fishing effort were operated in the lagoon at the same time. Six hours, average fishing effort daily, then, the losses were estimated at least of 1228 kg per hour, meaning that, we waste more than 7 ton daily, including the juvenile of economic species such as gilthead sea bream, soles, sea bass, groupers, glass eel and rabitfish, addition to other quantity of under sized fish, non-targeted species and very small crabs were caught as by-catch daily.

The study showed that the use of 7.5 mm as a mesh size will slightly decrease the total income on a short term but will protect fish stock and secure a profitable on long term. Hence, there is a need to identify the potential long and short-term benefits by lagoon management.

Statistical Analysis

Analysis of variance (ANOVA) was used to examine the differences of catch, the length at first capture (L_{50}) and income with mesh sizes as:

1. For the weight of catches: small meshes (4 and 5 mm) are the highest in weight and there are no significant differences between them. Large meshes (7.5 and 10 mm) are lower in weight and significant differences evident with the other smaller meshes. There were no significant differences evident between large meshes.
2. For the total income: Despite the smaller mesh size of shrimp trawl gear had the highest income, there were no substantial differences among incomes of meshes. No significant differences evident between small and large meshes.

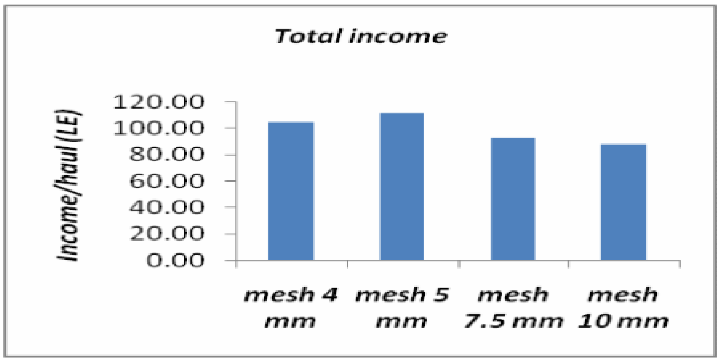

Fig. (9):Total income with different mesh size in Bardawil lagoon, 2013

Recommended and Conclusion

The minimum mesh size of the shrimp trawl especially used in shrimp fishery must be 7.5 mm in order to protect fish stocks and optimum catch efficiency for the future. On the economic level, the study showed that the use of 7.5 mm as a mesh size will slightly decrease the total income on a short term but will protect fish stock and secure a profitable on long term. L_{c50} of shrimp was increased as a mesh sizes increases.

The most of catch is immature individuals, where the nets are harmful since in this way they do not reach the age of first spawning.

This study concluded that, it is possible to reduce of waste fish (discards) by modified of shrimp trawl cod end from current use by fishermen to 7.5 mm meshes. This mesh will not substantial reduced of total income.

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استُخدمت أربعة أنواع من شباك جرافة الجمبري، مختلفة في سعة الماجا على النحو التالي: ٤، ٥، ٧,٥، ١٠ مليمتر لتقييم فعالية الماجات المختلفة في مصيد والحد من الصيد العرضي واسماك النفايات. بعد خمسة عشر رحله صيد، تم حساب متوسط المصيد لكل سرحه من جرافة الجمبري على النحو التالي ١١,١١، ١٠,٨٣، ٧، ٦,٢٤ كجم للأنواع ٤، ٥، ٧,٥، ١٠ مم على التوالي. أيضاً، تم حساب متوسط وزن المصيد من الأنواع المستهدفة وغير المستهدفة للجرفة الواحدة على النحو التالي: المستهدف/ ١,٣٩، ١,٦٤، ١,٤، ١,٣ كجم غير المستهدف/ ٩,٩١، ٩,٧٢، ٥,٦، ٤,٩٣ كجم لنفس الأنواع على التوالي. تأثرت أحجام الأسماك بالماجات المختلفة. حيث أدي زيادة حجم الشباك إلى (٧,٥، ١٠) ملم إلى تحسين مستوي المصيد. تُشير النتائج إلى تحسن كبير في حجم الأسماك والجمبري عن طريق التحول من الأنواع التقليدية العاملة بالمنخفض (٤) ملم إلى النموذج ٧,٥ ملم وهو النوع الأدنى المناسب في صيد الأسماك الجمبري لأجل حماية الثروة السمكية واستمرارية الصيد الأمثل في المستقبل. على الصعيد الاقتصادي، أظهرت الدراسة أن استخدام أنواع (٧,٥ ملم) سيخفض قليلاً من إجمالي الدخل على المدى القصير ولكن من شأنه حماية المخزون السمكي وتأمين ربحية جيدة على المدى الطويل وهذا ما توصى به الدراسة. بالتالي، هناك حاجة إلى تحديد الفوائد المحتملة قصيرة وطويلة الأجل من قبل إدارة منخفض البردويل لضمان استمرارية الإنتاج والحفاظ على المخزون السمكي داخل البحيرة.

الكلمات الإسترشادية: الجمبري، متوسط المصيد، المخزون السمكى، منخفض البردويل.

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