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ORIGINAL PAPER

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Gillnet Selectivity Experiments in Bahrain Waters on the Spanish Mackerel, *Scomberomorus commerson (Lacepede)*Fishery

Abstract: The selectivity of 9.5, 11.4, and 14.0 cm mesh size gillnet was tested experimentally in the Bahrain waters. A total of 12 hauls were conducted during the period from 5th June to 27th December 1999. Significant differences in the first girth indicted smaller (mean fork length 75.2 SD ± 5.0) and mainly immature Spanish mackerel were caught by 9.5 mesh panels. Milk Shark *Rizoprionodon acutus* numbers exceeded the Spanish mackerel numbers, and made up 85% of the total bycatch. Most of these sharks were caught in the 9.5 mesh panel. The importance of the shark issue in the management of the Spanish mackerel fishery was highlighted by the present study. It is suggested that future management of the Spanish mackerel fishery should take into the consideration the conservation of the shark stocks. It is also suggested that better management results can be achieved by increasing the lower limit of mesh size to 14.0cm. This study provides a preliminary list of the drift gillnet bycatch species. This is probably the first attempt to provide information on drift gillnet by catch in the Arabian Gulf.

Keywords: Gillnet, selectivity, Spanish mackerel, Bahrain *Scomberomorus commerson.*

تجارب على انتقائية الشباك الخيشومية في
مصايد الكنعد سمبيروموروس كمرسون (لاسيبيدي) في البحرين

إ ع عبد القادر

المستخلص:لقد تم تجربة انتقائية الشباك الخيشومية ذات الفتحات قياس 9..5 و 11.4 و 14.0 سم على مصايد الكنعد البحرينية. و قد نفذت 12 رمية خلال الفترة من 5 يونيو إلى 27 ديسمبر 1999م. و تم استخدام شبكة بطول 1..5 كم، مكونة من 9 قطع، و فيها كل ثلاث قطع ذات فتحات شباك قياس 9..5 و 11.4 و 14.0 سم. و قد تم ترتيب هذه القطع في الشبكة بترتيب منتظم. تم تسجيل الأعداد و الأطوال على حسب نوع السمكة و القطعة من الشباك. بالنسبة للكنعد فقد تم تسجيل الطول الشوكي والمحيط الأول و المحيط الثاني للجسم، بينما سجلت الأطوال الكلية و عرض الجسم (في حالة اللخم) للأنواع، الأخرى من الأسماك. وجدت فروق حقيقية في معدلات المحيط الأول للجسم تدل على أن الكنعد التي تم صيده بواسطة الشباك قياس 9.5سم أحجامه أصغر و أغلبه غير ناضجة جنسيا. و أن أعداد سمك القرش رايزوبريودون أكيوتس قد فاقت أعداد الكنعد، و قد شكلت 85% من إجمالي الصيد الجانبي. معظم أسماك القرش تم صيدها في القطع ذات فتحات قياس 9.5سم. و قد أشارت هذه الدراسة إلى أهمية موضوع أسماك القرش في إدارة مصايد الكنعد. و قد اقترح أنه في الإدارة المستقبلية لمصايد الكنعد، فأنه يجب أن تأخذ التدابير للمحافظة على مخزون أسماك القرش. و أقترح أنه يمكن الحصول على نتائج أفضل من خلال إدارة المصايد عن طريق زيادة الحد الأدنى لقياس فتحات الشباك إلى 14.0سم. و قد وفرت هذه الدراسة قائمة ابتدائية للأنواع الأسماك في الصيد الجانبي للشباك الخيشومية، و هذه هي أول محاولة لتوفير مثل هذه المعلومات لمنطقة الخليج العربي.

كلمات مدخلية:البحرين-إنتقائية-مصايد الكنعد-الشباك الخيشومية

Introduction

The mackerel fisheries of Bahrain and other GCC countries are based on a single species, i.e., the Narrow-barred Spanish mackerel *Scomberomorus commerson* (Marine Fisheries Department 1999, Department of Fisheries Statistics 1994). Despite the importance of the Spanish mackerel to the Arabian Gulf fisheries, the published biological information is limited (Dudley *et al.* 1992, Kedidi *et al.* 1993).

The contribution of Spanish mackerel in quantity and value to the total Bahraini landings averaged between 1.1 and 1.4 percent in 1994, 1995, and 1996 (Directorate of Fisheries 1997). During the nineties, the Spanish mackerel landings ranged from 44 to 159 tons, with first sale value of 74 to 247 thousand of Bahraini Dinars.

In 1993 there were 213 and 854 boats operating gillnet and hook and troll fishing respectively (Radhi *et al* 1999). These numbers included boats that targeted other fish species. The actual number of boats involved in Spanish mackerel fishery is smaller than these numbers.

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Four types of fishing gear are mainly used in the Spanish mackerel fishery in Bahrain waters. Drift gillnets are the most used fishing gear. They were introduced in the mid eighties, and shortly afterwards the use of this gear was banned in Bahrain waters. These nets are operated on the onset of tidal current, where the start of the net is usually marked and anchored, and the other end is moored to the boat. The net is allowed to drift with the water current for a few hours. This method is used more in open areas. The total length of drift gillnets ranges from 1.8 to 3.2 km. The mesh size of these nets range from 9.5 to 11.4 cm, based on the size of the fish. Fixed gillnets are shorter and mainly fixed in channels. Both ends of the net are usually marked and anchored. This gear is usually erected for a full tidal period. Fixed gillnets are less used at present. Both fixed and drift gillnet fishing is used during the dark nights, which usually start by the 21st and end by the 7th of the next lunar month.

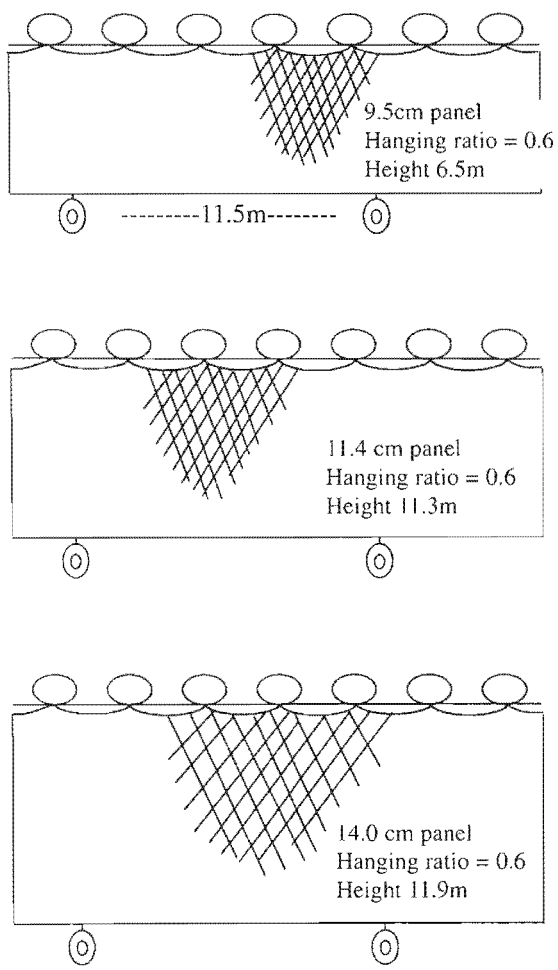
Both moving "troll" and stationary hooks are used in Bahrain waters for Spanish mackerel fishing. These methods are more frequently used after the decline in gillnets catches in March. Large Spanish mackerel are usually caught by stationary hooks in April and May.

A general decline in Spanish mackerel landings has been observed in all GCC countries, in particular in the Oman waters (Dudley *et al.* 1992). Recruitment over-fishing was defined as the possible cause of this decline (Abdulqader *et al.* 2000). The minimum legal mesh size was set at 8cm for Bahrain waters (Ministerial Decree No. 6 for year 1986). It has been proposed to increase the minimum size to 14cm. The move of the fishery to 14 cm will raise complaints and resistance from fishermen. To promote the adoption of this regulation with minimal consequences, experiments have been conducted on the selectivity of different mesh sizes on the fishery. The current work reveals the results of the selectivity experiments conducted in Bahraini waters.

Materials and Methods

The drift gillnet was used as sampling gear for its high fishing efficiency. Also, this gear provides better media to compare different mesh sizes by using a single net. A 1.5 km drift net was built of 9 panels; each was made of 270m of netting material (Figure 1). Three mesh sizes 9.5, 11.4 , and 14.0cm, were used. Their heights were 6.5, 11.3, and 11.9m respectively. Multifilament twine of sizes #30, #24, and #12 was used for the 14.0, 11.4, and 9.5cm netting. Panels were arranged in a systematic order, starting with the 14.0cm mesh panel, then the 11.3cm panel, and then the 9.5cm panel. The same sequence was maintained for the remaining panels. The hanging ratio was about 0.6 in all panels. Panel lengths were 179, 164, and 157 m for the net sizes 14.0, 11.4, and 9.5 cm respectively.

Sampling was conducted during dark nights between the 21st and the 7th of the next lunar month. A total of 12 hauls were conducted under normal fishing conditions by using a commercial fishing boat. Fishing was undertaken between latitudes 26° 32.312N and 26° 40.600E, and longitudes 50° 00.025N and 50° 44.421E, during the period from 5th June 1999 to 27th December 1999.



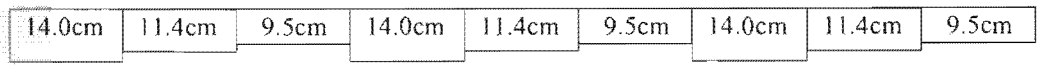


Fig. 1: Diagram showing the panels arrangement of the 1.5km drift gillnet used, and details of the 9.5, 11.4, and 14.0 cm mesh size panels.

After hauling, the catch was removed and analyzed separately for each panel. The number of fish and the total length (cm) and weight (g) per species were recorded. Body width was measured (cm) only for the rays. Forked length (cm), and first and second girth measurements (cm) were recorded for the Spanish mackerel. First girth was measured at the operculum posterior margin. The second girth was measured at the start of the second dorsal fin.

The One-Way Analysis of Variance (ANOVA) test (Sokal and Rohhlf 1981) was used to determine fish number and mean size significant differences in the three mesh size panels used. This test is valid only if the variances of the two samples were equal. The Levene test for homogenous variances was indicated in cases when ANOVA results were significant at p values equal to or smaller than 0.05.

Results

Spanish Mackerel

Low and nil Spanish mackerel catches were observed on most trips. A total of 94 Spanish mackerel were caught during this study; 81 were caught in Haul 7. Statistical analyses of the Spanish mackerel data was restricted to Haul 7 data. ANOVA test ($F = 0.375$, $p = 0.694$) indicted no significant differences in the Spanish mackerel mean numbers in three mesh size panels. Similarly ANOVA results indicated no significant differences between fork length ($F = 5.728$ at $p = 0.005$, Levene statistics = 1.62 at $p = 0.204$) and second girth means ($F = 6.392$ at $p = 0.003$, Levene statistics = 1.928 at $p = 0.152$) in three mesh panels. While significant differences between first girth means were indicted by ANOVA test ($F = 21.411$ at $p<0.000$). The Tukey Post Hoc test indicted that all first girth means are different. These means were 25.3 SD ± 1.77, 27.0 SD ± 1.52, and 28.8cm SD ± 2.1 for the 9.5, 11.4, and 14.0cm panels respectively (Figure 2). The corresponding forked length means were determined as 75.2 SD ± 5.0, 78.0 SD ± 4.9, and 81.0 SD ± 6.5 in respective order.

Bycatch

From all hauls, a total of 10 species were found in the drift gillnet bycatch (Table 1). A single shark species, the Milk Shark *Rizoprionodon acutus* was found to be the most dominant bycatch species. It's number exceeded the number of the target species, i.e. the Spanish mackerel. It made up 63% of the total catch, and 85% of the bycatch by numbers.

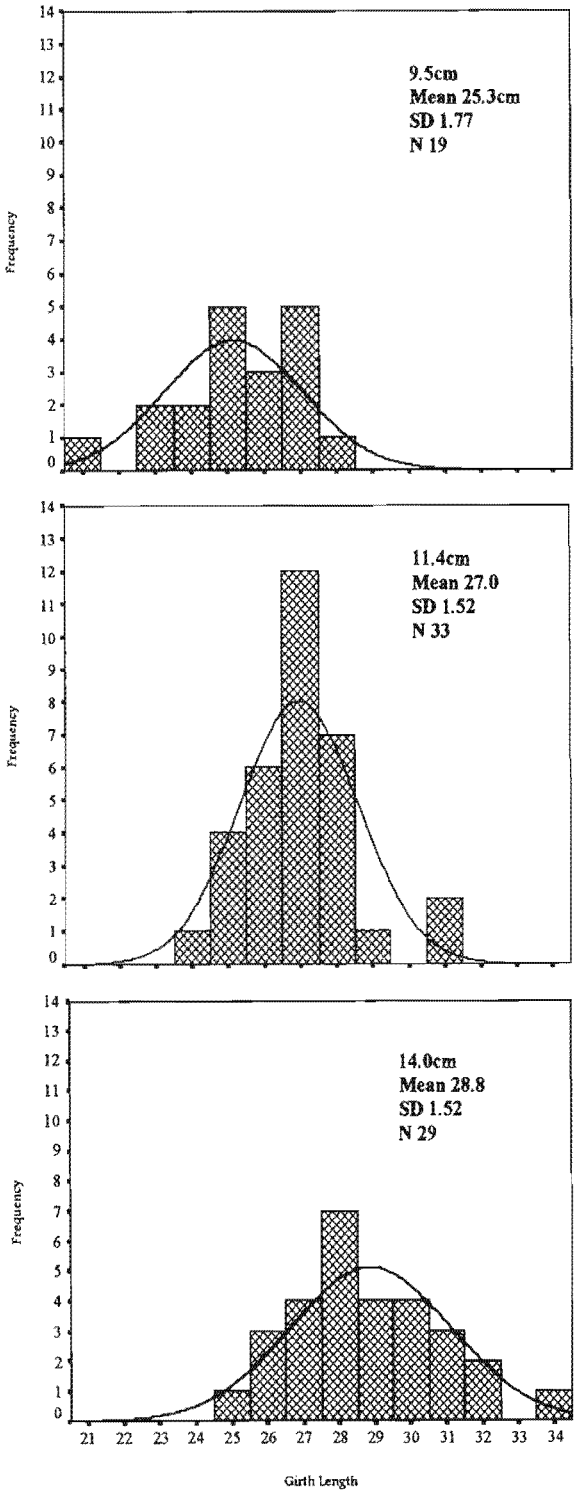


Fig. 2: Spanish mackerel first girth frequency distribution in 9.5, 11.4, and 14.0cm mesh panels. Mean girth size, standard deviation (SD), number of fish (N) are shown for the different panels. Means are statistically different.

Sailfish *Istiophorus platypterus* is the second most important drift gillnet bycatch species in Bahrain waters (Table 1).

Table 1. Total number of fish per species (N) caught in drift gill nets, their percentage in number (%), and their size range in cm (SR) for the study period. Scientific, English, and local names of these species are shown.

Species Name			N	%	SR
Scientific	**English**	**Local**			
Lethrinus nebulosus	Spangled Emperor	Sharee	1	0.3	45
Seriolina nigrofasciata	Blackbanded Trevally	Hamam Arabi	4	1.1	44-50
Euthynnus affinis	Little Tuna	Jibab	1	0.3	42
Scomberomorus commerson	**Spanish Mackerel**	**Channad**	**94**	**26.1**	**48-98**
Tylosurus crocodilus	Crocodile Needlefish	Hagol	2	0.6	78-122
Ablennes hains	Barred Needlefish	Musaffaha	1	0.3	114
Arius thalassinus	Giant Sea Catfish	Chim	6	1.7	39-51
Rhizoprionodon acutus	Milk Shark	Naood	227	63.2	47-82
Aetomyleus nichofii	Striped Eagle Ray	Thour Amer	4	1.1	54-59
Echeneis naucrates	Sharksucker	Lazzag	1	0.3	85
Istiophorus platypterus	Sailfish	Faras	18	5.0	137

The ANOVA test indicted significant differences ($F = 5.824$ at $p = 0.004$, Levene Statistics = 20.306 at $p<0.000$) between Milk Shark mean numbers in the three mesh size panels. The Tukey Post hoc test indicated differences between the 9.5cm (4.2 SD ± 7.6) and both 11.4 (1.56 SD ± 3.0) and 14.0cm (0.53 SD ± 1.1) panel means (Figure 3). Shark total length means for the three mesh panels were not statistically different ($F = 4.075$ at $p = 0.018$, Levene Statistics = 0.471 at $p = 0.625$). These means were 61.6 (SD ± 6.5), 64.4 (SD ± 6.6), and 64.4cm (SD ± 6.2) for the 9.5, 11.4, and 14.0cm mesh panels respectively.

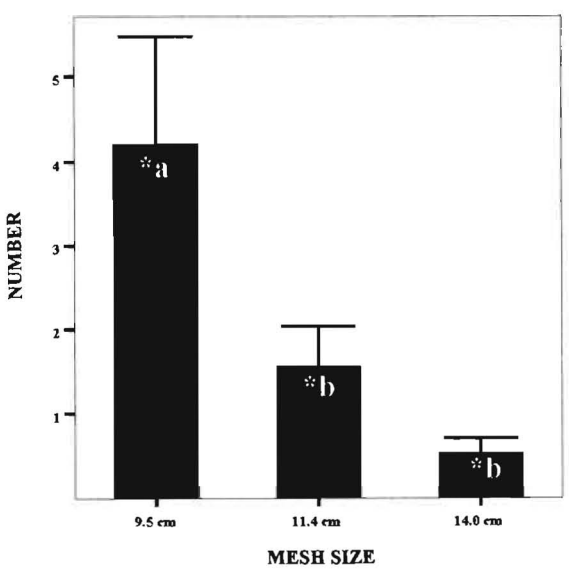


Fig. 3: Milk shark *R. acutus* mean number and confidence intervals of s for the whole sampling period for three different size panels. Mean number of 9.5cm mesh panels is staistically different from 11.4, and 14.0cm mesh panel means, this is noted by the different letters.

Discussion

Reasonable catches of Spanish mackerel were only caught in Haul 7 despite the fact that the sampling was conducted under normal fishing conditions and by an experienced fisherman. Throughout this work, boats were regularly observed fishing with illegal drift gillnets despite the ban on the use of this gear. The nil and low catches reported by this study may indicate a status of over-fishing for the Bahrain Spanish mackerel fishery. The Bahrain Spanish mackerel fishery has exhibited low catches for a relatively long period (Fisheries Statistical Section, 1998).

This study provides a preliminary list of the drift gillnet bycatch species. This is probably the first attempt to provide information on drift gillnet bycatch in the Arabian Gulf. The most important bycatch species determined by this study is the Milk Shark. This indicted the importance of the shark in managing the Spanish mackerel fishery.

Figure 2 of this study suggested an increase in Spanish mackerel first girth length with the increase in the mesh size. In general, mesh size, fish shape, fish behavoir, swimming speed and the visibility of twine are the main factors affecting selectivity (Hamley, 1975). Smaller Spanish mackerels were caught in the 9.5cm panel with an average fork length of 75.2cm. Spanish mackerel attains sexual maturity at a total length of 75cm in Indian waters (Devaraj, 1983), and 85cm total length in the Red Sea (Bouhlel, 1985). In the Saudi waters of the Arabian Gulf side, it was found that Spanish mackerel smaller than 75cm total length were

sexually immature (Kedidi *et al.* 1993). Based on the results of this study it is most likely that most Spanish mackerel caught in Bahrain waters by the 9.5cm mesh size were immature or probably a few had attained first maturity.

Spanish mackerel possesses high potential for fishery promotion by avoiding fishing smaller individuals. It attains maximum length at 220cm fork length (FAO 1983). Small Spanish mackerel were found in the Bahrain landings during December 97, January to April 98, and October 98, where their standard length modes were 52, 56, 61, 56, 65, and 48cm (Abdulqader *et al.* 2000). The author observed small Spanish mackerel (30cm) in the local market. This indicated that small mesh size gillnets were used to catch these fish. The Ministerial Decree No. 6 for the year 1986 determined the minimum allowed mesh size at 8cm.

The shark species *R. acutus* was the main component of the Spanish mackerel drift gillnet bycatch as found by this study (Fig. 3). Sharks are usually caught in gillnets in many parts of the world (Trent *et al.* 1997, Pawson and Vince 1999, Shing, 1999, Japp, 1999). A higher number and smaller sharks were mainly found in the 9.5cm panel. Mean total length in the 9.5cm panel was 61.6cm. This species attains 102cm total length (Al-Baharna, 1986). It reaches sexual maturity at 70cm for males and 82.5cm total length for females in the Guinea-Bissau waters (Kromer, 1994). In South African waters, this species reaches sexual maturity at 68cm for males and 70cm for females (Bass *et al.* 1973). This species is viviparous, the size at birth ranging between 25 and 39cm (Compagno, 1998). Based on the results of this study, it is most likely that a higher percentage of immature Milk sharks were caught by the 9.5cm mesh size. The present study demonstrates that the drift gillnet has impacted on the sharks population and may cause an over-exploitation of this resource. Sharks are relatively vulnerable to exploitation, as they are slow growing, mature late in life and produce small numbers of young compared to marine teleost (Pawson and Vince 1999).

The lowest shark catches were found in the case of the 14.0cm mesh panels, while the highest were found in the 9.5cm panels. Smaller Spanish mackerel were found in the 9.5cm and 11.4cm panel catches, while relatively bigger individuals were found in the 14.0cm catches. This suggests that managing at a minimum allowed mesh size of 14.0cm will produce better returns from the fishery, whereby larger sizes of the Spanish mackerel will be caught with minimum shark bycatch.

Spanish mackerel catches produced by the fishery are low at present, and consequently fishermen's returns from the fishery are low. This condition forces fishermen to make quick earnings from the fishery by catching smaller fish. Therefore, smaller mesh sizes are preferred by fishermen in order to make profits from the fishery. This behavior is supported by the present common access strategy followed in managing the Bahrain fisheries. Also the use of small mesh sizes is not prevented in the Bahrain waters. The present minimum mesh size is set at 8cm for Spanish mackerel fishery.

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