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RESEARCH PAPER

Drift Gillnet Selectivity for Indo-Pacific King Mackerel, *Scomberomorus guttatus*, Using Girth Measurements in the North of Persian Gulf

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Abstract

In this study, size selectivity of *Scomberomorus guttatus* sampled from commercial surface and mid-water drift gill nets off the northern part of Persian Gulf were studied using model inferring retention from girth measurements. For the net marks at five positions on fish's body, the girth at the second dorsal fin was considered as a maximum girth (ANCOVA, $P<0.05$). Fish were captured at the most efficiency when the ratio of girth at capture to mesh perimeter ranges from 1 to 1.2. In all meshes, fish enmeshed vertically between opercular and maximum section body accounted for the most frequency of catches. Optimum selection length was estimated as 33, 37, 42, 44, 50 and 59 cm FL for the nominal stretched mesh size of 70, 76, 79, 90, 101 and 114 mm respectively. For the mesh size at 76 mm, however, there was also a second mode with low level which was resulted from snagging processes, leading to inconsistency to the selectivity curve. It seems that the nets with 90 mm mesh size to be more suitable for the exploitation of *S. guttatus* taking into consideration both the catch efficiency and protection of juvenile fish.

Keywords: S. guttatus, Persian Gulf, girth measurements, drift gillnets, selectivity.

Introduction

Indo-Pacific king mackerel, *Scomberomorus guttatus*, (locally known as Ghoad), belonging to the family Scombridae and seerfish group, is a pelagic (photosynthetic), neritic species and is believed to be less migratory when compared to *S. commerson* (FishBase, 1995). This species is usually found in small schools inhabiting mostly in clean coastal waters between 15 to 200 m depths, and sometimes enters turbid estuarine waters. *S. guttatus* distributes along the shores of continental Indo-West Pacific from Wakasa Bay, Sea of Japan and Hong Kong south to the Gulf of Thailand and west to the Persian Gulf lying between the Arabian Peninsula and Iran (Collette, 2001), but it is more common on the Iranian side of the Persian Gulf (Collette, Abdulqader, Kaymaram, & Bishop, 2015). The species may live to be 16 years old (Devaraj, 1987).

The primary gear used for the *S. guttatus* in Indian Ocean is the gillnet (65.4% of the total landings), but the species is also caught with lines including hand line, hook and line and troll line (collectively 7.9%), trawls (19.3%) purse seine (2.6%), long line (0.2%) and others including danish seine, beach seine, liftnet and trap (collectively 4.6%) (IOTC Secretariat, 2015). In the gillnet, two mesh size ranges are commonly used to catch small and large seerfish in the Ocean (Siddeek, 1995). The gillnets with small-mesh nets include 6, 7, 7.6, 8.9 and 9.5 cm, while the nets of larger mesh sizes are 10, 11.4, 12, 12.7, 14, 14.6 and 15 cm. In Indian Ocean, nominal catches of *S. guttatus* are lower when compared with many of the other neritic species, fluctuating with a total catch of 6,744 t in 1950 to 46,354 t in 2013 (IOTC Secretariat, 2015). Seven countries including, in order of magnitude, India (a contribution of 34% of the total landings), Indonesia (32%), Iran (11%), Myanmar (9%), Pakistan (4%), Malaysia (3.8%) and Bangladesh (3%) have formed major contributions to the total catch of *S. guttatus* in the Ocean (IOTC Secretariat, 2015).

In Iran, *S. guttatus* was landed annually on average 4530 t from 2009 to 2014, and contributes only 1% of the total marine fish landed in southern coastal waters in the Persian Gulf and Oman Sea (IFO, 2014). Although its share is minor in quantity in comparison with the landings of other major species, but it is still considered as the valuable fish in consumption (IFO, 2014). Fiberglass boats in 7-11 m size class operated by outboard engine and wooden dhows in 15-23 m size class operated by inboard engine are employed to catch the species.

Generally, gillnets are widely used in small-scale fisheries because they need minimal investment in manpower and equipment and are efficient in catching species distributed in low densities (Hamley, 1975). Compared with other fishing gears, gillnets are highly size selective i.e. a particular mesh size retains individuals with the highest proportion and then catches decrease sharply for fish either smaller or larger than the modal size class retained. Gillnet selectivity relies on both the probability that a fish encounters the net and on the probability that the fish is caught and retained by the net (Regier, 1969; Hamley, 1975). Knowledge of gillnet selectivity is useful in fisheries management as a proper mesh size aids in obtaining the maximum yield and also protecting small fish to allow them to spawn at least once before the initial entry of the fish into the fishery operations (Millar & Fryer, 1999).

Gillnet selectivity may be estimated either directly or indirectly. The direct estimation of gillnet selectivity compares the length distributions of gillnet catches of a known population. Due to the difficulty of direct method, almost all estimates have been done "indirectly" by examining the size distribution of gillnets catches of specified mesh sizes or from maximum measurements (Kawamura, 1972; Reis & Pawsot, 1992; Bartoo & Holts, 1993; Millar & Holst, 1997; Millar & Fryer, 1999; Lucena, O'Brien, & Reis, 2000; Hovgård & Lassen, 2000; Fujimori & Tokai, 2001; Özekinci, 2005). To our best knowledge, in spite of the commercial importance and wide distribution of *S. guttatus* within the Indian Ocean, information on gillnet selectivity is rare (Sreekrishna, Sitarama Rao, Percy Dawson, Joseph Mathai, & Sulochanan, 1972). The authors calculated a suitable mesh of 52 mm mesh bar (104 mm stretched mesh size) for sustainable exploitation of *S. guttatus* in Indian waters.

In Iran, *S. guttatus*, like other neritic tuna species, is the economically-important commercial fish species and have been exploiting with an open access fishery without any input or output control. Hence, for sustainable exploitation of the resources the use of optimum mesh size of gillnets is needed, aimed at protecting immature fish and thus let them to spawn at least once. Also, no study has so far been undertaken on the selectivity of gillnets for the species in the area. Investigations were, therefore, initiated to demonstrate how the size selectivity of *S. guttatus* may be predicted from a theoretical model proposed by Sechin (1969a, b) using length-girth measurements and to suggest a suitable mesh size of the commercial gillnet used currently for the exploitation of the species under study.

Materials and Methods

Length-girth measurements of *S. guttatus* were taken from commercial surface and mid-water drift gill nets fisheries in the northern part of Persian Gulf of Iranian coastal waters during the period of January 2014 to July 2015 (Figure 1). Overall, 491 specimens of Indo-Pacific king mackerel were randomly selected from the vessels' landings for which fork length was recorded to the nearest 0.5 cm and girth data were measured to the nearest 1 mm with a loop of non-stretchable synthetic twine which was then extended on a measuring board. Girth measurements were recorded across the vertical at five positions of

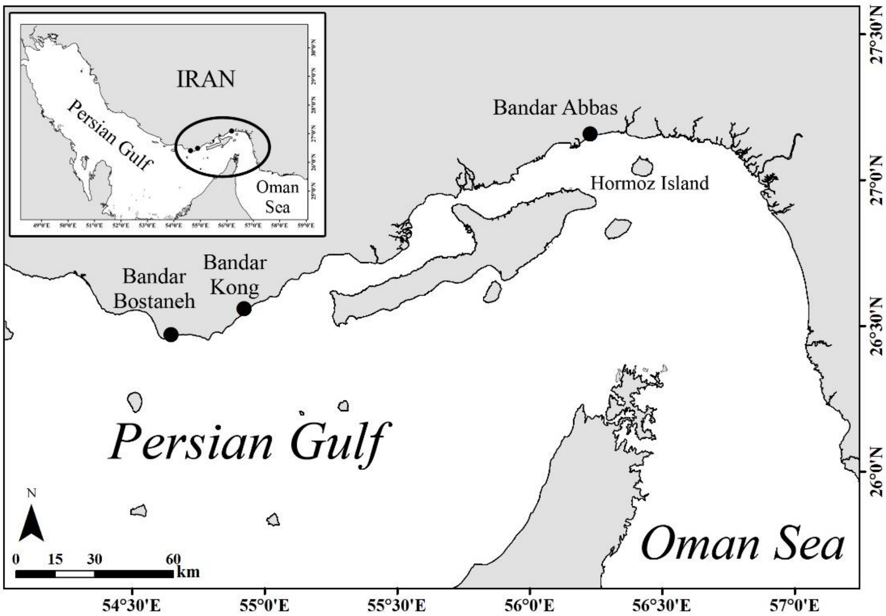

Figure 1. Maps indicating the study area. Closed circle with black dots denotes the landing sites for sampling.

enmeshment on the fish's body: Orbital (Orb), Pre-opercular (Preop), Opercular or head (Op), First dorsal fin (D_1) and Second dorsal fin (D_2) (Figure 2). Given that, fish wedged at the right angle between first dorsal fin and second dorsal fin (BD) these points were also recorded for the purposes of capture processes analysis.

During the sampling, the inside mesh sizes in opposite knots were measured in the dry state for the mean of 20 randomly selected meshes by inserting a steel ruler using light hand force to stretch the mesh. These measured mesh sizes were used as input data for the selectivity analysis. The samples of *S. guttatus* were taken by the drift gillnets with different ranges of mesh sizes: small-mesh nets with nominal stretched sizes of 70 mm (2 $^3/_4$"), 76 mm (3"), 79 mm (3 $^1/_8$"), 90 mm (3 $^1/_2$") and large-mesh nest with sizes of 101 mm (4") and 114 mm (4 $^1/_2$") (Table 1). The nets were constructed from monofilament and multifilament netting materials depending on mesh size, with twines of white color and different numbers or thicknesses. The difference between measured mesh sizes and nominal mesh sizes from manufacturer were between 1 to 4 mm.

The gillnets consist of 10 to 50 panels, depending on the vessel type; each ranged between 86-95 m in length and 7-23 m in depth, rigged with hanging ratios of 0.52. The general configuration of the two kinds of drift gillnets, namely surface and mid-water methods, used for the *S. guttatus* fisheries is shown in Figure 3. The small-meshed nets are only used in the surface drift gillnets, while the large-meshed nets are used for both the surface and mid-water methods depending the occurrence of fish schools by water depth and season. The small-meshed nest are specifically used by the commercial fishermen for the seerfish (namely *S.guttatus* and *S.commerson*), and the nets of large-meshed sizes are used for the seerfish coupled with neritic tuna. The different meshes of the nets are arranged in random order at each setting during the fishing seasons. The nets are hauled in waters for a period of 12-15 h (from dusk to dawn).

In gillnets, retention occurs when a fish swims into a mesh beyond its gill covers, but does not pass completely through (Hamley, 1975). Based on this, model inferring retention from girth measurements was theoretically proposed by Sechin (1969a, b) for estimation of the selectivity curves of gillnets to account for opercular (beyond its gill-cover) and maximum girth independent of the size distribution data. This model is only applied when the gilling and wedging are the main ways of capture, and also is based on two assumptions: (a) all fish are fully selected whose maximum girth is greater, but head (opercular) girth is smaller than the mesh perimeter and (b) girths among any one length class of fish are distributed normally. In this paper, we used the refined version of the model by adding the coefficients to account for twine elasticity, compressibility at retention girth and variation in mesh size. The probability of retention of a fish

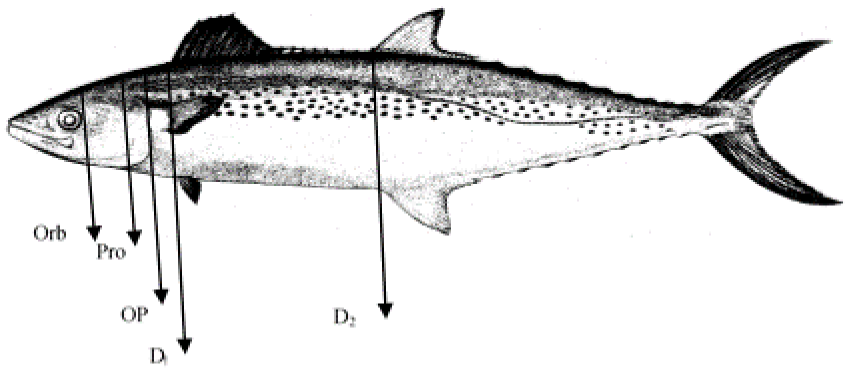

Figure 2. Body profiles of *S. guttatus* with some girth positions at capture along the fish's body are indicated by lines (Orb, Orbital; Preop, Pre-opercular; Op, Opercular; D_1, First dorsal fin; D_2, Second dorsal fin).

Table 1. Dimensions of sampled drift gillnets during the study. Mesh sizes are given in mm and inch (″)

Mesh size in mm (inch)					
Nominal mesh size	Measured mesh size	Netting material	Twine No. (Dia. or 210D/Ply)	Depth (No. meshes)	Stretched length (Yards)
70 (2 ¾″)	73 (2.86″)	Monofilament	0.4	120	180-200
76 (3″)	77 (3.1″)	Multifilament	9	140	" "
79 (3 1/8″)	83 (3.28″)	" "	9	140	" "
90 (3 1/2″)	92 (3.62″)	" "	9,12	200	" "
101 (4″)	104 (4.1″)	" "	18	240	" "
114 (4 ½″)	117 (4.6″)	" "	24	200	" "

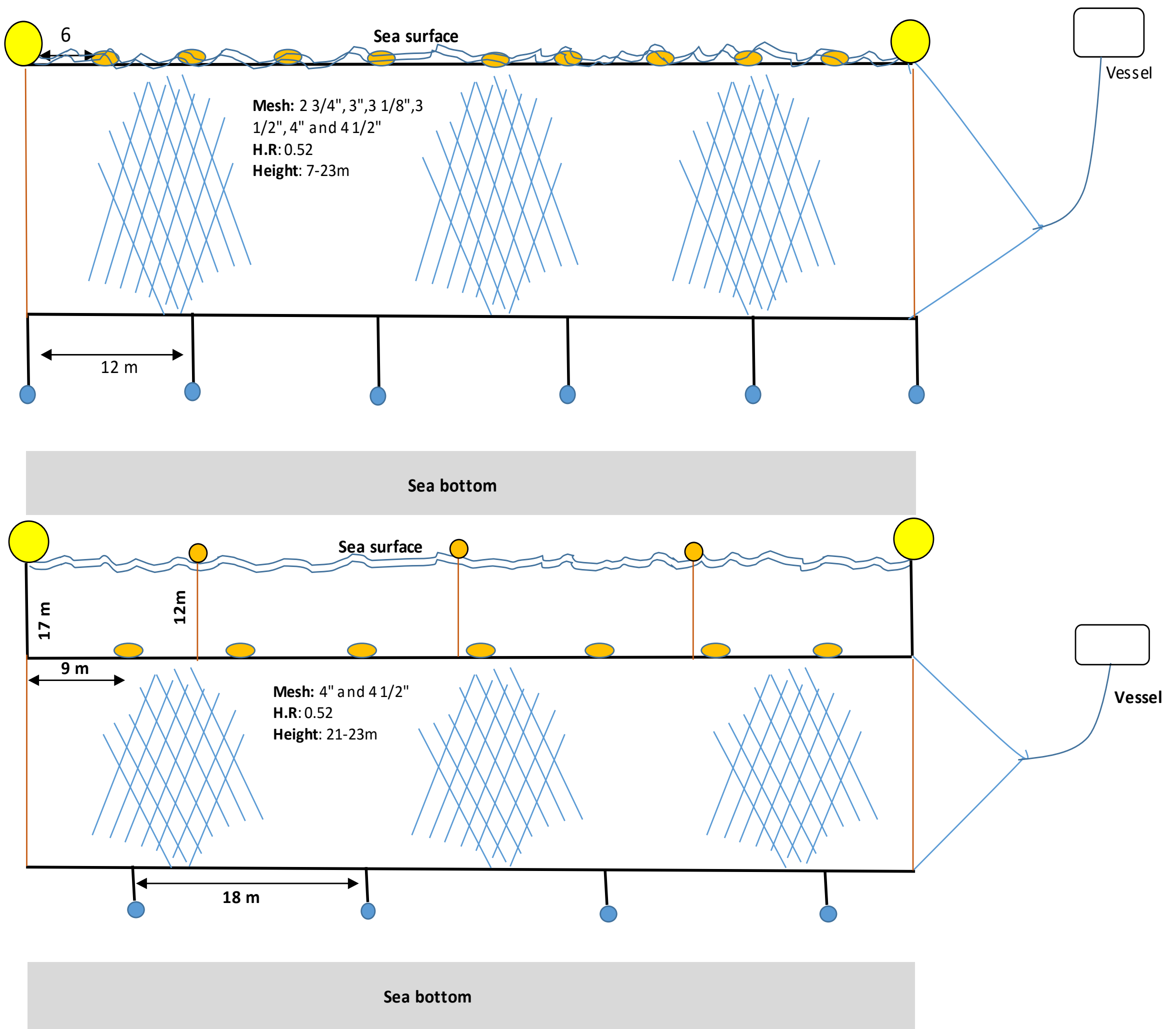

Figure 3. General configuration of the typical surface (above) and mid-water drift gillnets (down) arrangement for fishing *S. guttatus* in the Persian Gulf. The mesh sizes in inch (Mesh), hanging ratios (H.R) and the height are given for each net.

whose head is small enough to enter the mesh, but a maximum girth large enough to prevent it from passing through is given by:

$$S_j = \Phi\left(\frac{(2M - K_g G_g)}{\sqrt{\sigma_{gj}^2 + \sigma_m^2}}\right) * \left[1 - \Phi\left(\frac{(2M - K_{max} G_{maxj})}{\sqrt{\sigma_{maxj}^2 + \sigma_m^2}}\right)\right]$$

where S_j is the probability of retention of fish of size-class j, ϕ is the cumulative function of standard normal distribution, G_{gj} is the mean opercular girth for fish of size-class j, K_g is the measured girth/mesh perimeter at meshing mark in gill position, σ_{gj} is the standard deviation of opercular girth of size-class j, σ_m is the standard of mesh perimeter, G_{maxj} is the mean maximum girth for fish of size-class j, K_{max} is the measured girth/mesh perimeter ratio at meshing mark in maximum position, σ_{maxj} is the standard deviation of maximum girth of size-class j, 2M is the mesh perimeter.

The maximum efficiency of the selection curve was assumed to be 1 for all mesh sizes. A constant coefficient of variation was assumed for both maximum and opercular girths for each fish girth by plotting the estimated standard deviation derived from constant coefficient of variation on mean girth per length class (Pet, Pet-Soedea, & van Densena, 1995), which were used as input in the Sechin model. To find out the effect of point or points on fish body at which the fish are caught, the maximum girth-mesh perimeter (G_{max}: P) ratio and the girth at captured position (marked by mesh around the fish body)/mesh perimeter (G_c: P) ratio were plotted against the relative frequency of the fish captured as proposed by McCombie and Berst (1969). The selection range of each mesh size was considered for the size class in which the fish being caught with a 5% probability ($p \geq 5\%$). Also, tangling percentages at different points on fish body were performed per mesh size.

The slopes of length–girth relationships at different girth measurements were statistically compared using analysis of covariance (ANCOVA) (Zar, 1999), and significant F ratios detected in the

ANCOVA were investigated using Student-Newman-Keuls (SNK) multiple comparisons at a significance level of *P=0.05. In cases where* length–girth relationships *have not significant differences* for *slopes*, the corresponding data for positions of enmeshing can be aggregated in the analysis.

Results

The Opercular girth and maximum girth were obtained by pooling the data from all mesh sizes. Both girth measurements were linearly increased by fork length (Figure 4). The girth-length relationships indicated that maximum girth increased faster with length than did opercular girth. The parameters derived from the equations are given in Table 2. One-way ANCOVA revealed that the slopes of the general girth–FL relationships differed significantly (Table 3; F = 371.813, p = 0.000). For equal FL, the girth values decreased in order $D_2 > D_1 >$ OP > Preop > Orb (Table 4; SNK: $P<0.05$). The assumption of a constant coefficient of variation in girth showed an increased trend by straight line approximately through the origin (Figure 5). Coefficients of variation for opercular and maximum girths show values between 2.62 and 3.74% respectively.

For the mesh sizes of 70, 76, 79 and 90 mm, fish caught by second dorsal fin contributed to predominant modes of the catch curves, representing respectively 66, 36.8, 34.1, 33.3% of the all fish captured (Figure 6). At 76 mm net, the second mode in the catch curve is due to fish captured at pre-opercular position. The fish captured at the orbital girth were only found in the mesh sizes of 76 and 79 mm, with a minority proportion of 5 and 1% in the respective mesh size. These both capture processes tended to be the largest of the length range, without considering mesh size.

For the mesh sizes of 101 and 114 mm, fish were only captured at first and second dorsal fin positions, irrespective of the mesh size. To better understand the capture processes by mesh size, the fish caught were grouped in three modes, namely snagged (collectively fish captured at orbital and pre-opercular girths), gilled (fish enmeshed at opercular girth) and wedged (specimens enmeshed due to the first dorsal fin girth, second dorsal fin girth, and somewhere between them (BD). Based on this, wedging in mesh was the most common position of captures in all meshes (Table 5). Fish caught by BD were also observed almost in all mesh sizes (except mesh of 114 mm), comprising 15% of the total catches on average. Moreover, for the fish captured at the second dorsal fin, some specimens (15% of the catches) were wedged diagonally at the position.

The overall modal values for G_{max}/P ratio were found to be 1.2 and 1.5, which were resulted from fish caught by second dorsal fin (maximum girth) and

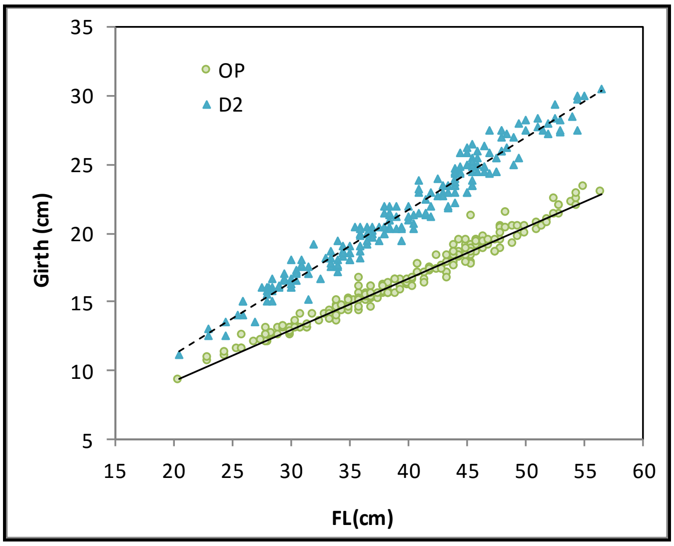

Figure 4. Relationships between fork length (FL) and Opercular girth (OP) and maximum girth (in front of the second dorsal fin, D_2) for *S. guttatus.*

Table 2. Regression coefficients for length-girth relationships for *S. guttatus*

Girth	Equation	r^2
Opercular	Girth (cm) = 1.714 + 0.373 x FL (cm)	0.97
Maximum girth (D_2)*	Girth (cm) = 0.705 + 0.524 x FL (cm)	0.96

*D_2: Girth in front of second dorsal fin.

Table 3. Analysis of covariance (ANCOVA) between the regressions of Orbital girth (Orb); pre-opercular girth (Preop); Opercular girth (Op); girth in front of first dorsal fin (D_1); girth in front of second dorsal fin (D_2) and fork length (FL) (P.0.05) for *S. guttatus*

Source of Variation	df	SS	F	*Significance F*
Orbital	207	41		
pre-opercular	216	47		
Opercular	216	56		
First dorsal fin	216	98	371.81	0.000
Second dorsal fin	216	144		

Table 4. Student-Newman-Keuls (SNK) slope separation test between girth at different positions (treatments) and fork length (FL) for *S. guttatus*, where different lowercase letters indicate unequal slopes in the order a > b > c > d > e (P<0.05)

SNK grouping*	Slope	Treatment
a	0.524	Second dorsal fin
b	0.430	First dorsal fin
c	0.373	Opercular
d	0.338	pre-opercular
e	0.249	Orbital

*All slopes that are grouped by different letters are significantly different from each other.

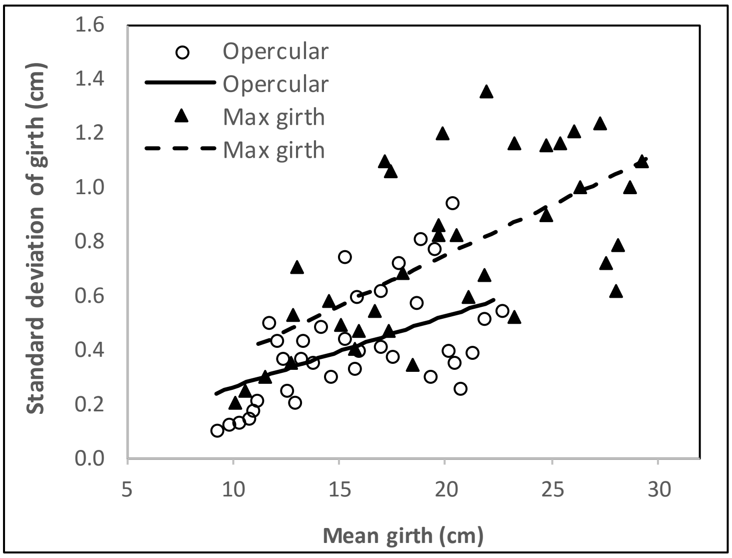

Figure 5. Plots of recorded and estimated standard deviation on mean girth per length class for maximum and opercular girth for *S. guttatus*. Dots indicate the measured standard deviation based on constant coefficients of variation in body girth, while the lines indicate the estimated one.

opercular girth respectively (Figure 7, up). There are a considerable number of values of G_{max}/P greater than 1.2 (68.0 %) and no fish was recorded for G_{max}/P less than 1.0. The frequency distributions of Gc/P ratio, the girth of fish where actually caught, had a mode at 1.15 (Figure 7, down). The lower modal value of Gc/P was 1.0 for captures from orbital and the higher was 1.2 for the fish caught by second dorsal fin. The average girth where fish were caught is 162, 175, 194, 212, 240 and 278 mm with mesh perimeters of 146, 154, 166, 184, 208 and 234 mm for the corresponding stretched mesh sizes.

The sampled length of *S. guttatus* was ranged from 30 to 56.5 cm, irrespective of mesh size (Figure 8). As expected, there was an increase in the length distribution of fish captured as mesh size increased. The k-factor (as a correction factor) combining fish body compressibility and mesh elasticity are estimated to be larger for opercular girth than maximum girth for all mesh sizes (Table 6). These parameters were used to estimate the probability of retention predicted for each mesh size by the selection model.

Both the optimal selection length (length at which catch probability is higher) and the selection range increases with an increase in mesh size (Figure

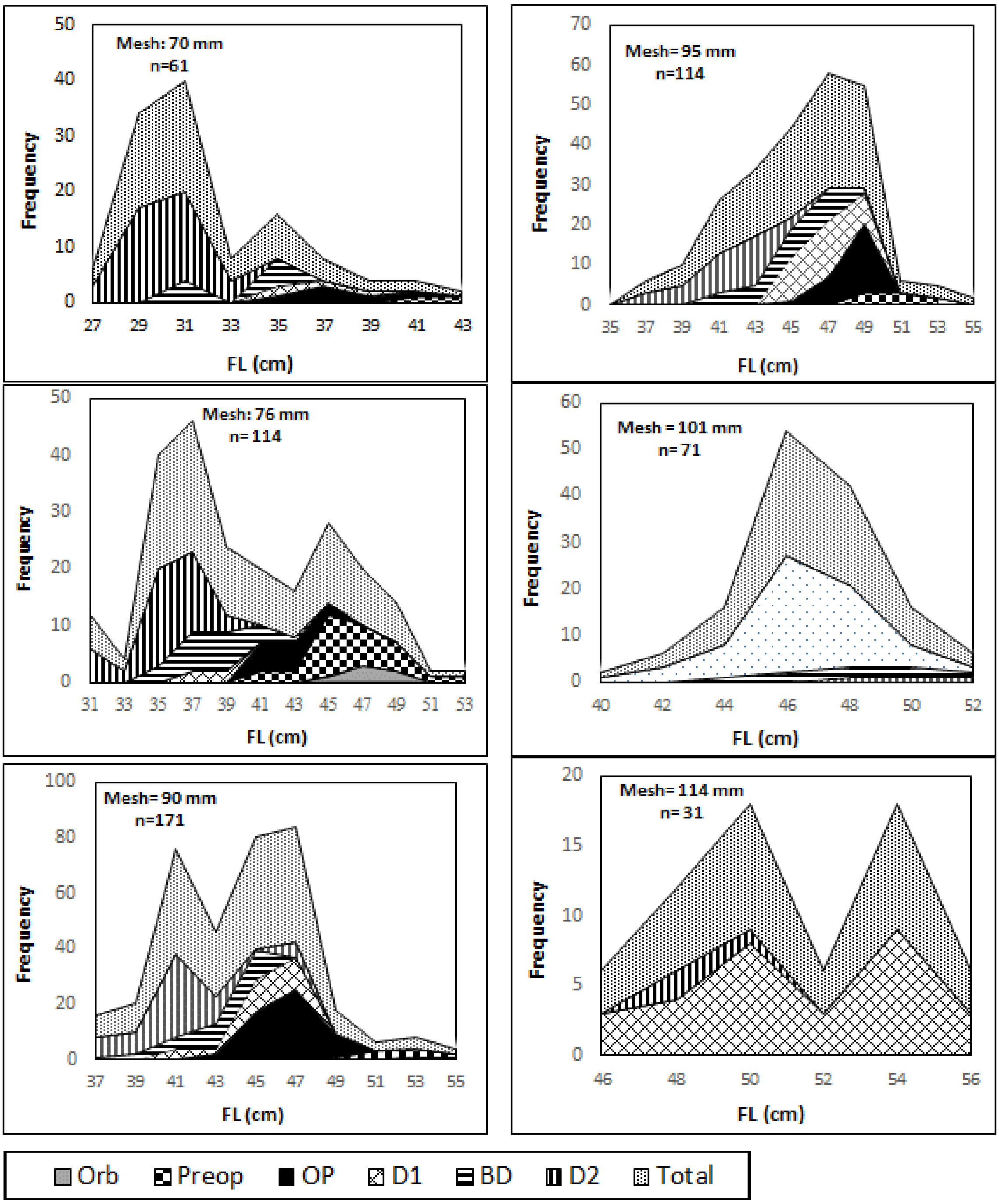

Figure 6. Length distributions by position of capture (Orb, Orbital; Preop, Pre-opercular; Op, Opercular; D_1, First dorsal fin; BD, between D_1 and D_2; D_2, Second dorsal fin) in different mesh sizes. N, is the number of specimen sampled, and Mesh is the mesh size.

8). The optimal selection length estimated by the model were 33, 37, 42, 44, 50 and 59 cm FL for the 70, 76, 79, 90, 101 and 114 mm mesh sizes ,respectively, with a selection range of 28-39 cm, 30-34 cm, 35-49 cm, 36-51cm, 41-51cm and 48-69 cm FL for the corresponding mesh size. But, there was a different pattern of consistency between the length frequency distributions and the selectivity curves by mesh size. The length frequency distributions of mesh sizes at 70 and 79, and 90 mm produced uni-modal histograms, and the theoretical selection curves were reasonably consistent with their size distributions. For the mesh size of 76 mm, the length frequency data produced histograms with a low definition of the second mode which resulted in inconsistency with selectivity curve. At both meshes of 101 and 114 mm, there was a shift of length frequencies to left side of the selectivity curves.

We could not access CPUE (Catch Per Unit Effort) data for *S. guttatus* by mesh size, but the

Table 5. Capture processes in percentage for *S. guttatus* sampled from different mesh sizes.

Mesh size (mm)	Snagged	Gilled	Wedged
70	3	8	87
76	31	11	59
79	6	29	65
90	8	26	66
101	-	-	100
114	-	-	100

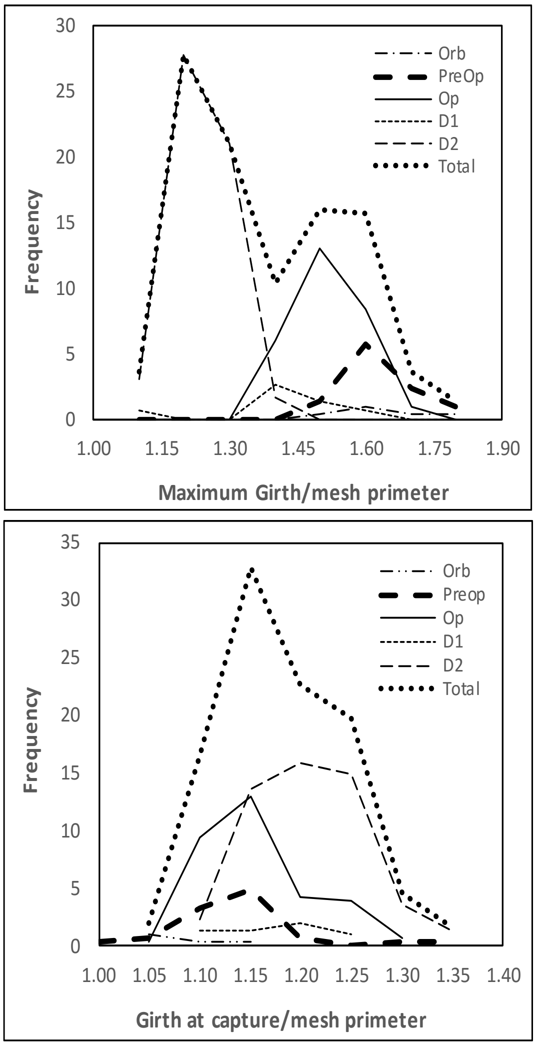

Figure 7. Frequency distributions of maximum girth/mesh perimeter (up) and girth at capture/mesh perimeter (down) for fish enmeshed at different body positions.

overall CPUE (kg/fishing day) from August 2014 to May 2015 in mesh size range indicated that the CPUE in weight (W) for small-meshed nets (including 76, 79, 90) was 12.4 kg/fishing day, whereas 4.9 kg/fishing day for the large mesh sizes of 101 and 114 mm.

Discussion

The data analyzed in this study indicated that most of *S. guttatus* were caught by enmeshing through the opercular (OP) and maximum girth (D_2), and in a mesh size at 76 mm, by contrast with other meshes, a considerable number of fish (31%) were caught by snagging (collectively from the orbital and pre-opercula girths). Fish caught by snagging are expected to be entangled at last. That is, these fish initially penetrate a mesh beyond the orbital or pre-opercula girths, and then rolled around inside the net and thus became entangled. For all meshes studied,

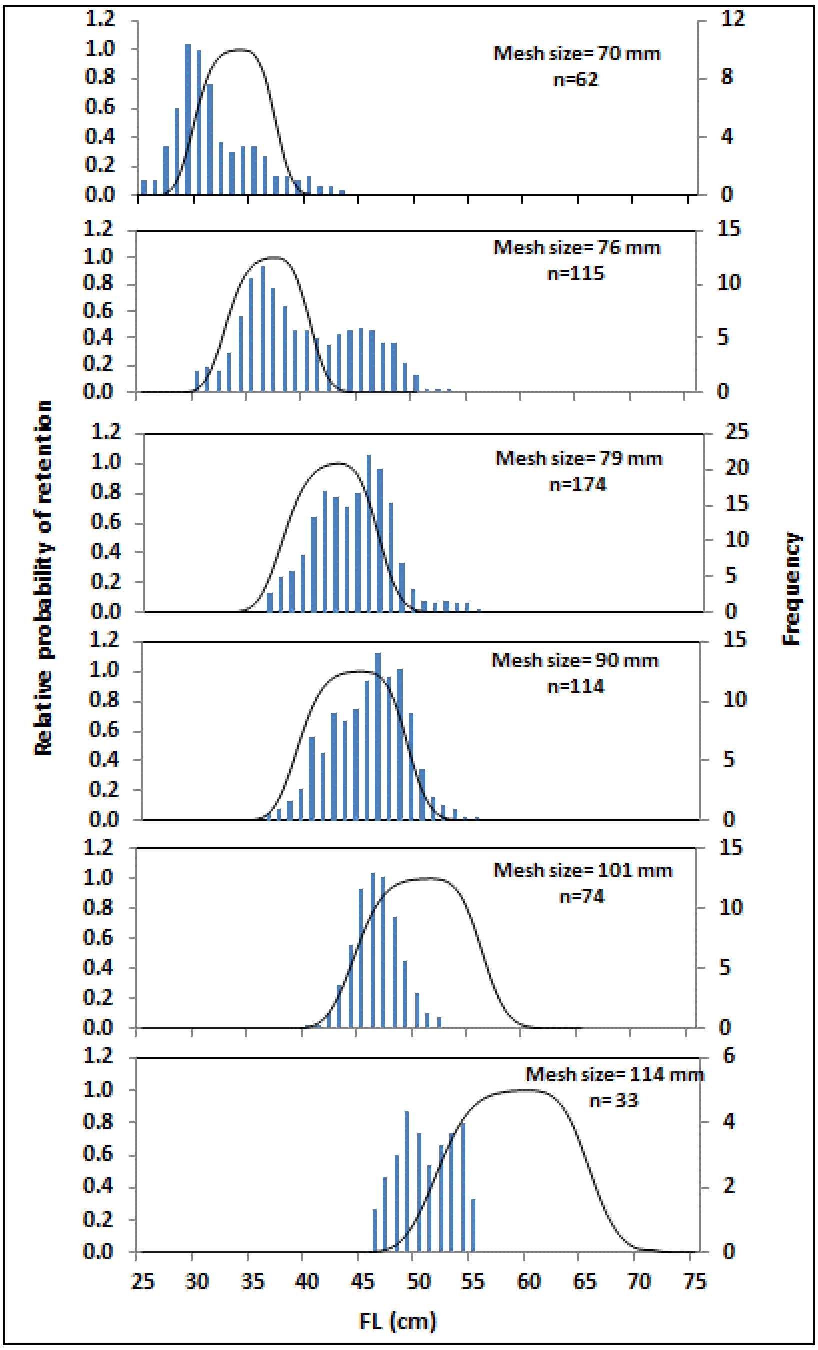

Figure 8. Selectivity curves (lines) of *S. guttatus* in drift gillnets by mesh size compared with size frequency distributions (bars). n, showing the number of specimen sampled.

smaller fish were often caught at the maximum girth position due to passing through the meshes, and contrary to these fish, the larger fish caught near the head. The statistical difference between the various girth measurements means that captures at these enmeshing positions are impossible be aggregated and be considered separately.

According to our findings, the captures by gillnets is most efficient when the girth of the fish at the capture position slightly exceeds the mesh perimeter, i.e. Gc/P ranging from 1 to 1.1, regardless of the site of enmeshing on fish body, but very few fish were captured when the ratio was as high as 1.35. McCombie and Berets (1969) and Lucena *et al.* (2000) also concluded in their study that most of fish were caught when the Gc/P was ranged between 1 and 1.1. Concerning the maximum girth/mesh perimeter (G_{max}/P), the modal value shitted to 1.2 and there was a number of values of the ratio G_{max}/P greater than or equal to 1.5 (37%). Also, the G_{max}/P ratio was greater for the pre-opercular (Preop) than for opercular (Op). No fish was caught when the ratio G_{max}/P was less than 1.0, because when maximum girth is smaller than the mesh perimeter, the fish can probably swim

Table 6. Selectivity parameters of *S. guttatus* estimated for each mesh size

Mesh size (mm)	$L_{opt.}$	SR	$K_{op.}$	$K_{max.}$
70	33	28-39	0.936	0.897
76	37*	30-43	0.923	0.867
79	42	35-49	0.884	0.824
90	44	36-51	0.925	0.876
101	50	41-51	0.921	0.868
114	59	48-69	0.890	0.840

* First mode
SR: Selection range
$L_{opt.}$: Optimum length

through the net with a little struggling unless they are caught by mouth or teeth or appendages on the body (Reis & Pawson, 1999).

The model used here gives rational results of the gillnet selectivity, as it incorporated both the effects of mesh elasticity and body compressibility at retention girth (Regier, 1969). This study also revealed that nets used for catching *S. guttatus* in Iranian coastal waters has the elasticity and its relationship with the fish body compressibility gives bigger fish more opportunity to be caught in a smaller fishing nets that were designed to catch smaller individuals. The compressibility of the tissue was larger at the position of the maximum girth (due to the soft tissue of the body cavity) compared to the opercular region which was in conformity with the previous findings (Lucena *et al.,* 2000; Reis & Pawson, 1999).

In this paper, an increase of optimum selection length with mesh size is due to the intra-specific selectivity characteristic of gillnets, as indicated by other authors (Regier, 1969; Neves Santos, Costa Monteiro, & Erzini, 1995; Sbrana, Belcari, De-Ranieri, Sartor, & Viva, 2007). Also, the selection range increased by mesh size, which is reflected from the fact that maximum girth increased rapidly with length when compared with opercular girth, and as a consequence the cumulative functions of normal distribution $G_{gj} \leq p$ (mesh perimeter) and $G_{maxj} \geq P$ moved farther apart in location as mesh size increased. Our observation of difference in selection range by mesh size is inconsistent with the fundamental assumptions adopted for other indirect methods that the selection curves are of the same shape for all mesh sizes, but are quite similar to that observed by Ehrhardt & Die (1988) for *S. maculatus* off southern Florida waters.

Our results indicated that the length frequency distributions of mesh sizes of gillnet at 70, 79 and 90 mm are overlapped by the selectivity curves when the fish were mostly caught through wedging, and thus the length distributions are unimodal. On the contrary, in situation when the entanglement (or snagging) effect is highly significant in the catches, the length frequency distribution is partially corresponded by the selectivity. This was evident by the fish caught at 76 mm mesh size. In this case, it is needed to use compound curve (bi-modal function) to adjust the selectivity curve to the length frequency distribution to account for both enmeshed and entangled individuals (Millar & Fryer, 1999).

All these results support the provisions considered for the Sechin (1969a, b) model that gillnet selectivity inferring retention from girth measurements is applied in situations where fish being gilled or wedged are the main way in which the fish are captured in gillnets. Typically, fusiform, smooth-headed fish could be primarily responsible for these kind of capture processes as was also found in the present study for Indo-Pacific king mackerel. For larger mesh sizes, i.e. meshes of 101 and 114 mm, we did not observe fish larger than 56.5 cm which corresponds to the maximum size recorded herein, consequently the observed length frequencies of these large-meshed gillnets are shifted to the left in respect to the selectivity curves. These fish all captured either by first dorsal fin or second dorsal fin girths. If larger specimen of *S.guttatus* than 56.5 cm had encountered these larger mesh sizes they would more probably have been caught by other capture processes such as gilling. Such findings with selectivity curves of large mesh sizes were also reported for Atlantic herring, *Clupea harengus*, by Clarke and King (1986) and for Spanish mackerel, *Scomberomorus maculatus*, by Ehrhardt and Die (1988). Our report of maximum size of *S. guttatus* is comparable with samples taken by gillnets from different areas by various authors; Muthiah *et al*. (2002) and Ghosh, Pillai, & Dhokia, (2009) reported a maximum size of 58 and 62 cm FL, respectively, for *S. guttatus* from the samples of mesh seizes of 85-115 mm in Indian waters. Ahmed, Bilgin, and Bat (2016) also found a maximum length of 55.8 cm TL for Indo-Pacific king mackerel in Pakistan waters in Arabian Sea taken from mesh sizes ranging between 13 cm to 17 cm (average 15 cm).

To date, a minimum landing size has not been enforced for Indo-Pacific king mackerel in the fishing circular in Iran. Also, no estimate of length at first maturity, Lm50%, was given for the species due to the lack of study on reproductive biology. However, if we base 42.0 cm FL, which was reported for *S. guttatus* in Indian waters (IOTC Secretariat, 2016), as the length at first maturity in our area we can observe that only the optimal catch size computed for the mesh sizes of 90, 101 and 114 mm (44, 50 and 59 FL cm, respectively) are larger than Lm50% reported for the species. In the mesh size of 90 mm, the specimens below Lm50% (undersized fish) were caught at 15% of the catches, but obtained as 1% in the mesh of 101 mm, and virtually disappeared in the catches made with114 mm, Although the juvenile fish are minimal in the 101 mm mesh, but based on CUPE in weight recorded herein, the small- meshed nest are more efficient (2.5 times in weight) in catching *S. guttatus*, compared with the large ones (101 and 114 mm) and consequently, mesh sizes of 90 mm is expected to be more beneficial to the local fishermen.

In our area, the nets with small mesh sizes of 70, 76 and 79 mm are the specific gillnets targeted concurrently for catches of *S. guttatus* and *S. commerson.* In these nets, the two respective species constitute an average of 11 and 37% of the total catches of these mesh sizes, with the rest catches being kept on board as bycatch for consumption (unpublished data). It is noted that using the suitable mesh size proposed here for *S.guttatus* does not conflict with banning all small mesh sizes on *S. commerson*, as two species are mainly fished in different areas (unpublished data). Also, mesh sizes of 101 and 114 mm are the targeted gillnets for neritic tuna and Indo-Pacific king mackerel is caught (an average of less than 1.5% of the total catches) mixed by the same gillnets, given their overlapping distributions (unpublished data). By above consideration, the nets of 90 mm is expected be suitable for *S. guttatus* compared to the other nest currently used by the commercial fleet in a best compromise between the catch efficiency and protection of juvenile fish. Our suggestion of suitable mesh size is different from that of Sreekrishna *et al*. (1972) who estimated 104 mm stretched mesh size as an appropriate mesh size for the exploitation of *S. guttatus* in East and West coasts of India, which may be due to the different method implemented in the calculation. The authors applied Baranov's empirical formula (l9l4) and also considered fish with 52.5 cm total length as a modal length for the calculation, expecting that fish at this length have spawned at least once.

In conclusion, the results of the paper indicated that girth at the point of capture are somewhat greater than the mesh perimeter for the fish to be captured, and thus, fish retention by gillnets is primarily related to girth rather than to length as the variance of the length distributions of fish from a given mesh size would be larger than the girth distribution (Kawamura, 1972; Petrakis & Stergiou, 1995; Neves Santos *et al.*, 1995), and that relevant data to positions at which fish are caught clarifies the features of the selectivity of gillnets derived from length-based retention curves. This study is the first in which selectivity along with length frequency distributions of *S. guttatus* were observed for the gillnet fishery in the Iranian coastal waters. From a management point of view, the gillnets with a mesh size of 90 mm size appear to be the sutaible nets in order to attain high attainable catches and reasonable probability of allowing undersized fish to escape through meshes of gillnets.

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