

# Selectivity of tigertooth croaker (*Otolithes ruber*) gillnet in fishing grounds of Oman Sea, Iran

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## Abstract

Tigertooth croaker (*Otolithes ruber*) fishing has increased recently in southern Iran due to its economic value. In the present study, *O. ruber* gillnets with opening mesh sizes of 73, 85 and 90 mm were used to assess the selectivity of the nets. For this purpose, three panels each of commercial nets having mesh sizes of 73, 85 and 90 mm, were connected which formed an experimental net for sampling from January to May 2020. A total of 619 specimens of *O. ruber* were caught and the selectivity curves were plotted using the Sechin method. Results showed that the mean total lengths of *O. ruber* caught with mesh sizes of 73, 85 and 90 cm were,  $26.89 \pm 4.00$ ;  $35.33 \pm 3.43$  and  $37.05 \pm 3.32$  cm, respectively. Considering the length at sexual maturity of 40 cm, it seems that gillnet with mesh size of 90 cm is the most suitable fishing net for catching the species.

## Introduction

*Otolithes ruber* (Bloch and Schneider, 1801) is one of the shore migratory fish and belongs to the Sciaenidae family (Escalle *et al.*, 2015). It is distributed in the Persian Gulf, Oman Sea, Western Indian Ocean, and South-east Asia (Froese and Pauly, 2013). The fish is caught by several fishing gears, including gillnet, trawls and pots (Beckley and Fennessy, 1996; Capietto *et al.*, 2014; Sepahi *et al.*, 2018).

One of the important issues in fisheries management is selectivity of fishing gear (Borgstrom, 1992; Sepahi *et al.*, 2019). Selectivity of gillnet is usually estimated using gillnets of different mesh sizes (a minimum of three), to catch the target species (Madsen, 2007). Hosseini (2016), studied the selectivity of gillnets of several fish species in the southern coasts of Iran, by the Sechin method and the results showed that most of the gillnets have low selectivity. Haghghatjou *et al.* (2018) studied the selectivity of Crimson

snapper (*Lutjanus johni*) gillnets by length-girth relationships in the coastal waters of Bandar Abbas and got similar results in their studies. Sadough Niri *et al.* (2020) evaluated the selectivity of *Thunnus tonggol* gillnets by the Sechin method in the Gulf of Oman and found that the optimal fishing length for the mesh sizes of 100, 110, 130 and 165 mm were 35, 38, 46 and 57 cm, respectively. Also, their study showed the gillnets used in the region are not standard. Pouladi *et al.* (2021) studied the gillnet selectivity of *Scomberomorus commerson* based on the SELECT method in the Persian Gulf and the results showed Log-Normal curve with the lowest standard deviation (66.94) as the most appropriate selectivity curve. Also, the optimal lengths for stretched mesh sizes of 130, 140 and 150 mm were measured as 74.5, 80.5 and 86 cm, respectively. Despite the importance of tigertooth croaker (*O. ruber*) in the south of Iran, so far no study has been carried out on its gillnet selectivity and the present study was undertaken to address this research priority.



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## Material and methods

The research was carried out in Pozm and Konarak fishing grounds, off Chabahar City, Iran from January to May 2020 (Fig. 1). Three types of gillnets with opening mesh sizes of 73, 85 and 90 mm are used by fishermen in the area to catch the species. All the gillnets have similar characteristics viz, length 182.88 m, depth 7.74 m and monofilament (PA) body with twine of 210D/18 for each panels. Twelve to fifteen panels are connected to each

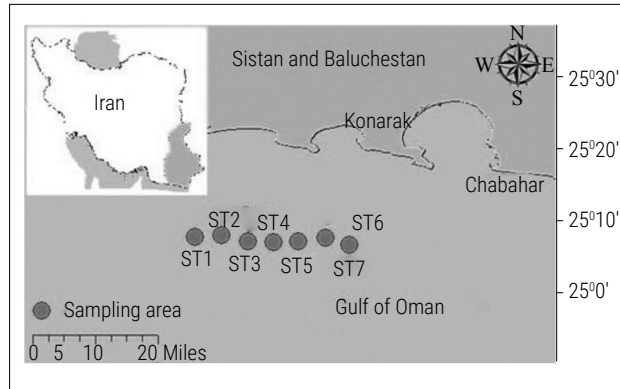


Fig. 1. Sampling area. ST = Station

Table 1. Characteristics of the commercial drift gillnet used by fishermen in the region

| Net details                       |                 |
|-----------------------------------|-----------------|
| Mesh size (mm)                    | 73, 85, 90      |
| Type of yarn                      | Single strand   |
| Thread number                     | 210d/18         |
| Hanging ratio: Horizontal net     | % 50            |
| Hanging ratio: Vertical net       | % 83            |
| Yarn type                         | Monofilament PA |
| Thread colour                     | Green           |
| Net hanging height                | 7/74 m          |
| Length of each arch (yards)       | 182/88 m        |
| Type of buoyancy                  | EVA             |
| Form of buoyancy                  | Oval            |
| No. of floats                     | 20              |
| Buoyancy distance                 | 7 m             |
| Weight type                       | Cement mold     |
| Weight shape                      | Circular        |
| Number of weights                 | 25              |
| Distance between the weights      | 5 m             |
| Float line and lead line diameter | 10 mm           |
| Type of float line and lead line  | PE              |
| Fishing type                      | Bottom gillnet  |
| Type of mesh                      | Knotted         |

other with a hanging ratio of 0.5 to form commercial gillnets in the region (Table 1).

The nets were set with an anchor and buoy attached to each end. Fishing operation comprised setting the drift gillnets from 06:00 to 07:00 hrs and hauling them after 5 h (at 11:00 to 12:00 hrs). The experimental net used for the present study had three panels of commercial gillnets with mesh sizes of 73, 85 and 90 mm, which were connected to each other (Fig. 2).

The experimental net was used in the same area for the same time duration as commercial gillnets. Data were collected 4 times per month, from January to May 2020. Six hundred and nineteen samples of *O. ruber* were caught and parameters related to the length and girth such as total length (TL), gill girth (OP), and anterior part of the first dorsal fin (D1) were measured.

Sechin model was used to determine the selectivity curves (Sechin, 1969; Booth and Potts, 2006). The length frequency of small fish that can cross the net was calculated using the equation:

$$P(G_{opj} \leq 2m) = \Phi[(2m - G_{opj}) / \sigma_{opj}^{-1}]$$

The length frequency of larger fish trapped through the trunk was calculated using the equation:

$$P(2m \leq G_{maxj}) = 1 - \Phi[(2m - G_{maxj}) / \sigma_{maxj}^{-1}]$$

The length selectivity curve or the probability of catching fish of a certain length in the gillnet mesh size was obtained using the equation:

$$\text{Selection } (S_j) = \Phi[(2m - G_{opj}) / \sigma_{opj}^{-1}] \{1 - \Phi[(2m - G_{maxj}) / \sigma_{maxj}^{-1}]\}$$

where  $S_j$  = Probability of catching fish in gillnet mesh size with length class  $j$ ;  $G_{opj}$  = Average gill girth of fish in length class  $j$ ;  $\sigma_{opj}$  = Standard deviation of fish gill girth in length class  $j$ ;  $G_{maxj}$  = Mean maximum body girth of fish in length class  $j$ ;  $\sigma_{maxj}$  = Standard deviation of the maximum body girth of the fish in the length class  $j$ ;  $2m$  = Girth of the gillnet mesh size and  $\Phi$  = Standard normal cumulative distribution function (in the excel environment, the NORMSDIST function is equivalent to the standard cumulative normal distribution function).

The following equation was used to calculate the optimal mesh size of the gillnet (Fridman, 1986):

The optimal stretched mesh size of gillnet = Selectivity coefficient  $\times$  Total length for catching  $L_{m50} \times 1.1$ .

Therefore, the selectivity coefficient is equal to the mesh size of the gillnet divided by the optimal length of the catch ( $K = m / L_{opt}$ ). One-way ANOVA test was used to compare the measured parameters of each net.

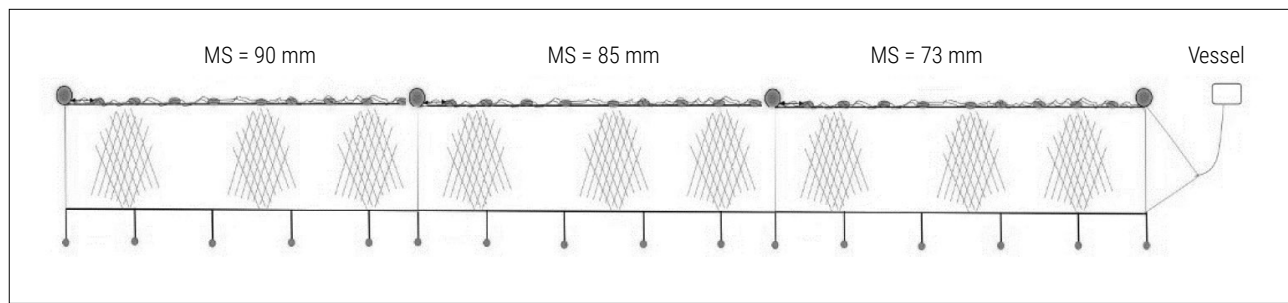


Fig. 2. Schematic of the experimental fishing net. MS: Mesh size

## Results

The length class of fish caught in each of the fishing nets with their means and standard deviations (SD) are shown in Table 2. The average lengths of *O. ruber* caught in fishing nets of 73, 85 and 90 mm, were  $26.89 \pm 4.00$ ,  $35.33 \pm 3.43$

Table 2. Fork length frequency distribution of fish caught according to mesh size, mean and standard deviations of Op girth and maximum girth for *O. ruber*

| Length class (cm) | Mesh size (mm) |    |    | Op. Girth |      | Max. Girth |      |
|-------------------|----------------|----|----|-----------|------|------------|------|
|                   | 73             | 85 | 90 | Mean      | SD   | Mean       | SD   |
| 20                | 3              |    |    | 10.5      | 0.2  | 12.03      | 0.25 |
| 21                | 3              |    |    | 10.9      | 0.1  | 12.27      | 0.25 |
| 22                | 6              |    |    | 11.1      | 0.36 | 12.4       | 0.56 |
| 23                | 6              |    |    | 11.3      | 0.61 | 12.63      | 0.32 |
| 24                | 8              |    |    | 11.67     | 0.76 | 12.83      | 0.76 |
| 25                | 11             |    |    | 11.9      | 0.36 | 13.4       | 0.79 |
| 26                | 14             |    |    | 12.27     | 0.46 | 13.73      | 0.64 |
| 27                | 17             |    |    | 12.75     | 0.5  | 13.93      | 0.51 |
| 28                | 32             |    |    | 13        | 0.41 | 14.93      | 0.54 |
| 29                | 41             | 3  |    | 13.23     | 0.93 | 15.1       | 0.66 |
| 30                | 57             | 4  |    | 13.83     | 0.35 | 15.73      | 0.46 |
| 31                | 48             | 7  | 1  | 14.07     | 0.4  | 16.1       | 0.36 |
| 32                | 34             | 24 | 3  | 14.5      | 0.5  | 17         | 0.87 |
| 33                | 6              | 47 | 4  | 15.43     | 0.21 | 17.73      | 0.25 |
| 34                |                | 42 | 25 | 16.3      | 0.26 | 18.43      | 0.21 |
| 35                |                | 40 | 21 | 16.4      | 0.36 | 18.83      | 0.29 |
| 36                |                | 30 | 19 | 16.57     | 0.4  | 19.33      | 0.99 |
| 37                |                | 15 | 11 | 17.75     | 1.47 | 20.25      | 1.37 |
| 38                |                | 4  | 9  | 18.33     | 0.76 | 20.77      | 0.68 |
| 39                |                | 3  | 6  | 18.42     | 0.8  | 21.17      | 0.61 |
| 40                |                | 2  | 5  | 18.5      | 1.32 | 21.33      | 0.76 |
| 41                |                |    | 3  | 18.83     | 0.76 | 21.67      | 1.04 |
| 42                |                |    | 3  | 19.33     |      | 22.17      |      |
| 43                |                |    | 2  |           |      |            |      |
| Mean              |                |    |    | 14.65     | 0.56 | 16.69      | 0.60 |

and  $37.05 \pm 3.32$  cm respectively (Table 3). It is evident that, with the increase in the size of the mesh size, the length class of the fish caught increases. As evident from Table 3, there is a significant difference between gillnet with mesh size of 73 mm and the other two gillnets (85 mm and 90 mm) ( $p < 0.05$ ). Table 4 shows catch pattern of *O. ruber* in gillnets of different mesh sizes. In gillnet with mesh size of 73 mm, about 67% of the fish were caught by operculum and about 30% by trunk. In gillnets with 85 and 90 mm mesh size, the rate of catching fish through gills was 71 and 74% respectively. As the number of fish caught through the operculum decreases, more fishes are caught through the head and snout.

The independent t-test shows, the mean gill girth ( $G_{op}$ ) and maximum body girth ( $G_{max}$ ) of all samples are significantly different ( $p < 0.05$ ). Also, the linear relationship between total length and gill girth ( $G_{op}$ ) ( $0.4342 TL + 1.0614$ ,  $R^2 = 0.9398$ ) and maximum body girth ( $G_{max}$ ) ( $0.5167 TL + 0.5092$ ,  $R^2 = 0.959$ )

Table 3. ANOVA of measured parameters including total length, gill girth ( $G_{op}$ ), and maximum body girth ( $G_{max}$ ) samples of *O. ruber*

| Parameter         | Mesh size (mm) | Mean $\pm$ SD         | N   | F     | Significance. |
|-------------------|----------------|-----------------------|-----|-------|---------------|
| Total length (cm) | 73             | $26.89 \pm 4.00^a$    | 286 |       |               |
|                   | 85             | $35.33 \pm 3.43^b$    | 221 | 98.61 | $p < 0.05$    |
|                   | 90             | $37.05 \pm 3.32^b$    | 112 |       |               |
| Total weight (g)  | 73             | $196.93 \pm 89.35^a$  | 286 |       |               |
|                   | 85             | $431.79 \pm 116.84^b$ | 221 | 84.26 | $p < 0.05$    |
|                   | 90             | $488.33 \pm 123.94^b$ | 112 |       |               |
| $G_{op}$ (cm)     | 73             | $12.62 \pm 1.47^a$    | 286 |       |               |
|                   | 85             | $16.39 \pm 1.99^b$    | 221 | 82.95 | $p < 0.05$    |
|                   | 90             | $17.19 \pm 1.81^b$    | 112 |       |               |
| $G_{max}$ (cm)    | 73             | $14.28 \pm 1.82^a$    | 286 |       |               |
|                   | 85             | $18.80 \pm 2.22^b$    | 221 | 91.78 | $p < 0.05$    |
|                   | 90             | $19.73 \pm 1.95^b$    | 112 |       |               |

\*Values bearing different superscripts are significantly different at  $p < 0.05$  level

Table 4. Different types of trapping of fish in the experimental gillnets (%)

| Mesh size (mm) | Type of trapping the fish |       |       |
|----------------|---------------------------|-------|-------|
|                | Head                      | Gill  | Trunk |
| 73             | 2.22                      | 67.15 | 30.63 |
| 85             | 5.16                      | 71.56 | 23.28 |
| 90             | 4.81                      | 74.61 | 20.58 |

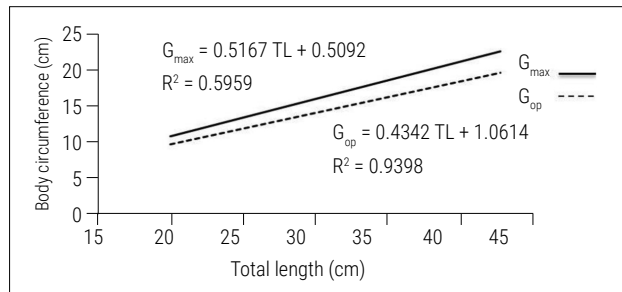
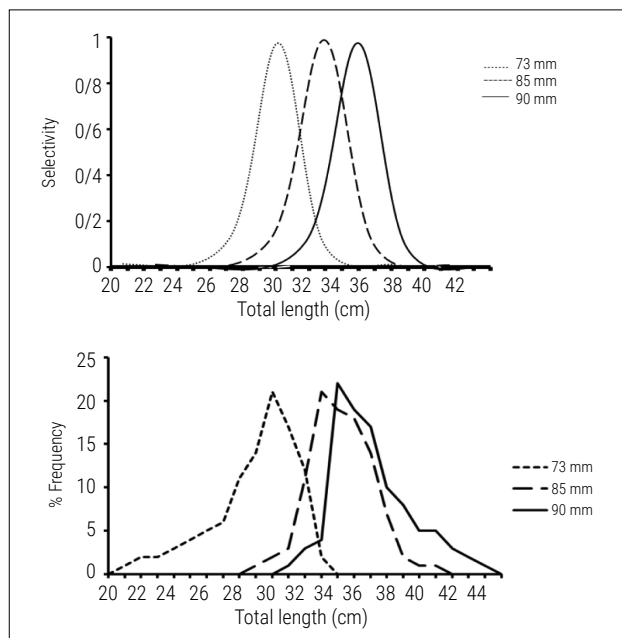
Fig. 3. Relationship between total length-gill girth ( $G_{op}$ ) and total length-maximum body girth ( $G_{max}$ ) of fish caught by gillnet

Table 5. Selectivity parameters of the fish caught using the experimental gillnets

| Mesh size (mm) | Optimal fishing length (cm) | Selectivity coefficient | Length range (cm) | Percentage of non-standard fish* |
|----------------|-----------------------------|-------------------------|-------------------|----------------------------------|
| 73             | 30                          | 0.243                   | 20-33             | 100                              |
| 85             | 33                          | 0.257                   | 29-40             | 97.96                            |
| 90             | 35                          | 0.257                   | 31-43             | 92.97                            |

\*Fish whose length is less than the length of sexual maturity ( $L_{m50}$ ) are called non-standard.

Fig. 4. Length frequency distribution of *O. ruber* and estimated gillnet selectivity curve for the 73, 85 and 90 mm mesh sizes

shows a significant positive correlation ( $p < 0.05$ ) (Fig. 3). In this regard, the correction coefficient ( $K$ ) for gill girth ( $G_{op}$ ) and maximum body girth ( $G_{max}$ ) in the 73 mm opening mesh size were 0.971 and 0.954, in the opening mesh size of 85 mm, were 0.978 and 0.951 and for 90 mm opening mesh size were 0.97 and 0.955, respectively. Selectivity curve was plotted for total lengths of 20-33 cm, 29-40 cm, 31-43 cm and total optimal lengths obtained were 30, 33 and 35 cm respectively for mesh sizes of 73, 85 and 90 mm (Fig. 4). Table 5 shows that the selectivity coefficient ranged from 0.243 to 0.257. Fridman's formula was used to calculate the optimal mesh size of the gillnet:

The optimal stretched mesh size of gillnet (ST) = Selectivity coefficient (0.25)  $\times$  Total length for catching  $L_{m50}$  (40 cm)  $\times$  a (1.1) = 11 cm (110 mm).

## Discussion

In the present study, the optimal fishing lengths obtained for the mesh sizes of 73, 85 and 90 mm were 30, 33 and 35 cm, respectively. Average lengths of *O. ruber* caught in gillnets of mesh sizes 73, 85 and 90 mm were  $26.89 \pm 4.00$  cm,  $35.33 \pm 3.43$  cm and  $37.05 \pm 3.32$  cm, respectively. Saberi *et al.* (2016) reported that the minimum, maximum and average lengths of *O. ruber* caught by the gillnet mesh size of 85 mm were 17.3, 58 and 36.93 cm, respectively. Taghavi *et al.* (2004) reported 38.6, 41.7 and 39.5 cm as the total length averages of *O. ruber* caught in Bushehr, Hormozgan, and Sistan and Baluchestan provinces. Samroz (2021) also reported 30.34 cm as the average length of the *O. ruber* landed by gillnets in the coastal waters of Pakistan. Kazemi *et al.* (2013) also reported the size range of 22.5-58.0 cm of this species for the same region. Santhoshkumar *et al.* (2017) reported a range of 11.2-42.5 cm for *O. ruber* caught from the Thoothukudi coast of India. The length range of fishes caught during the present study is almost similar to previous studies. Fisabilillah *et al.* (2021) reported the minimum and maximum lengths of 14 and 30 cm and average length of 19.35 cm for *O. ruber* in Indonesian waters. They also reported that most of the fish were caught by the head in gillnets.

Hosseini (2003), found that 30% of the fish escaped from the gillnet with mesh size of 145 mm. Ozekinci (2005) observed that a gillnet with a mesh size of 52 mm caused overfishing and pressure on the fish stock of *D. annularis* in Uzmir Bay, but gillnets with mesh size of 54 and 56 mm would not have such an effect.

Haghighatjou *et al.* (2018) used different gillnets for studying the selectivity of *Lutjanus campechanus* by length-girth relationships in the coastal waters of Bandar Abbas. In their research, the length of the fish caught was between 62 to 76 cm, with an average length of 69 cm and they concluded that gillnet with 17 cm mesh size is suitable for catching *L. campechanus*. Different maturity lengths from 30 to 43.3 cm are reported for *O. ruber* in different regions of the Persian

Gulf and Oman Sea (Azhir et al., 2007; Eskandari et al., 2012; Kamali et al., 2012; Farkhondeh et al., 2018).

Considering the average length of *O. ruber* caught in each gillnet (26.89±4.00 cm; 35.33±3.43 cm and 37.05±3.32 cm for 73, 85 and 90 mm respectively), and considering the length at sexual maturity as 40 cm, it appears that gillnet with mesh size of 90 cm is more suitable for catching the species.

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