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RESEARCH PAPER

Size Selectivity of 75 and 90 mm Square Mesh Windows (SMW) Codend for Four Species in Persian Gulf (Hormuzgan Province, Iran) Dhow Prawn Fisheries

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Abstract

Square mesh windows (SMWs) with 75 (75SMW; 37.5 mm bar length) and 90 mm (90SMW; 45 mm bar length) nominal mesh size were tested for determining size selectivity in dhow prawn fisheries of the Persian Gulf (Hormuzgan province). Fishing trials were conducted on the commercial fishing grounds of Hormuzgan province of the northern Persian Gulf by commercial dhow trawler. Covered codend methods were utilized for collecting data during October and November 2012. Totally 21 and 16 valid hauls were performed with 75SMW and 90SMW, respectively. The mean L_{50} values of 75SMW and 90SMW were found as 3.6 ± 0.03 and 3.7 ± 0.02 cm carapace length for banana prawn (*Penaeus merguiensis*), 2.9 ± 0.03 cm and 2.9 ± 0.05 cm carapace length for Jinga shrimp (*Metapenaeus affinis*), 8.0 ± 0.08 cm and 9.5 ± 0.11 cm fork length for Indian ilisha (*Ilisha melastoma*), and 8.1 ± 0.04 and 8.4 ± 0.03 cm fork length of sulphur goatfish (*Upeneus sulphurous*), respectively. This study clearly shows that there is not any notable different in size selectivity of square mesh windows with different mesh sizes for investigated species. Future studies on different by-catch reduction methods such as full square mesh codends or grids should improve size selectivity of the species and efforts to reduce by-catch in this fishing system.

Keywords: Dhow trawl, codend selectivity, square mesh windows, Persian Gulf.

Introduction

The Persian Gulf, with a 36 m average depth, lies in a sub-tropical climate located between latitudes 24°-30° 00’ N and longitudes 49°-61° 25’E (Kampf and Sadrinasab, 2006). There is a wide variety of marine biota in the Persian Gulf and lots of these fishes are endemic and heavily dependent on the Gulf environment (UNEP, 1999). Penaeids have high commercial value and caught throughout the Persian Gulf using mainly trawls, gillnets, set nets from various fishing vessels such as, boats, dhows and trawlers. Trawl is the most important fisheries techniques for catching prawns, mainly has been accomplished by dhows. Dhows are small-scale prawn trawlers and limited to 30 m and made of wood or fibreglass. They are concentrated at depth of 8-30 m and fishing time is between 1-3 hours depends on fishing area and catch bulk.

Hormuzgan Province is the most important Penaeid fishing area in the Persian Gulf and the main target species is banana prawn (*Penaeus merguensis*). Other commercially important species are *Scomberomorus commerson*, *Pampus argenteus*, *Psettodes erumei*, *Eleutheronema tetradactylum*, and *Sillago sihama*. As smaller individuals of many commercial fish species such as *Scomberomorus commerson*, *Parastromateus niger*, *Sillago sihama*, *Otolithes ruber*, *Trichiurus lepturus*, *Pennahia macrophthalmus*, and *Pompus argenteus*, are being caught. So, dhow prawn fishery is destructing their stocks and increase overfishing in the area (Kazemi *et al*., 2014). From the scientific studies conducted on by-catch and discards rate of prawn trawl fishery in the Persian Gulf, about 68 % incidental and discard catches were caught by dhow Penaeid fisheries (Azar, 1981; Ibrahim *et al*., 1989; Yimin *et al*., 2000; Paighambari *et al*., 2003; Valinassab *et al*., 2006; Kazemi *et al*., 2014).

Improving selectivity has been a strong priority in terms of achieving the sustainable management of marine resources (Ohaus, 1990; Schoning *et al*., 1992; Alverson *et al*., 1994; Alverson and Huges, 1996; Alverson, 1997; Crawder and Murawski, 1998; Kelleher, 2005; Catchpole and Gray, 2010). Furthermore from the biodiversity perspective, by-catch, discarding and captured of small individuals affect the ecology of a marine system, the economy of fisheries and management structure, and the sociology of a community (Alverson *et al*., 1994). Trawl fisheries for prawn and demersal finfish account for over 50 percent of total estimated discards and tropical prawn trawl fisheries have the highest discard rate and account for over 27 percent of total estimated discards (Kelleher, 2005). A great deal of progress has recently been made in reducing by-catch and discards (Suuronen, 2005). There are many scientific papers conducted on reduced discard rate and by-catch (improving size and species selectivity) around the world. There is one study about using BRD in the Persian Gulf which related trawlers (Paighambari, 2003), but there is no studies conducted on the Persian Gulf dhow prawn trawl.

There are some codend modifications to improve trawl selectivity, such as increase mesh size, using square mesh codend, lastridge rope and narrowed codend, etc. (Stewart, 2002), among which square mesh window fitted in the top panel of the trawl codend is the simplest method to decrease by-catch and improve trawl selectivity (Arkley, 1990; Ulmestrand and Larsson, 1991; Thorsteinsson, 1992; Briggs and Robertson, 1993; Robertson and Shanks, 1994; Metin *et al*., 2005).

The aim of this study is to determine the size selectivity square mesh windows (SMWs) with 75 (75SMW; 37.5 mm bar length) and 90 mm (90SMW; 45 mm bar length) for banana prawn (*Penaeus merguiensis*), jinga shrimp (*Metapenaeus affinis*), Indian ilisha (*Ilisha melastoma*) and sulphur goatfish (*Upeneus sulphurous*). Size selection performance of square mesh windows were assessed for the first time from dhow prawn fisheries in the Persian Gulf (Hormuzgan province).

Material and Methods

The study was carried out in Hormuzgan province of the Persian Gulf (Figure 1) during October and November 2012. Average towing duration and trawling depth were 1.5 h (1.3-1.8 h) and 14.5 m (5-22 m), respectively. A total of 37 valid hauls were conducted using two different codends; 21 hauls for 75SMW and 16 for 90SMW. All hauls were done in daylight at an average speed of 2.5 knots (1.8-3.1 knots). Samplings were conducted aboard 19.8 m long conventional dhow prawn trawler with 400 HP main engine. The dhow was rigged with a bottom trawl net made of polyethylene material (PE 3mm diameter – double braided), the overall length, footrope and headline were 26.5m, 25.1m and 22.3m, respectively (Paighambari, 2003). The ratio between the number of meshes in extension and codend circumferences was 1:1.

Square mesh windows (SMWs) with 75 (75SMW; 37.5 mm bar length) and 90 mm (90SMW; 45 mm bar length) were tested during the experiment. Both windows are same length size: 75SMW has 57 bars in length, 34 bars in height; 90SMW has 48 bars in length and 28 bars in height. Both SMWs were inserted in the upper panel of the codend. The codend was polyethylene material with nominal 25 mm mesh size and 4.3 m in length (Figure 2).

The hooped covered codend method was used to collect the selectivity data for four species (Wileman *et al.,* 1996). The cover was 7 m in length and was made of 10 mm mesh size PE netting. To prevent masking, supported by two 1.8 m diameter hoops made of 5 cm diameter polyvinylchloride (PVC) material was rigged. The hoop was mounted at a distance of 2.5 m and 4.0 m from the ends of the funnel (Figure 2).

After hauling up the gear, catches from the codend and cover were emptied on the deck separately, sorted by species, and weighed. The total catch was classified as prawn, incidental (some specific species) and discarded catch, and each part was weighed separately. Sub-samples were taken from prawn and discard catch. The length class frequencies were then estimated by raising the sub-sampled frequencies obtained by the ratio of the total weight to the sub-sample weight. Carapace length (from the orbital sinus to the internal posterior margin of the carapace) of *Penaeus merguiensis* and *Metapenaeus affinis* were measured by digital caliper, fork lengths of *Ilisha melastoma* and *Upeneus sulphureus* were measured by measuring board as nearest cm.

Selectivity curves of the individual hauls were obtained by fitting the logit function: $r(l)=\exp(v_1+v_2l)/[1+\exp(v_1+v_2l)]$ by means of maximum likelihood method (Wileman *et al*., 1996) where the parameters v_1 and v_2 are the intercept and slope of the linear logistic function, respectively. Selectivity parameters for individual hauls and pooled data were estimated by using the CC2000 software (*ConStat*, 1995). The mean selectivity of individual hauls was found by taking into account between-haul variation (Fryer, 1991) using the ECModeller software (*ConStat*, 1995). Individual selectivity parameters were analyses according to existence of investigated species both in codend and cover. Mean selectivity results according to Fryer (1991) were analyses from valid hauls. On the other hand, all specimens were added in pooled data for calculating the selectivity parameters.

Results

Totally 37 valid hauls, 21 with 75SMW and 16 with 90SMW, were performed. We found more than 50 species of teleost fishes, elasmobranches, cephalopods, crustaceans and invertebrates. A total weight of 1 374.24 and 807.73 kg prawns and 3 598.41 and 1 979.01 kg by-catch were caught in the 75SMW and 90SMW codends and covers combined, respectively. Sufficient amount of specimens were presented in order to estimate the selectivity, only for two crustaceans and two fish species

Table 1 shows numbers and weight and % total catch of both codend and cover in 75SMW and

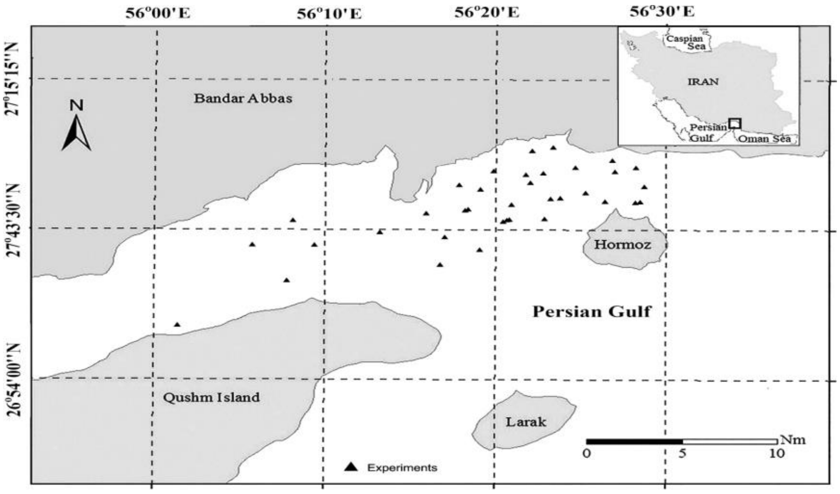

Figure 1. Study area (Hormuzgan province of the Persian Gulf).

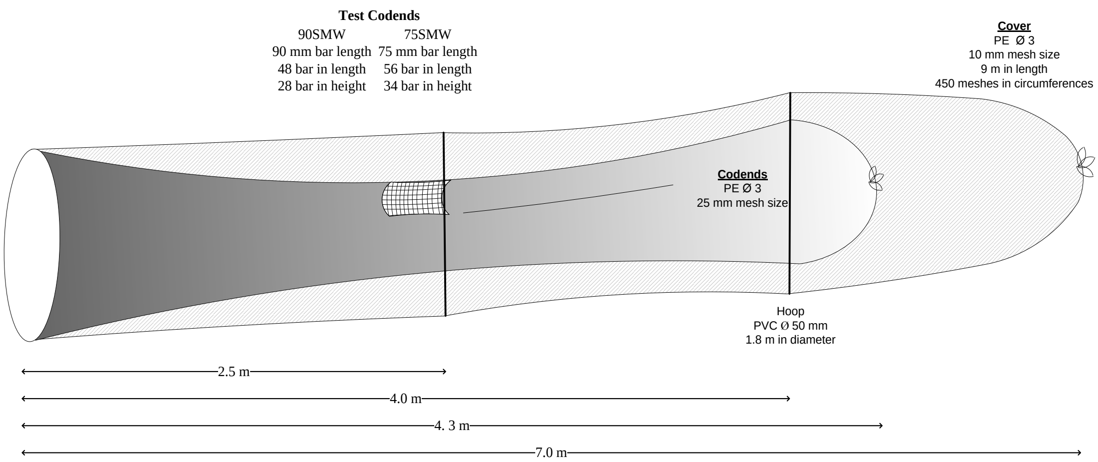

Figure 2. Schematic diagram of codend and cover used in experiments.

90SMW. The total catch (codend +cover) of 75 SMW contained 25.8 % *Penaeus merguiensis*, 9.2 % *Ilisha melastoma,* 8.8% *Leiognathus sp., 7.2* % *Upeneus sulphureus,* and 3.6% *Trichiurus lepturus,* and 1.8 % *Metapenaeus affinis* in terms of weight. 90SMW total catch consist of 27.1 % *Penaeus merguiensis*, 9.8 % *Ilisha melastoma,* 7.8% *Trichiurus lepturus,* 7.1% *Leiognathus sp, 6.6% Upeneus sulphureus and 1.6% Metapenaeus affinis.* All other remaining species (fish, crustacean and invertebrate) accounted for 43.6 and 40.1 % of the catch in 75 SMW and 90SMW, respectively. Some of the other commercial species were yellowtail scad (*Atule mate*), jelly fish (*Aurelia aurita*), Ponyfish (*Leiognathus* sp.), Bloch's gizzard shad (*Nematalosa nasus*), Cuttlefish (*Sepia pharaonis*), Fourfinger threadfin (*Eleutheronema tetradactylum*), Silver pomfret (*Pampus argenteus*) and Indian halibut (*Psettodes erumei*).

A total of 14 and 11 hauls estimated for *Penaeus merguiensis* selectivity in 75SMW and 90SMW, respectively. Figure 3 give selectivity curves for individuals and mean curves of banana prawn. Figure 3 also give (right Y -axis) that normalized length frequency distributions in the codend and cover for each length class. The mean L_{50} values for 75SMW and 90SMW were 3.6 ± 0.03 cm and 3.7 ± 0.02 cm, respectively. SR values for 75SMW and 90SMW were 1.0 ± 0.03 cm and 1.2 ± 0.10 cm, respectively (Table 2). There was no significant differences both L_{50} and SR values between two nets (P>0.05).

Selectivity curves for 12 and 8 individual hauls were estimated for *Metapenaeus affinis* in the 75SMW and 90SMW, respectively and mean curves are shown in Figure 4. Figure 4 also present (right Y -axis) that normalized length frequency distributions in the codend and cover for each length class. The mean L_{50} values were 2.9 ± 0.03 cm and 2.9 ± 0.05 cm for 75SMW and 90SMW, respectively. SR values for 75SMW and 90SMW were 1.3 ± 0.09 and 1 ± 0.08 cm, respectively (Table 2). The mean L_{50} values of both nets were higher than L_{50} (2.71 cm). The differences were not significant between two nets both L_{50} and SR values (P>0.05).

A total of 13 and 7 valid hauls were obtained

Table1. Total catch of investigated species from codend and covers of two modified nets; 21hauls with 75SMW and 16 hauls with 90SMW; N:

	75SMW					90SMW				
	Codend		Cover			Codend		Cover		
Species	N	W	N	W	% in total	N	W	N	W	% in total
Penaeus merguiensis	74035	1202,9	6120	80,8	25,8	41393	688,5	4498	67,4	27,1
Ilisha melastoma	36141	235,9	35793	220,9	9,2	27921	188,7	13151	83,6	9,8
Leiognathus Sp.	71367	413,8	5273	24,1	8,8	26948	155,83	8526	41,1	7,1
Upeneus sulphureus	29479	275,1	13028	82,5	7,2	12306	122,5	8337	60,8	6,6
Trichiurus lepturus	3961	163,8	556	13,9	3,6	4872	186,3	1030	29,8	7,8
Metapenaeus affinis	14915	77,4	2653	12,8	1,8	7373	40,64	1048	5,1	1,6
Others		1925,3		243,4	43,6		939,33		177,4	40,1
Total		4294,2		678,5			2321,8		464,9	
Number of individuals, W: Total weight (kg)										

Number of individuals, W: Total weight (kg)

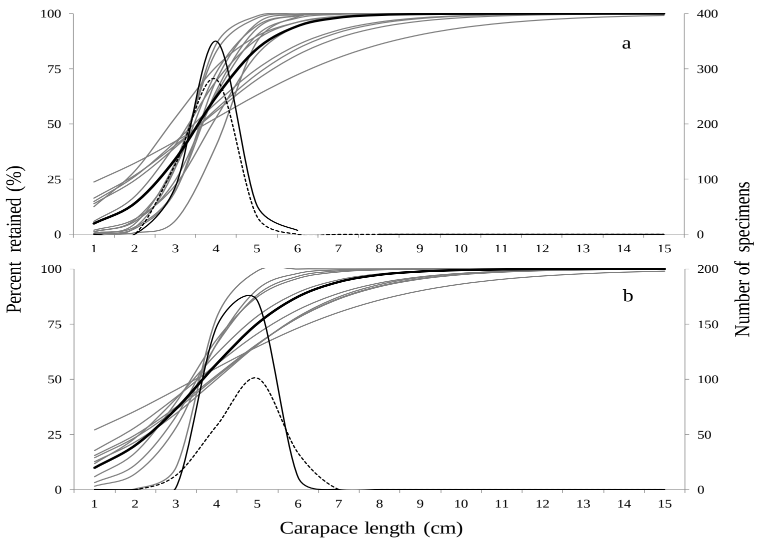

Figure 3. The selection curves and length distribution of the banana prawn (*Penaeus merguiensis*),Y-axis left: percentage retained for the selection curves of: a; 75SMW and b; 90SMW (thick drawn lines; mean selection curve, thin drawn lines; individual selection curves). Y-axis right: normalized length-frequency distribution, drawn lines; codend specimens, broken lines; cover specimens.

from selectivity analyses of *Ilisha melastoma* in the 75SMW and 90SMW, respectively. Figure 5 shows individuals and mean selectivity curves for Indian ilisha. Figure 5 also shows (right *Y* -axis) that normalized length frequency distributions in the codend and cover for each length class. The mean L_{50} values for 75SMW and 90SMW were 8.0 ± 0.08 cm and 9.5 ± 0.11 cm, respectively. SR values for 75SMW and 90SMW were 2.7 ± 0.20 cm and 2.2 ± 0.44 cm, respectively (Table 2). 75SMW gave significantly higher L_{50} value ($P<0.05$), while smaller SR value did not significantly different from 90SMW ($P>0.05$).

Selectivity curves for 12 and 14 individual hauls were estimated for *Upeneus sulphurous* in the 75SMW and 90SMW, respectively. Figure 6 shows individuals and mean curves (based on Fryer, 1991) of sulphur goatfish. Figure 6 also shows (right Y -axis) that normalized length frequency distributions in the codend and cover for each length class The mean L_{50} values for 75SMW and 90SMW were 8.1 ± 0.04 cm and 8.4 ± 0.03 cm, respectively. SR values for 75SMW and 90SMW were 1.1 ± 0.05 cm and 1.4 ± 0.07 cm, respectively (Table 2). The mean L_{50} values of both nets were smaller than Lm (9.9 cm of FL).There wasn't any significant differences between L_{50} and SR values between two nets ($P>0.05$). Although, vi_2 value was significantly differed between the nets ($P<0.05$).

Discussion

This research was taken under commercial condition and it is the first report of using square mesh window in the Persian Gulf dhow prawn trawl fishery. A 25 mm mesh size codend (conventionally used) destructive effect on species caught by dhow trawl (Kazemi *et al*., 2014). Therefore, it was not

Table 2. Mean (according to Fryer, 1991) and pooled selection parameters and estimated number in codend, cover and total of investigated species for 75SMW and 90SMW. All measures are in centimetre. (L_{50}, 50% retention lengths; SR, selection range; se, standard error; v_{i1} and v_{i2} regression parameters; F.: mean parameters according to Fryer; P.: pooled parameters)

		75SMW									90SMW								
								Catch (number)									Catch (number)		
		L_{50}	*se*	S.R.	se	v_{i1}	*vi2*	Codend	Cover	Total	L_{50}	*se*	S.R.	se	v_{i1}	v_{i2}	Codend	Cover	Total
Penaeus merguensis (Carapace length)	1	2,9	0,47	2,1	1,25	-2,976	1,030	4090	208	4298	3,6	0,12	0,6	0,21	-12,572	3,462	2288	193	2482
	2	3,6	0,16	1,0	0,30	-8,149	2,244	3243	291	3535	3,5	0,21	1,6	0,74	-4,786	1,362	3328	314	3642
	3	3,6	0,53	3,5	3,20	-2,251	0,620	2820	264	3084	3,5	0,87	3,6	3,72	-2,140	0,604	2912	363	3275
	4	3,7	0,19	1,3	0,60	-6,137	1,671	3384	291	3676	3,4	0,43	2,7	2,31	-2,841	0,829	2392	230	2622
	5	3,7	0,55	5,2	2,62	-1,596	0,426	5923	555	6478	3,6	0,18	1,4	0,62	-5,777	1,613	3016	314	3330
	6	4,2	0,14	0,9	0,34	-9,673	2,318	3384	333	3718	3,9	0,48	3,7	4,03	-2,290	0,591	2704	339	3043
	7	3,3	0,28	1,8	1,10	-3,978	1,199	3384	264	3648	4,0	0,52	3,4	1,88	-2,574	0,644	2496	266	2762
	8	3,5	0,49	3,1	2,32	-2,457	0,710	3102	250	3352	4,0	0,49	3,9	4,62	-2,268	0,563	3120	399	3519
	9	3,6	0,45	3,1	2,72	-2,527	0,699	2961	305	3267	3,5	0,74	5,5	8,94	-1,391	0,400	2600	290	2890
	10	3,9	0,87	1,6	1,65	-5,332	1,361	4372	333	4705	3,9	0,62	3,6	3,89	-2,386	0,608	1768	242	2010
	11	3,7	0,54	1,1	0,97	-7,397	2,002	2820	278	3098	3,4	0,33	1,9	1,50	-3,960	1,179	1976	181	2157
	12	3,3	0,16	0,8	0,26	-8,824	2,661	2679	236	2915									
	13	3,5	0,18	1,2	0,36	-6,329	1,833	3666	333	4000									
	14	3,3	0,16	1,0	0,30	-7,579	2,285	3102	291	3394									
	P	*3,5*	*0,21*	*3,2*	*1,27*	*-2,362*	*0,684*				*3,6*	*0,24*	*3,9*	*2,10*	*-2,030*	*0,569*			
	F	3,6	0,03	1,0	0,03	-4,131	1,157	48930	4232	53168	3,7	0,02	1,2	0,10	-3,041	0,831	28600	3131	31732
Metapenaeus affinis (Carapace length)	1	2,8	2,74	1,1	0,61	-5,606	2,033	714	80	794	3,6	0,63	3,7	3,61	-2,093	0,589	400	94	493
	2	3,0	0,37	2,6	2,23	-2,575	0,845	873	187	1060	3,0	0,50	3,3	2,78	-1,952	0,660	555	89	645
	3	2,9	0,44	2,3	1,96	-2,777	0,952	555	107	662	3,2	0,19	1,4	0,57	-5,257	1,618	555	102	657
	4	3,0	0,78	4,6	7,00	-1,428	0,478	635	134	768	3,0	0,52	3,5	3,49	-1,851	0,621	555	94	649
	5	3,1	0,20	1,4	0,55	-4,771	1,518	1111	214	1324	2,5	1,91	5,7	10,46	-0,961	0,388	511	68	579
	6	3,0	0,24	1,7	1,08	-3,886	1,284	1071	205	1276	2,5	0,41	2,0	1,12	-2,747	1,093	711	72	783
	7	3,2	0,69	3,2	4,39	-2,199	0,685	912	214	1126	2,6	0,22	1,0	0,42	-5,918	2,282	511	47	558
	8	1,9	1,49	2,8	3,41	-1,469	0,789	595	53	648	3,2	0,18	0,8	0,34	-8,712	2,750	333	47	380
	9	2,5	0,70	3,4	3,39	-1,660	0,653	1190	187	1377									
	10	2,9	0,29	1,6	1,14	-3,849	1,333	595	134	729									
	11	2,8	0,53	3,1	2,91	-2,000	0,707	674	134	808									
	12	3,0	0,33	2,0	1,30	-3,211	1,074	793	151	945									
	P	*2,7*	*0,18*	*3,9*	*1,14*	*-1,490*	*0,561*				*2,8*	*0,17*	*3,3*	*0,82*	*-1,849*	*0,667*			
	F	2,9	0,03	1,3	0,09	-2,731	0,947	9718	1800	11517	2,9	0,05	1,0	0,08	-2,498	0,854	4131	613	4744
Ilisha melastoma (Fork length)	1	7,8	0,85	3,2	2,29	-5,362	0,688	1171	1333	2504	9,6	1,78	11,3	8,29	-1,873	0,194	3682	2073	5755
	2	8,2	2,67	9,5	15,15	-1,903	0,232	1004	1333	2337	7,6	1,98	5,3	6,51	-3,150	0,415	1687	518	2205
	3	7,9	2,03	10,1	9,11	-1,719	0,217	2175	2094	4269	7,3	6,68	0,0	0,16	-362,027	49,876	1687	713	2400
	4	7,6	0,40	3,0	1,28	-5,479	0,724	4685	5140	9825	8,9	1,75	10,6	8,84	-1,853	0,208	2761	1036	3797
	5	7,3	2,54	10,4	11,25	-1,532	0,211	2008	1731	3739	10,4	1,06	5,3	4,13	-4,301	0,415	1841	713	2554
	6	7,9	1,65	7,3	6,12	-2,394	0,302	2342	1904	4246	9,8	0,75	4,7	2,04	-4,528	0,463	2915	1425	4340
	7	6,5	4,41	8,3	13,06	-1,714	0,264	2175	1333	3508	9,5	0,36	1,4	0,53	-14,523	1,523	920	907	1827
	8	8,2	0,60	2,1	0,94	-8,783	1,068	1673	4379	6052									
	9	6,9	4,40	16,8	44,71	-0,897	0,131	1506	1523	3029									
	10	9,3	1,75	7,0	7,58	-2,914	0,312	1171	1904	3075									
	11	9,1	4,21	16,6	15,59	-1,211	0,132	1506	1904	3410									
	12	9,1	1,55	10,3	7,86	-1,947	0,214	3681	5140	8821									
	13	7,7	0,99	3,8	3,20	-4,405	0,573	1171	1333	2504									
	P	*7,8*	*0,74*	*9,1*	*3,69*	*-1,883*	*0,241*	*36141*	*35793*	*71934*	*9,5*	*0,83*	*9,2*	*3,82*	*-2,285*	*0,240*	*27921*	*13151*	*41072*
	F	8,0	0,08	2,7	0,20	-2,351	0,282	26268	31051	57319	9,5	0,11	2,2	0,44	-2,639	0,280	15493	7385	22878
Upeneus sulphureus (Fork length)	1	8,1	0,28	1,2	0,61	-15,387	1,903	1512	629	2141	8,3	1,02	2,3	2,98	-7,853	0,950	674	587	1261
	2	7,6	0,53	2,5	1,41	-6,747	0,888	1663	692	2355	8,1	0,55	2,7	1,87	-6,609	0,815	618	352	970
	3	7,6	0,77	3,6	2,67	-4,625	0,612	1512	629	2141	9,3	0,58	3,4	1,43	-6,067	0,653	1124	1057	2181
	4	7,4	1,27	5,2	5,87	-3,160	0,424	1512	503	2015	9,4	1,12	5,7	3,98	-3,626	0,385	899	704	1603
	5	7,6	0,36	1,2	0,56	-13,903	1,822	1361	566	1927	9,2	0,38	1,8	0,58	-11,050	1,201	843	939	1782
	6	8,4	0,34	1,7	0,71	-10,778	1,289	2268	1888	4156	8,2	0,68	3,7	2,17	-4,890	0,594	787	470	1257
	7	7,5	0,44	2,0	1,31	-8,067	1,083	1663	692	2355	7,8	0,46	2,9	1,87	-5,924	0,762	955	558	1513
	8	8,0	0,24	0,9	0,43	-18,967	2,365	1209	944	2153	9,0	0,77	4,0	2,37	-4,906	0,543	843	646	1489
	9	8,4	0,28	1,0	0,43	-18,724	2,227	1814	503	2317	8,5	0,52	2,8	1,43	-6,668	0,789	787	440	1227
	10	9,0	0,27	0,9	0,40	21,612	2,394	1512	629	2141	8,2	0,25	1,0	0,48	-17,454	2,127	730	411	1141
	11	8,8	0,26	0,8	0,34	-24,307	2,772	1663	629	2292	8,6	0,24	0,6	0,27	-28,992	3,388	562	352	914
	12	7,9	0,35	1,3	0,58	-13,249	1,670	1361	755	2116	9,0	0,64	3,2	1,59	-6,172	0,688	730	382	1112
	13										8,4	0,28	1,0	0,48	-17,947	2,148	618	352	970
	14										8,3	0,63	3,0	1,74	-6,088	0,736	618	352	970
	P	*8,0*	*0,20*	*2,7*	*0,56*	*-6,663*	*0,829*	*29479*	*13028*	*42507*	*8,7*	*0,16*	*3,3*	*0,46*	*-5,702*	*0,659*	*12306*	*8337*	*20643*
	F	8,1	0,04	1,1	0,05	-6,658	1,255	19050	9059	18109	8,4	0,03	1,4	0,07	-5,546	0,634	10788	7602	18390

tested in the study. In order to improve size selectivity square mesh windows with 75 and 90 mm mesh size (37.5 mm and 45 mm bar length, respectively) were investigated for four species. There was no significant difference between the 75 and 90mm SMWs effectiveness based on size selectivity of the species,

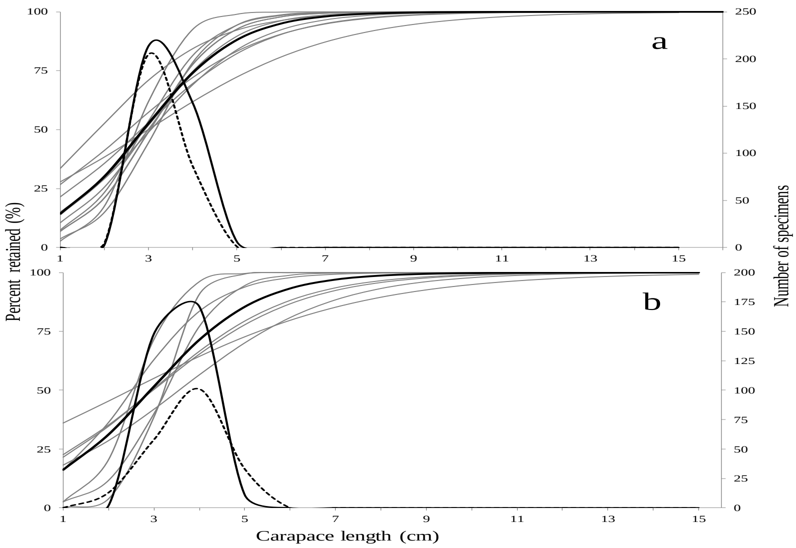

Figure 4. The selection curves and length distribution of the jinga shrimp (*Metapenaeus affinis*) .Y-axis left: percentage retained for the selection curves of: a; 75SMW and b; 90SMW (thick drawn lines; mean selection curve, thin drawn lines; individual selection curves). Y-axis right: normalized length-frequency distribution, drawn lines; codend specimens, broken lines; cover specimens.

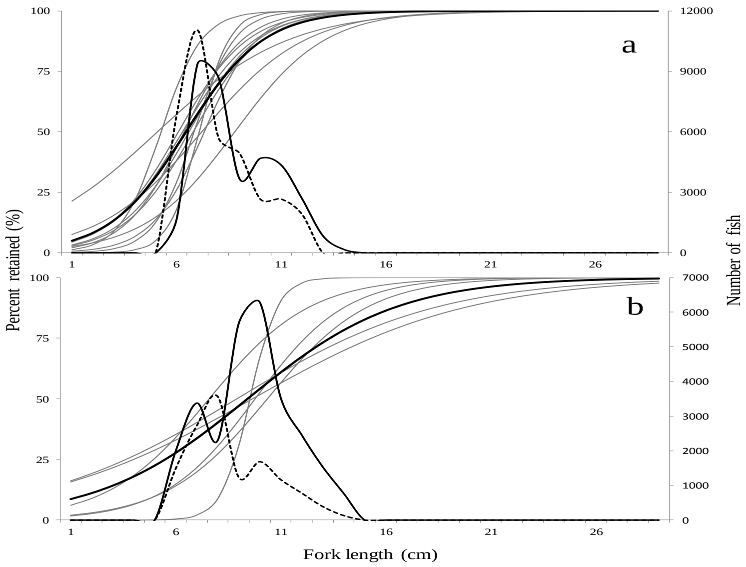

Figure 5. The selection curves and length distribution of the Indian ilisha (*Ilisha melastoma*). Y-axis left: percentage retained for the selection curves of: a; 75SMW and b; 90SMW (thick drawn lines; mean selection curve, thin drawn lines; individual selection curves). Y-axis right: normalized length-frequency distribution, drawn lines; codend specimens, broken lines; cover specimens.

except L_{50} of Indian ilisha (which was significantly higher in 75SMW, Table 2).

We fitted SMWs close to codend exactly before it, as suggested by Robertson, (1993). This probably made changes in SMW open meshes when large amount of jelly fishes (*Aurelia aurita*) have caught in trawl net. This part of by-catch especially when a large amount of it caught in a haul (we have caught nearly 600 kg jellyfish in a haul by 75SMW) can altered codend geometry and degree of mesh opening in SMW and codend both, increasing catch bulk and drag, also this made fishers distraught, because they spent a long time separating and returning jellyfish to the sea. From a management standpoint, it is an important factor to convince fishers to fit by-catch excluder devices (BRD) in their nets. It seems that using a grid for removing big hydro-bios (mostly *Aurelia aurita*, *Portunus pelagicus* and *Sepia pharaonis*) and flatfish, which added to a square mesh window or codend, could be useful for removing by-catch in such multispecies system that most of the by-catch species have length close to target species and

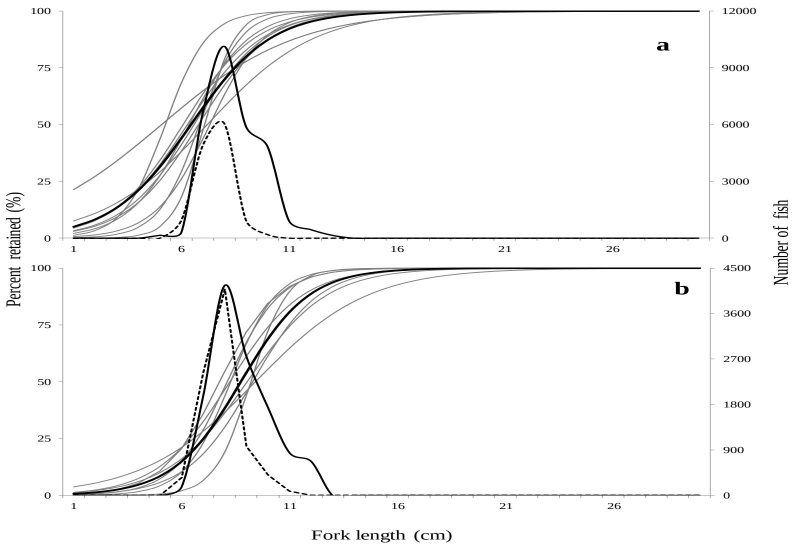

Figure 6. The selection curves and length distribution of the sulphur goatfish (*Upeneus sulphurous*). Y-axis left: percentage retained for the selection curves of: a; 75SMW and b; 90SMW (thick drawn lines; mean selection curve, thin drawn lines; individual selection curves). Y-axis right: normalized length-frequency distribution, drawn lines; codend specimens, broken lines; cover specimens.

removing rather by-catch is the main aim (Stewart, 2002; Broadhurst *et al*., 2004; Aydin *et al*., 2011).

Rogers *et al*. (1997) demonstrated that gear efficiencies depended on local species composition and size distributions. Furthermore, size selection is not only depend on species lengths; mesh size, twine diameter (Sala *et al*., 2007) and materials (Tokaç *et al*., 2004; Deval *et al*., 2006), catch bulk (Campos *et al*., 2003; Broadhurst *et al*., 2005; Aydin *et al*., 2014), towing speed (Broadhurst *et al*., 2005), number of meshes in the codend circumference and hanging ratio (Broadhurst and Millar 2009; Graham *et al*., 2009) all can effect on species escape, So, we cannot compare the result of the present work with any other study.

There were 4.38 and less than 1 % of *Penaeus merguiensis* individuals below LFM (3.021 cm; Safaei, 2005) in 75SMW and 90SMW codends, respectively. Whereas, 22.34 and 12.04 % of *Metapenaeus affinis* subsamples were found below LFM (2.716 cm; Kamrani *et al*., 2005) in the 75SMW and 90SMW codends, respectively. These were due to the different behaviours in different Penaeid species (Whitaker *et al*., 1992; Rogers *et al*., 1997). However, a very large amount of fish species are caught below their sexual legal length in this fishing system at Hormuzgan province and removing further fish species should be the aim of management strategies.

In conclusion, this study clearly shows that there is not any notable different in size selectivity of square mesh windows with different mesh sizes for investigated species. On the other hand, reduction in weight of juvenile species could be achieved by adding square mesh windows in the dhow prawn trawl nets of the Persian Gulf. Also, nevertheless, future studies on different by-catch reduction methods such as full square mesh codends or grids should improve size selectivity of the species and efforts to reduce by-catch in this fishing system.

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