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RESEARCH PAPER

Gillnet Selectivity on the Small Yellow Croaker *Larimichthys polyactis* in the Southern Yellow Sea

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Abstract

Gillnet selectivity on the small yellow croaker, *Larimichthys polyactis*, was investigated in the southern Yellow Sea. Ten gillnet series were tested: two net heights (6 and 10 m) and five mesh sizes (35, 40, 45, 50, and 55 mm). The age 0+ and 1+ groups dominated the catch with proportions of 43% and 53%, respectively. The sex ratio was found to be size- and age-dependent in gillnet surveys, with males increasingly dominant in the smaller size and younger age classes. Nets with heights of 10 m caught selectively more age 0+ individuals and males than 6 m height nets. Gillnet selectivity estimates derived from girth frequency distribution were represented by a binormal model, and the optimal mesh size for 50% retention for the proposed minimum landing size (body length 148.3 mm) of *L. polyactis* was estimated as 45 mm. We suggest that a gillnet with a mesh size of 45 mm and net height of 6 m is optimal for exploiting *L. polyactis* as it is less selective for juveniles and smaller males.

Keywords: Larimichthys polyactis, gillnet, selectivity, age structure, sex ratio, southern yellow sea.

Introduction

The small yellow croaker *Larimichthys polyactis* is an economically and ecologically important demersal fish in the Yellow Sea, the Bohai Sea and the East China Sea. It is one of the targeted species for gill-netting, bottom-trawling and stow-netting fisheries in China, Japan and Korea. This fish was one of the “four major fishery species” in China with three other species, including the large yellow croaker (*Larimichthys crocea*), hairtail (*Trichiurus lepturus*) and cuttlefish (*Sepiella maindroni*) (Xiong, Zhong, Tang, & Yang, 2016). *L. polyactis* has been exploited since the early 1950s and was considered most representative of the commercially exploited fish stock in China (Liang, Sun, Yan, Huang, & Tang, 2014).

The contribution of gillnet fishery to total marine capture fishery has increased progressively in China, whereas other main fishery types, e.g. bottom trawl and stow net, are unchanged or have decreased in use from 1983 to 2011 (Sun, 2014). According to the statistics of China Fishery Statistical Yearbook in 2011, gillnet fishery production accounted for 21.1% of the total marine capture production in 2011 (The Fishery Bureau MoA, 2011). Although there are 100 target species in gillnet fishery, only about 10 target species have a high catch yield, such as common mackerel (*Scomber japonicus*) and small yellow croaker (*L. polyactis*) (Sun, 2014). The optimum season for the capture of *L. polyactis* is winter. The professional fisher searched for overwintering stock in high yield fishing grounds at 32°N-34°N, 123°E-126°E (Cheng, Zhang, Li, Zheng, & Li, 2006), mainly by gillnet, bottom trawl, and stow net (Kim, Jung, & Zhang, 1997; Cheng *et al*., 2006). Since 2000, the gillnet fishery targeting the wintering small yellow croaker developed rapidly in the southern Yellow Sea. There is limited knowledge about gillnet fishing for small yellow croaker, except for data published regarding the coastal waters in Korea (Kim, Park, Bae, & Kim, 2009; Kim, Park, Lee, & Yang, 2012). To date, no regulation regarding the minimum mesh size of gillnet for small yellow croaker has been indicated by the Bureau of Fisheries, Ministry of Agriculture of China.

The current knowledge of small yellow croaker has been still almost obtained from the data of bottom trawl fishery rather than those from gillnet fishery. Most of the landings (>80%) were <1 year old, particularly after 2000 (Yan, Hu, Ling, & Li, 2006). A significant decrease in body length and increase in absolute and relative fecundity was found in small yellow croaker stocks (Lin, Jiang, Yan, Gao, & Wang, 2009; Li, Shan, Jin, & Dai, 2011). In recent years, the impacts of heavy fishing on fishery resources and the ecosystem have become increasingly serious; the population genetic characteristics of several species have significantly changed, and life-history tactics have been altered (Hauser, Adcock, Smith, Ramirez, & Carvalho, 2002; Yang *et al*., 2015; Thériault, Dunlop, Dieckmann, Bernatchez, & Dodson, 2008; Sharpe & Hendry, 2009). Gillnet-selective has caused adverse ecological and evolutionary changes in wild populations and has also affected sex ratios; this is particularly apparent in commercially and biologically important species (Sbrana, Belcari, Ranieri, Sartor, & Viva, 2007; Kendall, Hard, & Quinn, 2009; Kendall & Quinn, 2009, 2013.) These assessment approaches require information on population structure and selectivity to determine the impact of fishery on the population. However, information regarding biological structure of *L. polyactis* in gillnets, as well as the impact of different types of gillnets on the *L. polyactis* catch, is lacking.

Therefore, we hypothesize that the comparison of gillnet mesh sizes will make it possible to objectively assess the impact of gillnet selectivity for *L. polyactis.* Collected data will provide effective information for protecting juveniles and controlling sexual selection in gillnet fishery prior to the implementation of minimum gillnet mesh size for small yellow croaker. The focus of this study is to investigate the catch composition (age and sex ratio) and selectivity of experimental gillnets with 5 mesh sizes and 2 net heights used in the artisanal fishery.

Materials and Methods

Field Methods

Prior to the experiment, we investigated gillnet structures commonly used by local fishermen in the southern Yellow Sea, which was gear with a net height of 5 m to 8 m, with mesh size approximately 45 mm and length roughly 30 m. Based on the gillnet structure used in artisanal fishery, we tested 10 types of gillnets with alternate combinations of 2 net heights (H; 6 and 10 m) and 5 mesh sizes (M; 35, 40, 45, 50, and 55 mm): H6M35, H6M40, H6M45, H6M50, H6M55, H10M35, H10M40, H10M45, H10M50, and H10M55. The construction of all gillnets in the present study was the same. The hanging ratios were 0.6, in order to prevent possible effects on fishing species and size selectivity from differential net construction. Each gillnet was 30 m in length and constructed of 0.2 mm thick monofilament nylon twine. Nets of both heights were constructed of sheets of the five mesh sizes arranged in the following order: 35, 40, 45, 50, and 55 mm. Total net length was 600 m (with two sheets of each net). Adjacent nets were joined end-to-end with an interval of 6 m rope, which prevented the fish from migrating into larger mesh size nets from smaller mesh nets.

The experimental selectivity trials (50 valid hauls) were carried out during October-November, 2011 in the southern Yellow Sea. The study area, in overwintering ground of small yellow croaker, was located at 32°02′ N-33°16′ N, 123°25′ E-123°54′ E at a depth of approximately 60 m (Figure 1). The nets were deployed in the same general area and set in

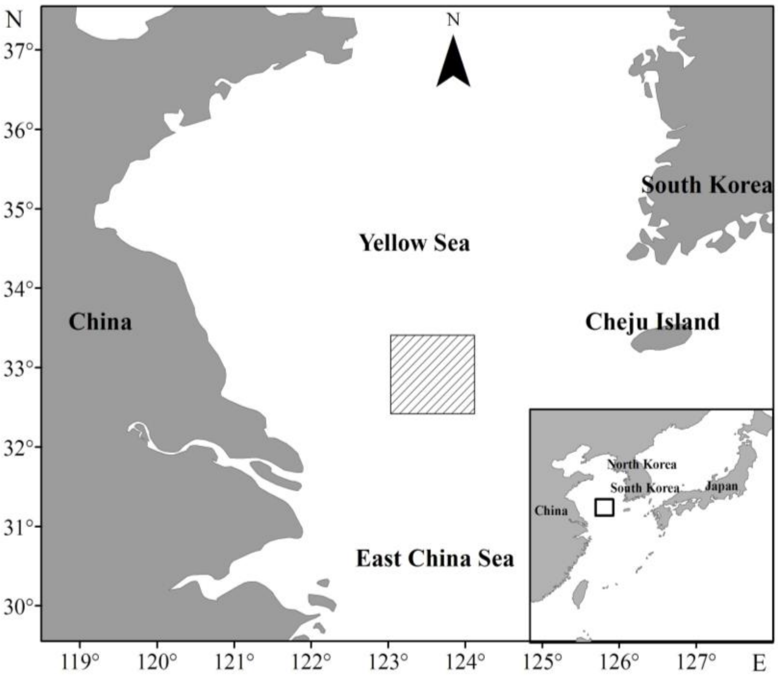

Figure 1. Location of the study area (striped square) in the southern Yellow Sea.

relation to the tidal and prevailing current. The nets were tied end-to-end in a single gang and set on the bottom by adjusting the floaters and sinkers, with an average soaking time of 4 h.

The catches, sorted according to each type of gillnet, were classified to the species level. The total weight and number was registered for each species. Each *L. polyactis* individual caught was measured for body length and girth to the nearest 0.1 mm and weight to the nearest 0.1 g.

Estimation of Gillnet Selectivity

Although gear selectivity is generally estimated based on length frequency distributions, previous literature has proven that girth distributions can be used as well (Reis & Pawson, 1999; Stergiou & Karpouzi, 2003; Carol & García-Berthou, 2007). The fish size caught by different mesh sizes mainly depended on fish girth at the point of capture, which has to be equal to the mesh perimeter or slightly higher (Hovgård, 1996; Carol & García-Berthou, 2007). In this study, data for fish girth was sampled for a wide length range of the studied species.

The model implemented in EXCEL for the estimation of the selectivity parameters was proposed by Kirkwood and Walker (1986) (See Petriki, Erzini, Moutopoulos, & Bobori, 2014). Based on a hypothesis that catch variables are obeying Poisson distribution, the model could well simulate the observed catch and expected catch proportion using maximum likelihood (Millar, 2000; Carol & García-Berthou, 2007; Márquez-Farías, 2011). Gillnet selectivity is derived from the probability density function of a binormal distribution with this equation:

$$S_{ij} = \exp\left(-\frac{(R_{ij}-R_{o1})^2}{2\sigma_1{}^2}\right) + w\cdot\exp\left(-\frac{(R_{ij}-R_{o2})^2}{2\sigma_2{}^2}\right)$$

where R_{o1} and R_{o2} are the relative modal girth (mm), R_{ij} is the relative girth (mm), and σ_1 and σ_2 are the spread of model. The details of the SELECT and GILLNET methods are presented in previous literature (Millar & Holst, 1997; Millar & Fryer, 1999; Stergiou & Erzini, 2002; Petriki *et al*., 2014).

Statistical Analysis

Length-girth relationship was used to estimate body length for each girth of fish, and the t-test was used to test the regression of girth on length. Age was calculated with the von Bertalanffy Growth Function (Bertalanffy, 1934) $L_t = 24.06\left[1-e^{-0.56(t+0.25)}\right]$, based on Zhang, Li, Jin, Zhu, and Dai (2010a). To explain the sex ratio variation (the proportion of males) with increasing girth and age, Pearson's test was used to analyze the correlation between the proportion of males and girth, and Spearman's test was used for the proportion of males and age.

Girth-frequency distributions were simulated for *L. polyactis* catch obtained with each height and mesh size and compared using the two-sample Kolmogorov-Smirnov test.

The t-test was used to examine whether the catch sex ratios (the proportion of males) were significantly deviated from the theoretical value of 0.5 and the catch age 0+ ratios (the percentage of age 0+ fish in total catches) were significantly deviated from 0.8. The current age 0+ ratios in small yellow croaker stock in the southern Yellow Sea were close to 0.8 (Lin, Liu, Jiang, Huang, & Gao, 2011). Significance was accepted at the 5% level.

All statistical tests were performed using SPSS v. 19.0 software (IBM Corp., Armonk, NY, U.S.A.).

Results

A total of 1,777 fish were caught, and the catch rate and catch per unit effort (CPUE) for all species in ten types of gillnet are listed in Table 1. *L. polyactis* represented over 43% of the total number of captured. Figure 2 indicates the girth frequency distribution of the caught fish by all gillnets. The sex ratio of females to males in the total *L. polyactis* caught was 1:1.44, representing the sexual structure of the *L. polyactis* population targeted by the gillnets. Three age classes were identified in the catches: age 0+ (girth: mean±SD, 80.6±8.1 mm), age 1+ (107.3±9.9 mm), and age 2+ (120.9±10.1 mm), which accounted for 43%, 53%, and 4% of the total catch, respectively.

The smaller individuals were dominated by males (girth: mean±SD, 91.1±16.1 mm), whereas the larger one was dominated by females (104.2±14.6 mm) (Figure 3). The number of fish caught decreased dramatically for sizes larger than 130 mm girth, with only 7 individuals caught. A significant negative correlation was noted between the proportion of males and fish girth (Pearson's test, r = -0.621, $P < 0.001$). The age 0+ group of the small yellow croaker was dominated by male fish (79%), but the age 1+ and age 2+ groups were dominated by female fish with proportions of 55% and 73%, respectively (Figure 3). Correlation was significant between the age and proportion of males (Spearman's test, r = -0.638, P<0.001).

The proportion of male fish in each gillnet ranged from 0.45 to 0.82 for 6 m height and from 0.58 to 0.70 for 10 m height, respectively (Figure 4a). The proportion of age 0+ in H6M40, H6M45, H6M50 varied from 0.20 to 0.53, whereas the value in H10M35, H10M40, H10M45, H10M50 ranged from 0.60 to 0.80 (Figure 4b). For the 6 m and 10 m height nets, the proportions of males were higher than females, except in H6M55 (Table 2). The proportion of age 0+ in all gillnets had no difference than 0.8 (t-test, $P > 0.05$; Table 2).

There was no obvious mode of the age 0+ group in the 6 m height net; conversely, there was a

Table 1. The catch composition in the experimental gillnet in the study area

Species	Scientific name	Number (ind.)	Weight (g)	Catch rate (%)	CPUE (g/net)
Small yellow croaker	*Larimichthys polyactis*	764	43178.3	33.72	863.6
Bluefin searobin	*Chelidonichthys spinosus*	415	33252.9	25.97	665.1
Common mackerel	*Scomber japonicus*	164	24377.9	19.04	487.6
Belanger's croaker	*Johnius belangerii*	83	2501.1	1.95	50.0
Hairfin anchovy	*Setipinna taty*	69	2160.0	1.69	43.2
Blue scad	*Decapterus maruadsi*	50	2164.9	1.69	43.3
Japanese anchovy	*Engraulis japonicus*	48	767.0	0.60	15.3
White croaker	*Argyrosomus argentatus*	29	2999.6	2.34	60.0
Red tongue sole	*Cynoglossus joyneri*	21	968.2	0.76	19.4
Devil stinger	*Inimicus japonicus*	21	392.7	0.31	7.9
Finespot goby	*Chaeturichthys stigmatias*	17	854.8	0.67	17.1
Brown croaker	*Miichthys miiuy*	15	2955.0	2.31	59.1
Swimming crab	*Portunus trituberculatus*	11	1443.0	1.13	28.9
Snailfish	*Liparis tanakae*	11	1168.1	0.91	23.4
Portunid crab	*Charybdis bimaculata*	10	64.0	0.05	1.3
Southern rough shrimp	*Trachypenaeus curvirostris*	7	30.7	0.02	0.6
Big head croaker	*Collichthys lucidus*	7	82.3	0.06	1.6
Yellow goosefish	*Lophius litulon*	6	5172.7	4.04	103.5
Bombay duck	*Harpodon nehereus*	4	194.8	0.15	3.9
Spearnose grenadier	*Caelorinchus multispinulosus*	4	140.6	0.11	2.8
Japanese stone crab	*Charybdis japonica*	3	87.3	0.07	1.7
Hairtail	*Trichiurus japonicus*	2	442.2	0.35	8.8
Goneplacid crab	*Carcinoplax vestitus*	2	26.1	0.02	0.5
Japanese flying squid	*Todarodes pacificus*	2	713.3	0.56	14.3
Spanish mackerel	*Scomberomorus niphonius*	1	724.5	0.57	14.5
Conger pike	*Muraenesox cinereus*	1	462.8	0.36	9.3
Slender lizardfish	*Saurida elongata*	1	335.7	0.26	6.7
Blotched eelpout	*Zoareces gilli*	1	190.0	0.15	3.8
Tapertail anchovy	*Coilia nasus*	1	68.2	0.05	1.4
Japanese butterfish	*Psenopsis anomala*	1	43.5	0.03	0.9
Saddled weever	*Parapercis sexfasciata*	1	39.6	0.03	0.8
Yellow drum	*Nibea albiflora*	1	29.3	0.02	0.6
Sand-looking crab	*Ovalipes punctatus*	1	10.3	0.01	0.2
Neptune rose shrimp	*Parapenaeus fissuroides*	1	10.2	0.01	0.2
Dorippe crab	*Dorippe japonica*	1	5.1	0.00	0.1
Chinese ditch prawn	*Palaemon gravieri*	1	3.2	0.00	0.1
Total		1777	128059.9	100.00	2561.2

Note: Catch rate = weight of species / total weight; CPUE = weight of species / 50 valid hauls

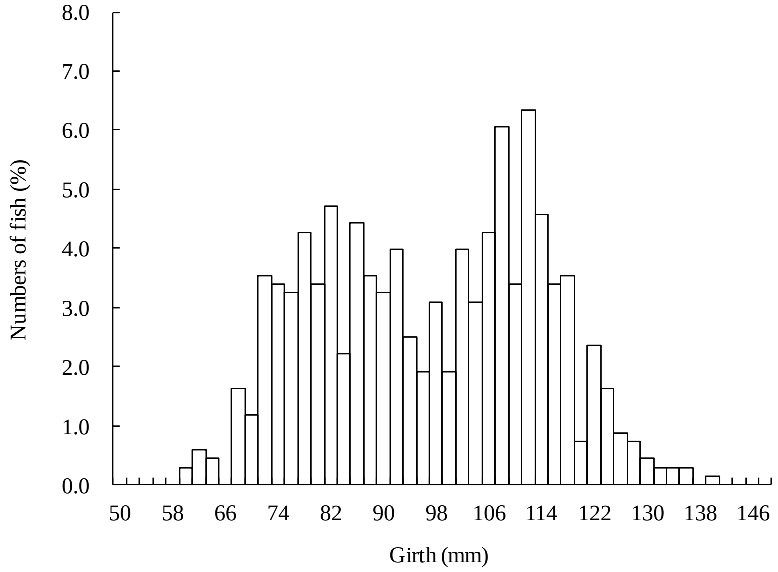

Figure 2. Frequency percentages of the observed fish girth of *Larimichthys polyactis* caught by the gillnets.

pronounced age 0+ mode in the 10 m height net (Figure 5). For the 6 m height nets, 44% of the small yellow croaker was represented by the age 0+ group; whereas in the 10 m height nets, 53% were the age 0+ group (Figure 5). There were significant differences between 35 mm and other mesh sizes (except for 55 mm mesh size) in 10 m height nets, and similarly, between 40 mm and other mesh sizes (except for 55 mm mesh size) in 10 m height nets (Kolmogorov–Smirnov test, $P<0.05$).

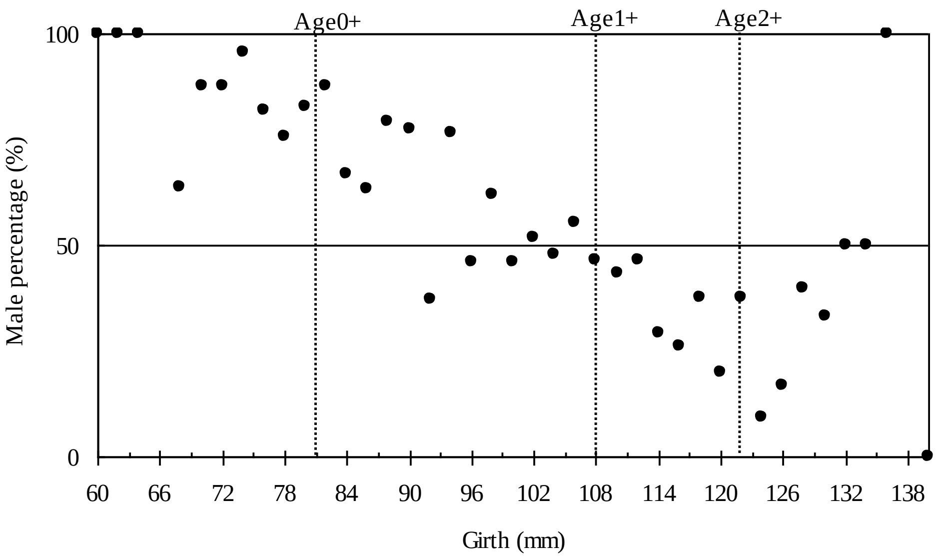

Figure 3. Proportion male and age in each size interval of girth of *Larimichthys polyactis* from the gillnet catches. Each vertical dashed line indicates the mean girth value of each age class. Pearson's test was used to analyze the correlation between proportion of males and girth, and Spearman's test between proportion of males and age classes.

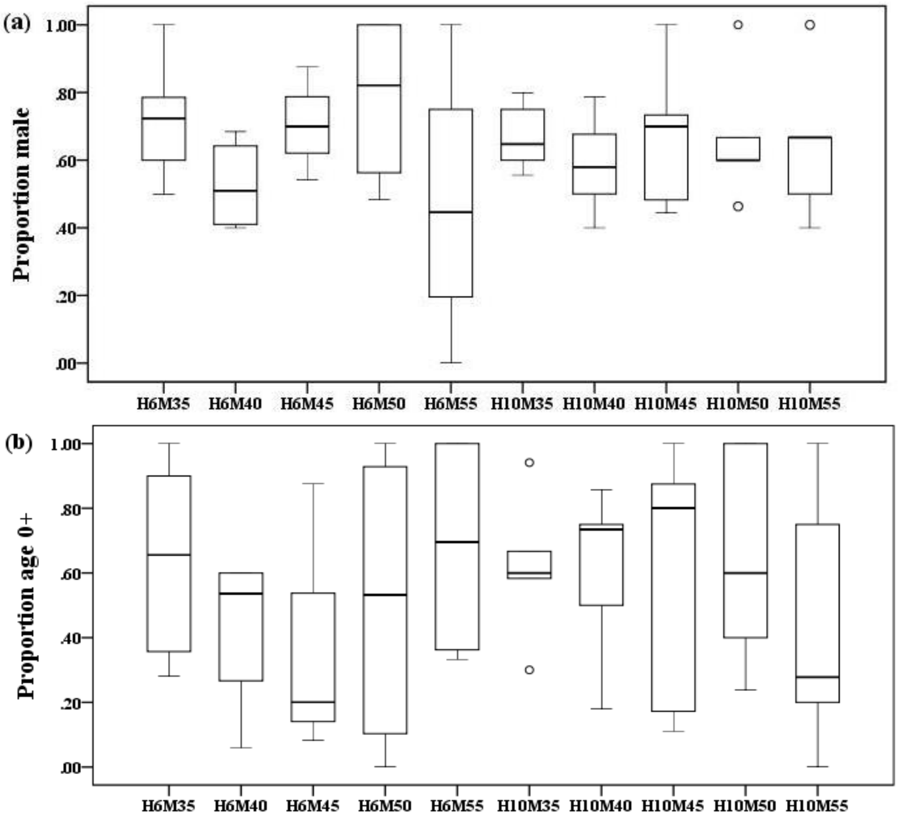

Figure 4. Boxplots of each gillnet (a) proportion of male *Larimichthys polyactis* in the catch (b) proportion of age 0+ group in the catch. The smallest and largest observations (in the range not considered as outliers) are shown as error bars, the lower and upper edges of the box are the lower and upper quartiles (25th and 75th percentiles, respectively), the line in the middle of the box is the median, and the circles represent data points considered to be outliers (1.5 times the inter-quartile range).

The fitted binormal selectivity curves are shown in Figure 6. The length-girth relationship for small yellow croaker applied in the model was found to be $G = 2.489L^{0.745}$ with correlation coefficients (r^2) equal to 0.925 (t-test, P<0.001). The estimated modal girths for the five mesh sizes were 99 mm, 114 mm,

Table 2. Average proportion of male and age 0+ *Larimichthys polyactis* in the total catch of each of the 10 gillnets. The *t*-test results (test statistic and *p*-value) comparing the proportion male values to 0.5, and the proportion age 0+ values to 0.8, which is close to the current age 0+ ratios in small yellow stock. H, net height (m); M, mesh size (mm)

Gillnet Type	Avg. proportion male*	Different from 0.5		Avg. proportion age 0+*	Different from 0.8	
		Test statistic	*P*		Test statistic	*P*
H6M35	0.72 (0.49,0.96)	2.602	0.060	0.64 (0.24,1.03)	-1.132	0.321
H6M40	0.53 (0.31,0.75)	0.376	0.732	0.43 (0.03,0.84)	-2.864	0.064
H6M45	0.71 (0.29,1.12)	2.135	0.166	0.39 (-0.68,1.45)	-1.677	0.235
H6M50	0.78 (0.37,1.20)	2.159	0.120	0.52 (-0.26,1.29)	-1.166	0.328
H6M55	0.47 (-0.18,1.13)	-0.132	0.903	0.68 (0.09,1.27)	-0.644	0.565
H10M35	0.67 (0.54,0.80)	3.729	0.020	0.62 (0.33,0.90)	-1.776	0.150
H10M40	0.59 (0.40,0.77)	1.318	0.258	0.60 (0.27,0.94)	-1.615	0.182
H10M45	0.67 (0.40,0.95)	1.722	0.160	0.59 (0.07,1.11)	-1.116	0.327
H10M50	0.67 (0.42,0.92)	1.849	0.138	0.65 (0.22,1.08)	-0.984	0.381
H10M55	0.65 (0.36,0.93)	1.438	0.224	0.45 (0.07,0.96)	-1.912	0.128

* mean (95% confidence intervals)

128 mm, 142 mm, and 156 mm, respectively. The main modal girths of the fitted selectivity curves increase with mesh size, followed by small secondary modes in the selectivity curves at small sizes (Figure 6).

Discussion

The girth-frequency distributions showed significant differences between 6 m and 10 m nets at a given mesh size in this fishing trial, and the 10 m nets caught age 0+ fish more than the 6 m nets. Size-dependent behaviors appear to be the intuitive factors, accounting for the observed difference of size distribution between 6 m and 10 m gillnets. One factor may be the size-related vertical distribution of *L. polyactis*. Although previous studies have not been performed to establish a link between the vertical distribution of the small yellow croaker and their size and age, the tendency for larger fish to occur in deeper water is common for demersal species (Haedrich & Rowe, 1977). The Argentine hake *Merluccius hubbsi* showed a progressive shift towards the bottom with increasing total length of fish, and the vertical distribution layer of age 0+ hake was above the reach of the bottom trawl nets (Álvarez-Colombo, Dato, Machinandiarena, Castro-Machado, & Betti, 2014). It has been demonstrated for Carangidae species that Japanese jack mackerel *Trachurus japonicus* tend to occupy deeper water with increasing size and age (Nakamura & Hamano, 2009). Age at first maturity were 1 year for small yellow croaker (Jiang, Cheng, & Li, 2009), and 10 m gillnets caused higher fishing mortality for immature specimens (age 0+). There may be another factor generating a sudden increase in feeding activity of the fish, or size-related diet shifts above a certain size. In this study, the younger (age 0+) size mode of body girth is 80.6 mm with body length 107 mm, and the older size (age 1+) mode of body girth is 107.3 mm with body length 156 mm. The marked differences in diet between the two modes of the observed size distribution in the study were apparent, based on the results from Xue, Jin, Zhang and Liang (2005). In the small individuals (age 0+, body length <109 mm), the diet comprised amphipods, copepods and euphausiids, whereas fish in the larger mode (age 1+, body length >109 mm) preyed on fishes and decapods, with the dietary breadth of *L. polyactis* increasing markedly for fish > 109 mm (Xue *et al*., 2005). Small yellow croakers exhibit diet shift patterns, which is consistent with the vertical distribution of its prey (Xue *et al*., 2005). Similar ontogenetic niche shifts have been observed in other species of the family Sciaenidae (Sardiña & Cazorla, 2005; Taylor , Fielder, & Suthers, 2006).

The efficiency of the five mesh sizes showed significant differences with respect to sizes of the specimens caught. The girth distributions in 35 mm and 40 mm mesh sizes both differed obviously from the other mesh sizes by the Kolmogorov-Smirnov test. The optimum mesh size is attributed to the length-frequency distribution of fish in the fishing ground (Millner, 1985). The minimum landing size for *L. polyactis* is 148.3 mm body length (equating with a mean girth of 104 mm) proposed by Zhang, Li, Jin, Zhu, and Dai (2010b). Our study revealed that the G_{50} (50% selection girth) in 35 mm and 40 mm mesh sizes estimated for *L. polyactis* were all smaller than 104 mm girth, and the selectivity of 104 mm girth is corresponding to 53% in 45 mm mesh size. The optimal mesh size for 50% retention of the proposed minimum landing size (148.3 mm) in this study is smaller than 49.6-51.5 mm for *L. polyactis* minimum landing size (191 mm) in the coastal waters in Korea (Kim *et al*., 2009; Kim *et al*., 2012). The dominant length that ranged from 160 mm to 210 mm (Kim *et al*., 2009; Kim *et al*., 2012) was also larger than the body length from 88 mm to 182 mm (equating with the girth from 70 mm to 120 mm) in this study.

This study showed that more males in the smaller fish (age 0+) group and more females in the larger fish (age 1+ and age 2+) group in the wintering populations were caught. The sizes of females were significantly larger than the males in the previous study from Zhang *et al*. (2010a). Alós, Alonso-

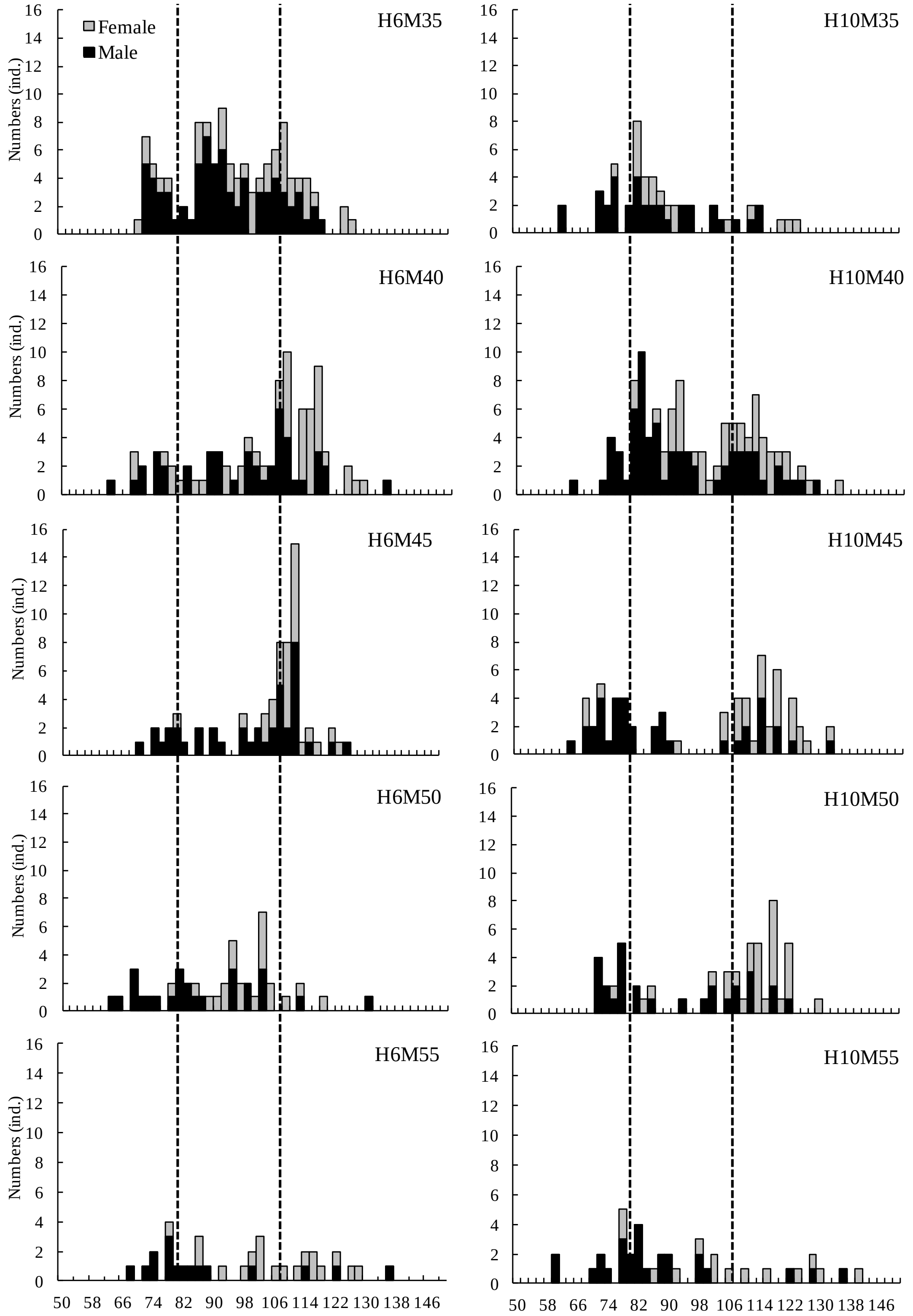

Figure 5. Comparison of the girth distribution of female *Larimichthys polyactis* (gray bars) with that of males (black bars) in the 10 gillnets. The vertical dashed lines indicate the position of the size at age 0+ and age 1+.

Fernández, and Morales-Nin (2010) suggested that the difference in the growth rate at the moment of first sexual maturity appeared to explain the sex-related growth pattern of *Diplodus annularis*. The reason for sex-specific differences in growth rate for *L. polyactis* is unclear and needs further investigation; the phenomenon is worthy of attention in size-selective fisheries. The proportions of males and females caught were 0.60 and 0.40 in the 10 m height, and 0.57 and 0.43 in the 6 m height gillnets, respectively.

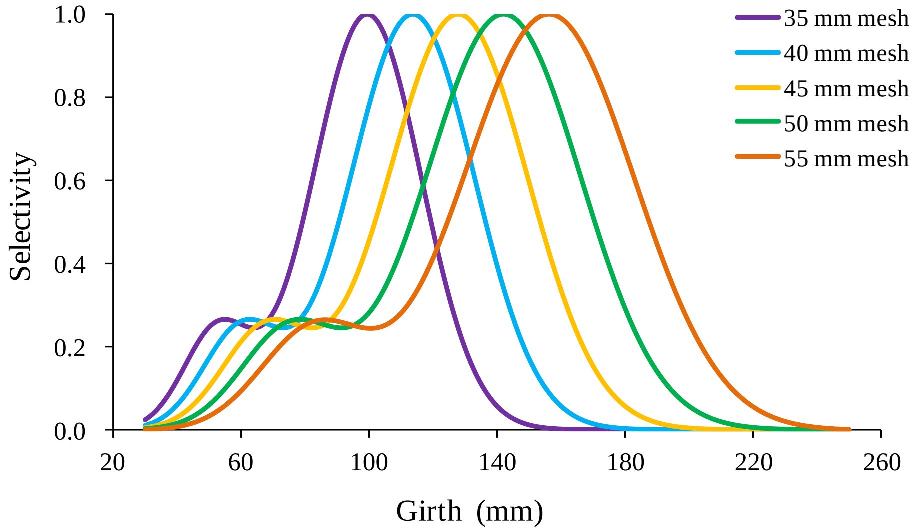

Figure 6. Selectivity curves for *Larimichthys polyactis* caught by gillnets in the southern Yellow Sea.

The proportions of males in the age 0+ group in the 6 m and 10 m height nets were 0.71 and 0.79, respectively. The sex ratio (female to male) of small yellow croaker in the catch composition depended on the selectivity of the fishing gear (Xiong *et al*., 2016). Kendall and Quinn (2013) reported that there were significantly higher catch rates for male Alaskan sockeye salmon *Oncorhynchus nerka* than for females over six decades, and revealed that skewed sex ratios may change intra-sexual competition and behavior characteristics of mate choice on the breeding grounds, altering the demographic and evolutionary pressures on fish. A similar viewpoint, that sexual selection likely caused greater fishery-induced evolution toward small individuals was favored by both Hutchings and Rowe (2008) and Urbach and Cotton (2008). Additionally, the changes of biological characteristics and population structure of *L. polyactis* have become particularly evident in commercially exploited fishery populations in China (Liang *et al*., 2014). The life span of *L. polyactis* has been reported to be 23 years at the most before the 1990s (Liu, Wu, & Han, 1990); however, in this study the age 0+ and age 1+ group dominated the catch in the gillnets. The population structure, composed of two age groups (age 0+ and age 1+) in gillnets was consistent with the results revealed by previous bottom trawl studies. The catches obtained with 10 m nets were characterized by the evident shift of sex ratio in favor of males. Using 10 m nets might result in high fishing pressure on the selectivity of male fish.

These considerations suggest that gillnets with mesh size of 45 mm and net height of 6 m are optimal, in order to obtain the best compromise between high attainable yields and reasonable probability of reducing the mortality of juveniles, as well as relieving simultaneous sexual selection associated with the size-selective fishing. From a management point of view on gillnet fishing, the results of this study may be used to determine the minimum gillnet mesh size for the small yellow croaker.

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