Sex Ratio and Size Composition of Striped Marlin *(Tetrapturus audax)* in Waters off Eastern Taiwan[1]

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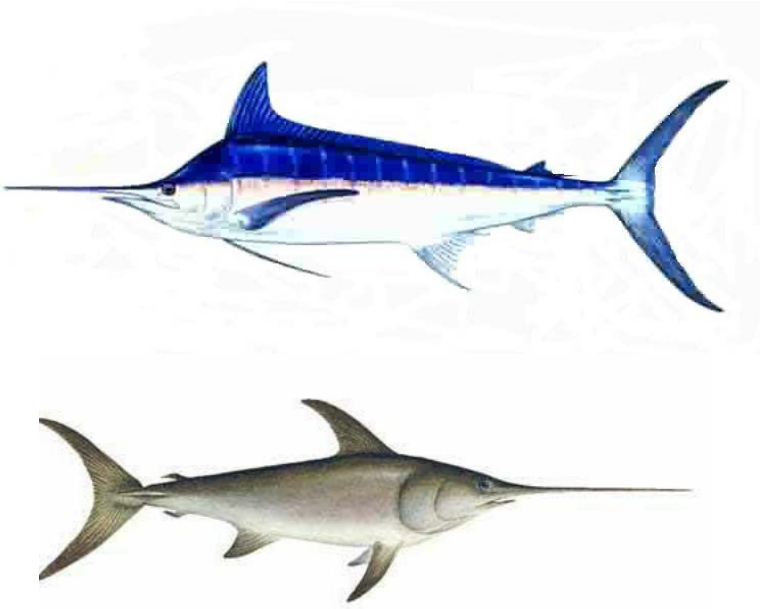

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Sex Ratio and Size Composition of Striped Marlin (*Tetrapturus audax*) in Waters off Eastern Taiwan*

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Introduction

Striped marlin is one of the important economic billfishes in the waters off Taiwan's eastern coast. For the past five years, annual landings of striped marlin from Taiwanese eastern coastal and offshore fisheries have fluctuated from 115 to 50 metric tons, of which more than 35% are from waters off Shinkang area (Fig.1). In the waters off eastern Taiwan, striped marlin is taken primarily by drift gill nets, secondarily by harpoons and as incidental bycatch in offshore longline fisheries (Fig.2). The biological data provide basic information for stock assessment (Hilborn and Walters 1992). In this report, we describe the sex ratio and sex-specific size composition data for striped marlin in the eastern Taiwanese coastal and offshore fisheries.

Data Collection

The historical catch data of striped marlin in the eastern coastal and offshore waters of Taiwan were provided by the Shinkang Fishermen's Association from June 1999 to February 2007. Biological data were collected monthly at Shinkang fishing port (Fig.3) from November 2004 to December 2006. Specimens were selected at random from landings and length/weight data and gonad samples were collected. The sex of each specimen was identified based on the appearance of the gonads. Sex ratio was expressed as proportion of females to total numbers of females and males by size class (5-cm length or 5-kg weight intervals) and by fishing methods. Specimens were measured to the nearest centimeter for length (EFL = eye fork length, LJFL = lower jaw to fork length), to the nearest kilogram for weight (RW) and to the nearest 0.1 g for ovarian weight (OW). Gonads were preserved in 10% sea water formalin and the

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dorsal fin samples were kept in cold storage. Both of them will be used for histological examination and age study in the near future.

Results and Discussions

The weight-frequency distribution of the striped marlin landed in Shinkang fish market during June 1999 to February 2007 are shown in Figure 4. These samples caught from eastern waters by all gears combined ranged from 10 to 140 kg RW (mean=40.74, SD=18.71). No fish are larger than 140 kg in RW. The weight data used in this report were preliminarily, from the daily electronic fish market report, more data will be needed from the adjacent fishermen's association.

The landing data by gear and by season interval during the sampling period are shown in Figure 5. In all seasons except for the 2nd season of 2005 and 2006, gillnet contributed more than 80% of the catch. Seasonal abundancy is not clear for the striped marlin in eastern Taiwan. However, it should be noted that the sample sizes in some seasons were small.

The LJFL and RW of 340 males and 253 females were measured for size-specific sex ratio analysis. The range of the LJFL was 121-243 cm for males and 122-249 cm for females, and the range of RW was 10-109 kg for males and 11-131 kg for females (Figs. 6, 7). Table 1 summarizes the relationships between EFL and LJFL and TL, and that between LJFL and weight. The latter relationship differed significantly between males and females (analysis of covariance; $P<0.05$).

The estimated sex ratio for all samples was 0.43 which differed significantly from the expected value of 0.5 or 1:1 ($\chi 2 = 12.76$; $P < 0.005$). The proportion of males was higher than the proportion of females for gillnet and longline (Table 2). Sex ratios differed significantly from the expected value of 0.5 in gillnet. However, it should be noted that the sample sizes in longline and harpoon were small. Sex ratio of striped marlin differed significantly with size, increasing with size for length > 155 cm LJFL. All striped marlin > 110 kg were females. Billfishes have a clear sexual dimorphism, which may result from growth rate differences between males and females (Sun et al., 2002, Chiang et al., 2004).

The length frequency distribution by gear of striped marlin showed significant differences between samples (ANOVA, $F= 6.95$; df: 2, 590; $p<0.05$)(Fig. 8), whatever the gear used, the mean of the LJFL of females was always higher. The gillnet caught striped marlin had a larger length range, the maximum LJFL is 248 cm for gillnet, compared to 228 and 223 cm LJFL for longline and harpoon (the mean was 183.4± 24.2, 175.6±24.8, 189.8±19.6 cm LJFL, respectively) (Table 3). The size-selectivity of

fishing gear must be taken into consideration when stock assessment is done in near future.

Research

The Kuroshio flows through the eastern Taiwan waters from south to north and is abundant in pelagic fishes, such as billfishes, tunas, tunalike species and dolphin fish. Many species migrate with this warm water mass to eastern Taiwan for feeding and spawning in spring and summer, making this area one of the important fishing grounds in Taiwan waters for migratory fishes. Sex-specific size composition data and biological information for billfish have been collected for these years in Eastern Marine Biology Research Center (EMBRC) of Fisheries Research Institute. In future, population dynamic and stock assessment studies of striped marlin will be conducted in collaboration with Dr. Chi-Lu Sun's laboratory at Institute of Ocenography, National Taiwan University.

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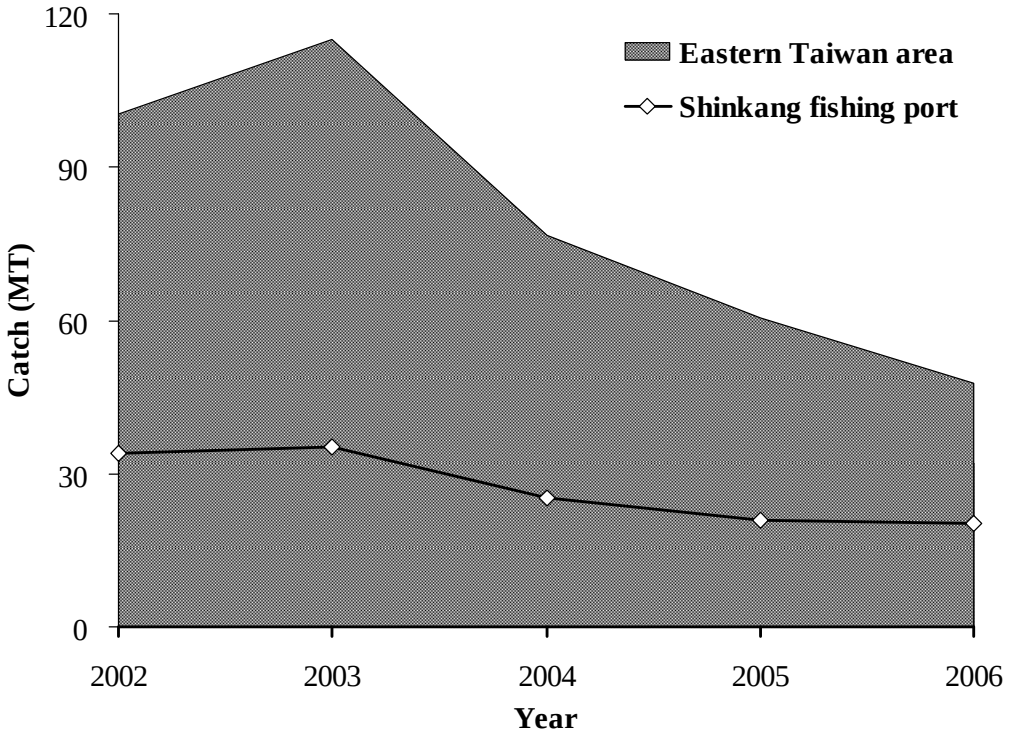

Fig. 1. Annual total landings of striped marlin (*T. audax*) in Taiwan and eastern counties and Shinkang fishing port. (Data source: Shinkang, Hualien and Suao Fishermen's Association)

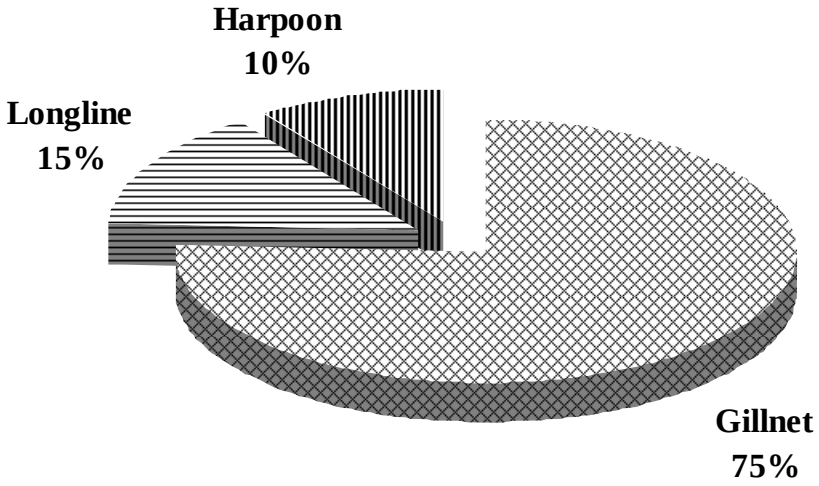

Fig. 2. Percent catches by gear of striped marlin (*T. audax*) landed in Shinkang fish market during November 2004 to December 2006. (Data source: Shinkang Fishermen's Association)

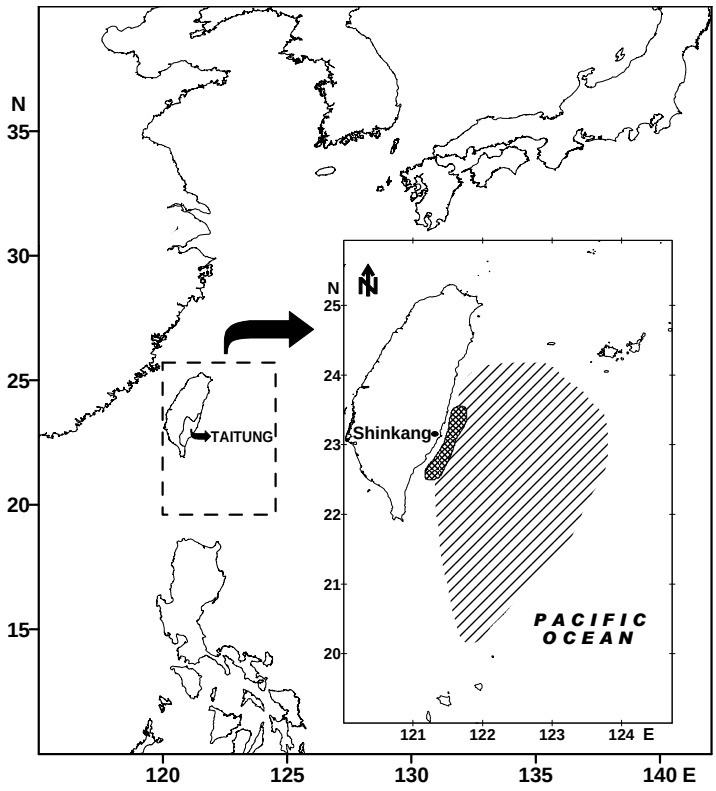

Fig. 3. The fishing grounds of gillnet and harpoon (cross lines) and longline (oblique lines) fishing boats based in Shinkang fishing port.

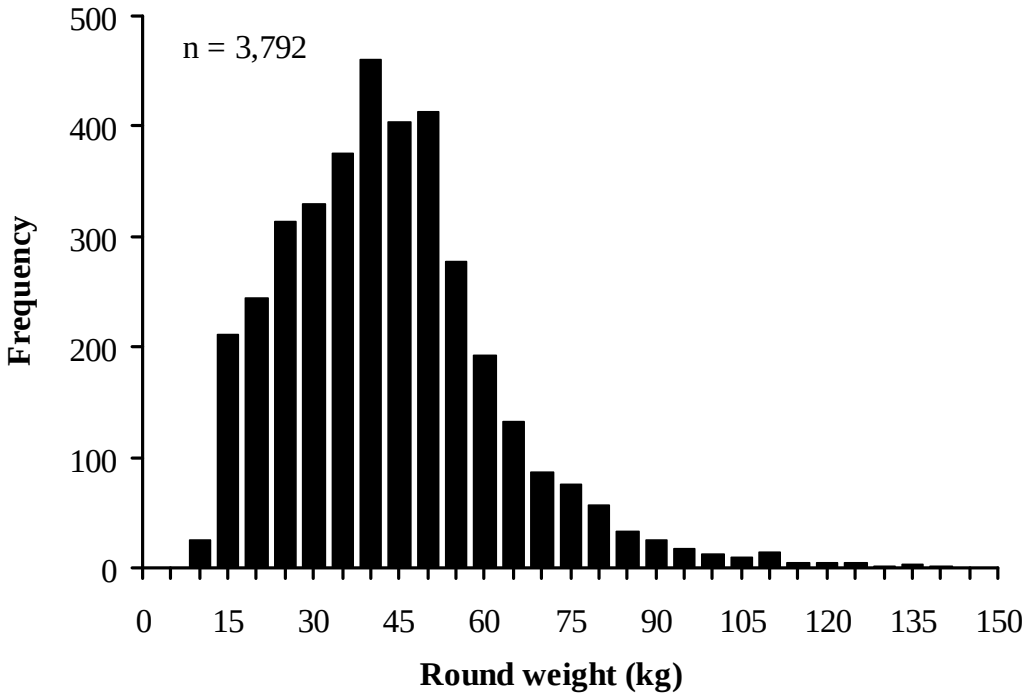

Fig. 4. The size-frequency distribution by 5-kg intervals for the striped marlin (*T. audax*) landed in Shinkang fish market during June 1999 to Febuary 2007.

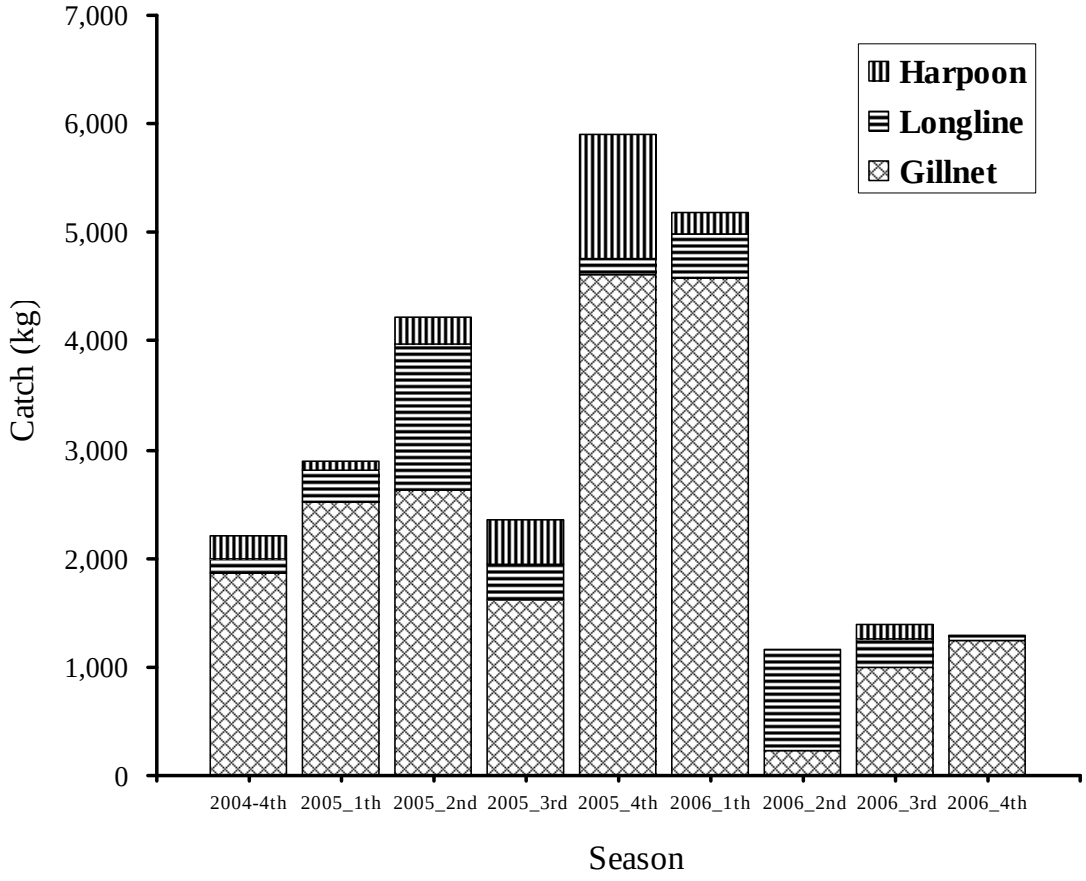

Fig. 5. The total catches by gear of striped marlin (*T. audax*) grouped by season interval in Shinkang fish market during November 2004 to December 2006.

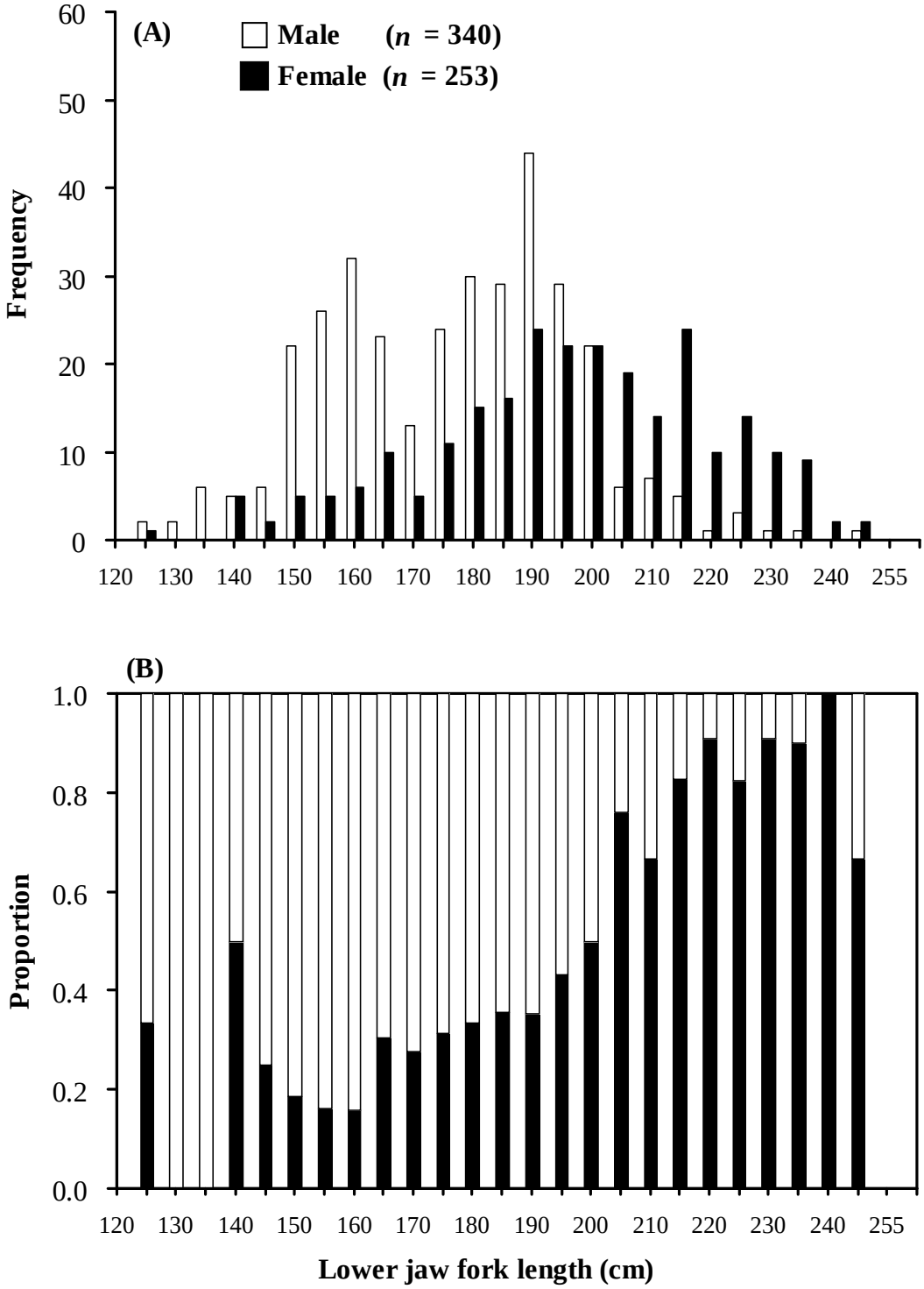

Fig. 6. The size-specific size frequency (A) and sex ratios (B) by 5-cm interval for the striped marlin (*T. audax*) collected from the waters off eastern Taiwan.

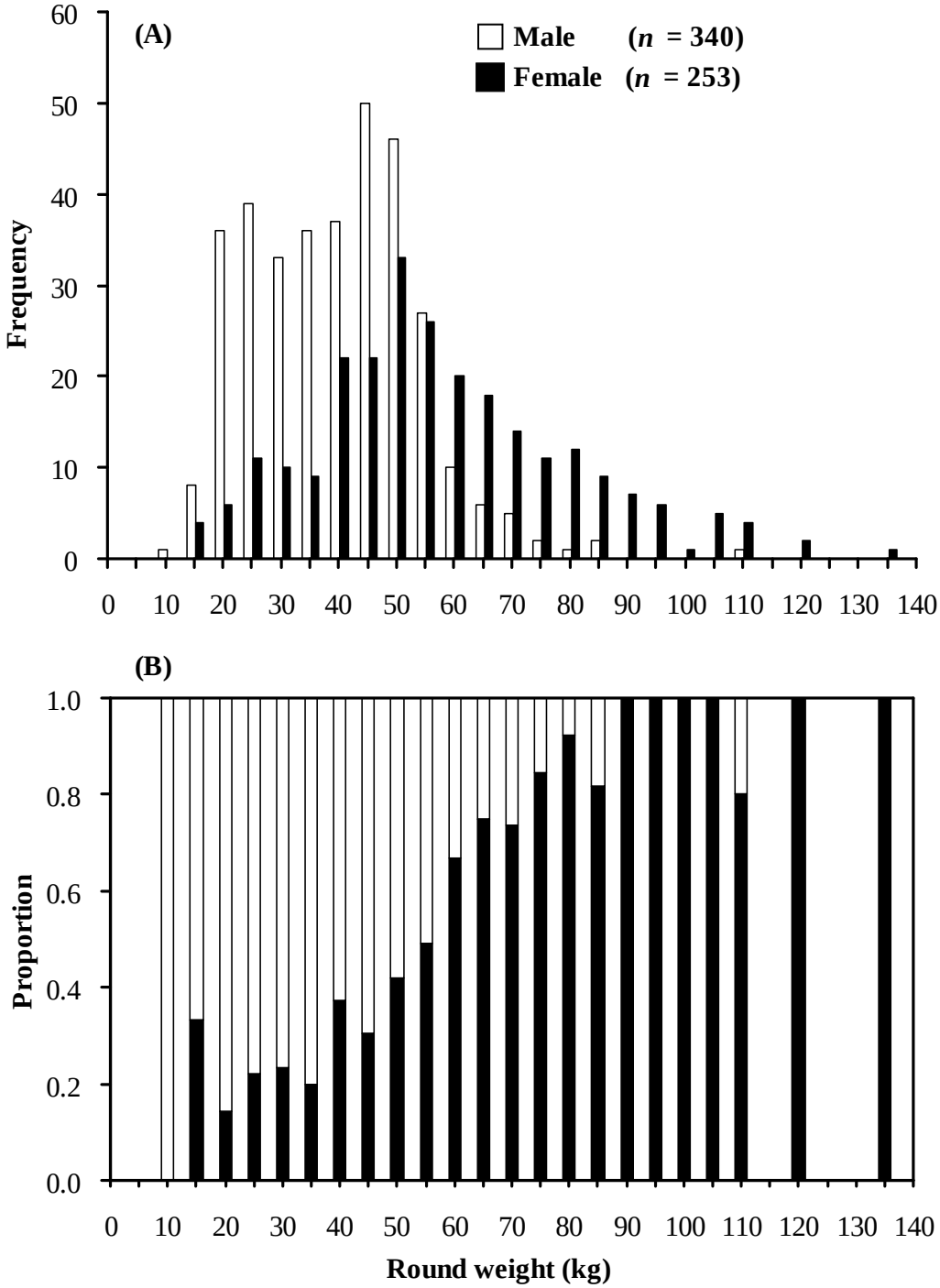

Fig. 7. The sex-specific size-frequency (A) and sex ratios (B) by 5-kg interval for the striped marlin (*T. audax*) collected from the waters off eastern Taiwan.

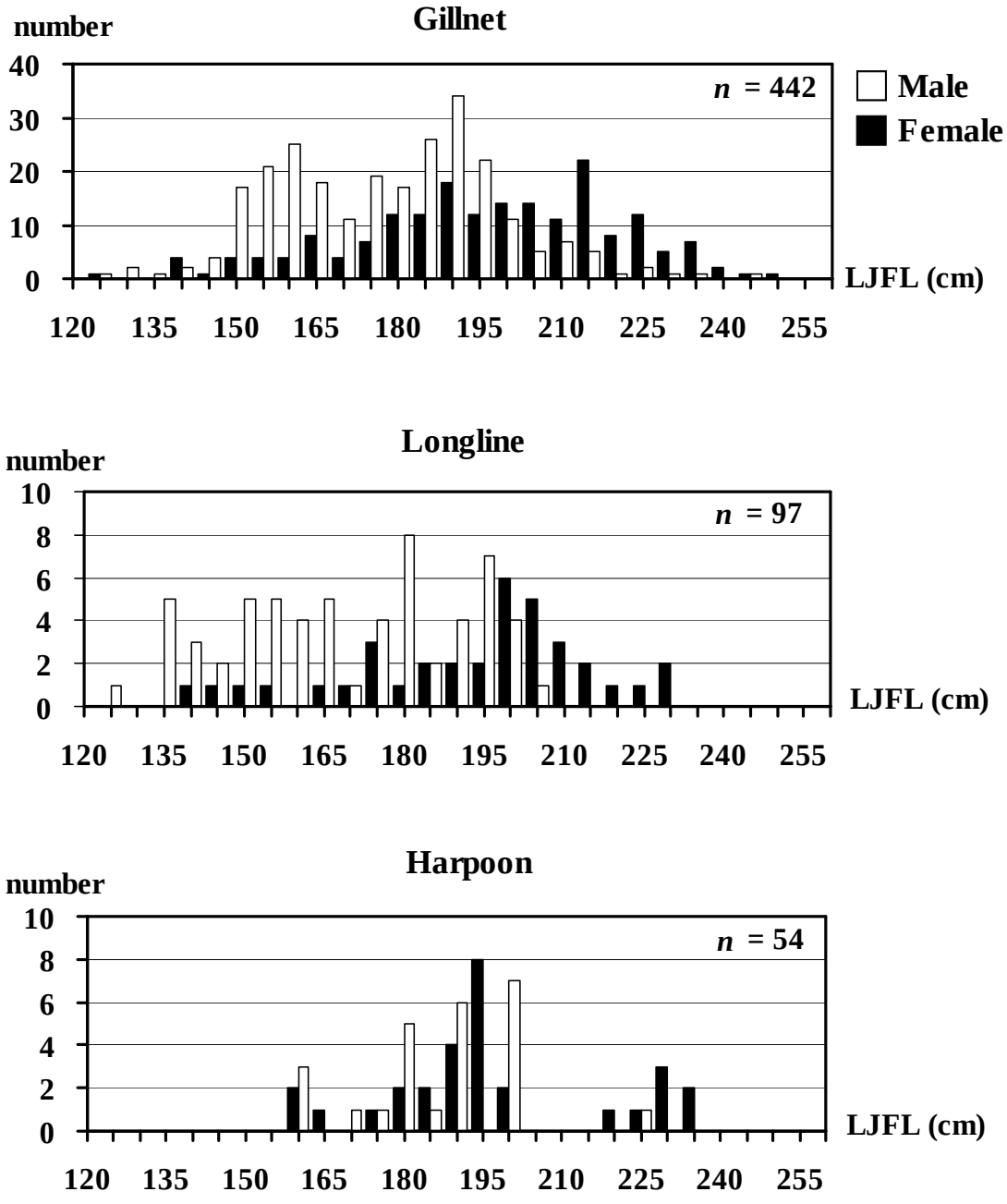

Fig. 8. The sex-soecific size-frequency by gear and by 5-cm interval for the striped marlin (*T. audax*) collected from the waters off eastern Taiwan.

Table 1. Sex-specific linear relationships ($Y = a + bX$) between total length (TL, cm) and lower jaw fork length (LJFL, cm) and eye fork length (EFL, cm), and the log-linear length-weight (round weight, RW, kg) relationships for striped marlin (*T. audax*) in eastern Taiwan waters. Values in parentheses are standard errors.

Y	*X*	*a*	*b*	*n*	*LJFL* Range (cm)	*RW* Range (kg)	r^2
Male							
TL	*LJFL*	6.084 (7.896)	1.257 (0.047)	37	134–223		0.953
TL	*EFL*	20.718 (7.829)	1.383 (0.055)	37	134–223		0.948
EFL	*LJFL*	–4.652 (1.133)	0.881 (0.006)	340	121–243		0.982
$\log_{10}RW$	$\log_{10}LJFL$	–5.696 (0.116)	3.233 (0.052)	340	121–243	10–109	0.920
Female							
TL	*LJFL*	–2.93 (16.238)	1.294 (0.091)	14	136–222		0.944
TL	*EFL*	11.123 (16.700)	1.431 (0.110)	14	136–222		0.820
EFL	*LJFL*	0.443 (1.328)	0.856 (0.007)	253	122–249		0.984
$\log_{10}RW$	$\log_{10}LJFL$	–5.756 (0.154)	3.267 (0.067)	253	122–249	11–131	0.904

Table 2. Numbers of male and female striped marlin (*T. audax*) and the sex ratios by gear with chi-square values assuming a 1:1 sex ratio in each gear, and the chi-square values assuming a homogeneous sex ratio among gears.

Fishing method	Number of females	Number of males	Total	Sex ratio (female/total)	χ^2	*p*
Gillnet	188	254	442	0.43	9.86	< 0.005
Longline	36	61	97	0.37	6.44	0.011
Harpoon	29	25	54	0.54	0.30	0.586
Total	253	340	593	0.43	12.76	< 0.005
χ^2 among intervals					3.92	0.27

Table 3. Size composition by sex and by gear for the striped marlin (*T. audax*) collected during November 2004 to December 2006 from the waters off eastern Taiwan.

Fishing method	Female		Male		Total	
	Range (cm)	Mean ± SD (cm)	Range (cm)	Mean ± SD (cm)	Range (cm)	Mean ± SD (cm)
Gillnet	121～248	194.6 ± 24.5	121 ～243	175.2 ± 20.4	121 ～248	183.46 ± 24.2
Longline	137～228	190.7 ± 22.7	121 ～204	166.6 ± 21.6	121 ～228	175.6 ± 24.8
Harpoon	156～233	194.5 ± 21.9	156 ～223	184.4 ± 15.3	156 ～233	189.8 ± 19.6
Total	121～248	194.1 ± 23.9	121 ～243	174.3 ± 20.7		