NOTE

LENGTH DISTRIBUTIONS, WEIGHT-LENGTH RELATIONSHIPS, AND SEX RATIOS AT LENGTHS FOR THE BILLFISHES IN TAIWAN WATERS

Sheng-Ping Wang, Chi-Lu Sun, Su-Zan Yeh, Wei-Chuan Chiang, Nan-Jay Su, Yi-Jay Chang, and Chien-Hsian Liu

In the waters around Taiwan, the catches of billfishes consist of swordfish, *Xiphias gladius* (Linnaeus, 1758), striped marlin, *Tetrapturus audax* (Philippi, 1887), blue marlin, *Makaira mazara* (Jordan and Snyder, 1901), black marlin, *Makaira indica* (Cuvier, 1832), and sailfish, *Istiophorus platypterus* (Shaw in Shaw and Nodder, 1792). Most of the catch is taken by offshore longline, followed by offshore gillnet and coastal harpoon fisheries (Sun et al., 2005). Historically, the catches of blue marlin have been larger than that of swordfish and the catch of both species usually exceeds that of the other billfishes. Blue marlin and swordfish are primarily taken as by-catch of the offshore longline fishery targetting yellowfin and bigeye tunas. For black marlin, catches are made primarily by coastal harpoon and offshore longline, whereas offshore gillnet catches rates of sailfish are similar to those of the offshore longline fishery. Comparatively, the catches of striped marlin are slightly less than those of the other billfishes.

Size and sex ratio data provide basic information for stock assessment. Here we report the sex and size data for five species of billfishes caught by the Taiwanese offshore and coastal fisheries.

Material and Methods

Sex and size data were collected from the landings of the Taiwanese offshore longline, offshore gillnet, and coastal harpoon fisheries at the following three fishing ports, Tungkang, Nanfanao, and Shinkang (Fig. 1), over various sampling periods from 1997 to 2005 (Table 1). Lower jaw fork length (*LJFL*, cm) and body weight (kg) were measured for each sample and sex was determined by the appearance of gonads. The likelihood ratio test (Huelsenbeck and Bull, 1996) was used to test for differences in the length-weight relationship between sex. Sex ratios of each species (the proportion of females to the total samples) varied with size and were fitted by either a power function or logistic regression.

Results and Discussion

Sex-specific size frequency distributions indicated that for all billfishes, females grew to larger body lengths than the males and encompassed a greater range of lengths (Fig. 2). Female swordfish, blue marlin, and black marlin grew to lengths of ≥ 300 cm LFJL. The lengths of most of the male billfishes' ranged between 150 and 200 cm, except for the swordfish whose lengths ranged from 100 to 170 cm.

Results of likelihood ratio tests indicated that the length-weight relationship did not differ significantly between sexes for all the billfishes (P = 0.79–0.96) so the data

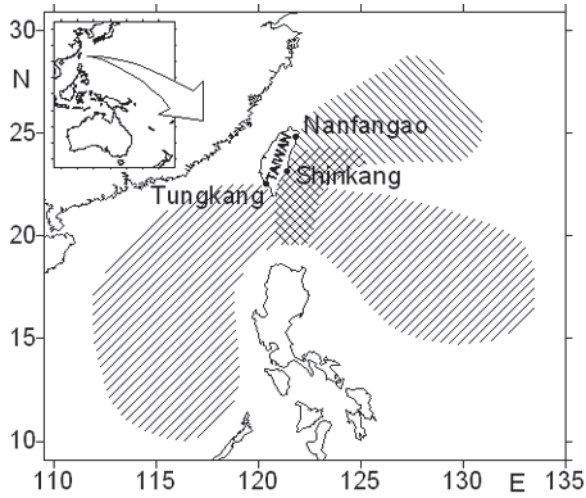

Figure 1. Three fishing ports in Taiwan where the size data of billfishes were collected (right diagonal, left diagonal, and mesh represent the fishing area for the fleets based at Tungkang, Nanfanao and Shinkang, respectively).

were pooled (Fig. 3). This contrasts with a previous finding by Chiang et al. (2004) who used an analysis of covariance to demonstrate a sexually dimorphic relationship for sailfish. The difference between these findings for sailfish may be due to our use of updated data and different statistical analyses.

Sex ratios for swordfish, blue marlin, black marlin, and sailfish differed significantly with size, increasing for lengths > 150 cm (Fig. 4). All swordfish > 210 cm, all blue marlin > 280 cm, all black marlin > 270 cm, and all sailfish > 230 cm were females. The relationships between sex ratios and *LJFL*s were well described by power functions for striped marlin, sailfish, and swordfish (Wang et al., 2003), while for blue and black marlins, the relationships were best described by logistic curves (Table 2). Although the sample size of striped marlin was small compared to those of the other billfishes, the sex ratio also increased with length.

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Table 1. The sampling periods and locations for the billfishes caught by the Taiwanese offshore and coastal fisheries.

Species	Location	Period
Swordfish	Tungkang, Nanfanao, and Shinkang	Sep. 1997–Sep. 2001
Striped marlin	Shinkang	Jul. 2004–Jul. 2005
Blue marlin	Tungkang	Jan. 2001–Dec. 2001
	Shinkang	Jul. 2004–Jun. 2005
Black marlin	Shinkang	Jul. 2004–Jul. 2005
Sailfish	Shinkang	Jul. 1997–Jul. 2005

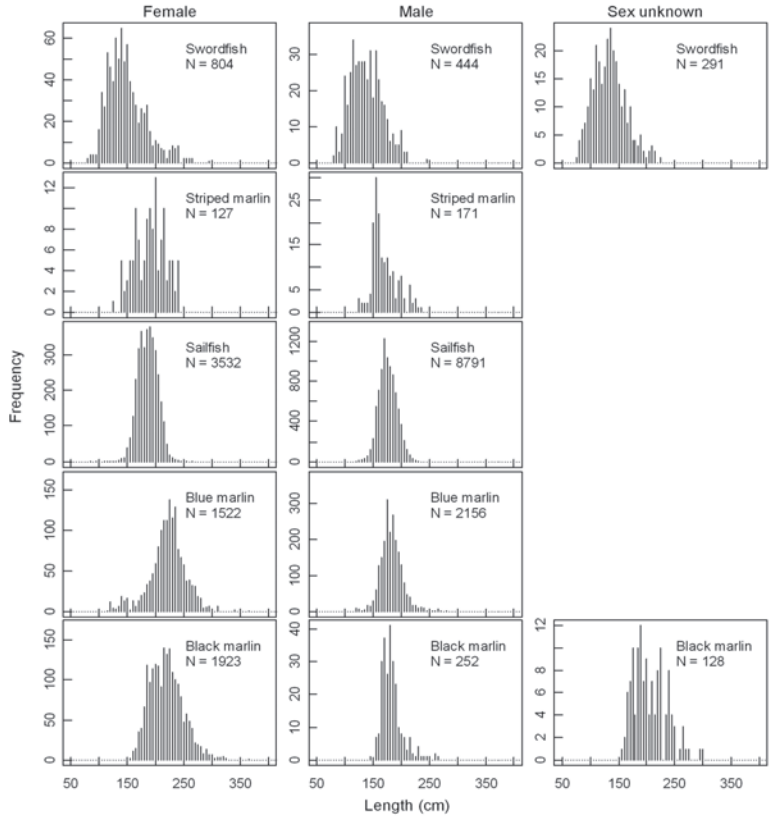

Figure 2. Length (lower jaw fork length) frequency distributions by 5 cm intervals for five species of billfish caught by the Taiwanese offshore and coastal fisheries.

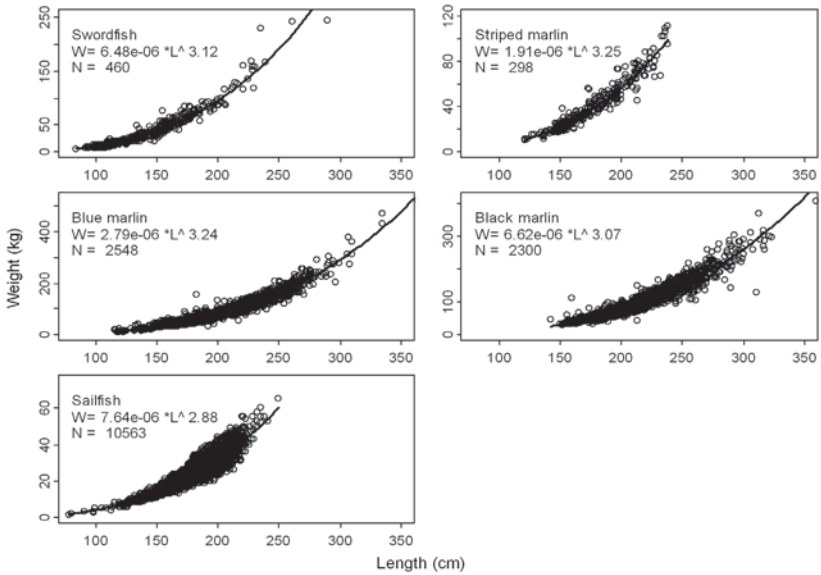

Figure 3. Length-weight relationships for five species of billfish caught by the Taiwanese offshore and coastal fisheries. Data from both sexes were pooled.

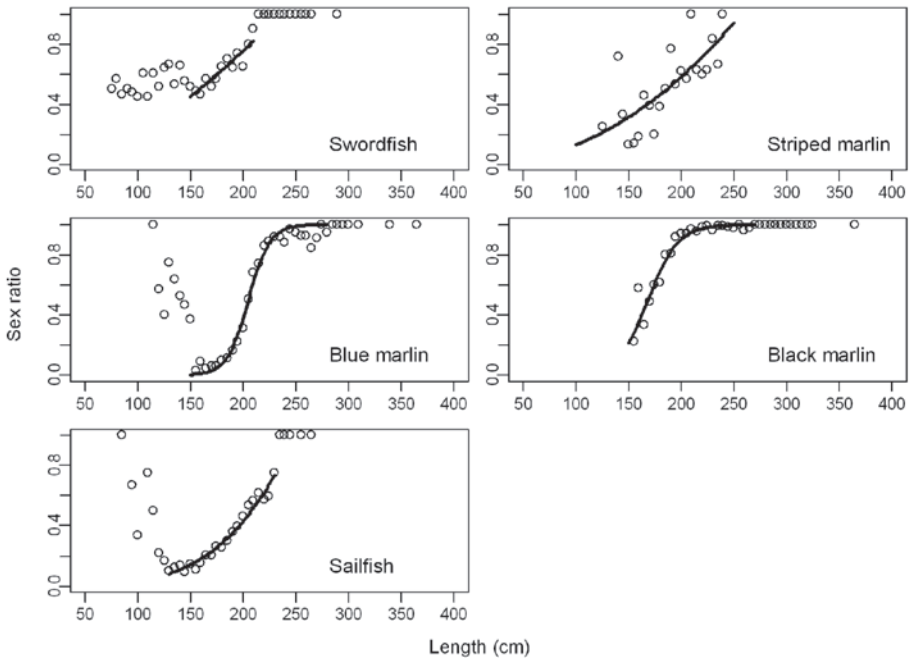

Figure 4. Relationship between sex ratio and lower jaw fork length (in 5 cm intervals) for the five billfish species caught by the Taiwanese offshore and coastal fisheries. Lines are best fit power and logistic curves (Table 2).

Table 2. Relationships between sex ratio and lower jaw fork lengths (*LJFL*) for billfishes caught by the Taiwanese offshore and coastal fisheries.

Species	*LJFL* (cm)	Relationship	R^2
Swordfish	150–210	Sex ratio = $1.1263 \times 10^{-4}\, LJFL^{1.6601}$	0.83
Striped marlin	100–250	Sex ratio = $6.7619 \times 10^{-6}\, LJFL^{2.1455}$	0.54
Blue marlin	150–280	Sex ratio = $1/\,[(1 + e^{-0.0993(LJFL-205.1518)}]$	0.96
Black marlin	150–270	Sex ratio = $1/\,[(1 + e^{-0.0699(LJFL-168.4437)}]$	0.94
Sailfish	130–230	Sex ratio = $6.0403 \times 10^{-10}\, LJFL^{3.8467}$	0.97

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Literature Cited

Chiang, W. C., C. L. Sun, and S. Z. Yeh. 2004. Age and growth of sailfish (*Istiophorus platypterus*) in waters off eastern Taiwan. Fish. Bull. 102: 251–263.

Huelsenbeck, J. P. and J. J. Bull. 1996. A likelihood ratio test to detect conflicting phylogenetic signal. Syst. Biol. 45: 92–98.

Sun, C. L., S. Z. Yeh, S. P. Wang, W. C. Chiang, and N. J. Su. 2005. A review of Taiwan's billfish fishery in the Pacific Ocean. The 1st Joint Intercessional Meeting of the Marlin and Swordfish Working Groups of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific. August 29, 2005–September 2, 2005, Shimizu, Japan. ISC/05/MAR&SWO-WGs/7. 16 p

Wang, S. P., C. L. Sun, and S. Z. Yeh. 2003. Sex Ratios and Sexual Maturity of Swordfish (*Xiphias gladius* L.) in the Waters of Taiwan. Zool. Studies 42: 529–539.

Addresses: (S.-P.W.) *Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Keelung 202, Taiwan.* (C.-L.S., S.-Z.Y., N.-J.S., Y.-J.C., C.-H.L.) *Institute of Oceanography, National Taiwan University, Taipei 106, Taiwan.* (W.-C.C.) *Eastern Marine Biology Research Center of Fisheries Research Institute, Council of Agriculture, Executive Yuan, Taitung 961, Taiwan.* Corresponding Author: (C.-L.S.) *E-mail: <chilu@ntu.edu.tw>.*