

Updated size composition of shortfin mako shark caught by the Taiwanese tuna longline fishery in the North Pacific Ocean ¹

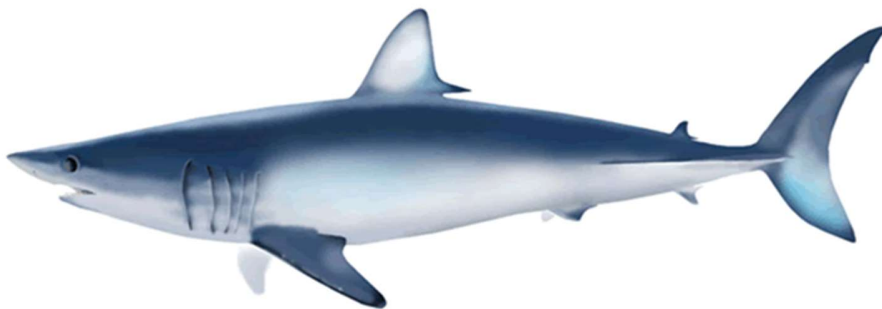
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ABSTRACT

This study presents size data of shortfin mako sharks caught by two types of Taiwanese tuna longline vessels: large-scale tuna longline vessels (LTLL, ≥ 100 GRT) and small-scale tuna longline vessels (STLL, < 100 GRT). Size data were obtained by converting recorded measurements to pre-caudal length (PCL) using available conversion equations. For STLL, spanning from 1989 to 2019 in the North Pacific, female shortfin mako sizes ranged from 61 to 338 cm PCL ($n = 116,281$), and males ranged from 60 to 262 cm PCL ($n = 108,505$). The logbook data for LTLL from 2005 to 2019 included 11,173 individuals (sexes combined) with sizes ranging from 61 to 303 cm PCL. Size distribution analysis revealed bimodal patterns in STLL catches, indicating a prevalence of immature fish (female < 228 cm, male < 172 cm PCL). The capture of a high proportion of immature sharks poses sustainability concerns for the fishery.

1. Introduction

The shortfin mako shark (*Isurus oxyrinchus*) is a prominent species in the Taiwanese commercial offshore longline fishery, especially in tuna longline operations in distant seas. Known for slow growth, low fecundity, and late maturity, the shortfin mako is susceptible to overexploitation. Approximately half a million shortfin mako sharks were reported in the global shark fin trade in 2000 (Clarke et al., 2006), leading to its "Endangered" status on the IUCN Red List of Threatened Species (Rigby et al., 2019) and inclusion in CITES Appendix II (CITES, 2019). Despite stock assessments by the ISC Shark Working Group in 2018, concerns about the stock status in the North Pacific persist. Size-frequency data are crucial for stock assessment modeling, providing insights into recruitment, growth, and mortality. This study aims to update size distributions of shortfin mako caught by Taiwanese tuna longline fisheries to contribute baseline information for fishery research and management.

2. Material and Methods

2.1. Analysis of Size Frequency

Data from two fisheries were used: commercial landing data for STLL and logbook data for LTLL. STLL catch data, primarily landed at the Nanfangao fish market, included whole weights and opportunistic measurements of total length (TL), fork length (FL), and pre-caudal length (PCL). Sex information for STLL was derived from weight-specific sex ratios estimated from a sub-sample of fish collected between 1995 and 2005 ($n=1944$). The fork length measurements of these specimens were taken and their sexes were identified. The sex ratios (the proportion of females) of sharks smaller than 130 kg and greater than 230 kg were set as 0.5 and 1.0, respectively, based on our observations. For fish between 130 and 230 kg,

the sex ratio of weight (S_w) was obtained from W through the equation $S_w = 8.35 \times 10^{-3} W^{0.876}$ (Tsai et al., 2011). The whole weights were then converted to pre-caudal length (PCL) using the sex-specific W-PCL relationships: $W = 3.4 \times 10^{-5} PCL^{2.84}$ for female and $W = 4.62 \times 10^{-5} PCL^{2.77}$ for male, respectively (Su et al., 2017). LTLL logbook data, covering 2005-2022, provided daily position, number of hooks used, catches by species, and length measurements of the first 30 fishes per operation. Sex-specific W-PCL relationships converted whole weights to PCL for LTLL.

3. Results and discussion

Using the weight-specific sex ratio, 235,086 shortfin mako sharks landed at Nanfangao fish market between January 1989 and December 2022 were separated into 121,703 females and 113,383 males. For STLL, female sizes ranged from 55 to 338 cm PCL (Figure 1), males from 60 to 262 cm PCL (Figure 2), with modes around 148 cm for females and 149 cm for males. Generally, the modes in the size distributions were similar for both sexes. The length frequency distribution exhibited two modes at 100 cm and 150 cm PCL post-1995, suggesting an increase in smaller-sized fish. Different fishing gears and fishing grounds for large mesh drift net (coastal), STLL < 50 GRT (offshore), and STLL > 50 GRT (far sea) are possible reasons resulted in the two modes.

LTLL catches showed similar bimodal size distributions, with sizes ranging from 58 to 247 cm PCL and a mode at approximately 131 cm PCL (Figure 3). Significant differences in mean PCL were found among areas (A, B, C, D) in the North Pacific (Figure 4, Table 1). Significant difference in mean PCL among areas was found ($P < 0.05$) except between areas A and D ($P > 0.05$). The mean PCL of shortfin mako shark by $5^\circ \times 5^\circ$ grid indicated that the mean sizes in the waters north of 25° and the East Pacific were larger than that in the tropic waters (Figure 5).

Comparison between STLL and LTLL suggested that LTLL caught smaller shortfin mako, potentially due to differences in fishing grounds and hook numbers. The bimodal distributions (mostly 100 and 150 cm PCL) indicated a predominance of immature fish (female < 228 cm, male < 172 cm PCL) in the catches, raising concerns for population sustainability. Furthermore, information on the size at birth and size at maturity (Joung and Hsu, 2005) indicated that the species was vulnerable to capture immediately after birth, and that immature sharks formed a large component of the landings, particularly in the case of females (Tsai et al., 2014). Precautionary management measures should be considered to ensure the viability of North Pacific shortfin mako stock.

References

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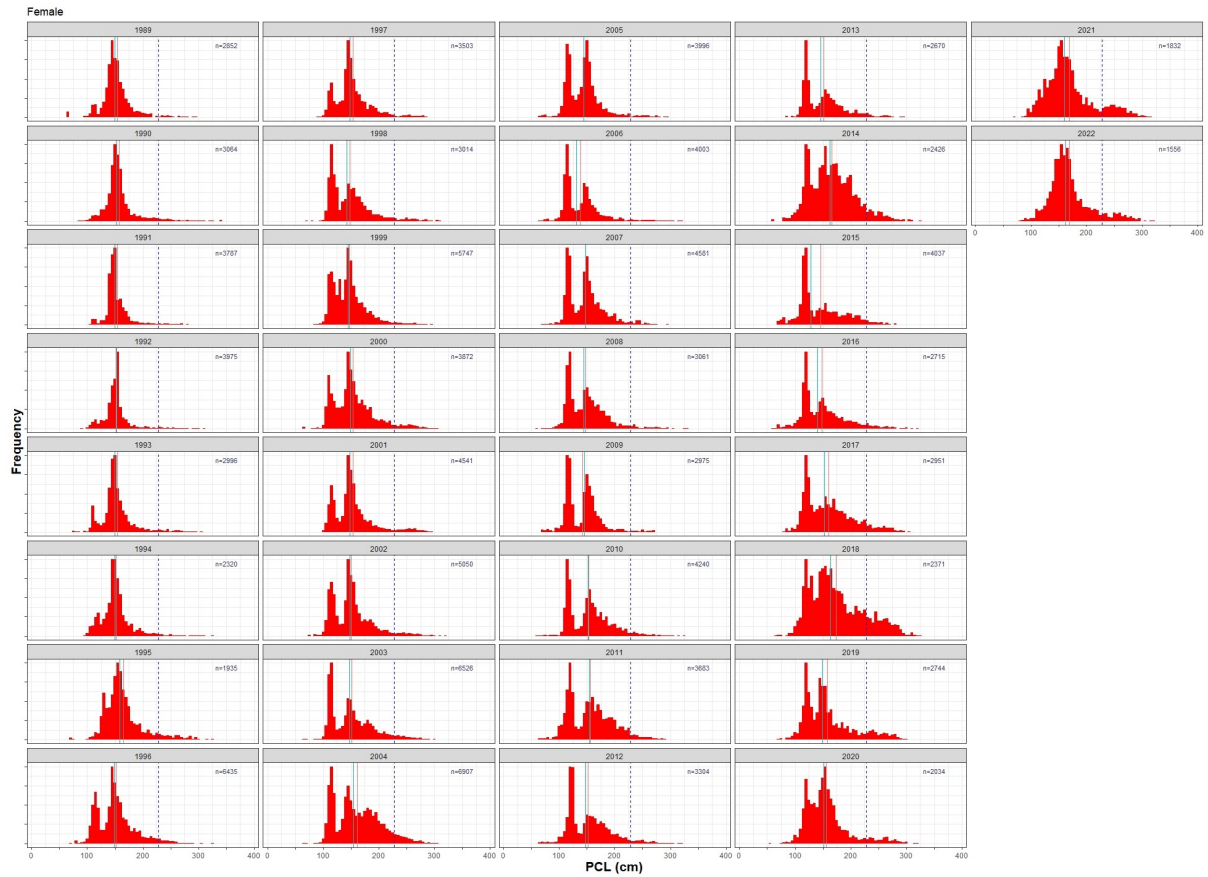


Figure 1. Length frequency of female shortfin mako shark caught by the Taiwanese STLL vessels in the North Pacific.
 (blue line: mean length at maturity; green line: mean pre-caudal length; pink line: mode pre-caudal length)

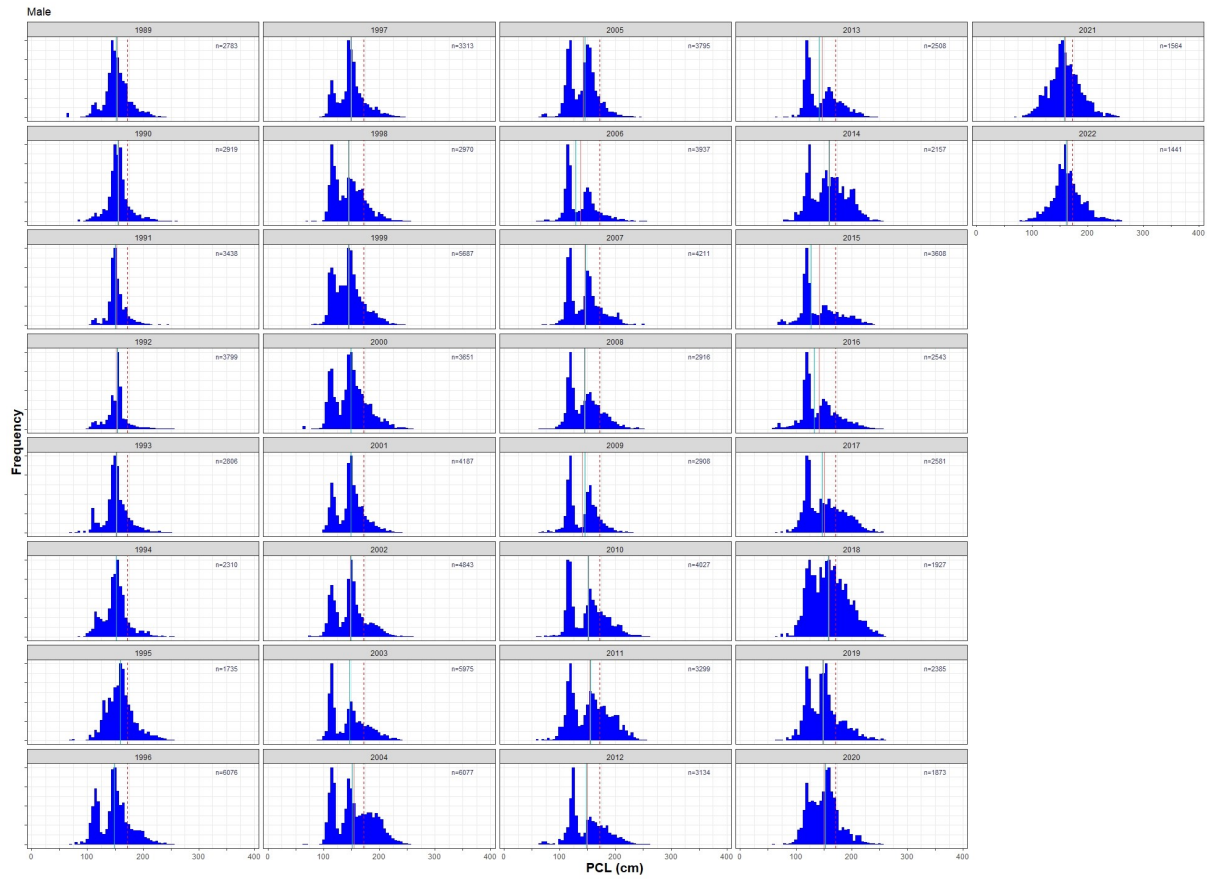


Figure 2. Length frequency of male shortfin mako shark caught by the Taiwanese STLL vessels in the North Pacific.
 (red line: mean length at maturity; green line: mean pre-caudal length; pink line: mode pre-caudal length)

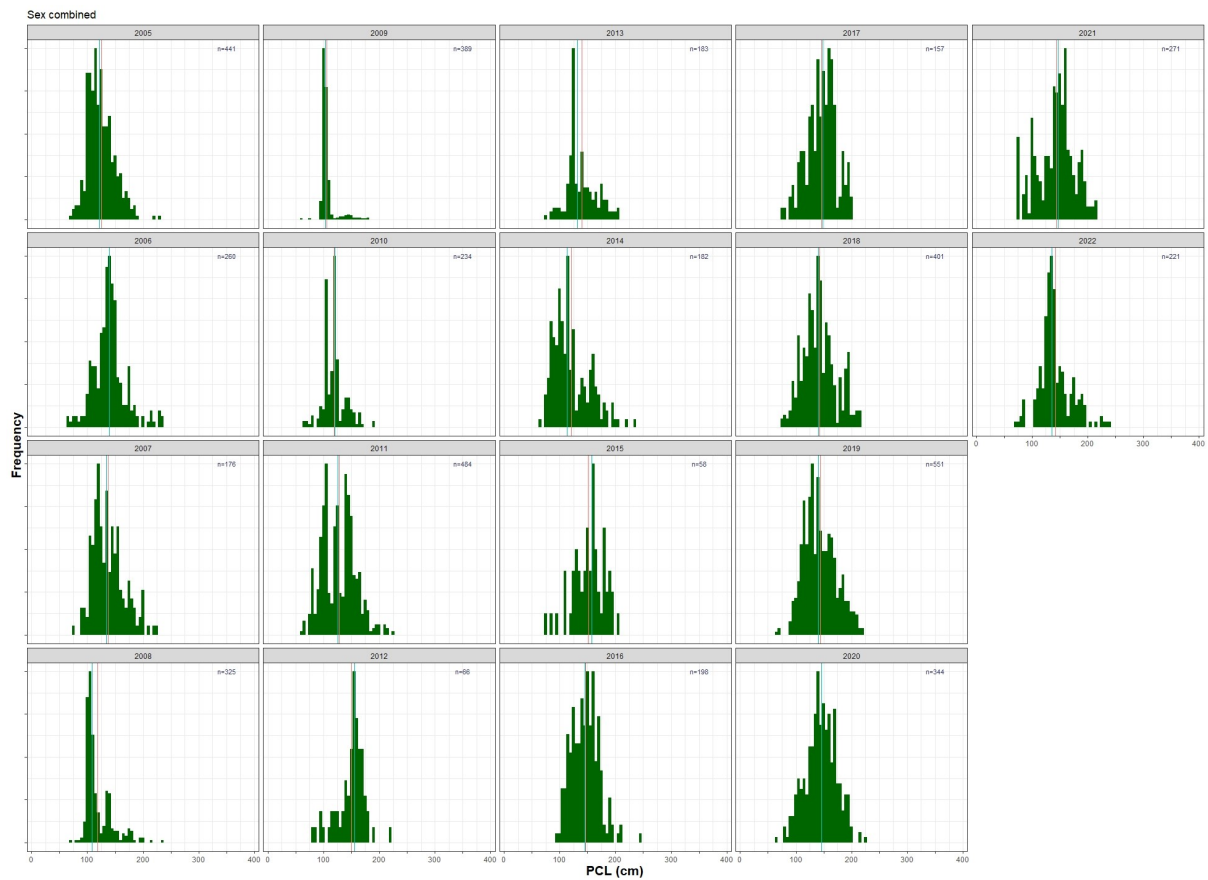


Figure 3. Length frequency (sexes combined) of shortfin mako shark caught by the Taiwanese LTLL vessels in the North Pacific.

(green line: mean pre-caudal length; pink line: mode pre-caudal length)

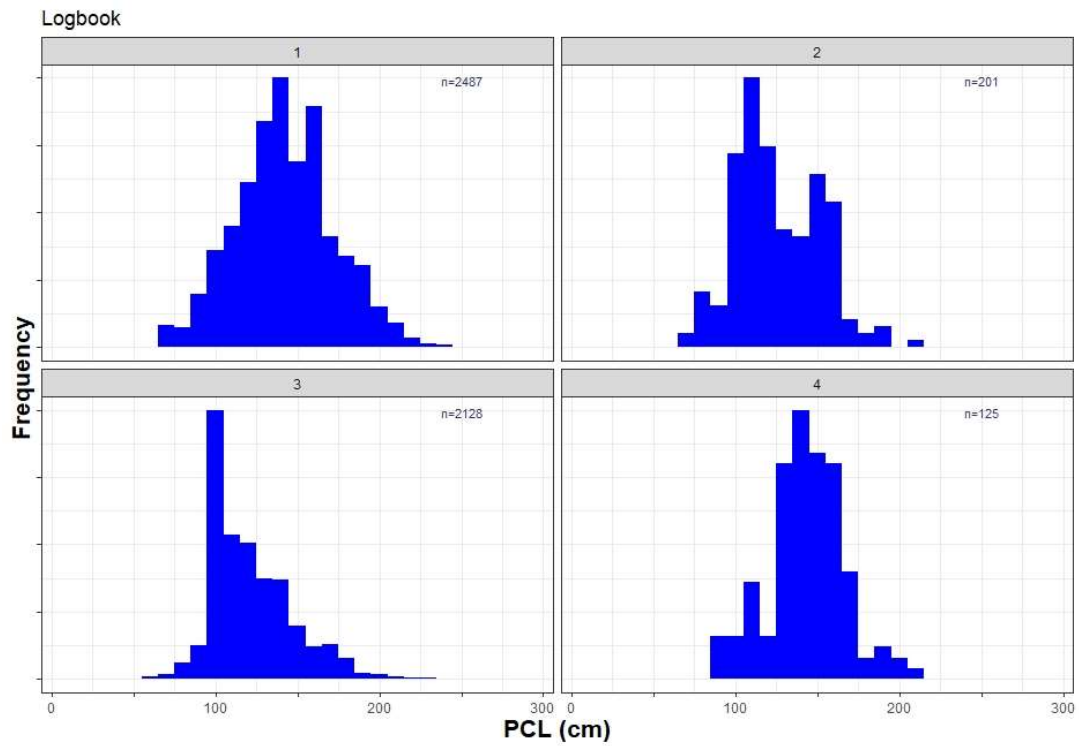


Figure 4. Length frequency of shortfin mako shark by area caught by the Taiwanese LTLL vessels in the North Pacific.

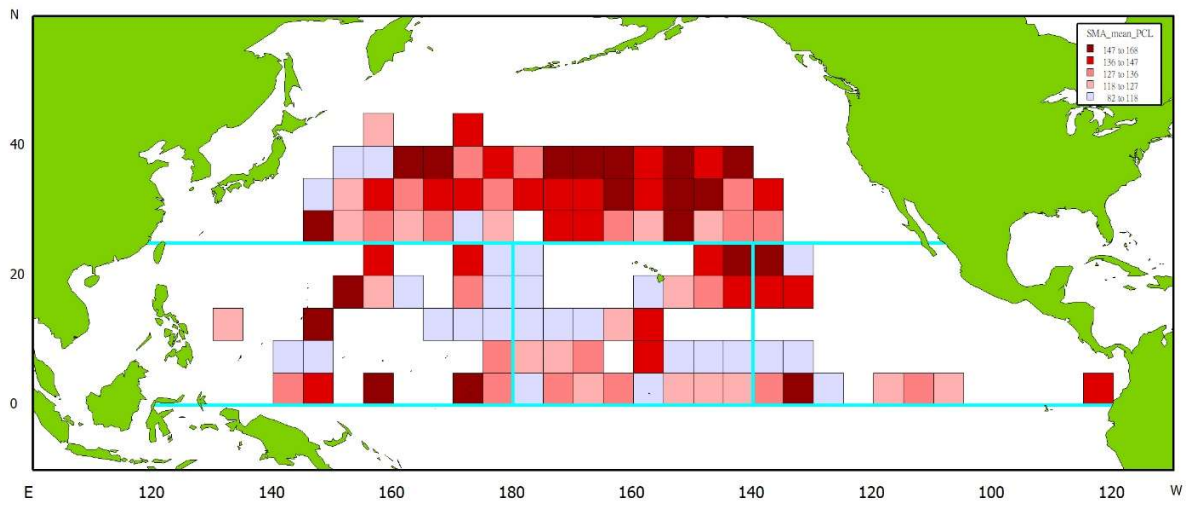


Figure 5. The mean PCL of the shortfin mako shark by 5×5 grid caught by the Taiwanese LTL vessels in the North Pacific.

Table 1. Details of the length data of the shortfin mako shark from the logbook of the Taiwanese LTL vessels in the North Pacific.

Area	SMA_n	Mode_PCL	mean_PCL	std_PCL	min_PCL	max_PCL
A	2,487	142	143	29.97	63	247
B	201	121	126	25.75	73	213
C	2,128	117	122	25.22	58	235
D	125	144	143	22.45	92	213
Total	4,941	131	133	29.56	58	247