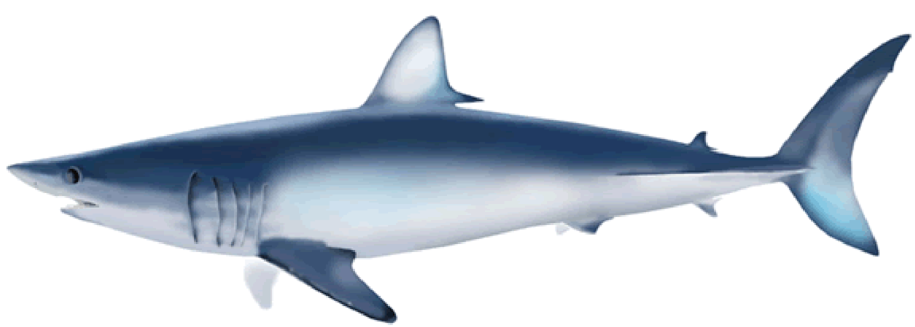
ISC/16/SHARKWG-1/13

Direct Estimates of Gear Selectivity for the North Pacific Blue Shark Using Catch-at-Length Data: implications for stock assessment[1]

Felipe Carvalho[2,3], and Tim Sippel[4]

[2]Joint Institute for Marine and Atmospheric Research, Honolulu, HI, USA.
[3]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, USA.
[4]NOAA - Southwest Fisheries Science Center (Contractor with Ocean Associates, Inc.), 8901 La Jolla Shores Drive, La Jolla, CA 92037

Email: felipe.carvalho@noaa.gov



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Abstract

Understanding the size-selectivity characteristics of fishing gear is fundamental to interpreting catch data accurately, determining the size structure of fish populations, and assessing the effects of fishing on exploited stocks. Selectivity is one of the main processes modeled in contemporary statistical stock assessments, but its influence on management advice has been under-appreciated. We fitted the logistic size selectivity model to blue shark catch-at-length data from the different fleets operating in the NPO. Further, we compared the catch-at-length frequency distributions and selectivity estimates for the different fleets. In this document, catch-at-length data submitted to the SHARKWG was summarized using the Data-prep tool developed in R (DPT). Length frequency distribution for each fleet was summarized using 5 cm bins. In addition, logistic selectivity curves were developed for each fishery separately. Results presented here will assist the SHARKWG to appropriately define fleets to be used in an SS3 assessment, if it chooses that approach.

Introduction

Stock status of blue sharks in the North Pacific Ocean (NPO) was last assessed in 2014 (ISC, 2014). A Bayesian Surplus Production (BSP) model and a length-structured model using stock synthesis (SS3) were both developed for the assessment. Although the SS3 model was developed collaboratively within the SharkWG, there was not sufficient opportunity at the time to carefully review all of the model assumptions and data inputs. Moving forward, the WG identified further review of size data, fishery definitions, and gear selectivity as priorities for ongoing SS3 model development.

Understanding the size-selectivity characteristics of fishing gear is fundamental to interpreting catch data accurately, determining the size structure of fish populations, and assessing the effects of fishing on exploited stocks.

Selectivity is one of the main processes modeled in contemporary statistical stock assessments, but its influence on management advice has been under-appreciated. Selectivity, as used in stock assessment models, is the relative vulnerability of fish to the gear by size or age, and is a combination of both availability (i.e. being in the area where the gear is deployed) and contact selectivity (i.e. being retained if contacted by the gear).

On a multi-fleet fishery, contact selectivity is most commonly estimated using indirect methods, in which size distributions of catches among different fleets are used to infer the relative selectivity of each fleet. In this context, estimating fleet-specific selectivity patterns from blue shark catch-at-length data can be a useful alternative to define fleets in the next stock assessment.

In this paper, we fitted the logistic size selectivity model to blue shark catch-at-length data from the different fleets operating in the NPO. Further, we compared the catch-at-length frequency distributions and selectivity estimates for the different fleets.

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Materials and Methods

Catch-at-length data

Fishery catch-at-length from ISC member nations and observers compiled and submitted to the Shark Working Group by August 1st 2016 are used here. Subsequent to the original data submission, some updates to Japanese fishery definitions were submitted which are not reflected here. Six member nations submitted catch-at-length from a variety of fisheries covering the period between 1990 and 2016 (Table 1), with a total of 664,053 blue sharks measured. Working papers describing the fisheries included here are cited within (Sippel et al., 2016).

Length frequency and selectivity

A toolbox termed "Data preparation tool" (DPT) was created using R (R Core Team, 2015) and used to summarize the catch-at-length data. The DPT consistent of a series of functions that automatically generates length frequency distribution for each fleet, estimates length selectivity, and outputs length data in a csv format suitable for directly integration in the Stock Synthesis data file.

Catch-at-length data were submitted using a variety of different measures, including total length (TL, from tip of snout to posterior end of dorsal caudal lobe in natural position), fork length (FL, form tip of snout to caudal fork), alternate length (AL, distance between the origin of both dorsal fins), dorsal length (DL, distance from the front of the first dorsal fin to the back of the second dorsal fin) and pre-caudal length (PCL, from tip of snout to pre-caudal pit). The working group has previously adopted PCL as the standard reference measurement to use with blue sharks, thus all measurements were converted to PCL using the following equations:

PCL = (TL*0.748) + 1.063

PCL = (DL*2.56) + 9.97

PCL = (FL*0.894) + 2.547

PCL = (AL*2.462702) + 12.7976

Selection curves were fit to fishery specific catch-at-length data following the approach proposed by Szuwalski and Punt (2016). The goal is to investigate the relationship between length of blue shark and the probability it is retained by a longline. Selectivity is assumed to be a logistic function of size and to be time-invariant. The selectivity patterns are given by:

$$S_l = (1 + exp[-S_{slope}(\bar{L}_l - S_{50})])^{-1}$$

where $\bar{L}_l$ is the midpoint of length-class l, S_{slope} is the slope of the selectivity curve, and S_{50} is the length at which 50% of individuals encountered are selected.

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The probability of a blue shark in length-class l being retained given that it was caught in the fishery, $\tilde{R}_l$, is given by:

$$\tilde{R}_l = (1 + exp[-\tilde{S}_{slope}(\bar{L}_l - \tilde{S}_{50})])^{-1}$$

Results

- The size compositions from the Japan driftnet fishery ranged from 75 to 230 cm PCL, with most individuals in the size bins of 125 and 140 cm PCL. The estimated $\tilde{S}_{50}$ was 116.92 (±6.45).

- The size compositions from the Japan JRTV fishery ranged from 50 to 300 cm PCL, with most individuals in the size bins of 160 and 170 cm PCL. The estimated $\tilde{S}_{50}$ was 149.89 (±4.79).

- The size compositions from the Japan JRVD fishery ranged from 70 to 295 cm PCL, with most individuals in the size bins of 165 and 175 cm PCL. The estimated $\tilde{S}_{50}$ was 140.4 (±7.02).

- The size compositions from the Japan JRVS fishery ranged from 40 to 240 cm PCL, with most individuals the size bins of 125 and 135 cm PCL. The estimated $\tilde{S}_{50}$ was 110.31 (±7.22).

- The size compositions from the Japan Kinkai shallow longline **sn** fishery ranged from 50 to 290 cm PCL, with most individuals in the in the size bins of 150 and 165 cm PCL. The estimated $\tilde{S}_{50}$ was 157.9 (±6).

- The size compositions from the Japan Kinkai shallow longline longline fishery ranged from 60 to 290 cm PCL, with most individuals in in the size bins of 150 and 155 cm PCL. The estimated $\tilde{S}_{50}$ was 126.64 (±10.98).

- The size compositions from the Japan observer longline fishery ranged from 45 to 265 cm PCL, with most individuals in the size bins of 130 and 150 cm PCL. The estimated $\tilde{S}_{50}$ was 129.78 (±8.61).

- The size compositions from the Japan small longline fishery ranged from 85 to 245 cm PCL, with most individuals in the size bins of 135 and 140 cm PCL. The estimated $\tilde{S}_{50}$ was 119.91 (±7.6).

- The size compositions from the US driftnet gillnet fishery ranged from 35 to 245 cm PCL, with most individuals in the size bins of 95 and 105 cm PCL. The estimated $\tilde{S}_{50}$ was 79.71 (±6.91).

- The size compositions from the US juvenile survey ranged from 35 to 235 cm PCL, with most individuals in the size bins of 70 and 75 cm PCL. The estimated $\tilde{S}_{50}$ was 66.27 (±4.05).

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- The size compositions from the Hawaii longline deepset fishery ranged from 45 to 255 cm PCL, with most individuals in the size bins of 165 and 170 cm PCL. The estimated $\tilde{S}_{50}$ was 153.77 (±5.35).

- The size compositions from the Hawaii longline shallow-set fishery ranged from 40 to 240 cm PCL, with most individuals in the size bins of 155 and 165 cm PCL. The estimated $\tilde{S}_{50}$ was 143.91 (±11.37).

- The size compositions from the Mexico Ensenada longline fishery ranged from 55 to 340 cm PCL, with most individuals in the size bins of 95 and 105 cm PCL. The estimated $\tilde{S}_{50}$ was 83.84 (±5.39).

- The size compositions from the Mexico San Carlos longline fishery ranged from 70 to 245 cm PCL, with most individuals in the size bins of 130 and 135 cm PCL. The estimated $\tilde{S}_{50}$ was 121.84 (±6.7).

- The size compositions from the China longline fishery ranged from 55 to 295 cm PCL, with most individuals in the size bins of 165 and 175 cm PCL. The estimated $\tilde{S}_{50}$ was 157.9 (±6).

- The size compositions from the Korea longline fishery ranged from 70 to 270 cm PCL, with most individuals in the size bins of 155 and 180 cm PCL. The estimated $\tilde{S}_{50}$ was 146.67 (±5.79).

- The size compositions from the Taiwan large longline fishery ranged from 35 to 300 cm PCL, with most individuals in the size bins of 190 and 200 cm PCL. The estimated $\tilde{S}_{50}$ was 167.62 (±10.53).

Discussion

In this document we investigated the size composition of blue sharks caught by several fisheries across the North Pacific Ocean. SS3 can integrate size composition data from multiple fleets, but aggregating fleets by selectivity patterns is commonly done to simplify the models and interpretation of their results. Changes in size composition of the catch might indicate changes in selectivity, which can affect estimates of recruitment etc, so fleet aggregation requires careful consideration. Results presented here will assist the SHARKWG to appropriately define fleets to be used in an SS3 assessment, if it chooses that approach.

The size composition data from Japan represents the bulk of the submitted data. Consequently, special attention needs to be given when defining and possibly aggregating the fleets for the several Japanese fisheries. Based on the results found here and the size analysis presented by Dr. Yasuko Semba in the last SHARKWG webinar (September 26-27, 2016) we would like to recommend the following fleet definitions for Japan:

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- Aggregate Kinkai-shallow, Kinkai-shallow sn, and JRVS. This would reflect the longline fishery targeting sharks and swordfish with common fishing patterns.
- Aggregate JRTV, and JRVD. This would reflect the longline fishery targeting tunas with common fishing patterns.
- Size composition data from Japan observer and small longline fisheries should be separated between shallow and deep sectors to reflect the targeting strategy.
- Japanese driftnet data should be considered a distinct fishery and should not be aggregated with any other fleet.

Other fisheries had one or two fleets only

- Mexico Enseneda and Mexico San Carlos longline fisheries should be aggregated.
- In order to match the CPUE index provided for the Hawaii longline fishery only the size composition from the deepset longline fishery should be considered.
- Korea longline fishery should be considered as a single fleet
- Taiwan large longline fishery should be considered as a single fleet.

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Table 1. Summary of blue shark catch-at-length data submitted to the ISC SHARKWG by august 1st 2016.

Nation	Fishery	Years	Sex			Total
			F	M	U	
Japan	Driftnet	2011-2016	7654	11645	1	19300
Japan	JRVD	1995-2015	200	444	12	656
Japan	JRVS	1999-2015	556	2187	111	2854
Japan	JTRV	1992-2015	79661	111654	2656	193971
Japan	Kinkai shallow longline	2008-2016	89285	226689	145	316119
Japan	Kinkai_shallow_longline_sn	2011-2015	19088	31713	122	50923
Japan	Observer_longline	2009-2015	3868	20622	263	24753
Japan	Small longline	2012-2016	1224	1938	1	3163
China	Longline	2009-2015	820	1199	127	2146
USA	Hawaii longline (deep-set)	1994-2014	1888	2412	18	4318
USA	Hawaii longline (shallow-set)	1994-2014	1756	3001	8	4765
USA	Drift gillnet	1990-2014	4651	7569	54	12274
USA	Juvenile survey	1993-2015	2509	2582	55	5146
México	Ensenada longline	2006-2014	9550	12204	69	21823
México	San Carlos longline	2007-2013	482	1359	1	1842
Korea	Longline	2005-2016	192	366	58	616
Taiwan	Large longline	2004-2014	2123	2584	12	4719

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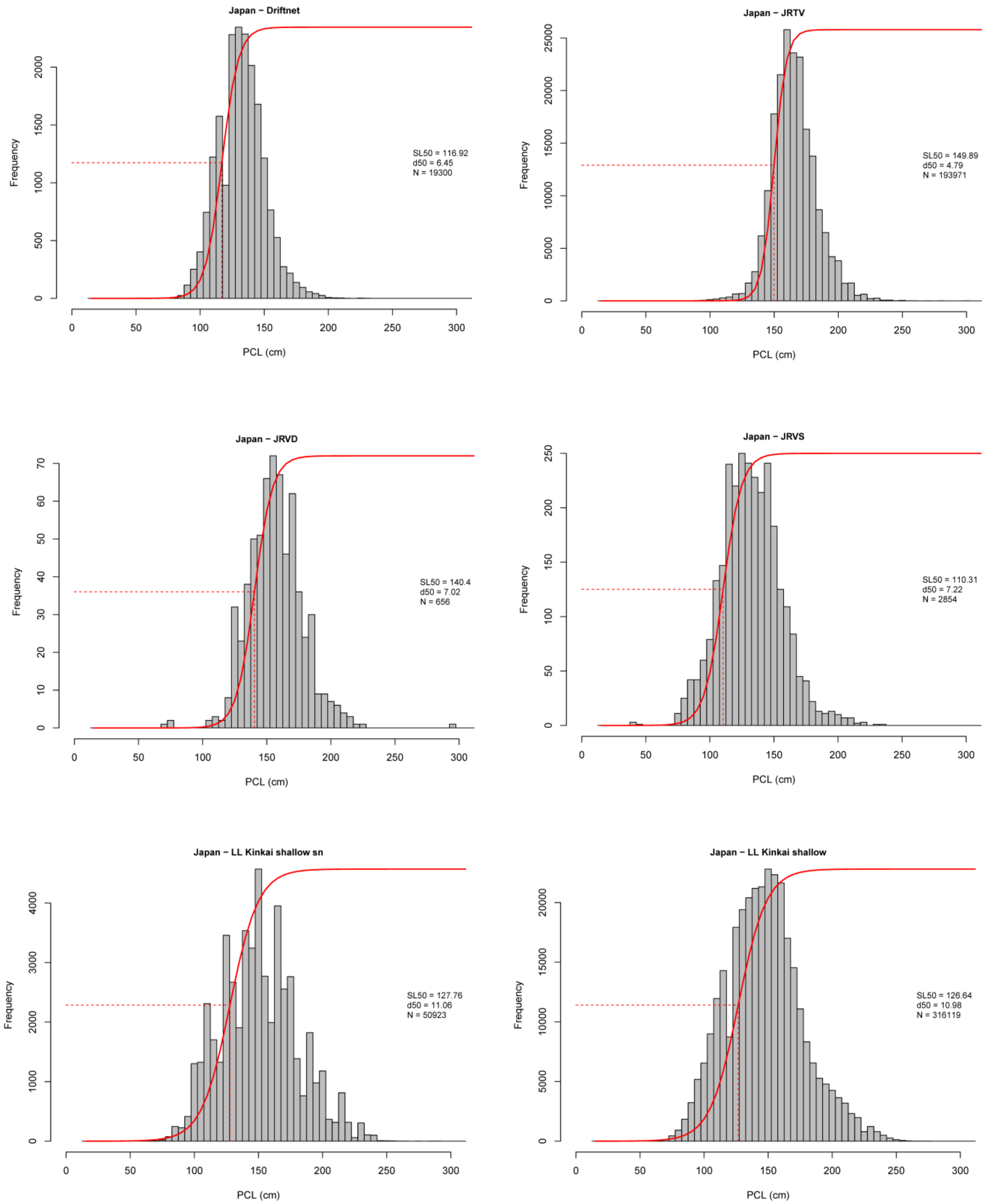

Figure 1. Blue shark catch-at-length frequency distribution and logistic selectivity curve by fleet.

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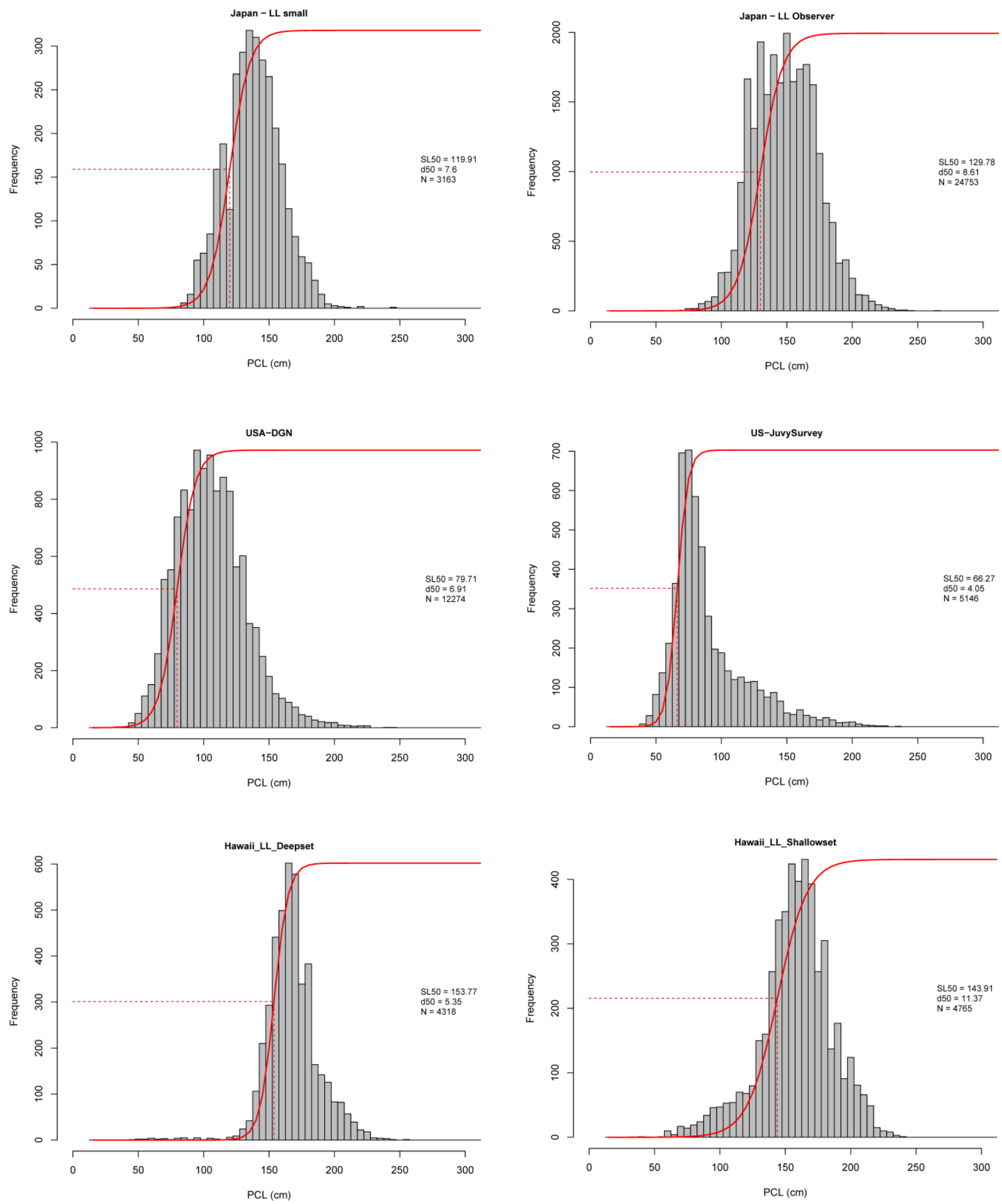

Figure 1 (cont). Blue shark catch-at-length frequency distribution and logistic selectivity curve by fishery.

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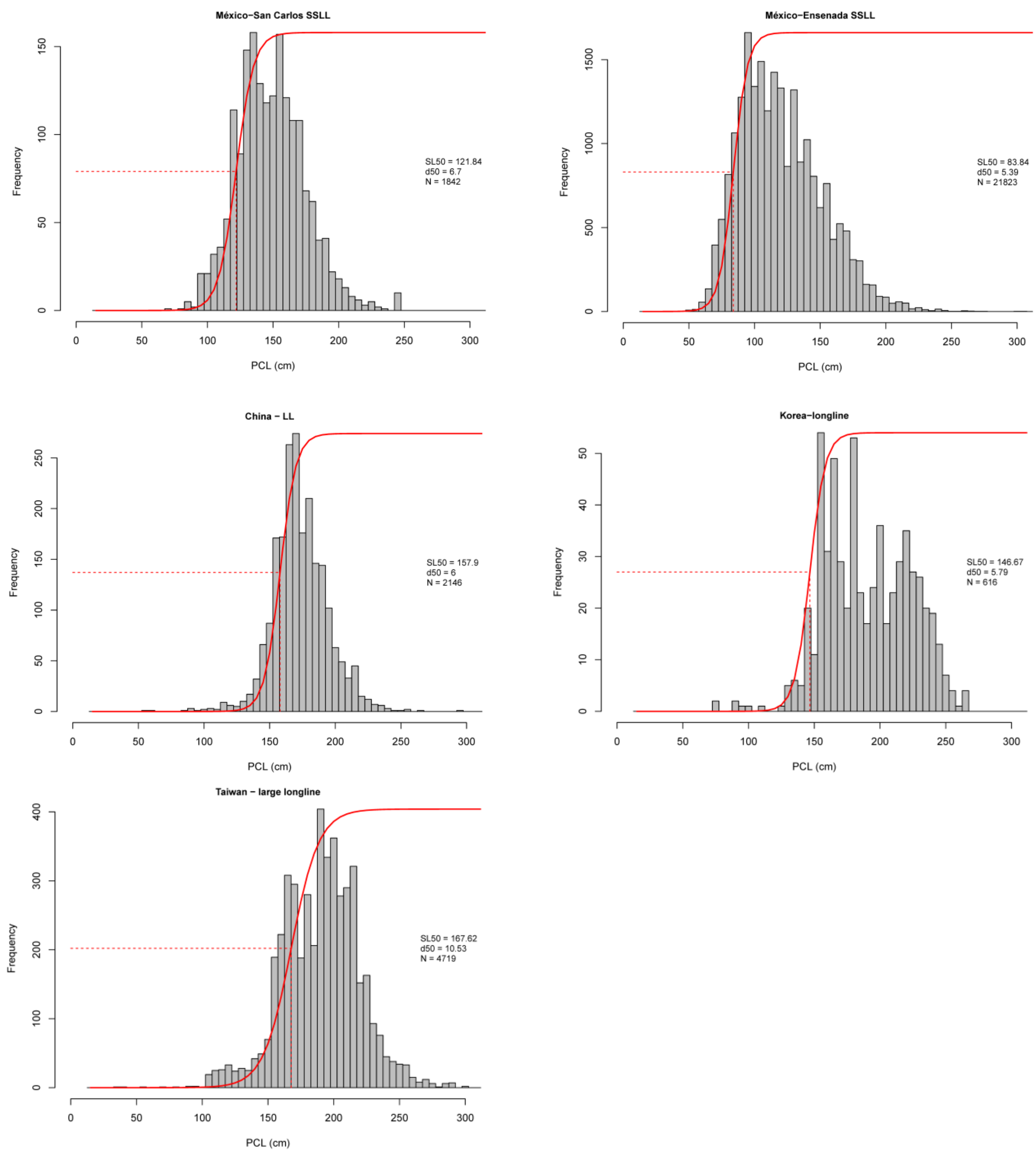

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