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Review of data to estimate the length and age distribution of SBT in the Indonesian longline catch

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Acknowledgments

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Abstract

This paper provides a preliminary review of the SBT size data collected in Indonesia and the effect of the dataset choice on estimates of the age distribution of the spawning population. To monitor changes in the SBT spawning population, it is important to obtain length data from a random sample of the Indonesian longline catch in CCSBT statistical area 1 only. Until recently, the primary source of size data for SBT caught by Indonesia was from the catch monitoring program in Benoa. Recent investigations, however, suggest that a proportion of the fish monitored are likely to have been caught south of the SBT spawning ground. To improve the SBT length frequency data analysed, the DGCF provided SBT length and weight data from the CDS for SBT caught in area 1 for the last five spawning seasons. The size data from the two sources analysed (catch monitoring and CDS) provide different age composition results for the five years compared. There could be several explanations for these differences and further work in needed to examine the uncertainties identified and to refine and improve the quality control of the data. We recommend this work be considered as an immediate priority under the Scientific Research Plan.

Introduction

The spawning ground for southern bluefin tuna (SBT) is located in an area between Indonesia and the northwest coast of Australia, where spawning occurs during September to April each year (Farley and Davis 1998). The Indonesian longline fishery targets bigeye and yellowfin tuna on the spawning ground, with SBT as a by-catch. Obtaining an accurate estimate of the size and age composition of SBT landed by the Indonesian longline fishery is central to population modelling and stock assessments and close-kin mark recapture (CKMR), which are used by CCSBT to monitor changes in the spawning population over time.

The method used to estimate the age distribution of SBT in the Indonesian catch is the age-length key method. The age-length key gives the proportion of fish at age in each length class, which enable us to infer the age composition of the catch from the length-frequency data. Central to developing and applying an age length key is obtaining (i) length data for a large random sample of the catch, and (ii) age estimates from a smaller subsample of fish randomly selected through length-stratified sampling. To monitor changes in the SBT spawning population, it is important to obtain a random sample of the Indonesian longline catch in CCSBT statistical area 1 only (i.e., the spawning ground).

This paper provides a preliminary review of the SBT size data collected in Indonesia and the effect of the dataset choice on estimates of the age distribution of the spawning population. Recommendations for future work are provided.

Data sources

Catch monitoring program, Benoa

SBT size data has been collected since 1993 through a catch monitoring program in Benoa, Bali. The program was first established through a series of collaborative projects between Indonesia's marine fisheries research institutes[4] within the Ministry of Marine Affairs and Fisheries (MMAF) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The main location monitored for SBT was the Benoa Fishing Port in Bali. In 2002, the scope of research collaboration expanded to include all tuna species (yellowfin and bigeye tuna, and albacore) and related species (billfish and other bycatch species) landed by the longline fleet. This occurred with the addition of new partners to the collaboration, the Indian Ocean Tuna Commission (IOTC) and Japan's Overseas Fishery Cooperation Foundation (OFCF). The monitoring locations expanded to three fishing ports, including Muara Baru (Jakarta) and Cilacap (south cost Central Java), in addition to Benoa (Farley et al. 2007). The majority of targeted SBT sampling, however, still occurs at Benoa, as this is the port where the majority of Indonesian caught SBT are landed.

Length data

The catch monitoring program has a target to monitor at least 30% of landings by each fishing company in Benoa (Jatmiko et al. 2017), although monitoring is often >50%. When fish are landed, they are classified as either 'export' or 'reject' based on flesh quality. Enumerators from the Research Institute of Tuna Fisheries (RITF) record the dressed weight of each SBT landed and the length of as many fish as possible. Dressed weight is converted to round (whole) weight using the CCSBT agreed conversion value for SBT (x1.15). Measuring the length of fish classed as export grade can be difficult because access to the fish is limited. If the length of all fish in a landing cannot be measured, the reject (low-grade) fish are measured as they are assumed to be a random sample of the catch (Jatmiko et al. 2017).

In the late 1990s, Davis and Farley (2001) compared length data of 102 export and 102 reject SBT from 20 landings (in which all fish measured) and found no significant difference in the length distributions of export and reject fish (Davis and Farley 2001). This suggests there was no size-based bias in fish graded as reject at that time. The study also reported that, at the time, 30% of export-grade SBT were measured in the monitoring program, and 89% of reject-grade fish were measured (15,882 landings monitored between 1992 and 1999).

Otolith and tissue sampling

Since 1995, otoliths from SBT have also been collected through the Benoa catch monitoring program. In 2006, the sampling was expanded to muscle tissue samples for close-kin mark recapture (CKMR). Only fish graded as reject quality are available for sampling and they are

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[4] Indonesian collaborating institutions, in chronological order: Central Research Institute for Fisheries Indonesia (CRIFI), Research Institute for Marine Fisheries (RIMF), Research Centre for Capture Fisheries (RCCF), Research Centre for Fisheries Management and Conservation (RCFMC), and currently Centre for Fisheries Research (CFR) in Jakarta, and Research Institute for Tuna Fisheries (RITF) in Bali.

assumed to be a random sample of all fish caught in CCSBT area 1. Currently around 1500 otoliths and muscle tissue samples are collected each year. A subsample of 500 otoliths are selected for ageing. All fish sampled are classified into 1-cm length bins and a pre-specified number of fish are randomly selected to be aged from each length bin. This ensures a sufficient number of age estimates for all length classes, including those with small sample sizes. All muscle tissue samples are sequenced for CKMR.

Since the fish with otoliths sampled each year are a subset of all SBT measured in the monitoring program, we compared length frequency distributions for the 2012/13 to 2015/16 seasons to determine if there was a difference. Although the length distributions are similar (Figure 1), we found a statistically significant difference for each season compared (Kolmogorov-Smirnov two sample test, $P<0.05$). In three of the four seasons, the proportion of small fish (<160 cm FL) was higher in the fish sampled for otoliths compared to all fish measured, and in the fourth season (2014/15), the proportion of large fish (<160 cm FL) was higher in the otolith sampled fish.

Catch Documentation Scheme (CDS)

In 2019 the Directorate General of Capture Fisheries (DGCF) (Indonesia) provided SBT length and weight data from the CDS for the 2015/16 to 2018/19 spawning seasons (Sulistyaningsih et al. 2019, 2020). The DGCF updated the data in 2020 and 2021 to include the 2020 calendar year.

The DGCF identified vessels operating in CCSBT statistical areas 1 and 2 using vessel monitoring system (VMS) tracking information. Vessels that had >70% of all tracks in area 1 were classes as operating on the spawning ground (Fahmi and Mardi, 2020a). Figure 2 shows the length frequency data for area 1 and area 2 in 2017/18 and 2018/19, as examples. It is evident that smaller fish comprise a greater proportion of the catch in area 2 compared to area 1, which is consistent with the fish being caught south of the spawning ground. However, the modes in the data vary between years.

Preliminary examination of the length-weight data showed that a reasonable proportion of the outliers had been removed (e.g., Figure 3) and that a proportion of fish were measured to the nearest 5-cm length class, rather than 1 cm, which has the potential to bias estimates of the size distribution of the catch (e.g., Figure 4). Since individual weight data were more likely to be accurate (as the data are used for export purposes), these data were used in the analysis, rather than the 5 cm binned data. Weight was converted to length using a weight-length relationship derived from SBT in the Benoa monitoring program over the same time period (see Sulistyaningsih et al. 2019).

Length frequency distribution

Figure 5A shows the length distribution of the Indonesian catch based on the Benoa catch monitoring. Length data for the last four spawning seasons were obtained from SBT with otoliths sampled. The data shows a mode of small fish progressively moving through the distribution starting in the 2012/13 season until 2015/16. After this time, the length distribution of SBT monitored appears relatively stable with a single mode between 150 and 170 cm fork length (FL).

Figure 5B (red box) shows the length frequency distribution of the Indonesian catch based on the CDS data for SBT caught in area 1 from 2015/16 to 2019/20. The CDS data shows a shift towards larger fish in the catch from 2016/17 and a single mode between 160 and 180 cm FL for the last three spawning seasons, which is not observed in the Benoa catch monitoring data (Figure 5). This mode of larger fish is more consistent with the mode in length data observed prior to 2012/13.

Effect of the dataset choice on age distribution

Figure 6 shows the age frequency distributions for SBT in the 2015/16 to 2019/20 seasons. The age distributions were estimated using an age-length-key developed for each spawning season applied to the length data from the catch monitoring program (Figure 6A) and the CDS (Figure 6B). Otolith age data were not available for the 2019/20 spawning season due to COVID-19 travel restrictions prevented the shipping of otoliths from Indonesia to Australia. The ALK developed using direct age data for the preceding spawning season (2018/19) was applied to the 2019/20 length frequency data. Although the age frequency distributions appear similar, there are differences particular in the relative abundance of SBT aged <10 years, which is higher in the catch monitoring data compared to the CDS data.

Summary and Recommendations

Obtaining an accurate estimate of the size and age composition of SBT landed by the Indonesian longline fishery is central to population modelling, stock assessments and close-kin mark recapture (CKMR), which are used by CCSBT to monitor changes in the spawning population over time. Until recently, the primary source of size data for SBT caught by Indonesia has been the catch monitoring program in Benoa. Length data were obtained from fish predominantly classed as reject quality (low grade), which were assumed to be a random sample of the landed catch. It is unclear if this is still the case. In addition, it was assumed that all fish measured were caught in CCSBT statistical areas 1; this is unlikely since vessels operating in CCSBT statistical areas 2 also land SBT in Benoa (Fahmi et al. 2020a, b).

To improve the SBT length frequency data analysed, the DGCF provided SBT length and weight data from the CDS for the last five spawning seasons. Only size data from vessels operating in areas 1 were included in the analyses. Preliminary examination of the length-weight data showed that a reasonable proportion of the outliers had been removed and we elected to estimate the length of fish caught from the individual weight data.

The size data from the two sources analysed (catch monitoring and CDS) provide different age composition results for the five years compared. There could be several explanations for these differences and further work in needed to examine the uncertainties identified and to refine and improve the quality control of the data. We recommend this work be considered as an immediate priority under the Scientific Research Plan.

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Figures

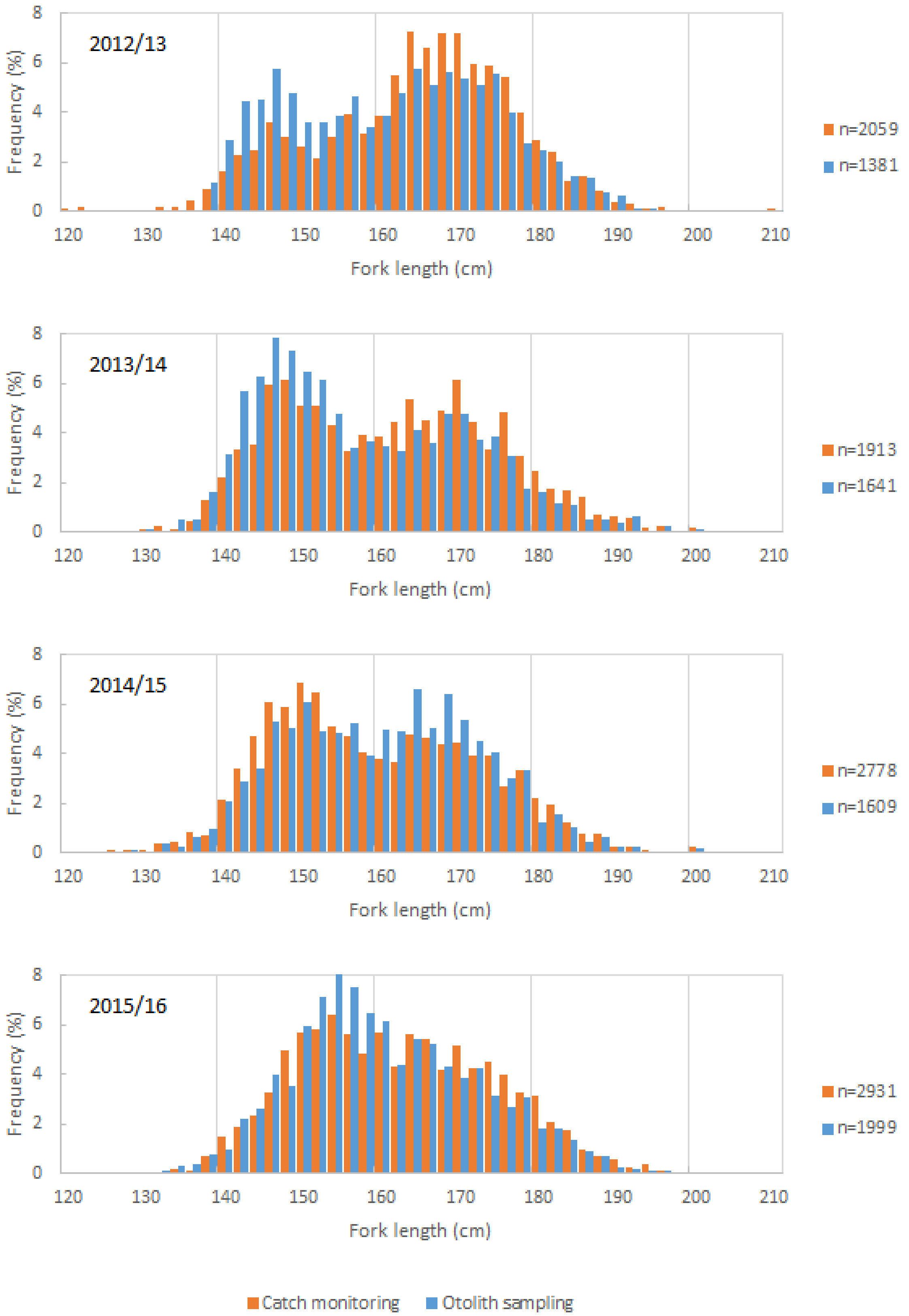

Figure 1. Comparison of length frequency distributions of SBT measured in the Benoa catch mornitoring program and SBT with otolthis sampled as part of the same program for the 2012/13 to 2015/16 spawning seasons.

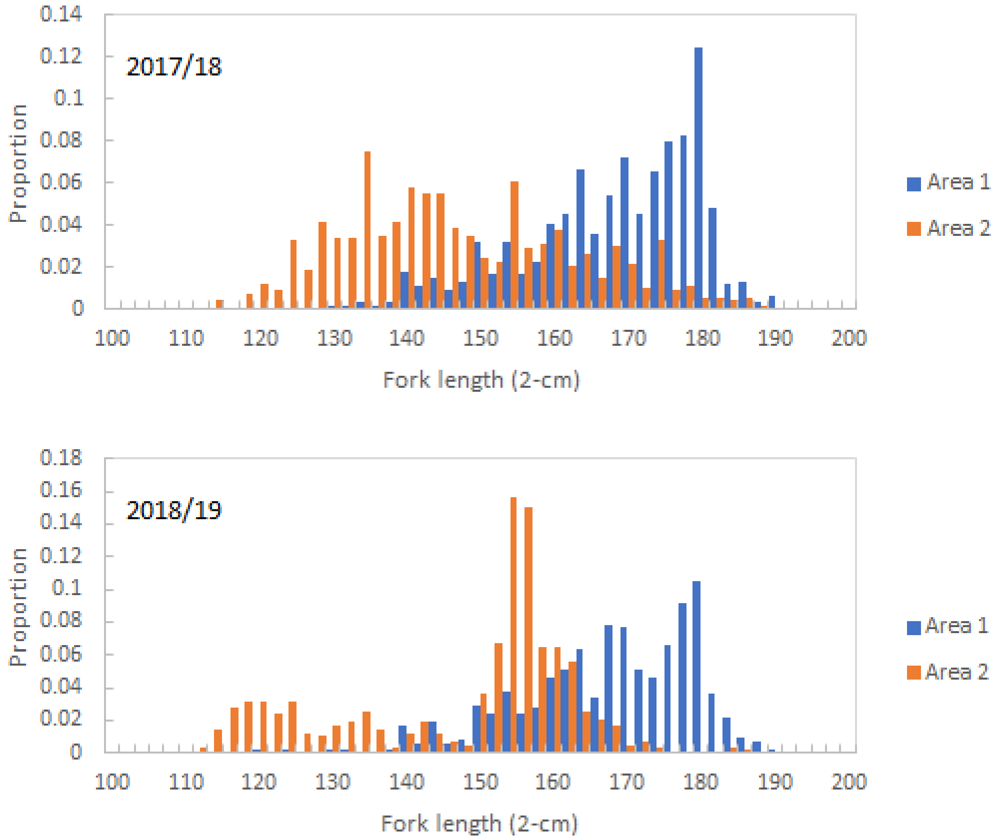

Figure 2. Length frequency distribution of SBT in CCSBT statistical area 1 and area 2 from the CDS dataset for 2017/18 and 2018/19 seasons.

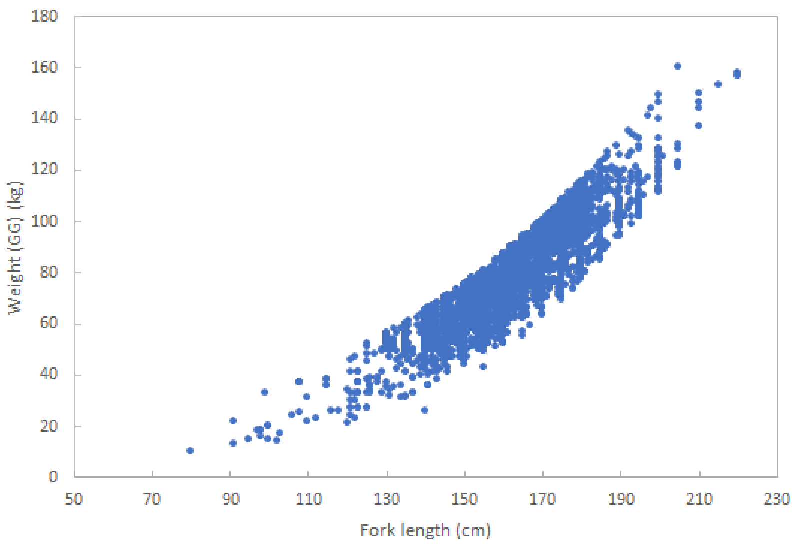

Figure 3. Weight-at-length data for SBT in the 2015/16 spawning season from the CDS dataset with outliers removed.

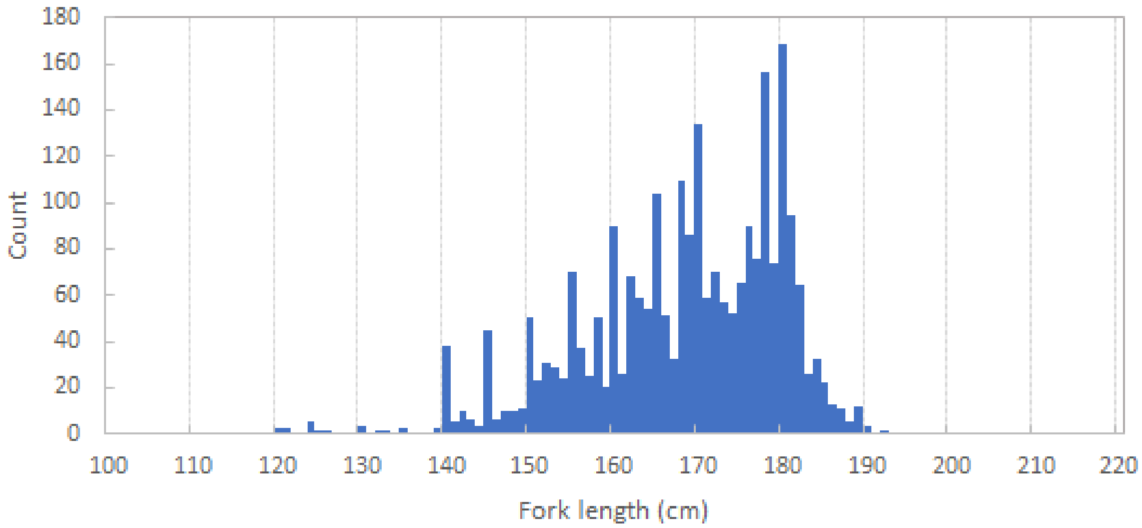

Figure 4. Length frequency distribution of SBT in 2018/19 from the CDS dataset.

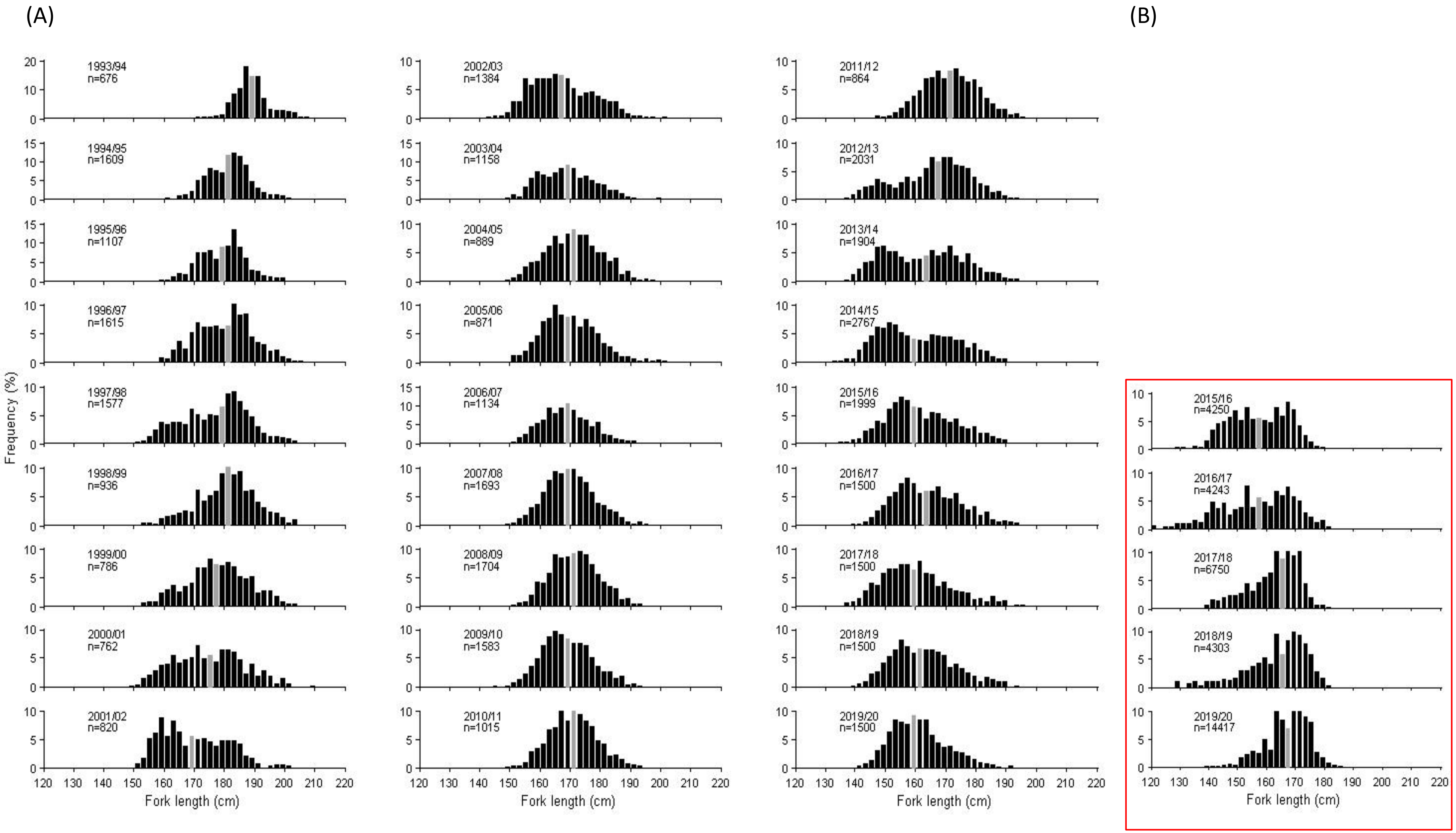

Figure 5. Length frequency (2 cm intervals) of SBT caught in the Indonesian longline catch estimated from (A) length data obtained in the Benoa catch monitoring program for all seasons, and (B) CDS individual weight data converted to length for 2015/16 to 2019/20 (red box). The grey bar shows the median size class.

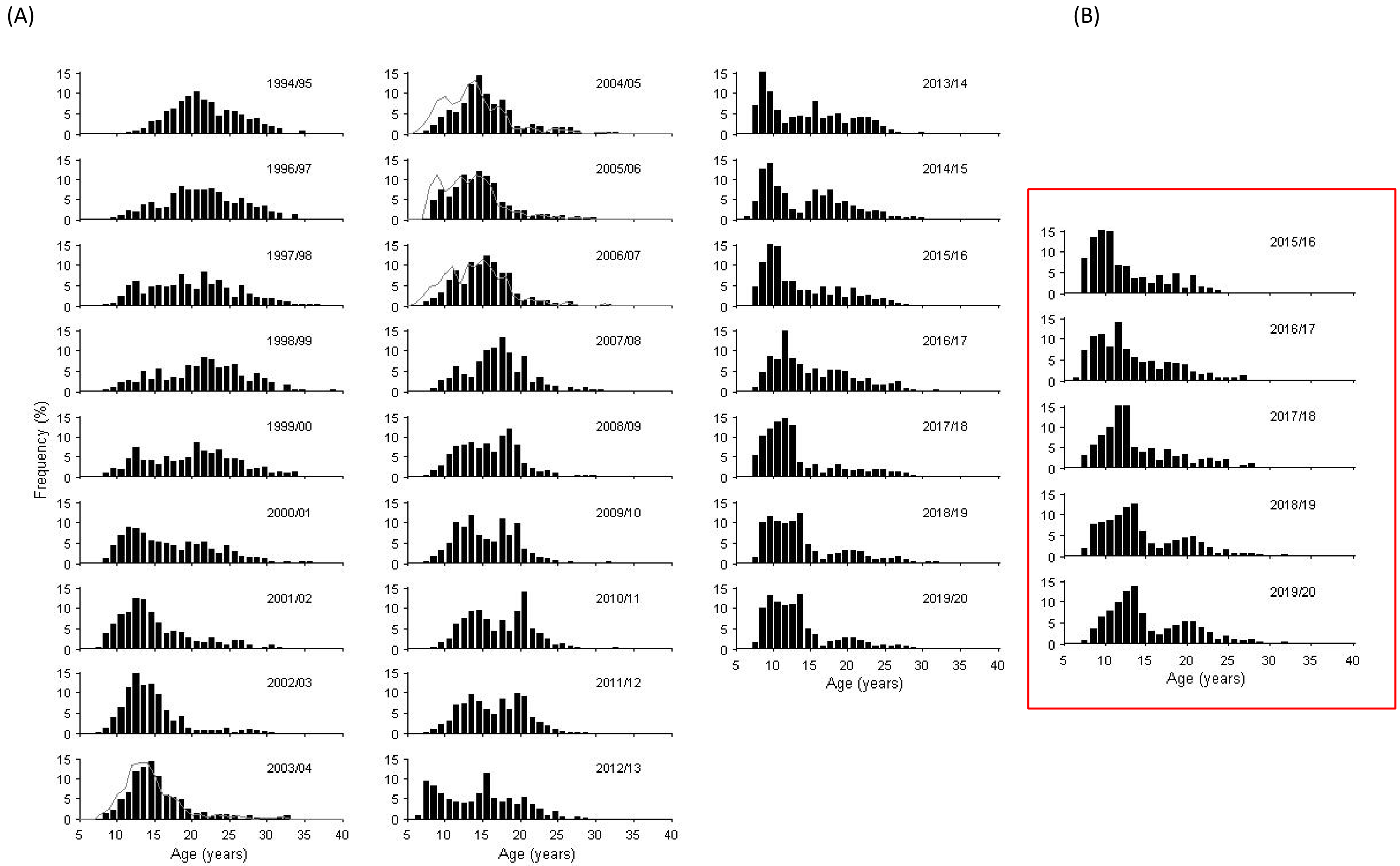

Figure 6. Age frequency distribution of SBT caught in the Indonesian longline catch estimated from (A) length data obtained in the Benoa catch monitoring program for all seasons, and (B) CDS individual weight data converted to length for 2015/16 to 2019/20 (red box).

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