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Review of the biological data for the North pacific albacore tuna from Japan

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Abstract

This study examines biological data of North Pacific albacore tuna (Thunnus alalunga) collected from Japanese fishing vessels between 1998 and 2025. A total of 3,195 individual samples were analyzed, with data on length, weight, otoliths, and gonads collected to assess sex ratio, maturity, and age structure. Sex ratio analysis revealed a male-biased population, particularly in southern waters, with larger males dominating in areas south of 30°N. Maturity assessment showed that female albacore reached reproductive maturity predominantly in waters south of 25°N, with seasonal variation in the proportion of mature individuals. Age determination based on otolith samples indicated differences in growth patterns from current stock assessment models, particularly for individuals below 90 cm in fork length.

Introduction

The Albacore Working Group (ALBWG) has tasked the review of biological data to improve stock assessments for North Pacific albacore tuna (ISC, 2024). This study aims to analyze the biological characteristics of the species, including size distribution, sex ratio, maturity, and age structure, based on extensive sampling conducted by the Fisheries Research Institute, Japan. These biological parameters are essential inputs for stock assessment models, influencing estimates of population dynamics, growth rates, and reproductive potential.

Material and methods

Biological data

Biological samples of albacore tuna (*Thunnus alalunga*) were collected from three types of fishing vessels between 1998 and 2025 (Fig. 1). Sampling aboard training vessels (T/V) and research vessels (R/V) was conducted and commercial vessel (C/V) samples were collected from landings at Nachikatsuura, Yaizu, and Kesennuma fishing ports, representing catches from longline, pole-and-line, and trolling vessels.

A total of 3,195 individual albacore tuna were sampled. The sampling locations ranged from 128°W to 180°W and 13°N to 43°N, covering areas 1 to 4 (Fig. 2). Biological samples included otoliths, muscle, and gonads collected after measuring fork length and body weight. The relationship between body length and weight in each statistical area is shown in Fig. 3. Larger individuals were predominantly found in areas 2 and 4, while smaller individuals (under 90 cm and 15 kg) were prevalent in area 3.

Result and Discussion

Sex ratio

Gonadal tissue examination determined the sex of 3,125 individuals, identifying 2,055 males, 252 females, and 188 individuals of undetermined sex. The highest number of sexed individuals was found in areas 2 and 4, particularly in the southern waters between 15°N and 25°N, while sexed individuals north of 30°N were concentrated along the offshore water of Japan (Fig. 4). There was a difference in size between sexes. The mean fork length of females was 92.0 cm (55.0-120 cm), with a mean weight of 17.1 kg, whereas males averaged 101.3 cm (46.2-122 cm) (Fig. 5). The sex ratio varied geographically; the southern waters were male-dominated, whereas north of 30°N, the ratio was closer to 1:1 or slightly male-biased (Fig. 6). Additionally, Individuals over 80 cm were predominantly male in the southern area, whereas individual below 80 cm had a nearly 1:1 sex ratio in the northern region, whereas in the southern region, (Fig. 7).

Maturity

Following the method of Ashida et al. (2020), histological examination of gonadal samples from 45 females determined maturity status (Fig. 8). A total of 868 female samples were classified as either immature or mature based on the presence of advanced oocytes and post-ovulatory follicles. Mature females were found primarily south of 25°N, with the proportion of mature individuals increasing towards the southern water (Fig. 9). Seasonally, in area 2, the proportion of mature individuals peaked in the Q2 and 3, whereas immature individuals were predominant north of 25°N during the Q1 and 2 and around 20°N during the Q4 (Fig. 10). These results indicate that spawning activity is highly concentrated in specific regions and seasons. Stock assessment models might account for these temporal and spatial variations in reproductive activity to accurately estimate spawning stock biomass and recruitment rates.

Growth and Age structure

Otolith samples were collected from 175 individuals ranging from 51.5 cm to 114.5 cm in fork length. Age estimation followed the methodology (Chen et al., 2012; Chen & Holmes 2015), and annual growth rings were counted. Among these, 49 individuals over 100 cm, with 48 males and one female (Fig. 11). Larger individuals were primarily collected south of 30°N, while individuals around 60-80 cm were mainly sampled near Japan (Fig. 12). The relationship between age and fork length by sex is presented in Figure 13. Growth curves derived from this study differed from those used in the current stock assessment models. Estimated ages were higher for individuals below 90cm in fork length and females over 90 cm appeared younger relative to their size.

Growth curves derived from this study differed from those used in the current stock assessment models (ISC 2023). Estimated ages were higher for individuals below 90 cm. Additionally, females over 90 cm appeared younger relative to their size compared to males. However, there is a possibility that the age estimation method used in this study may be inaccurate. To verify the accuracy of the age determination in this study, we plan to conduct an independent age assessment using the other otoliths from the same individuals at Fish Aging Services Pty Ltd, Australia, which specializes in age estimation of South Pacific albacore tuna. This validation process will help assess potential biases in our age estimation methodology.

Future works

- Expand the spatial and temporal coverage of biological sampling by increasing the number of sampling locations
- Improve sex determination methods by implementing more advanced histological and genetic analysis techniques to enhance accuracy in identifying sex at different developmental stages.
- Validate and evaluate age determination results.

References

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Xu, Y., Sippel, T., Teo, S. L., Piner, K., Chen, K. S., & Wells, R. J. (2014). A comparison study of North Pacific albacore (Thunnus alalunga) age and growth among various sources. Chinese Taipei: ISC Albacore Working Group Meeting.

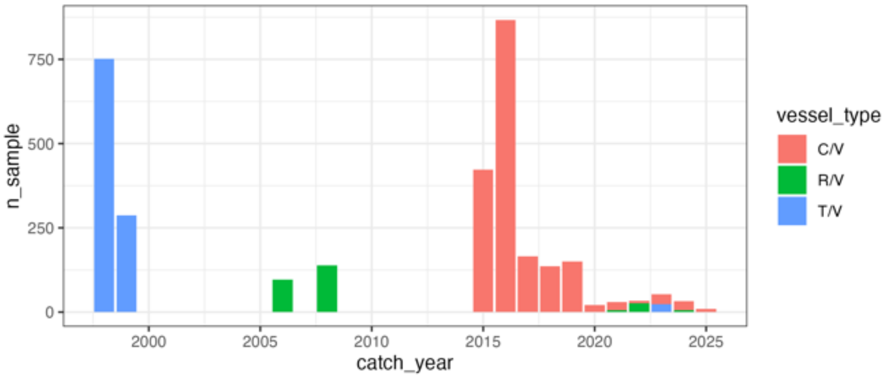

Figure 1 Number of samples collected by vessel type.

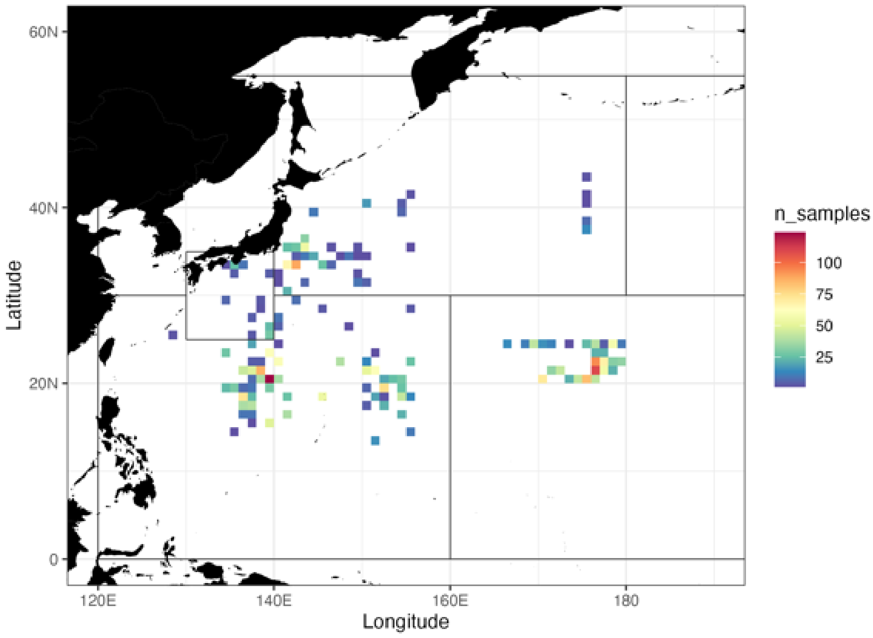

Figure 2. Spatial distribution of collected samples by 1°x1° latitude-longitude grid.

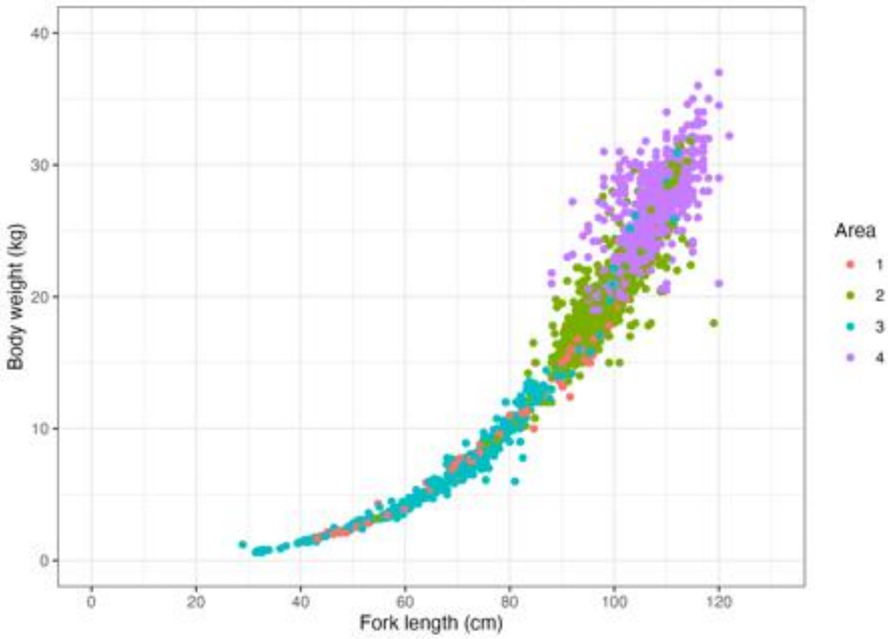

Figure 3. Relationship between fork length and body weight by statistical area.

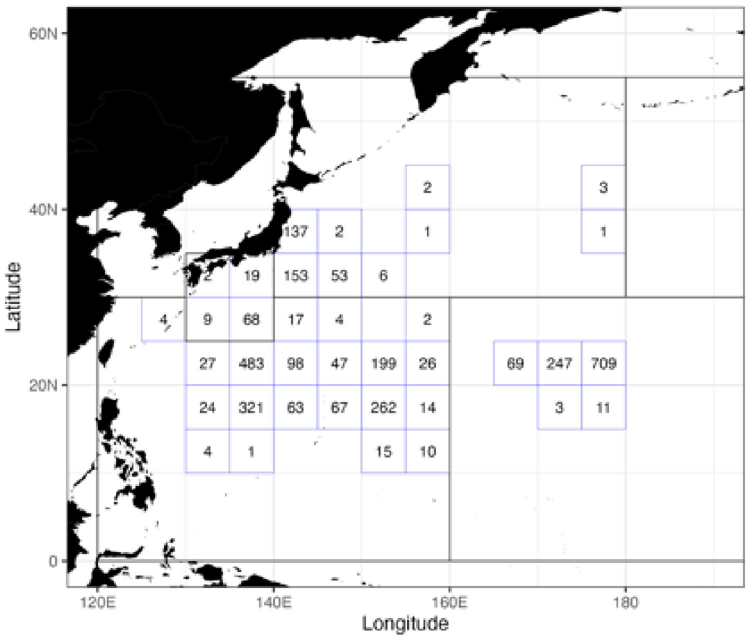

Figure 4. Number of sex-identified samples by 5°x5° latitude-longitude grid.

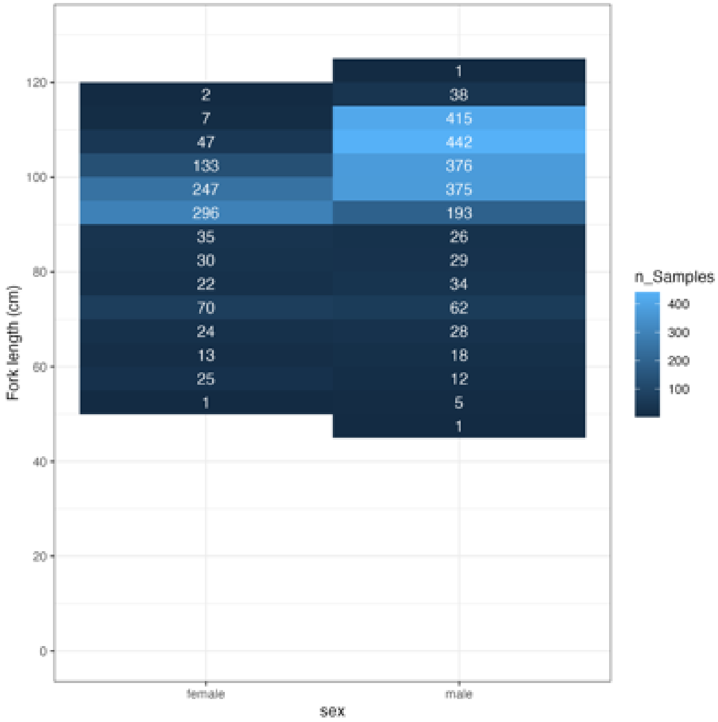

Figure 5. Number of samples of fork length by sex.

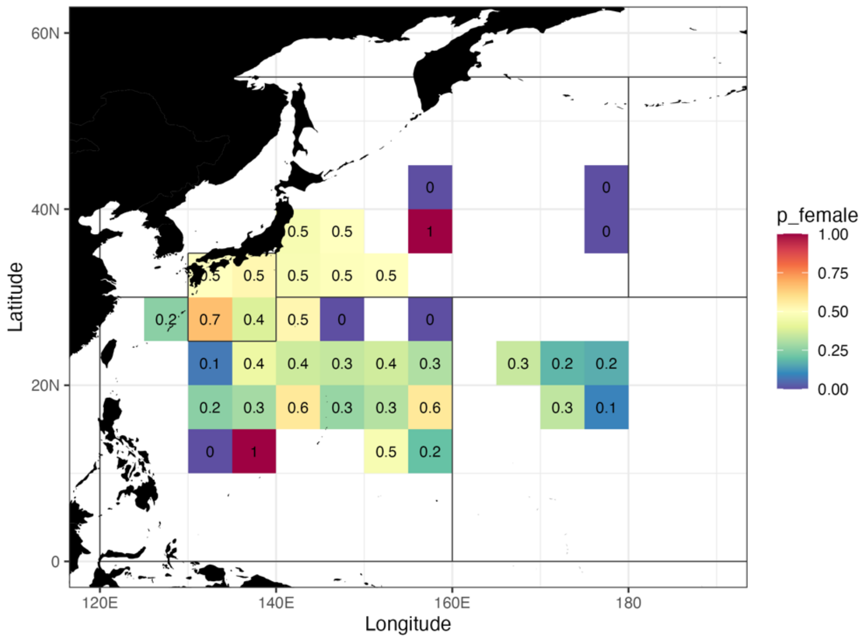

Figure 6 Sex ratio (female proportion: female/number of male and female) by 5°x5° latitude-longitude grid.

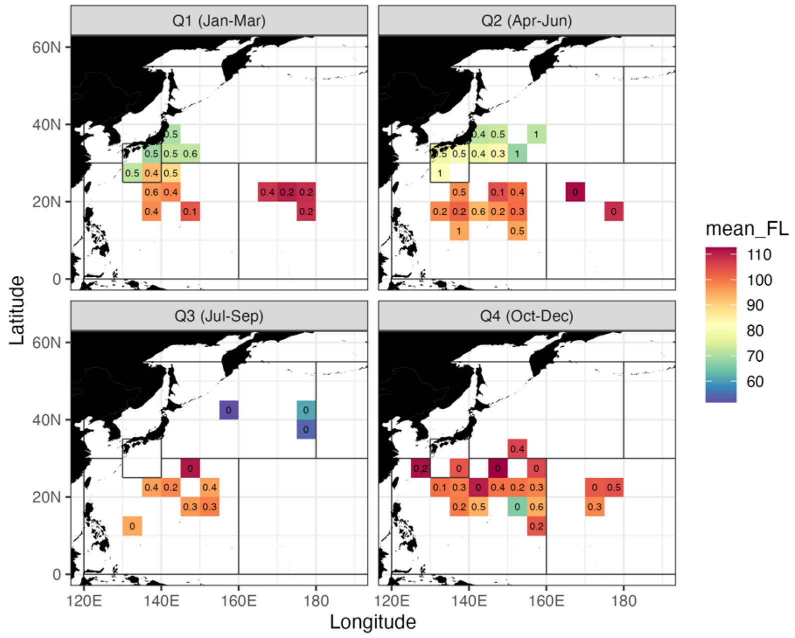

Figure 7 Quarterly sex ratio (female proportion) and mean fork length (color in each cell) by 5°x5° latitude-longitude grid.

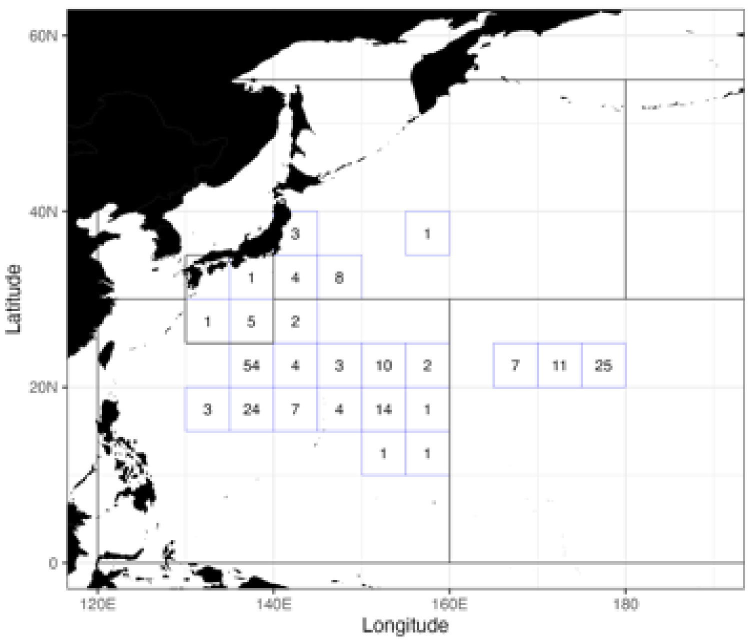

Figure 8. Number of gonad samples by 5°x5° latitude-longitude grid.

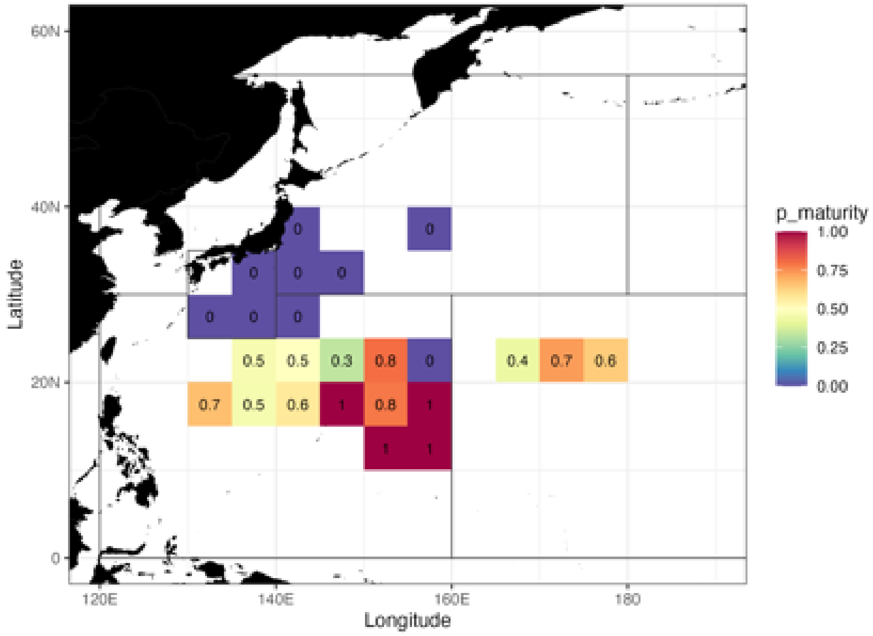

Figure 9. Proportion of mature-phase female by 5°x5° grid area and quarter.

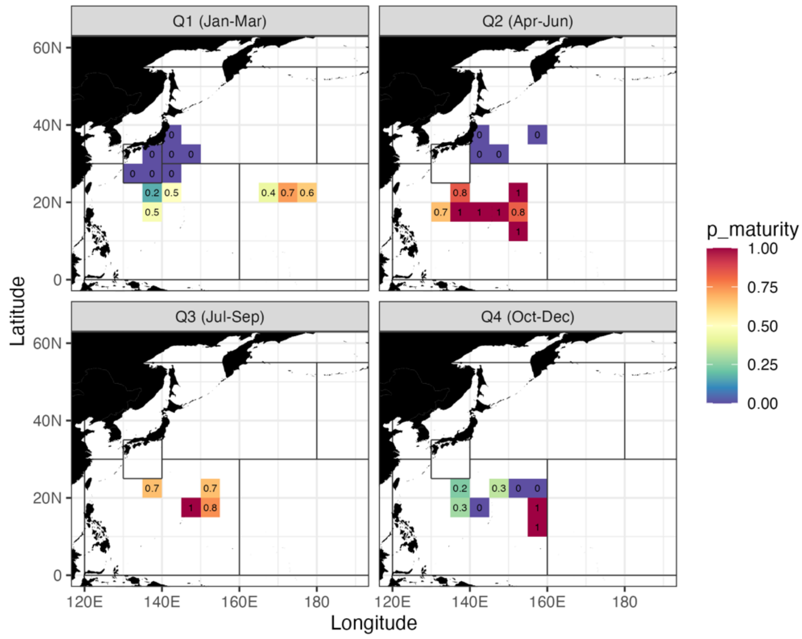

Figure 10. Seasonal variation in the proportion of mature female.

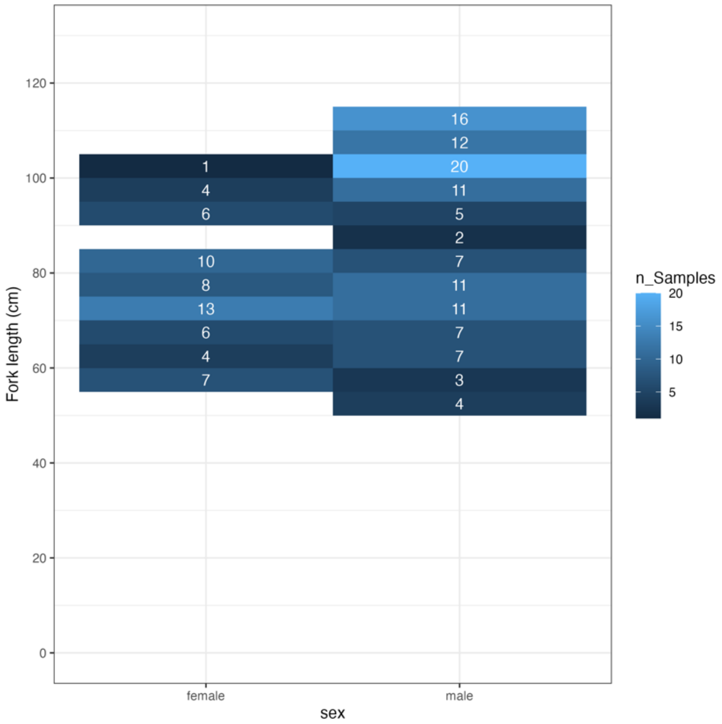

Figure 11 Number of otolith samples and fork length by sex.

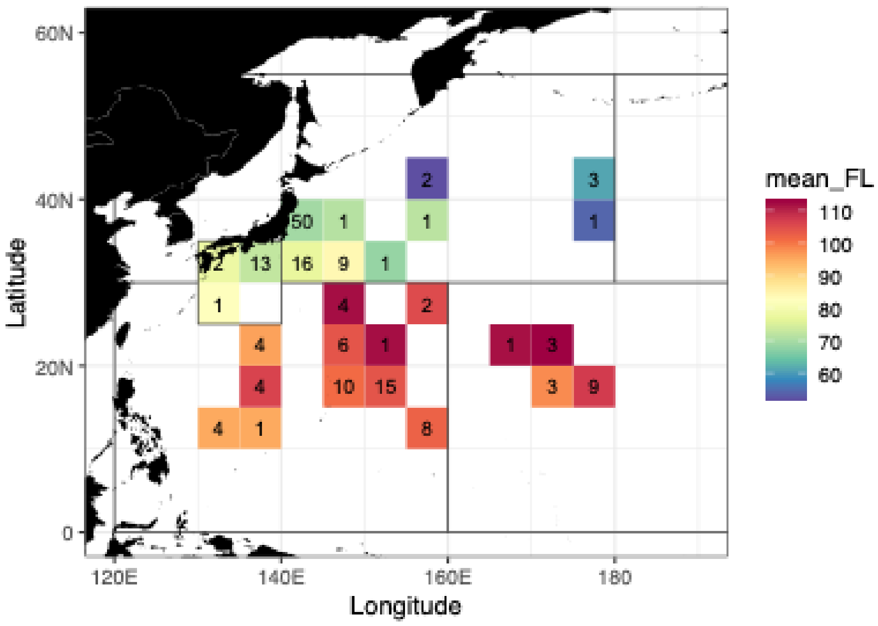

Figure 12 Number of otolith samples by 5°x5° latitude-longitude grid.

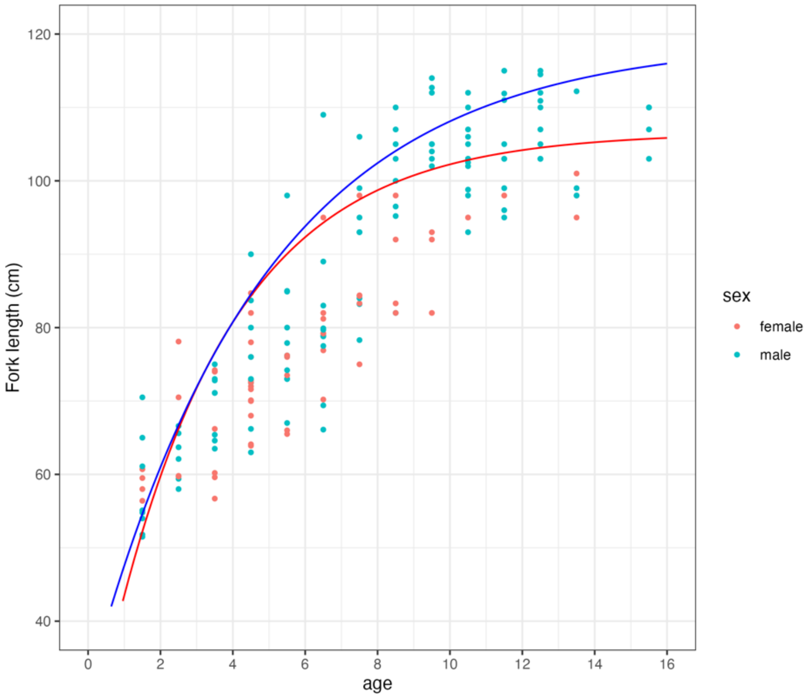

Figure 13 Relationship between age and fork length for males and females, with sex-specific growth curves used in stock assessments (blue: males, red: females).