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The estimation method and data on catch, weight, and maturity at age of the chub mackerel caught by Japan up to CY2024 Q2

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**Summary**

Stock assessment of chub mackerel (CM) in the Northwest Pacific has long been conducted in Japan. For nearly half a century, the length and age data of chub mackerel are collected based on the catch from the Pacific coast of Japan. Catch data are collected by month, prefecture, and gear type. Measurement of length data is obtained from the major landing port to develop catch at length from each prefectures on quarterly basis. Age data are obtained from the subsample of mackerels which fork length are measured and annulus of scale or annual increments of otolith are counted. The age data are subdivided into the Eastern and Western part of Pacific coastal prefectures of Japan to construct age-length key and catch at age is calculated for each quarter. In the present paper, data to construct catch at age up to the second quarter of 2024 (CY2024 Q2) are presented. The trend of catch at age show decreased catch number in CY2023 Q3-CY2024 Q2 compared to the previous years. With that influential information, the data is proposed to be incorporated into the forthcoming stock assessment of CMs in NPFC.

**Introduction**

In 2024, the Technical Working Group on Chub Mackerel Stock Assessment (TWG CMSA) had completed its first stock assessment in the northwest Pacific incorporating the data from China, Japan, and Russia in both the EEZ and the conventional area (NPFC 2024). The stock assessment, however, is based on the data up to 2022 in fishing year (FY2022) (i.e., June 2023) owing to the timing of stock assessment and data availability. Toward the next stock assessment, it is important to update the catch at age, weight at age, and maturity at age data to sufficiently capture the most recent population dynamics.

In this document we summarized the methodology for estimating catch at size, catch at age, and weight at age of chub mackerel in the Northwest Pacific Ocean estimated in Japan. This document also describes the methodology to derive maturity at age data used for the stock assessment. Furthermore, this document presents updated data on catch at age, weight at age, and maturity at age up to FY2023 to be used for the forthcoming stock assessment.

**Method**

**Catch data**

Catch data of chub mackerel are collected from 19 prefectures along the Pacific coast of Japan. The data are collected at the major landing ports by the local prefectural fisheries research institutions. The catch data are categorized by prefecture, month, and gear type. In some prefectures, the catch data of chub mackerel and blue mackerel (*S. australasicus*) are combined and reported as the “mackerels”. In such cases, the proportion of chub mackerels and blue mackerels are estimated by sorting the subsample of the catch every month. Then the monthly catch of chub mackerel is estimated by applying the monthly chub-blue ratio to the catch of mackerels of the same month.

**Length, weight, and age data**

Length frequency data are collected from each prefecture by month. Since the selectivity of gear type is not the same throughout different gear types, the length frequency data are treated differently for each gear type. The sample for length frequency measurement is obtained by spill sampling from the catch at the major landing port and fork length (FL) is measured up to 1 millimeter. Likewise, weight data are measured from the same sample up to 0.1 gram. The measured length and weight data are combined by each prefecture level every year and length-weight relationship is estimated every year for each prefecture as , where is body weight, is FL, and and are coefficients.

Each set of length frequency data is gathered by prefecture, month and gear. Using the length-weight relationship, the mean length and the mean weight of the sample are calculated as follows:

(1)

(2)

where is the length bin of the length frequency of sample, is number of fishes in the length bin .

Next, number of fishes caught in a single prefecture, month, and gear are calculated as:

(3)

where is the catch in weight of the same prefecture, month, and gear of the equivalent length frequency data. The number of fishes is multiplied by the length composition ratio to calculate catch at size as:

(4)

where is catch number at length .

Age data are collected from each prefecture. Sample for age estimation are subsampled at random from the length sample and increments of otolith or annulus of scale are counted to estimate the age. For fish with age of 7 or older, age is categorized as 7+ owing to the difficulty of age estimation and small proportion within the samples.

**Age-length keys**

To construct age-length key for chub mackerel, length and age data from each prefecture are combined and subdivided by quarter-year: January to March (Q1), April to June (Q2), July to September (Q3), and October to December (Q4). Since the stock of chub mackerel migrates seasonally, the age-length data are subdivided into two geographical groups: Eastern and Western part of Pacific coast of Japan (fig 1). Eastern and Western groups consist of catches from East of Shizuoka Prefecture and West of Mie Prefecture, respectively.

Age-length key is developed for each group and each quarter-year using the method of forward-age-length key, which describes the probability of age at given size (Fridriksson 1934, Ailloud and Hoenig 2019).

Age and length data are sorted in 1 year old and 1 cm bins, respectively. Any CMs with FL below 15 cm and 45 cm are treated as age 0 and 7+, respectively. The proportion of age *t* at length bin *j* is described as is calculated as,

(5)

where is the number of measured samples at age *t* and length bin *j*.

When there is no age composition information available at a certain length bin in which the catch is observed, a mean ALK of CY2002-CY2014 is used for substitution to that bin as the “default ALK” for each quarter and region.

**Catch at age**

Age length key is applied to catch at length data for each quarter/year. The proportion of age *t* at length *j* is described as and catch at length is converted into age basis as follows,

(6)

where is number of catch with age *t* at length *j*. Catch at age for each quarter and region is calculated as

(7)

Catch at age for each quarter and region is calculated by aggregating the catch at each length bin for each age group. Catch at age in number from Japan is calculated by adding the quarterly catch at age from Eastern and Western Japan.

**Weight at age**

Catch number at length is converted into weight basis by applying L-W relationship to the equivalent quarter and region, catch number at age. Using equation (7) and L-W relationship, catch in weight at age is calculated as

(8)

and weight at age is calculated as

(9)

**Maturity at age**

For the stock assessment, maturity at age is derived based on Watanabe and Yatsu (2006) that studied the maturation of spawning chub mackerel in waters around Izu Islands and Joban area. Since the maturity at age is known to differ by the stock status as presented in Watanabe (2010), the observed maturity rate at age is averaged during the periods with similar stock levels (very high, high, medium, low, and extremely low) estimated from in the domestic stock assessment (Yukami *et al*. 2024). The maturity at age is estimated using combined method of KG observation and age composition of aggregating spawning fish in the main spawning ground, *i.e.*, Izu Islands waters.

**Results and Discussion**

**Length frequency from major landing ports**

Catch at length from CY2014-CY2023 is presented in figure 2 and figure 3 for Eastern and Western Japan, respectively. Catch at length by region shows the difference in center of data in each quarter as the chub mackerel growth proceeds. Likewise, the catch at length pattern of Eastern and Western Japan are different throughout the quarters and years which justifies the separation of data into two geographical regions.

**Age determination and Age-length key**

Table 1 presents the number of age determination conducted from the Eastern and Western Japan between CY2014-CY2024 Q2. Age determination is consistently conducted throughout the region with a greater number of age measurements being conducted in the Eastern region from 1125 to 3320 measurements annually, meanwhile the age measurement in the Western region is less from 119 to 1867 measurements annually. In CY2014 Q3, CY2015 Q3, and CY2020 Q3, Western region has no aged data.

Figures 4 and 5 show the ALK for CY2014-CY2024 for the Eastern and Western Japan, respectively with ages 0 to 7+. To match the calendar year and submitted data for TWG CMSA08, the age is adjusted to be incremented on January 1st, which requires additional procedure to convert into the fishing year basis.

**Catch-at-ag**e

Catch-at-age is calculated from catch-at-length data and ALK from the Eastern and Western Japan. Figure 6 shows the catch-at-age from two regions from CY2014 to CY2024. Figure 6 captures the shift of strong year classes of CY2013 and CY2018 as the prominent peak age shifts with proceeding years. Figure 7 shows the annual catch at age based on the calendar year. The quarterly and annual pattern exhibit significant decreasing trend in catch numbers in the recent years especially in CY2022, CY2023, CY2024/Q1 and Q2.

**Weight at age**

Figure 8 shows the quarterly weight at age for Eastern and Western Japan from CY2014 to CY2024/Q2. As described in Kamimura et al. (2021), which presented the recent decline in growth rate due to density dependence, the overall weight at age exhibits decreasing trend especially in the recent years (i.e., CY2020-CY2024). The weight at age is greater in Western Japan than Eastern Japan, that may be due to difference in migration pattern, which CMs in Western Japan tend to be more coastally associated while CMs in Eastern Japan migrate further in offshore for feeding.

**Maturity at age**

Figure 9 shows the proportion of matured females at age used for the stock assessment in Japan since FY1970. Maturity at age 0 is considered as 0 (immature) throughout the years and maturity at age 1 is consistently immature except for FY2000-FY2005, where stock level was considered as low. Age 2 fish exhibit dynamic variations in maturity throughout the years with increased maturity to FY2000-FY2005, with declining trend to 0 in FY2015 and thereafter. Age 3 fish are considered fully matured in FY1987-FY2015 but declined to 0.3 since FY2016 and thereafter. Age 4 and above are considered as fully mature for FY1970-FY2023.

**Conclusions**

This document summarized and overviewed the methodology to estimate the catch at age of chub mackerel caught in the northwestern Pacific Ocean by Japanese fleets. The measurement of length, weight, and age of chub mackerel on the annual basis allows development of age-length key and estimation of catch at age with up-to-date demographics. The newly introduced data that construct FY2023 catch at age has presented that catch is even more decreased compared to FY2022, which is believed to play an influential role to the stock assessment.

**Reference**

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ダイアグラム が含まれている画像

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 1. Area definition of Eastern and Western Pacific coast of Japan.

1. CY2014-CY2017

グラフ

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 2. Quarterly catch at length of CM from Eastern Japan for (a) CY2014-CY2017, (b) CY2018-CY2021, and (c) CY2022-CY2024.

(b) CY2018-CY2021

グラフ, 散布図

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 2. Continued.

(c) CY2022-CY2024

グラフ, 散布図

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 2. Continued.

1. CY2014-CY2017

カレンダー

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 3. Quarterly catch at length of CM from Western Japan for (a) CY2014-CY2017, (b) CY2018-CY2021, and (c) CY2022-CY2024.

(b) CY2018-CY2021

ダイアグラム が含まれている画像

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 3. Continued.

(c) CY2022-2024

カレンダー

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 3. Continued.

CY2014-CY2017

絵と文字の加工写真

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 4. Quarterly ALK for Eastern Japan for (a) CY2014-CY2017, (b) CY2018-CY2021, and (c) CY2022-CY2024.

(c) CY2018-CY2021

棒グラフ

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 4. Continued.

(c) CY2022-CY2024

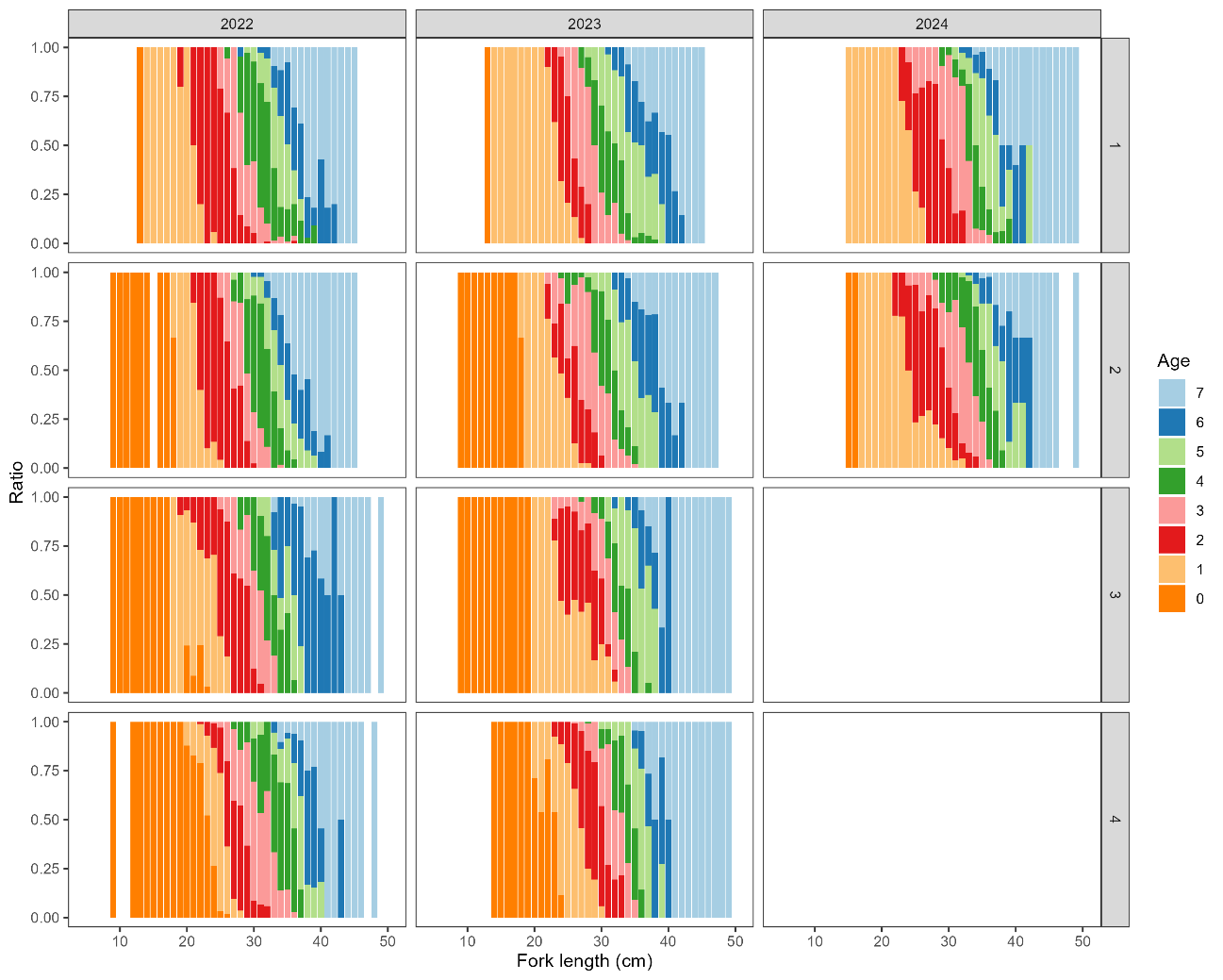


Figure 4. Continued.

1. CY2014-CY2017

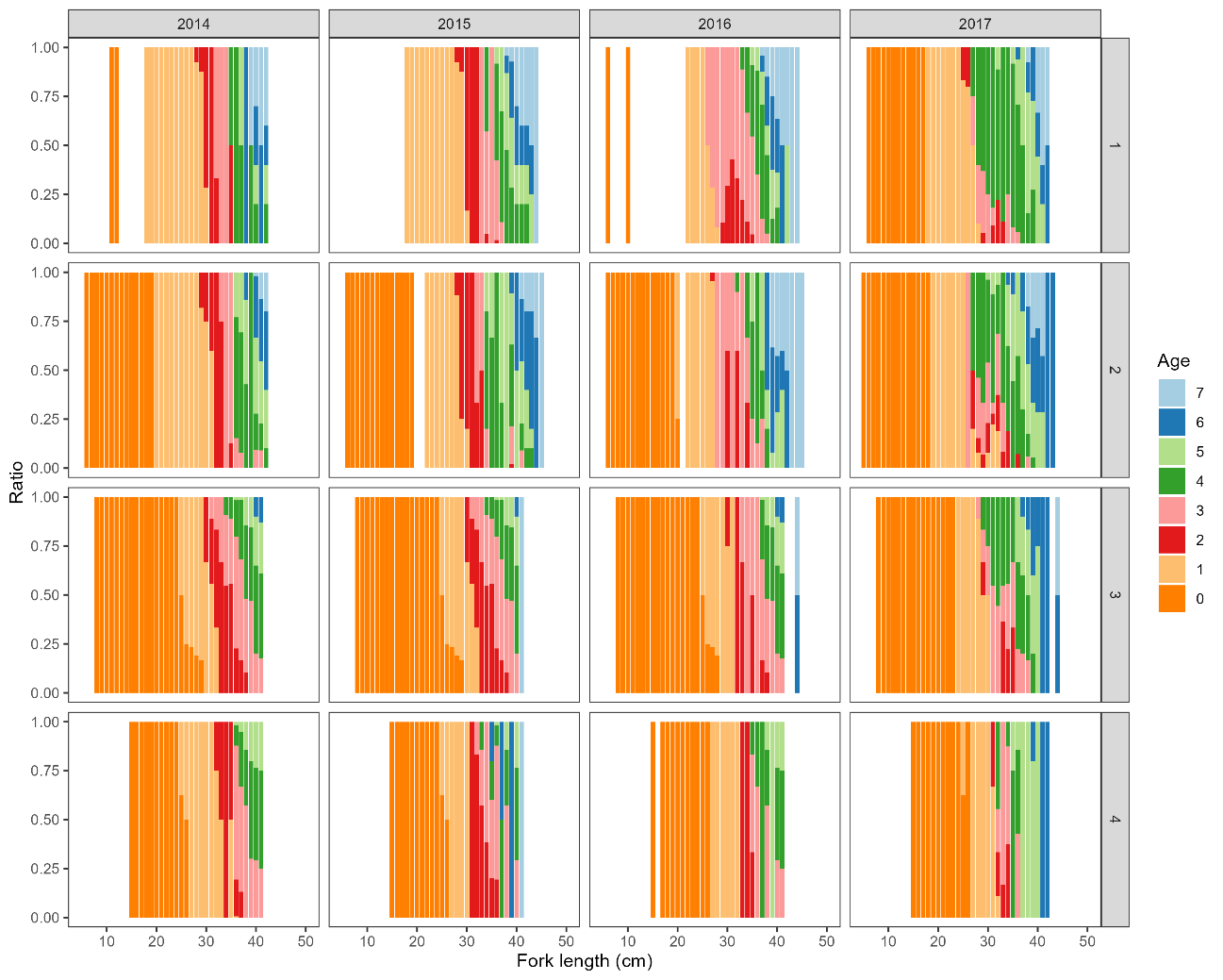


Figure 5. Quarterly ALK for Western Japan for (a) CY2014-CY2017, (b) CY2018-CY2021, and (c) CY2022-CY2024.

1. CY2018-CY2021

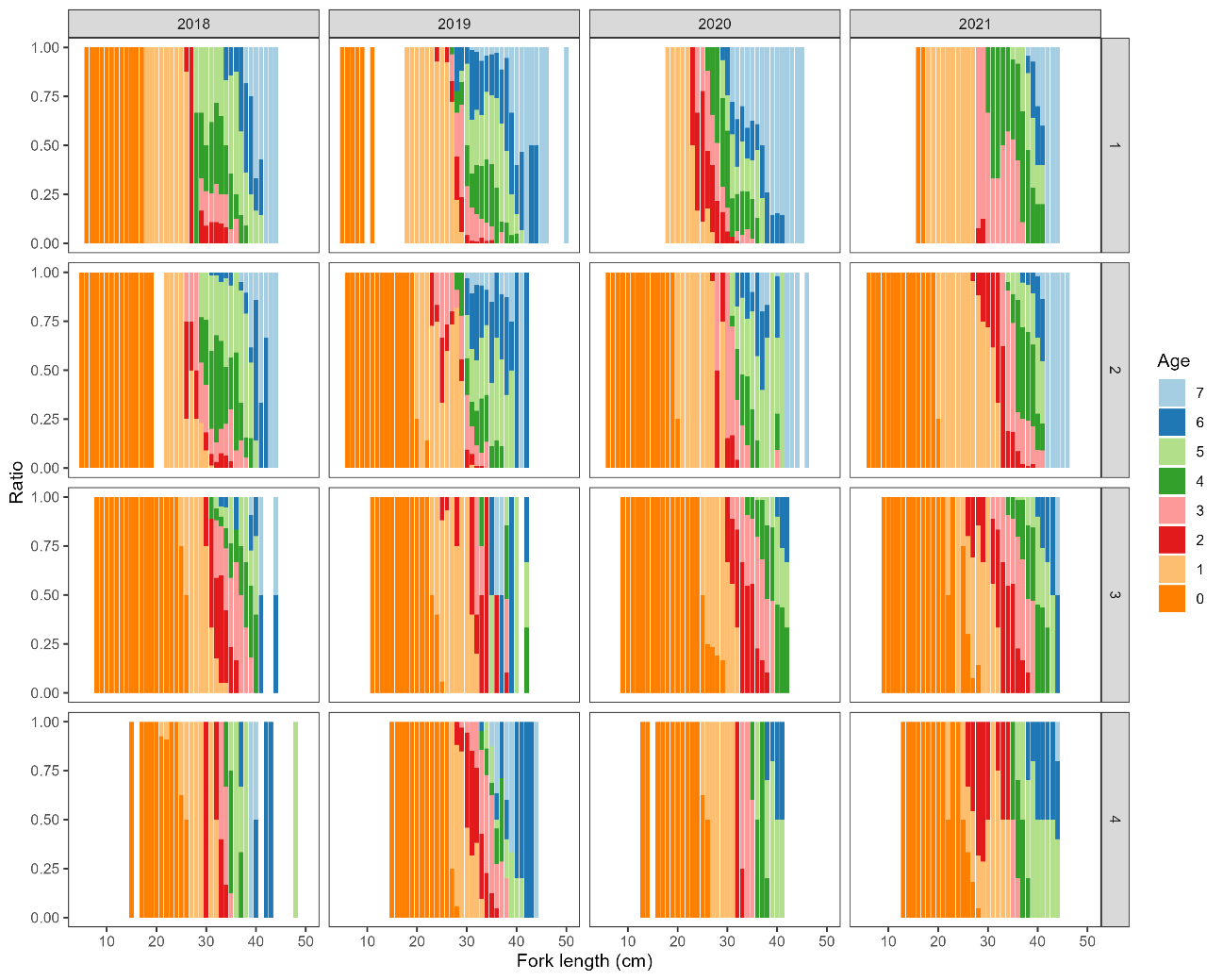


Figure 5. Continued.

1. CY2022-CY2024

文房具, 筆記用具, 鉛筆, 部屋 が含まれている画像

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 5. Continued.

1. CY2014-CY2017

カレンダー

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 7. Quarterly catch at age from Eastern and Western Japan for (a) CY2014-CY2017, (b) CY2018-CY2021, and (c) CY2022-CY2024.

1. CY2018-CY2021

グラフ

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 6. Continued.

(c) CY2022-CY2024

グラフ

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 6. Continued.

カレンダー

AI によって生成されたコンテンツは間違っている可能性があります。

Figure 7. Calendar year-based catch at age of CY2014 to CY2024 for Eastern and Western Japan.

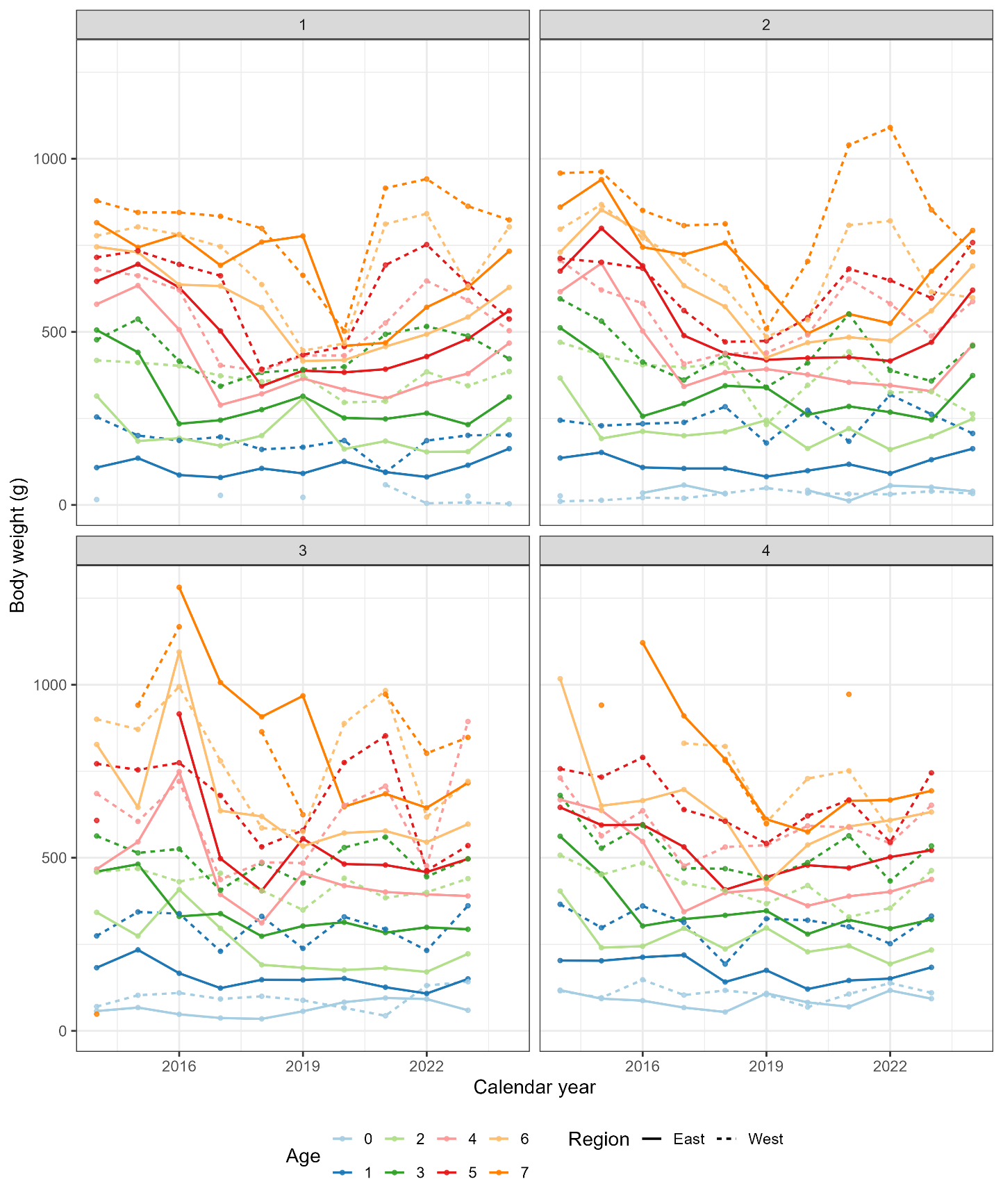


Figure 8. Timeseries of weight at age at each quarter from CY2014 to CY2024 for Eastern (solid line) and Western Japan (dotted line).

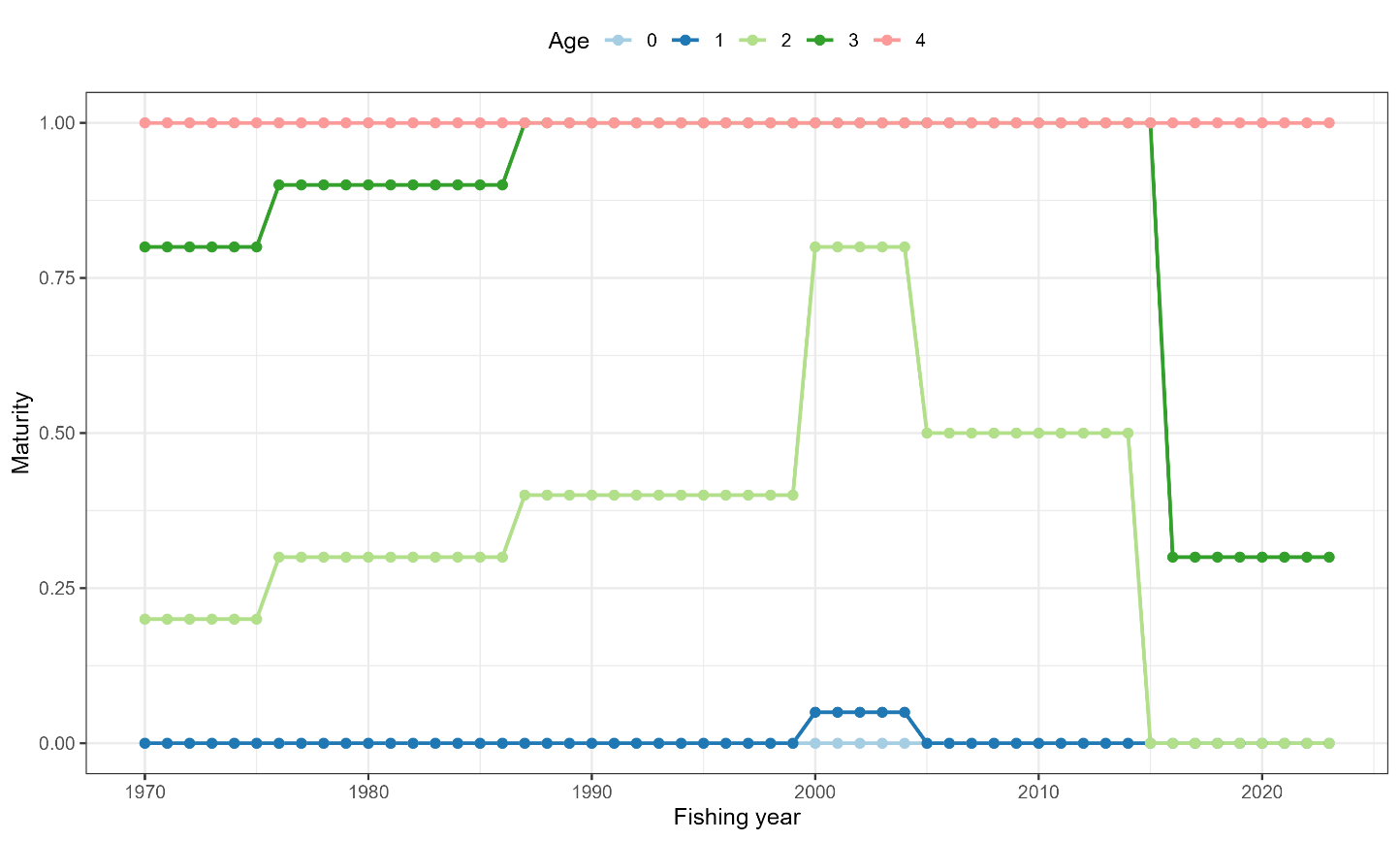


Figure 9. Maturity at age from FY1970 to FY2024. Ages 0 to 4 are presented and age 5 and above are displayed as age 4+ since they exhibit similar pattern of maturity of age 4.

Table 1. Number of age determination by year, quarter, and region from CY2014 Q1 to CY2024 Q2.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Calendar  Year | Region | Q1 | Q2 | Q3 | Q4 | Total |
| 2014 | East | 742 | 839 | 225 | 514 | 2,320 |
| 2015 | East | 739 | 1,029 | 494 | 505 | 2,767 |
| 2016 | East | 453 | 239 | 111 | 222 | 1,025 |
| 2017 | East | 752 | 592 | 194 | 491 | 2,029 |
| 2018 | East | 836 | 661 | 44 | 162 | 1,703 |
| 2019 | East | 808 | 485 | 340 | 641 | 2,274 |
| 2020 | East | 1,204 | 597 | 404 | 858 | 3,063 |
| 2021 | East | 1,012 | 818 | 645 | 845 | 3,320 |
| 2022 | East | 837 | 663 | 511 | 912 | 2,923 |
| 2023 | East | 734 | 622 | 373 | 797 | 2,526 |
| 2024 | East | 559 | 708 | - | - | 1,267 |
| 2014 | West | 96 | 131 | 0 | 2 | 229 |
| 2015 | West | 30 | 54 | 0 | 35 | 119 |
| 2016 | West | 240 | 88 | 22 | 33 | 383 |
| 2017 | West | 193 | 241 | 144 | 58 | 636 |
| 2018 | West | 311 | 388 | 296 | 124 | 1,119 |
| 2019 | West | 779 | 667 | 122 | 299 | 1,867 |
| 2020 | West | 659 | 126 | 0 | 17 | 802 |
| 2021 | West | 22 | 23 | 67 | 72 | 184 |
| 2022 | West | 68 | 64 | 201 | 82 | 415 |
| 2023 | West | 273 | 156 | 103 | 78 | 610 |
| 2024 | West | 101 | 27 | - | - | 128 |