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Compilation and Summary of Shared Data for Operating Models of the Chub Mackerel in the Northwestern Pacific

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Summary

As a lead of the OM Small Working Group, I compiled members' data to be used for the development of operating models in the stock assessment of chub mackerel (*Scomber japonicus*). I firstly compensated catch-at-age and weight-at-age of China by making simple assumptions because they had missing values in a few years. I then merged the members' data by using (weighted-)average for weight at age and maturity at age, because the figures were different among members. The four abundance indices of Japan have relatively long time series and clear tuning targets, whereas CPUEs from China and Russia have not associated with ages or growth stages. I distributed two kind of datasets (per-fleet data and the data merged into a single fleet) to the members, which will be used as an input of stock assessment model candidates. Simultaneously, it is important for us to review data quality, interpret large data discrepancies among members, and discuss ways for the data to be incorporated into the forthcoming formal stock assessment of chub mackerel in the Northwestern Pacific.

Introduction

The Technical Working Group on Chub Mackerel Stock Assessment (TWG CMSA) in NPFC determined that (1) the candidates of stock assessment models (VPA, ASAP, KAFKA, and SAM) would be compared by an operating model, and (2) the operating model would be based on POPSIM-A (NPFC 2019). POPSIM-A uses a stock assessment model as an operating model and, therefore, input data are needed for the development of operating models by fitting stock assessment model candidates (Deroba et al. 2014). Members in TWG CMSA (China, Japan, and Russia) respectively submitted potentially available data of chub mackerel. At the virtual intersessional meeting on May 2020, it was suggested that there were two options to either merge the shared data (i.e., merged data) or treat them separately as different fleets (per-fleet data) (NPFC 2020). Here I report the method of data compilation for the per-fleet and merged data, and summarize the characteristics of shared data.

Methods and Results

Per-fleet data

Catch-at-age (CAA) and weight-at-age (WAA) data from China, which reported their catch since 2015, were available for 2018 and 2019, and 2017 to 2019, respectively (Tables 1, 2). Moreover, the CAA data were recorded in not number but weight. In other to serve the Chinese CAA data, I converted the unit of CAA from weight to number by dividing the CAA in weight for 2018 and 2019 with the WAA for corresponding years. Before assigning the CAA to 2015 to 2017, two assumptions were made: (1) the WAA between 2015 and 2017 were equal to the averages of 2018 and 2019 (Fig. 1); and (2) the annual age composition of Chinese catch before 2018 was identical to the average of 2018 and 2019 (Fig. 2). I calculated the CAA data for 2015 to 2017 so that the total catch in weight was equal to the reported values under the above two assumptions (Fig. 3). The generated CAA is shown in Fig. 4.

There found differences in the maximum age classes defined by each member. Japan has decomposed age classes from 0 to 6+ for the domestic stock assessment (Yukami et al. 2020). Although the Chinese CAA data categorized into ages 0 to 7+, no catch was reported for in age 5 and older in any years (Tables 1, 2). I therefore regarded that the catches of China were limited from age 0 to 4, but it is not certain whether the category of age 4 included fish elder than age 5 and more (plus group). CAA, WAA, and maturity-at-age (MAA) in Russian data were available from age 0 to 4 (2014, 2019) or 5 (2015-2018). Although it is not certain whether the maximum age class were plus group or not, I assumed that the maximum age class was 4 or 5 (i.e., no plus group).

I then combined data from each member and distributed it as per-fleet (or per-member) data ("WholeData(chub_mackerel)200928.csv"). I re-numbered the fleet-numbers from Japan to China and Russia (Table 3). I separated the fleet of fisheries (CAA, WAA, and MAA) and that of abundance indices. The per-fleet data may be used in the stock assessment models that can incorporate multiple fleets.

Merged data

I generated merged data with single fleet from the per-fleet data. I simply summed CAA from each member to obtain the merged values (Fig. 4). The catches in China were mainly composed of young ages (ages 0 and 1), whereas the older ages dominated the Japanese catches except 2014 (Figs. 2-4).

I found a few large discrepancies in WAA among members (Fig.1). The first large discrepancy was found in the weight at age 1 between China and Japan; the weight at age 1 of China was 112 g in 2018 and 122 g in 2019, whilst that of Japan was 239 g in 2018 and 166 g in 2019. Another large discrepancy was much larger weights of age 3 and older in Russia than in China and Japan from 2016 (Fig. 1). I calculated WAA averaged by catch numbers so that the total catch in weight was identical between the per-fleet data and merged data (Fig. 1). The weights at age 1 in the merged data were close to those in the Chinese data, while the weights at age 3+ in the merged data were close to those in the Japanese data (Fig. 1). This is because the catch numbers at ages 1 and 3+ were the largest in China and Japan, respectively (Fig. 4).

The maturity rates for ages 1 to 3 were also considerably different among members: the maturity rate of Japan was lower than that of China and Russia (Fig. 5). I here calculated the simple average of MAA for the merged data because I did not think of any more appropriate way at present. I changed the fleet number of all fisheries to zero as the single fleet. I distributed this data for all candidate age-structured models (MergedData(chub_mackerel)200928.csv). The R code to generate these data is made available at GitHub upon request.

Abundance index

I did not do any treatment for the data of abundance indices. The two recruitment indices of Japan showed a similar yearly trend with the strong year classes of 2013, 2016, and 2018 (Fig. 6). Both indices of the spawning stock biomass exhibited an increasing trend (Fig. 6). The Chinese and Russian indices, which have not been assigned to specific ages/growth stages, are available only in recent years and relatively stable (Fig. 6).

Discussion

A few simple assumptions were needed to construct the shared data for the stock assessment model candidates. I assumed that WAA and the age composition of catch in number for 2015 to 2017 of China was identical to the average of 2018 and 2019 (Figs. 1-2). The proportions of catch numbers (especially for ages 0 and 1) were highly variable from 2018 to 2019 and, therefore, would possibly fluctuate greatly before 2018 (Fig. 2). These assumptions should be validated in future.

The age compositions of catch were greatly different among members (Figs. 2-4). The age composition of Japan reflected the strength of year classes: the large catches of age 1 in 2014, age 2 in 2015, age 3 in 2016, and age 4 in 2017 (Figs. 2-4) were attributed to the strong year class of 2013 (Fig. 6), and another strong year class of 2018 appeared in the moderately large catch of age 1 in 2019. Such patterns are not observed in Chinese and Russian data, however. For example, the catches of age 0 in China and Russia increased from 2018 to 2019 (Figs. 3-4). In contrast, the Japanese recruitment indices did not indicate the appearance of a strong year class in 2019 (Fig. 6). It is recommended that the differences in the catch trends of ages 0 and 1 in recent years observed between Japan and the other members should be investigated in the data preparation before benchmark stock assessment.

Chinese fisheries generally caught younger fish than Japanese fisheries (Figs. 2-4), which may suggest that that the selectivity was quite different between China and Japan. However, it should be noted that the weight at age 1 of China was much smaller that of Japan in 2018 and 2019, and the average value of these two years was used for 2015 to 2017 (Fig. 2). Therefore, the large catch numbers at age 1 in China might be attributed to this smaller weight. It is essential to interpret the large difference of weights between China and Japan, and to examine the validity of the assumption of WAA and CAA in China, especially because the selectivity to young ages is closely associated with the status of fishing impacts and stock abundances.

I also found a large discrepancy of body weights at old ages between Russia and the other members. A previous study showed that the growth rate and body size of chub mackerel shifted depending on the level of stock abundance (Watanabe and Yatsu 2004) and Japan has observed that the growth rate and body size has decreased due to the recent increase in stock abundance. The body weights of Russia in recent years approximately correspond to those of Japan in the period of low-level stock abundances (the 1990s and 2000s). Although the figures of Russia are little influential on the merged data because of smaller catch numbers of Russia (Fig. 1), the values of WAA are possibly related to the data generation of CAA. The small catches of old fish and relatively large catches of young fish of Russia may be linked to its WAA.

The maturity rate is one of the crucial biological parameters that are difficult to measure in fisheries stock assessments. Japan has inferred MAA based on the previous evidence that the maturity rate of chub mackerel changes according to the level of stock abundance (Watanabe and Yatsu 2006). The maturity rate of Japan in recent years, therefore, has declined in response to the increase of stock abundance (Manabe and Yukami 2020). However, the maturity rates in China and Russia were still high and has a large gap with Japan (Fig. 5). Review and appropriate choice of MAA are needed for accurate stock assessment because the maturity rate directly affect spawning stock biomass estimates and, thereby, influential on stock-recruitment relationship and biological reference points.

There are six potential abundance indices: four from Japan, one from China, and one from Russia (Fig. 6). The four indices of Japan are all standardized (Nishijima et al. 2017; Kanamori et al. 2018; Hashimoto et al. 2019, Kanamori et al. 2019) and have longer time series than the other two indices. Furthermore, their associations with abundance estimates are clear (two for recruitment and two for SSB), and hence, these indices are easy to use in stock assessment models at present. By contrast, the other two indices of China and Russia have shorter time series and are probably unstandardized. Moreover, their tuning targets and usage are unclear, and it would be hard to use them in the candidate models.

In conclusion, two kinds of datasets were generated and distributed; the merged data with single fleet can be used for all candidate age-structured models (VPA, ASAP, KAFKA, and SAM), while the per-fleet data can be used for the models that can deal with multi-fleets. Importantly, there found a few potential issues to be resolved toward the official stock assessment of chub mackerel in the Northwestern Pacific. First, the CAA and WAA are not available between 2015 and 2017 in China. Although I made the simple assumptions to construct the shared data for the OM works, the validity of the assumptions should be evaluated, and a more appropriate assumption may be needed. Alternatively, this problem might be solved by the application of models (e.g., SAM) that allow missing values (Perretti et al. 2020). Second, there are large discrepancies of catch compositions and body weights among members. A deeper understanding of reasons for the discrepancies will be important for the accurate estimation of stock status. Third, it is unknown how to use the abundance indices of China and Russia. I would like to know any idea of usage of the indices and any plan of index standardization. Fourth, we should determine the definition of fishing year. China and Russia probably compile annual data according to the calendar year (i.e., January to December). However, Japan differentially defines July to June in the next year as a fishing year and compiles annual data by the defined fishing year for the domestic stock assessment (Yukami et al. 2020). Model development and data review should be simultaneously progressed for efficiently conducting the stock assessment of chub mackerel in NPFC.

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Table 1: Catch weight (tons) at age data of China, Japan and Russia.

Year	Age0+	Age1+	Age2+	Age3+	Age4+	Age5+	Age6+	Age7+
2015	/	/	/	/	/	/	/	/
2016	/	/	/	/	/	/	/	/
2017	/	/	/	/	/	/	/	/
2018	3657.39	76805.24	36573.93	12191.31	1219.13	0.00	0.00	0.00
2019	15231.11	19030.34	10663.96	14340.58	5180.01	0.00	0.00	0.00

Table 2: Weight (g) at age data of China, Japan and Russia. Note that samples in 2017 were collected only in December.

Year	Age0+,(g)	Age1+,(g)	Age2+,(g)	Age3+,(g)	Age4+,(g)	Age5+,(g)	Age6+,(g)	Age7+,(g)
2015	/	/	/	/	/	/	/	/
2016	/	/	/	/	/	/	/	/
2017	109	116	/	/	/	/	/	/
2018	106	112	338	398	423	/	/	/
2019	75	122	263	325	404			

Table 3: Summary of shared data per fleet.

Fleet No.	Member	Data type	Year range	Note
1	Japan	CAA, WAA, MAA	1970-2019	
2	Japan	Abundance index	2002-2019	For recruitment
3	Japan	Abundance index	2005-2019	For recruitment
4	Japan	Abundance index	2003-2019	For SSB
5	Japan	Abundance index	2005-2019	For SSB
6	China	CAA, WAA, MAA	2015-2019	Assumed in 2015-2017
7	China	Abundance index	2015-2019	
8	Russia	CAA, WAA, MAA	2014-2019	
9	Russia	Abundance index	2016-2019	

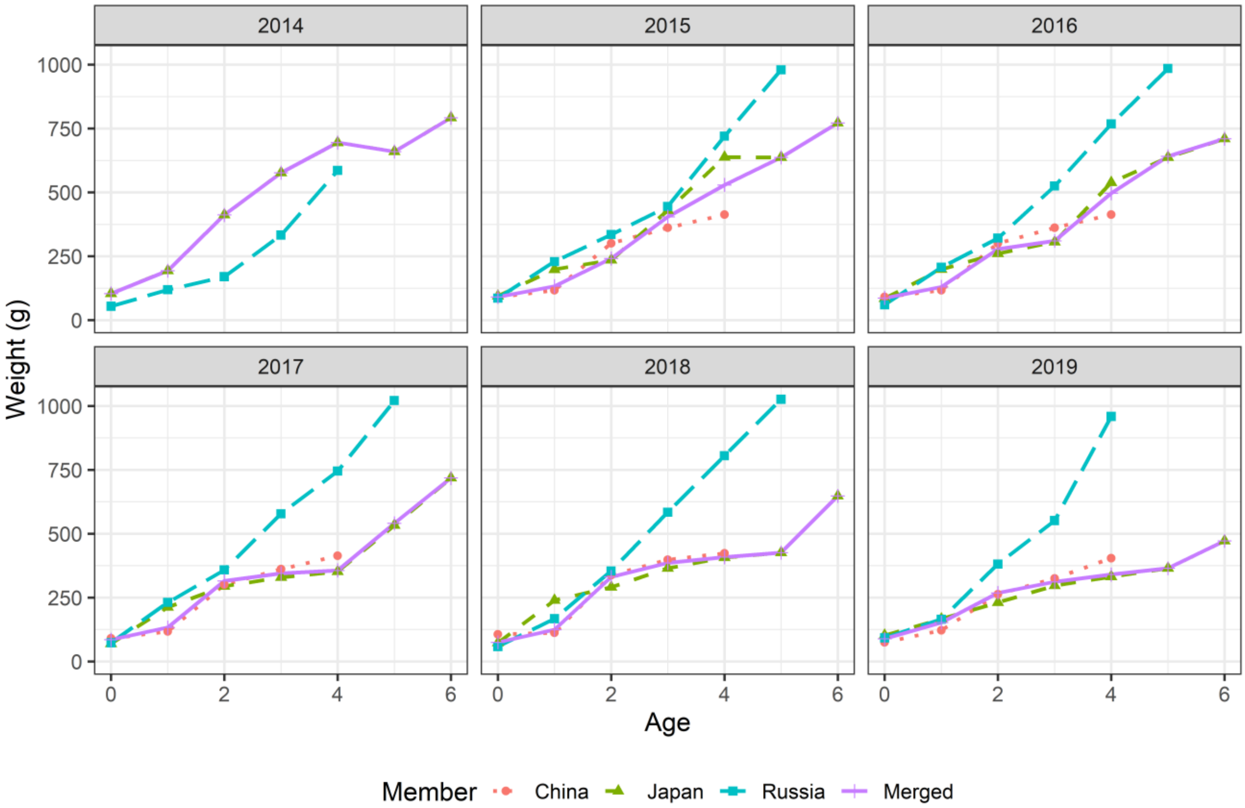

Figure 1: Weight-at-age of the members and merged data. Note that the values of China from 2015 to 2018 were assumed as the average of 2018 and 2019. Here focuses on 2014 and later during which data from multiple members are available, although Japan has data before 2013.

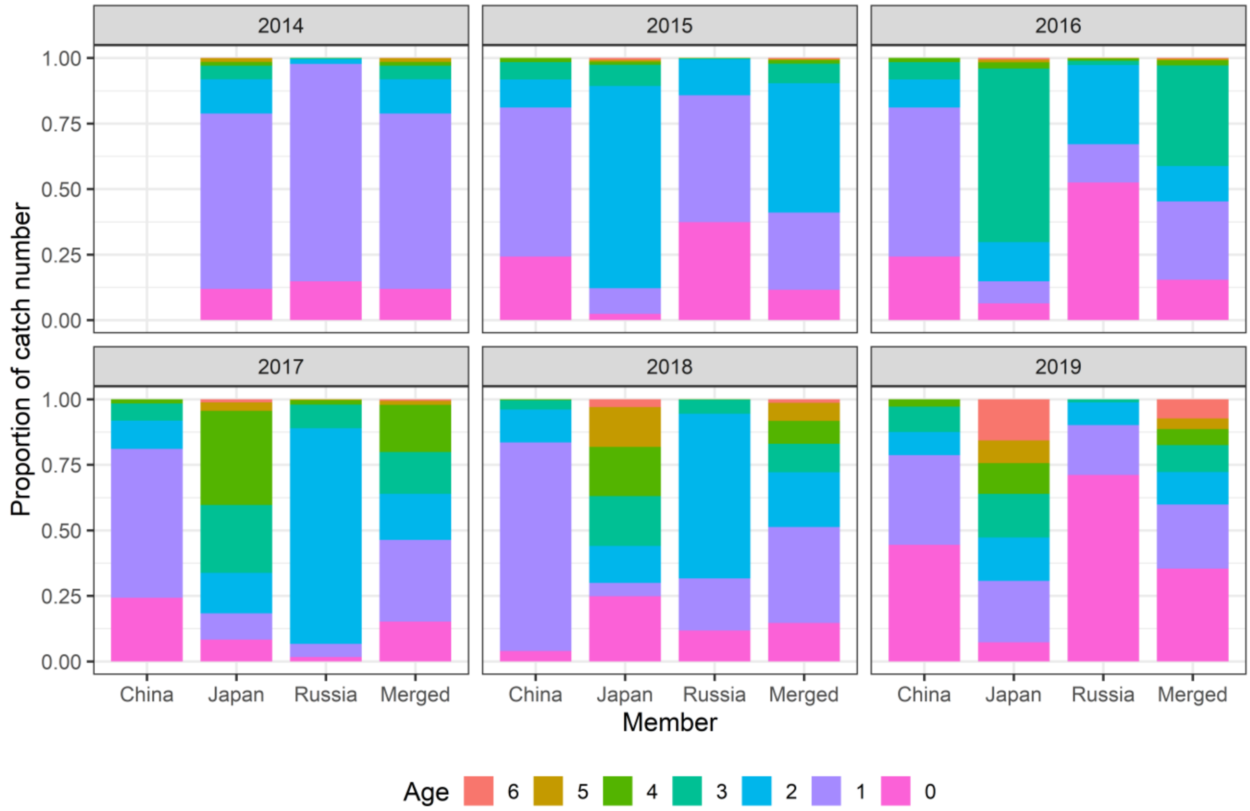

Figure 2: Age-specific proportions of catch numbers of members. Note that the proportions of China from 2015 to 2018 were obtained by assuming the average of 2018 and 2019. Here focuses on 2014 and later during which data from multiple members are available, although Japan has data before 2013.

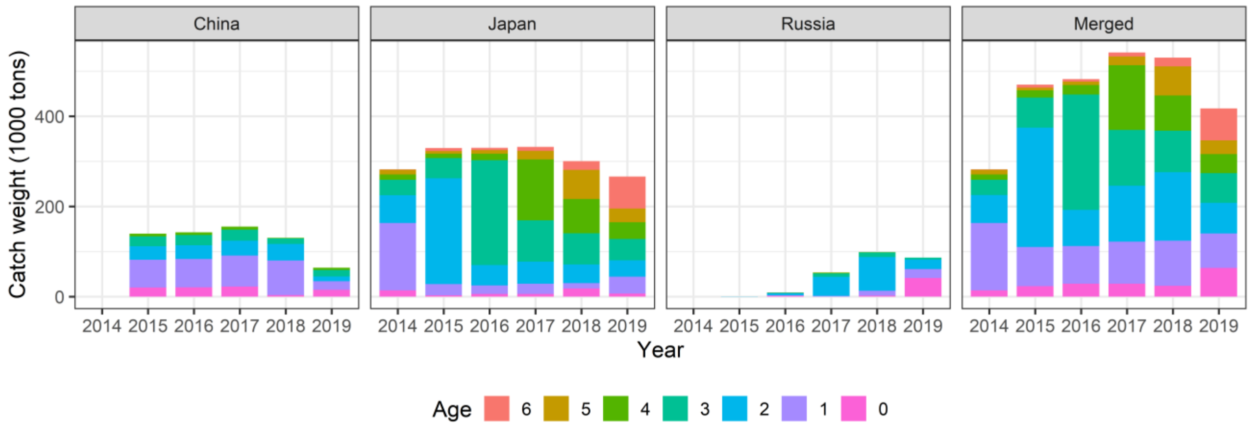

Figure 3: Catch weight at age of members and merged data. Here focuses on 2014 and later during which data from multiple members are available, although Japan has data before 2013.

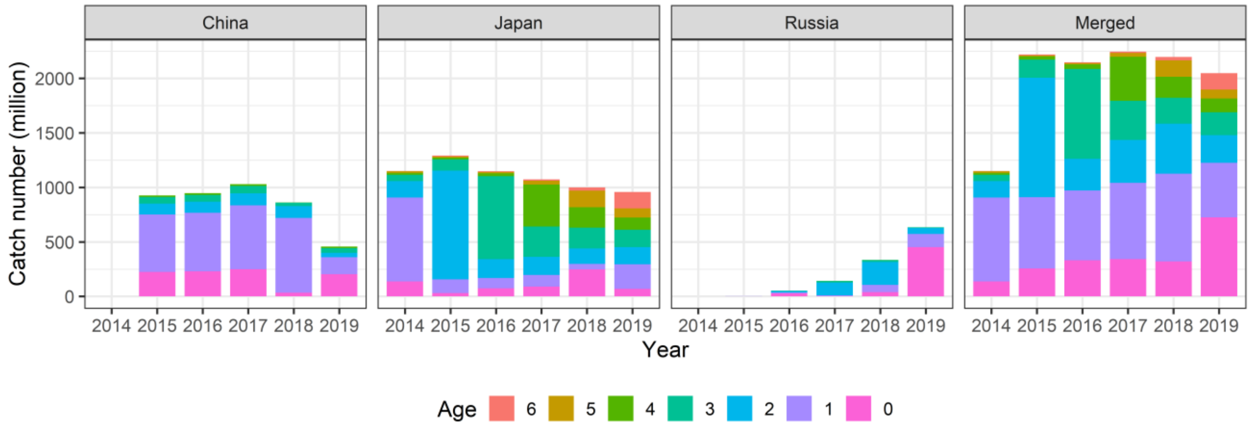

Figure 4: Catch numbers at age of members and merged data. Here focuses on 2014 and later during which data from multiple members are available, although Japan has data before 2013.

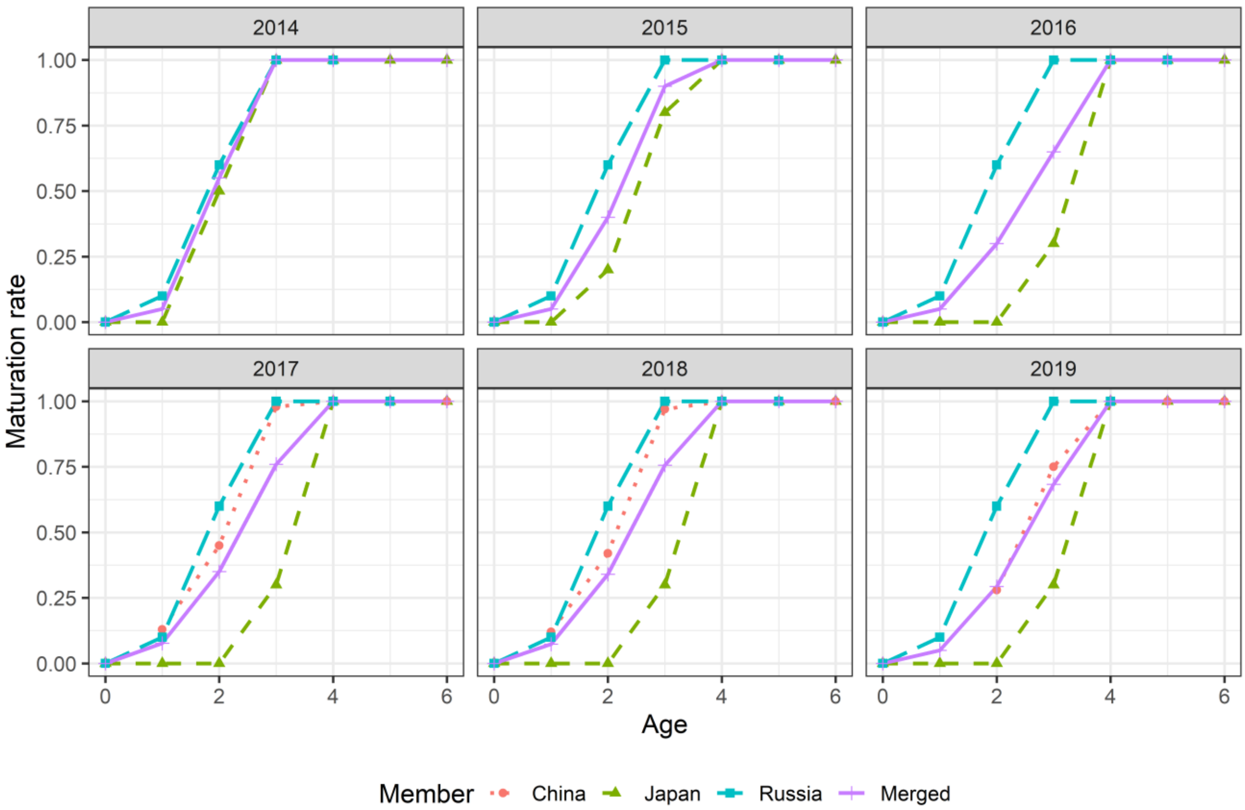

Figure 5: Maturity-at-age of the members and merged data. Here focuses on 2014 and later during which data from multiple members are available, although Japan has data before 2013.

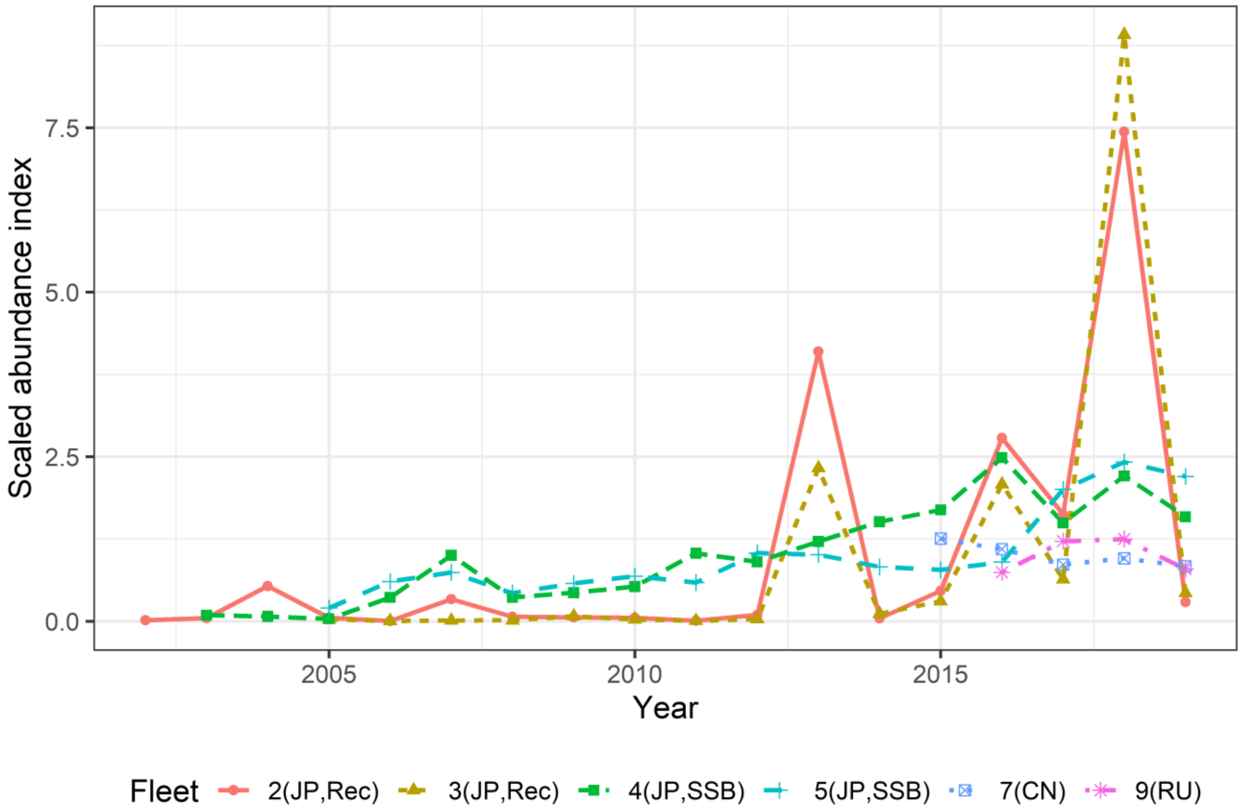

Figure 6: Yearly trends of abundance indices. Note that the values are scaled by dividing by the mean (i.e., the average is equal to one). Japan (JP) has four indices (two for recruitment and two for spawning stock biomass), while China (CN) and Russia (RU) has one index, respectively. The fleet numbers in the legend are of shared data.