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Japanese data update: Tagging, Size and Biological information

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Yoshinori Aoki, Naoto Matsubara, Yuichi Tsuda, Makoto Nishimoto, and Hidetada Kiyofuji[1]

[1] National Research and Development Agency, Japan Fisheries Research and Education Agency, Fisheries Resources Institute, Japan

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National Research and Development Agency, Japan Fisheries Research and Education Agency, Fisheries Resources Institute, Japan

Abstract

1. This document provides an overview of updates to Japanese tagging data and size data, as well as biological information obtained through Japanese research since last skipjack stock assessment.
2. Japanese Tagging Program (JPTP) data and size data, which are used as input data for the 2025 skipjack tuna stock assessment, have been updated from the 2022 assessment.
3. Data quality was evaluated by comparing the number of tag releases and recaptures as well as the size data between 2022 and 2025 data preparation for the stock assessment.
4. We also report results of biological studies conducted by Japan, including growth and early life history based on hatching experiments and larval/juvenile sampling surveys.

Introduction

The reproducibility and transparency of data submitted for stock assessments and management procedures (MPs) are essential for ensuring the robustness of assessment outcomes. Among the key data inputs for skipjack tuna (*Katsuwonus pelamis*, SKJ) assessments, tagging and size data play a central role in informing the MULTIFAN-CL stock assessment model—particularly in estimating fishing mortality, spatial dynamics, growth, and selectivity. Japan possesses one of the most extensive and long-running datasets of SKJ tagging and size information in the western and central Pacific Ocean (WCPO), accumulated over decades of research and monitoring. These data form a critical foundation for SKJ stock assessments. In preparation for the 2025 SKJ stock assessment, Japan updated tagging and size data from those used in the 2022 assessment.

In addition to incorporating newly collected data, historical records are periodically revised, for example through corrections of past entries or the digitization of paper-based legacy data. Consequently, both recent and historical datasets may be updated between assessment cycles. To enhance transparency and improve understanding of how such updates may influence assessment results, it is important to examine the differences between datasets used in successive stock assessments. The quality and consistency of these updates were evaluated by comparing the number of tag releases, recaptures, and size measurements across the two assessment cycles.

In parallel with data updates, Japan has also continued biological research efforts to support stock assessment modeling. These efforts include otolith-based aging studies and laboratory-based hatching experiments, which provide important insights into SKJ growth and early life history. This report summarizes recent updates to Japan's tagging and size datasets and presents new biological findings relevant to improving the scientific basis of SKJ stock assessments in the WCPO.

Materials and Methods

Japanese tuna tagging program

We used data from 1966 to 2024, following the same procedures as in the previous assessment (Aoki et al., 2022). The method for determining fork length at release was also identical to that adopted in 2022. Although the same programming code was used, some release project data that were included in the 2022 dataset were excluded in the current analysis. This exclusion was due to increasing difficulties in obtaining complete release information from relevant agencies since around 2022, as data that had previously been provided on a regular basis became less comprehensive. Accordingly, data from these agencies were retrospectively excluded from the entire dataset.

Japanese Size data for Pole-and-line and purse seine fisheries

Japanese size data for SKJ are maintained by the Fisheries Research Agency (FRA). Among these, size data collected from commercial pole-and-line and purse seine fisheries are submitted annually to the Pacific Community (SPC). Upon submission, these data are incorporated into the SPC database and subsequently used in regional stock assessments. As the FRA database undergoes regular updates, it is possible that additional records have been added since the previous stock assessment. In the present study, we assess the consistency of the size data by comparing record counts and size-frequency distributions for pole-and-line and purse seine fisheries across three sources: the FRA database as of July 2025, the dataset at the time of submission, and the SPC-archived datasets (JPPL and JPPS).

Biological research

Some biological data are not directly used in stock assessments, still they can be indirectly utilized to inform model assumptions or aid in interpreting results. In this section, we introduce two recent biological studies relevant to stock assessment: one on otolith growth study comparing micro increments using two different sections (surface and transverse sections) developed for SKJ (Aoki et al., 2024), and another on the relationship between egg hatching success and water temperature during the early life stages, where data remain particularly scarce (Fujioka et al., 2024).

Results and Discussion

Comparisons of JPTP releases and recaptures between 2022 and 2025

The number of releases and recaptures from the Japanese Tuna Tagging Program (JPTP) between 2022 and 2025 SKJ stock assessments are shown **Figures 1 & 2**, respectively. While minor changes are observed in the overall trends, the updated data does not indicate any substantial changes from the previous dataset. It should be noted that the number of releases for the years 2014–2018 have lower number compared to the 2025 assessment **(Figure 1**). This discrepancy is due to the exclusion of data from specific tagging projects as mentioned in Materials and Methods section. The current update also incorporates newly available data from 2022 to 2025; however, the 2025 data should be considered provisional. A notable decline in the number of releases in 2024 is associated with the postponement of tagging research in both tropical and temperate regions.

With respect to recapture data (**Figure 2**), the recent updates also resulted in slight year-to-year variations. While overall trends remain consistent with those reported in 2022, some differences can be traced back as far as 2011. The reduction in recaptures is primarily due to the exclusion of data from specific tagging programs, similar to the release data (**Figure 1**). On the other hand, the increase in recaptures is largely due to the addition of reports from foreign sources, some of which took over a decade to be incorporated into the dataset.

The updated release and recapture data are consistent with those used in the previous stock assessment, ensuring continuity and reliability in the 2025 evaluation. When examining the trends in the number of releases and recaptures alongside movement patterns (**Figure 3**), it is evident that substantial data exist from the 1980s and 1990s. Although the release data from the 1980s are limited (**Figure 1**), the number of recaptures during that period appears relatively high. This discrepancy is likely attributable to the fact that some tagging release records from the 1980s have not yet been digitized (Aoki et al., 2022).

Comparisons of size data between 2022 and 2025

The number of size data and size distribution caught by PL and PS fisheries for three different version of the data sources are shown in **Figures 4-7**. For PL size data (**Figures 4 & 5**), there was little difference between the data in the newly updated FRA database and the data originally submitted, except for the year 2020 (**Figure 4**). The cause of this discrepancy is currently under investigation. One possible explanation is that the current database applies stricter error-checking protocols compared to the system used in 2020. For instance, even if the data themselves are valid, discrepancies in character encoding—such as differences between types of Japanese characters or Latin alphabets—may now be flagged as errors. It is possible that such inconsistencies occurred only in the 2020 dataset. In contrast, for the year 2023, the dataset stored by the SPC contains more records than those submitted directly from Japan. The reason for this discrepancy will be examined in future analyses. To determine whether these differences in data volume are biased toward specific size classes, we compared their effects on the overall size distribution (**Figure 5**). No pronounced deviation in trends was found, suggesting that discrepancies among data sources have minimal impact on the overall analysis. One noteworthy issue that should be recorded is the sharp drop in the number of individuals measuring over 70 cm. This is due to a technical limitation during a certain period, when the maximum measurable size using punching measurement sheets was 70 cm. During punching measurements, data sheets are placed in advance in a punched form with a preset upper limit, and in this case, that limit was set to 70 cm, making it impossible to record larger fish.

For purse seine size data (**Figures 6**), a similar pattern was observed as in PL size data: the number of records in the FRA database for 2020 was lower, likely for the same reason described above. Apart from this, differences between data sources were minimal. A slight increase was observed in the number of records in the SPC database for 2021 compared to the FRA database. Regarding size composition (**Figure 7**), no substantial differences were identified between the datasets from different sources. These results indicate that the updates made to the size data since 2022 have not resulted in significant changes in data quality.

Recent FRA activity for biological updates

This section provides an overview of two previously published studies as FRA activity for SKJ biology. Readers interested in more detailed information are referred to the respective publications (Aoki et al., 2022; Fujioka et al., 2024).

SKJ Otolith study

Growth estimation remains one of the key sources of uncertainty in stock assessments of SKJ (Castillo-Jordan et al., 2022). Age determination based on otolith transverse section has not confirmed the daily periodicity of increment formation. In contrast, a few studies that used surface readings of otoliths have validated daily increment formation (Tanabe et al., 2003). However, it remains unclear whether the discrepancies between studies stem from differences in the otolith reading section or from individual variation, as otolith formation is influenced by environmental factors such as water temperature and feeding conditions. Although daily periodicity has been confirmed in some surface reading studies, the methods used to expose the otolith surface (etching techniques) have often been poorly described, and the criteria for increment reading have lacked clarity. This has raised concerns about the reproducibility of such methods.

In this study, we addressed these issues by comparing increment counts from paired otoliths obtained from the same individuals—one processed for transverse section reading and the other for surface section (**Figure 8**). Our results clearly showed that the number of increments observed in the transverse section was consistently lower than in surface section, indicating that transverse section is unsuitable for accurate daily increment counting in SKJ.

Furthermore, we developed and described a detailed etching procedure for exposing the otolith surface and established standardized criteria for interpreting daily increments. This approach significantly reduced inter-reader variability and improved the reproducibility of age estimates. When the growth curve derived from our method was compared with that of previous surface reading studies in which daily periodicity was validated, the results showed good agreement up to 40 cm in fork length, indicating that our method successfully reproduces past validated estimates.

Growth information for individuals smaller than 40 cm is particularly important for determining recruitment and age at maturity in stock assessments. Thus, the present study provides reliable age estimates for the early life stages of SKJ. By integrating otolith-based data from small individuals (<40 cm) with tagging data from larger individuals (≥40 cm), it may be possible to develop more robust growth models (Macdonald et al., 2022). This combined approach is expected to reduce uncertainty in growth estimates and enhance the accuracy of SKJ stock assessments.

SKJ egg hatching success as function of temperature

The survival of early life stages, such as eggs and larvae, plays a critical role in shaping the population dynamics of SKJ. These stages are thought to be highly influenced by oceanographic conditions. However, understanding the ecology of early life stages has remained a challenge, as SKJ spawn over vast areas in tropical and subtropical waters, making field surveys logistically difficult and time-consuming. Furthermore, inducing spawning under captive conditions has been considered extremely difficult, and as a result, no significant progress has been made in this area since the last notable study in 1974.

At the Kagoshima City Aquarium, successful captive spawning of SKJ—an exceptionally rare achievement worldwide—enabled the collection of fertilized eggs, providing a unique opportunity to investigate early developmental processes. To examine the effects of water temperature on hatching success, fertilized eggs collected from captive-spawned SKJ were incubated at a range of temperatures (21–33°C). The number of normally hatched larvae (hatching rate) and the duration until hatching were recorded (**Figure 9A**). The results revealed that SKJ eggs exhibited high hatching success (≥50%) across a wide temperature range of 23–31°C (**Figure 9B**). Furthermore, within this optimal temperature range, hatching time decreased with increasing temperature. Since eggs are highly vulnerable to predation, prolonged hatching durations can increase mortality risk (Gordoa and Carreras, 2014). Therefore, accelerated hatching at higher temperatures—such as those found in tropical waters—may serve as an adaptive strategy to enhance survival during the egg stage. This suggests that warm tropical waters may confer a selective advantage to spawning SKJ populations by reducing exposure time during early development.

However, projections of sea surface temperatures in the future indicate that large portions of the SKJ spawning grounds in the Pacific Ocean could exceed 32°C (Lehodey et al., 2013). Based on the results of this study, such conditions may surpass the upper thermal limit for successful egg hatching, suggesting that current spawning habitats may become less suitable in the near future.

These findings provide essential biological evidence for predicting future spawning habitat suitability under climate change scenarios. They offer fundamental insights that can inform sustainable management and utilization of SKJ stocks.

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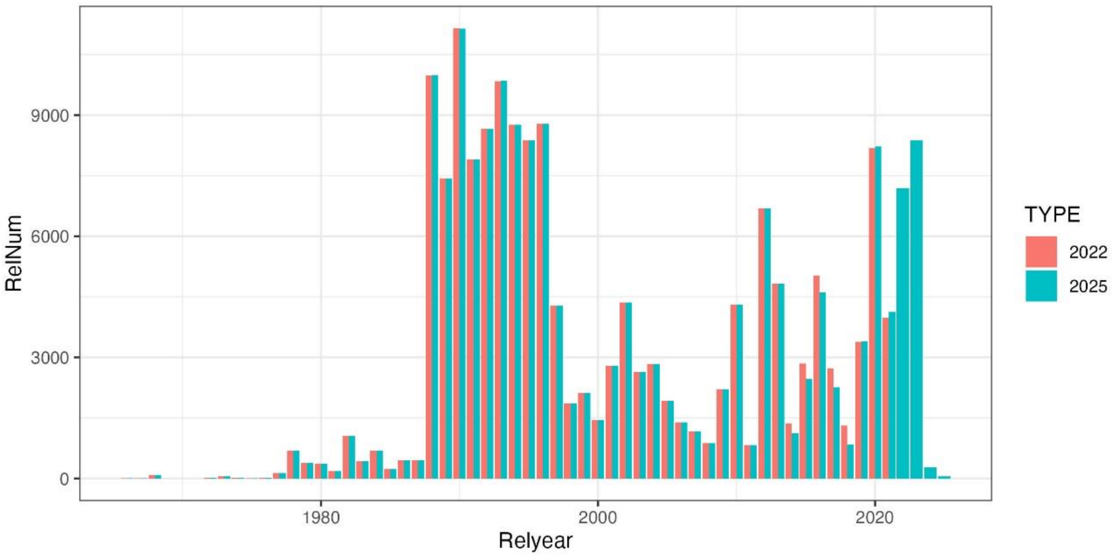

Figure 1. Comparison of the number of JPTP tag releases for SKJ submitted for the 2022 and 2025 stock assessments.

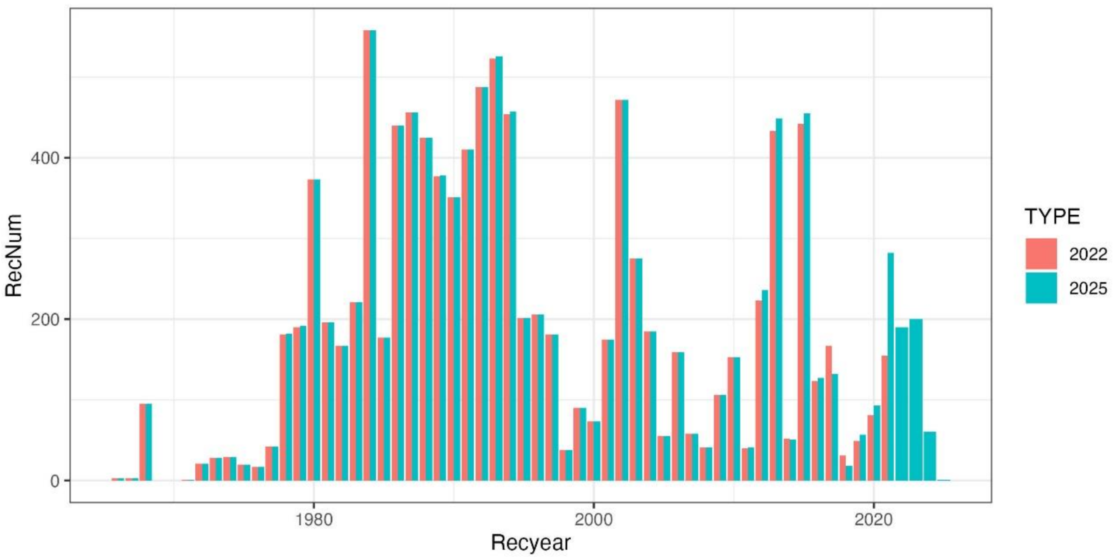

Figure 2. Comparison of the number of JPTP tag recaptures for SKJ submitted for the 2022 and 2025 stock assessments.

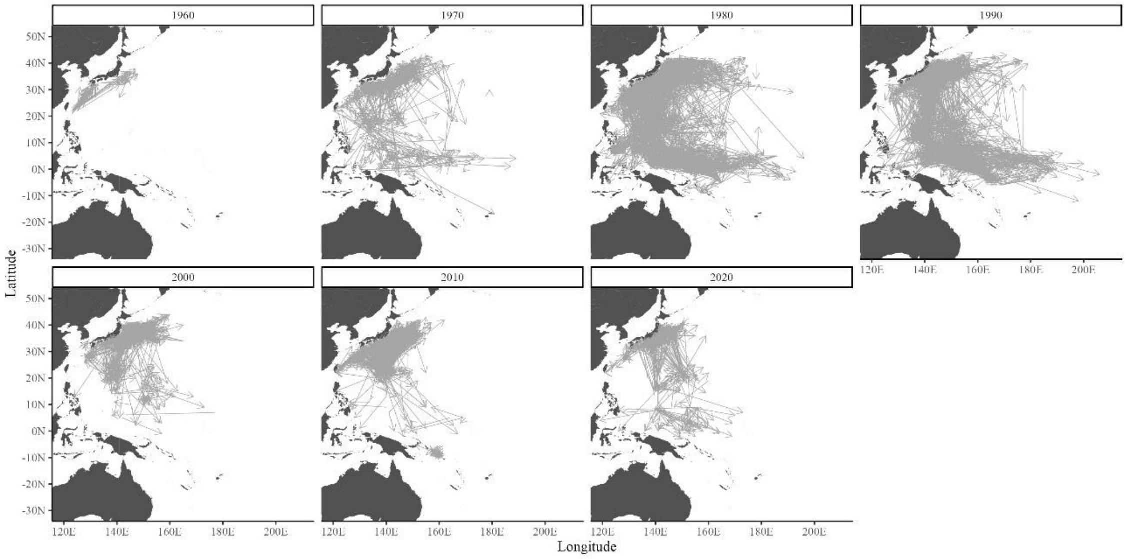

Figure 3. Release and recapture locations by decade.

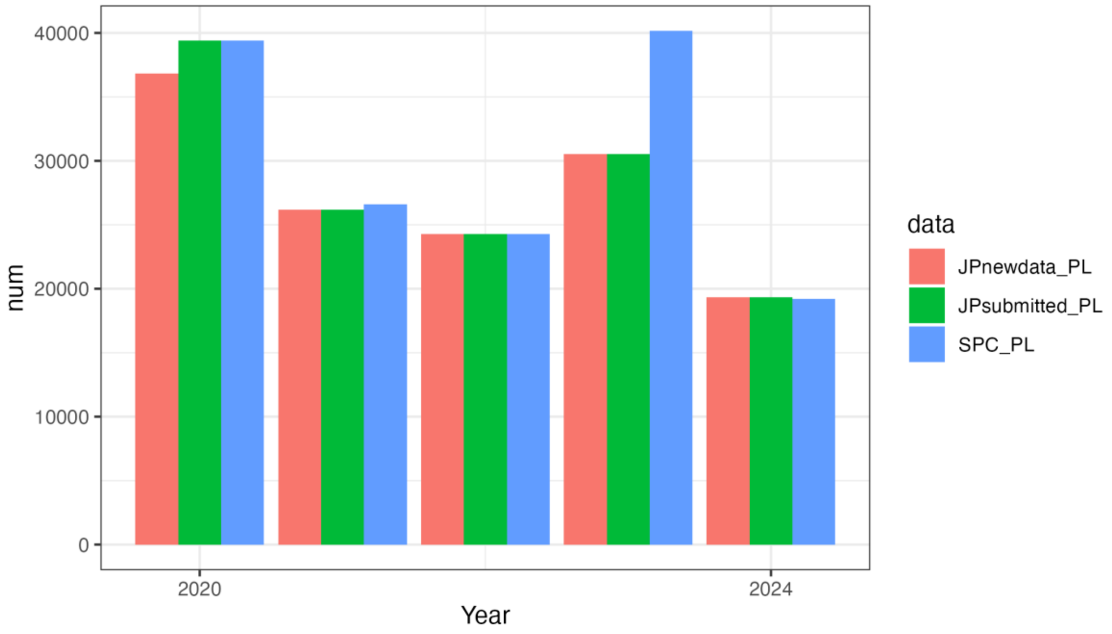

Figure 4. Evaluation of data consistency for the number of SKJ size records caught by PL fishery: A comparison among submission (green), SPC database (blue), and FRA new Databases (Red)

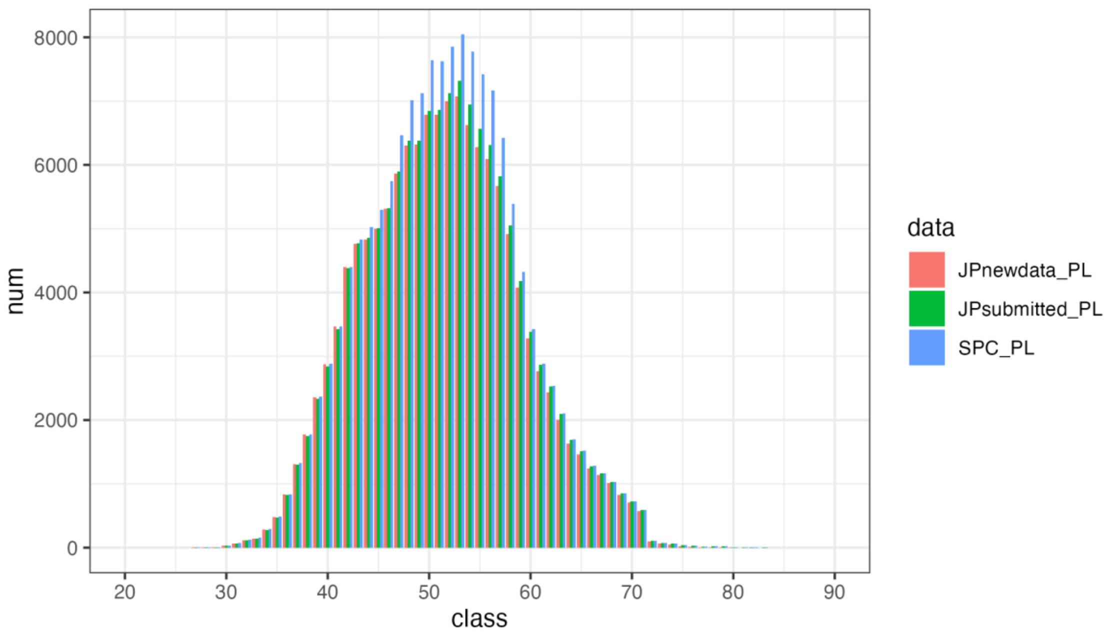

Figure 5. Comparisons of size distribution caught by PL fishery among three data sources (Red: FRA new database, green: submitted data, blue: SPC database)

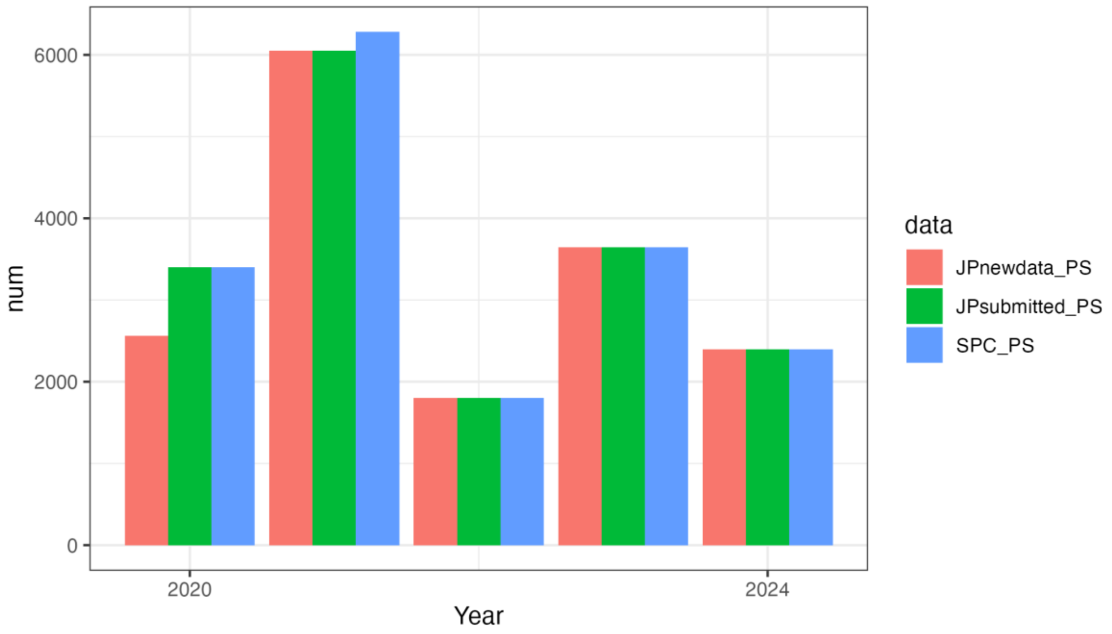

Figure 6. Evaluation of data consistency for the number of SKJ size records caught by PS fishery: A comparison among submission (green), SPC database (blue), and FRA new Databases (Red)

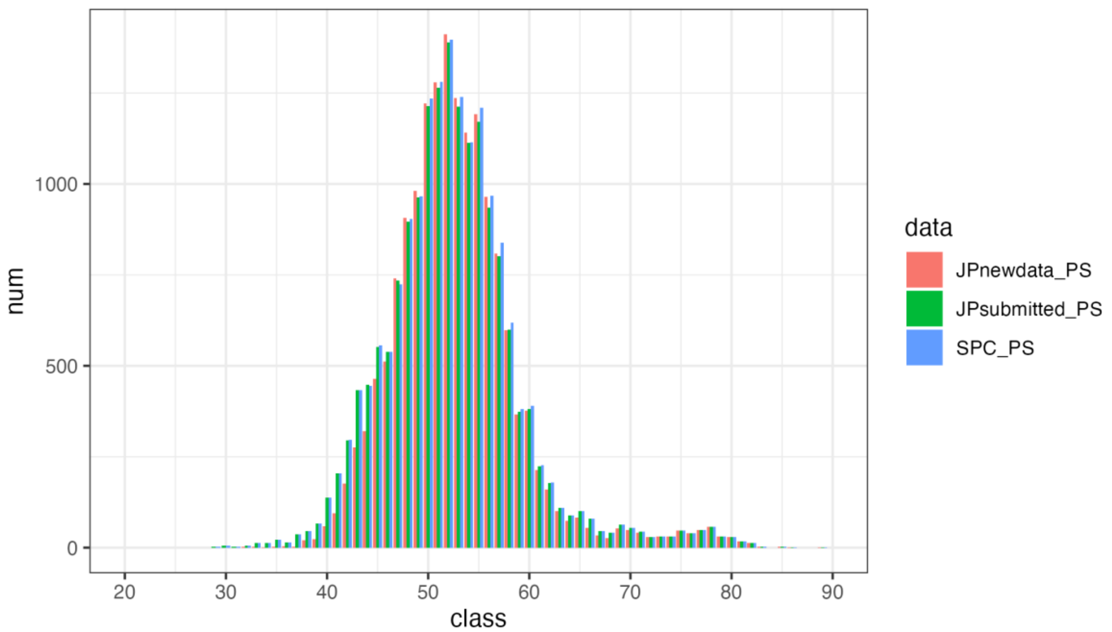

Figure 7. Comparisons of size distribution caught by PS fishery among three data sources (Red: FRA new database, green: submitted data, blue: SPC database)

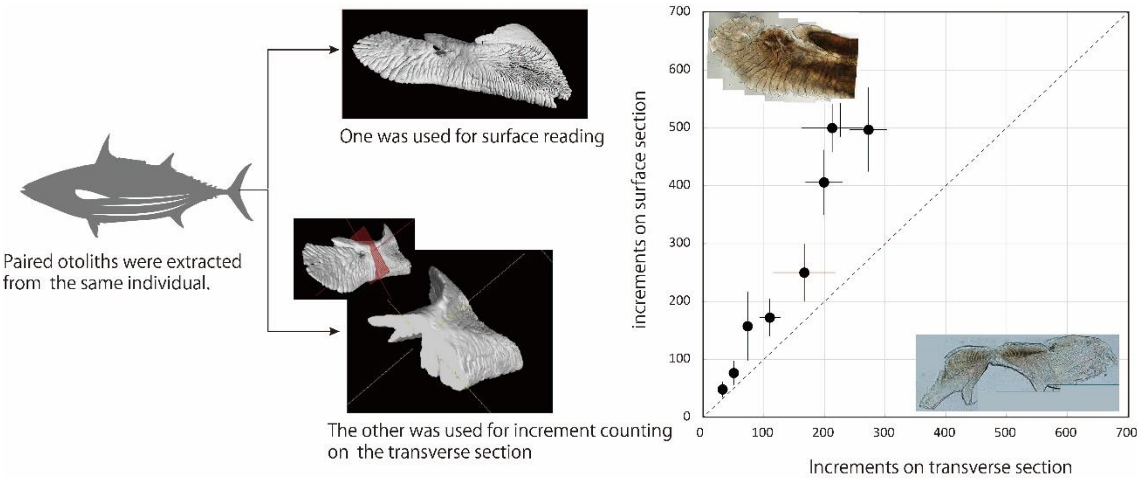

Figure. 8. Comparison of increment counts between otolith transverse sections (x-axis) and surface section (y-axis). Although otolith transverse sections have traditionally been used for age estimation in SKJ, the results indicate that the number of increments differs depending on reading sections. Specifically, the use of the transverse section leads to systematic underestimation of age compared to surface section.

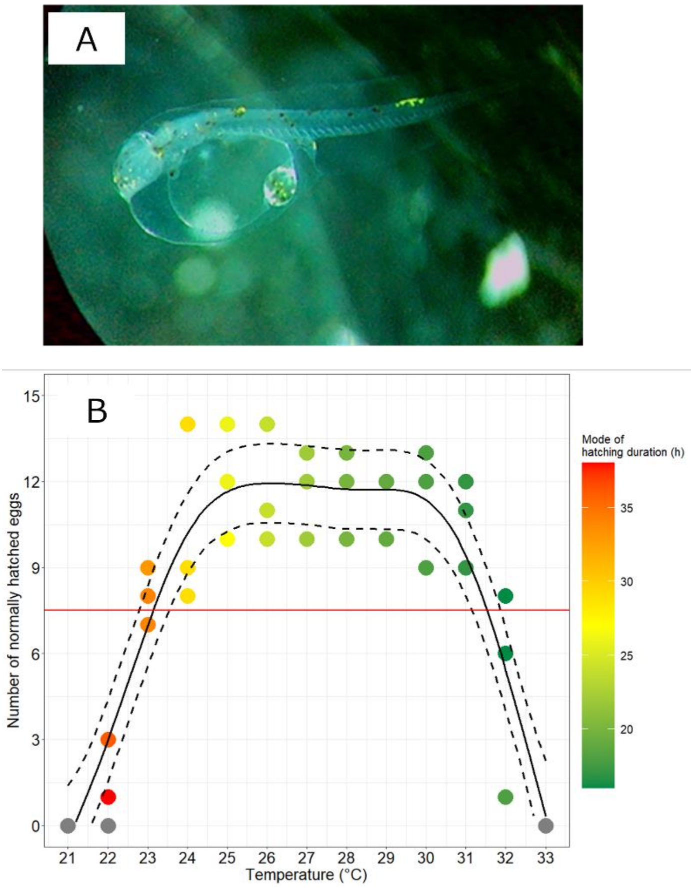

Figure 9. Effects of temperature on hatching success and timing in SKJ. **(A)** Normally hatched larva. **(B)** Relationship between water temperature (x-axis) and hatching success (solid black line) and hatching time (colored dots) for SKJ eggs. Dashed lines represent the 95% confidence interval for hatching success. The area above the red line indicates the temperature range (23–31°C) in which more than 50% of the eggs successfully hatched.