

Commission for the Conservation of
Southern Bluefin Tuna



みなみまぐろ保存委員会

Report of the Fifteenth Operating Model and Management Procedure Technical Meeting

**3 – 4 July 2025
Online**

Report of the Fifteenth Operating Model and Management Procedure Technical Group

3 – 4 July 2025

Online

Opening

1. The Chair of the Fifteenth Operating Model and Management Procedure Technical Meeting (OMMP15), Dr Ana Parma, opened the meeting and welcomed participants (**Attachment 1**). The Chair advised that, following the intersessional decision by the CCSBT Commissioners, the OMMP 15 meeting was being held as a two-day online meeting. The Chair also noted that the terms of reference for the meeting are to complete the analyses required to be in a position to provide advice on a TAC for the period 2027-2029 at the 30th Meeting of the Extended Scientific Committee (ESC 30), based on application of the Cape Town Procedure (CTP).
2. The draft agenda was discussed and amended, and the adopted agenda is shown in **Attachment 2**.
3. The list of documents for the meeting is shown in **Attachment 3**.
4. Due to the short time available, it was not possible to adopt a report during the meeting. Instead, this report was prepared after the online meeting by the Chair with the help of Drs. James Ianelli and D'Arcy Webber.

Agenda Item 1. Review of indicators and inputs to Cape Town Management Procedure

1.1. Gene tagging, and close-kin POPs and half-sibling indices

5. Dr Richard Hillary presented paper CCSBT-OMMP/2507/04 on Inputs to the Cape Town Procedure (CTP) for 2025. The paper outlines the key features of both the data inputs to the CTP (gene tagging, Japanese longline CPUE, CKMR POPs and HSPs), and the model-derived quantities from the adult population model that is fitted to the CKMR data. There are now 7 years of gene tagging data (2016–2023 excluding 2020); the 2023 estimate is the highest, but also the most uncertain, in the series. The CKMR data now cover the years 2002–2020 in terms of information on adult population dynamics. The fits to the updated CKMR data are within predicted confidence intervals, and the estimated trend in Total Reproductive Output (TRO) is continuing to increase, consistent with a recovering adult stock. Overall, the data and model-derived inputs to the CTP are all positive in terms of improving stock status, and the fits of the adult population model (contained within the CTP) to the CKMR data all look fine. No immediate issues are foreseen with respect to running the CTP on the basis of the data and model-derived inputs.

6. The group agreed with the conclusions of the paper and noted that the indication of a strong year class in 2021 from gene tagging is consistent with information from the Japanese LL CPUE data, as discussed below.
7. A question was raised about the information on adult mortality provided by the HSPs and the possibility of separating natural mortality from fishing mortality. It was noted that the simplified model fitted as part of the CTP includes only total mortality, but that this issue can be considered more directly using the full conditioning model.

1.2. CPUE

8. Dr Tomoyuki Itoh presented paper CCSBT-OMMP/2507/06 on possible change in operational pattern of the Japanese SBT longliners in the 2024 fishing season compared to the past 10 years. It concluded that no major change was evident in the 2024 operational pattern in terms of the amount of catch, the number of vessels, time and area operated, proportion by area, length frequency, release and discard, and spatial concentration of operations. The paper noted that the Japanese longline CPUE updated by including 2024 data reflects the change in SBT stock abundance consistently as in previous years. The increase in catch quotas over the last decade has had the greatest impact on the increase in CPUE, with the expansion of operating space-time and the increase in the number of operations to a lesser extent.
9. In discussion, the group noted
 - An increase in fishing effort observed in Statistical Area 8 during September and October, a shift from the July-September pattern in recent years back to that observed in the past (i.e., during the 1990s). This reflects greater operational flexibility enabled by increased quotas and the post-2006 individual quota (IQ) system, allowing vessels to spread operations across time and space.
 - The age composition in 2024 showed a peak in age-4 fish, potentially reflecting strong recruitment from the 2020 cohort. Smaller fish were predominantly caught in July, with larger fish appearing later in the season in Area 8, suggesting a size-area-time interaction.
 - There was a question whether discard and release data were included in CPUE and age composition information. Japan clarified that these are excluded from CPUE but are monitored via RTMP.
10. Dr Tomoyuki Itoh also presented paper CCSBT-OMMP/2507/06, which provided an update of the CPUE abundance index, standardised using a generalised additive model (GAM) developed for SBT, including data up to 2024. At ESC27 in 2022, the new method to calculate the CPUE index for SBT had been agreed. The CPUE abundance index, referred to as GAM22, applies a GAM in the two-step delta log-normal approach with area weighting. The paper presented the base case results as well as various sensitivity tests. The abundance index increased in

2024 compared to 2023, and reached the highest value on record since 1969. This was robust to a variety of sensitivity analyses, including model selection, retrospective analysis, and age range changes. The paper noted that the number of time and space strata without fishing operations has been increasing over the long term, and the predicted CPUEs for these strata were sometimes high.

11. The index, now a key input to the CTP, incorporates:

- Smooth interactions across time, space and targeting clusters,
- Age composition focused on age-4+ SBT,
- Area weighting and diagnostics for model fit.

The group agreed with the conclusions that GAM22 was robust to retrospective bias, age range sensitivity and model structure.

12. The group noted that in Figure 37 there appear to be discrepancies in predicted CPUE in effort-free areas, and raised concerns about differences in scaling. The issue of preferential sampling bias due to effort concentration was noted. Perhaps exploring spatio-temporal models such as tinyVAST or sdmTMB could help resolve some of these concerns. However, efforts to integrate data from other fleets would be necessary to mitigate sampling bias and effort concentration, as discussed below.

13. Dr Junghyun Lim presented paper CCSBT-OMMP/2507/07 on data exploration and CPUE standardisation for the Korean Southern Bluefin Tuna longline fishery. The CPUE standardisation used both lognormal and delta-lognormal Generalised Linear Models (GLM) with set by set (operational) data for 1996-2024. Two targeting methods were used: seasonal data selection and species-composition-based clustering. Two separate areas (statistical area 8 and 9) were identified where Korean vessels have targeted SBT, and CPUE was standardised for each of these areas. Two alternative approaches, data selection and cluster analysis, were applied to address concerns about changes in targeting over time that can affect CPUE indices. Explanatory variables for the GLM analyses were year, month, vessel identifier, location (5° cells), number of hooks and targeting (HBF and cluster). GLM results for each area suggested that year, month, location, and targeting effects were the principal factors affecting the nominal CPUE.

14. The results indicated that:

- The standardised CPUE for both areas decreased up to the mid-2000s but showed a post-2005 recovery, with 2024 values among the highest in the time series in Area 9.
- Area 9 is currently more heavily fished than Area 8, though fleet size has remained stable.

15. The question arose whether the Korean trends in Areas 8 and 9 were consistent with Japanese data and how area-specific indices affect whole-of-stock interpretation. The group suggested developing area-specific indices from the

Japanese dataset for direct comparison, and Dr Itoh agreed to provide summaries in this form for the ESC consideration.

16. Overall, CPUE trends from both Japan and Korea indicate a continued increase in SBT abundance since the mid-2000s, culminating in peak indices in 2024. While Japanese GAM22 is the primary index used in the CTP, the Korean indices offer important spatial context. Ongoing concerns regarding effort concentration and preferential sampling were acknowledged, with future improvements expected via spatio-temporal modelling and multi-fleet data integration. The discussions highlighted the value of cross-fleet consistency checks, and the need for harmonised data structures, in moving forward.

Progress of CPUE index development project

17. The CPUE consultant, Dr Simon Hoyle, reported the progress towards the development of joint CPUE indices based on data from multiple fleets. The main tasks in this project have been to develop R code to load operational and aggregated data; characterise each fleet's data to identify issues; clean data and recode variables into consistent data formats; conduct cluster analysis for the NZ, AU and KR datasets; combine the operational and aggregated JP data; and standardise the combined dataset using appropriate statistical weights. Japanese data are required to estimate relative abundances across areas and to allow the joint model to converge. There is little to no spatial overlap between the NZ, AU and KR datasets, and the Japanese data that do link the areas are available in aggregated form only. Code has been developed for all analysis components, and some debugging is ongoing. Results show similar trends across all datasets. Some issues that may not be addressed include variation between fleets in how discards are treated, and the availability of size data to develop a (4+) index. Assumptions required when combining operational and aggregated data are likely to influence the results of the developmental analysis, but the objective is to progress to 100% operational data. A paper describing the work will be provided to the ESC.
18. The group agreed on the importance of this project considering the continuing contraction of the area covered by the Japanese LL fleet.

Agenda Item 2. Discuss advice to ESC based on metarule process

2.1. Evaluate the possible existence of exceptional circumstances in relation to the data inputs to the MP

19. The group agreed that the indicators evaluated as part of Agenda 1, and mainly those used as inputs to the CTP, did not appear to present problems or inconsistencies that would suggest exceptional circumstances. There appears to be consistency in different indicators, especially gene tagging and CPUE of ages 3 and 4 in showing an increase indicative of a strong 2021 cohort. It was noted that the full evaluation of possible exceptional circumstances will be conducted at the ESC based on a more complete set of information.

Agenda Item 3. Progress report on the SBT code development project

20. The Chair advised that, following the intersessional decision by CCSBT Commissioners, a five-day in-person meeting was held from 23 – 27 June 2025 in Seattle, USA. This meeting was attended by the modellers who are more directly involved with the coding development process, including the OMMP Chair, Dr James Ianelli (scientific advisory panel), Dr D’Arcy Webber (consultant for the coding project), and Dr Richard Hillary and Ms Paige Eveson from CSIRO.
21. Dr D’Arcy Webber presented a report of the activities conducted during the meeting. As described in Attachment 4, major efforts focused on:
 - Porting legacy ADMB/TMB code to new software released in January 2025 called RTMB. The RTMB package provides a native R interface for TMB (Template Model Builder), so that models can be written entirely in R rather than C++.
 - Refining the formulation of the selectivity functions and evaluating MCMC performance.
 - Including separate length frequencies (LFs) for the CPUE series (i.e., different to the LL1 fishery LFs) and setting up separate time varying selectivity for these LFs.
 - Enhancing model diagnostics and usability of the code.
22. Once the code was translated to RTMB and all likelihood components matched the values calculated with ADMB and TMB, further model development was greatly facilitated. In addition, the adnuts package used for MCMC sampling has been greatly improved, resulting in major increases in efficiency. The SBT MCMC runs can now be completed in about 30 minutes per grid cell, which allows for fast checking of MCMC performance under different model configurations.
23. The last versions of the TMB code evaluated in 2024 were showing poor performance in MCMC, likely attributed to the formulation of the selectivity functions. The implementation of a 2-dimensional AR1 function to model time-varying selectivities resolved those issues, and resulted in very good MCMC diagnostics.
24. The treatment of some fisheries as direct removals had also appeared to cause some MCMC problems, especially in the case of fisheries that involve large catches during at least some period (e.g., the surface fishery and LL3 fisheries). LL4 had lower catches, but this fishery has been modelled assuming constant selectivity so that not many parameters would be saved by treating its catches as direct removals.
25. The preprocessing and fitting of the Japanese LL size frequency data as a separate “fleet” with its own selectivities used for CPUE prediction is documented in Attachment 5. The selectivity for this fleet was also formulated as a 2-dimensional AR1 function. A question was raised about why the selectivity was assumed to be

- time-varying when the size compositions were aggregated by weighing them by predicted CPUE by strata (a proxy for abundance). The rationale provided was that while the CPUE weights may account for changes in fishing selectivity associated with changes in the temporal-spatial allocation of fishing effort, other processes may cause changes in selectivity within strata. It was recommended that sensitivity to these assumptions be examined as part of the 2026 stock assessment. The preliminary results obtained did not have an appreciable impact on the estimated trends in biomass.
26. It was noted however that the Japanese LL size frequency data that had been fitted in these preliminary model runs spanned the entire range of sizes caught by the Japanese LL fishery, which include fish younger than age 4. The same cutoffs used to process the age 4+ CPUE index should be used in the future in order to exclude ages younger than 4.
 27. The question of the double use of the Japanese size-frequency data—to model catch removals for the LL1 fishery and to estimate selectivity for CPUE predictions—was posed, and whether the weights assigned to the respective size-frequency likelihoods would need to be adjusted. It was noted that, while the data are indeed used twice, for the LL1 fleet the Japanese data are combined with data from other LL fisheries (Korea, Australia and New Zealand). In terms of likelihood weighting, the issue needs to be revisited in general (not just for the new CPUE-index “fleet”) now that the new model has the option to use the Dirichlet or Dirichlet-multinomial distributions to fit size/age-frequency data.
 28. The main pending tasks in terms of preparing code for the 2026 stock assessment involve: 1) developing code in RTMB to run future projections based on the CTP, 2) translating the ADMB code used to calculate MSY-related reference points to RTMB, and 3) updating of the shiny application or some alternative (e.g., a website).

Agenda Item 4. Workplan

29. The group discussed the next steps and workplan in preparation for the stock assessment to be presented for review at the ESC meeting in 2026.
30. The group recommended to hold two separate intersessional webinars, one in November involving at least the core group of modellers (similar to the Seattle technical workshop) to evaluate the projection code, and a second in a date to be determined designed to present training material and example scripts to those interested in running the assessment and projections codes.
31. Input data for the stock assessment would be updated according to the usual schedule so that preliminary stock assessment results can be evaluated and advanced during an in-person OMMP workshop to be held in June 2026.

List of Attachments

Attachments

- 1 List of Participants
- 2 Agenda
- 3 List of Documents
- 4 Technical Workshop Summary, June 23–27, Seattle, USA
- 5 Treatment of Japanese LL size-frequency data for CPUE prediction.

Attachment 1

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Agenda

Fifteenth Operating Model and Management Procedure Technical Meeting

- 1. Review of indicators and inputs to the Cape Town Procedure**
 - 1.1. Gene tagging
 - 1.2. Close-kin: POPs and half-sibling indices
 - 1.3. CPUE
- 2. Discuss advice to ESC based on metarule process**
 - 2.1. Evaluate the possible existence of exceptional circumstances in relation to the data inputs to the MP
- 3. Progress report on the SBT code development project**
- 4. Workplan**

List of Documents

The Fourteenth Operating Model and Management Procedure Technical Meeting

(CCSBT-OMMP/2507/)

1. Provisional Agenda
2. List of Participants
3. List of Documents
4. (Australia) Inputs to the Cape Town Procedure for 2025 (OMMP Agenda item 1)
5. (Japan) Change in operation pattern of Japanese southern bluefin tuna longliners in the 2024 fishing season (OMMP Agenda item 1.3)
6. (Japan) Update of CPUE abundance index using GAM for southern bluefin tuna in CCSBT (GAM22) up to the 2024 data (OMMP Agenda item 1.3)
7. (Korea) Data Exploration and CPUE Standardization for the Korean Southern Bluefin Tuna Longline Fishery (1996-2024) (OMMP Agenda item 1.3)

(CCSBT-OMMP/2507/Rep)

1. Report of the Thirty-First Annual Meeting of the Commission (October 2024)
2. Report of the Twenty-Ninth Meeting of the Scientific Committee (September 2024)
3. Report of the Fourteenth Operating Model and Management Procedure Technical Meeting (June 2024)
4. Report of the Twenty-Eighth Meeting of the Scientific Committee (August/September 2023)
5. Report of the Thirteenth Operating Model and Management Procedure Technical Meeting (June 2023)
6. Report of the Twelfth Operating Model and Management Procedure Technical Meeting (June 2022)



CCSBT Technical Workshop Summary

June 23–27, 2025

Seattle, WA

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1 Overview/summary

On June 23–27, 2025, a small technical working group was convened at the behest of the CCSBT to address the ongoing development of the assessment and operating model upgrades using RTMB (R Template Model Builder). This workshop was held at the University of Washington and met from 0900-1700 each day. Major efforts focused on porting legacy ADMB/TMB code to RTMB, refining the formulation of the selectivity functions, and evaluating MCMC performance. The group also enhanced model diagnostics and usability. This report summarizes the tasks addressed during the workshop.

2 Background

The operating model used for SBT stock assessments and for testing management procedures is coded in ADMB. By the end of the OMMP technical workshop in Tokyo, November 2023, the ADMB model had been converted to TMB, and we had checked that the calculated likelihood values from the ADMB and TMB codes matched. This version of the TMB code is referred to as V1. Then, at the CCSBT OMMP workshop in Seattle, June 2024, we continued to make modifications to the TMB V1 code to add several improvements to the model, including: modifying the tag likelihood to directly remove

tags recovered during the year of release and thus eliminate the H^* parameters (noting that the H^* parameters mixed poorly during MCMC), addition of an option to fit to LFs/AFs using a multinomial, Dirichlet, or Dirichlet-multinomial distribution, and changes to the POP likelihood to account for age uncertainty in the adults (see Anon. (2024) for full details). These changes were made incrementally in TMB versions V2 through V4.

Since that time, RTMB (Kristensen 2024) has been released. RTMB allows model coding to be done completely within the R programming environment (R Core Team 2024), which is much more user-friendly than using “pure” TMB (which is basically a C++ library with quite strict coding practices, Kristensen et al. (2016)). It also means that the model can be run one line at a time, which significantly speeds up model development. As such, part of the work done during the June 2025 technical working group meeting was to convert the TMB code to RTMB, as outlined below.

3 Agenda Topics and Task Summary

3.1 Convert ADMB/TMB to RTMB

- **Dynamics:** Successfully translated state dynamics to RTMB for all the relevant population processes.
- **Likelihoods:** Continued work integrated more components including robust likelihoods for close-kin and tagging data. This was completed in two steps: first checking that the calculated likelihood values from the RTMB code matched those obtained with the ADMB and TMB V1 code, and then modifying the code to be equivalent to the TMB V4 model from 2024.

3.2 Fleet and Selectivity Adjustments

- **Options for selectivities:** Two different formulations for fisheries selectivities had been implemented in TMB and were converted to RTMB:
 1. Smoothers (transferred over from the ADMB model using third differences);
 2. Gaussian Markov Random Fields (GMRF);

As explained below, these formulations resulted in poor MCMC performance. A third option was therefore implemented in the RTMB code:

3. A 2-dimensional (age and year) AR1 process. Parameters of the 2D AR1 functions were tuned to obtain similar age/length-frequency likelihood values as with the ADMB approach.
- **LL3 and LL4 as direct removals:** LL4 implemented; LL3 flagged due to high early catches—requires careful MCMC evaluation. This was retained as an option but issues identified earlier on appear to be resolved.
 - **Japanese LL size composition:** Added capability to estimate separate selectivity functions for the Japanese LL fishery for the purpose of predicting CPUE.

Selectivity parameters are fitted to size frequency data processed by weighting the LL size frequency of each spatio-temporal cell by both nominal and model-derived CPUE for the cell. The model-based CPUE is derived from a GAM (generalized additive model). Details are provided in Attachment 1.

3.3 MCMC and Profiling

- **Performance of MCMC runs:** MCMC runs completed at the ESC meeting in 2024 using TMB code V4 were still having some issues with divergent transitions, likely arising from the parameterisation of selectivity and the treatment of catches as direct removals for some of the fisheries. Initial MCMC runs were conducted using the V1 version of the RTMB code and, as expected, diagnostics showed a high number of divergences, similar to the results obtained with the TMB code. MCMC performance was much improved when the RTMB equivalent to TMB V4 code was used with the 2D AR1 option for fishery selectivities. The mixing was very good, and issues identified in previous years appeared to be completely resolved: only a few (3-4) divergent transitions remained and the corresponding parameters did not appear to be outliers.
- **Likelihood profiling tailored to the new RTMB code:** Work initiated and completed.

3.4 Pending Coding Tasks

- **MSY estimation:** The old ABMB code used to estimate MSY parameters conditioned on selectivity, size-at-age parameters, and catch allocations needs to be converted to RTMB.
- **Projection code:**
 - Implemented assuming time-invariant weights and ALKs.
 - ARIMA for Rdev, selectivity, and q projections: In the ADMB projection code, catchability included autocorrelation and effort creep while recruitment deviations and selectivity at age parameters were projected based on AR1 models. Alternative options including multivariate ARIMA and 2D AR1 for selectivity will be implemented.
 - Simulation of datasets: CPUE, gene tagging and close-kin data.

3.5 Model Features and Testing

- **One-Step-Ahead (OSA) residuals:** Preliminary tests were made but further development required (this is an alternative model diagnostic to replace Pearson residuals).

3.6 Utilities and Communications

- **Example scripts:** Scripts will be prepared for running models, generating likelihood profiles, and basic diagnostics.
- **Issue on multinomial density:** Submitted to TMB / RTMB developer.

- **Divergent transitions plot:** Developed a plot to visualize divergent transitions in MCMC runs, aiding in diagnostics. This enhances the R package ADNUTS
-

4 Participants

1. Ana Parma
2. Darcy Webber
3. Richard Hillary
4. Paige Eveson
5. James Ianelli



Group photo from the technical workshop

References

- Anon. 2024. *Report of the Fourteenth Operating Model and Management Procedure Technical Meeting*. 24-28 June 2024, Seattle, USA.
- Kristensen, Kasper. 2024. "RTMB: R Interface to TMB for Fully Symbolic AD Models." <https://github.com/kaskr/RTMB>.
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Treatment of Japanese LL size-frequency data for CPUE predictions

1. Introduction

This document describes the processing of Japanese longline size frequency and CPUE data to compute size composition of the catch based on both nominal and model-derived CPUE. The model-based CPUE is derived from a GAM (generalized additive model).

2. Data Input and Cleaning

As a first step, files are read in and labelled consistently.

```
knitr::opts_chunk$set(
  echo = TRUE,
  message = FALSE,
  warning = FALSE
)
suppressPackageStartupMessages({
  library(tidyverse)
  library(janitor)
  library(here)
})
library(tidyverse)
library(janitor)
library(here)
df1 <- read_csv(here("JP_CatchSize", "JP_Size.csv"), show_col_types = FALSE) |> clean_names()
names(df1) <- c("year", "month", "lat5", "lon5", "length", "freq", "prec", "hooks")
df2 <- read_csv(here("JP_CatchSize", "model_est.csv"), show_col_types = FALSE) |> clean_names()
```

2.1 Spatial Adjustments and Filtering

The data is filtered to include only records after 1968, and the spatial coordinates are adjusted by shifting the latitude and longitude by -2.5 and +2.5 degrees, respectively:

```
df1 <- df1 |>
  filter(year > 1968) |>
  mutate(lat5 = lat5 - 2.5, lon5 = lon5 + 2.5)
df2 <- df2 |>
  filter(year > 1968) |>
  mutate(jap_cpue = value)
```

2.2 Normalized Length Frequencies by Cell

Each record is normalized to yield proportions at length within each spatial-temporal cell:

```
df1.1 <- df1 |>
  group_by(year, month, lat5, lon5, length) |>
  mutate(lft = sum(freq)) |>
  ungroup() |>
```

```
group_by(year, month, lat5, lon5) |>
mutate(lfnorm = sum(freq), prop = lft / lfnorm)
```

$$\text{prop}_l = \frac{\text{freq}_l}{\sum_l \text{freq}_l}$$

2.3 Merge with CPUE Data

```
dfj <- df1.1 |> inner_join(df2)
```

3. Size composition from CPUE-weighted Frequencies

We compute length-frequency estimates weighted by (for each i year-month-area grid):

- **Nominal CPUE:**

$$u_i = \frac{\sum_i \text{catch}_i}{\sum \text{hooks}}$$

(by year, month, and 5x5 degree spatial block)

- **Model-based CPUE:** from the GAM model output we have the predicted CPUE by year, month, 5x5 cell to get CPUE_i . See `jap_cpue` code in previous section.

Then for each length bin:

$$\begin{aligned} \bar{l}f_l^{\text{nom}} &= \sum_i u_i \cdot \text{prop}_{il}, \\ \bar{l}f_l^{\text{gam}} &= \sum_i \text{CPUE}_i \cdot \text{prop}_{il} \end{aligned}$$

And annual proportions:

$$p_l^{\text{nom}} = \frac{l f_l^{\text{nom}}}{\sum_l l f_l^{\text{nom}}}, \quad p_l^{\text{gam}} = \frac{l f_l^{\text{gam}}}{\sum_l l f_l^{\text{gam}}}$$

Mean lengths (for a given year; index dropped for clarity):

$$\bar{L}_{\text{nom}} = \sum_l l \cdot p_l^{\text{nom}}, \quad \bar{L}_{\text{gam}} = \sum_l l \cdot p_l^{\text{gam}}$$

As a diagnostic to compare with the GAM CPUE, we can also compute mean lengths from the assessment model's length frequency data. This is done by summing the product of length and proportion for each year. Comparing these values shows that the mean lengths from the GAM CPUE data and the nominal CCSBT data are similar, but not identical. The GAM CPUE is a model-based estimate that may differ from the nominal CPUE due to smoothing and other adjustments in the GAM ([Figure 1](#)). Importantly, the fact that the GAM and the nominal composition data differ more substantially from the catch-at-length data from the CCSBT assessment model. This suggests that the GAM

CPUE catch composition data should be used to align most appropriately with the Japanese-based CPUE data.

```
mnlen_cpue <- dfj %>%
  group_by(year, month, lat5, lon5) |>
  mutate(u = sum(freq) / mean(hooks)) |>
  ungroup() |>
  group_by(year, length) |>
  mutate(
    lf_u_nom = sum(u * prop),
    lf_u_gam = sum(jap_cpue * prop)
  ) |>
  ungroup() |>
  group_by(year) |>
  mutate(
    p_u_nom = lf_u_nom / sum(lf_u_nom),
    p_u_gam = lf_u_gam / sum(lf_u_gam)
  ) |>
  summarise(
    mean_len_u_nom = sum(length * p_u_nom),
    mean_len_u_gam = sum(length * p_u_gam)
  ) |>
  pivot_longer(cols = 2:3, names_to = "type", values_to = "Length")
mnlen_cpue <- dfj %>%
  group_by(year, month, lat5, lon5) |>
  mutate(u = sum(freq) / mean(hooks)) |>
  ungroup() |>
  group_by(year, length) |>
  mutate(
    # lf_catch = sum(freq),
    lf_u_nom = sum(u * prop),
    lf_u_gam = sum(jap_cpue * prop)
  ) |>
  ungroup() |>
  group_by(year) |>
  mutate(
    p_u_nom = lf_u_nom / sum(lf_u_nom),
    p_u_gam = lf_u_gam / sum(lf_u_gam)
  ) |>
  summarise(
    # mean_len_catch = sum(length*p_catch),
    mean_len_u_nom = sum(length * p_u_nom),
    mean_len_u_gam = sum(length * p_u_gam)
  ) |>
  pivot_longer(cols = 2:3, names_to = "type", values_to = "Length")

mnlen_LL1 <- sbt::length_freq |>
  filter(Year > 1968, Fishery == 1) |>
  pivot_longer(cols = 4:113, names_to = "len", values_to = "proportion") |>
  filter(proportion > 0) |>
  mutate(year = Year, len = as.numeric(len)) |>
  group_by(year) |>
  summarise(type = "Model", Length = sum(len * proportion))

rbind(mnlen_cpue, mnlen_LL1) |>
  ggplot(aes(x = year, y = Length, color = type)) +
  geom_point() +
  geom_line() +
  ggthemes::theme_few()
```

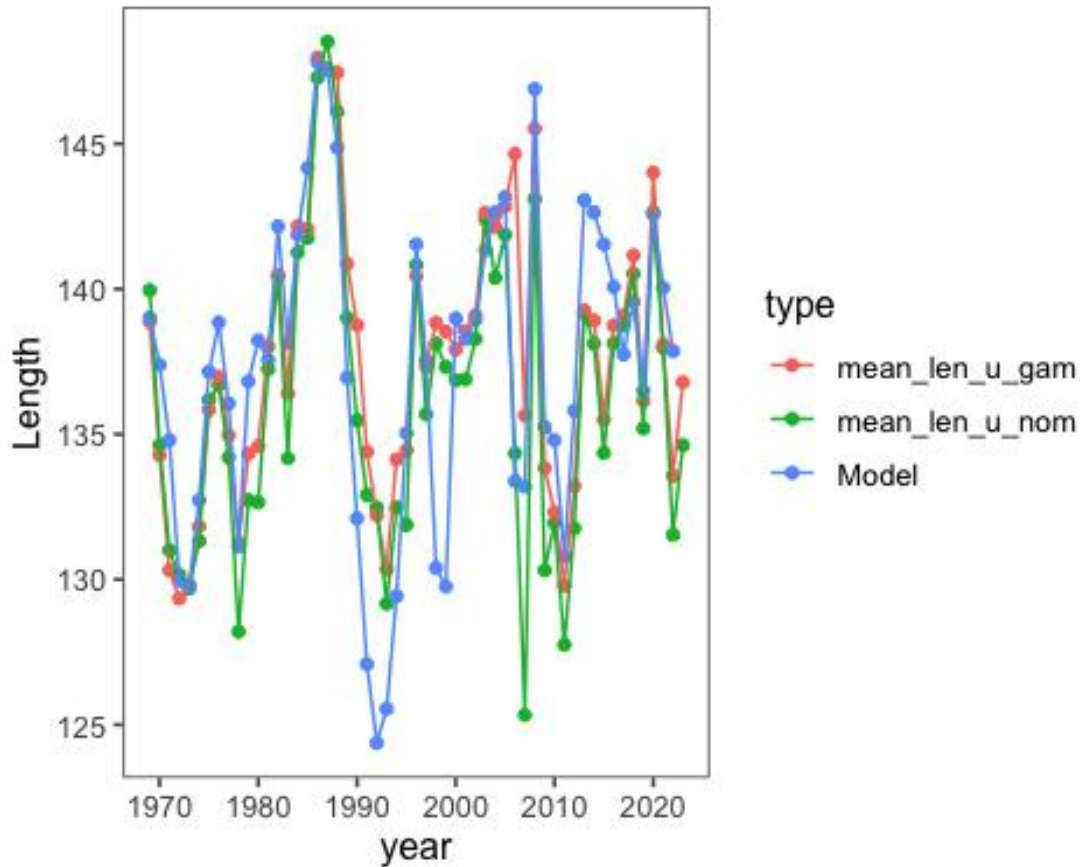


Figure 1: Mean lengths of SBT by year from the CCSBT data and the GAM CPUE data.

3.1 Length Frequency by GAM CPUE

To compute and optionally visualize full length frequency distributions weighted by GAM-predicted CPUE:

Length-frequency proportions by year are computed as:

$$\text{prop}_{l,\text{year}}^{\text{gam}} = \frac{\sum_i \text{CPUE}_i \cdot \text{prop}_{il}}{\sum_l \sum_i \text{CPUE}_i \cdot \text{prop}_{il}}$$

✦ Notes

- $\text{floor}(\text{length} / 2) * 2$ groups lengths 40 and 41 into bin 40, 42 and 43 into 42, etc.
 - The prop_{gam} is the proportion at each 2-cm bin within each year:

$$\text{prop}_{b,\text{year}}^{\text{gam}} = \frac{\text{freq}_b^{\text{gam}}}{\sum_b \text{freq}_b^{\text{gam}}}$$

- Use `length_bin` for plotting or comparison to model outputs.

3.2 Format to bring into the assessment as a new set of length-composition data

We write as matrix with rows are years and columns length bins. For comparisons, we show the length frequency (in proportions) for the GAM CPUE data ([Figure 2](#)) and the assessment model input data ([Figure 3](#)).

```
lf_gam_wide <- lf_gam %>%
  select(year, length_bin, prop_gam) %>%
  pivot_wider(
    names_from = length_bin,
    values_from = prop_gam,
    values_fill = 0
  )
flen=80;llen=190
library(ggribes)
p1 <- ggplot(lf_gam,aes(x=length_bin,y=as.factor(year),height = prop_gam)) + geom_density_ridges
(stat = "identity",scale = 4, alpha = .7,
  fill="salmon",color="black") + ggthemes::theme_few() +
  ylab("Year") + xlab("Length (2-cm bin)") +
  scale_x_continuous(limits=c(flen,llen),breaks=seq(flen,llen,6)) +
  scale_y_discrete(limits=rev(levels(as.factor(lf_gam$year)))); p1
```

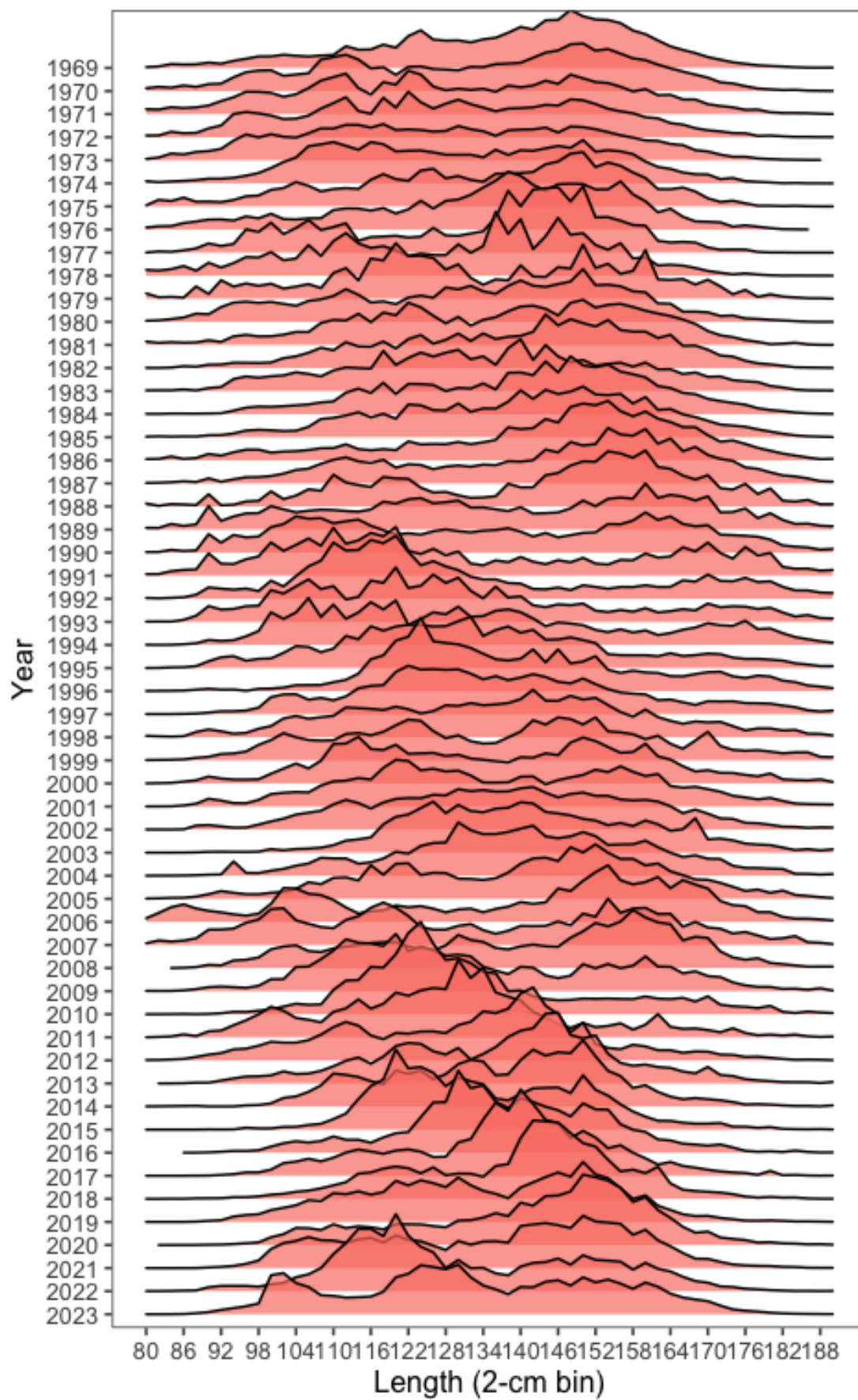


Figure 2: Length frequency matrix from GAM CPUE data.

```
lf_ass <- sbt::length_freq |>
  filter(Year > 1968, Fishery == 1) |>
  pivot_longer(cols = 4:113, names_to = "length_bin", values_to = "proportion")
p2 <- ggplot(lf_ass, aes(x=as.numeric(length_bin), y=as.factor(Year), height = proportion)) + geom_density_ridges(
  stat = "identity", scale = 4, alpha = .7,
  fill="salmon", color="black") + ggthemes::theme_few() +
  ylab("Year") + xlab("Length (2-cm bin)") +
  scale_x_continuous(limits=c(flen, llen), breaks=seq(flen, llen, 6)) +
  scale_y_discrete(limits=rev(levels(as.factor(lf_ass$Year))))
p2
```

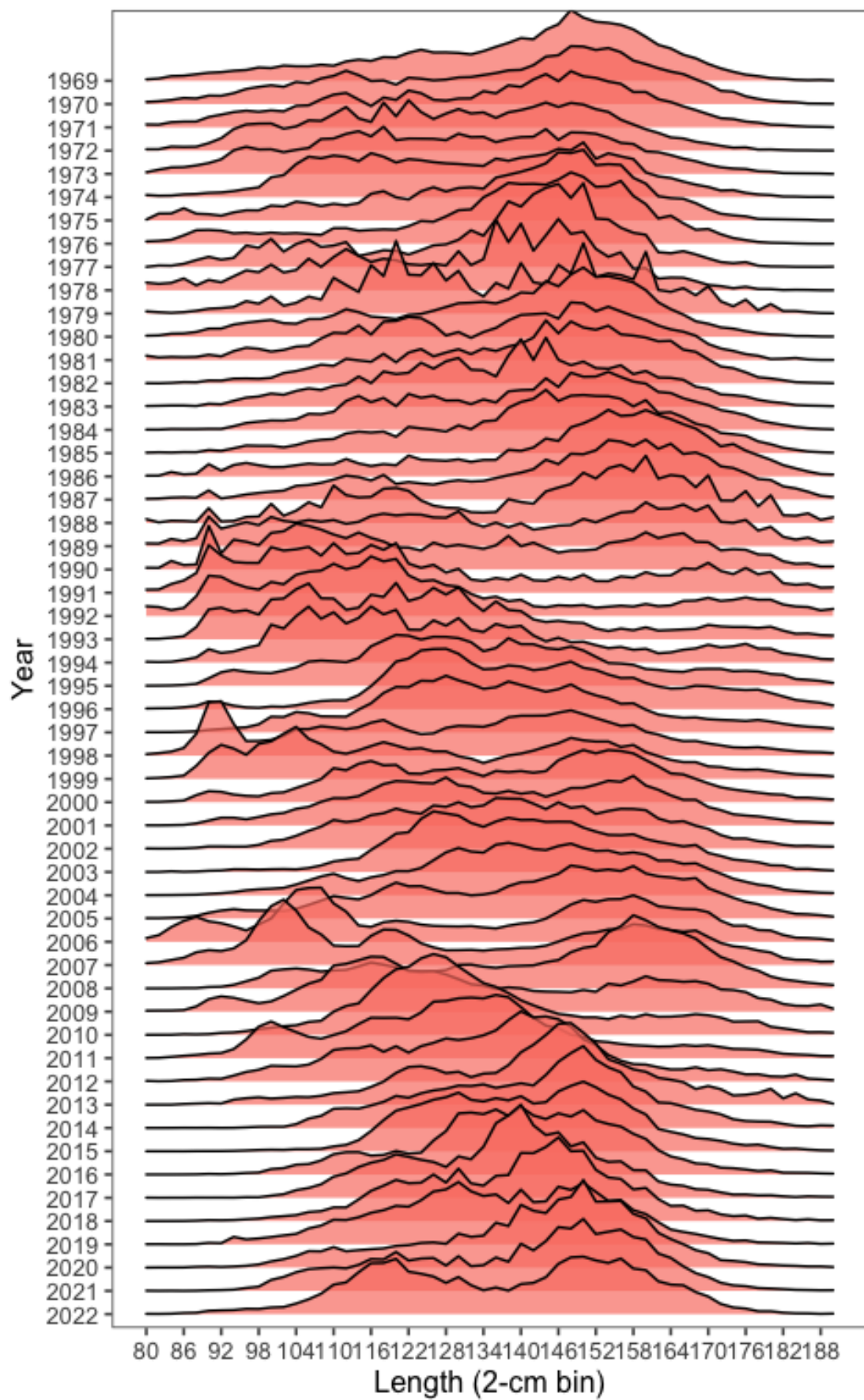


Figure 3: Length frequency matrix from the assessment model input.

4. Summary

This workflow merges catch-at-length observations with spatially resolved GAM model predictions to compute trends in average catch size. The final product includes both mean lengths and full length-frequency distributions weighted by GAM CPUE.
