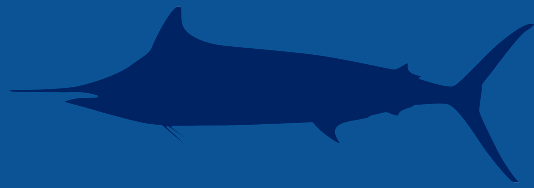
2026 Pacific Blue Marlin Stock Assessment

Michelle Sculley, BILLWG Chair
Erin Bohaboy, Lead Modeler

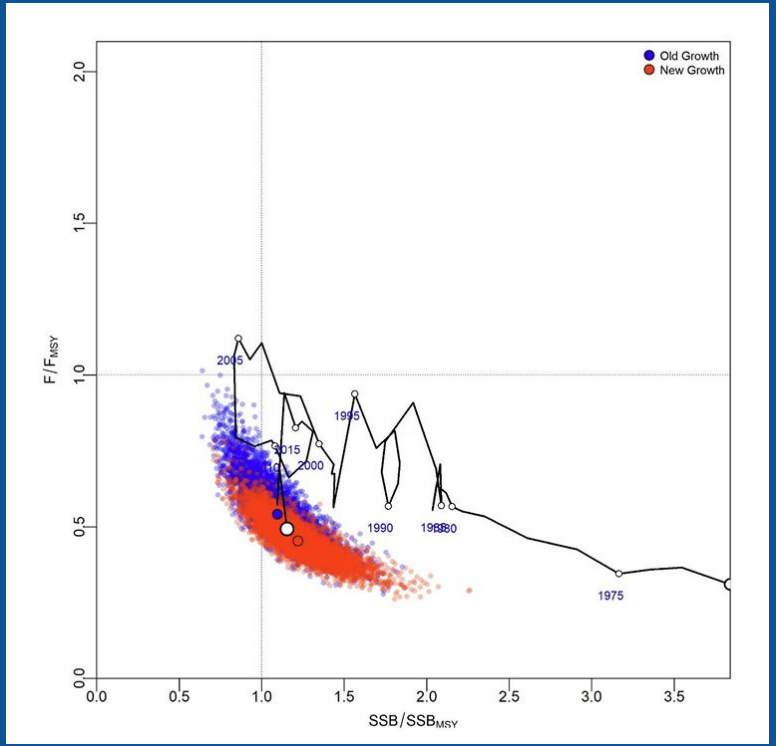
Overview

- Review of the 2021 Pacific Blue Marlin Assessment
- 2026 Assessment Data and Model
  - BUM life history information
  - Fishery definitions and selectivity modeling
  - Catch, standardized CPUE, and size composition data
  - Likelihood components and Data weighting
  - Model Diagnostics
- 2026 Assessment Results
  - Stock Status
  - Sensitivity Runs
  - Stock Projections

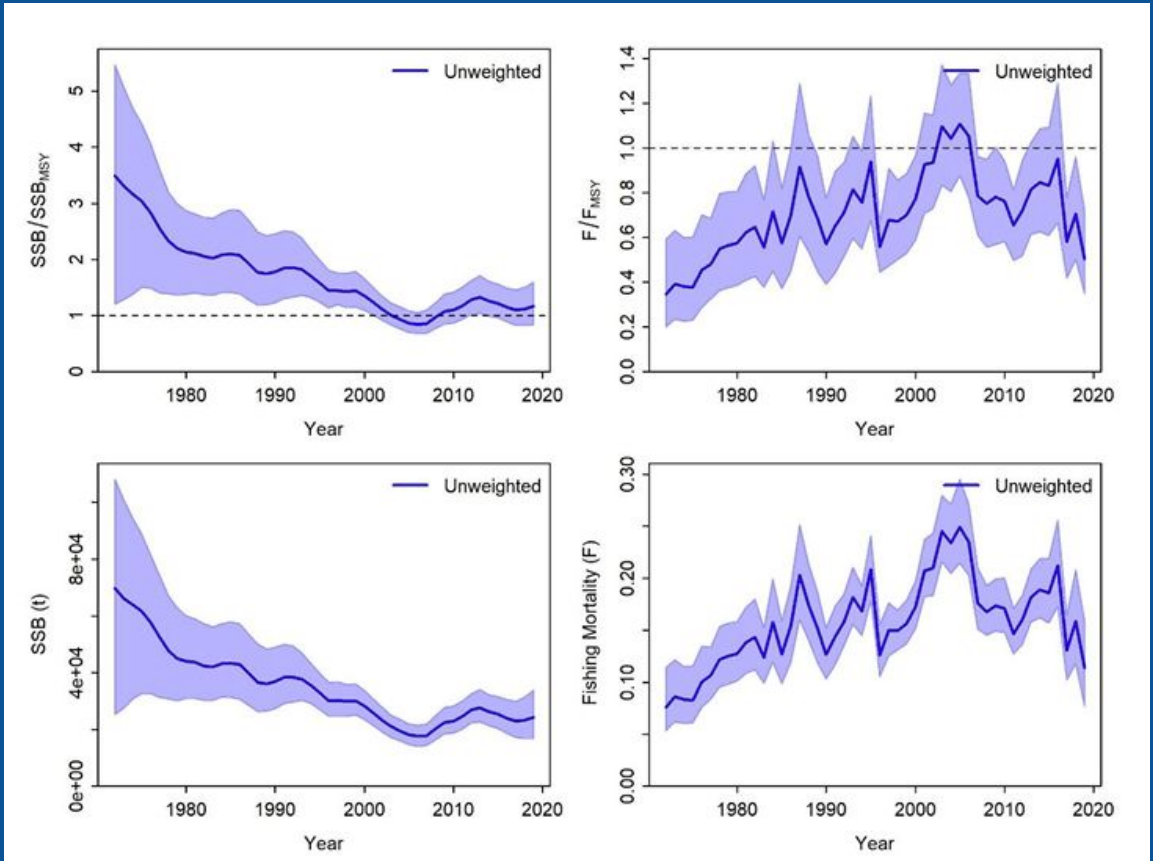


Overview of the 2021 Stock Assessment

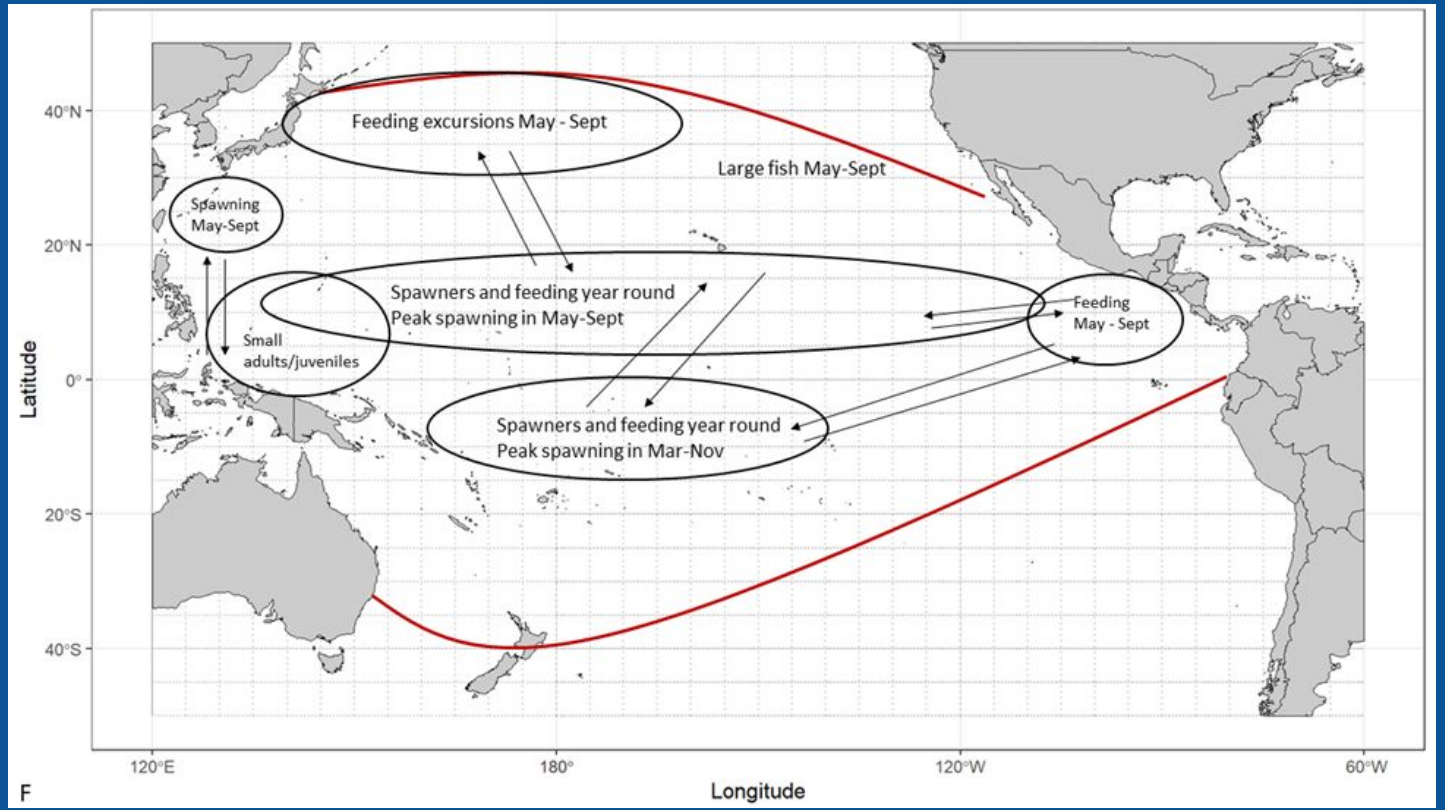
- Stock Synthesis 3.30 model
- Model ensemble averaging two growth curves:
  - “Old growth” from the 2016 stock assessment
  - “New growth” preliminary growth curve from Chang, et al.
- SSB_{2019} = 24,241 mt (17% above SSB_{MSY})
- F_{2019} = 0.13 (ages 1-10, 40% below F_{MSY})
- BUM was not experiencing overfishing and was not overfished relative to MSY-based reference points



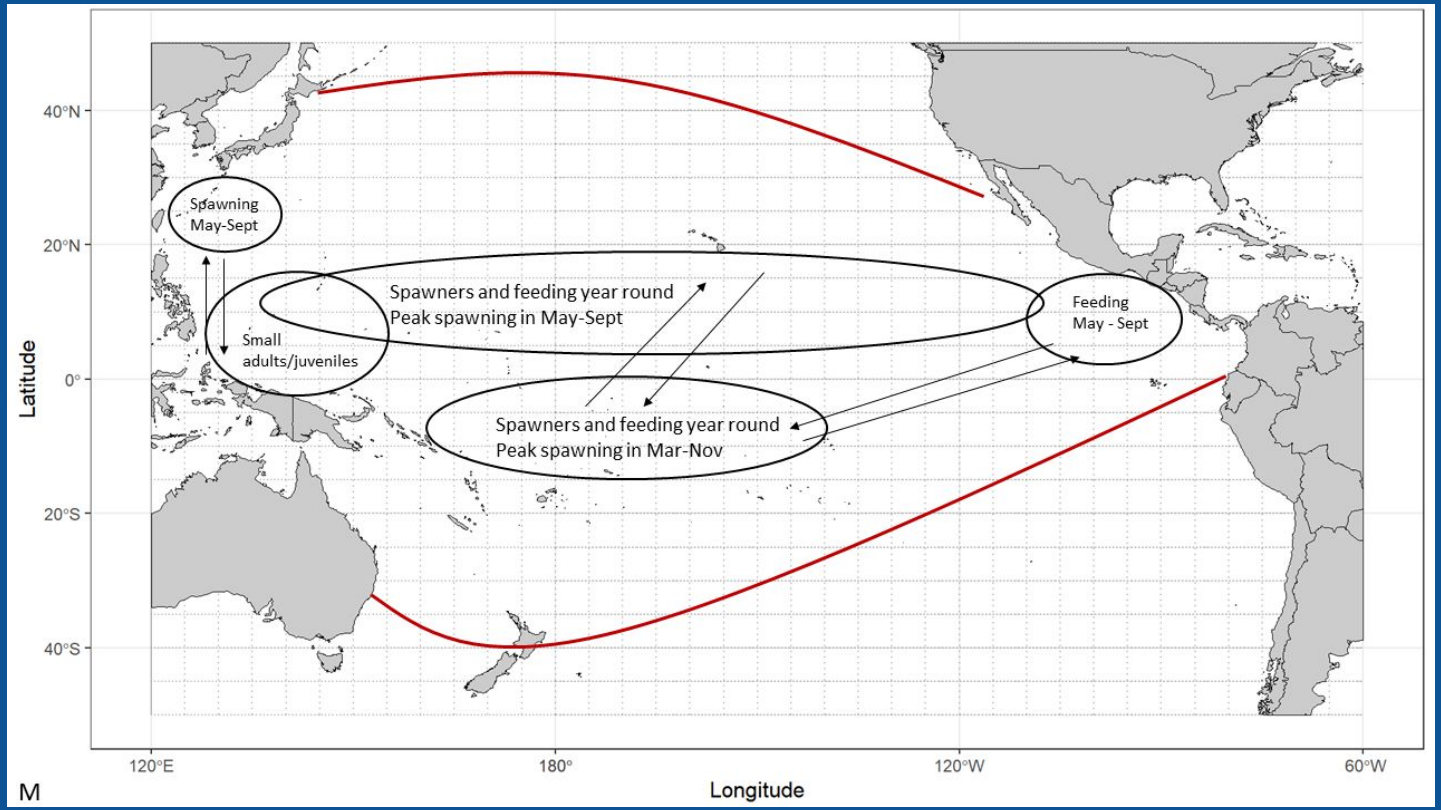
Overview of the 2021 Stock Assessment



2026 BUM Conceptual Model - Females

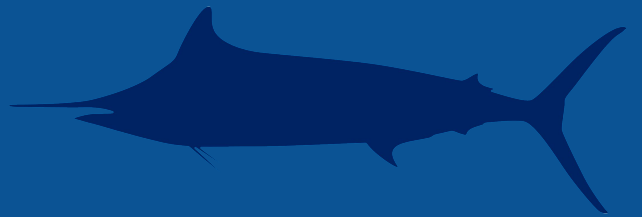


2026 BUM Conceptual Model - Males



2026 BUM Modeling Changes

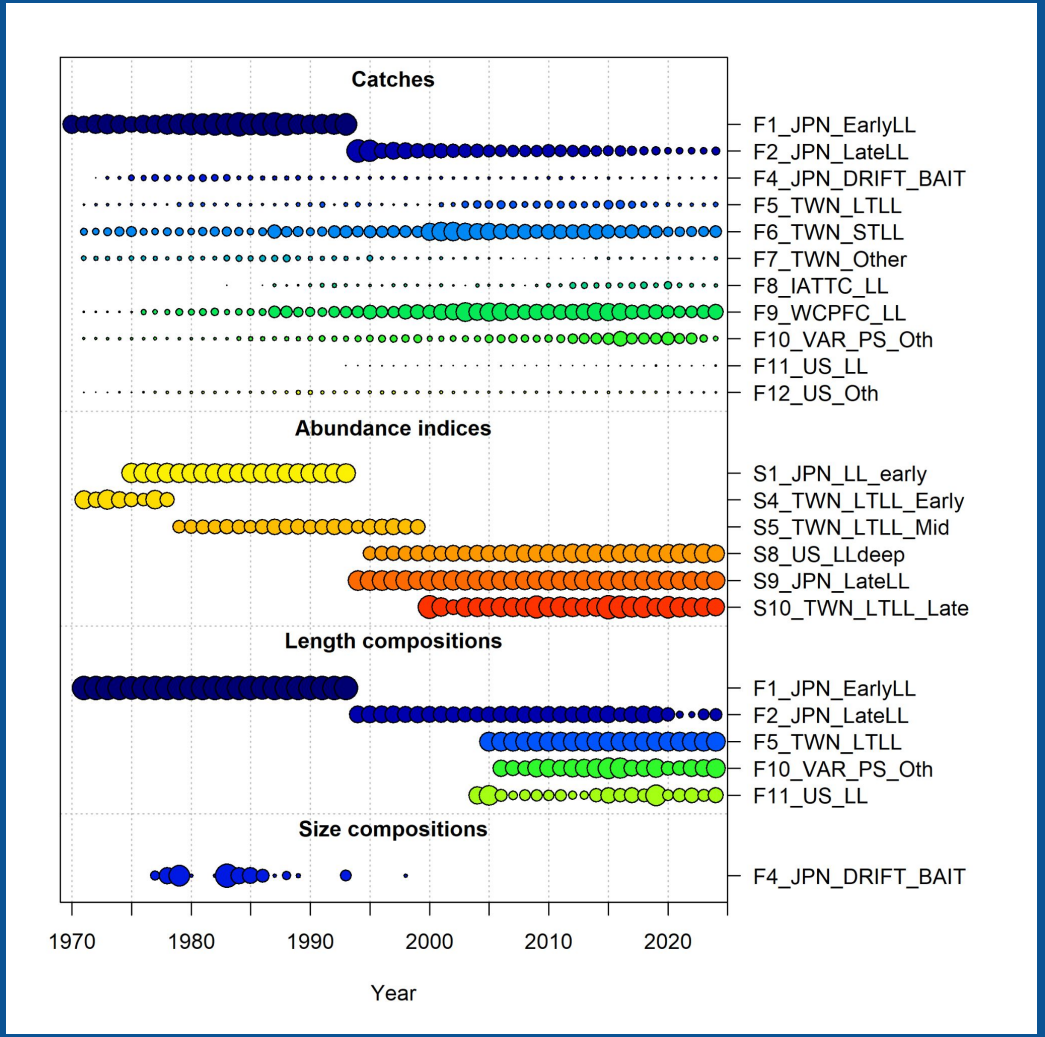
- Updated catch, CPUE, and size composition data
- Updated biology:
  - New growth curve from Chang, et al., 2025
  - Updated Natural Mortality (Lorenzen)
  - New conceptual model
  - Initial conditions estimated from historical catch (fixed F)
- Other biological parameters (steepness and maturity) unchanged
- Combined fleets with 2021 mirrored selectivities



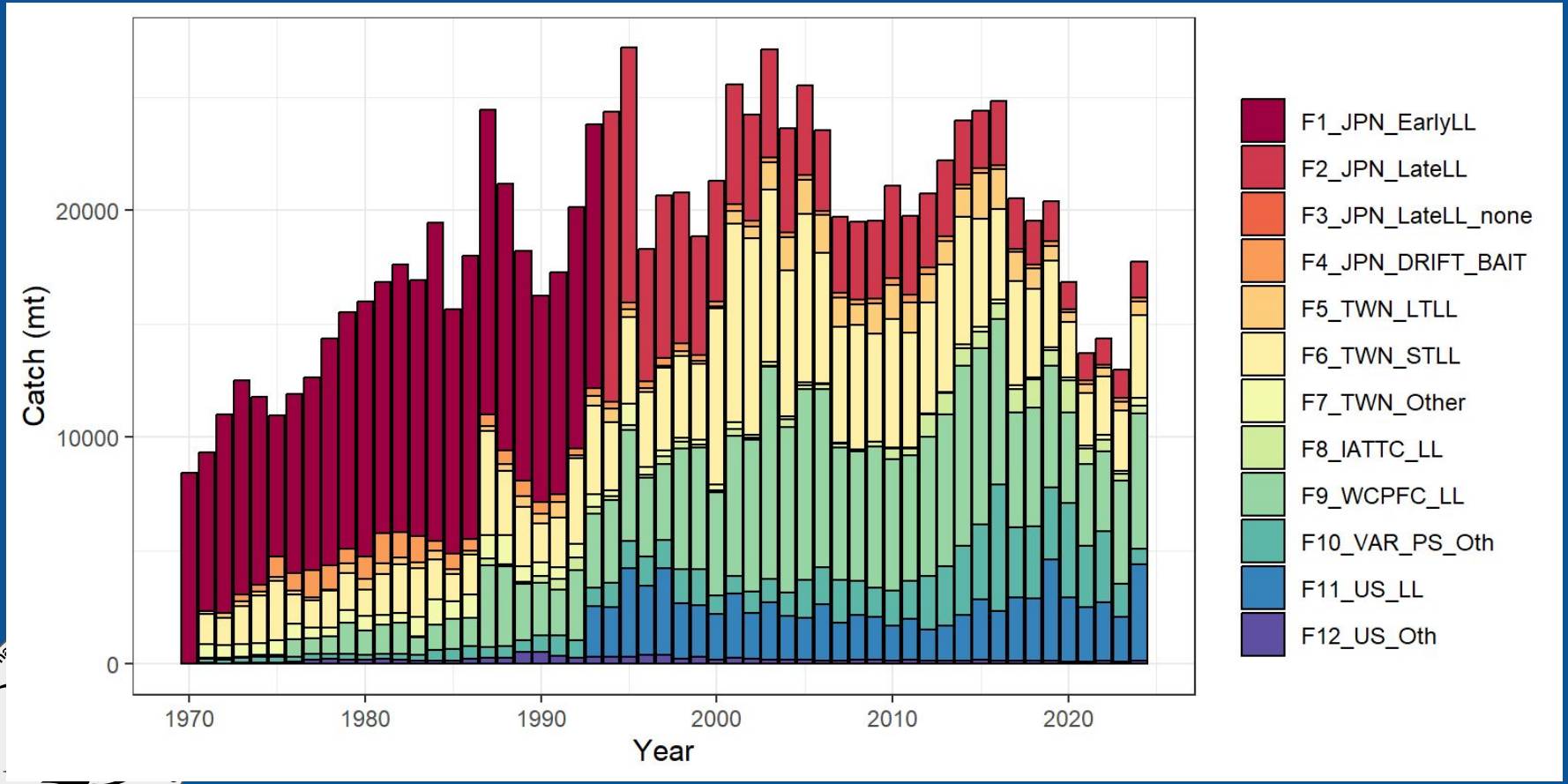
Fleet Structure

Fleet name	Description	Size data
F1_JPN_EarlyLL	Coastal, offshore, and distant water longline, other gears, 1971–1993	Length (U), 1971–1993
F2_JPN_LateLL	Offshore and distant water longline east, 1994–2024	Length (U), 1994–2024
F4_JPN_DRIFT_BAIT	High-seas large-mesh driftnet, coastal driftnet, and bait fishing 1972–2024	Weight (U), some years from 1977–1998
F5_TWN_LTLL	Large tonnage longline, 1971–2024	Length (U), 2014–2024
F6_TWN_STLL	Small tonnage longline, 1971–2024	NA: Selectivity mirrors F5_TWN_LTLL
F7_TWN_Other	Coastal longline, gillnet, setnet, harpoon, and others, 1971–2024	NA: Selectivity mirrors F5_TWN_LTLL
F8_IATTC_LL	Longline, 1983–2024	NA: Selectivity mirrors F5_TWN_LTLL
F9_WCPFC_LL	Longline, 1971–2024	NA: Selectivity mirrors F5_TWN_LTLL
F10_VAR_PS_Other	All gears and flags not otherwise included 1971–2024	Length (U), 2006–2024 from IATTC purse seine
F11_US_LL	American Samoa and Hawaii longline, 1993–2024.	Length (U/F/M), 2004–2024. Sex-specific selectivity
F12_US_Other	Troll, handline, 1971–2024, and longline, 1971–1992	NA: Selectivity mirrors F11_US_LL

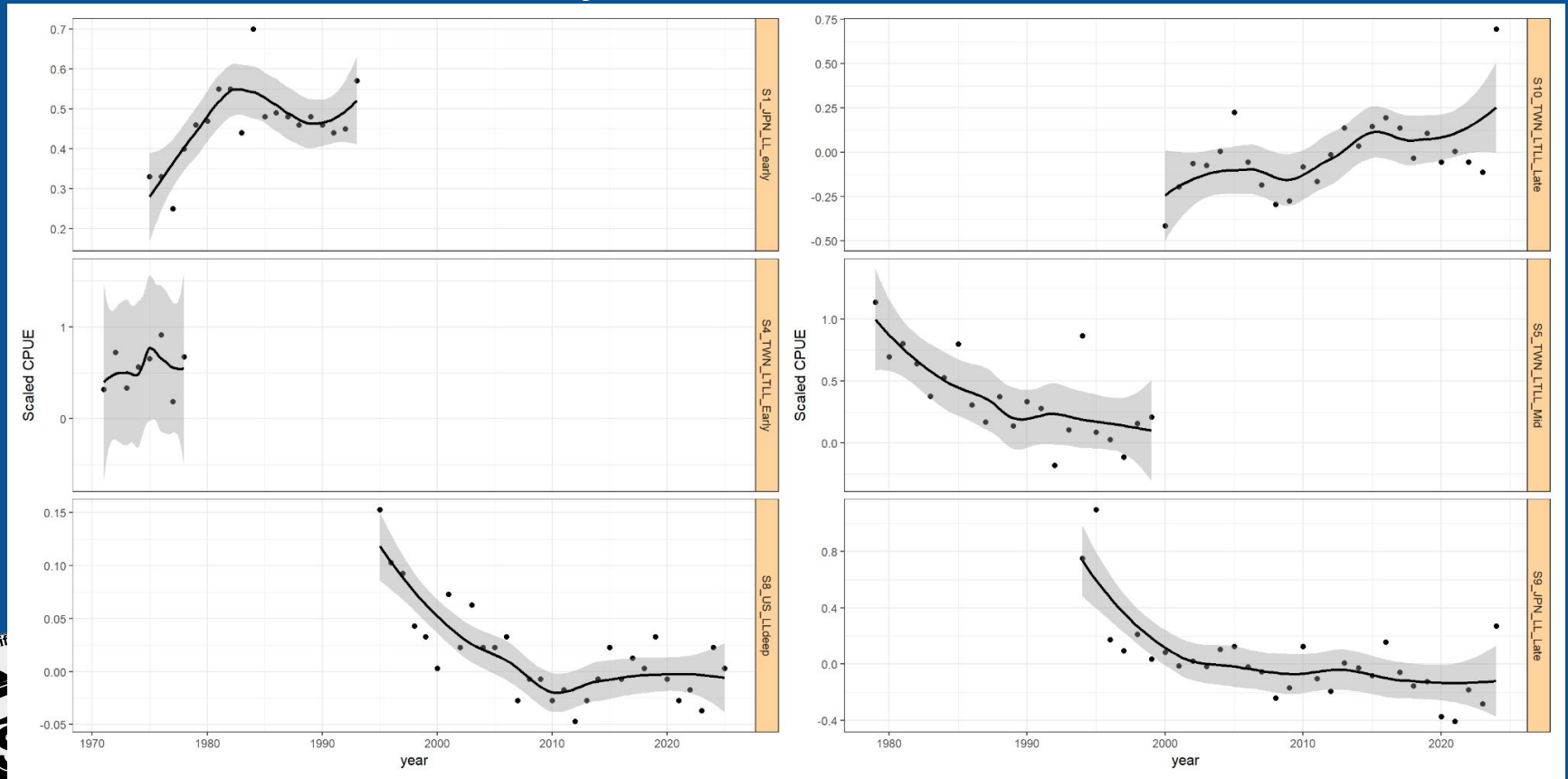
Fleet Structure



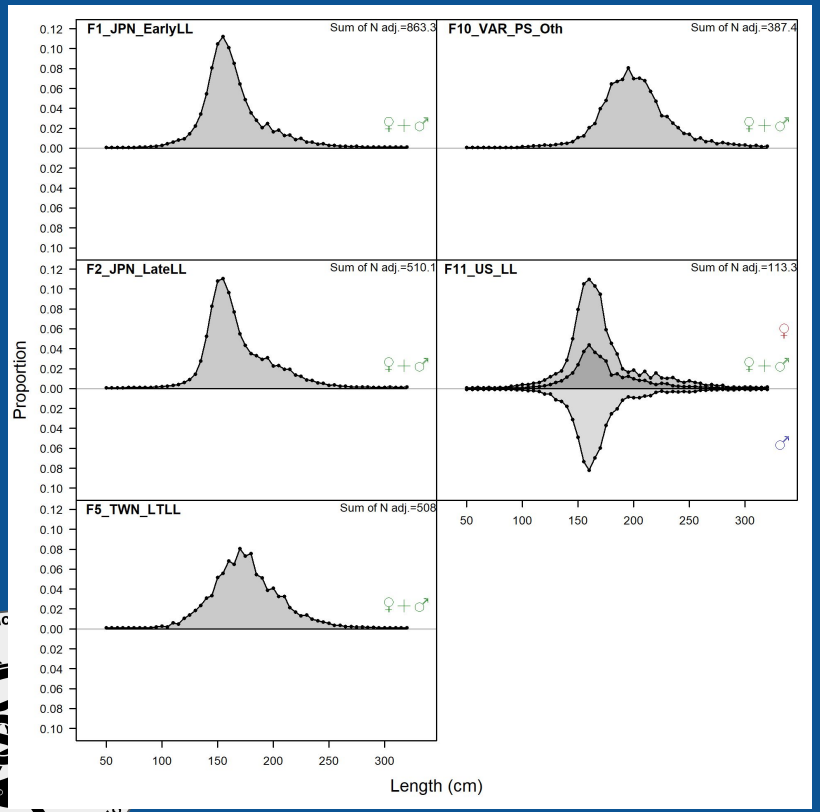
Catch by Fleet

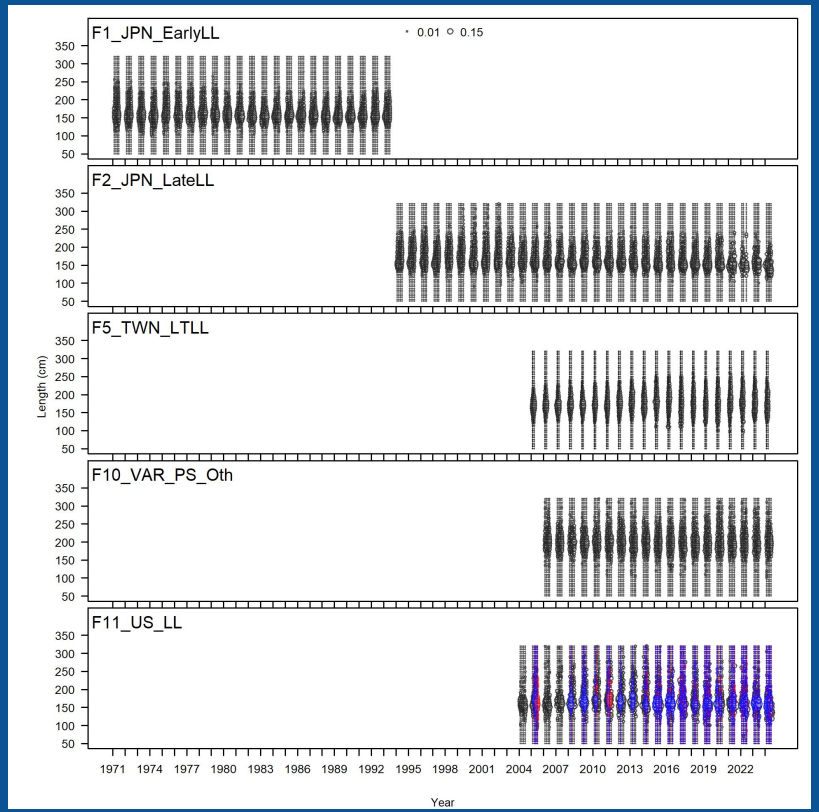


Standardized CPUE by fleet

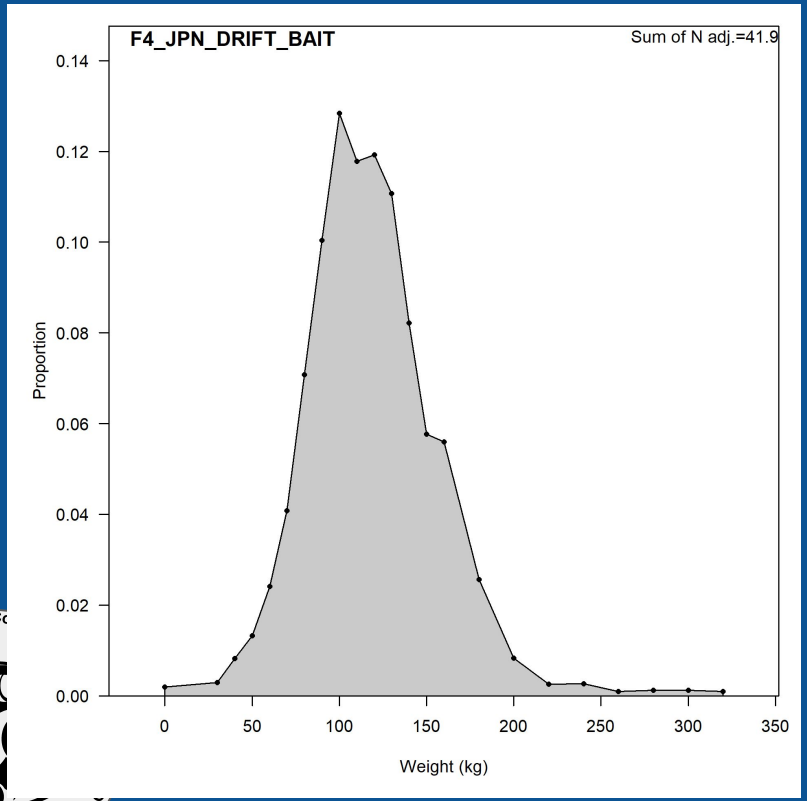


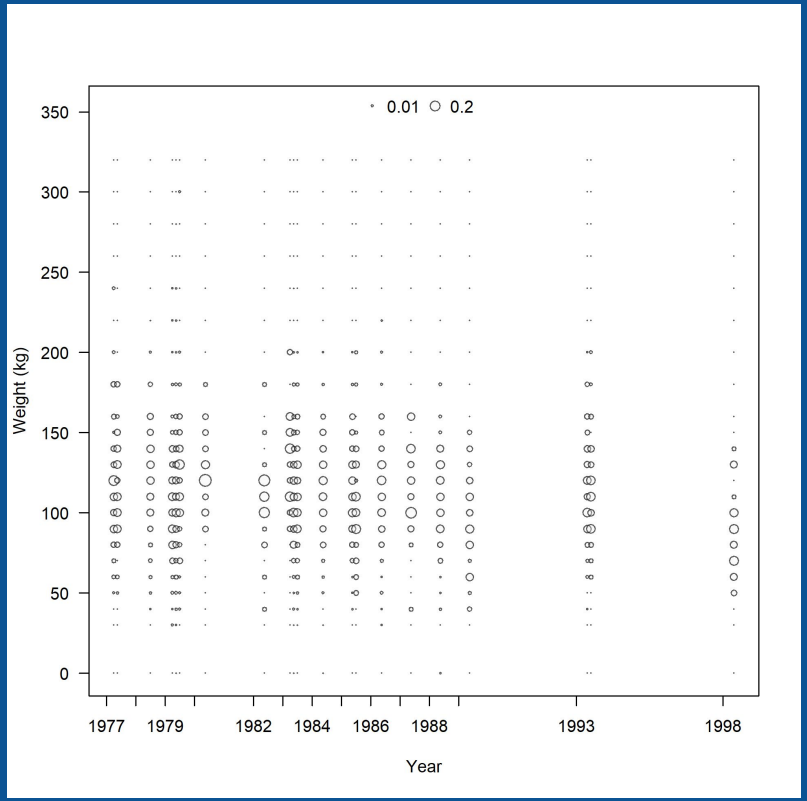
Length Composition Data by Fleet





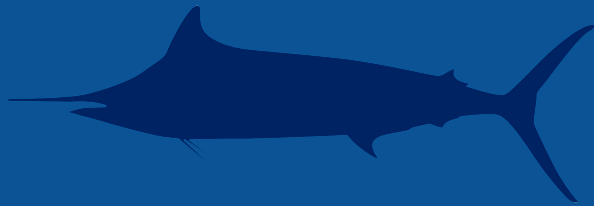
Weight Composition Data by Fleet





Biological Parameter Changes

New growth curve
Revised natural mortality



Growth

ICES Journal of Marine Science, 2025, Vol. 82, Issue 8, fsaf134
https://doi.org/10.1093/icesjms/fsaf134
Received: 19 March 2025; **revised:** 10 July 2025; **accepted:** 11 July 2025
Original Article

Estimation of the two-stanz
determination uncertainty fo
nigricans) in the western and

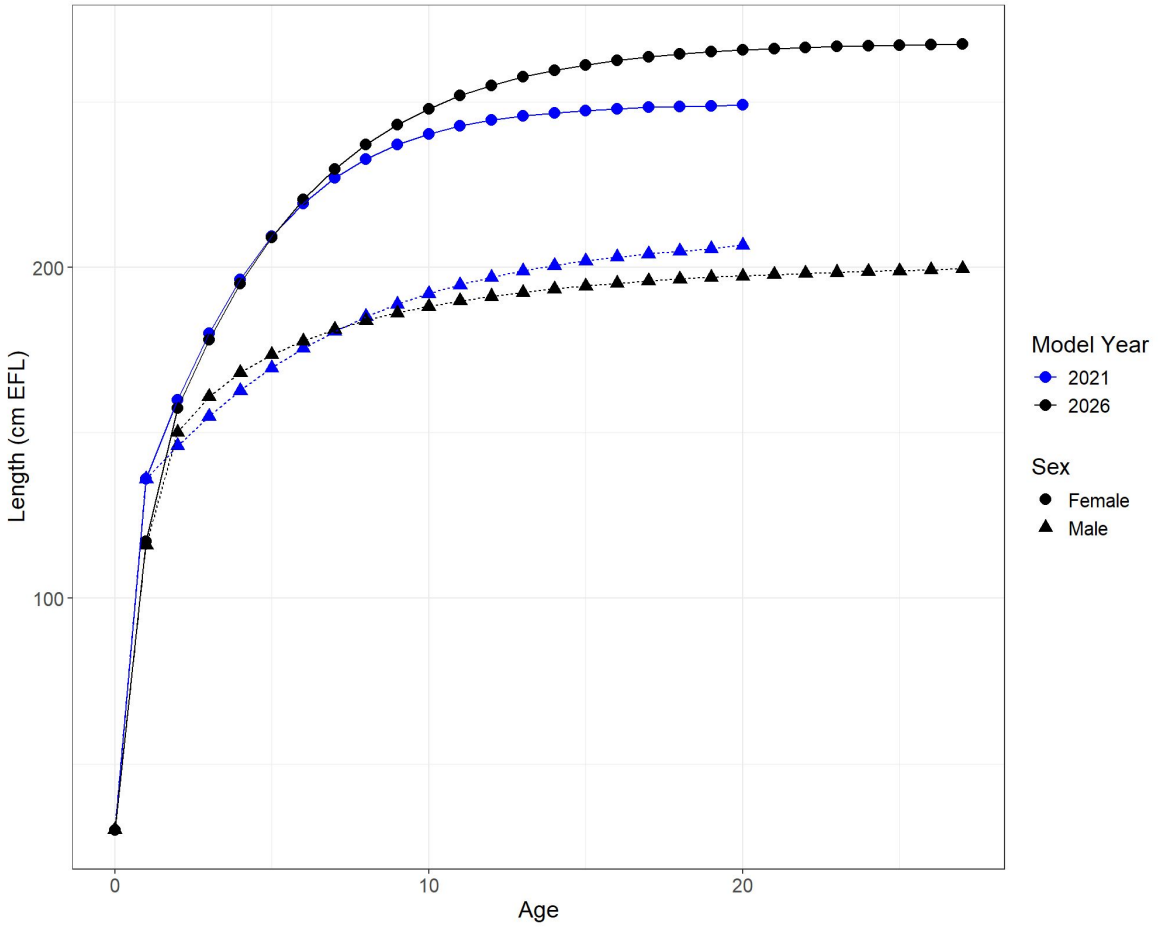
Yi-Jay Chang [1,*], Tamaki Shimose[2], Xu-Bang
Minoru Kanaiwa[3], Wei-Chuan Chiang [4], Jon K
Michelle L. Sculley [5], Michael J. Kinney[5]

[1]Institute of Oceanography, National Taiwan University, Taipei, 1061
[2]Sanriku Fisheries Research Center, Iwate University, Iwate, 020-85
[3]Mie University Graduate School, Faculty of Bioresources, Tsu, 514-
[4]Eastern Fishery Research Center, Fisheries Research Institute, Tait
[5]NOAA National Marine Fisheries Service, Pacific Islands Fisheries
[6]Fisheries Resources Institutes, Japan Fisheries Research and Edu

*Corresponding author. Institute of Oceanography, National Taiwan Univers

Abstract

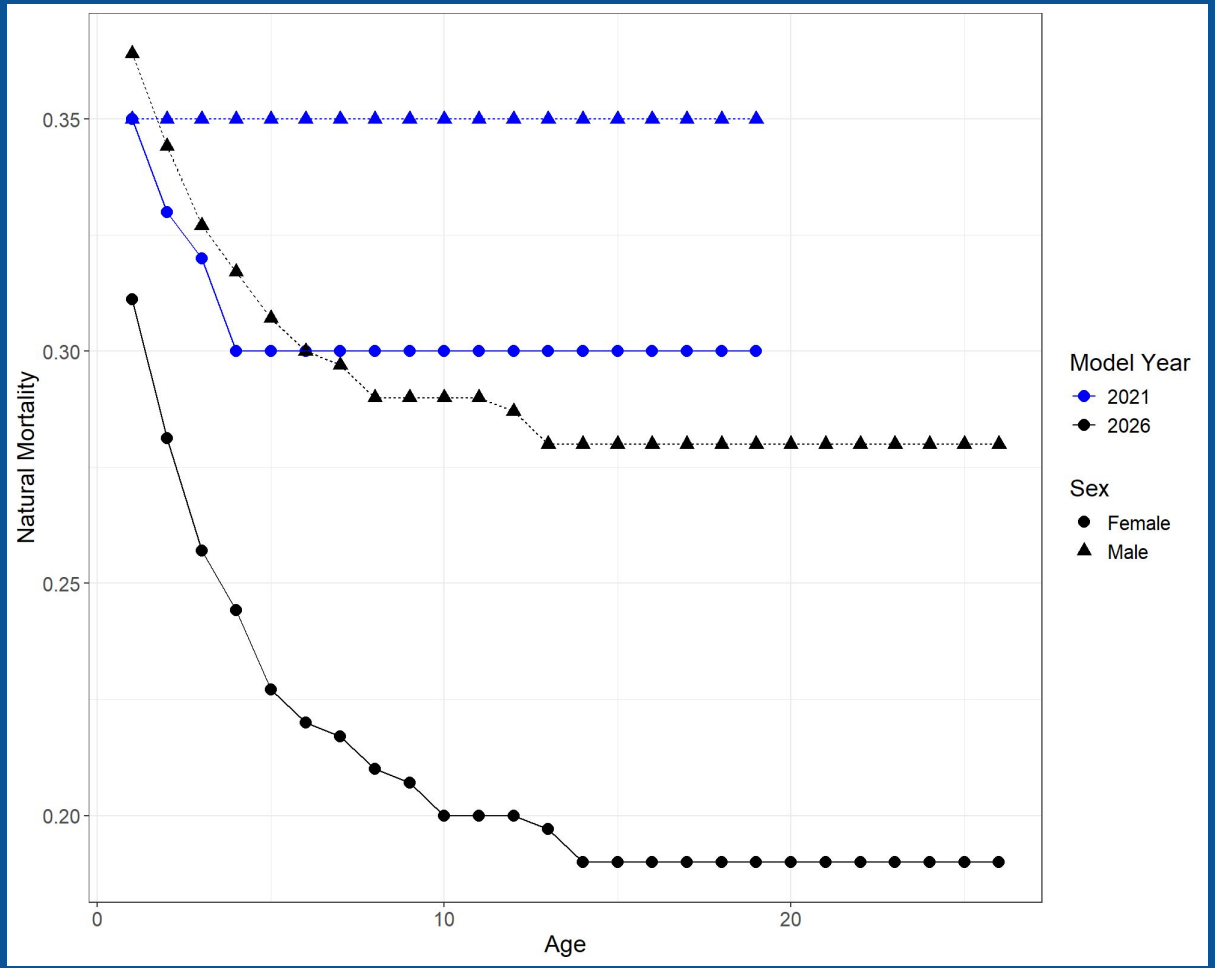
The Pacific blue marlin (*Makaira nigricans*) is a highly migrato
uncertainties in age and growth estimates remain a challenge
integrating otolith micro-increment counts from 13 juveniles (11
504 juveniles and adults (115–269.4 cm EFL) collected off Taiwan
International Billfish Biological Sampling Program using fin spin
EFL) methods and bomb radiocarbon dating ($n = 1$, 330.5 cm EF
Ocean (WCNPO). The combined otolith dataset ($n = 40$) yielded
model predicting an EFL of 146.92 cm at age one. Port-sampled
sexes: females aged 1.5–11 years (142.8–269.4 cm EFL) and mal
spine and bomb radiocarbon dataset showed age ranges of 1–2
232.1 cm EFL). Growth was sexually dimorphic, with females gro
males from age one onward. Mean marginal increment ratio ar
Sex-specific von Bertalanffy and two-stanza growth models (TSG



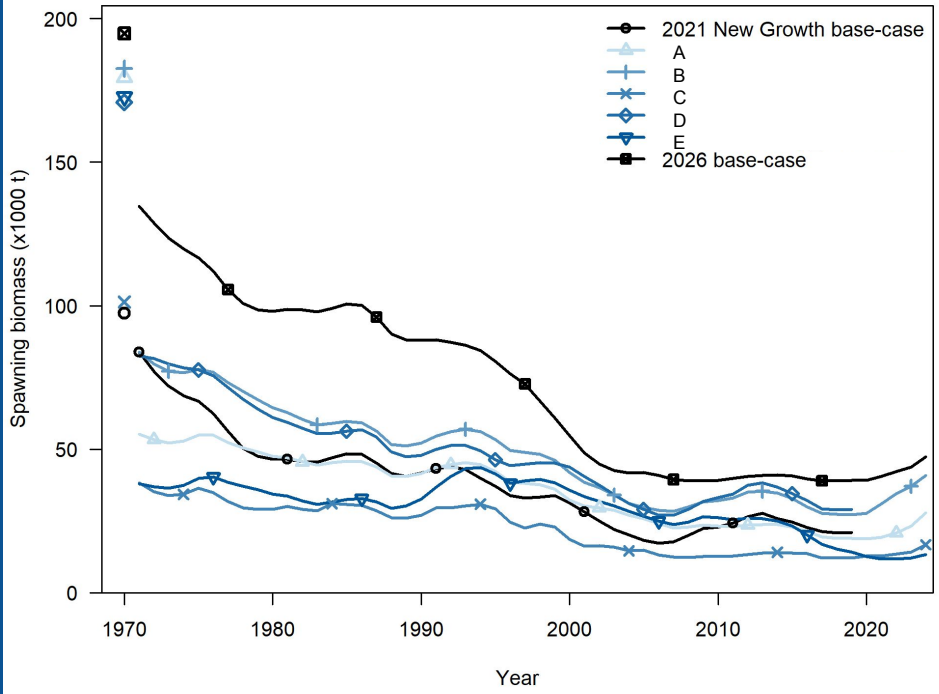
Natural Mortality

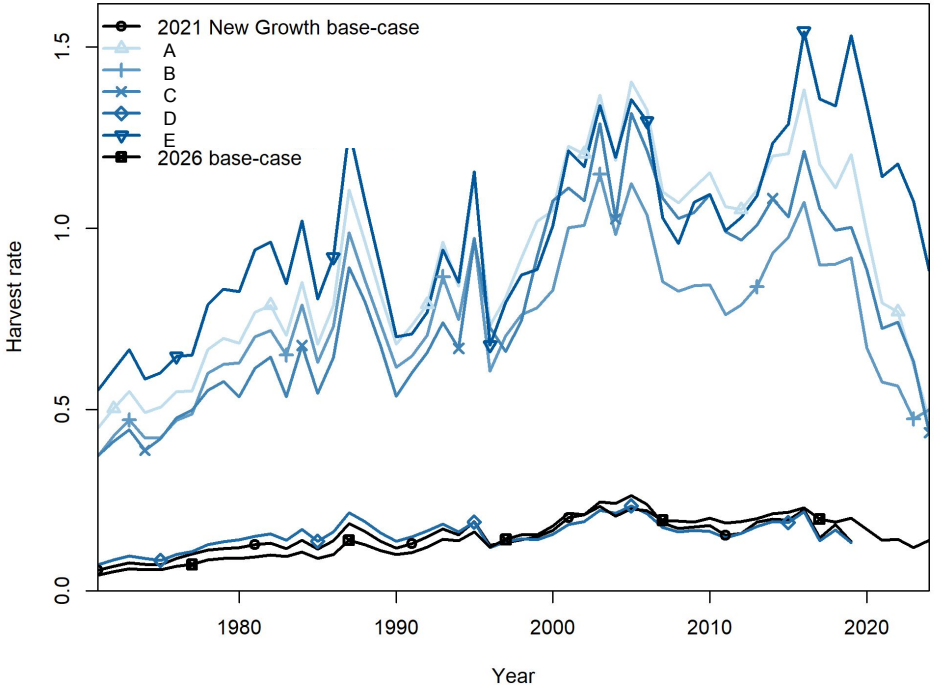
2021: Age-specific from a meta-analysis

2026: Lorenzen based on an Amax of 27



2026 BUM Assessment Bridging Analysis





A: 2021 model with 2026 data and biology
B: 2021 model with 2026 data and biology - TWN length data
C: 2021 biology ith 2026 data
D: 2021 data with 2026 biology
E: 2026 biology, catch, and size with 2021 CPUE

Modeling Approach

- 2026 benchmark stock assessment used Stock Synthesis 3.30 in a maximum likelihood estimation framework with some parameter constraints for fishery selectivity parameters
- The assessment covers the entire Pacific Ocean basin
- Initial conditions were fixed using the average catch from 1968 - 1972, which produced initial depletion consistent with the model runs starting in 1950 from an unfished stock.
    - Additional runs are provided exploring the sensitivity of the model to fixing initial conditions
- 2-sex model, one spawning event, one recruitment event, and a quarterly time step

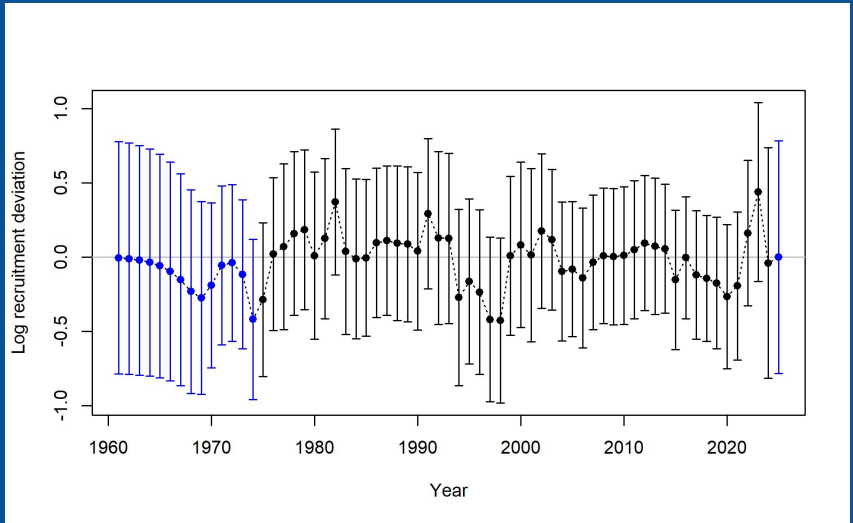
Data Observation Model

- Abundance Indices
  - Lognormal observation errors for abundance indices
  - log(SE) = sqrt(log(1+CV2)) for the individual CPUE standardizations
  - Input log(SE) values were estimated a priori, and increased to the index RMSE.

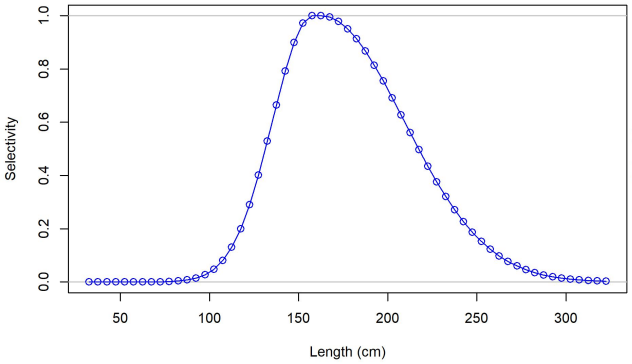
- Size Composition Data
  - Multinomial observation errors for size composition data
  - Size compositions with fewer than 15 individuals measured were removed
  - Effective sample size was number of fish measured/10, with all year/quarters greater than 50 set to 50.
  - Additional downweighting using rescaled Francis weights

Estimation of Recruitment Deviations From Stock-Recruitment Curve

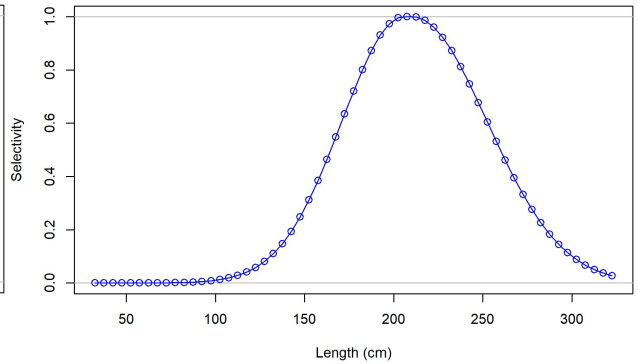
- Recruitment was estimated during 1975-2023 (with bias adjustment) and used the expected recruitment value from the estimated stock-recruitment curve for 2024
- Recruitment variability (σ_R, the standard deviation of log-recruitment) was fixed at $\sigma R = 0.4$. Rescaling σ_R was not suggested by the model outputs.



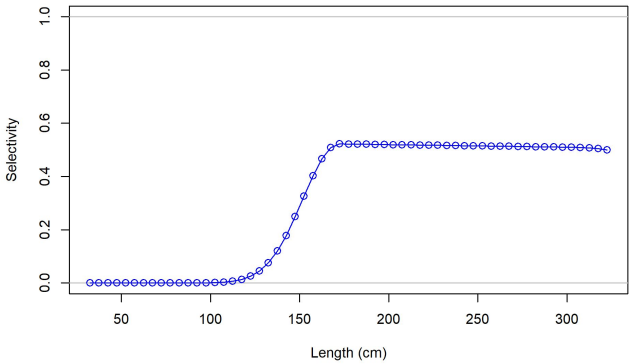
Selectivity



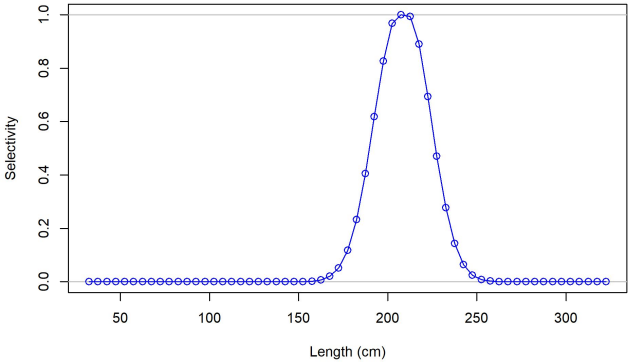
F1 JPN LL Early



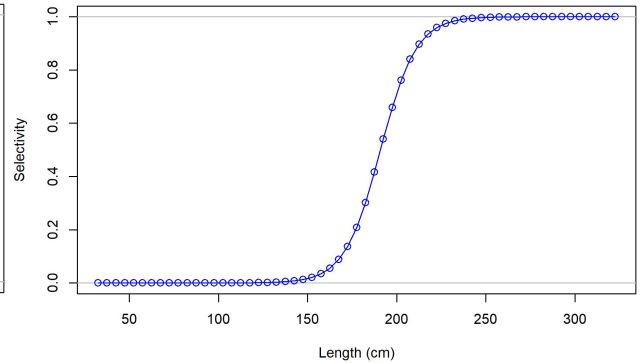
F5 TWN LTLL



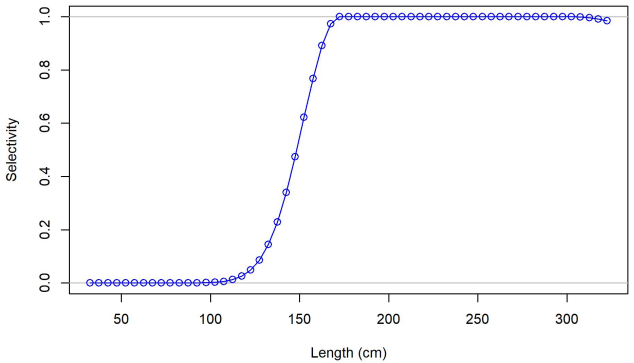
F11 US LL Female



F4 JPN Drift bait

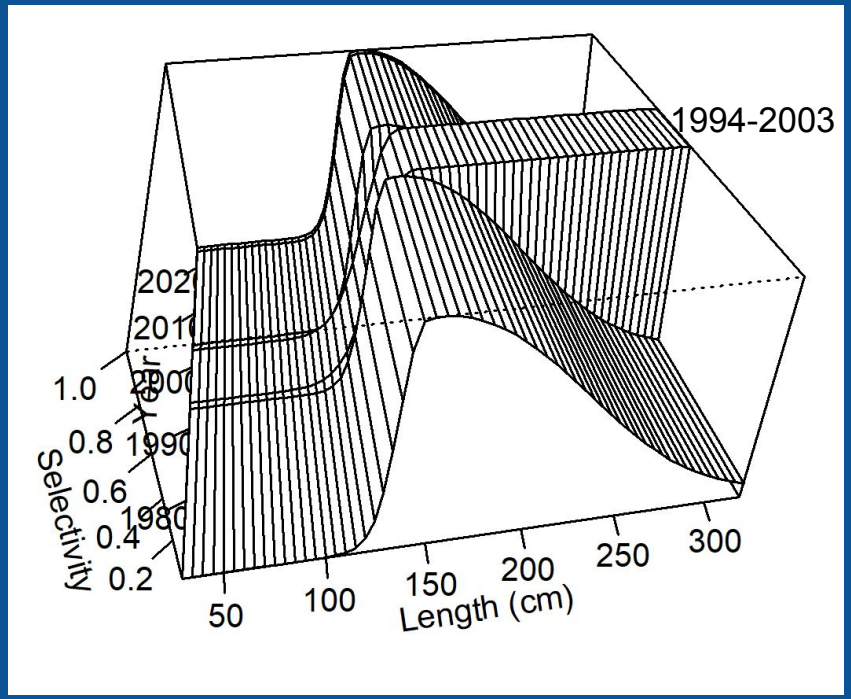


F10 Var PS Oth



F11 US LL Male

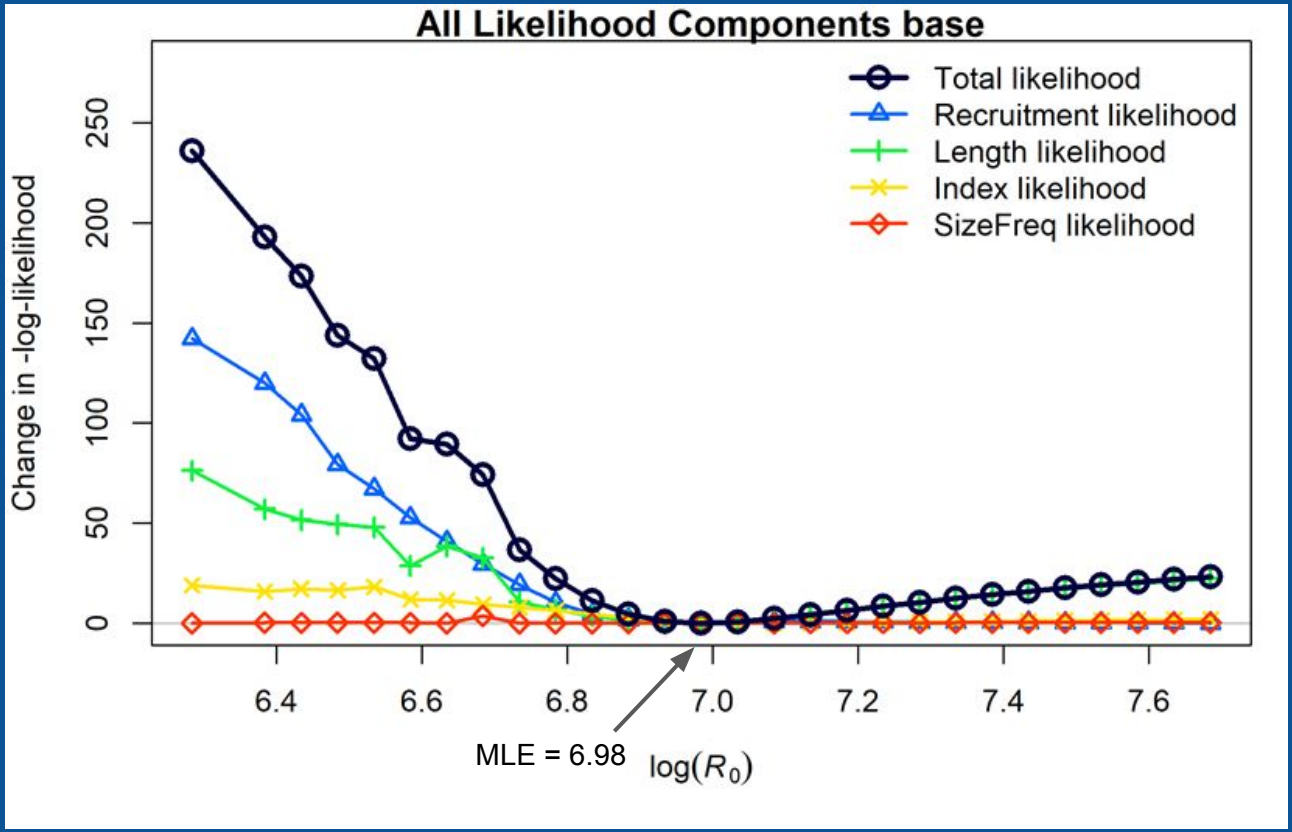
Time-varying selectivity



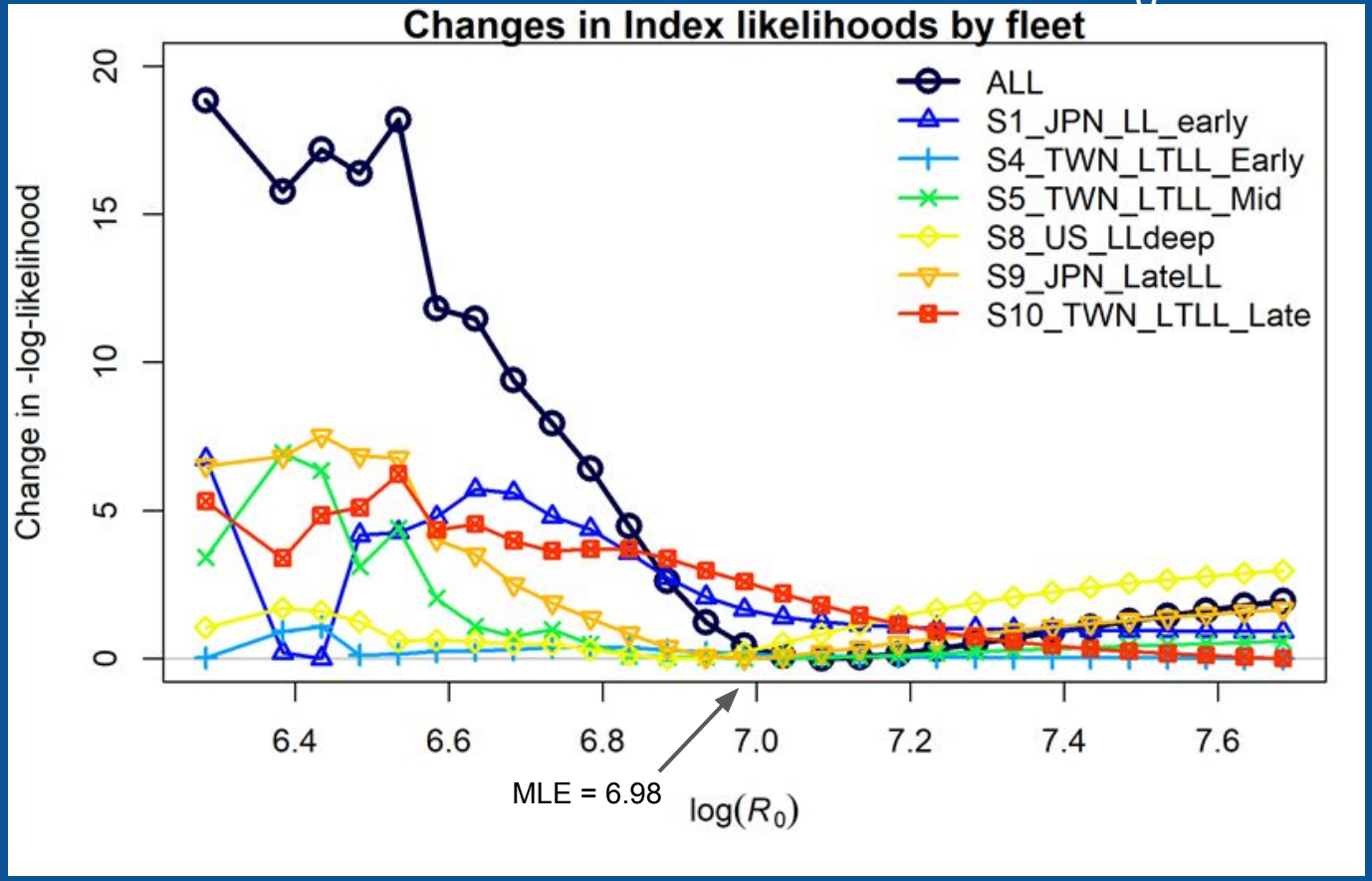
F2 JPN LL Late

Model Diagnostics

Likelihood Profile for Unfished Recruitment R_0

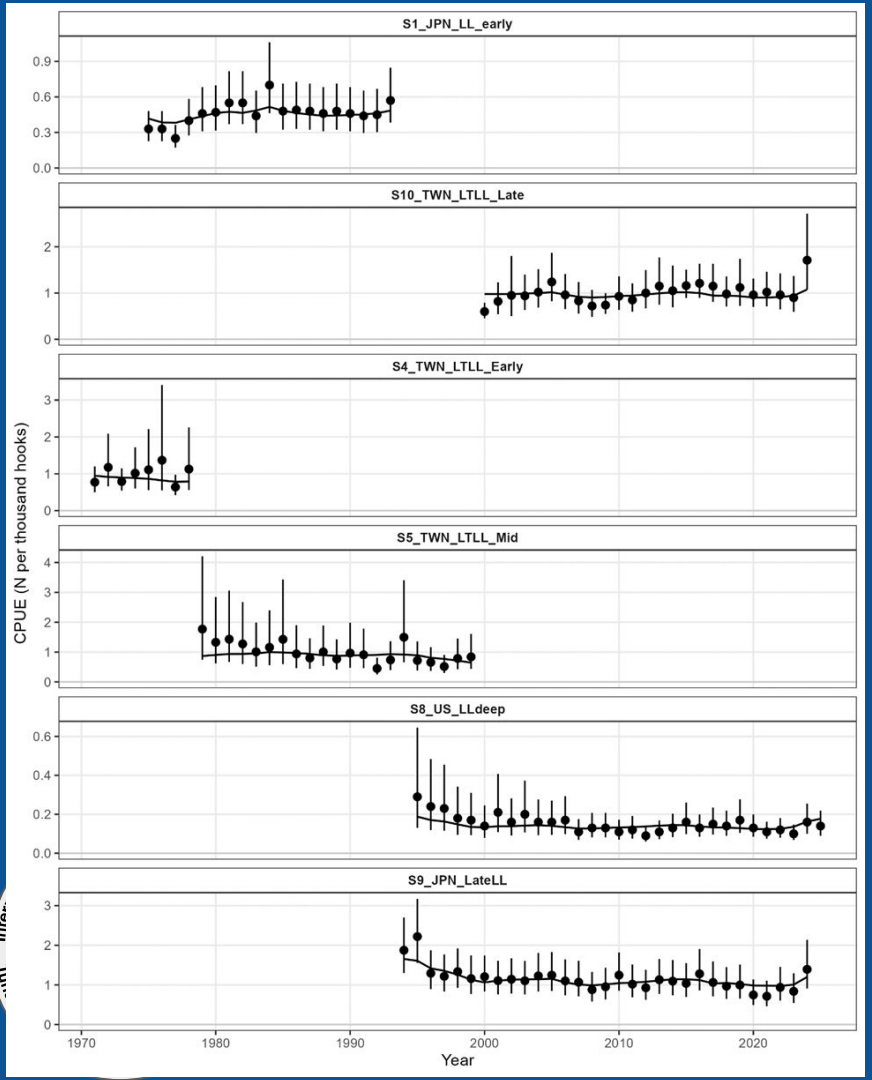


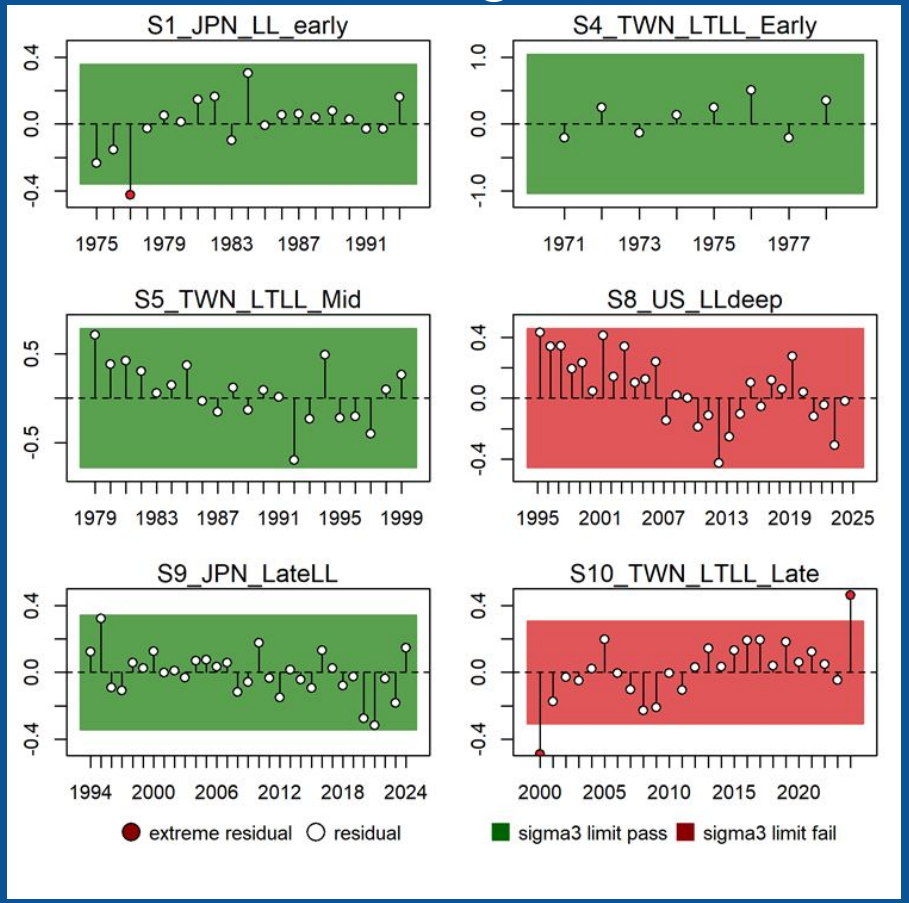
Likelihood Profile for Unfished Recruitment R_0 By CPUE



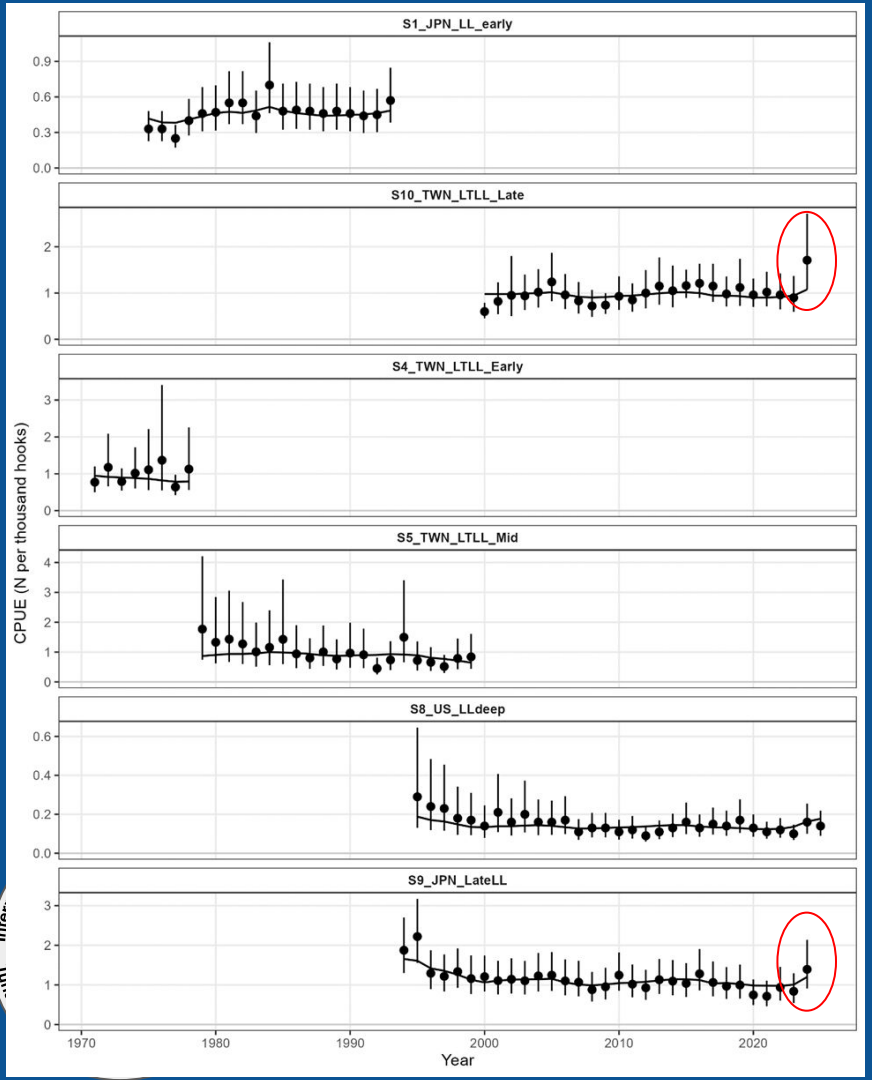
International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

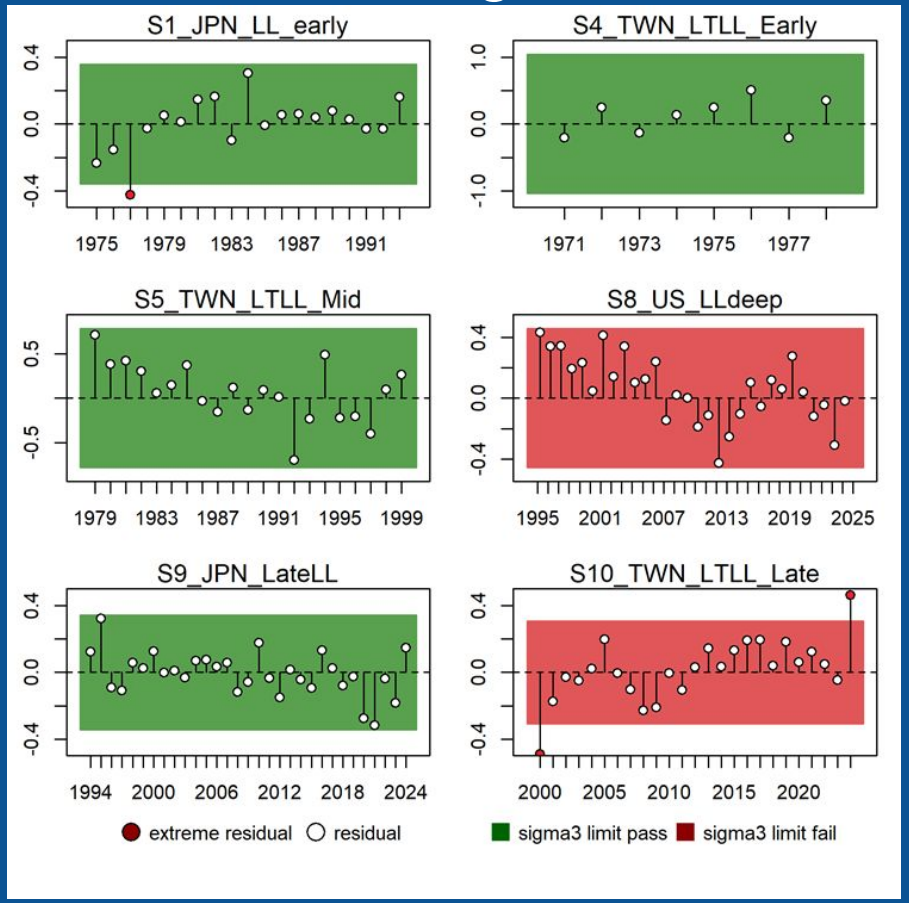
CPUE Diagnostics



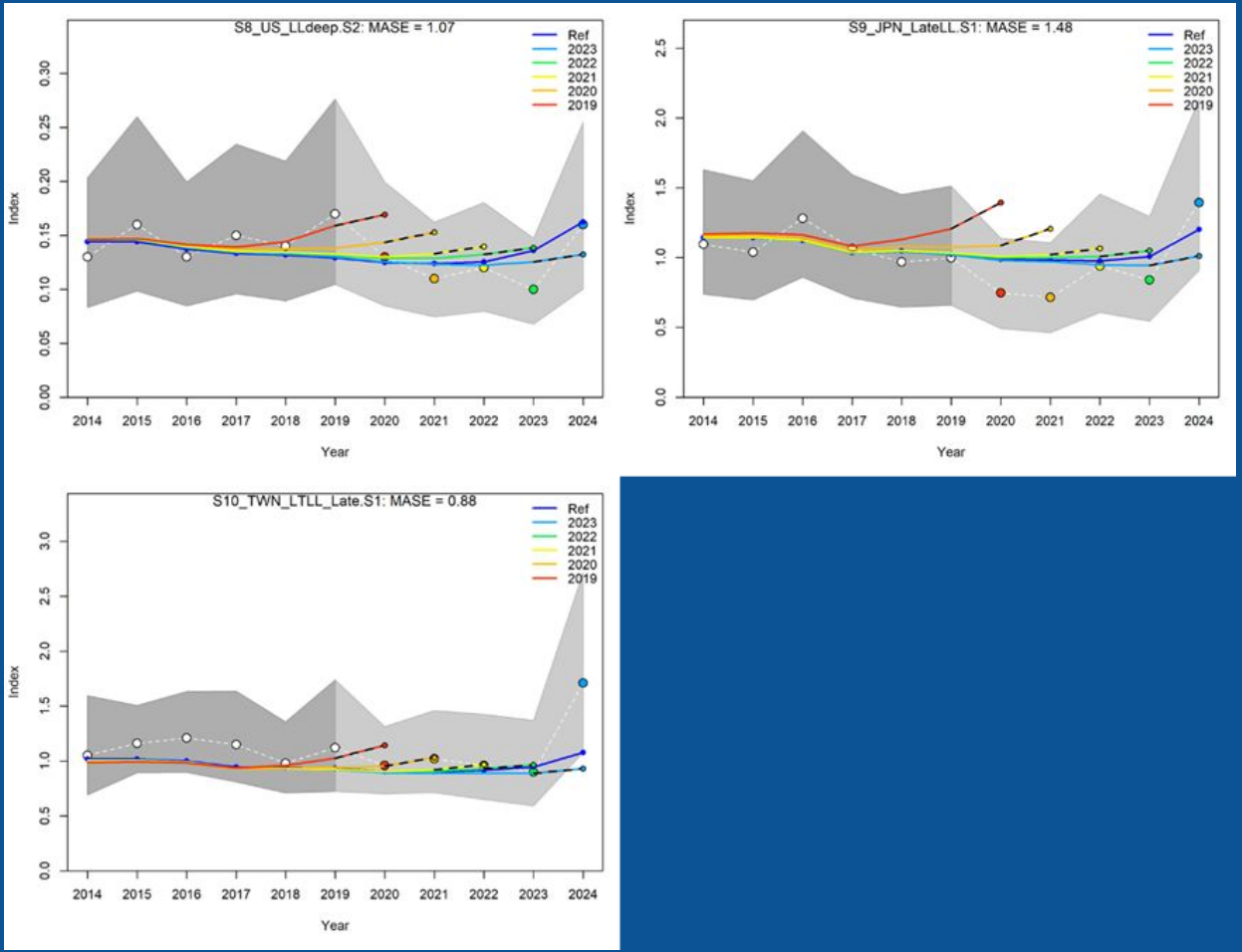


CPUE Diagnostics

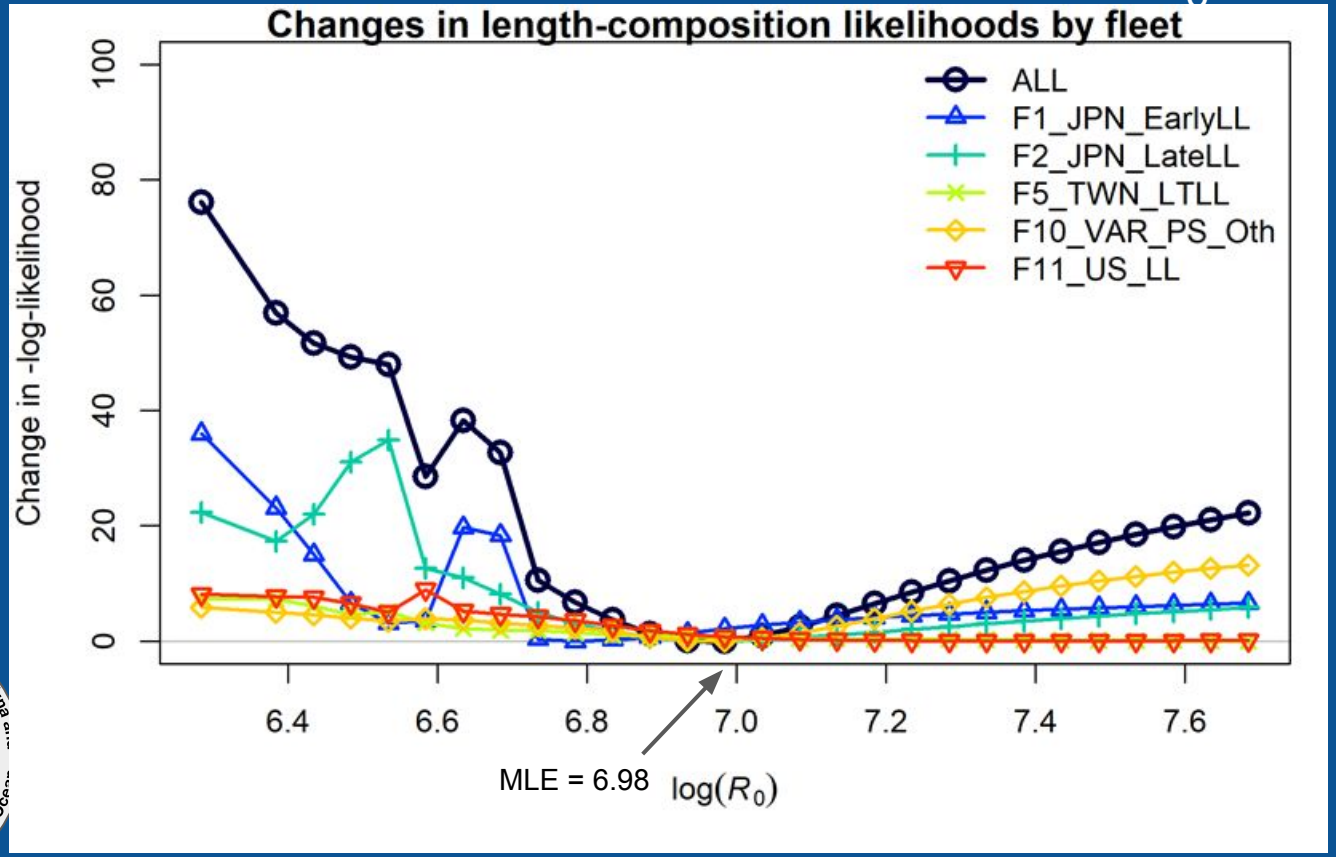




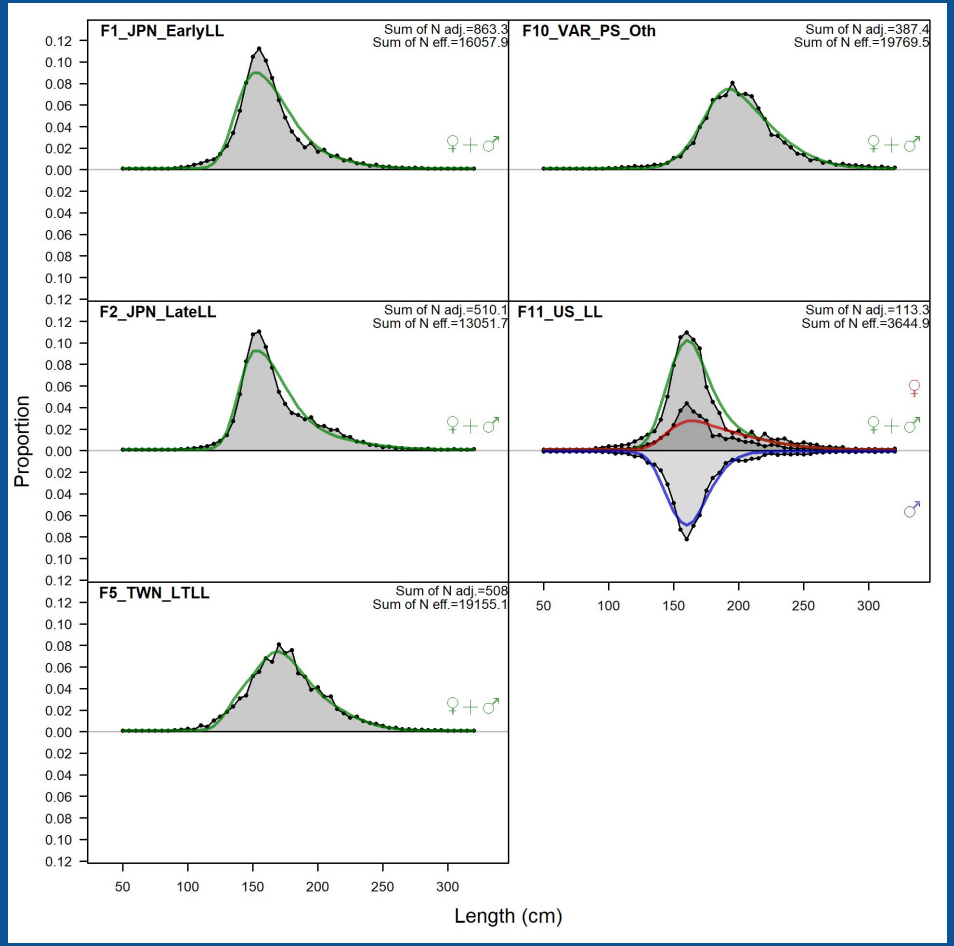
CPUE Hindcast Cross Validation



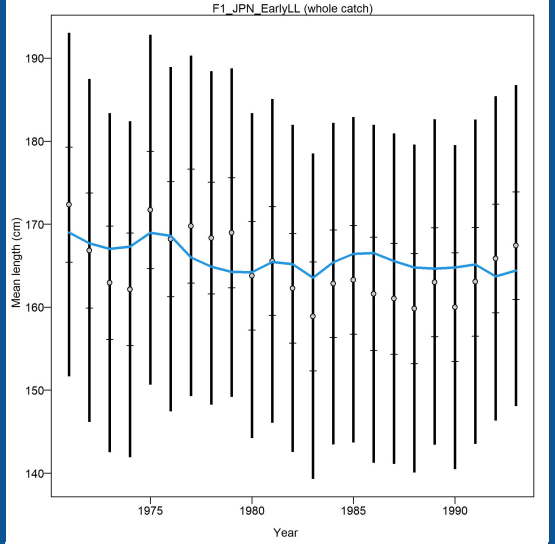
Likelihood Profile for Unfished Recruitment R_0 By CPUE

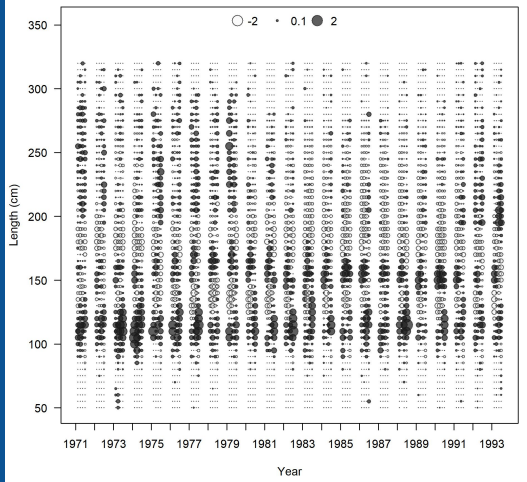


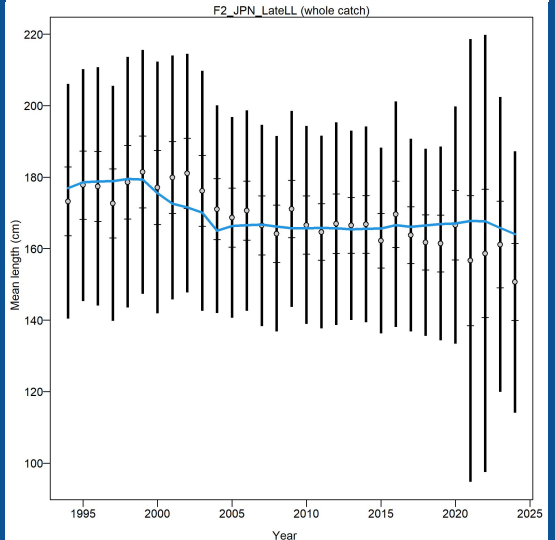
Fit to the Length Composition Data

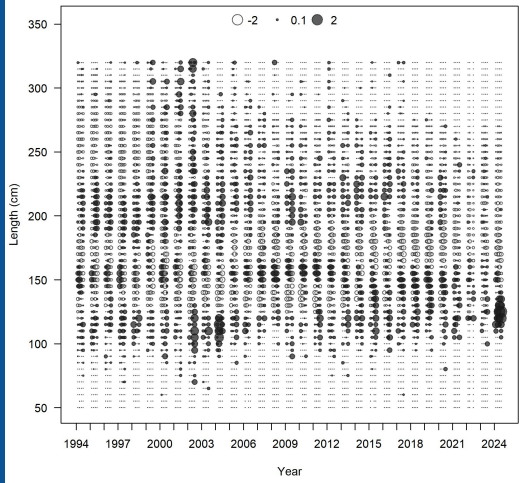


Fits to the Length Composition Data

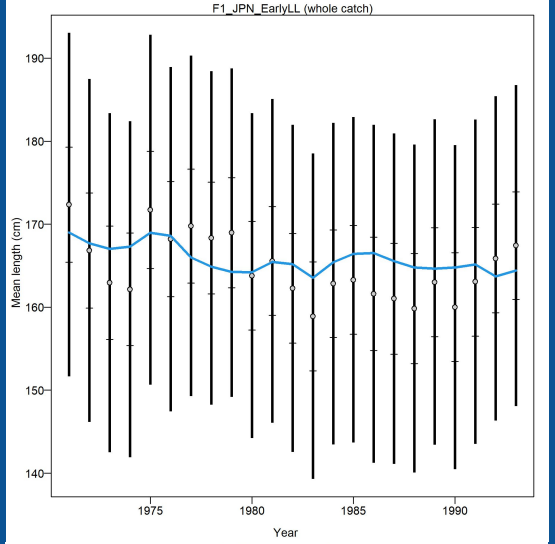


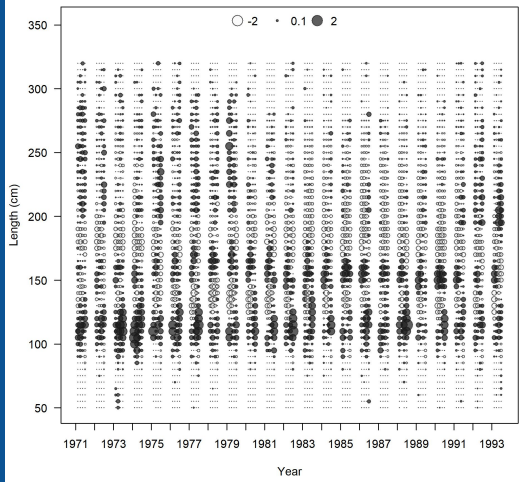


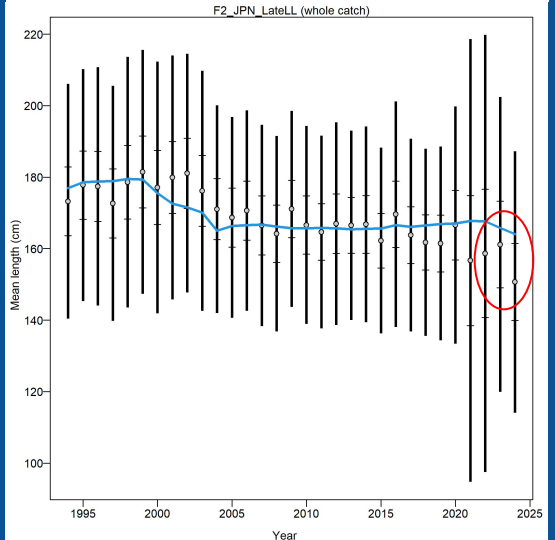


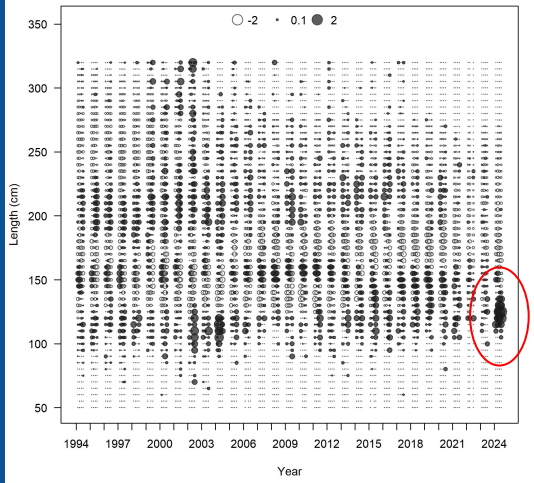


Fits to the Length Composition Data

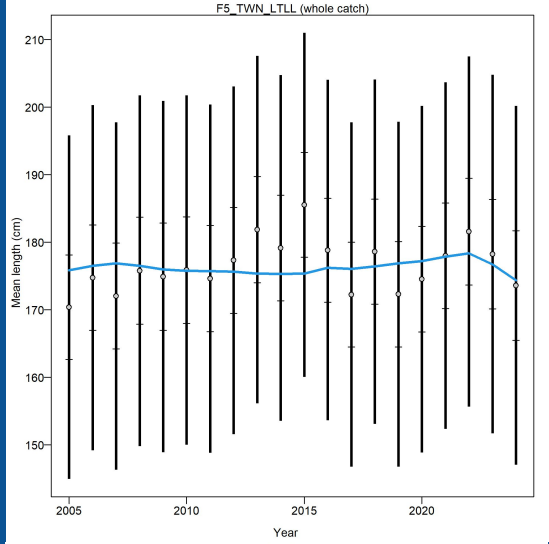


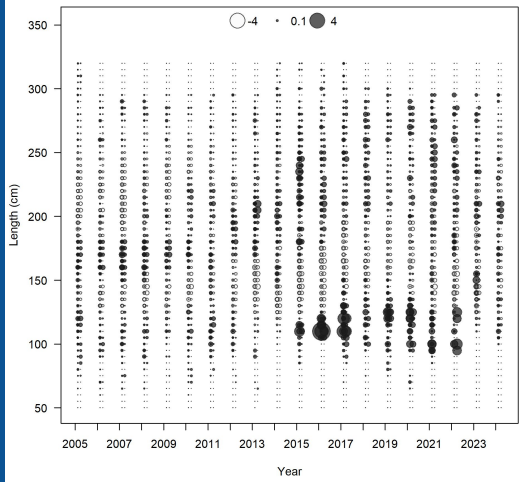


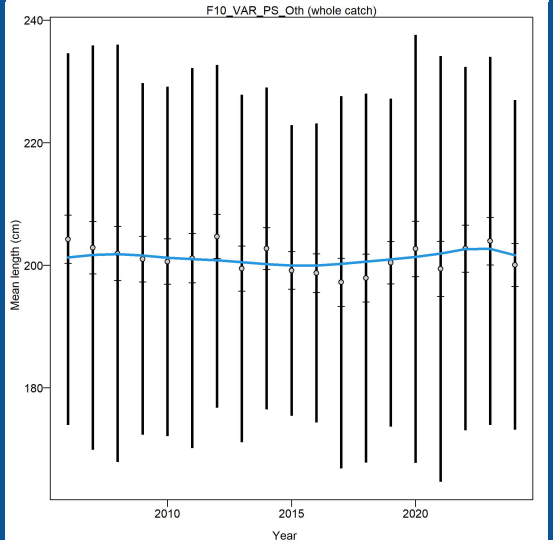


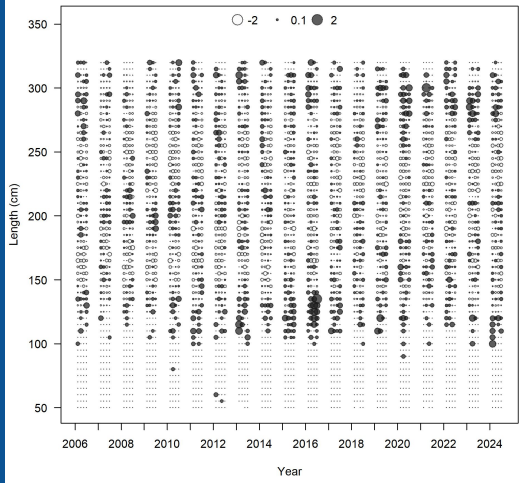


Fits to the Length Composition Data

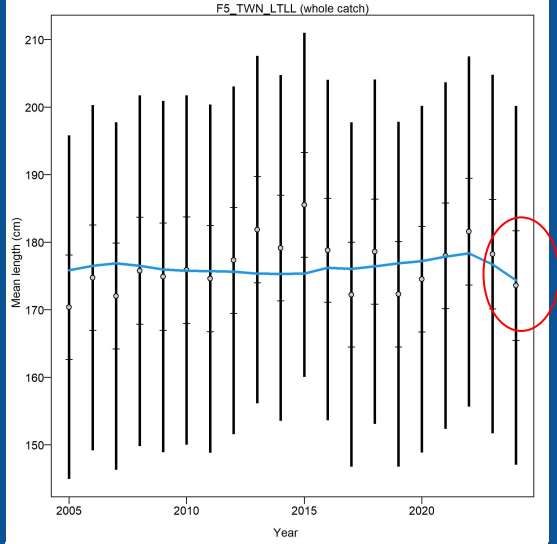


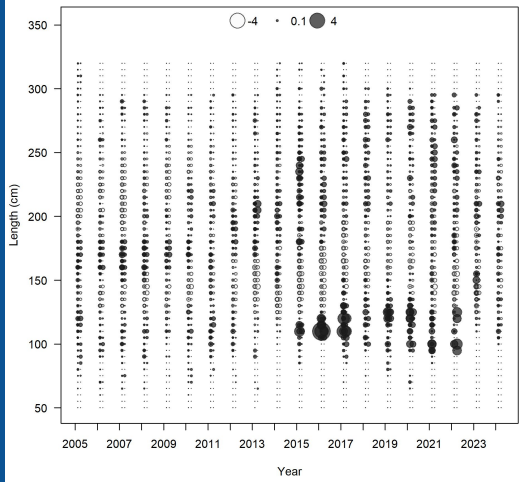


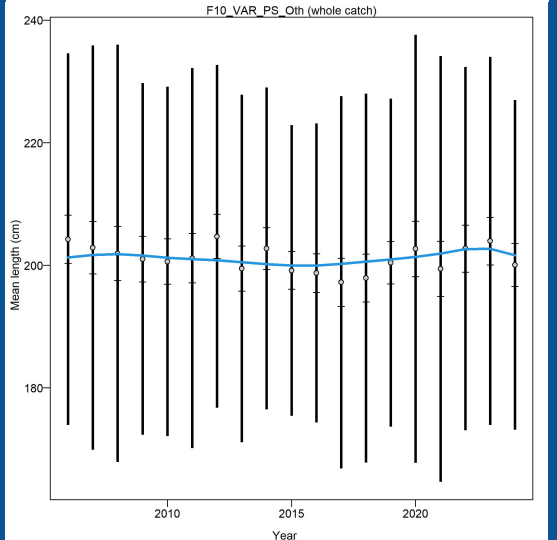


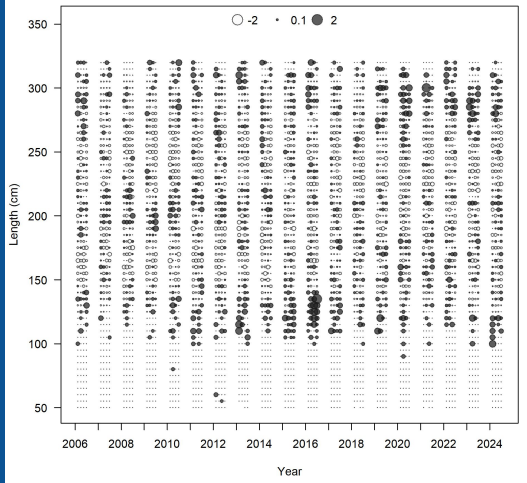


Fits to the Length Composition Data

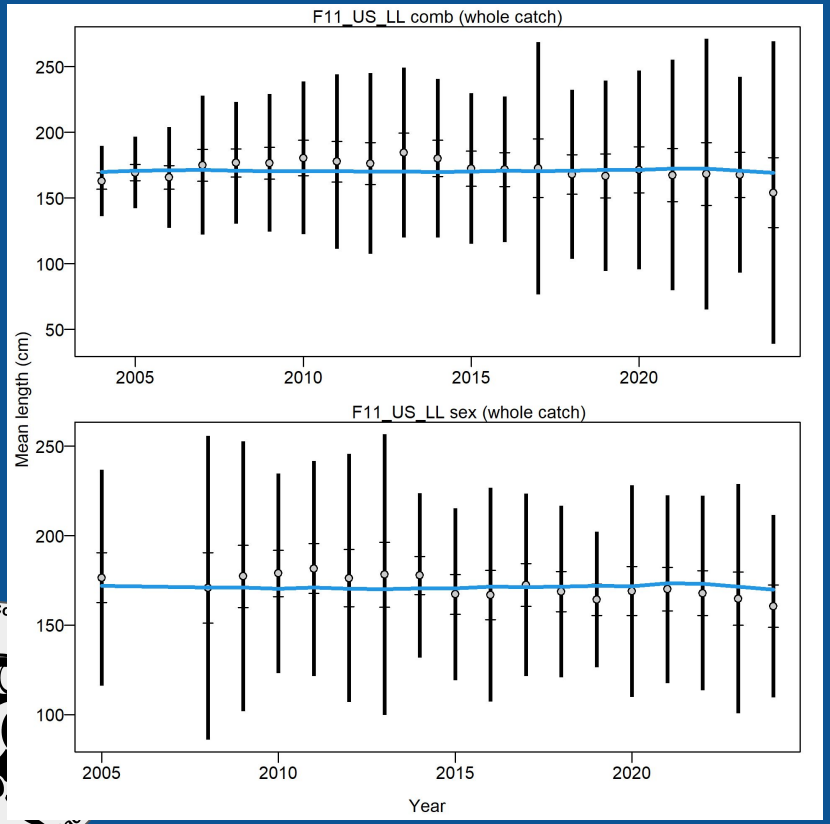


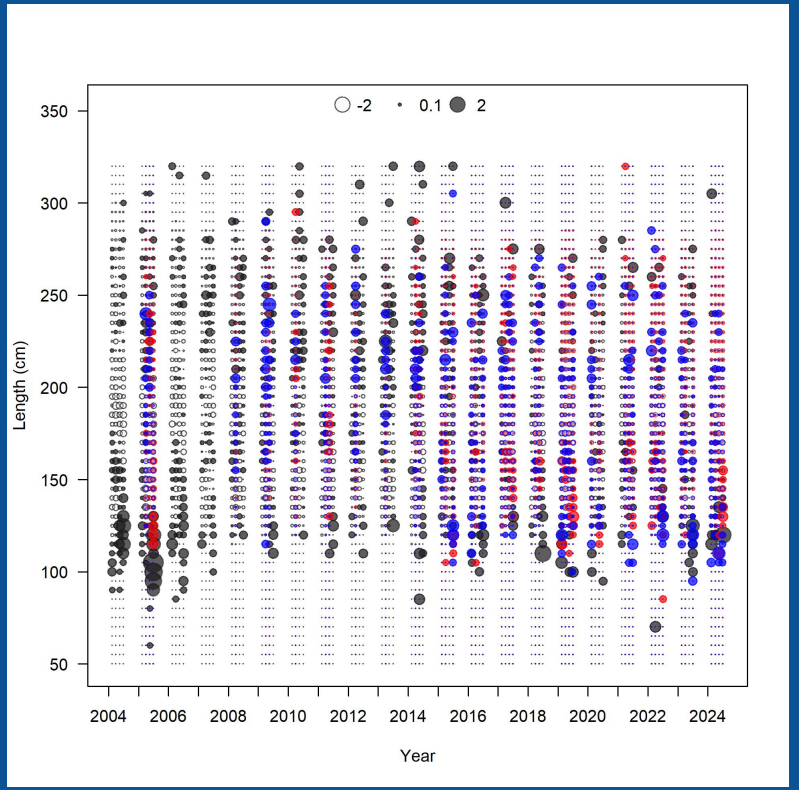




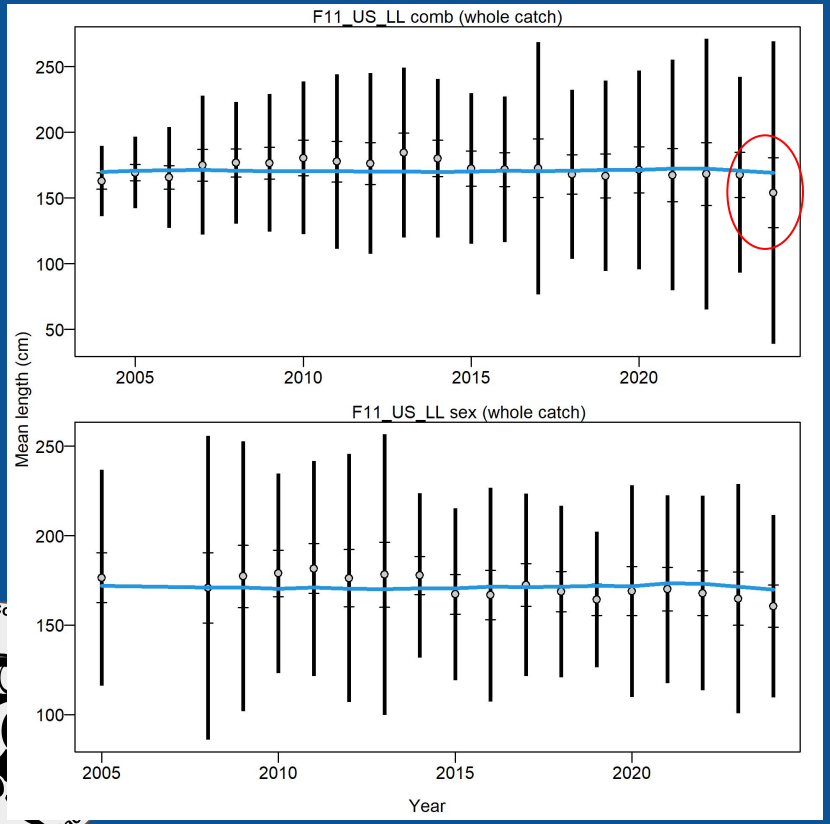


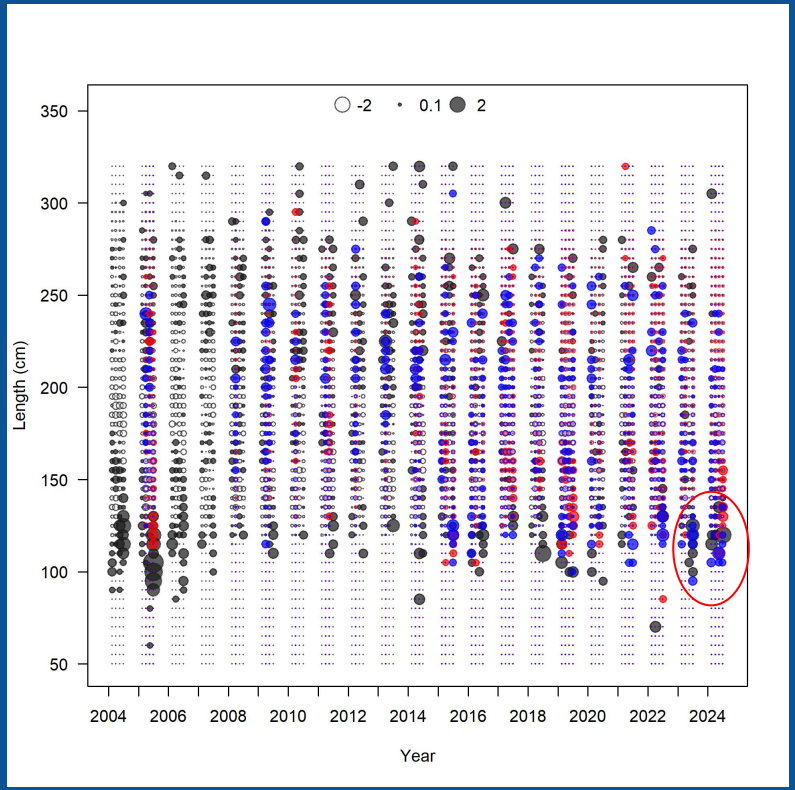
Fits to the Length Composition Data



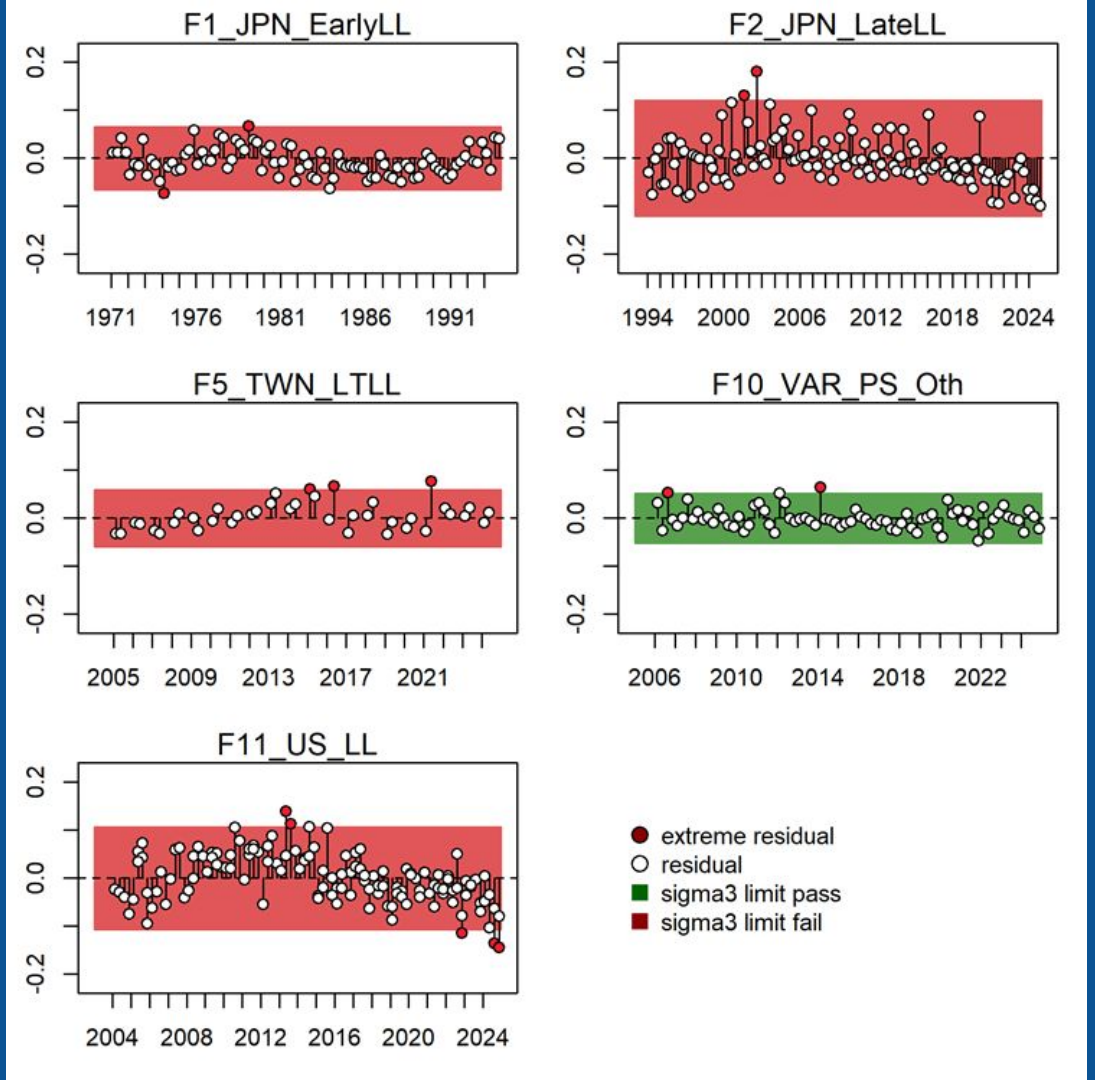


Fits to the Length Composition Data

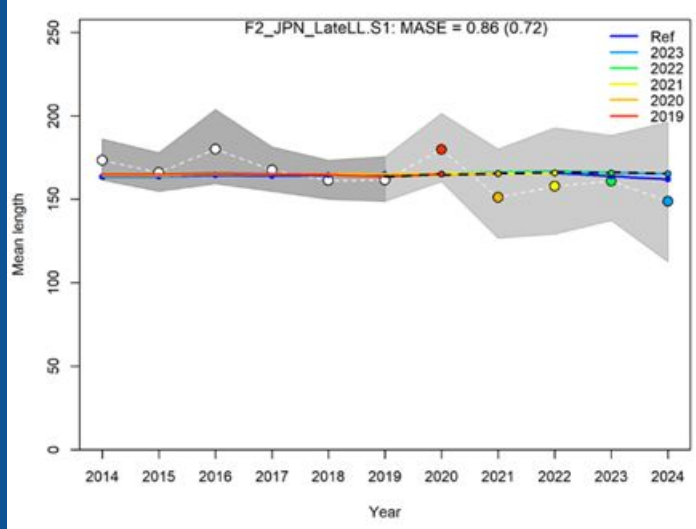


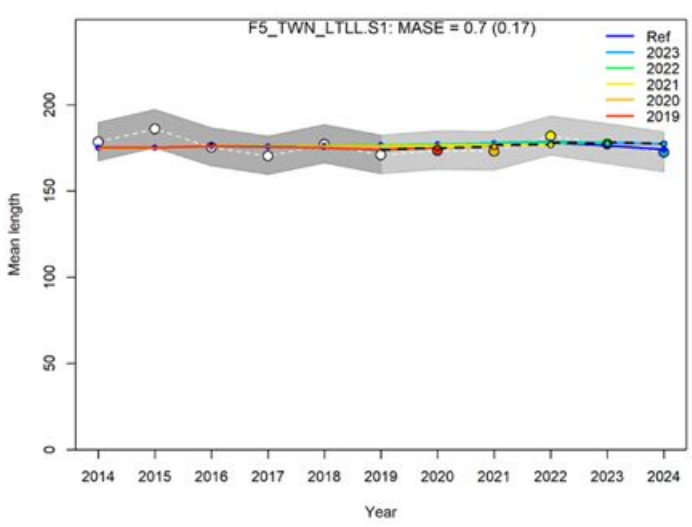


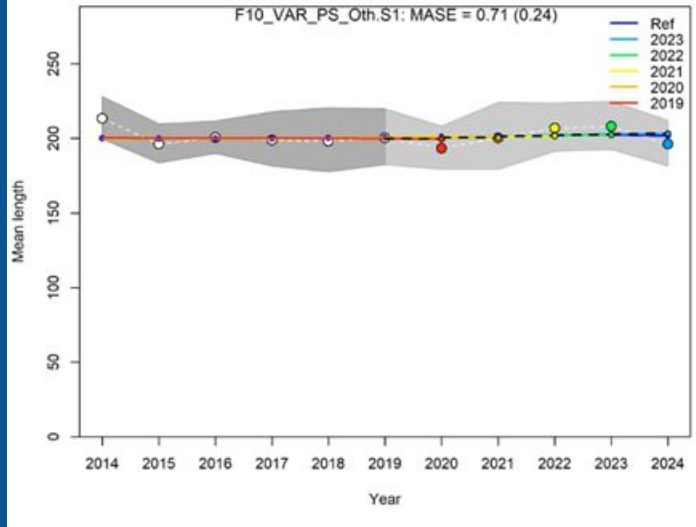
Length Composition diagnostics

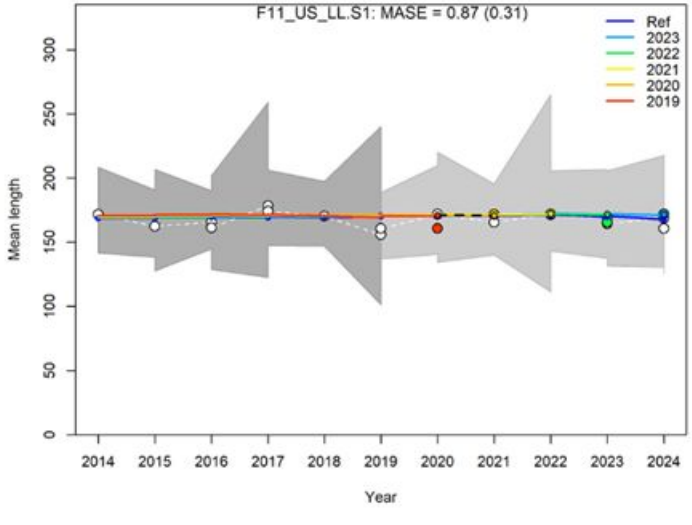


Length Composition Hindcast Cross Validation

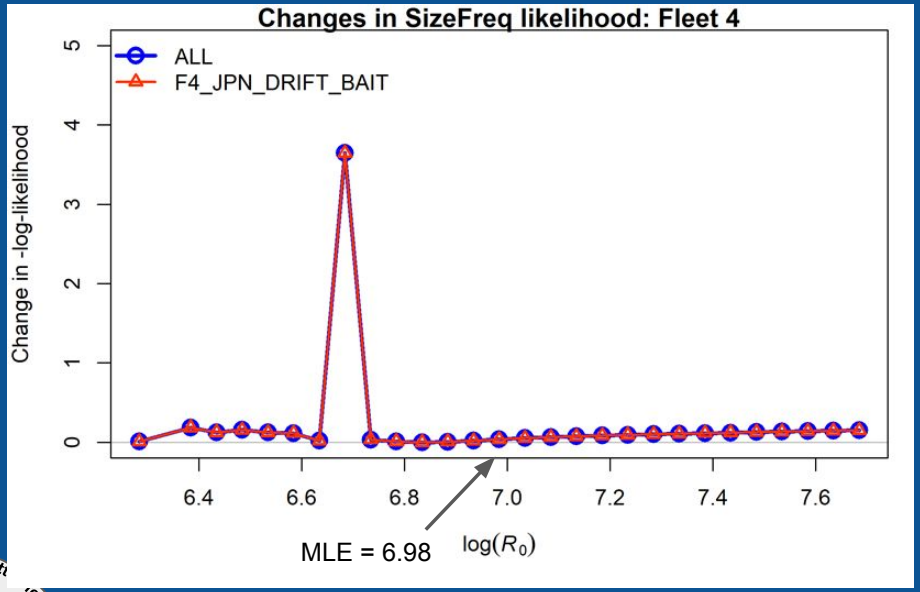


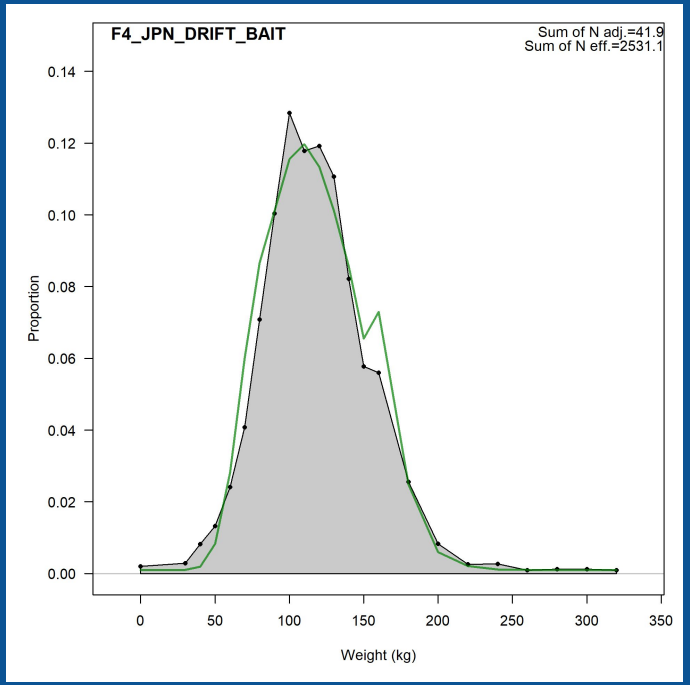




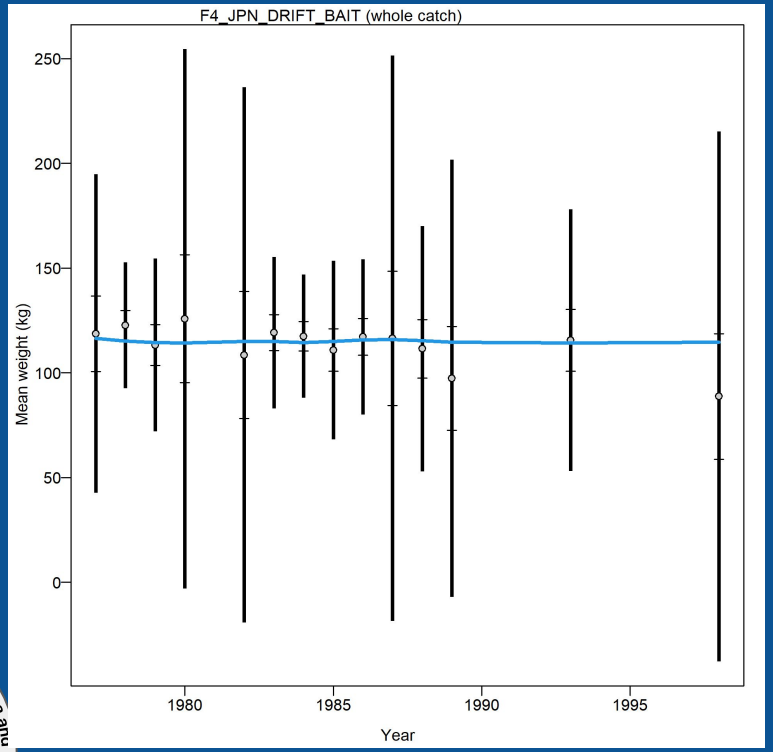


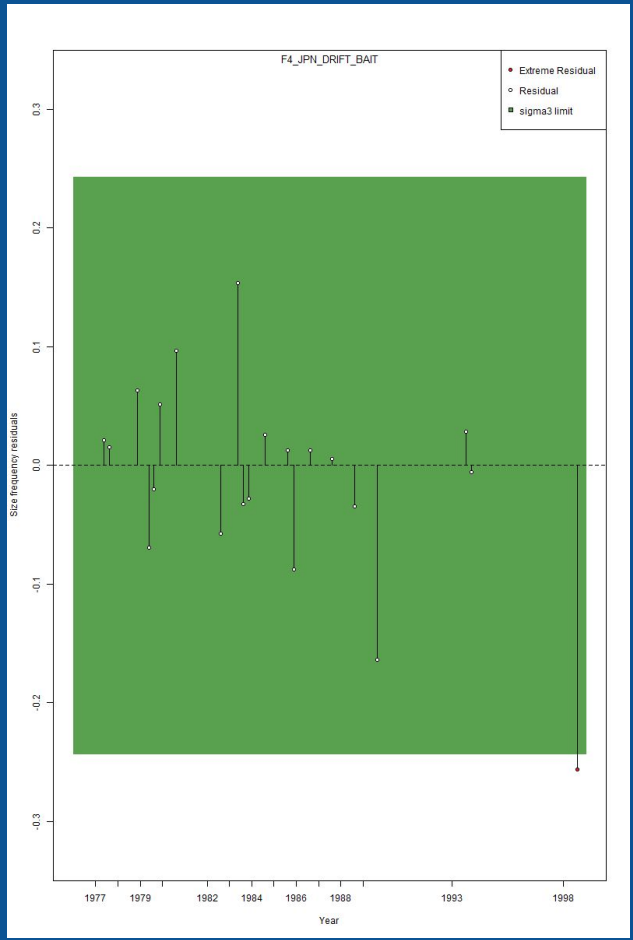
Fits to the Weight Composition Data



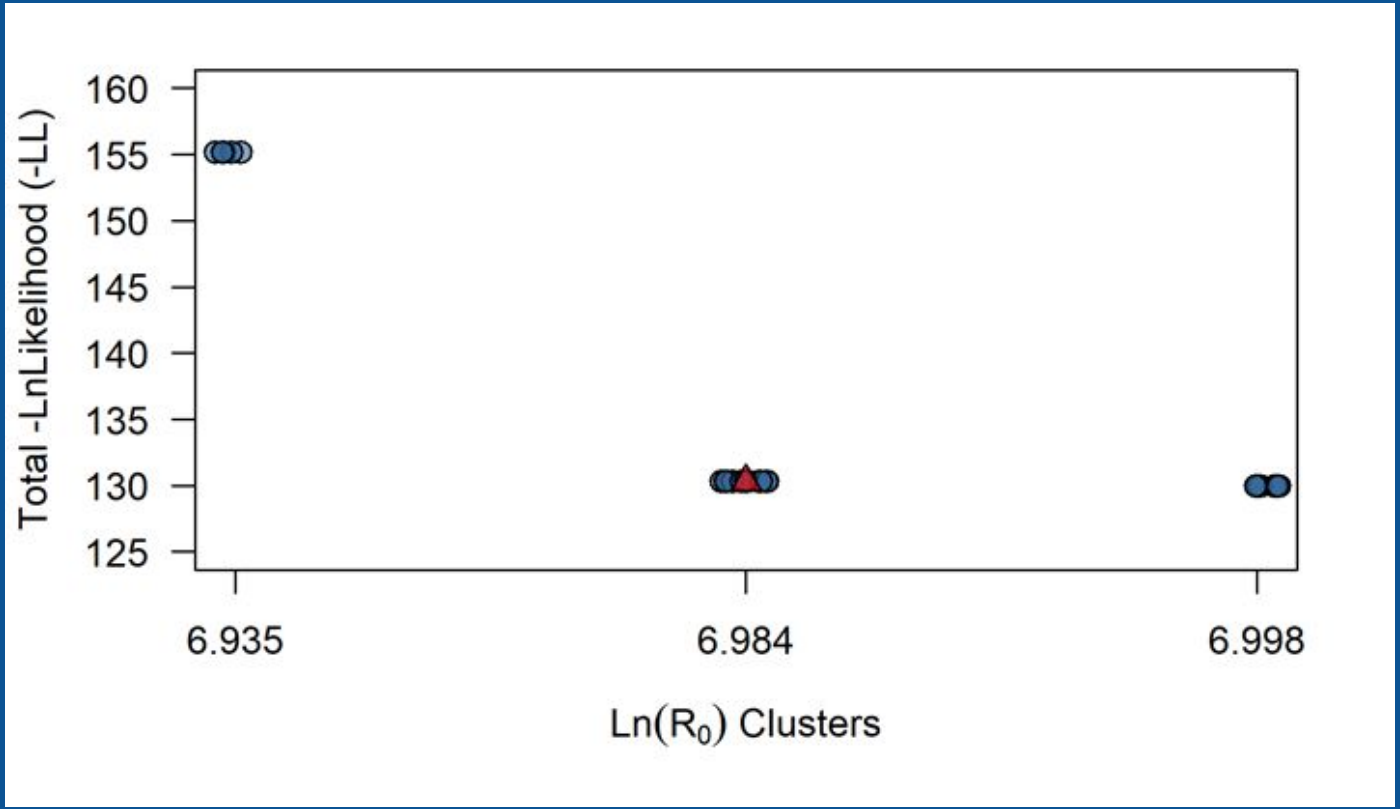


Fits to the Weight Compositon data

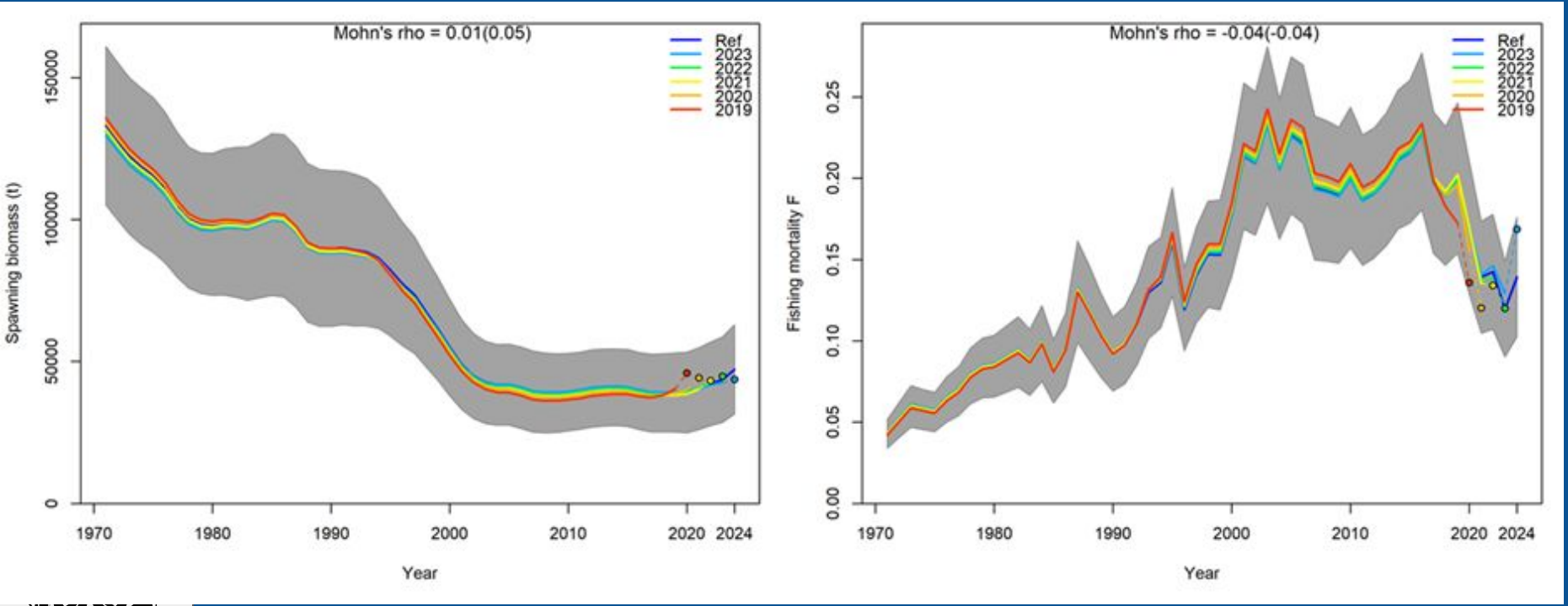




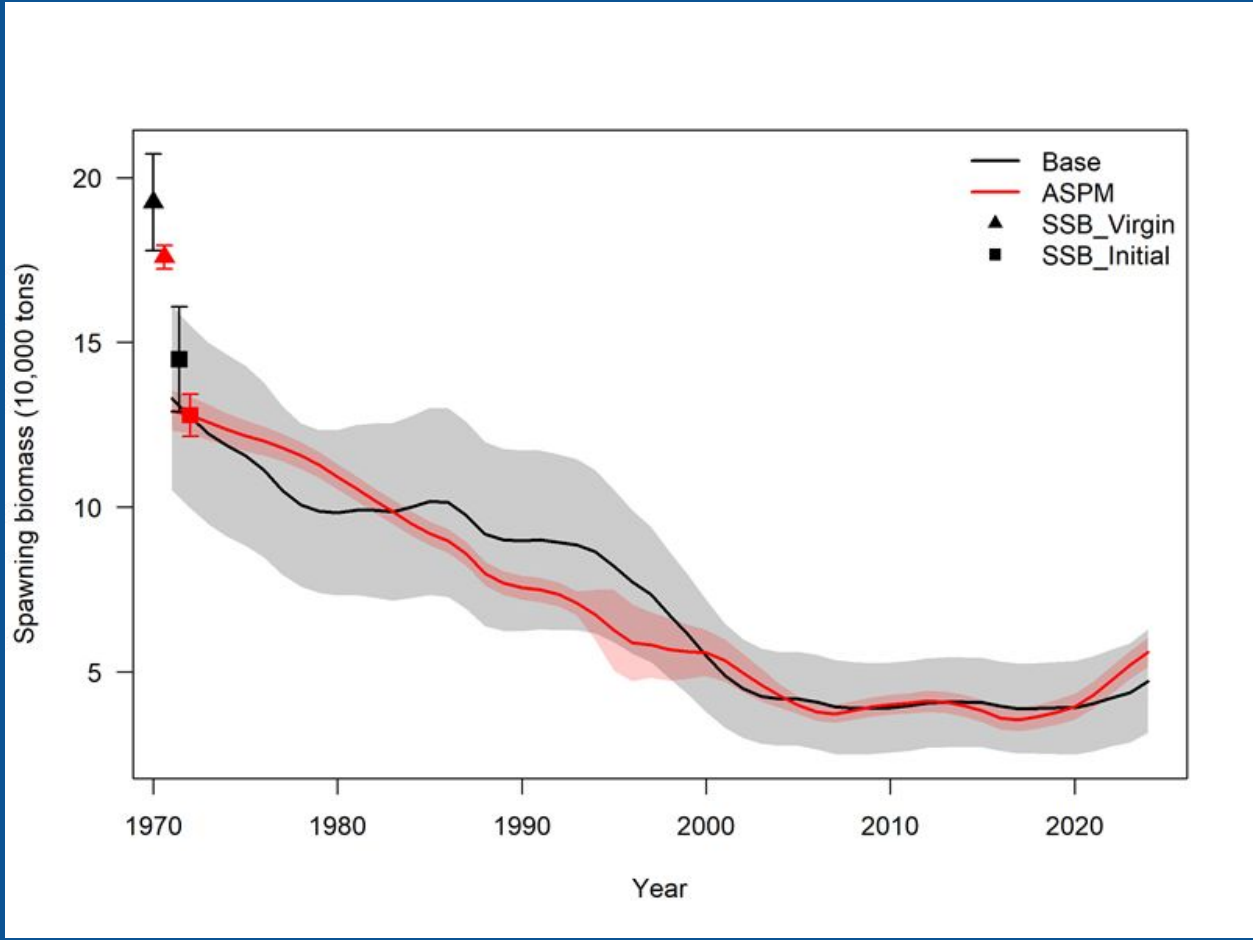
Jitter Analysis



Retrospective Analysis

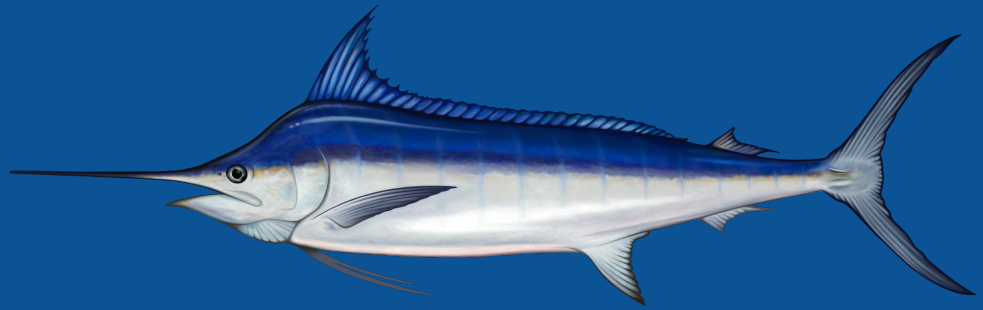


Age Structured Production Model



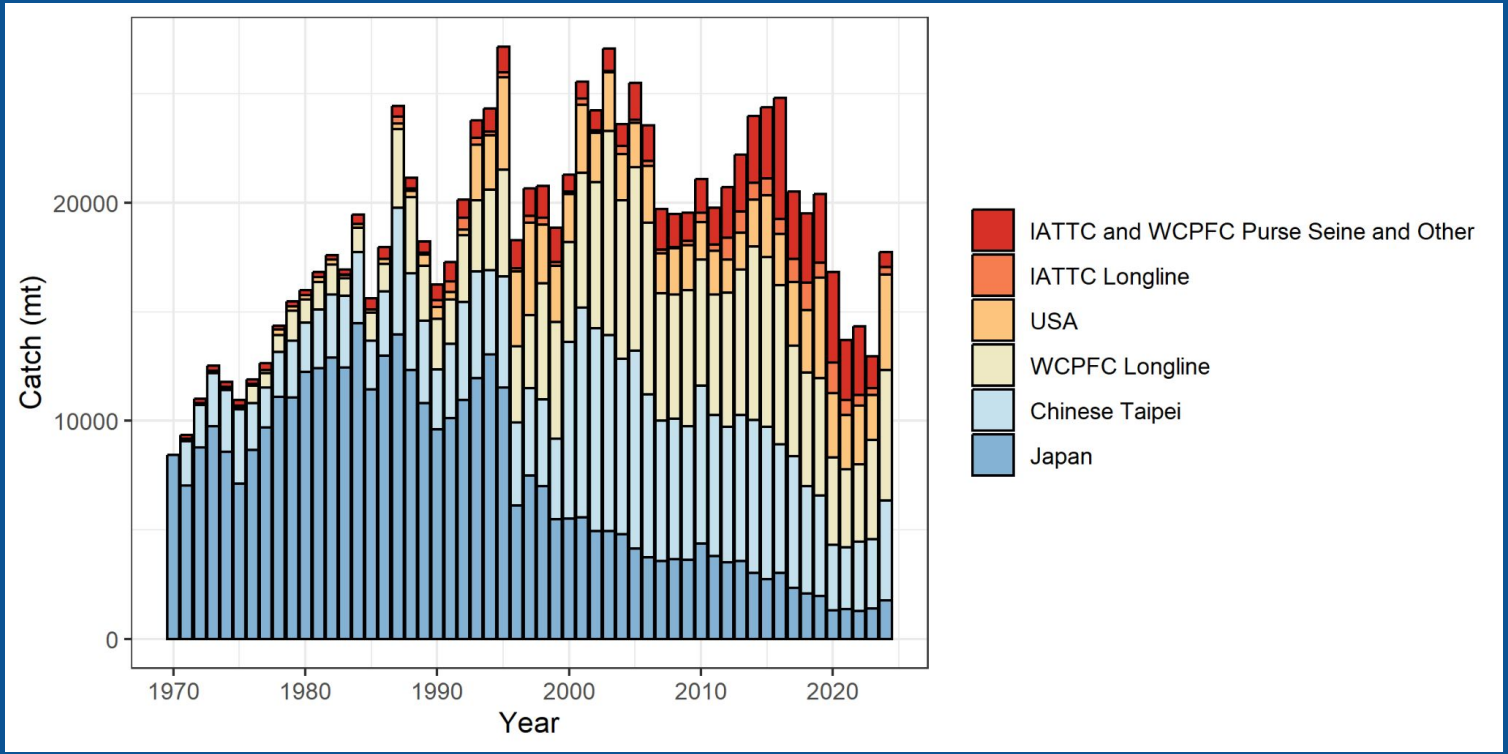
Pacific Blue Marlin Benchmark Stock Assessment

Stock Status and Conservation Information



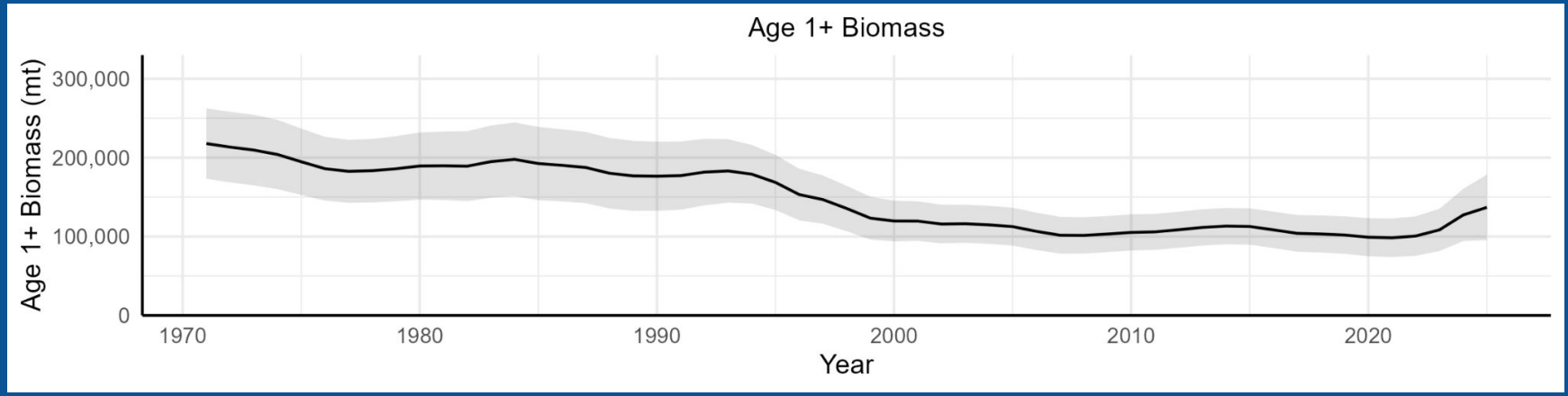
International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

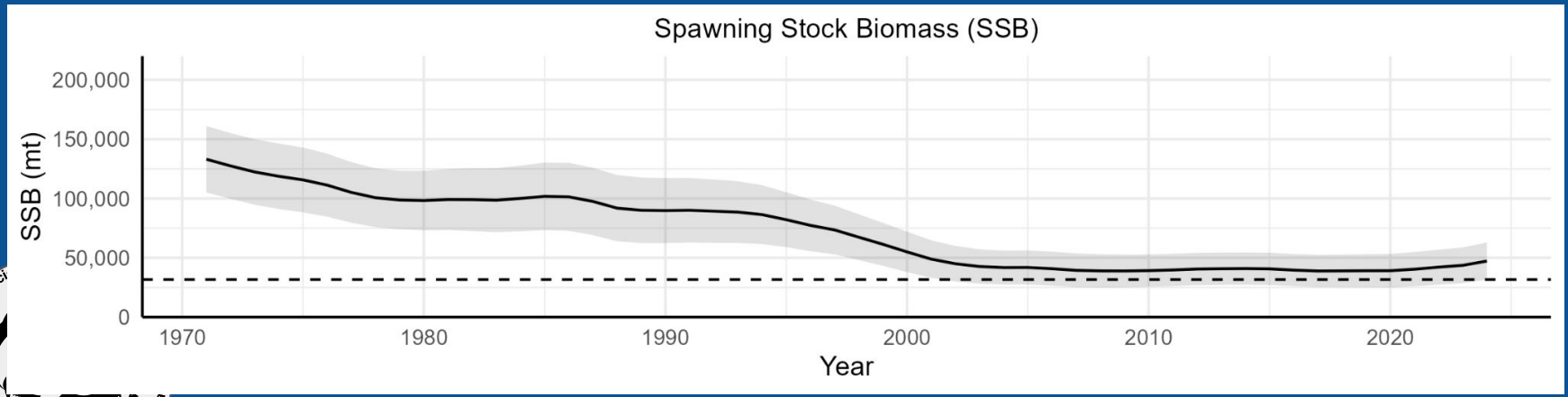
Pacific Blue Marlin Catch by ISC Member

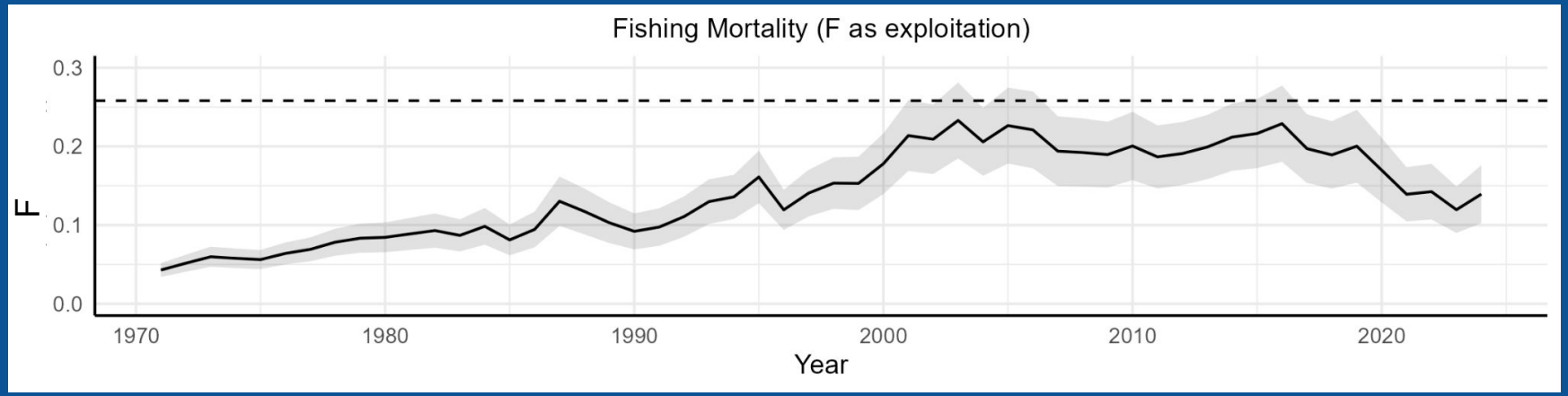


Pacific Blue Marlin Reference Points

- There are no defined reference points for Pacific Blue Marlin in WCPFC or IATTC
- Pacific Blue Marlin is considered a Tier 1 stock under WCPFC guidelines.
- Reference points will be provided with reference to MSY and 20%$SSB_{F=0}$

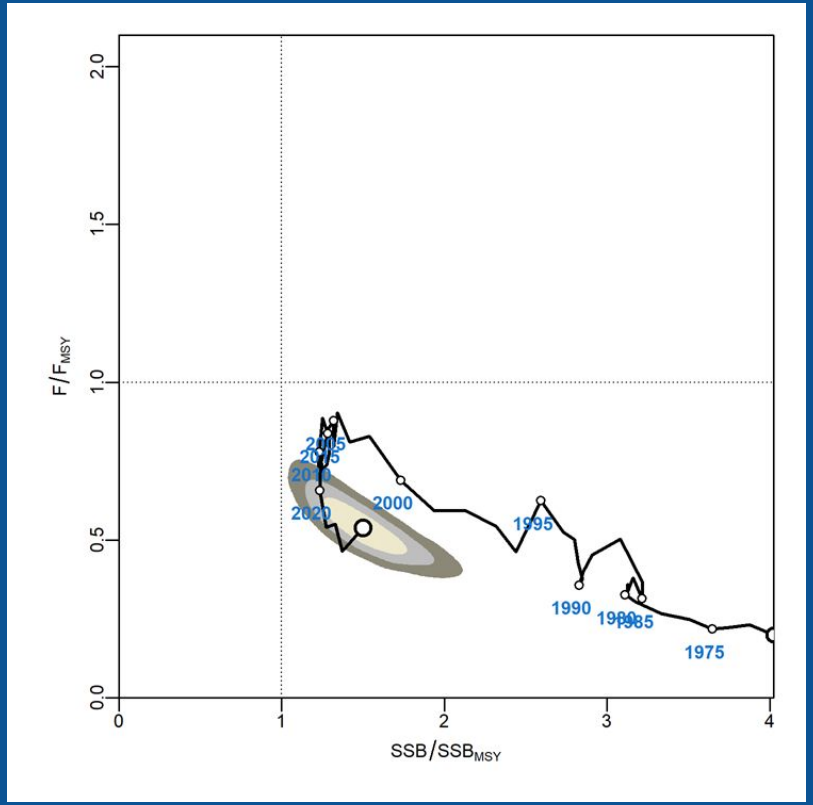

Age 1+ Biomass
Age 1+ Biomass (mt)
300,000
200,000
100,000
0
1970
1980
1990
2000
2010
2020
Year


Spawning Stock Biomass (SSB)
SSB (mt)
200,000
150,000
100,000
50,000
0
1970
1980
1990
2000
2010
2020
Year


Fishing Mortality (F as exploitation)
F
0.3
0.2
0.1
0.0
1970
1980
1990
2000
2010
2020
Year


Age-0 Recruits
Age-0 Recruits (thousands)
2000
1500
1000
500
1970
1980
1990
2000
2010
2020
Year

Reference Point	Estimate
F_{MSY}*	0.26
$F_{20\%SSB0}$*	0.23
F_{2003}*	0.23
$F_{2021–2023}$*	0.13
SSB_0	192,529
SSB_{MSY}	31,651
$20\%SSB_0$	38,506
SSB_{2003}	42,652
$SSB_{2021–2023}$	42,038
C_{MSY}	24,306
$C_{20\%SSB0}$	24,119
C_{2003}	27,073
$C_{2021–2023}$	13,662
SPR_{MSY}	0.196
$SPR_{20\%SSB0}$	0.230
SPR_{2003}	0.209
$SPR_{2021–2023}$	0.381

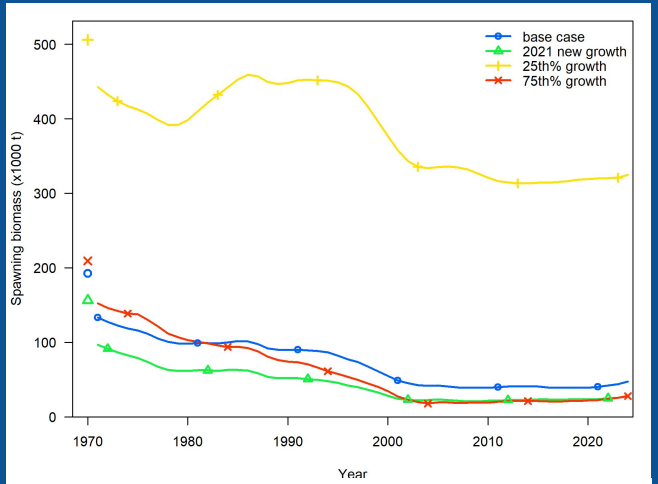


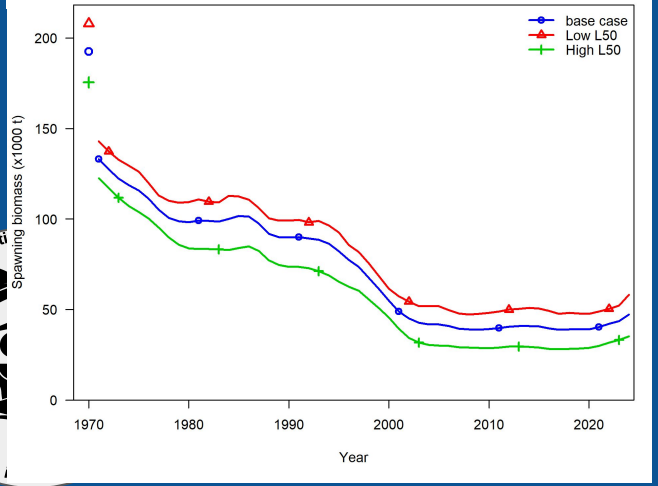
* F provided as exploitation rate

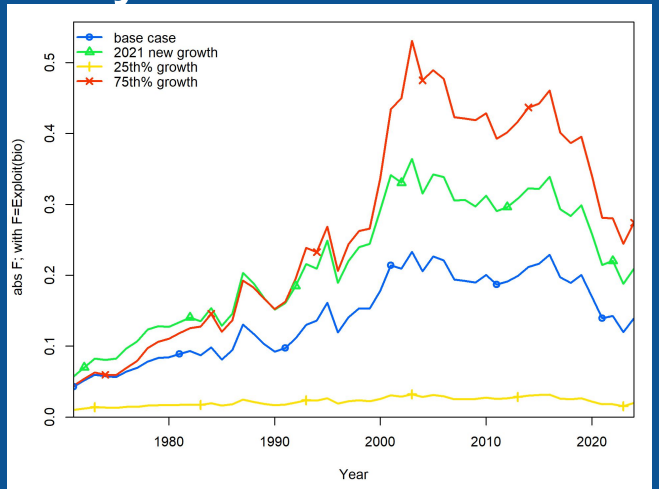
Pacific Blue Marlin Spawning Biomass

- Based on these findings, the following information on the status of the BUM stock is provided by the ISC26 Plenary:
  - No target or limit reference points have been established for BUM by the IATTC and the WCPFC;
  - Spawning stock biomass was estimated to be 42,038 mt in 2021-2023, or about 33% above SSB_{MSY} and 9% above 20%SSB0;
  - Fishing mortality on the stock averaged roughly F = 0.13 during 2021-2023, or about 50% below F_{MSY} and 56% below $F_{20\%SSB0}$; and
  - Blue marlin stock status relative to MSY-based reference points indicates that overfishing was virtually certain to be not occurring (>99% probability) and BUM is virtually certain to be not overfished (>99% probability).

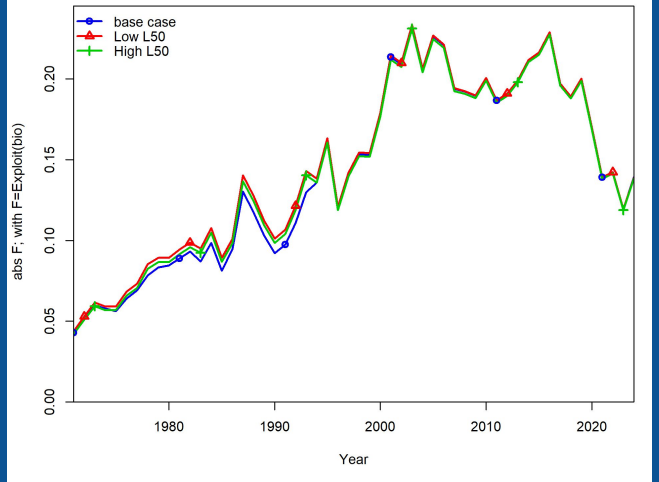
Sensitivity Analysis on Life History Parameters





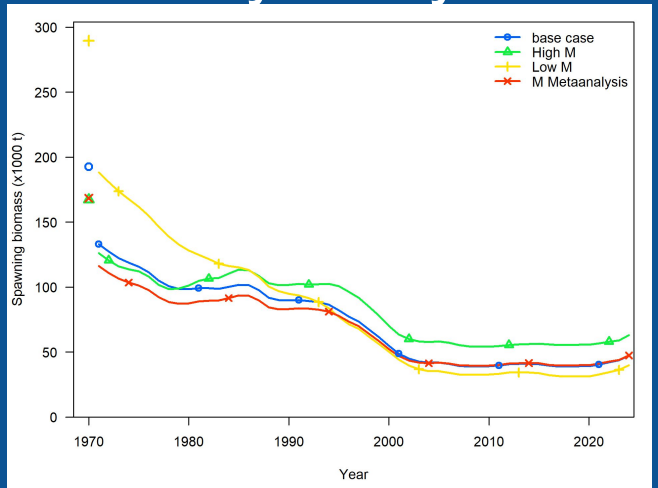


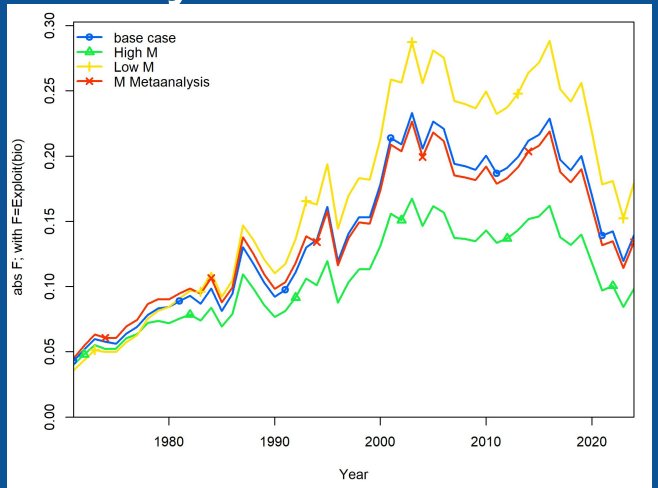
Growth



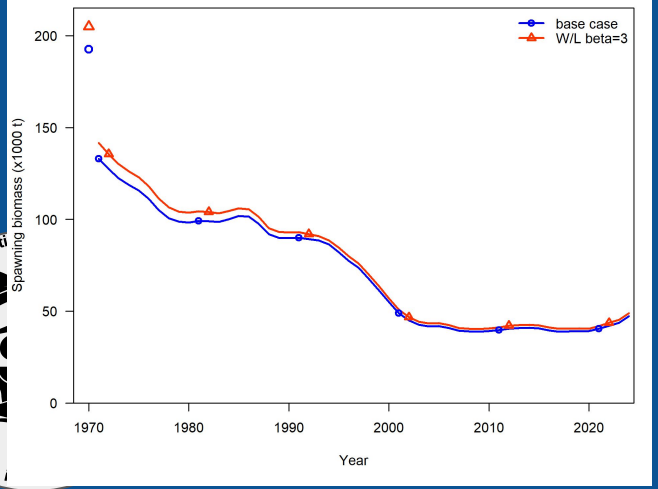
Maturity

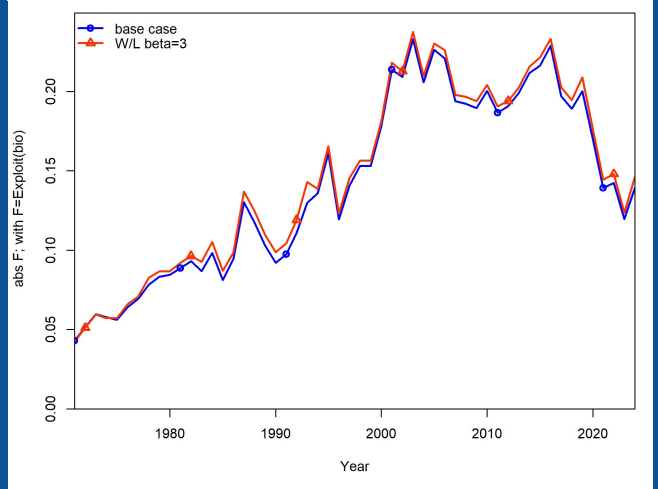
Sensitivity Analysis on Life History Parameters





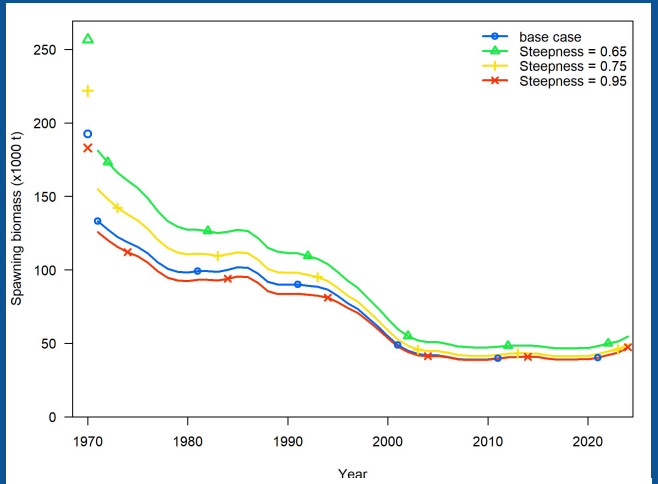
Natural Mortality

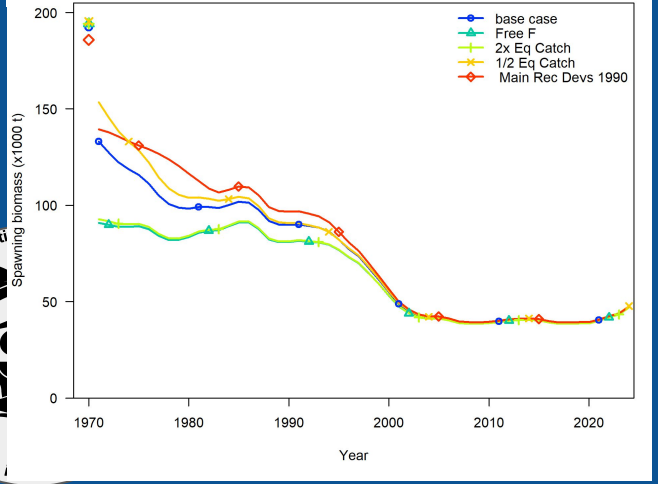


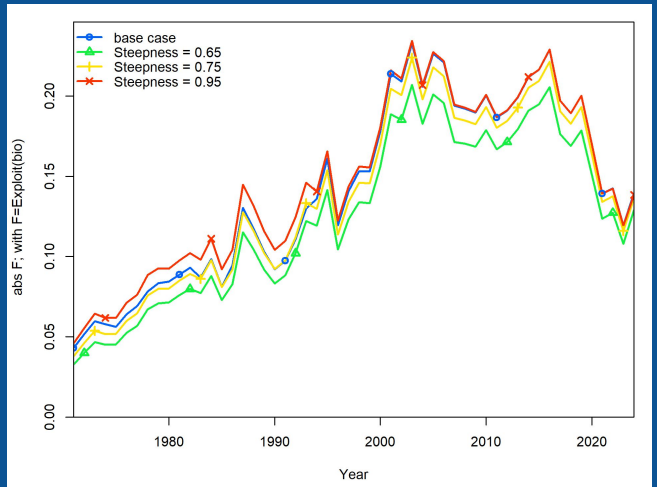


Weight-Length Relationship

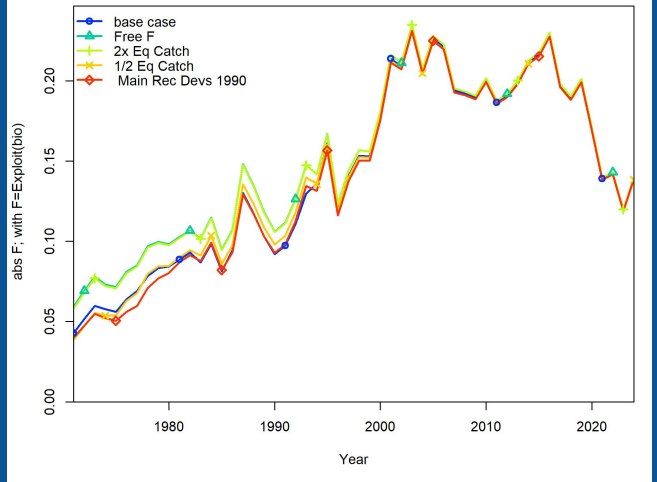
Sensitivity Analysis on Initial Conditions and Recruitment





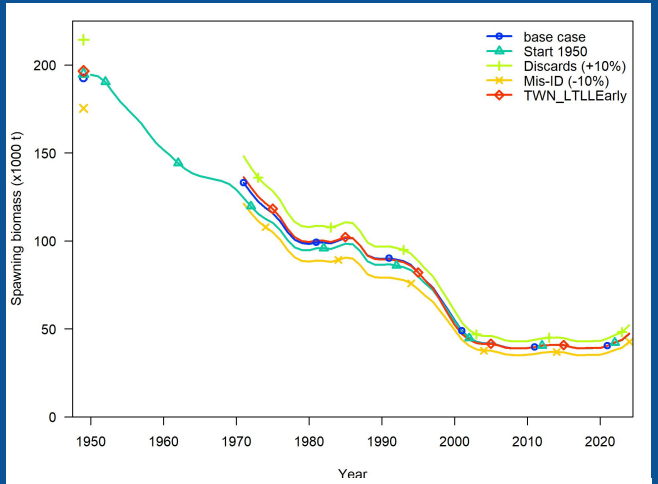


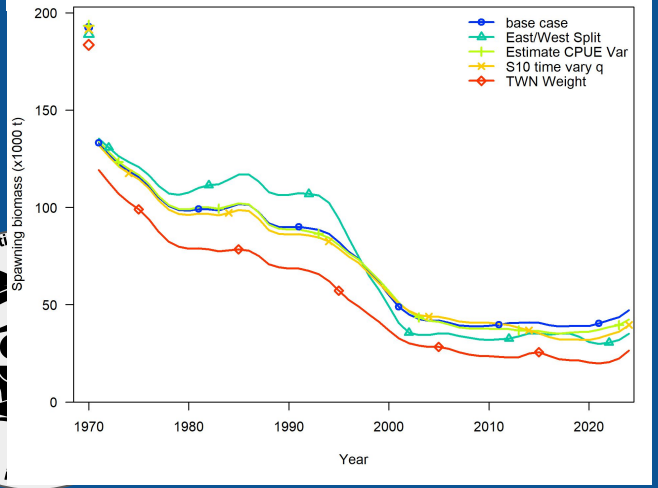
Steepness

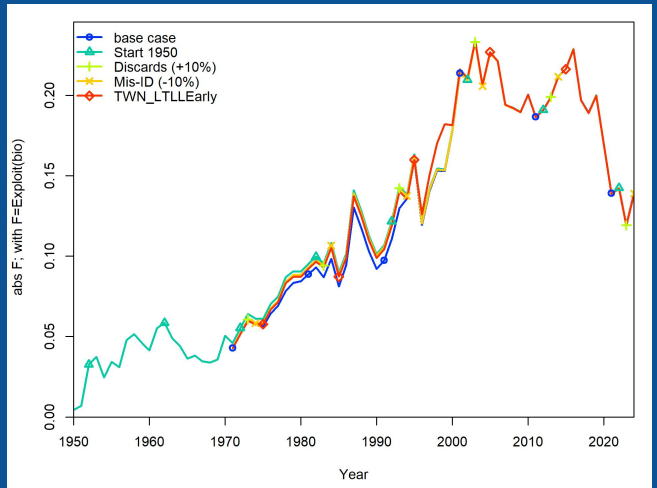


Initial Conditions

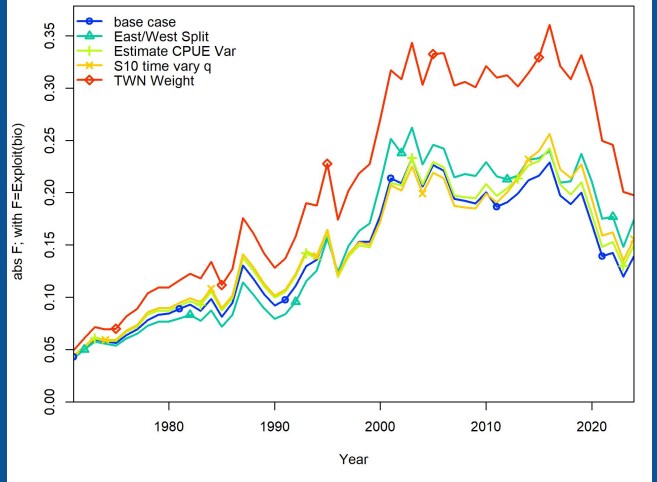
Sensitivity Analysis on Data







Catch



CPUE and Size Data

Sensitivity Runs Kobe Plot

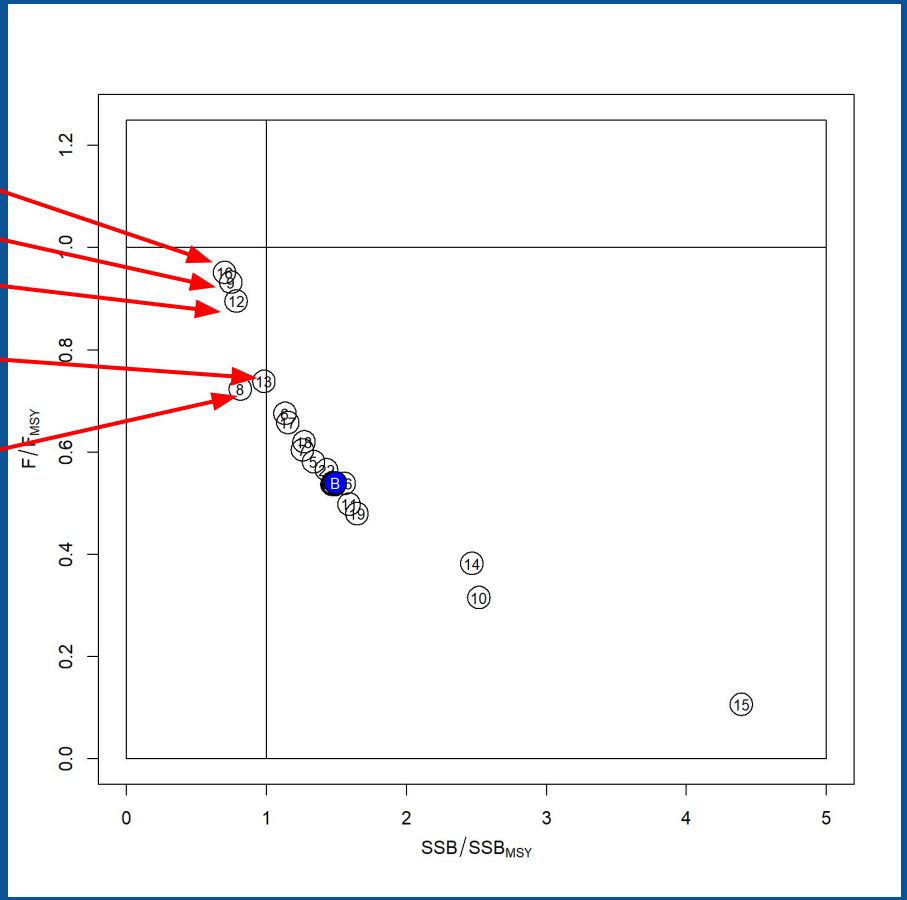
25% Growth

Low M

Steepness = 0.65

Steepness = 0.75

Using TWN Weight data



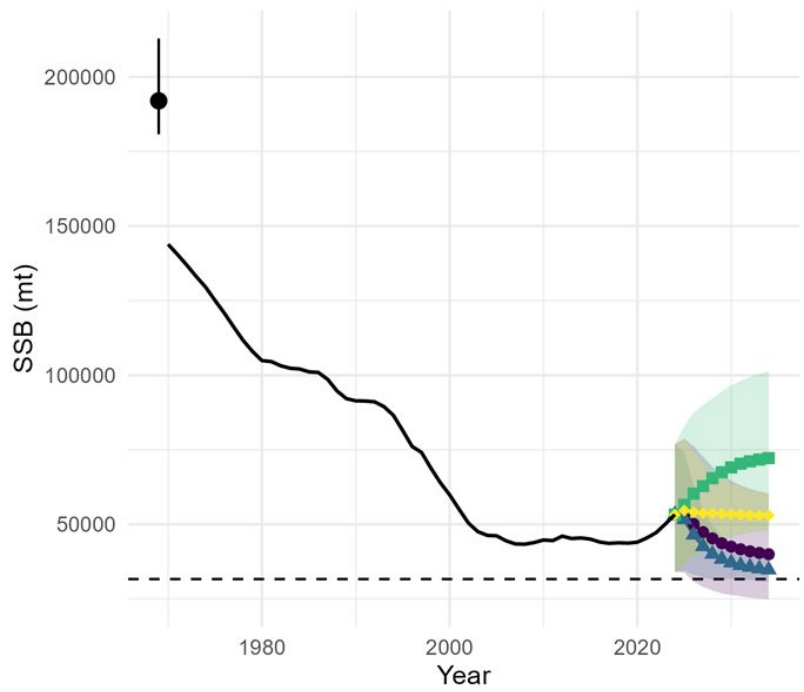
Pacific Blue Marlin Projections

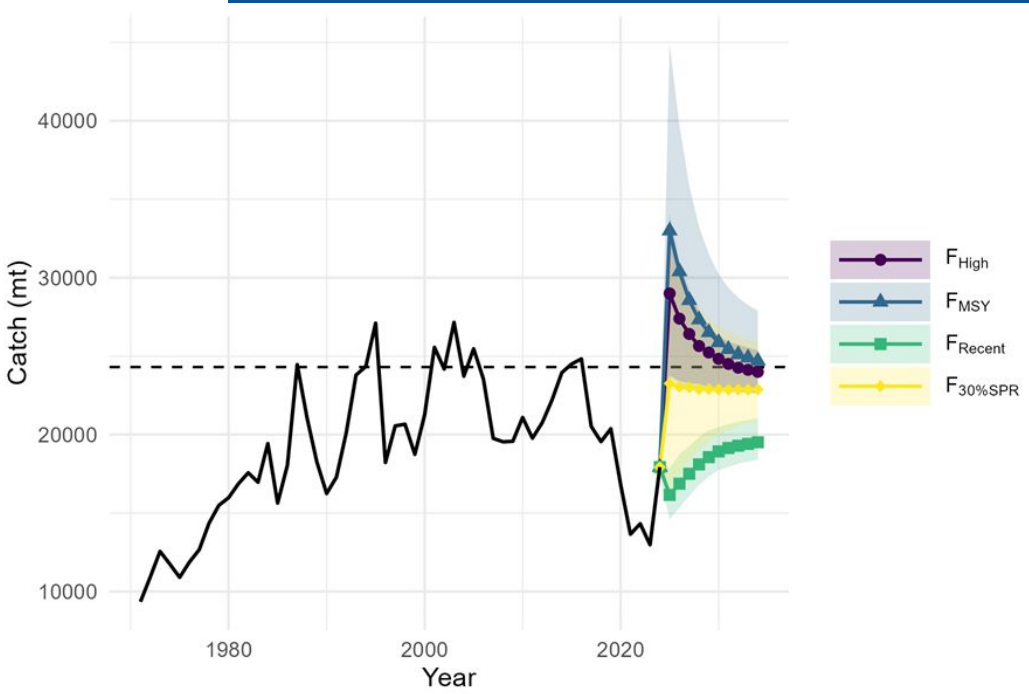
Four future harvest scenarios were analyzed for 2025-2034:

- F_{High} = Maximum F in the time series (2003)
- F_{MSY}
- F_{recent} = average F 2021-2023
- F_{Low} = F corresponding to 30%SPR

Recruitment based upon the stock-recruitment curve, based upon 100 bootstrap model runs

Projections





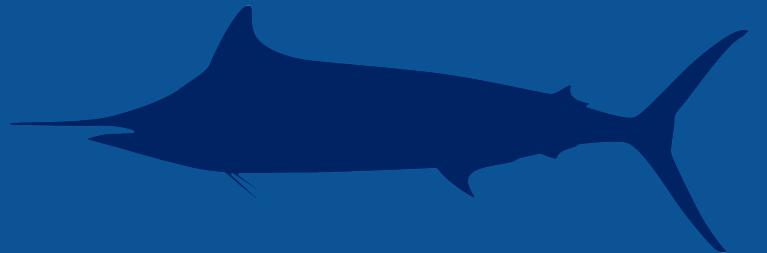
Conservation Information

Based on these findings, the following conservation information is provided for the BUM stock by the ISC26 Plenary:

- There is no evidence of fishing mortality exceeding F_{MSY} or substantial depletion in spawning potential or spawning stock biomass relative to MSY level;
- The Pacific blue marlin annual removals have been between 13,690–20,400 mt since 2019, corresponding to approximately 53–84% of the MSY catch. The stock may be able to support somewhat higher removals; and
- The results show that projected female spawning biomass is expected to increase or remain stable under the $F_{status\ quo}$ and $F_{30\%}$ harvest scenarios and decline toward SSB_{MSY} under the High F and F_{MSY} harvest scenarios. The probability that the stock is overfished or overfishing is occurring by 2034 under each harvest scenario is low.

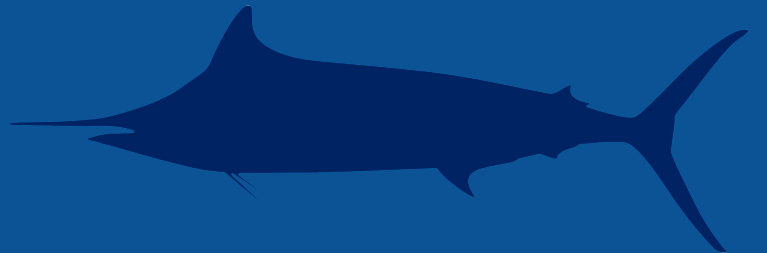
Special Comments and Research Recommendations

- The current assessment assumes a Pacific-wide stock with quarterly mixing, but the conceptual model and biological information suggest more complex spatial dynamics. More data and analytical development are needed before a fully spatial assessment can be implemented.
- Sex-specific biological and size data are important because blue marlin growth, selectivity, and reproductive dynamics may differ by sex. Improving collection of sex-specific size composition and biological information across fisheries would reduce uncertainty in future assessments.
- The assessment is limited by incomplete fishery-dependent and biological data from parts of the western and southern Pacific. Increased collaboration with WCPFC members and SPC was identified as important for improving data availability across the stock's range.



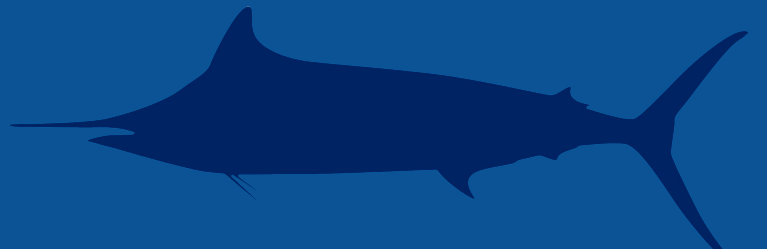
Conclusions

- The assessment is based on the best available science, but there are unresolved data conflicts that could not be fully resolved in the time available.
- The complexity of the conceptual model could not captured due to unresolvable conflicts among data sources. The simplified final model was not a rejection of the conceptual model, but a pragmatic decision given unresolved CPUE conflicts and time constraints.
- Several size composition datasets showed residual patterns and runs test failures. These diagnostics identify areas where the model and data may be in conflict, but runs test failures alone do not mean the assessment is unreliable. The broader integrated diagnostics were considered generally acceptable, and the model captured the principal trends in the available data.
- The revised growth curve, supported by extensive sampling and bomb radiocarbon age validation, represents a substantial improvement over previous assessments. Changes in growth, longevity, and natural mortality affected estimates of spawning biomass and population scale, but the Working Group expressed confidence in the updated biological parameters.



Conclusions

- Sensitivity analyses showed that stock status estimates were influenced by revised growth and natural mortality assumptions. However, the stock status determination remained positive across alternative model configurations, which provides an important robustness message.
- Blue marlin is a non-target species in longline. Changes in fleet behavior, targeting, spatial distribution, and contraction of some fisheries—especially in the eastern Pacific—make it difficult to separate changes in abundance from changes in fishing operations. Future work on CPUE standardization, especially spatio-temporal approaches, is critical.
- The next Pacific blue marlin benchmark assessment is expected to benefit from continued index development, improved diagnostics, better biological data, broader collaboration, and relevant advances from the 2024 WCNPO striped marlin assessment review.

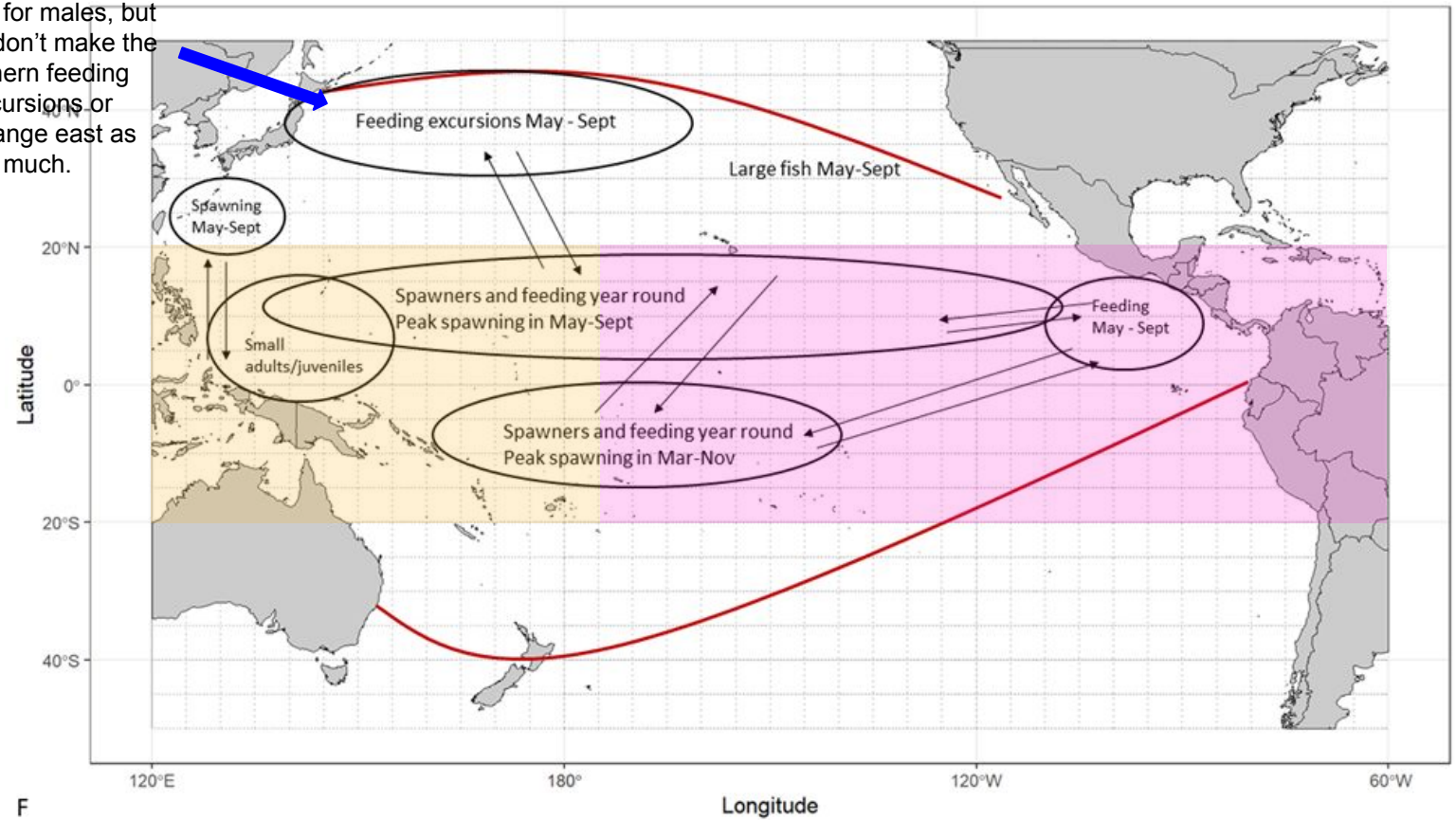


International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

Extra Slides

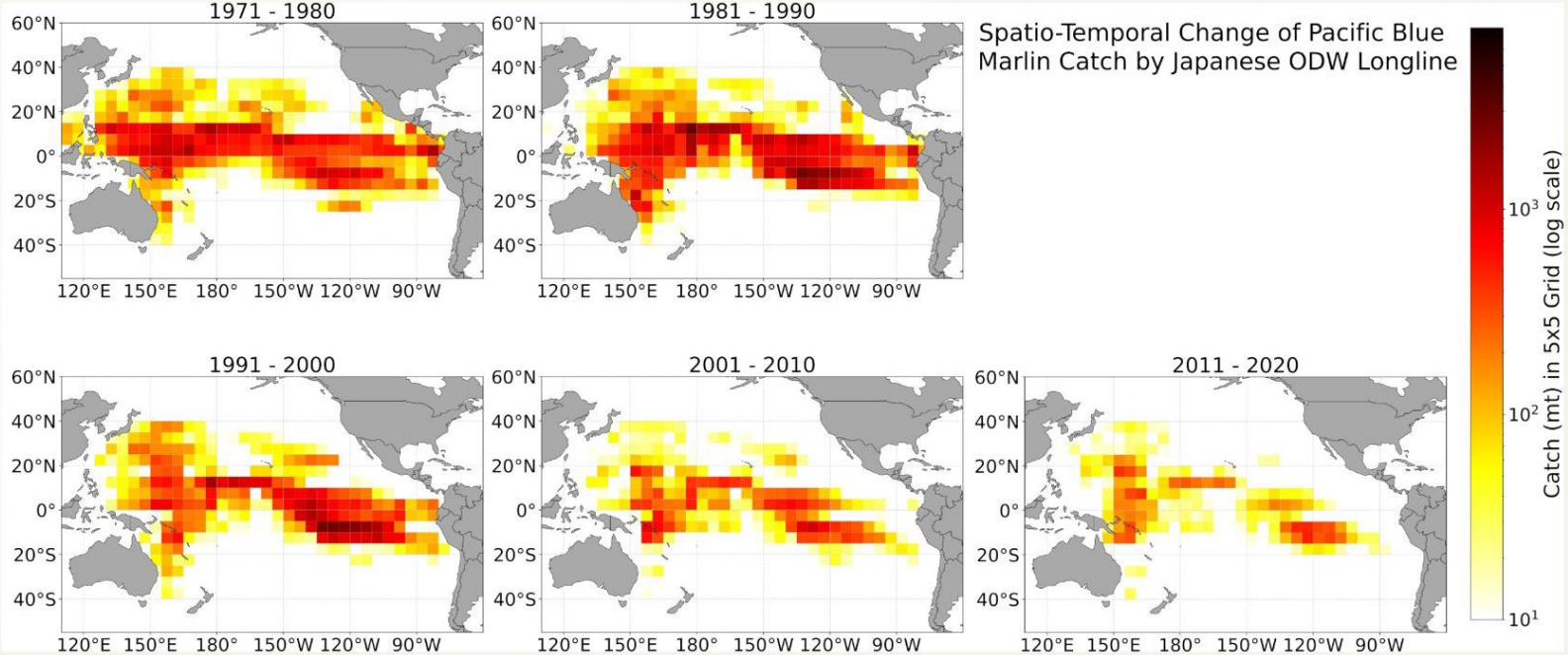
Conceptual Diagram: Blue Marlin (Female)

Similar for males, but males don't make the northern feeding excursions or exchange east as much.



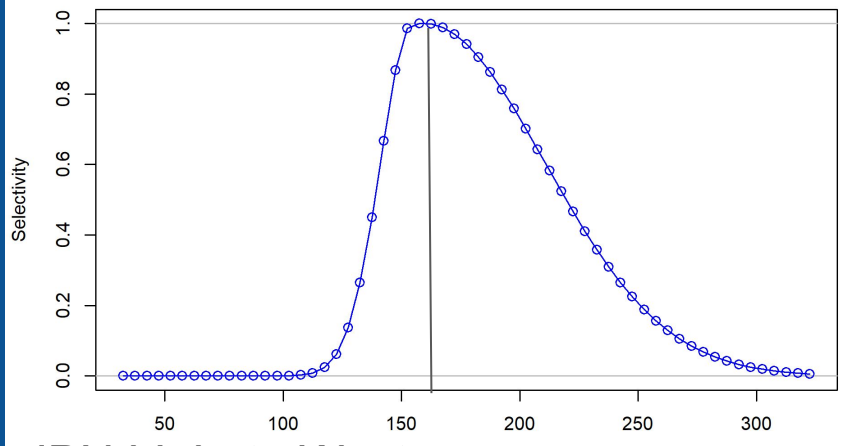
A diagram of the conceptual model developed by the BILLWG for female Pacific BUM. Figure 1. In the Data Prep Meeting Report

ODW Longline Fleet Has Largely Withdrawn from the Eastern Pacific Ocean Since the Mid-1990s

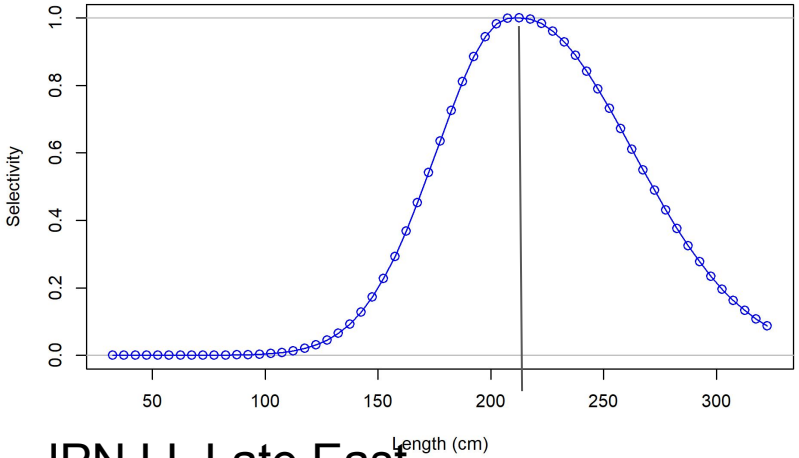


Key Observation

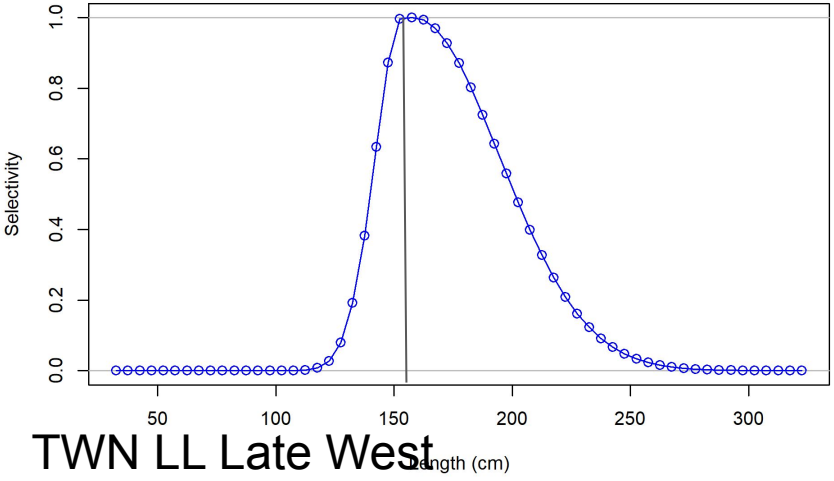
Fishing effort, once broadly distributed across the Pacific, became largely concentrated in the western and central Pacific by the 2011-2020 period. This coincides with the sharp decline in total catch and represents a fundamental shift in the operational footprint of the Japanese longline fishery.



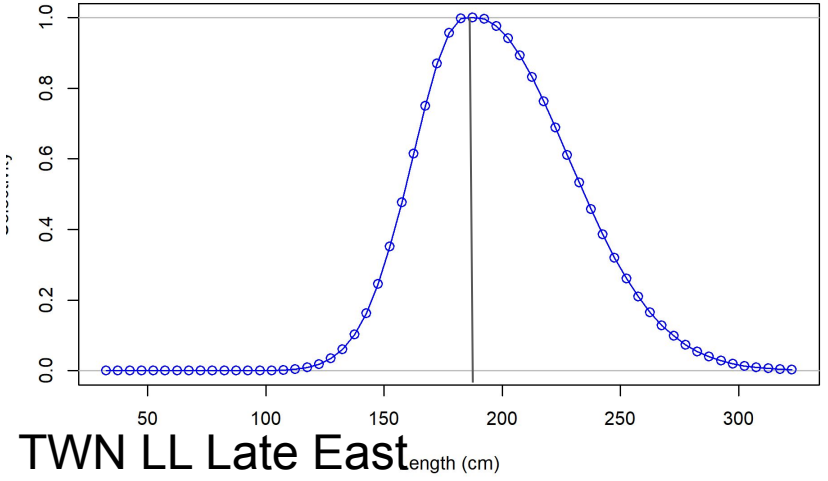
JPN LL Late West



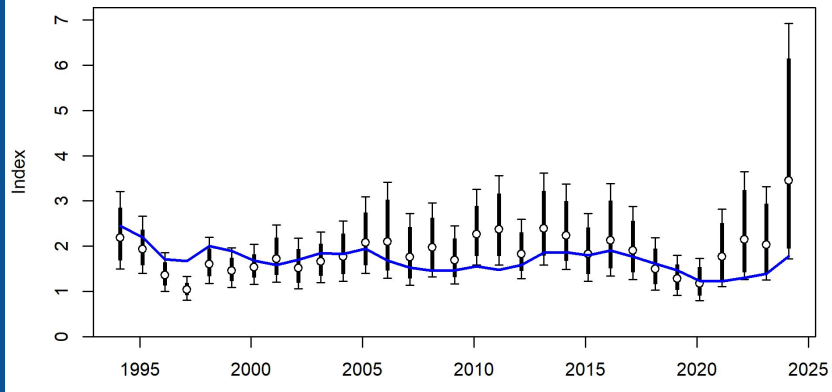
JPN LL Late East



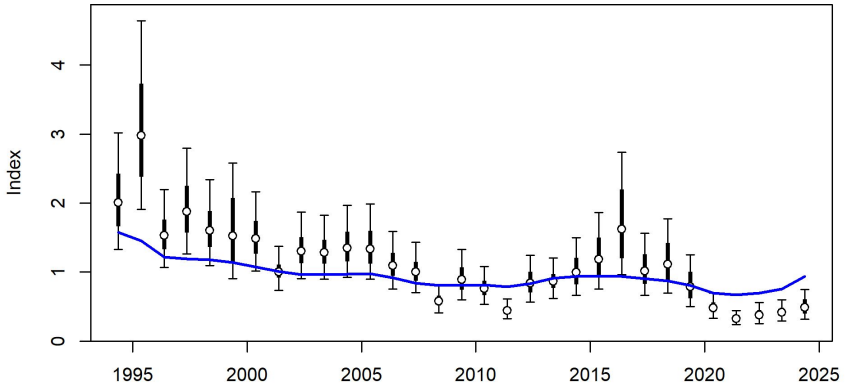
TWN LL Late West



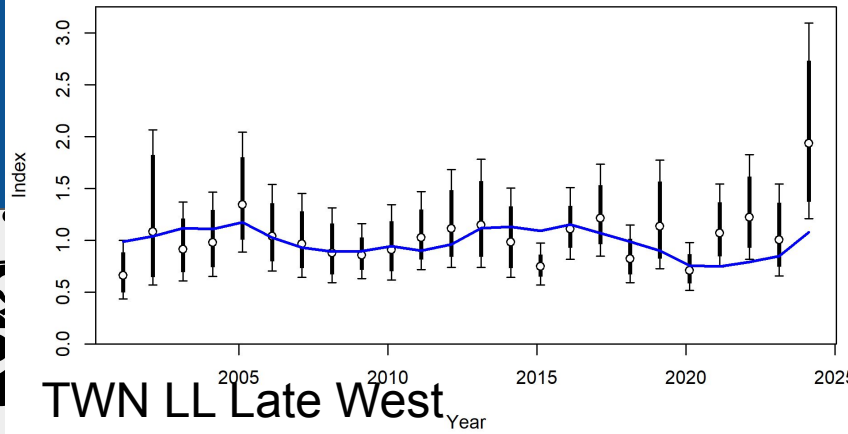
TWN LL Late East



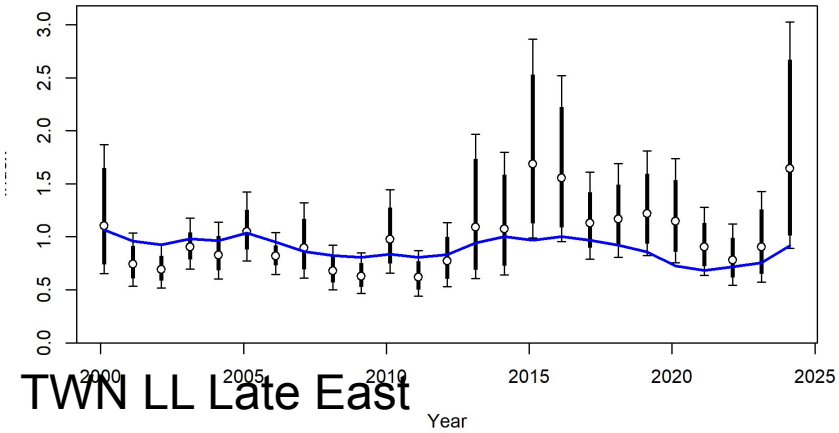
JPN LL Late West



JPN LL Late East

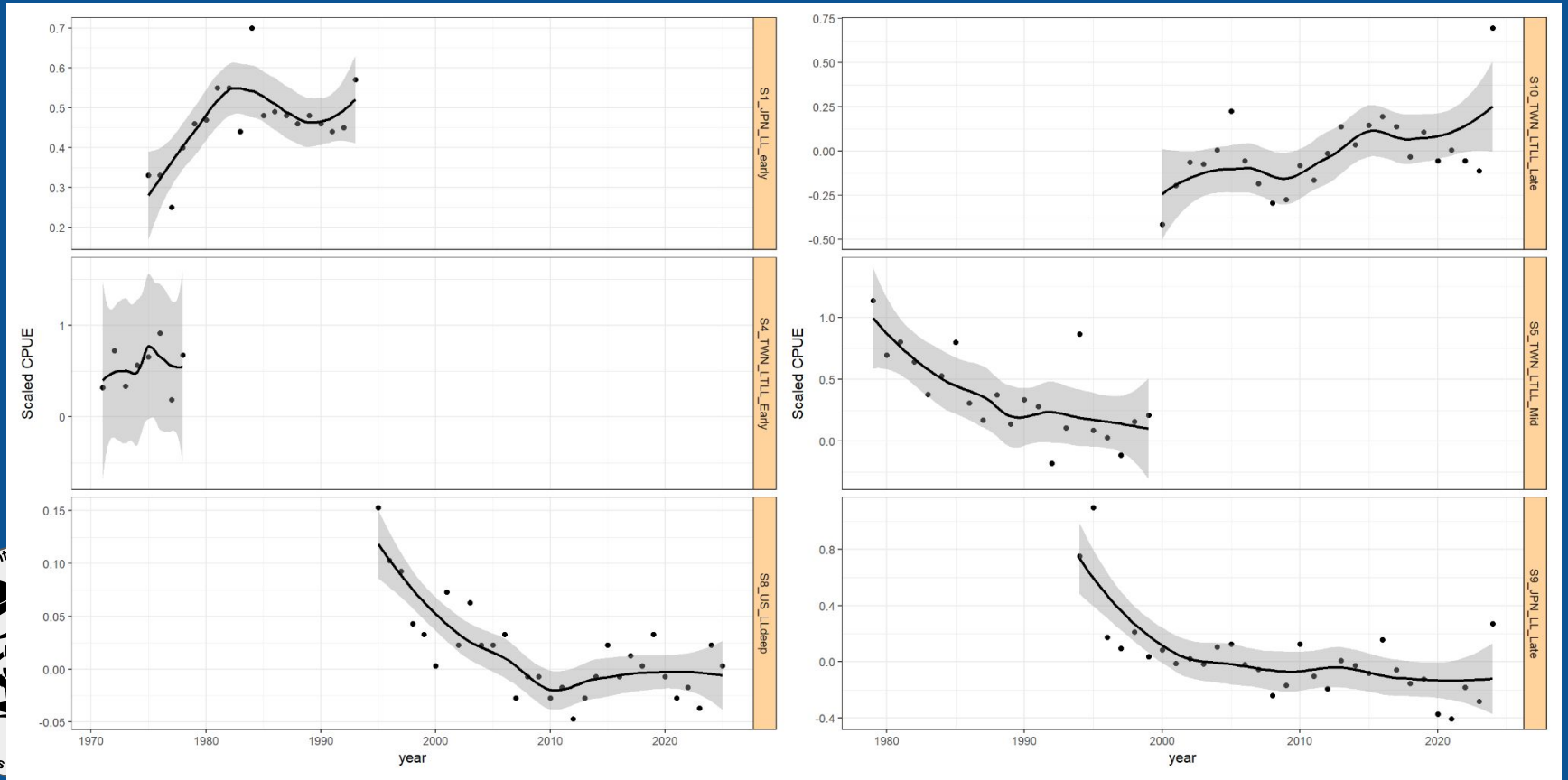


TWN LL Late West

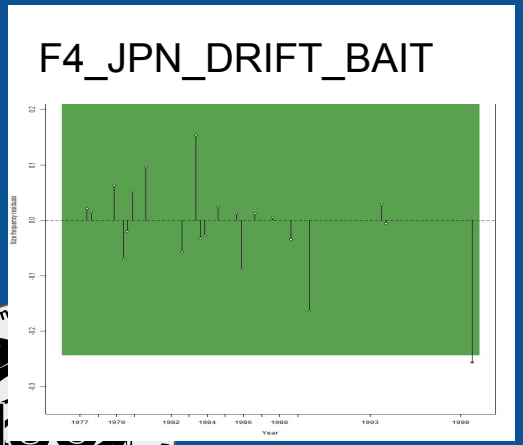


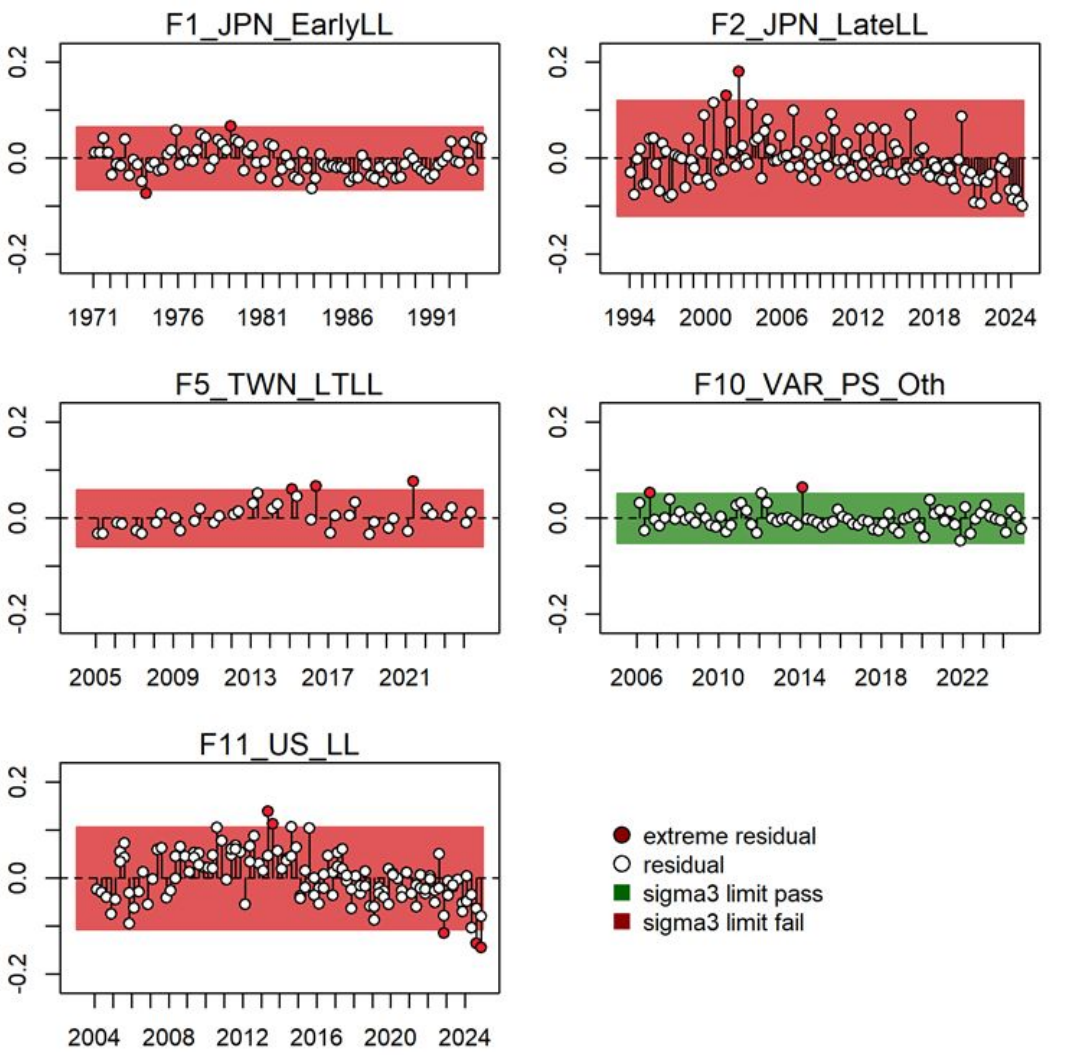
TWN LL Late East

CPUE indices

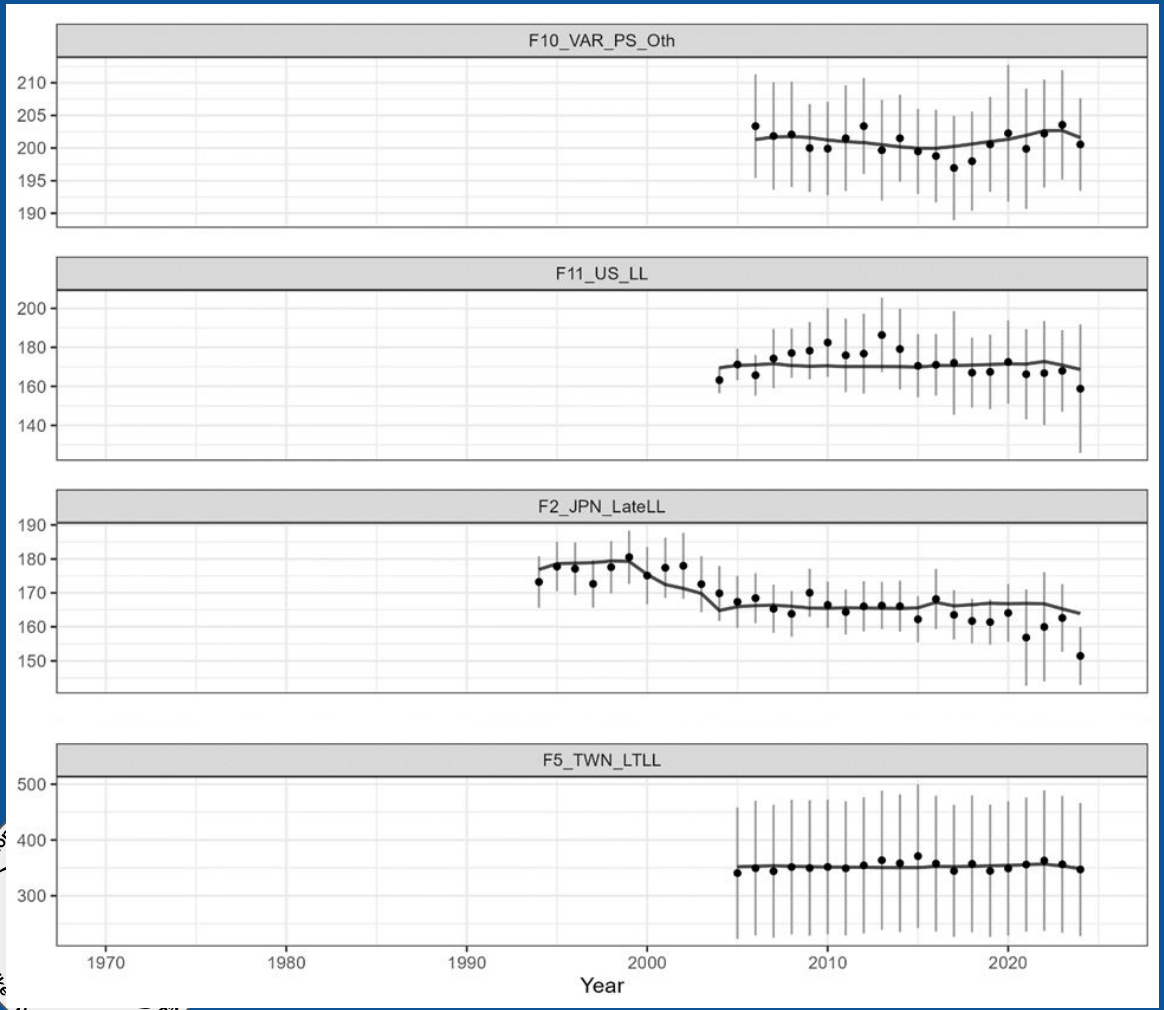


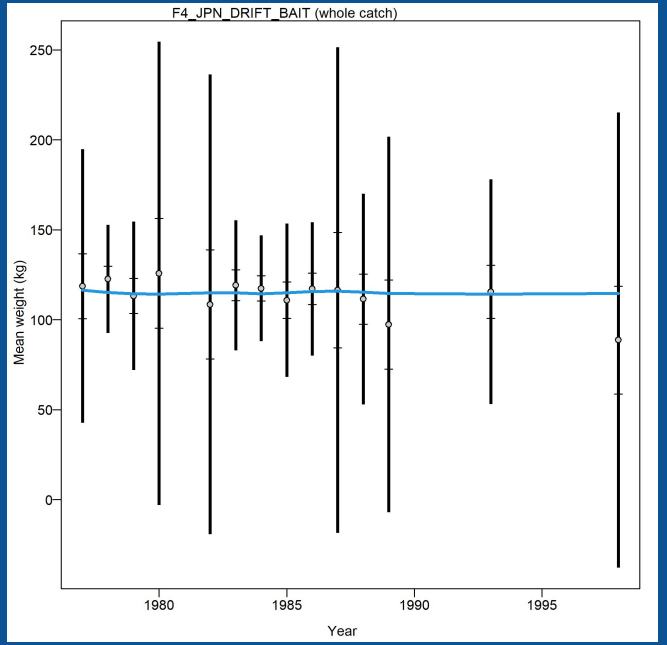
Size Composition Model Residuals w/ Runs Tests



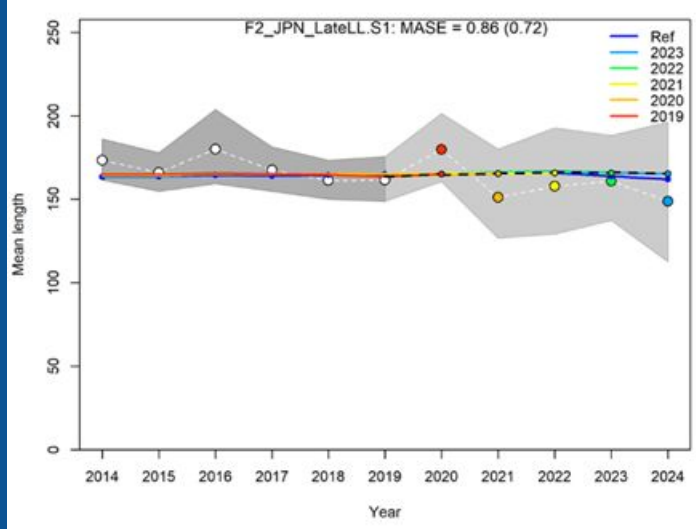


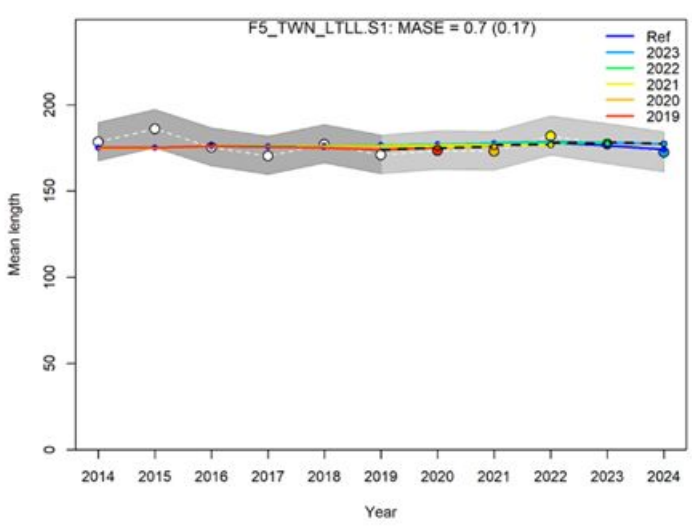
Model fit to mean size

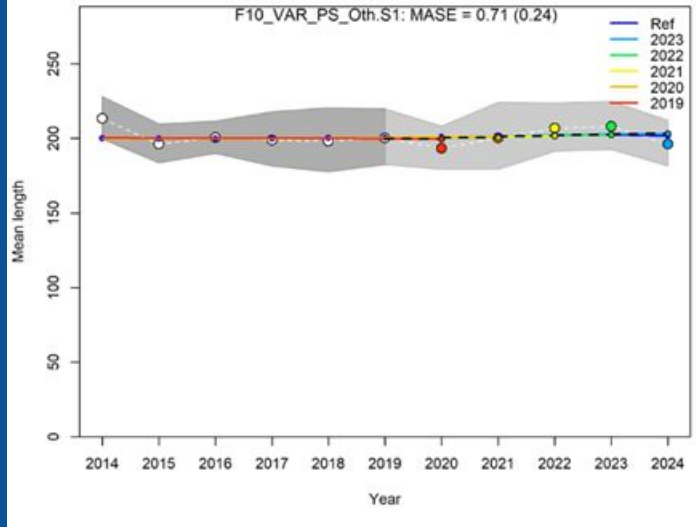


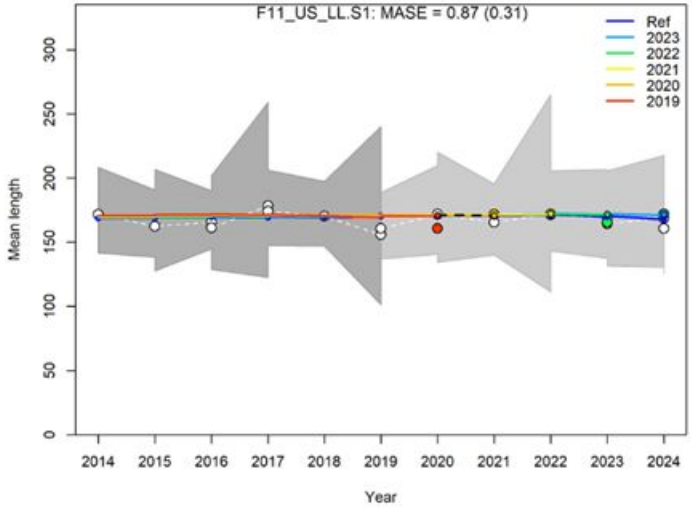


Length Composition Hindcast Cross Validation

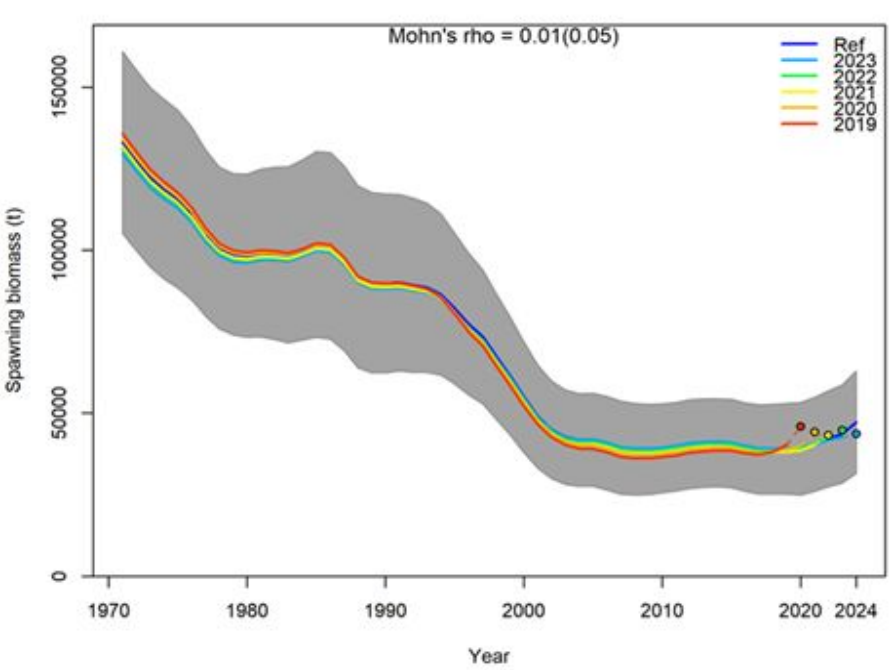


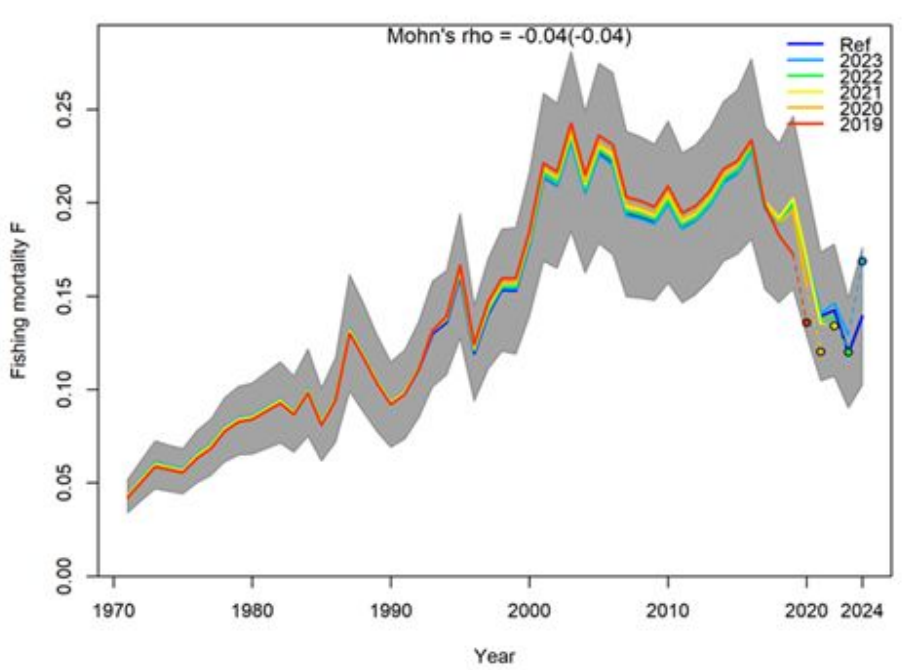


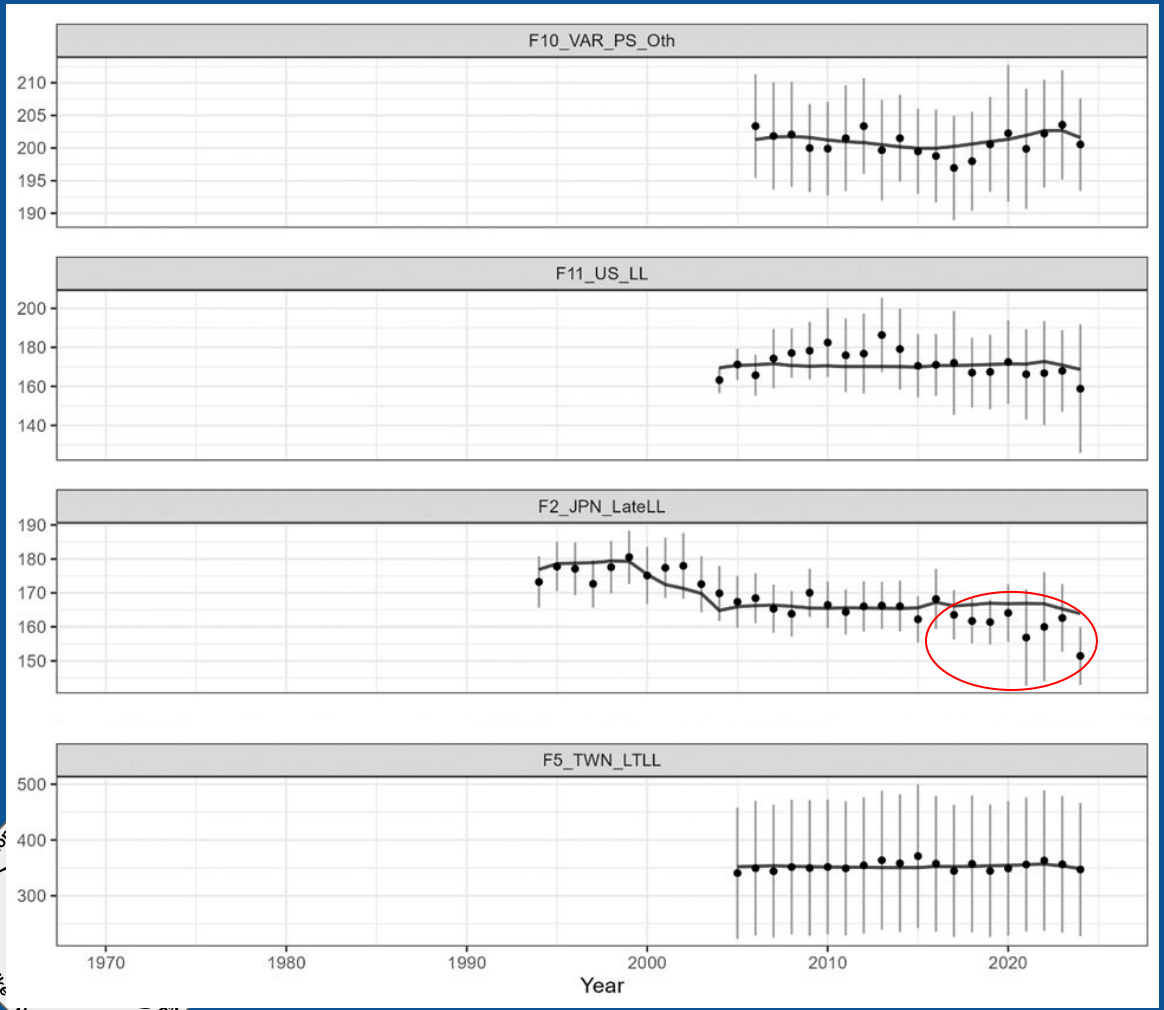




Retrospective Analyses

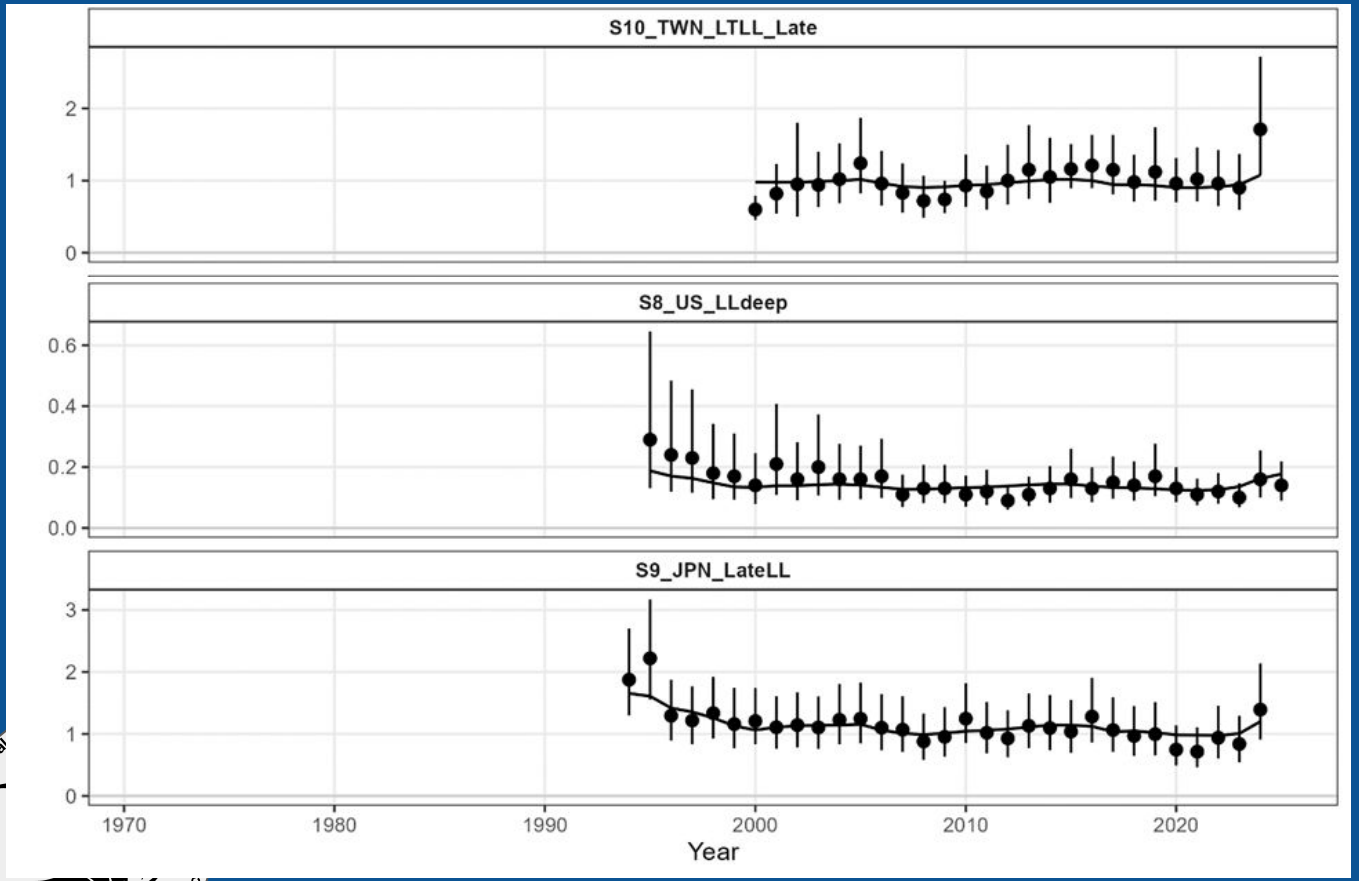






Model fit to mean length

Model fit to CPUE Indices



Special Comments and Research Recommendations

- Lack of sex specific size data
- Change of fleet distribution and fishing effort over time
- Continued exploration of the East-West model to capture spatial differences in size distributions
- Moving toward a quarters-as-years approach to better approximate the likely year-round spawning in the equatorial region