IATTC SAC 15 Agenda 7. a (Document SAC-15 INF-N)
ISC report on 2024 stock assessment of Pacific Bluefin tuna

SAC 15

2024/6/12

ISC Pacific Bluefin tuna Working Group

Acknowledgement

❖ All works related to the 2024 PBF stock assessment were done by a following members of the ISC PBFWG and invited experts as a team effort;

- S. Nakatsuka (WG chair)
- S.K. Chang (WG vice chair) and J.C. Shiao (Taiwan)
- Y.J. Kwon, J.B. Lee (Korea)
- M. Dreyfus-Leon, M. Betancourt (Mexico)
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- L. Knittweis, A Hann (NZ, Invited experts)
- M. Maunder, J. Valero (IATTC)

<u>The WG appreciated to the IATTC to advance their dedicated scientists to support the assessment works at the ISC.</u>

Today's talk – "2024 stock assessment of Pacific bluefin tuna"

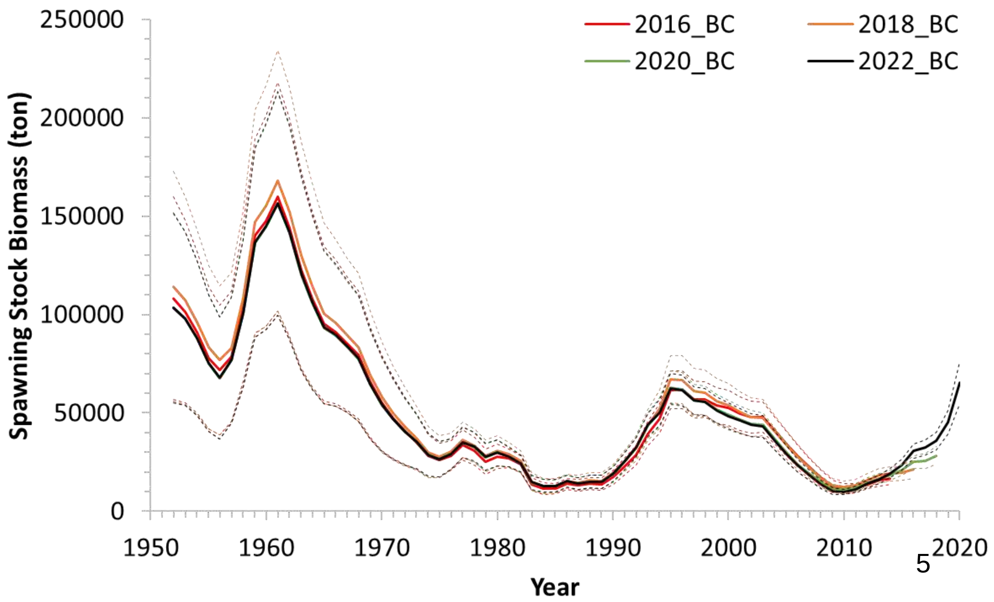
1. Background information
   1.1 Review of the previous assessments.
   1.2 Major Challenges for the 2024 assessment.
2. Assessment modeling
   2.1 Conceptual model
   2.2 Biology and Selectivity
   2.3 Input data
3. Model diagnostics
4. Assessment results
5. Sensitivity analysis
6. Future projection
7. Draft Stock Status and Conservation information

1.1 Review of the previous assessments.

History of the PBF stock assessment

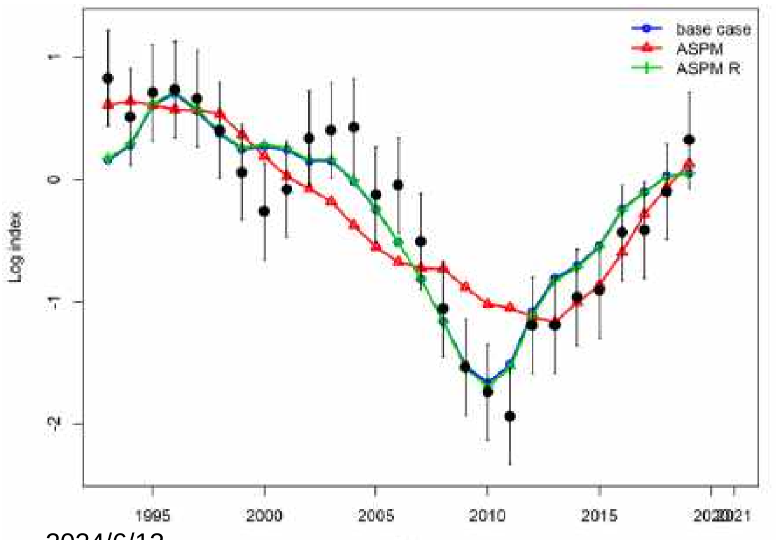
- 2016 benchmark assessment
  - 19 fleets, 3 terminal indices (Jpn LL (New GLMM, (ZINB)), Twn LL (New GLMM), Jpn troll (GLM))
  - New Growth curve based on the otolith data.
  - New Composition data (Kor PS, Revised Set Net etc) and initial input sample size
  - Time varying selectivity for many fleets.
- 2018 update assessment
  - Identical model configurations with the 2016 assessment.
- 2020 benchmark assessment
  - 25 fleets, 3 terminal indices (Jpn LL (Spatio-temporal GLMM), Twn LL (GLMM), Jpn troll (GLM))
  - New size data (US rec, Jpn LL and PS etc)
  - More time blocks
  - Modifications in Dome shape selectivity.
- 2022 update assessment
  - New Bootstrap method to reduce bias
  - Minor change in the JLL index data curation and associated comp data.

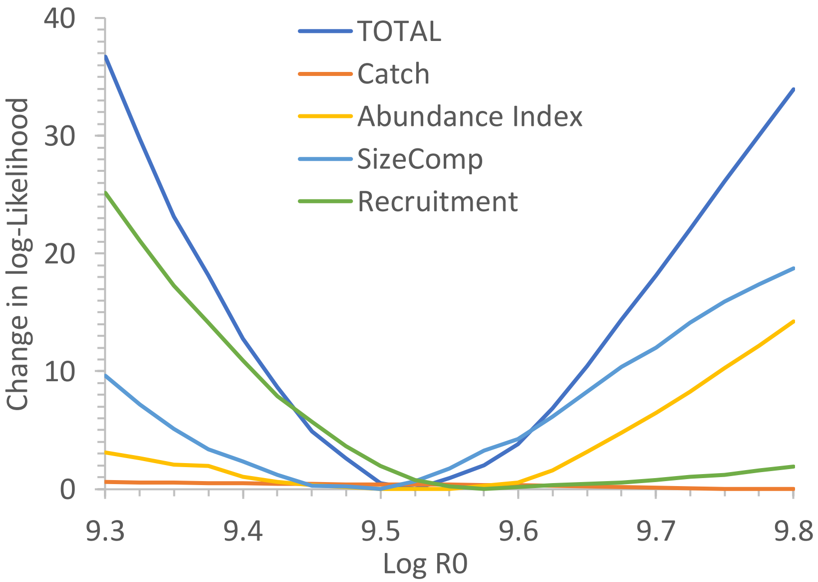
Assessments showed a high-consistency in past 4 assessments over 8 years.

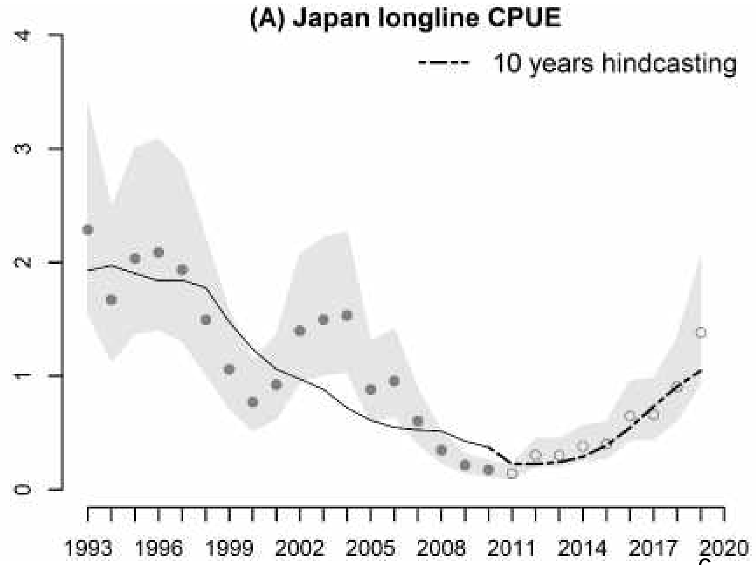


Major advantages of the PBF stock assessment

- ❖ Fluctuation in the index was explained by Catch@age given a productivity assumption (M, h, growth).
  - ○ Strong production relationship consistently evident in data under a model assumption.
  - ○ Input data and model assumption are basically internally consistent.
- ❖ Base-case model could reconcile all the important input observations (NLL profile).
  - ○ Another aspect of the internal consistency of the PBF assessment model.
- ❖ The model has a good skill to forecast the future dynamics that has already happened (hind-casting).
  - ○ Provide a rationale to use the projection result for the basis of the management advise.







1.2 Major Challenges for the 2024 assessment

Major unsolved issues in the 2022 PBF stock assessment

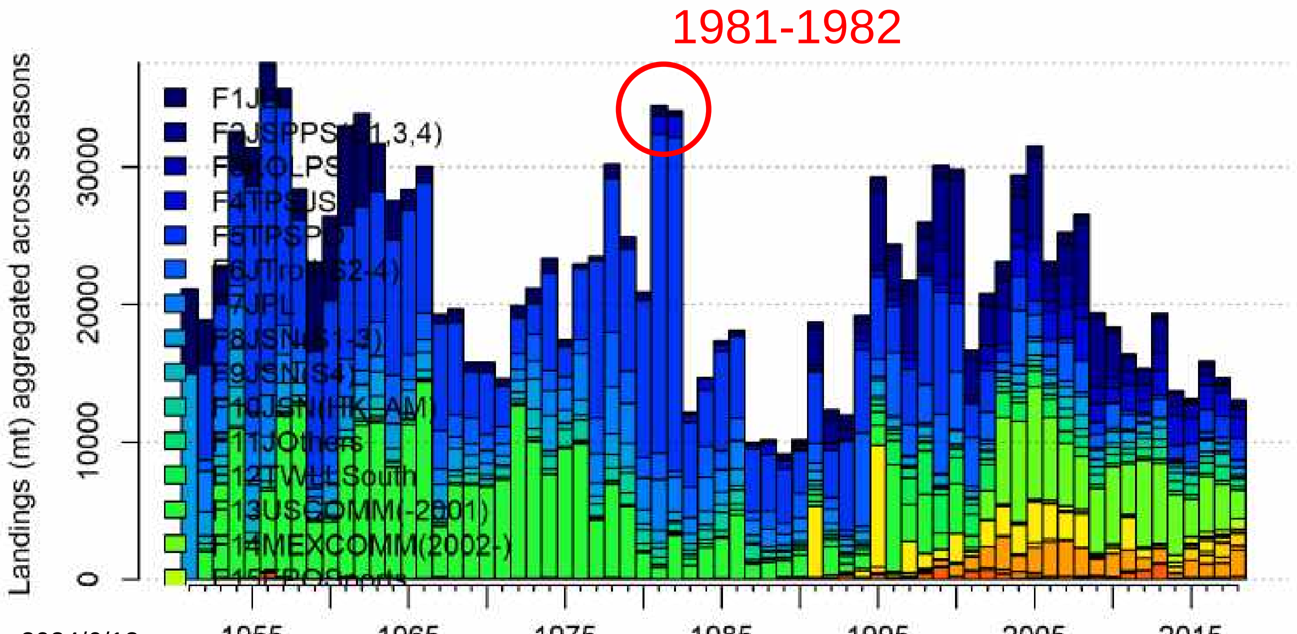
1. Convergence issue with an alternative productivity assumptions.
   - The model showed inflexibility to change in steepness (Only $\boldsymbol{h} \geq 0.99$).
   - This inflexibility made difficult to account the structural uncertainty for steepness.
   - This was highlighted as an assessment uncertainty at the past SAC meeting.
2. Small but persistent systematic retrospective pattern in the SSB.
   - The model showed a pessimistic pattern in the retrospective diagnostics.
   - This might be a sign of a biased data or model-misspecification.
   - This was pointed out as an assessment uncertainty in the other forum.

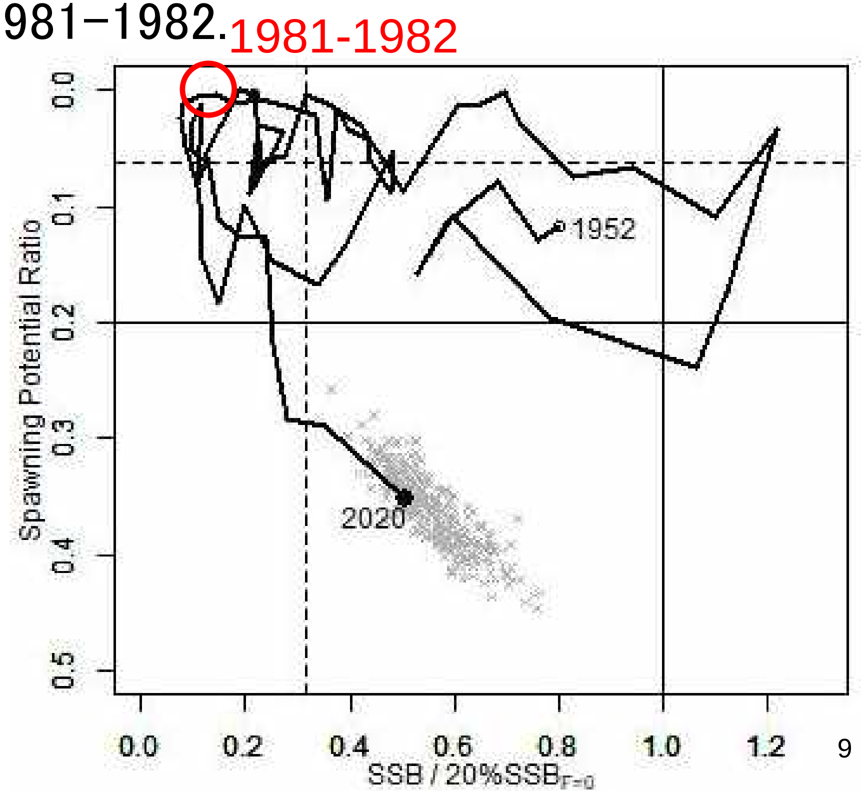
An objective of the 2024 PBF assessment was addressing those unsolved issues while maintaining the internal consistency of the model shown in the 2022 assessment.

Model convergence issue with an alternative *h* & *M*

External Requests	Internal Demand	Scientific Interests
Why is the PBF stock assessed under the steepness =0.999 only?	To develop more flexible model for the MSE work.	What is the cause of inflexibility to the alternative productivity assumptions?

- The population is observed at a very low stock size, and the model is fine-tuned to explain data (incl. some high catches) under the current assumption.
  - A possible issue could be a low availability of size comp data before 1994.
  - We do not know the size or age of fish actually caught at 1981-1982.

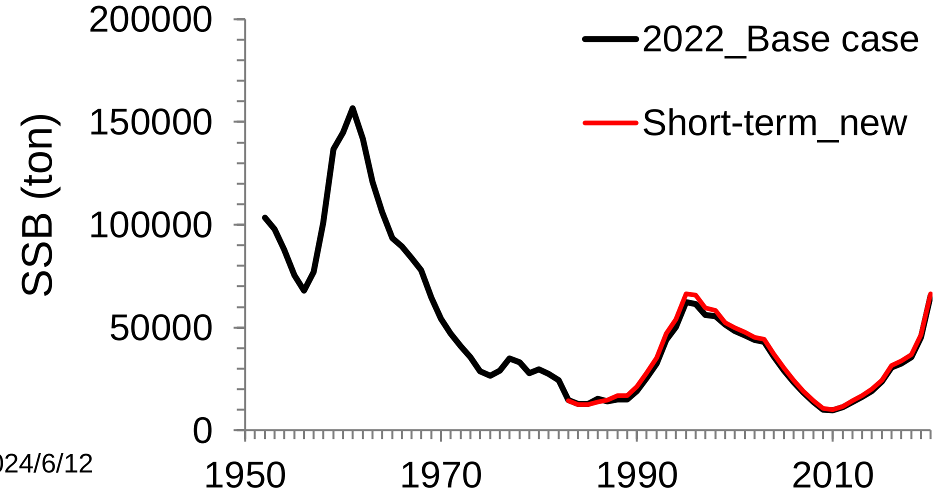


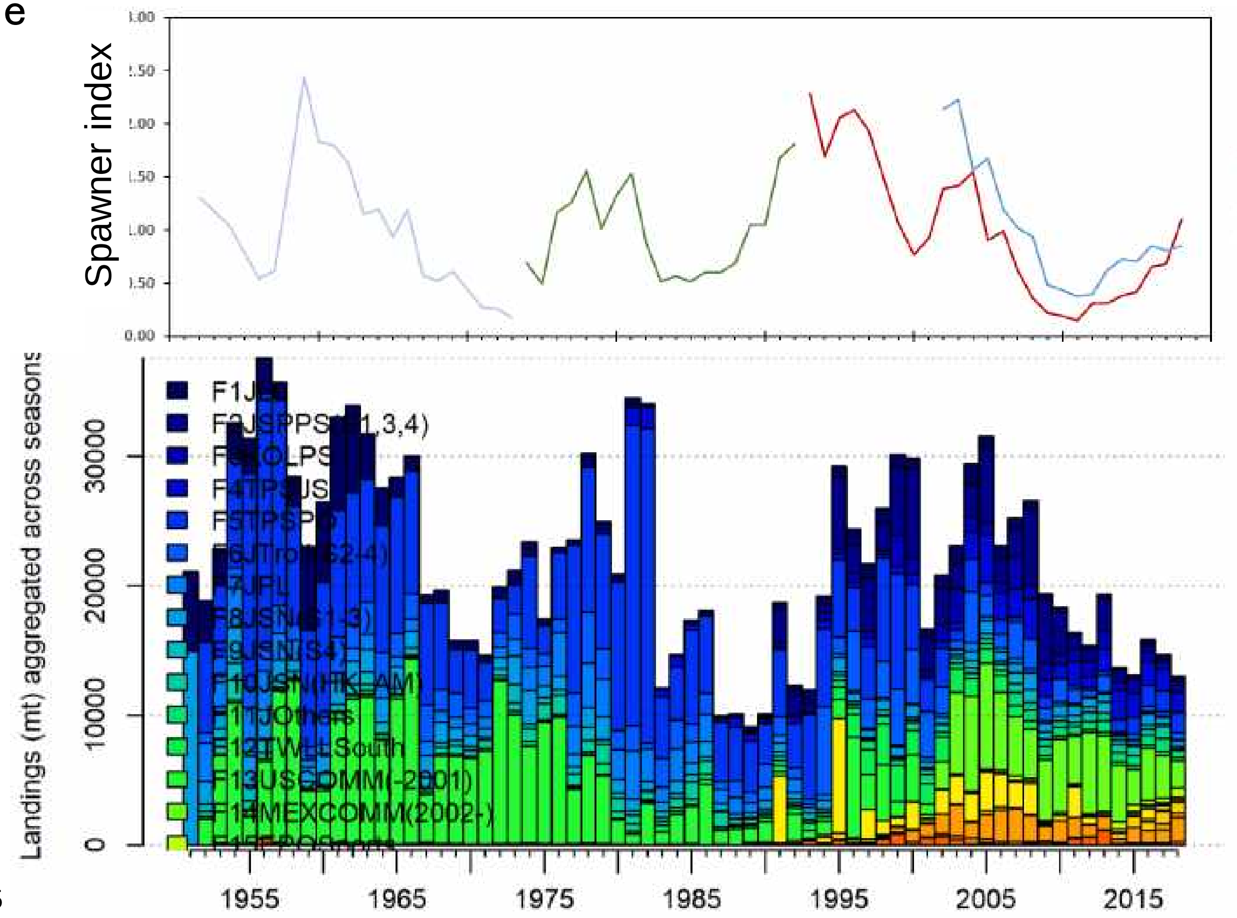


Idea of the short-term model

- Reconstruct the model with necessary data to estimate the scale, recent recruits and catch at age.
  - Relax the model from a mission to explain a high catch at a very low relative stock size.
  - A high contrast in catch and CPUE after 1983, good recruitment index after 1980, and available size data for most of the fleets after 1993.
- Short-term model could replicate the similar biomass scale and trend with the 2022 base-case.
- Short-term model converged for the models with a wider assumptions on productivity (h and M).

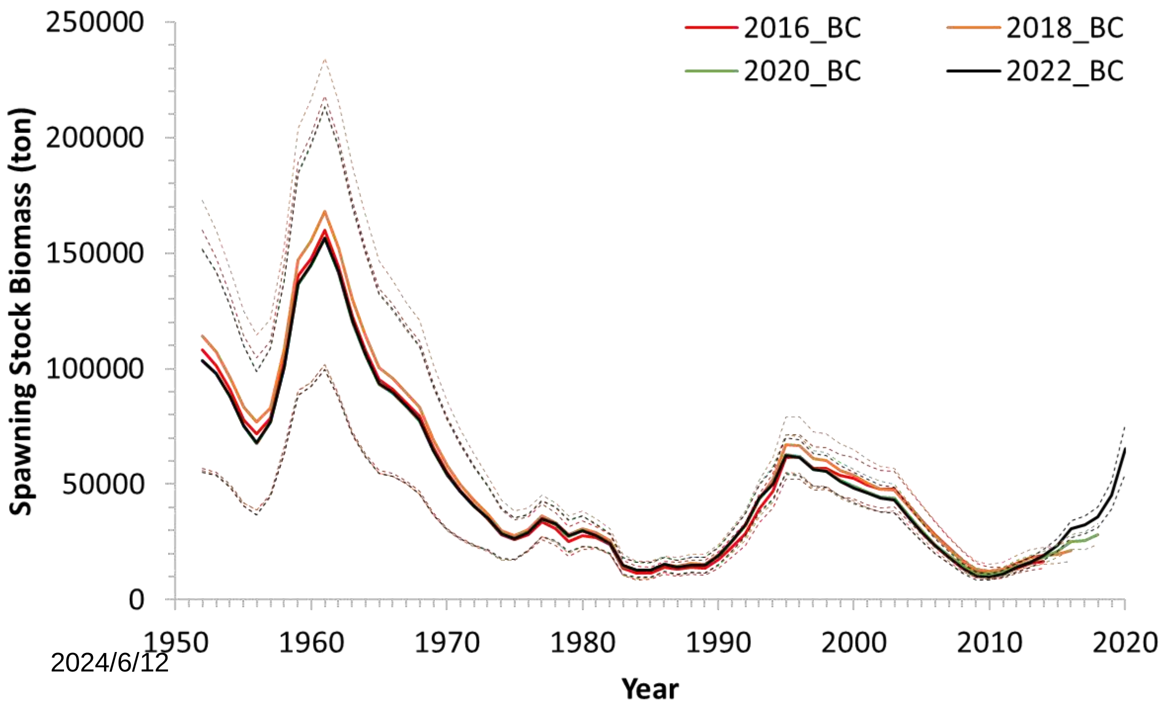
The WG agreed to change the model start year from 1952 to 1983 in the 2024 assessment base-case.

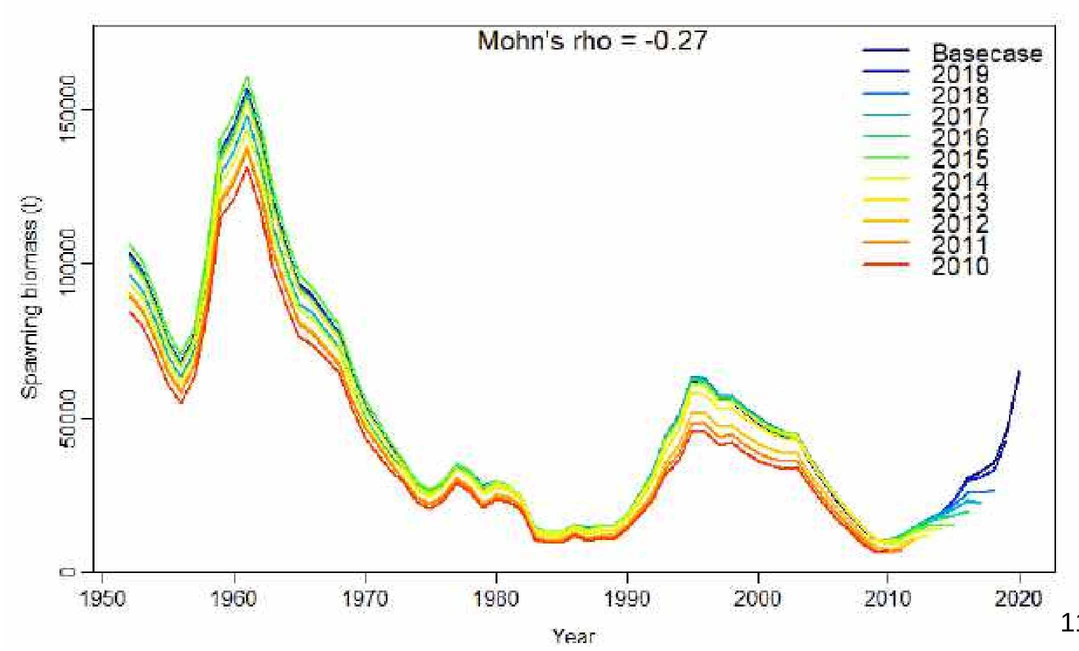




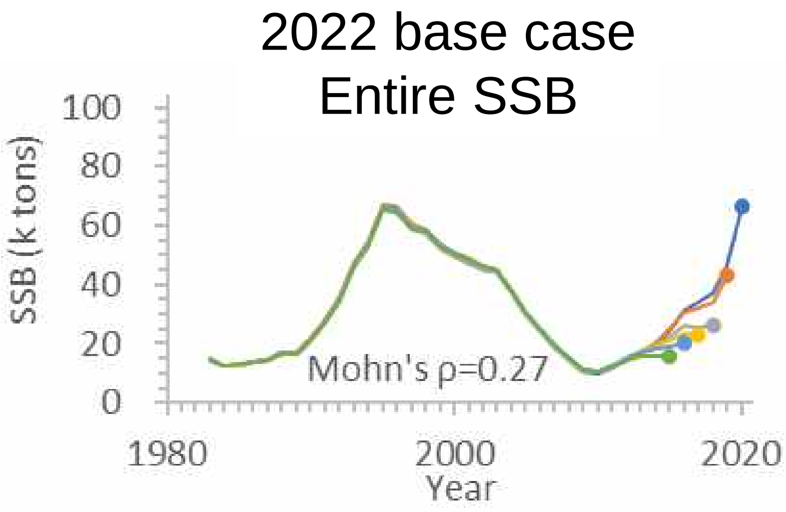
Retrospective pattern in the 2022 assessment

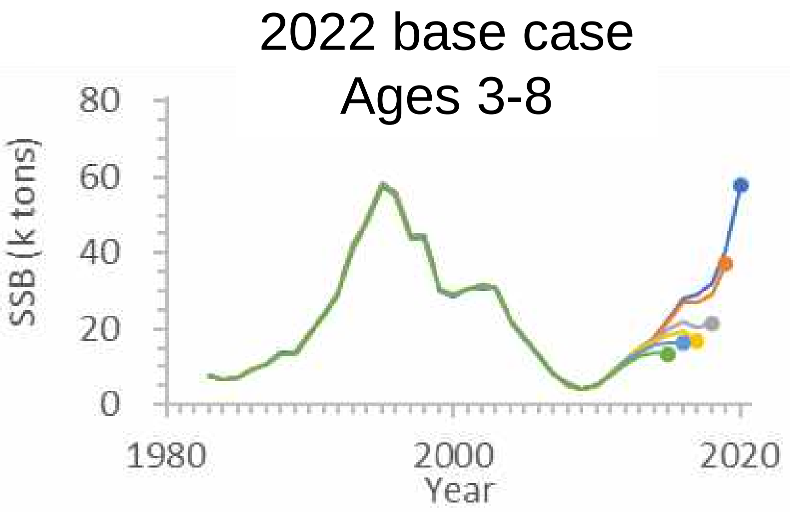
- ❖ Another long-lasting issue is the systematic retrospective pattern in SSB.
  - ○ Persistent negative bias in SSB for the models peeling 1 to 10 years data.
  - ○ This pattern was also observed in the comparisons of the SSB among recent 4 assessments.
- ❖ This might be a sign in a mis-specification in the model or input data issue.
- ❖ This issue was highlighted in the other forum as an uncertainty in the assessment.

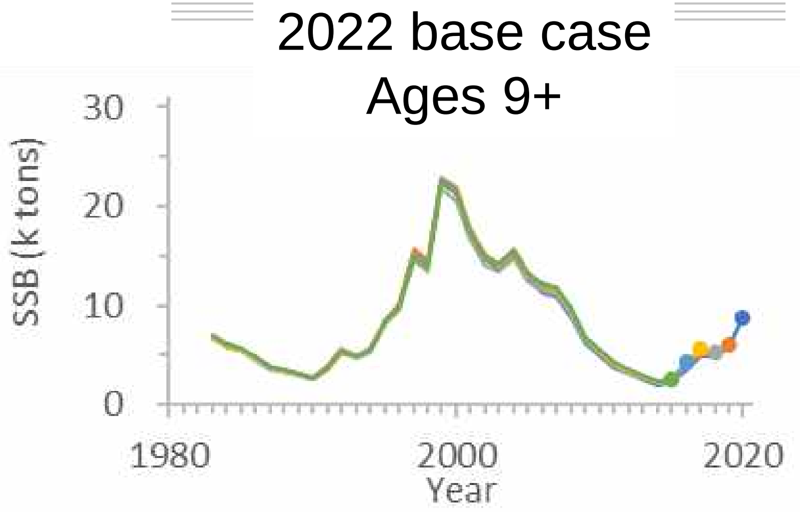


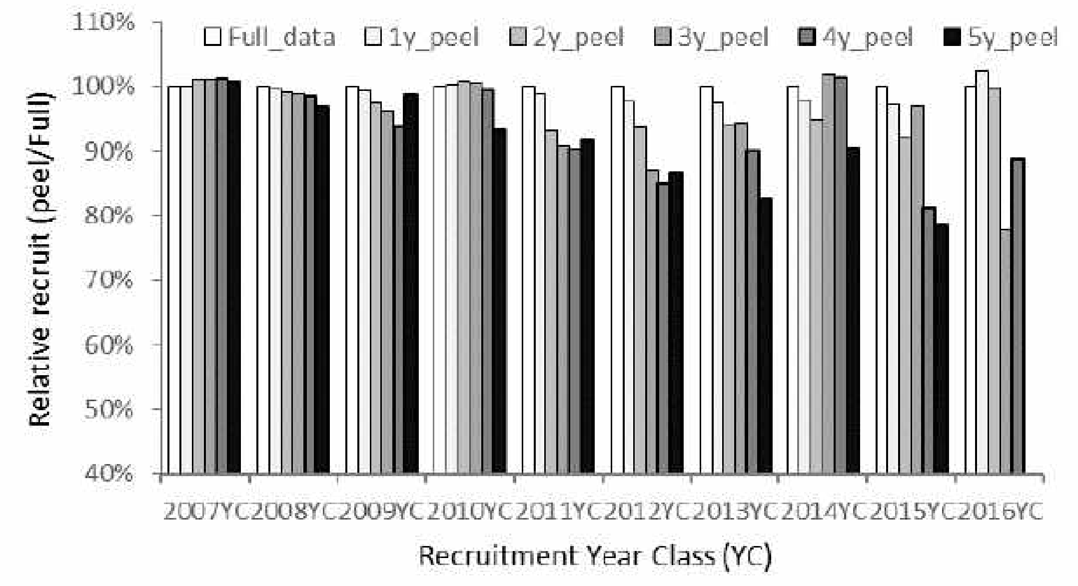


Comprehensive analysis to address the systematic retrospective pattern





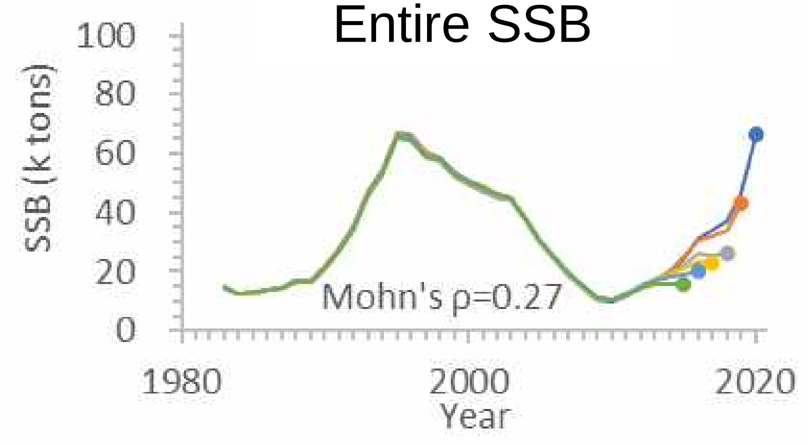




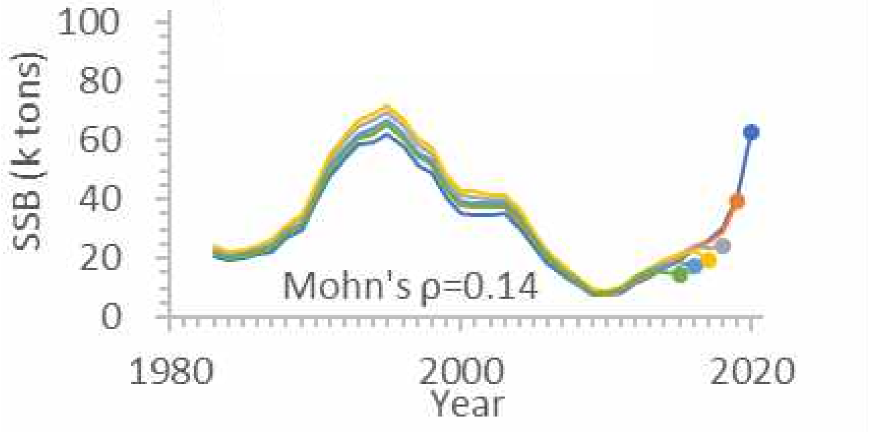
- Estimated SSB at relatively old ages (9+) were robust.
- The data peeling affected to the SSB estimates in particular ages 3-8 and recruitments of 2011 year-class and younger.
- Alternative assumptions for recruitment (*h*, *sigmaR*, Sum-to-zero constraint) or natural mortality did not solve the issue.

Comprehensive analysis to address the systematic retrospective pattern

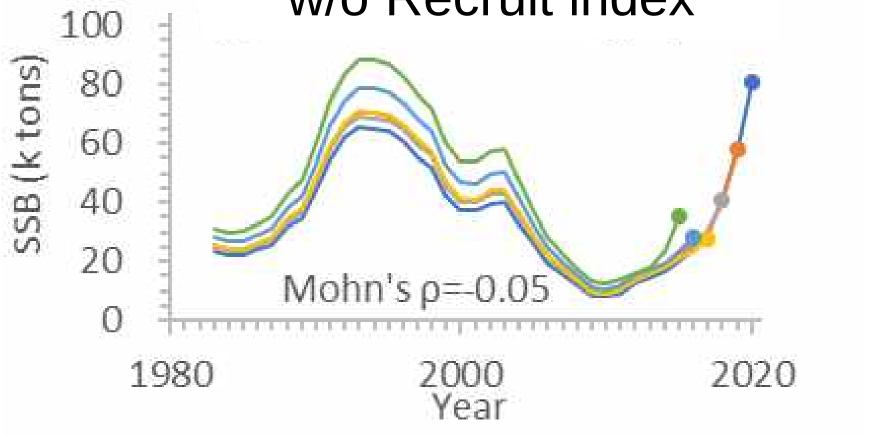
2022 base case
Entire SSB



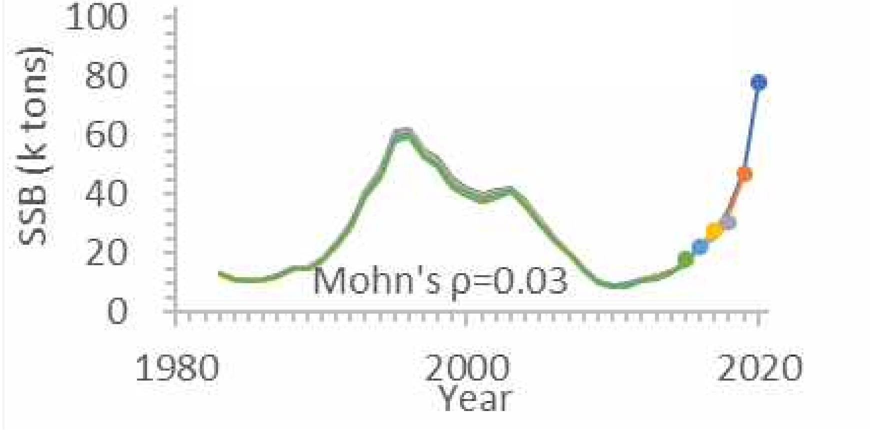
2022 ASPM-R_{est}



2022 ASPM-R_{est}
w/o Recruit index



Modified 2022 model

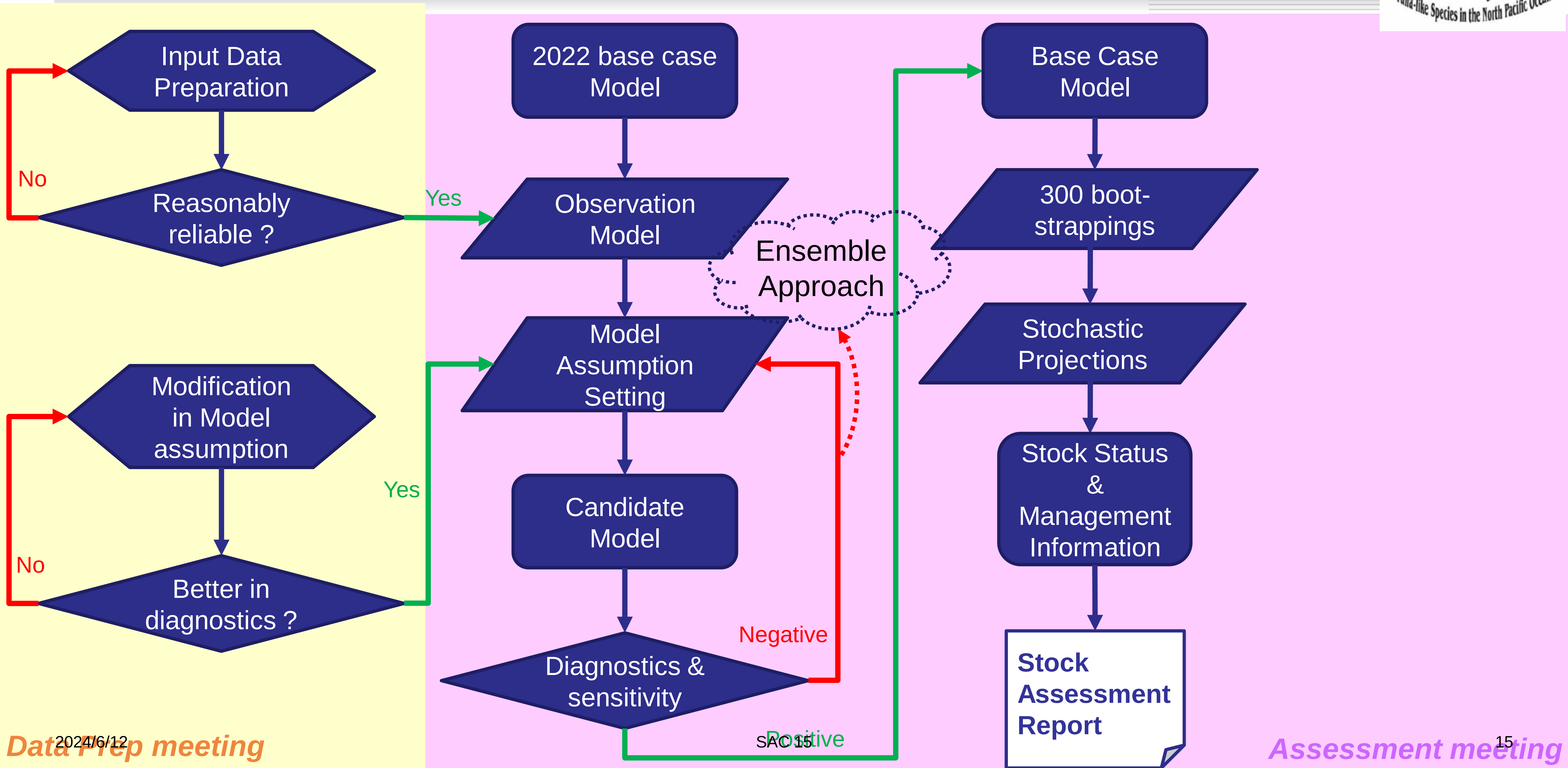


- Exclusion of size comp data (ASPM-R_{est}) got a better retrospective diagnostics.
- Exclusion of the recruitment index (Jpn troll CPUE) also showed a better diagnostics.
- PBFWG agreed to minimize the systematic retrospective pattern in the 2024 assessment by modifying the observation model.

2. Assessment modeling

2.1 Conceptual model

Procedure of the 2024 ISC PBF assessment

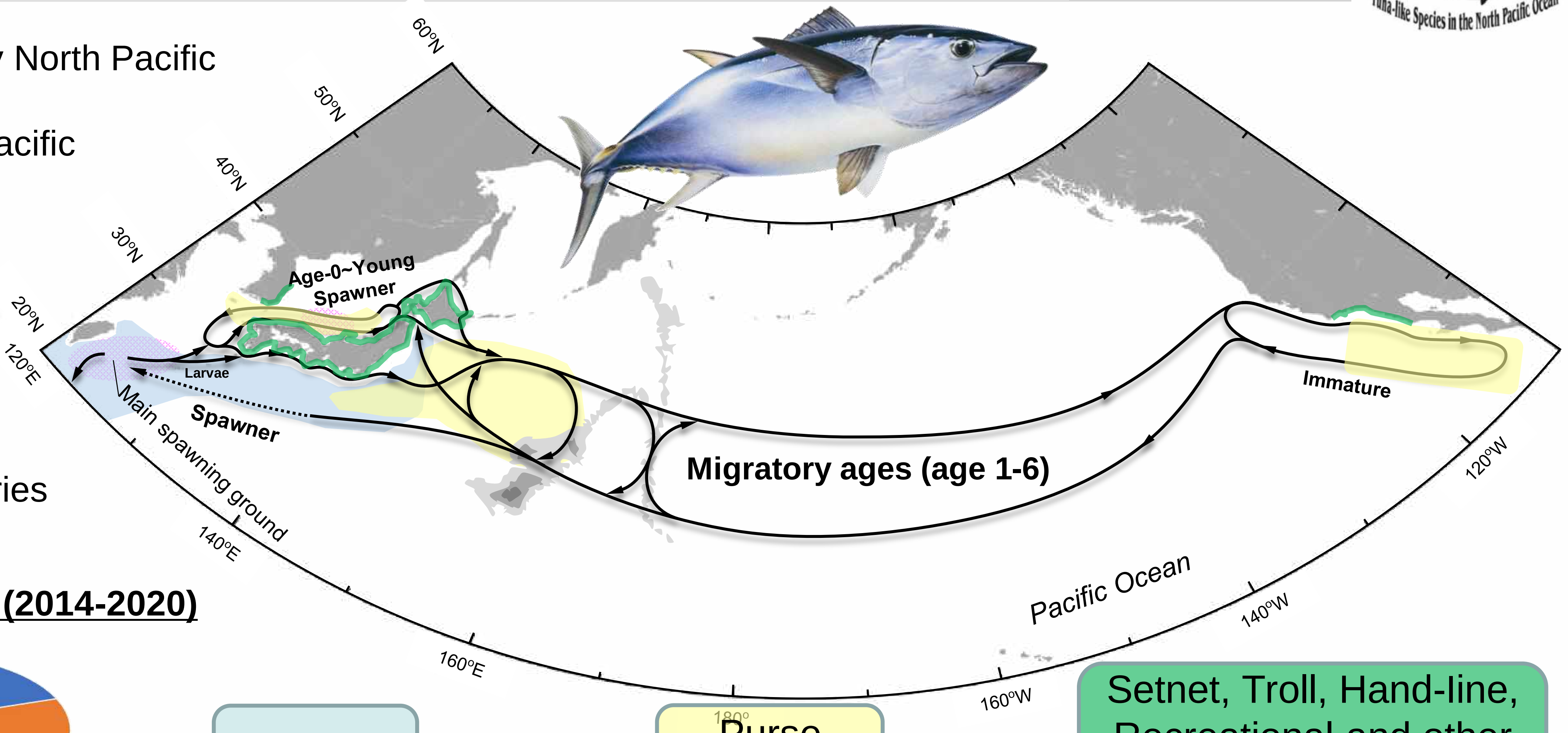


A conceptual model of Pacific bluefin tuna Dynamics

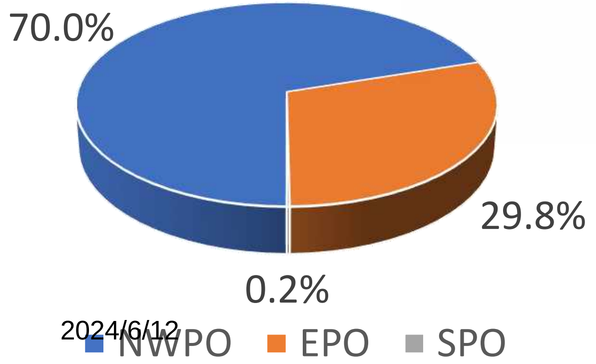
Migration; Mainly North Pacific
Age 0:NWPO
Age 1-6: North Pacific
Age 7-: NWPO

Spawning:
May-Aug.
Only in NWPO.
From Age 3-

Sex ratio:
1:1 in many fisheries



Catch distribution (2014-2020)



Longline	Purse seine	Setnet, Troll, Hand-line, Recreational and other coastal fisheries
Japan, Taiwan	Japan, Mexico, Korea, U.S.A.	Japan, U.S.A., Korea

Modifications in Data and Modeling

- Modeling
  - Update the Stock Synthesis version to the latest one (SS v.3.30.22) (Lee 2023).
  - Changing model start year from 1952 to 1983 (short-term model) (Fukuda 2021).
  - Modification in the estimation method for CV of the growth function (Tsukahara et al. 2024).
  - Modification in the selectivity parameter specification (Lee 2023).
  - Reducing residuals in size composition data by adding the model process or data aggregation with down-weighting (PBFWG 2024).
- Data
  - 2-year data update for all fleets (from July 2021 to June 2023) (Kwon et al. 2024, Dreyfus & Betancourt 2024).
  - Newly available size comp and catch data (Nishikawa & Fukuda 2023).
  - Shortened recruitment index time series (Fukuda et al. 2023).
  - Consideration for the newly developed indices of abundance (Fujioka et al. 2024, Yuan et al. 2024).
  - Consideration for the Index-fleet approach (Tsukahara & Fukuda 2024).

2.2 Biology and selectivity

Growth (von Bertalanffy growth function)

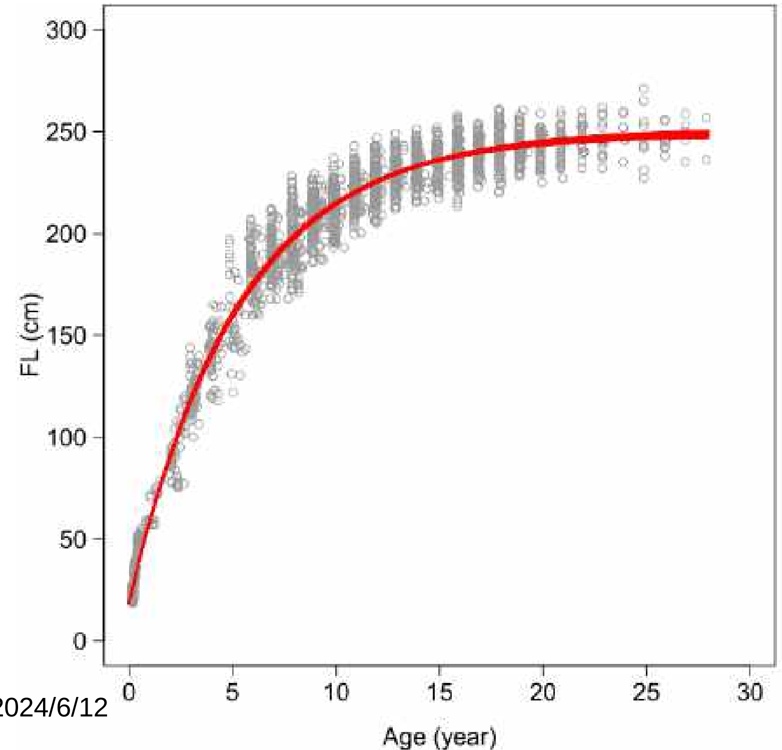
vB parameters were estimated outside the model using otolith annual and daily rings data.

K=0.188

Asymptotic length; 249.9 cm

Length at Age 0 = 19.05 cm

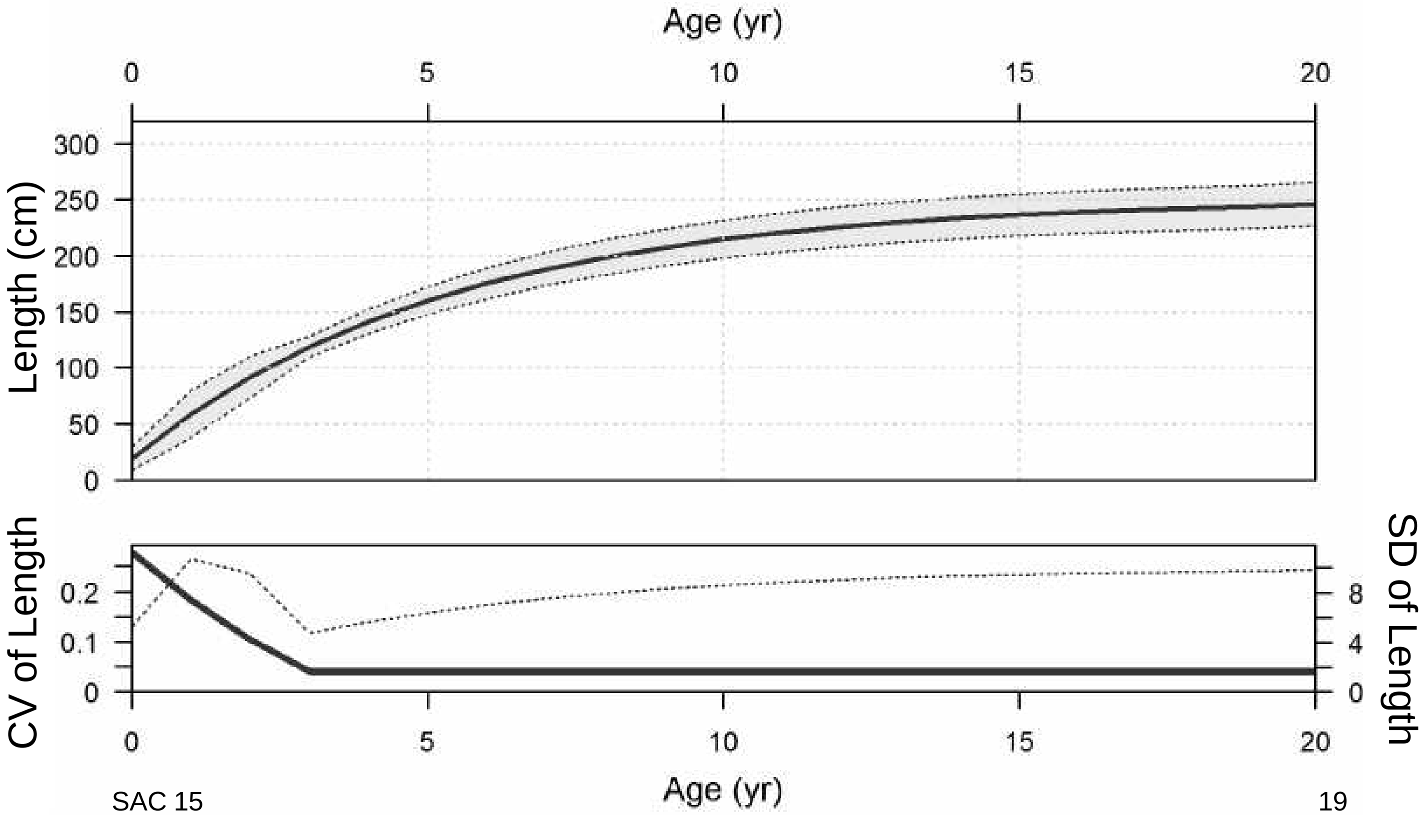
Length at Age 3 = 118.57 cm



CV of length at age was estimated using the ASPM-R_{fix} fitting to the conditional age at length data.

CV at length at Age 0 = 27.8%

CV at length at Age 3 = 4.01%



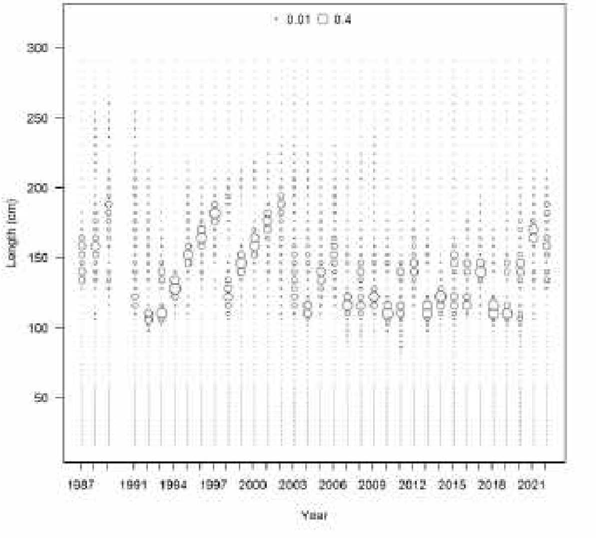
Other biology assumptions

- ❖ Population Dynamics
  - ○ Maturity and Stock Recruitment Relationship
    - ✓ 20%, 50%, and 100% maturity at ages 3, 4, 5 and older based on the histological study.
  - ○ Age specific Natural mortality
    - ✓ Based on the tagging study (age 0), other bluefine tuna data (age 1), and a suite of empirical and life-history based methods (age 2 and older fish).
  - ○ Recruitment
    - ✓ Beverton-Holt SRR (h = 0.999; estimated from life history information).
    - ✓ 0.6 of standardized deviation for the average recruitment deviation (SigmaR).
- ❖ Estimated parameters
  - ○ Initial conditions (Initial F, Early recruitments for 10 years),
  - ○ Population scale (logR0) and Main recruitment deviations from 1982 to 2021
  - ○ Catchability of the index
  - ○ Selectivity of fishery

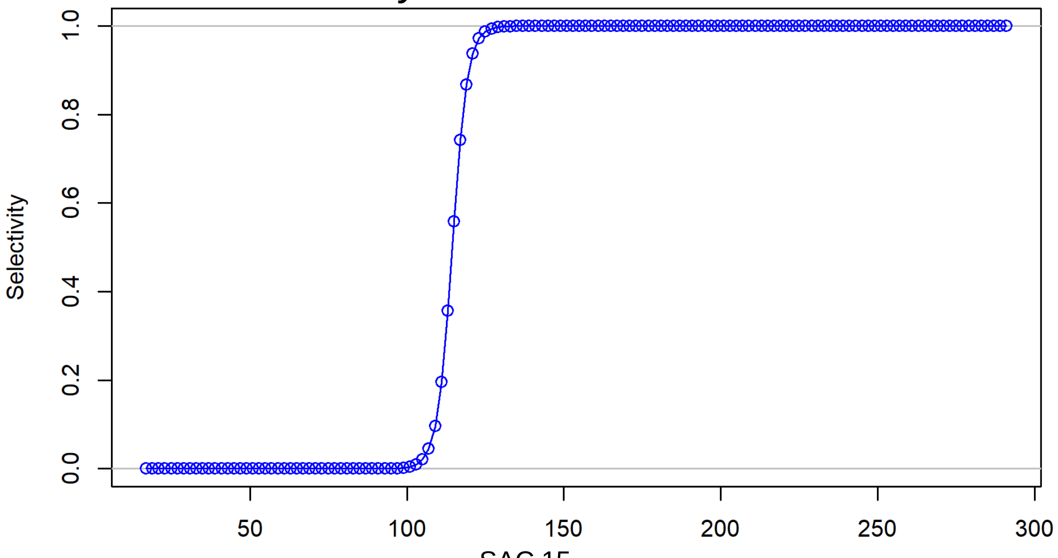
Area as Fleet Approach with time varying selectivity

- Fleet structure was determined based on the CPUE/country/gear/season, etc.
- Movement of fish among the Fleets were accounted by a selectivity modeling approach.
  - Contact gear selectivity as time invariant length-based selection.
  - Time varying Age-based availability.
    - ✓ Considering annual/seasonal variation of the age-specific movements.

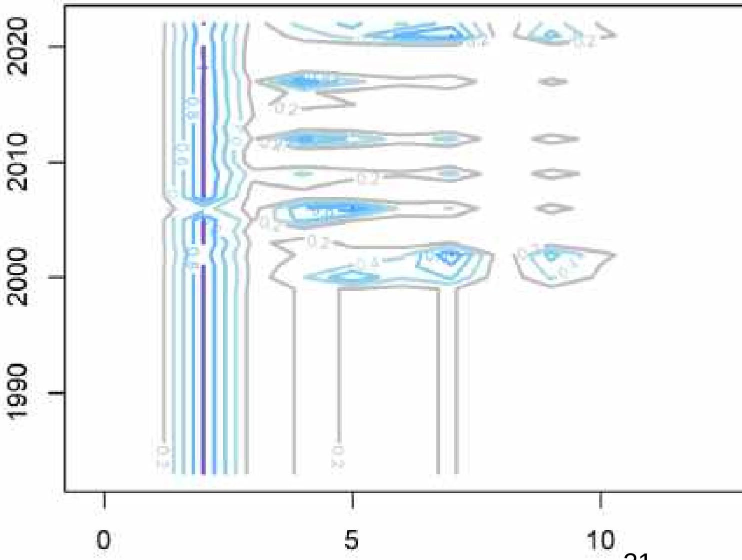
ex.) Jpn tuna Purse seine in SOJ



Gear selectivity



Age based availability



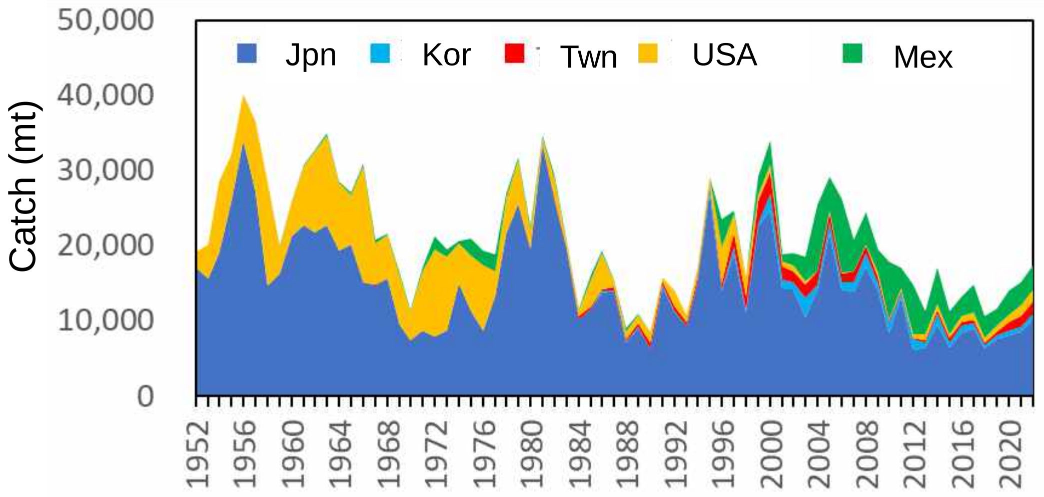
Qualitative evaluation to decide the selectivity

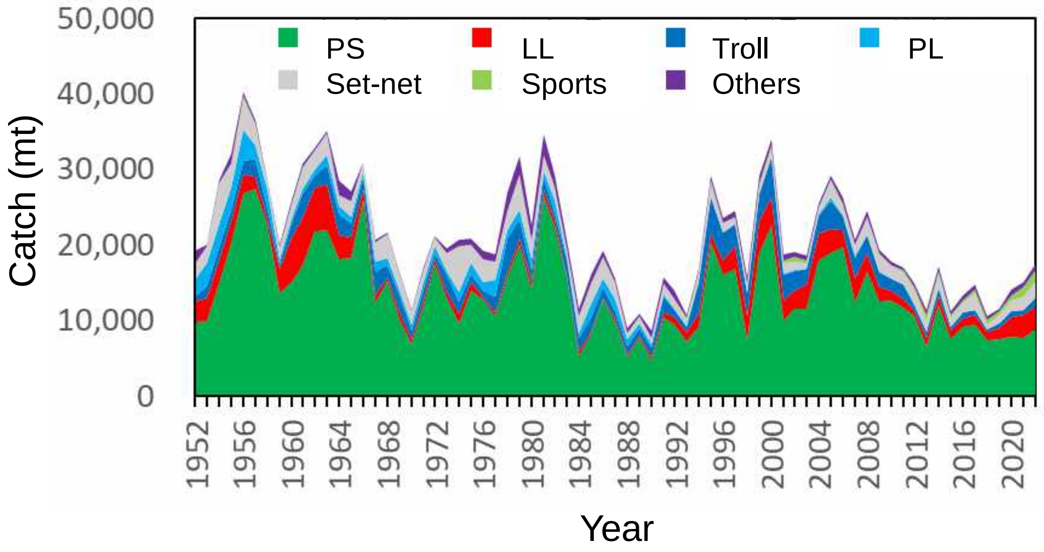
Fleet #	Fleet name	Main Ages of fish caught	Priority for size data	Type of size data	Sampling quality	CPUE index	Catch in number	Length-based contact selectivity	Age-based availability	Time-varying process	Time-varying Option
Fleet 1	JPN_LL (Seas 4)	Spawners in WPO	High*	Length	Good	Yes	Low	Dome-shaped (double normal)	-	-	-
Fleet 2	JPN_LL (1993-) (Seas 1-3)	Migratory ages & Spawner	Low*	Length	Good	-	Low	Dome-shaped (double normal)	-	-	-
Fleet 3	TWN_LLSouth	Spawners in WPO	High*	Length	Very Good	Yes	Low	Asymptotic (logistic)	-	-	-
Fleet 4	TWN_LLNorth	Spawners in WPO	Low*	Length	Good	-	Low	Dome-shaped (double normal)	-	-	-
Fleet 5	JPN_TPS_PO	Migratory ages (ages 1-7)	Medium*	Length	Fair to Good (improvement after 2014 by systematic sampling)	-	High-Med	Asymptotic (logistic)	Age-specific (ages 1-11)	Constant on length-based; time-varying on ages 1-2, 4-7 after 2004	Block
Fleet 6	JPN_TPS_SOJ	Migratory ages (ages 1-5)	High*	Length	Very Good	-	High-Med	Asymptotic (logistic)	Age-specific (ages 3-10)	Constant on length-based; time-varying on ages 3-7 for 2000-22	Deviation
Fleet 7	JPN_TPS_SOJ (Farming)	Migratory ages (ages 1-5)	Medium*	Length	Very Good	-	Med	Dome-shaped (double normal)	-		Deviation
Fleet 8	JPN_SPPS (Seas 1,3,4)	Age 0 fish in WPO	Medium*	Length	Good	-	High-Med	Dome-shaped (double normal)	Age-specific (age 0-1)	-	-
Fleet 11	KOR_LPPS	Age 0 and Migratory ages (ages 0-4)	Medium**	Length	Fair (opportunistically sampling was conducted for 2004-2009, systematically since 2010)	-	Med	Asymptotic (logistic)	Age-specific (ages 1-6)	Constant on length-based; time-varying on ages 1-2 for 2007-20	Deviation
Fleet 12	JPN_Troll (Seas 2-4)	Age 0 fish in WPO	High*	Length	Good	Yes	High	Dome-shaped (double normal)	Full selection at ages 0-2	-	-
Fleet 14	JPN_Troll (Farming)	Age 0 fish in WPO	Low	-	Catch in number of Age-0 fish are available	-	Med	-	Full selection at age 0	-	-
Fleet 18	JPN_Setnet (HK_AM)	Migratory ages (ages 1-6)	Medium*	Weight	Good	-	Low	Asymptotic (logistic)	Age-specific (ages 1-6)	Constant on length-based; Time blocks on ages1, 4-5 for 2004-13, 2014-22)	Block
Fleet 20	EPO_COMM (-2001)	Migratory ages (ages 1-5)	Medium*	Length	Fair (many samples)	-	High-historic	Dome-shaped (double normal)	-	Constant on length-based	-
Fleet 21	EPO_COMM (2002-)	Migratory ages (ages 1-5)	High*	Length	Fair to Good (improvement after 2013 due to the stereo-camera)	-	High	Dome-shaped (double normal)	-	Time–varying on length-based for 2006-22	Block
Fleet 22	EPO_Sports (2014-)	Migratory ages (ages 1-5)	Low	Length	Fair (Good samples are available after 2014)	-	Low	Dome-shaped (double normal)	Full selection at ages 0-7	Time–varying on length-based for 2014-22	Block

2.3 Input Data

Catch

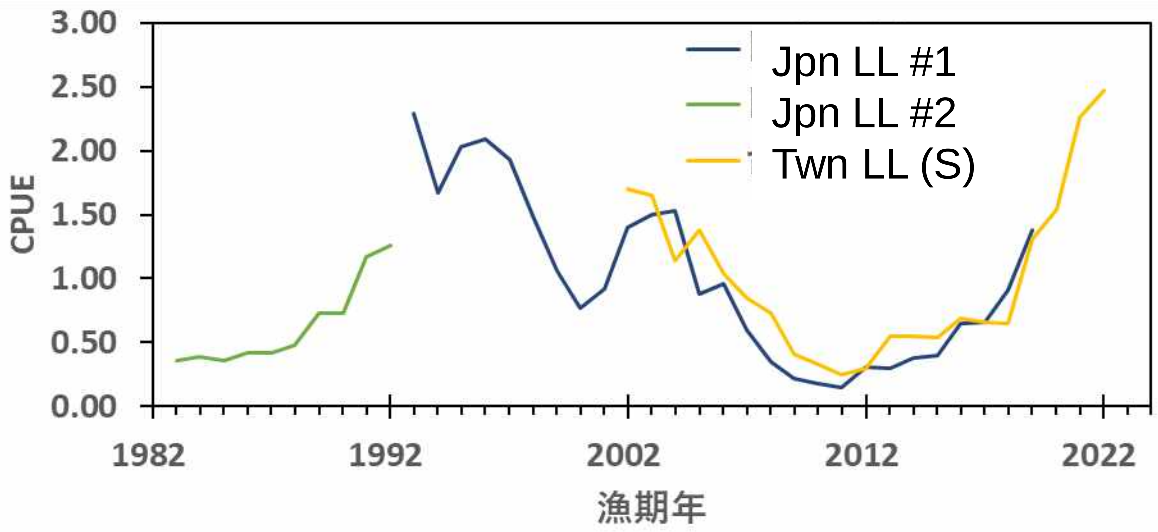
- Data collection
  - Submitted from the ISC members
    - ✓ In unit of number: Catch for farming, Sports.
    - ✓ In unit of weight: the rest of fleets.
  - NZ also submitted their catch to the WG.
  - The rest of catch in the Pacific Ocean was obtained from the WCPFC official statistics.
- Unseen mortality
  - After the implementation of the strict catch upper limit, there would be some unseen mortality due to the post-release mortality and unreported catch.
  - Some member estimated unseen mortality from data.
  - Others assumed 5% of reported catch.
  - 100% of reported catch is assumed as unseen mortality for Troll for farming (Fleet 14) due to its nature of fishery.



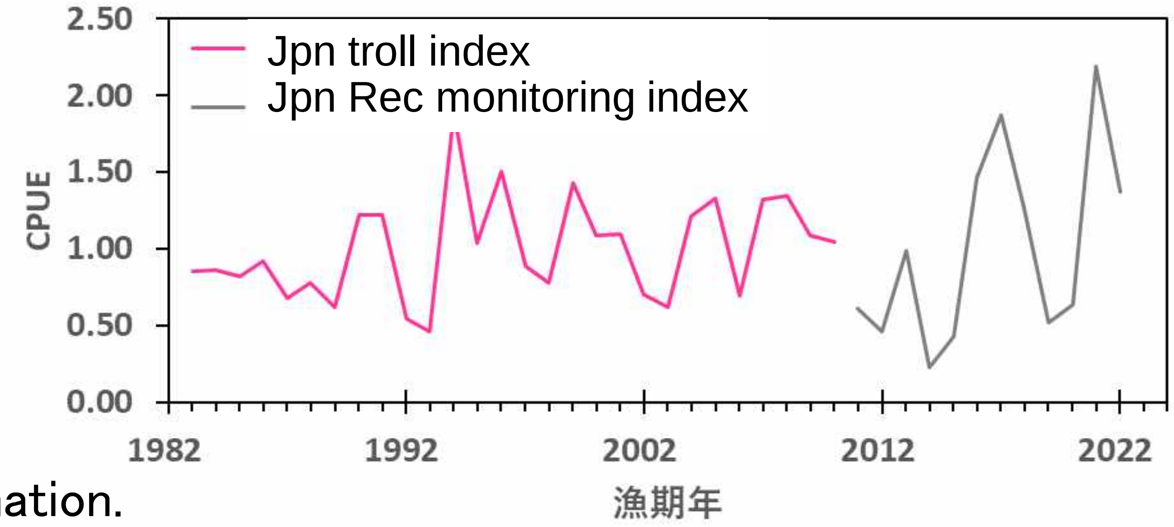


Abundance index

- Index for Spawning stock
  - Taiwanese longline (south) CPUE index
    - ✓ Standardized by GLMM
  - Japanese longline CPUE index
    - ✓ Spatio-temporal GLMM
    - ✓ Due to the possible catchability change, this index was terminated in 2019 FY.



- Recruitment index
  - Japanese Troll CPUE index
    - ✓ Standardized by GLM.
    - ✓ Since this index caused pessimistic bias in the SSB estimation, this was terminated in 2010 FY.
  - Jpn recruitment monitoring survey index was used outside the model as a qualitative information.

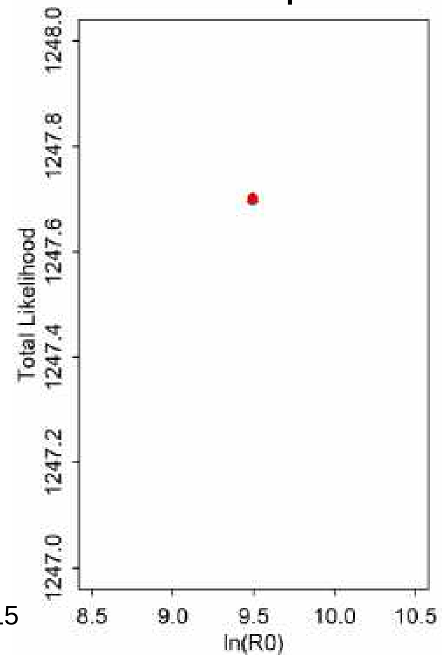


3 Model Diagnostics

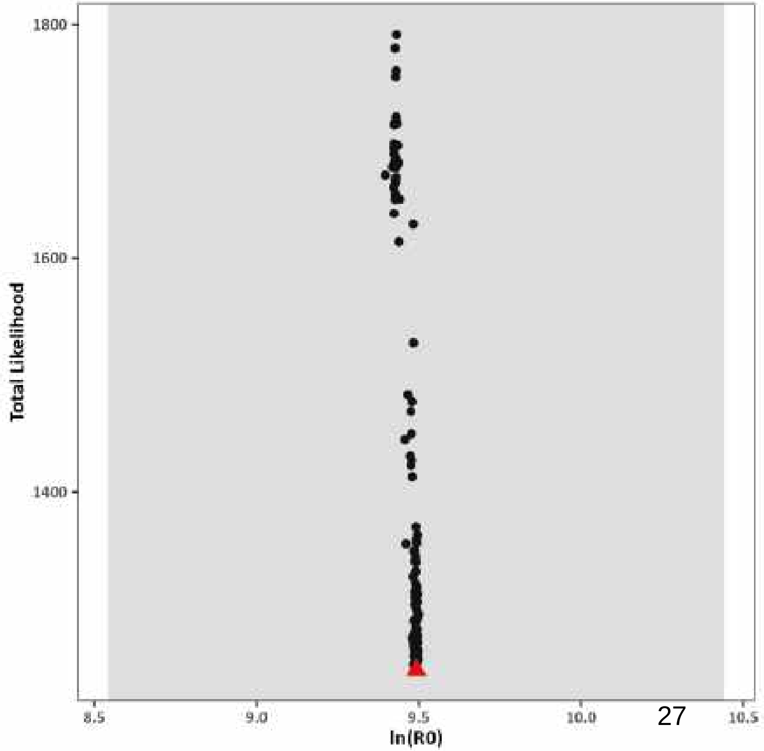
Random perturbations of parameter initial values

- 140 trials for random perturbation of the parameter initial values for all parameters and 500 trials for random perturbation of the parameter phasing for the selectivity parameters were conducted.
  - Most of the jitter runs estimated logR0 about 9.5, which is similar with the logR0 of MLE (9.49).
- The phase of the selectivity parameters were also randomly perturbing for 500 trials.

Random phase



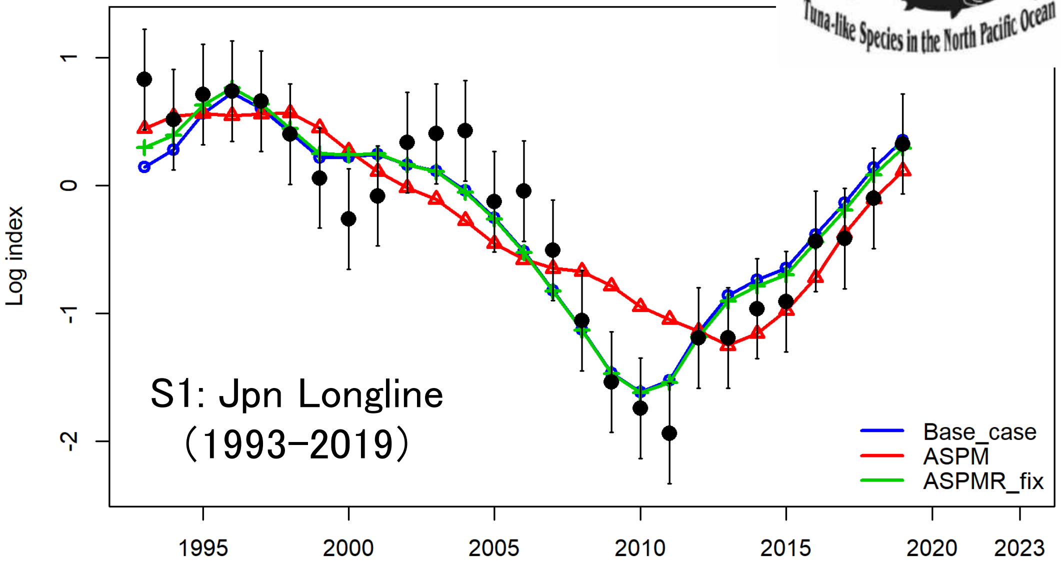
10% Random initial value

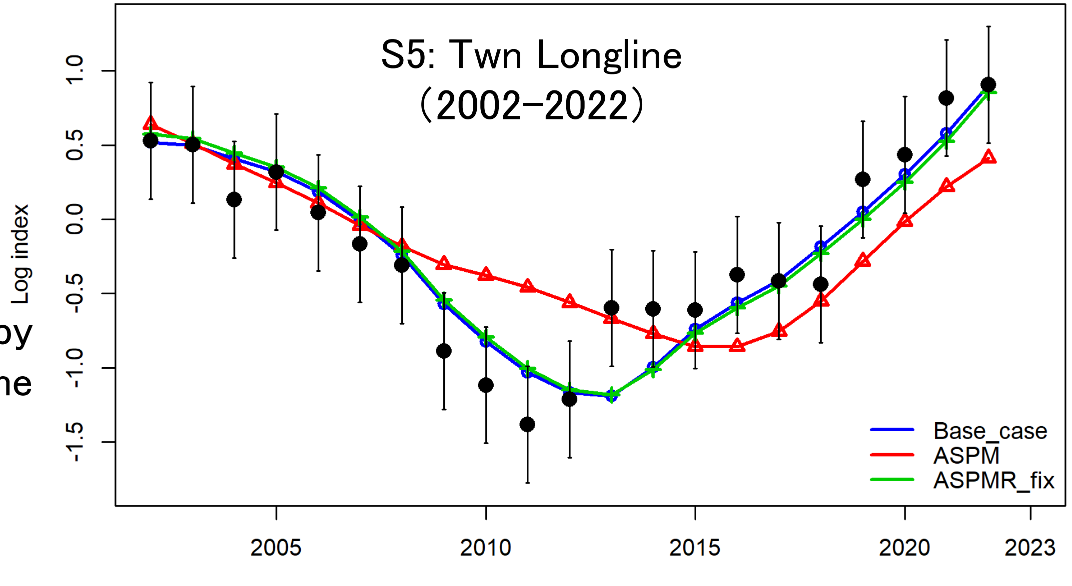


The current base case is the best fit model, and there is no evidence of further improvement.

Age Structured Production Model (ASPM)

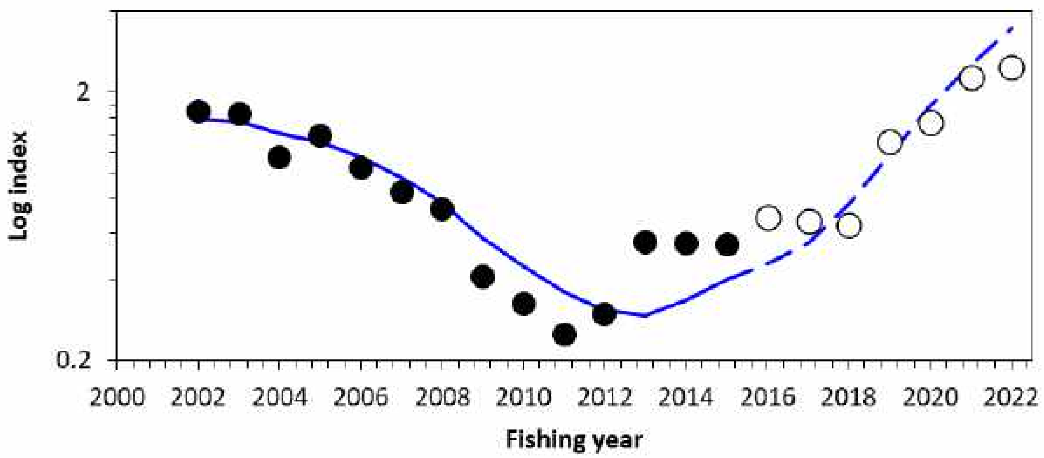
- ASPM (R) diagnostics
  - To evaluate the consistency between the catch and index observations under the specified productivity assumption.
  - The model fitted to the catch and adult indices only.
  - No recruitment deviation (ASPM) or specified recruitment deviations at those estimated by the base-case (ASPM-R).
- Results
  - ASPM could depict general trends of spawner indices.
    - ✓ The production model effect (net effect of growth, M, recruit, and catch) can provide information of the population scale.
    - ✓ This is a rationale to prioritize the goodness-of-fit to those spawner indices in this assessment.
  - ASPM-R improved the fits to spawner indices.
    - ✓ Specified recruitment deviations, which were mainly informed by the recruitment index in the full model, were consistent with the production model effect in the model.
    - ✓ Recruitment index would provide consistent information about recruitment with the spawner indices.





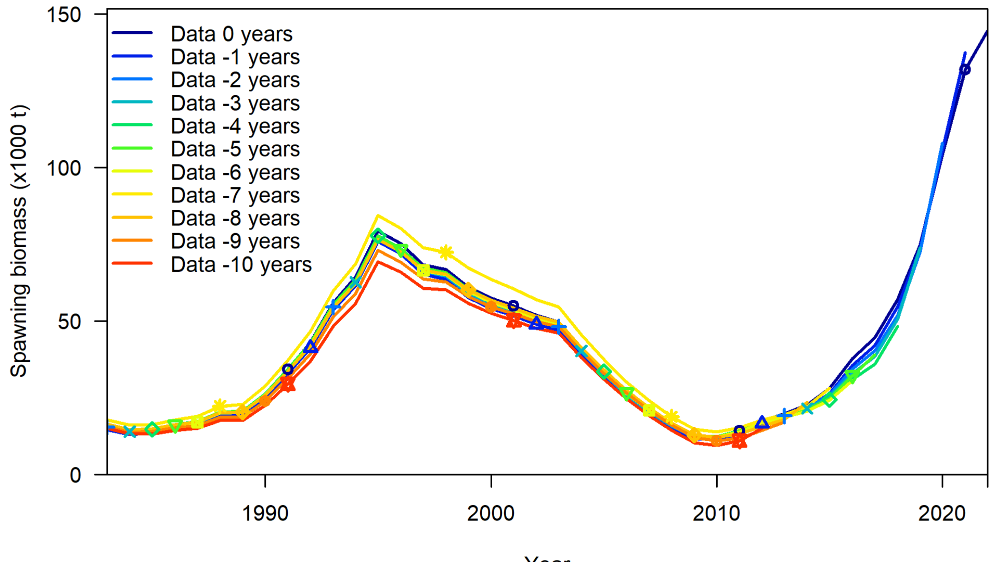
Hind-casting using the ASPM model

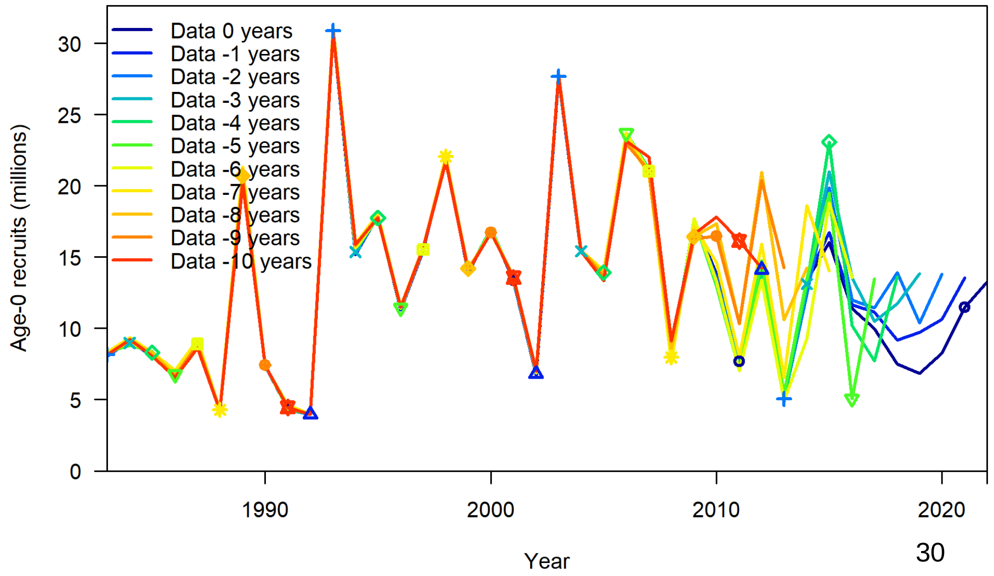
- A 7-year hindcasting diagnostics
  - Hind-casting a past 7-year (a generation time) based on a 7-year retrospected model.
  - Assessment period is the fully integrated model, where the forecasting period is the ASPM (no recruitment variation, time invariant selectivity).
  - The assessment model that worked well in the past and predicted the past well indicates that the assessment model has a good prediction skill.
- Results
  - A 7-years hindcasting model using ASPM could predict the past 7 years (from 2016 to 2022) trend of the Twn LL indices with good contrast.
  - The PBF assessment model has a good prediction skill because it uses a production function that can accurately describe the average effects of catch-at-age on abundance over a range of stock sizes.



Retrospective analysis

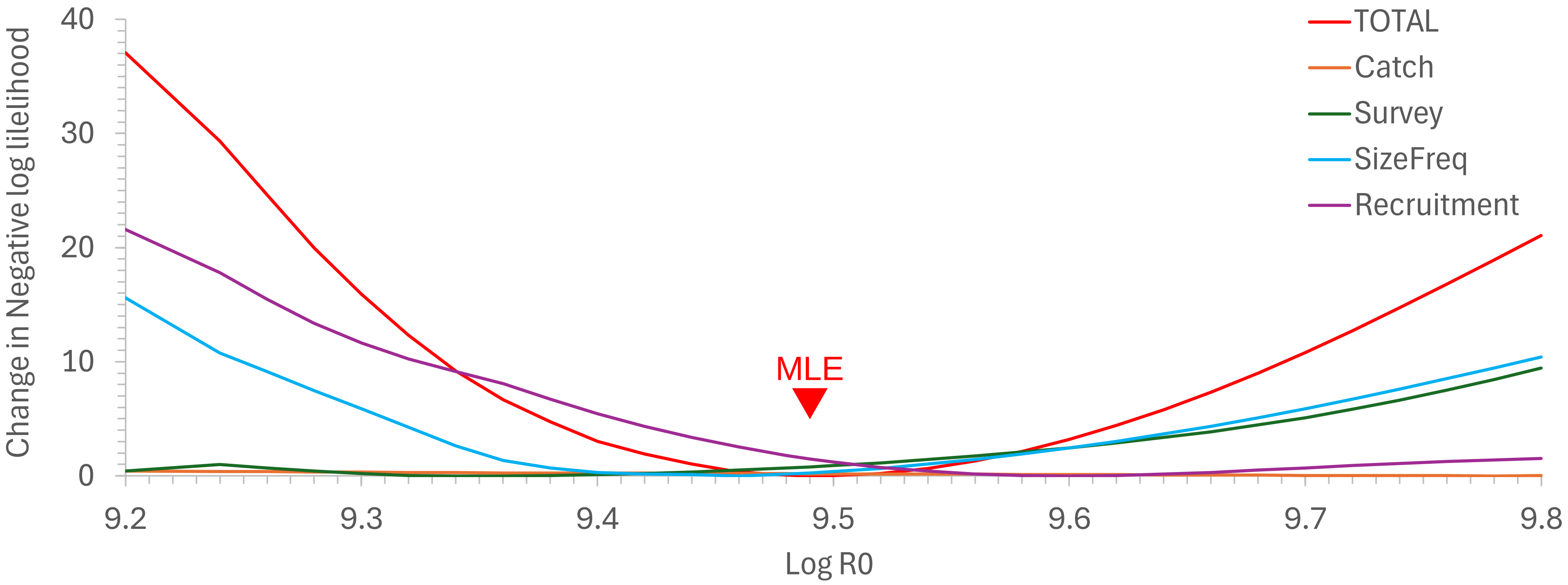
- Retrospective analysis showed a highly consistent estimation of terminal SSB over the past 10 years, with Mohn's rho = −0.06.
- This is a focal point for improvement in the previous assessment, and the PBFWG successfully resolved the negative systematic retrospective pattern by reducing the residuals for the size composition data and eliminating the recruitment index during 2011–2016.
- For recruitment, each data peeling run showed higher and lower terminal recruitments than those estimated by the full data series model.
  - The absence of the recruitment index during 2011–2022 might cause instability in some terminal recruitment estimates.



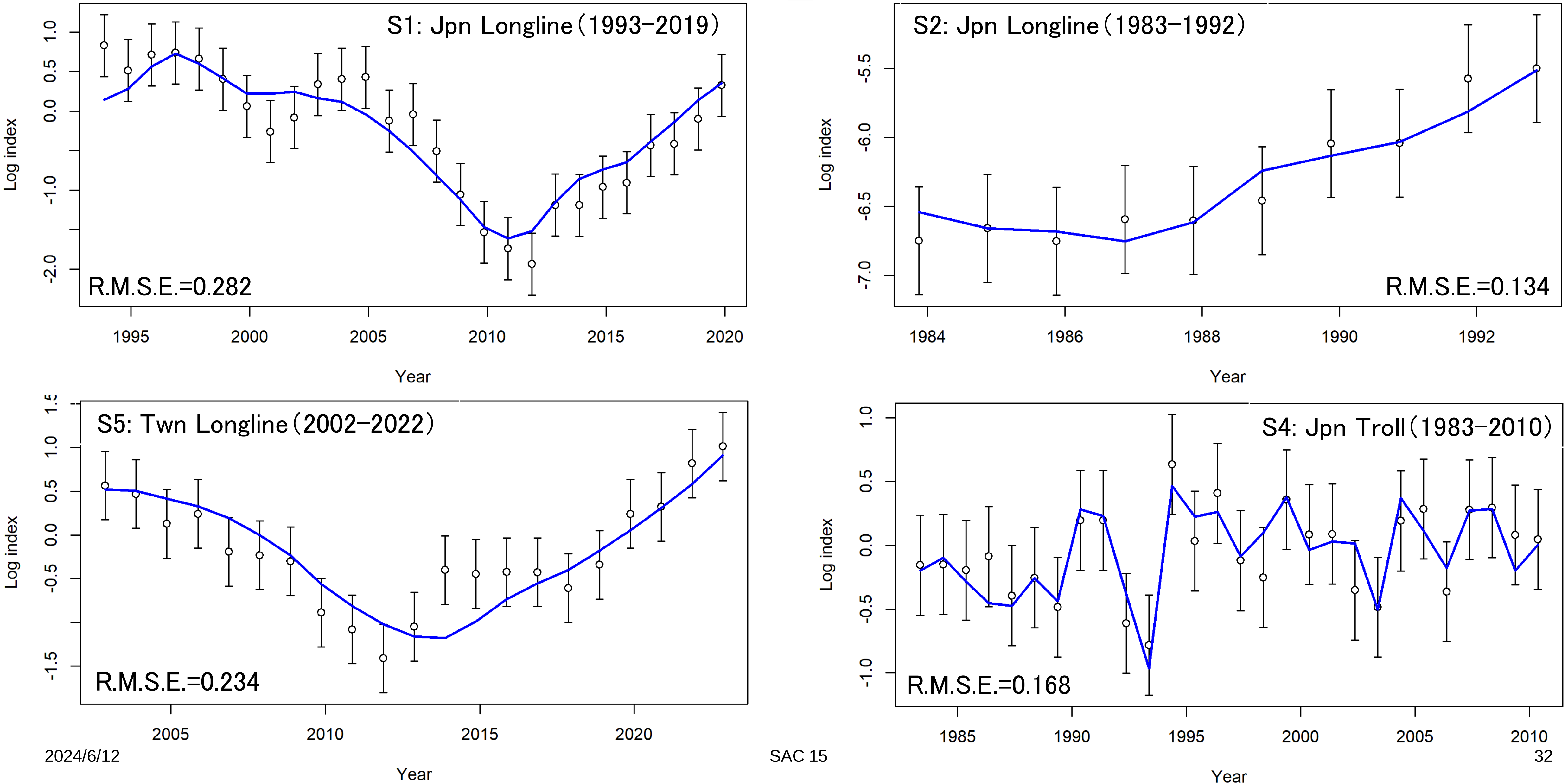


Likelihood profiles over fixed scaling parameter

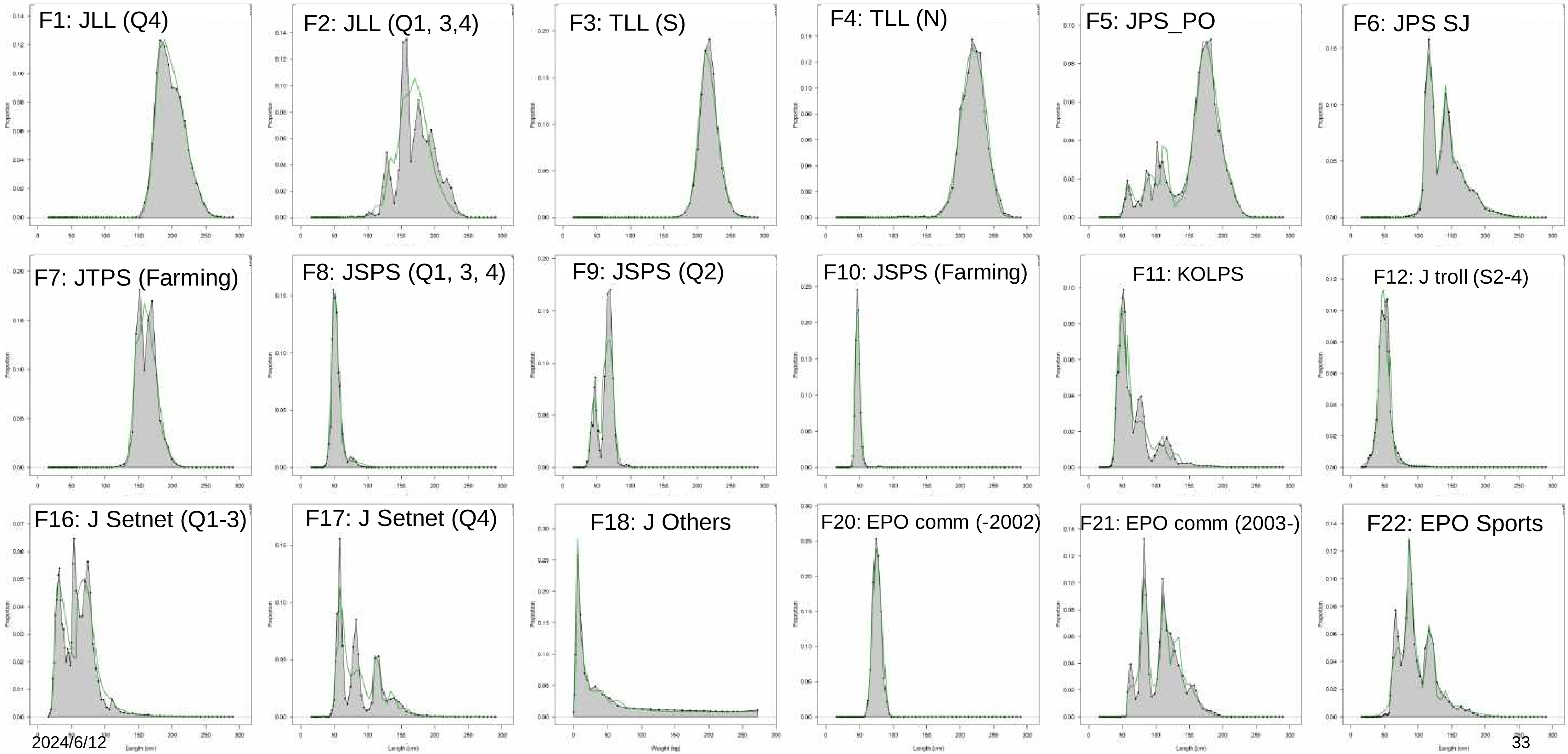
- Each component marked the lowest likelihood at the range of maximum likelihood estimate (MLE) of Log R_0 (9.49).
  - All likelihood components showed very low likelihood values (< 1.5 units) at the log R0 value of MLE.
    - ✓ The base-case model have the desirable property of being internally consistent regarding population scale.



Goodness of fit to Abundance index



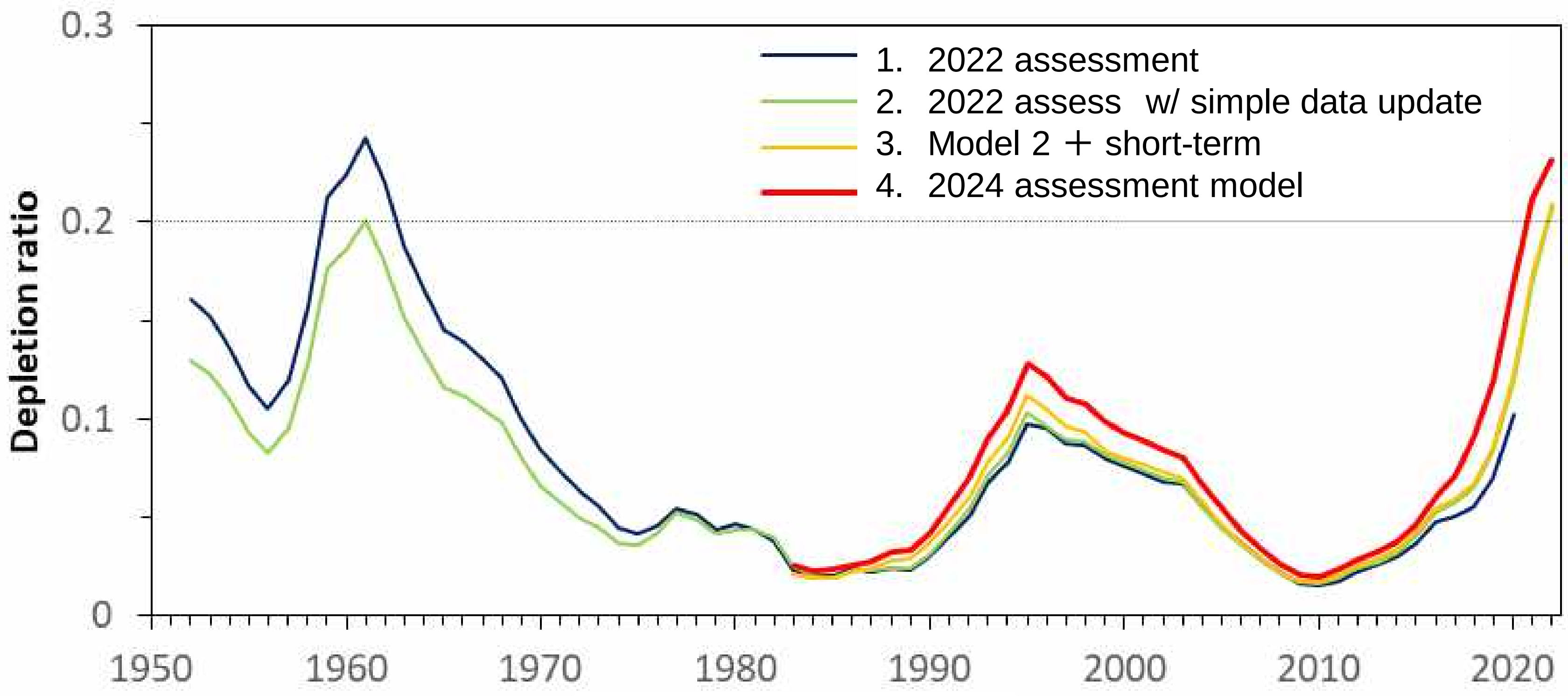
Average fits to the size composition data



4. Assessment Results

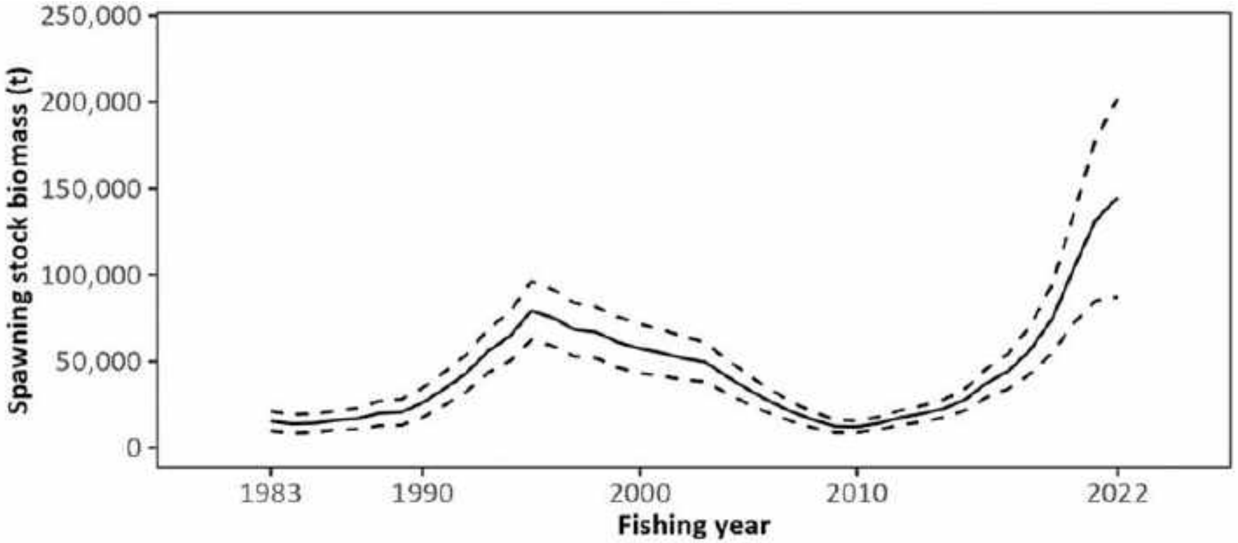
Results: Bridging analysis

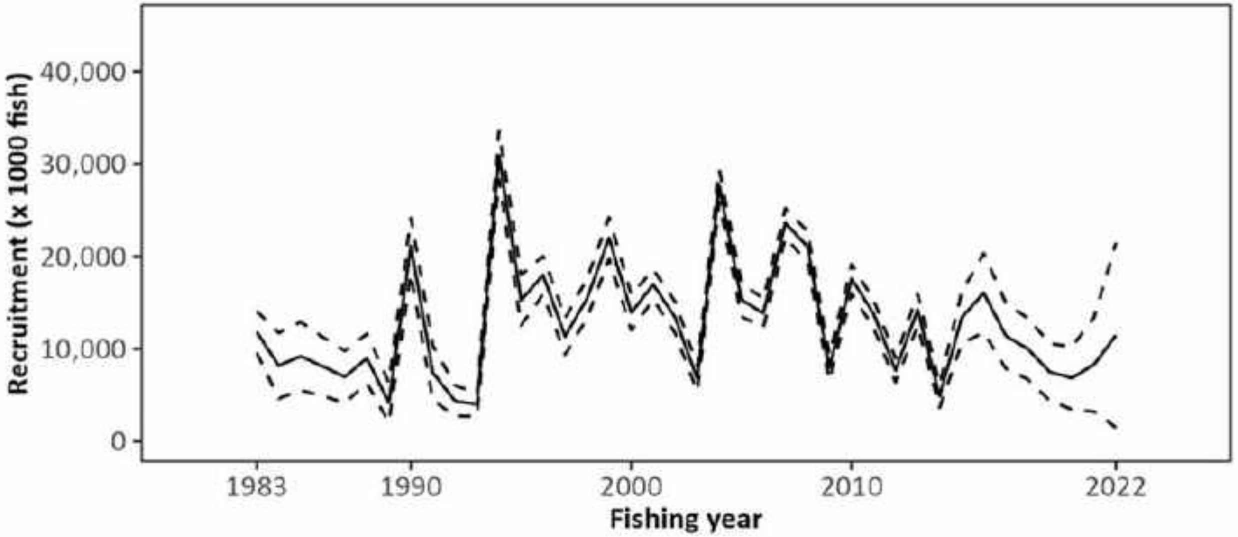
- Simple 2 years data update showed a rapid recovery to the level higher than 20%SSB0.
- Changing the model start year did not affect to the estimated trend of SSB.
- The 2024 base-case showed a slightly higher SSB than Model 3.
  - ✓ The model has been revised to reduce the pessimistic retrospective bias seen in the 2022 stock assessment, justifying the slightly higher SSB in the 2024 base-case.



Results: Biomass time series

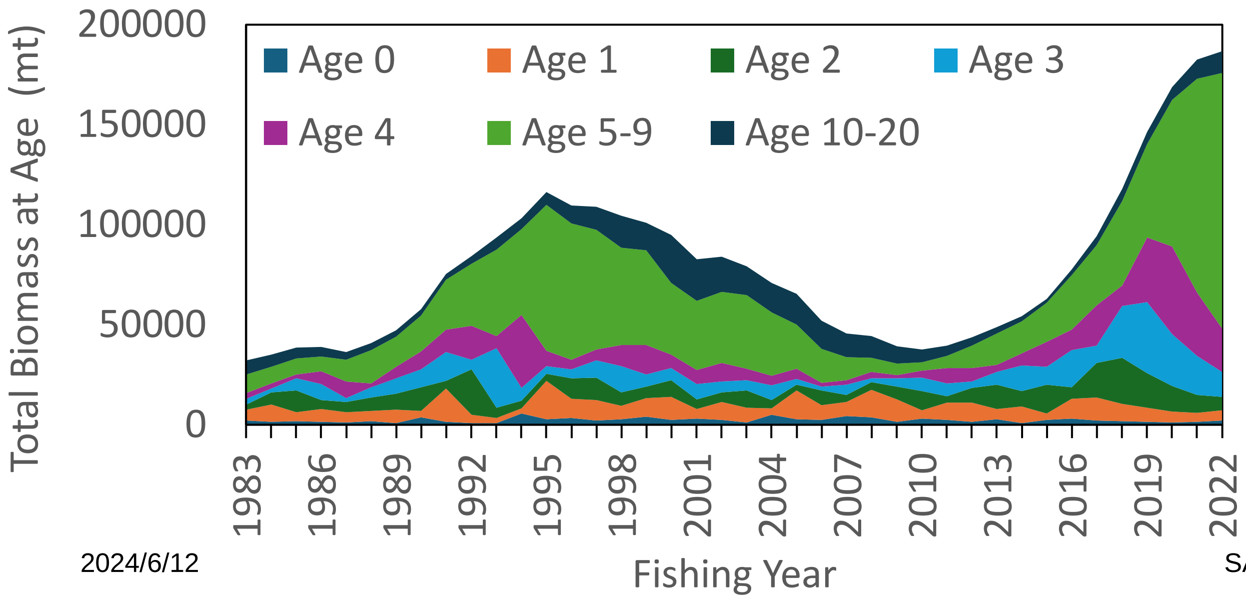
- SSB declined from 1996 to 2010 and has increased since 2011.
  - SSB at 2022 was about 144,000 mt (23.2% of SSB0).
  - Achieving the 2nd rebuilding target ($20\%SSB_0$) in 2021.
  - Relatively large confidence interval in a couple of terminal years.
- Recruitments have fluctuated since 1983.
  - 2016 year-class was estimated to be high.
  - Relatively large confidence interval for 2019–2022.
    - ✓ Lack of reliable recruitment index in the base case model.

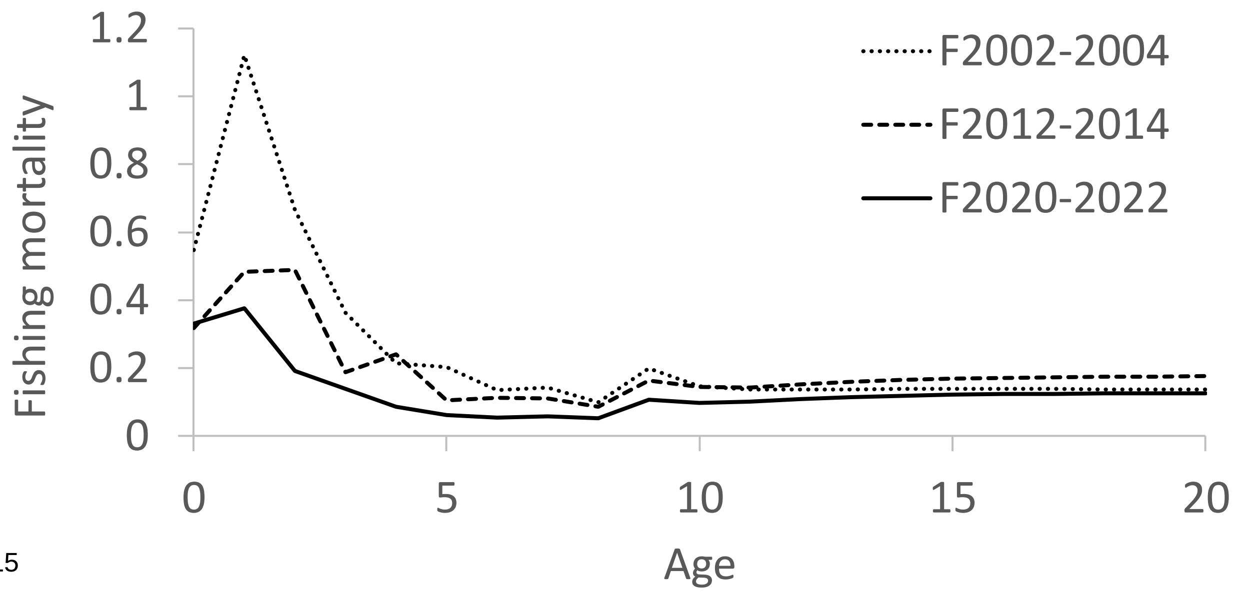




Results：Biomass and Fishing mortality at Age

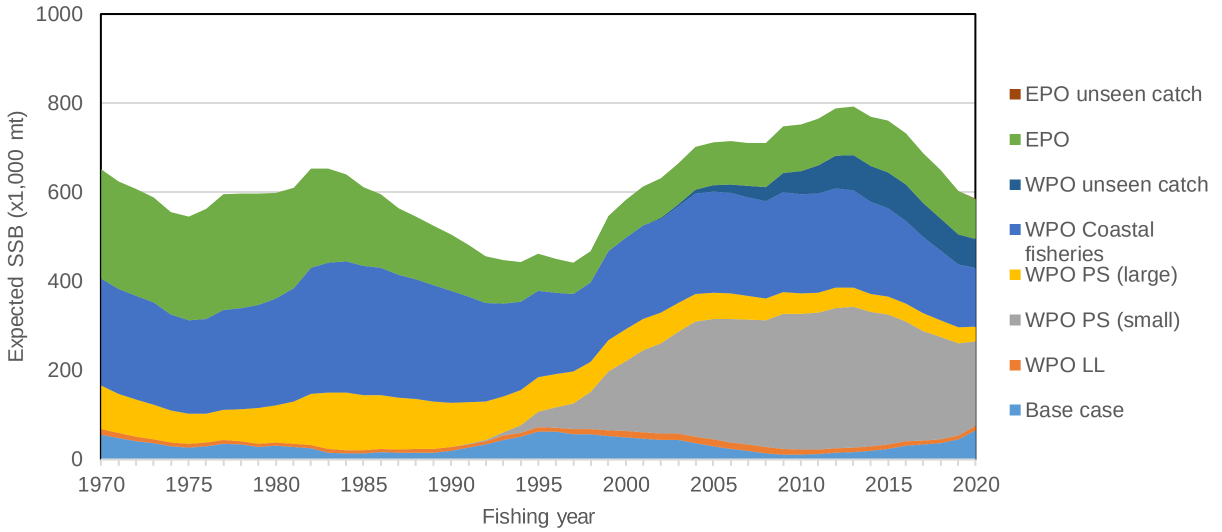
- Historically, the PBF has experienced a high fishing mortality in particular for fish for ages 0–2.
- After 2010, F gradually decreased, coinciding with the implementation of the first catch upper limits on both sides of the Pacific Ocean (2011 in the WCPFC and 2012 in the IATTC).
- A substantial decrease in estimated F-at-Age is observed for most of ages after 2015 when the stricter catch upper limits were implemented.
- An increase in immature fish (0–3 years old) is observed in 2016–2019, likely resulting from reduced fishing mortality on this age group. This led to a substantial increase in SSB after 2019.

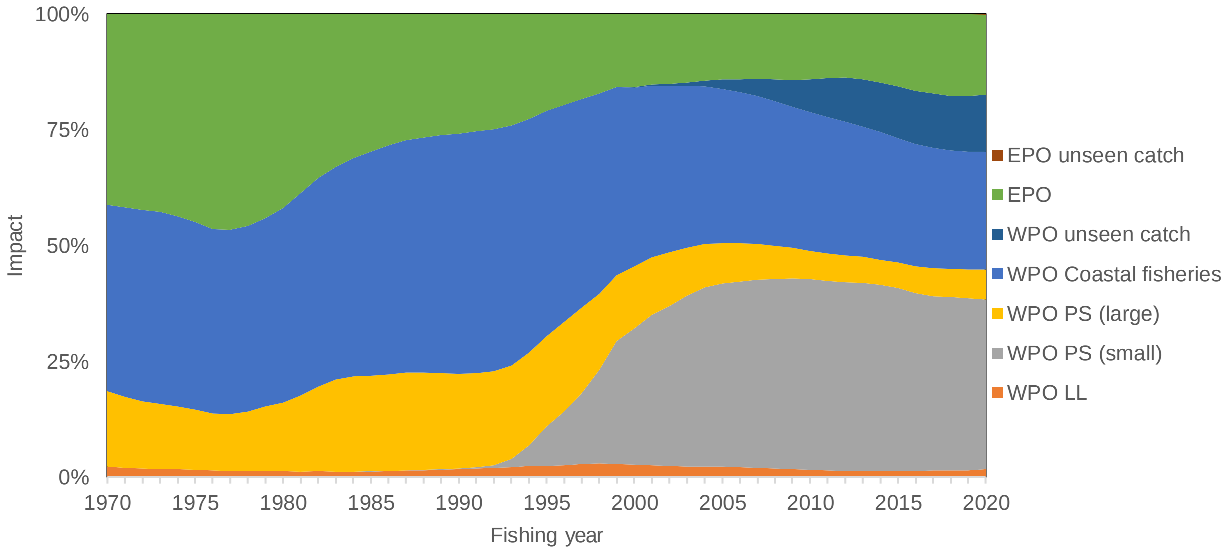




Results: Fishery Impact plot

- The impact of the EPO fisheries group was large before the mid–1980s, decreasing significantly thereafter.
- From the mid–1980s to the late 1990s, the WPO coastal fisheries group has had the greatest impact on the PBF stock.
- Since the introduction of the WPO purse seine fishery group targeting small fish (ages 0–1), the impact of this group has rapidly increased, and the impact in 2020 was greater than any of the other fishery groups.
- The WPO longline fisheries group has had a limited effect on the stock throughout the analysis period.
- In 2020, the estimated cumulative impact proportion between WPO and EPO fisheries is about 83% and 17%, respectively.

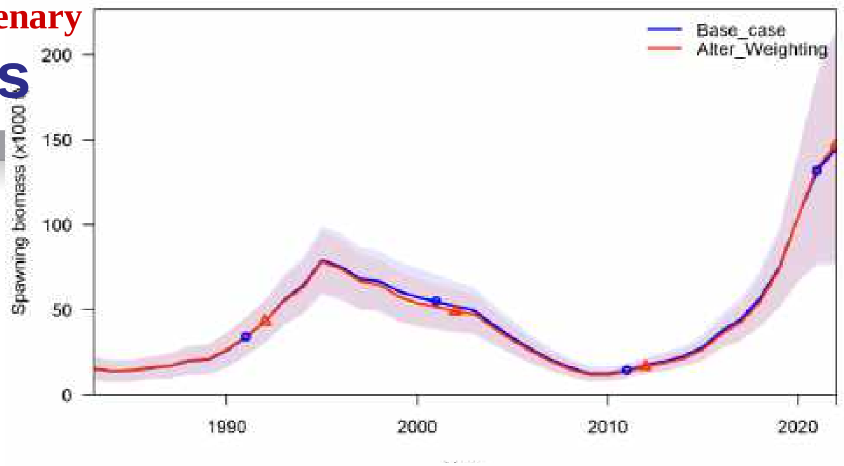


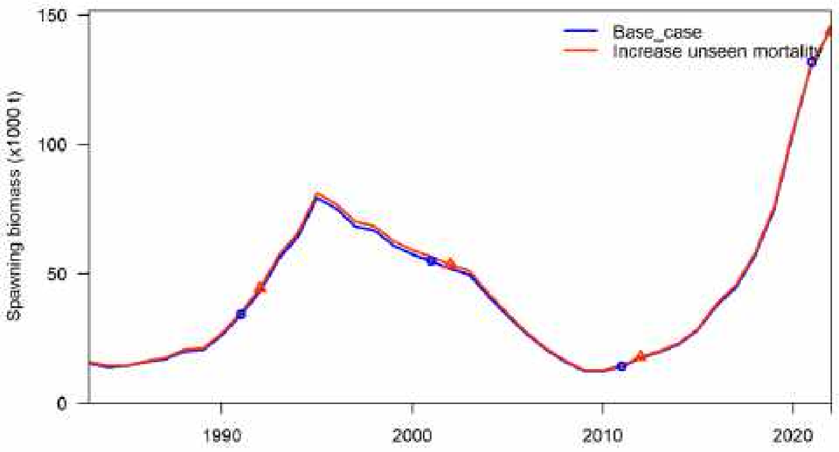


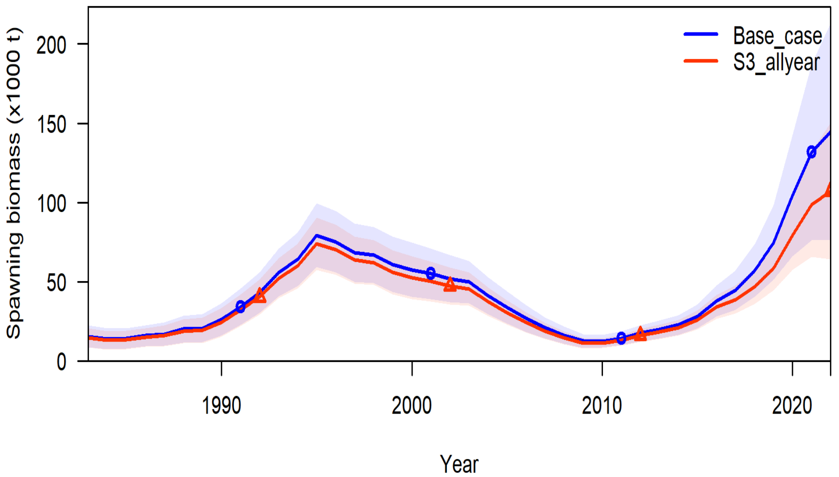
5. Sensitivity Analysis

Sensitivity runs for alternative observation processes

- Alternative data weighting
  - The harmonic mean of EffN in each fleet was all higher than those input sample size, further down-weighting for the size comps, which had a high gradient in the R0 profile, was tested.
  - The base-case model was robust to the additional down weighting to the size composition data.
- Increased unseen mortality
  - The base-case model was robust to the higher unseen mortality (two-times unseen catch).
- Fitting to the Recruitment index for 2011-2016
  - A sensitivity run fitting to the recruitment index (S3) for entire time-series (1983-2016) was tested.
  - This model estimated lower recruitment levels in 2013-2022, resulting in lower estimated SSB at the terminal year.
    - ✓ The base-case fits better than this sensitivity to the LL index.
    - ✓ This confirms a pessimistic bias of the index for eliminated period.

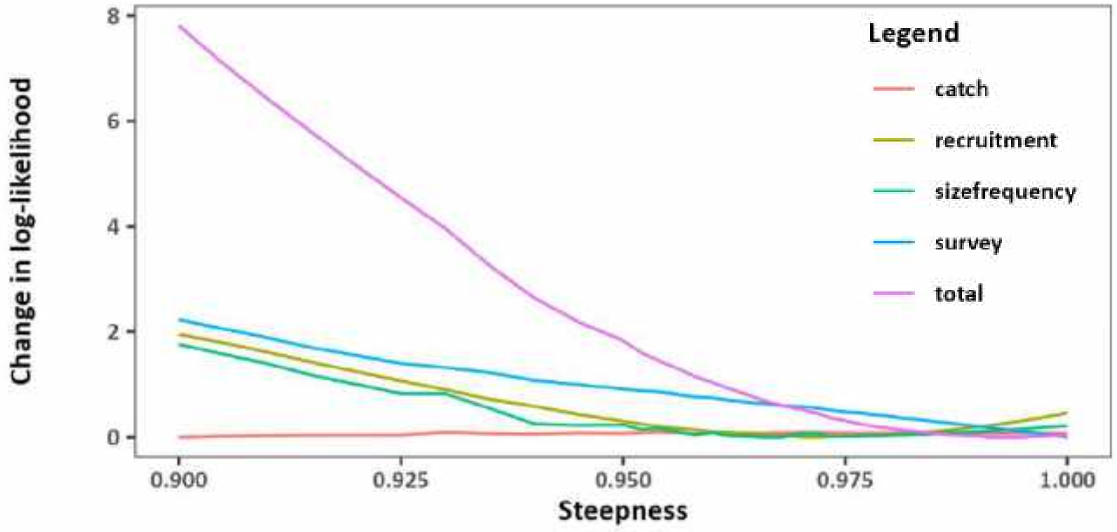


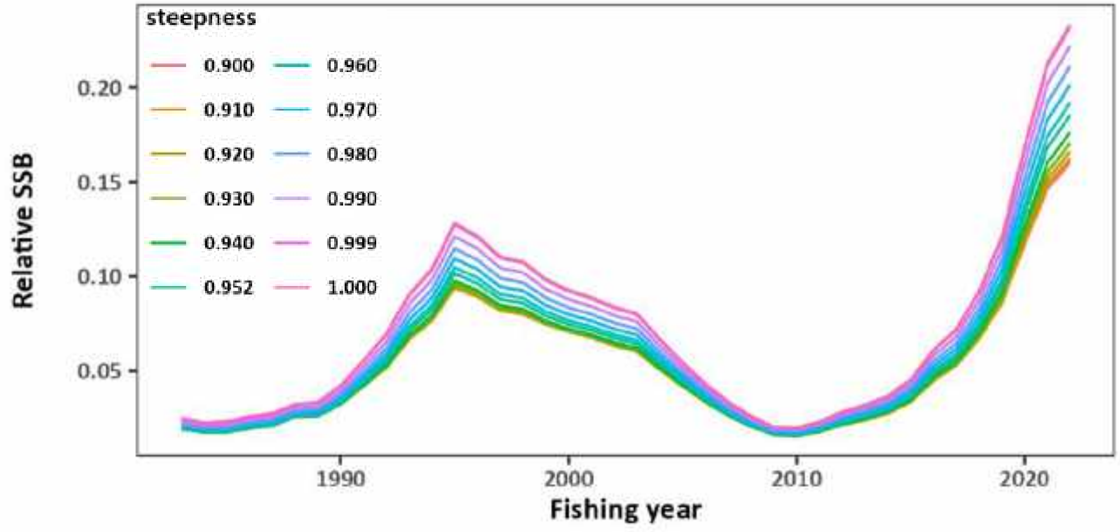




Sensitivity runs for alternative system dynamics processes

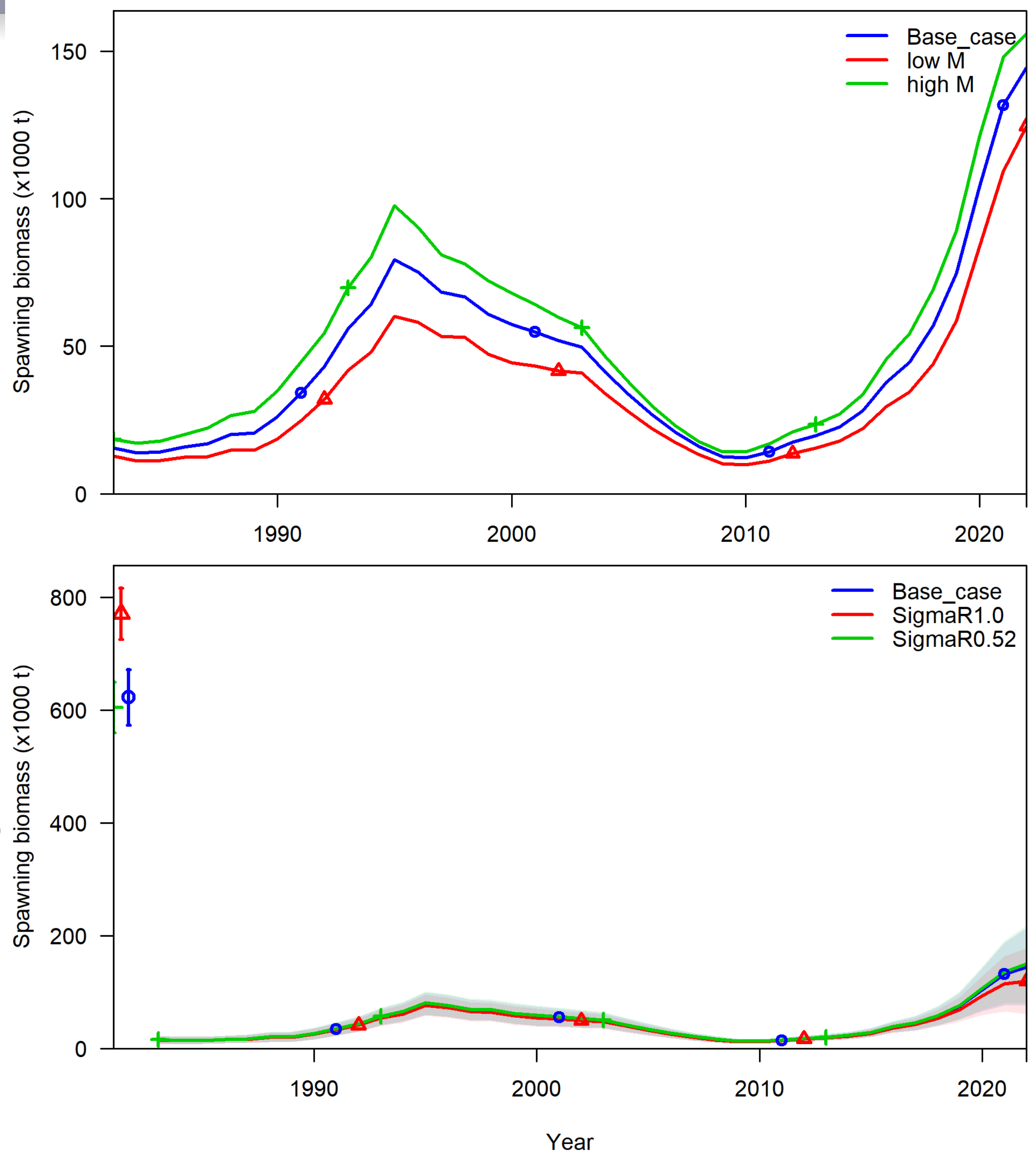
- Steepness
  - The total likelihood had the lowest value at around 0.99 and the improvement in the NLL was marginal.
  - Both size compositions and recruitment penalty components showed informative gradients on both low and high sides of the steepness, with the lowest NLL value at around 0.97.
  - CPUE component showed a one-way decreasing trend in NLL as steepness increased.
  - In the run with a lower h (h=0.97), where the recruitment penalty component showed the lowest NLL, relative SSB was slightly lower than the base case (20.1%).
  - The PBFWG concluded that further investigation was warranted in this regard, although there was no indication of the critical model misspecification.





Sensitivity runs for alternative system dynamics processes

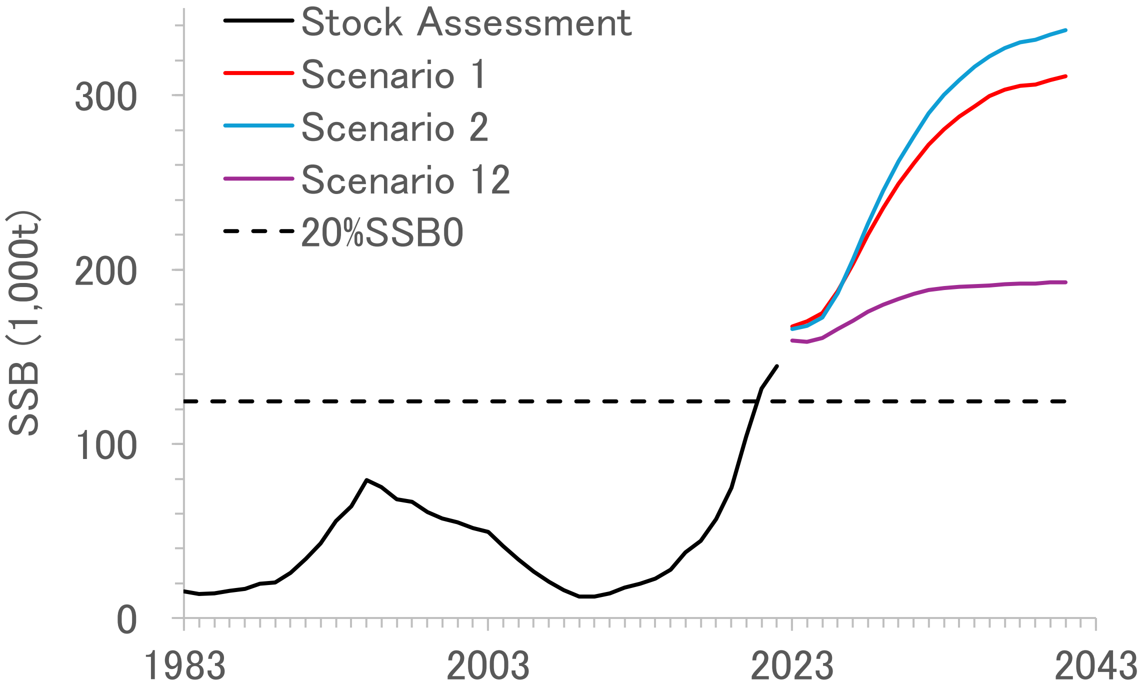
- Natural Mortality
  - 20% higher and lower M for age 2+ resulted in higher and lower relative SSB than the base-case model, respectively, as anticipated.
  - The PBFWG concluded that the current base-case model exhibits insensitivity to the assumptions regarding natural mortality for age 2 and older.
- Expected variation in recruitment (sigma R)
  - A run with higher (1.0) recruitment variation showed an apparently higher NLL (12 NLL units) in the recruitment penalty component than the base case, where a run with a lower recruitment variation (0.52) showed a slightly lower NLL (–1.5 units).
  - Estimated SSB was not sensitive to sigmaR, although the population scale was higher in a run with higher sigmaR.



6. Future projection

Results: projection

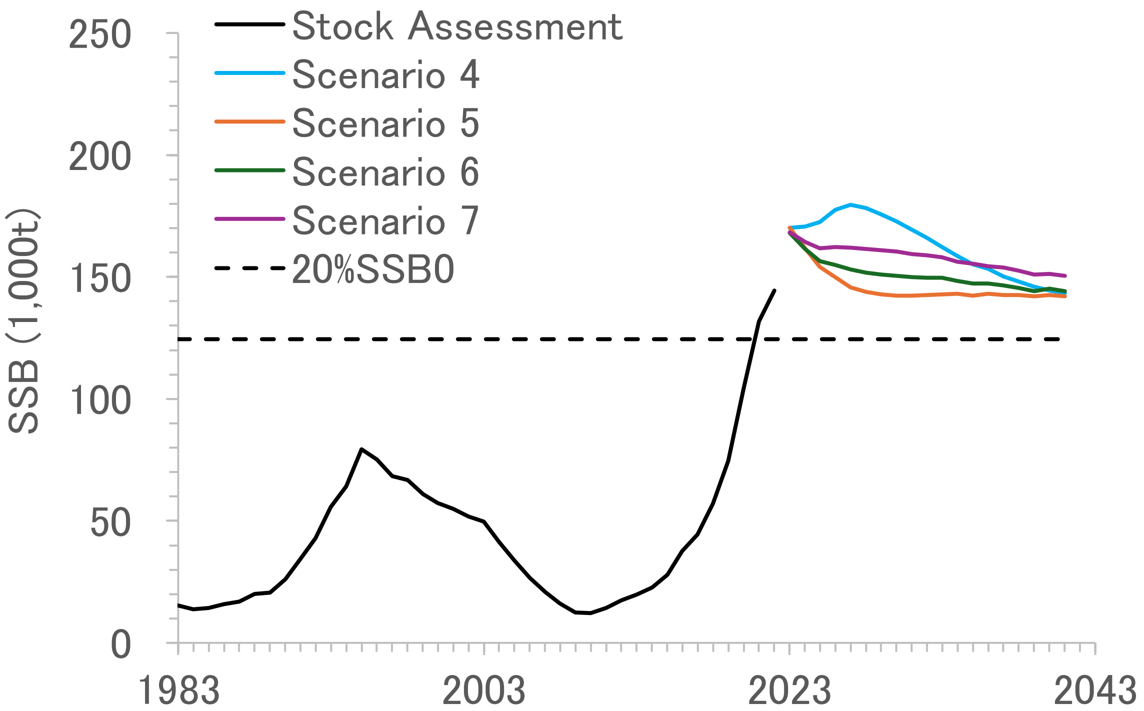
- Status quo (Scenario 1) projects the SSB in 2041 to be higher than 40% of SSB0.
- Scenario 2, which applies the conversion of small fish quota to large fish quota at the current conversion factor of 1.47, projects a similar trend but a higher SSB in 2034.
- Scenario 12, which applies a constant fishing mortality of F30%SPR, shows continuous increase of SSB towards 30%$SSB_{F=0}$ with a higher expected catch in 2034 than that of the status quo scenario.



#	Scenario			Fishery impact ratio (2034)		Probability (stock > 20%SSB0 in 2041)	Expected catch in 2034				
	WCPO		EPO				WCPO		EPO		Total
	Small	Large	Comm	WCPO	EPO		Small	Large	Comm	Sp	
1	Status quo			78%	22%	100%	4,179	8,232	4,011	2,005	18,428
2	1,239 t down	1,940t up	–	77%	23%	100%	3,256	9,895	4,018	2,189	19,358
12	FSPR30%			77%	23%	99%	4,812	19,436	5,668	733	30,649

Results: projection (scenarios achieving 20%SSB_0 with 60% of probability)

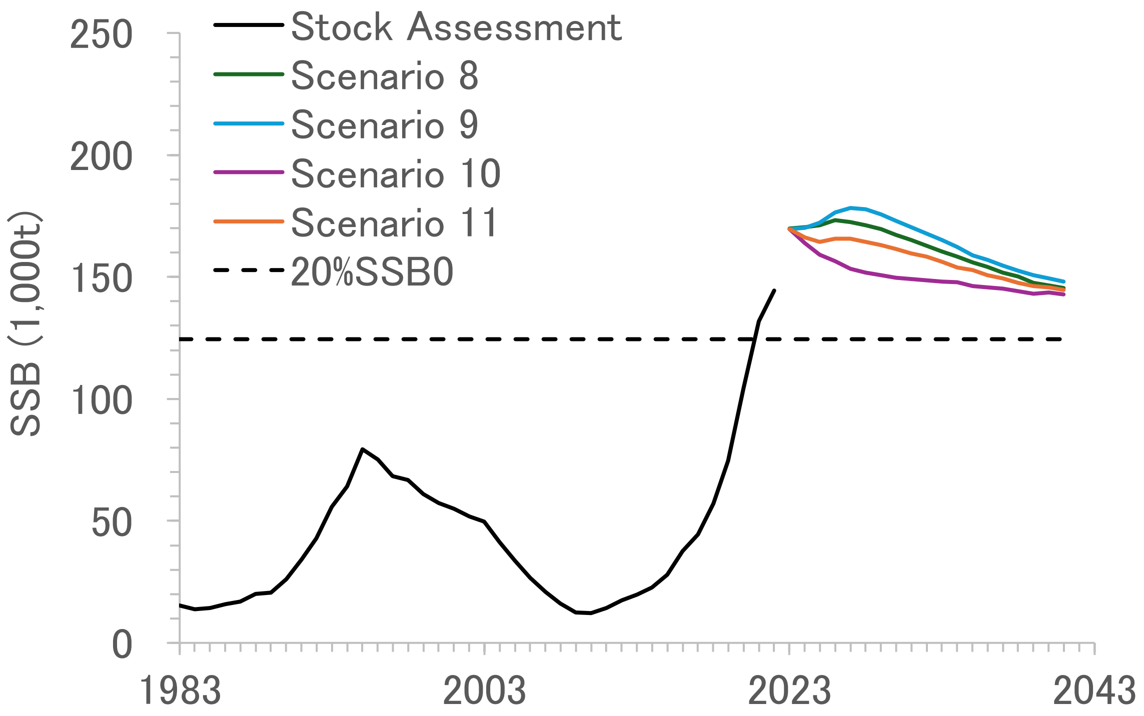
- Scenarios 4–11, which were fine-tuned to achieve the 20%$SSB_{F=0}$ with a 60% probability in 2041, resulted notably more aggressive catch, and those are exhibiting a decreasing trend from a peak biomass in the late 2020s to the end year of the projection.
  - Catching higher amounts of small fish (i.e. scenario 4) resulted in lower total catch in 2041 than that of a scenario catching lower amounts of small fish (i.e. scenario 5).



#	Scenario			Fishery impact ratio (2034)		Probability (stock > 20%SSB0 in 2041)	Expected catch in 2034				
	WCPO		EPO				WCPO		EPO		Total
	Small	Large	Comm	WCPO	EPO		Small	Large	Comm	Sp	
4	60% up	60% up	60% up	82%	18%	61%	6,540	12,969	6,332	926	26,767
5	SQ	180% up	180% up	71%	29%	60%	4,383	20,799	11,224	1,055	37,459
6	20% up	163% up	108% up	78%	22%	60%	5,394	19,989	8,330	1,035	34,749
7	30% up	131% up	92% up	80%	20%	63%	5,739	17,717	7,673	1,026	32,156

Results: projection (scenarios tuning fishery impact ratio between EPO:WCPO)

- Assumed future fishery impact ratio affect the future catch balance between EPO and WCPO.
  - Scenario 8 and 9.



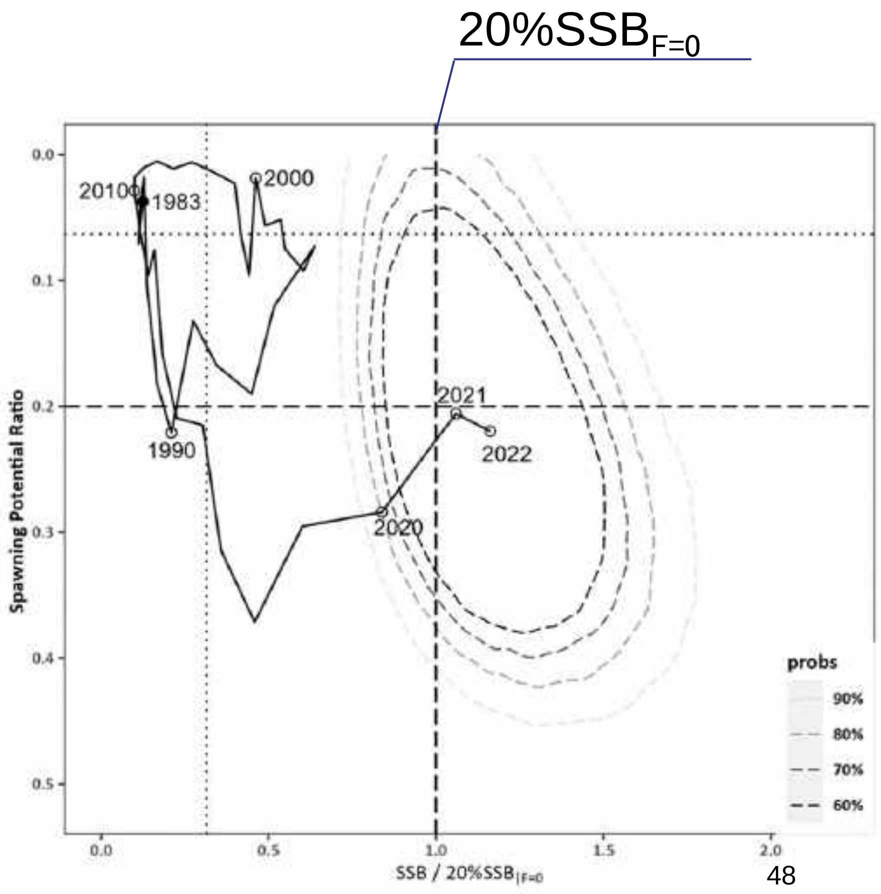
#	Scenario			Fishery impact ratio (2034)		Probability (stock > 20%SSB0 in 2041)	Expected catch in 2034				
	WCPO		EPO				WCPO		EPO		Total
	Small	Large	Comm	WCPO	EPO		Small	Large	Comm	Sp	
8	30% up	30% up	190% up	69%	31%	61%	5,508	10,420	11,556	950	28,434
9	55% up	55% up	80% up	79%	21%	63%	6,620	12,456	7,196	953	27,224
10	10% up	130% up	190% up	70%	30%	60%	4,707	17,667	11,589	1,025	34,989
11	40% up	120% up	80% up	80%	20%	61%	6,006	17,233	7,205	1,000	31,444

7. Stock status and Conservation information

Stock Status

PBF spawning stock biomass (SSB) has increased substantially in the last 12 years. These biomass increases coincide with a decline in fishing mortality, particularly for fish aged 0 to 3, over the last decade. The latest (2022) SSB is estimated to be 23.2% of $SSB_{F=0}$ and the probability to be above $20\%SSB_{F=0}$ is 75.9%. Based on these findings, the following information on the status of the Pacific bluefin tuna stock is provided:

1. No biomass-based limit or target reference points have been adopted for PBF, but the PBF stock is not overfished relative to $20\%SSB_{F=0}$, which has been adopted as a biomass-based reference point for some other tuna species by the IATTC and WCPFC. SSB of PBF reached its initial rebuilding target in 2017, 7 years earlier than originally anticipated by the RFMOs, and its 2nd rebuilding target ($20\%SSB_{F=0}$) in 2021;
2. No fishing mortality-based reference points have been adopted for PBF by the IATTC and WCPFC. The recent (2020-2022) F%SPR is estimated to produce a fishing intensity of 23.6%SPR and thus the PBF stock is not subject to overfishing relative to some of F-based reference points proposed for tuna species, including SPR20%.

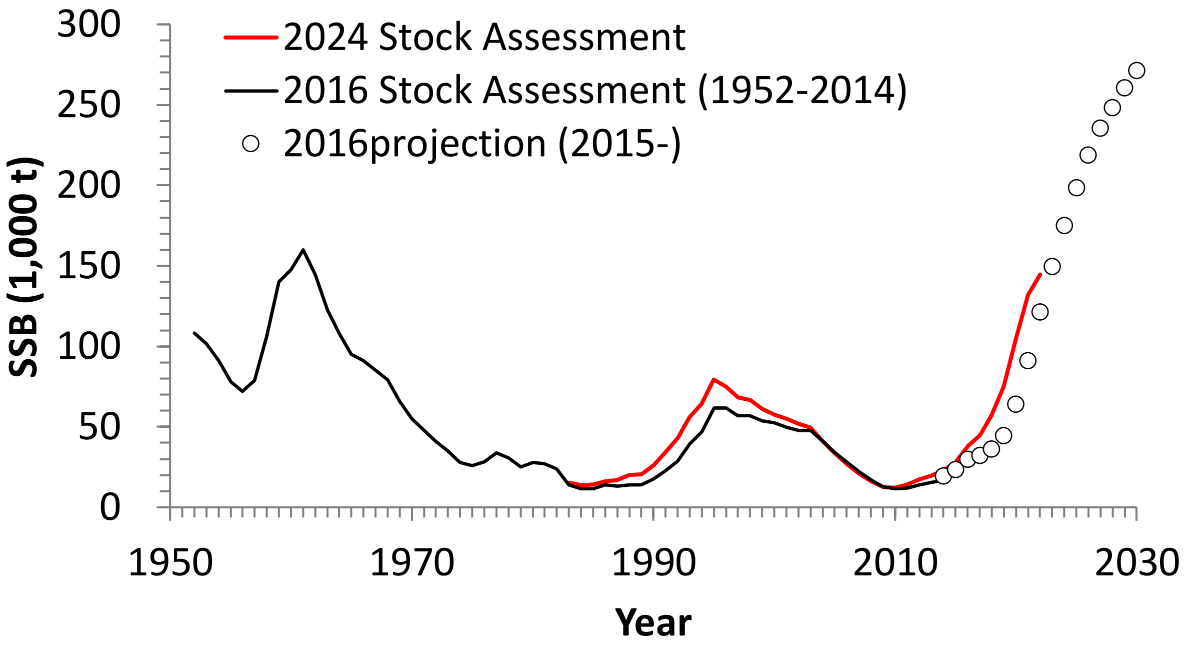


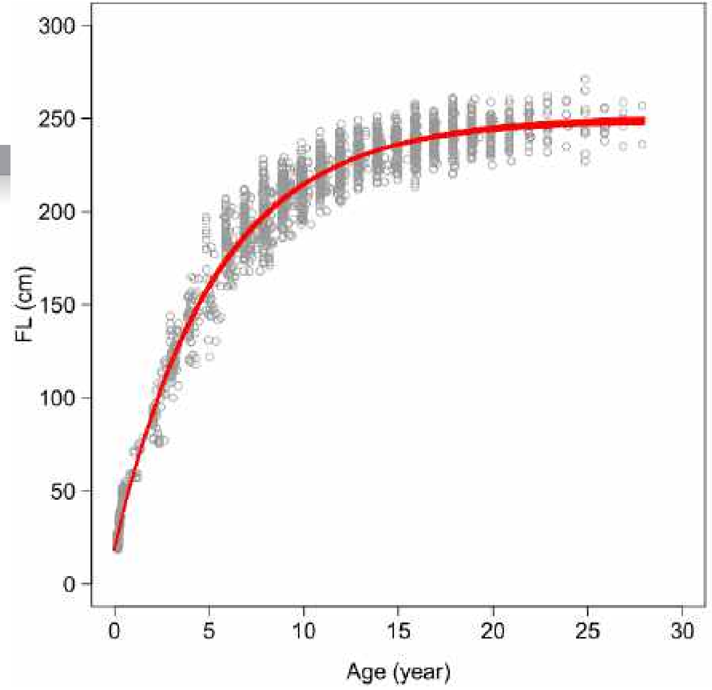
Conservation information

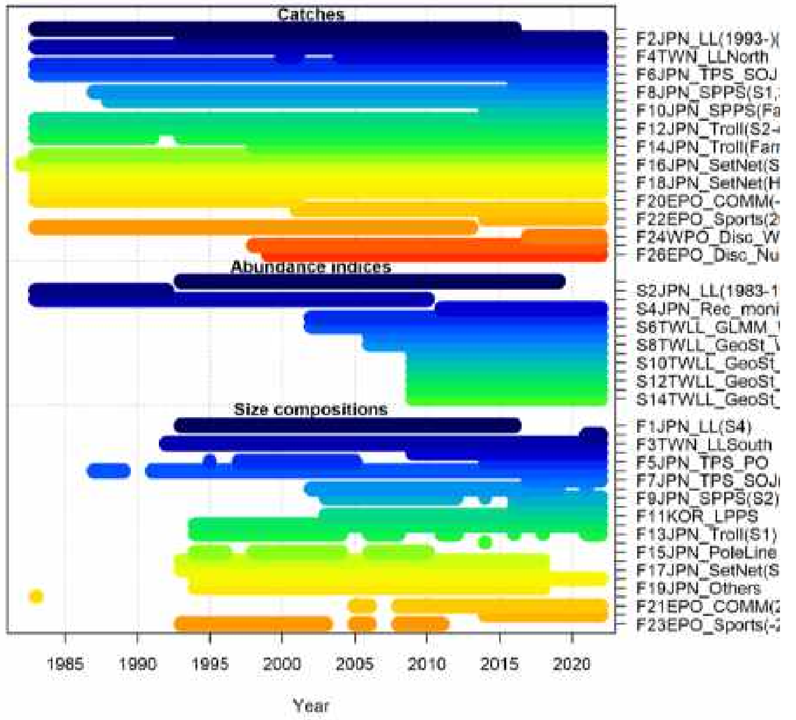
1. The PBF stock is recovering from the historically low biomass in 2010 and has exceeded the second rebuilding target (20%$SSB_{F=0}$). The risk of SSB falling below 7.7%$SSB_{F=0}$ at least once in 10 years is negligible;
2. The projection results show that increases in catches are possible, but the risk of breaching the second rebuilding target will increase with larger increases in catch;
3. The projection results assume that the CMMs are fully implemented and are based on certain biological and other assumptions. For example, these future projection results do not contain assumptions about discard mortality. Discard mortality may need to be considered as part of future increases in catch; and
4. Given the uncertainty in future recruitment and the influence of recruitment on stock biomass as well as the impact of changes in fishing operations due to the management, monitoring recruitment and SSB should continue. Research on a recruitment index for the stock assessment should be pursued, and maintenance of a reliable adult abundance index should be ensured. In addition, accurate catch information is the foundation of good stock assessment.

Epilogue

- Another benchmark assessment was completed.
  - ✓ Maintaining its consistency with the past assessments.
- High prediction skill is based on the production function.
- Consistent and comprehensive data collected by the members.
- Powerful tool for the management decision making.







Thank you

The PBFWG group photo with YUKIO TAKEUCHI in Feb 2012.
YUKIO passed away on July 21, 2023, at the age of 54.
The PBFWG mourns the loss of a dedicated professional who made significant contributions to the WG.