9th Joint IATTC-NC Working Group on PBF management

Agenda 3.1 Updates on the stock status of Pacific bluefin tuna

Report on 2024 PBF stock assessment (JWG09-IP-01)

Hiromu Fukuda

ISC PBF WG

9th JWG on PBF management

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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)

2024 stock assessment of Pacific bluefin tuna

❖ 2024 PBF stock assessment was conducted by the ISC PBFWG.

- Benchmark stock assessment.
- Data and model preparation meetings were held in Nov. 2022 and Mar. & Nov. 2023.
- Assessment meeting was held in March 2024@Kaohsiung.
- 24th ISC plenary (June 2024@Victoria) reviewed and adopted the assessment report (JWG09-IP-01) as the Best Available Scientific Information on the PBF stock.

Topics of the presentation

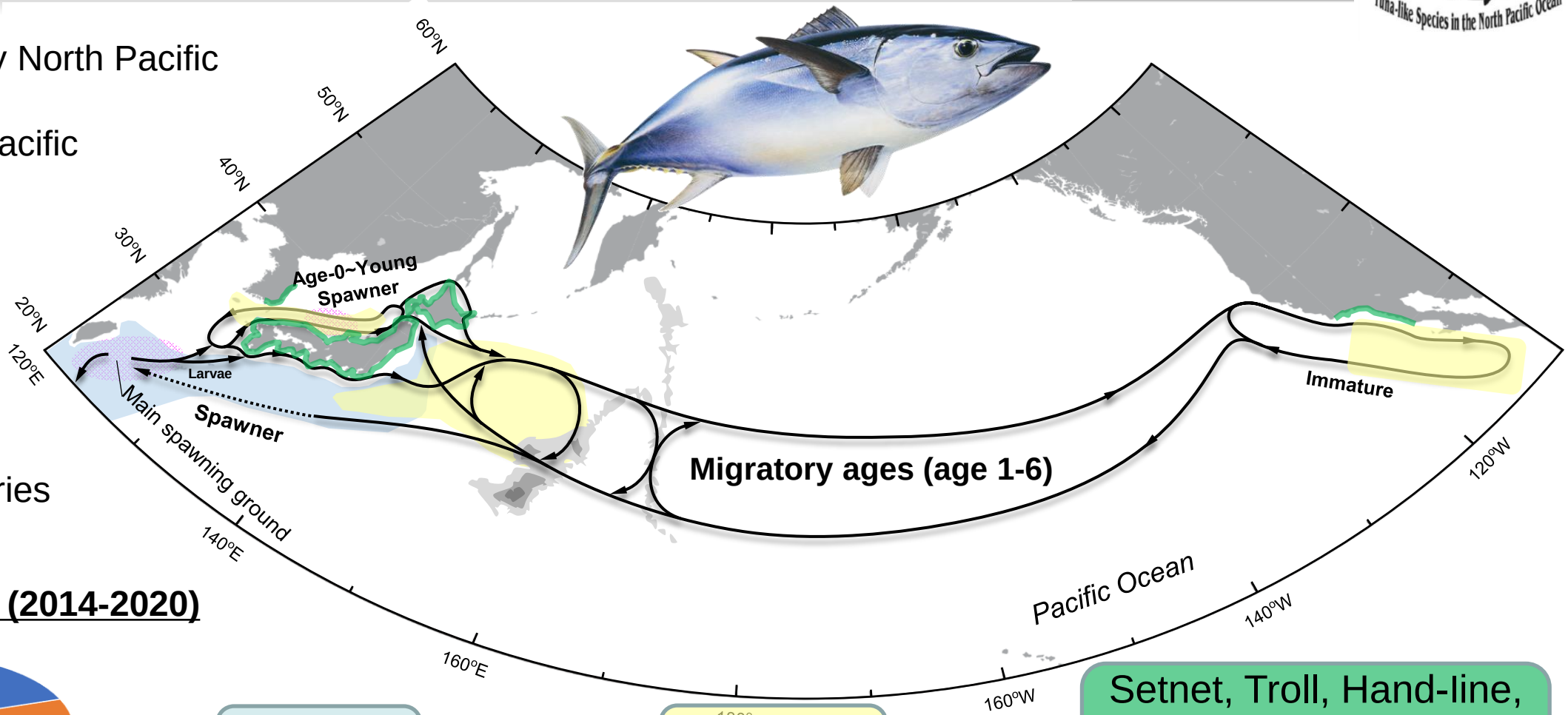
1. Assessment modeling and Data
2. Model diagnostics
3. Assessment results
4. Future projection
5. Stock Status and Conservation information

A conceptual model of Pacific bluefin tuna Dynamics

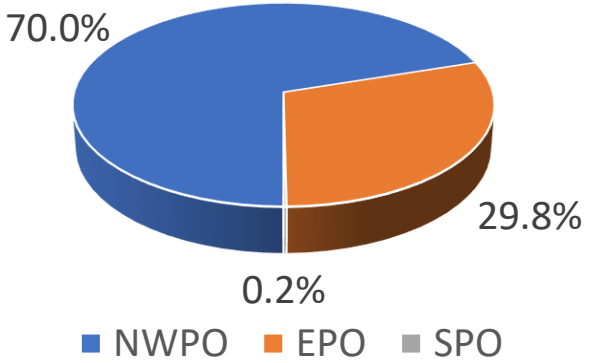
Migration; Mainly North Pacific
Age 0:NWPO
Age 1-6: North Pacific
Age 7-: NWPO

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

Challenges for the 2024 PBF stock assessment modeling

1. To solve the convergence issue with an alternative productivity assumptions.
   - The 2022 model showed an inflexibility to change in steepness (Only $\boldsymbol{h} \geq 0.99$).
   - This inflexibility made difficult to account the structural uncertainty for steepness.
     - ✓A potential problem for the PBF MSE work.
2. To reduce systematic retrospective pattern in the SSB.
   - The 2022 model showed a pessimistic pattern in the retrospective diagnostics.
   - Robust estimate of SSB is particularly important for this assessment.

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

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 (up to June 2023) (Kwon et al. 2024, Dreyfus & Betancourt 2024, etc).
  - Shortened recruitment index time series (Fukuda et al. 2023).
  - Newly available size comp and catch data (Nishikawa & Fukuda 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).

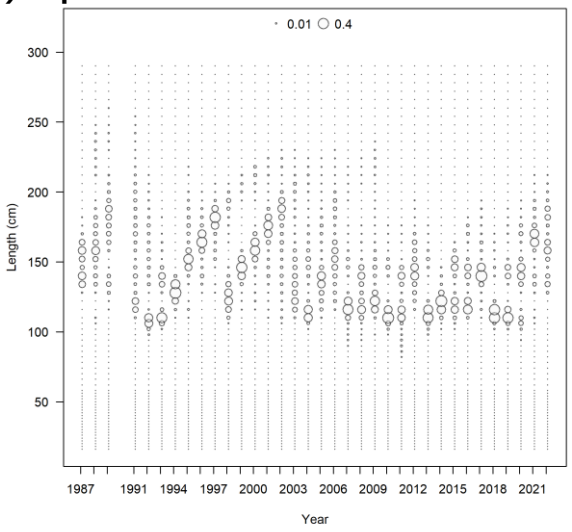
Model configurations

- Population Dynamics model
  - Growth and Length–weight relationship
    - ✓ v–Bertalanffy growth function estimated from 1,782 age at length data covered ages 0–28.
  - Maturity and Stock Recruitment Relationship
    - ✓ 20%, 50%, and 100% maturity at ages 3, 4, 5 and older based on the histological study.
    - ✓ Beverton–Holt SRR (h = 0.999; estimated from life history information).
    - ✓ 0.6 of standardized deviation for the average recruitment deviation (SigmaR).
  - Age specific Natural mortality
    - ✓ Based on the tagging study (age 0), other bluefin tuna data (age 1), and a suite of empirical and life–history based methods (age 2 and older fish).
- 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

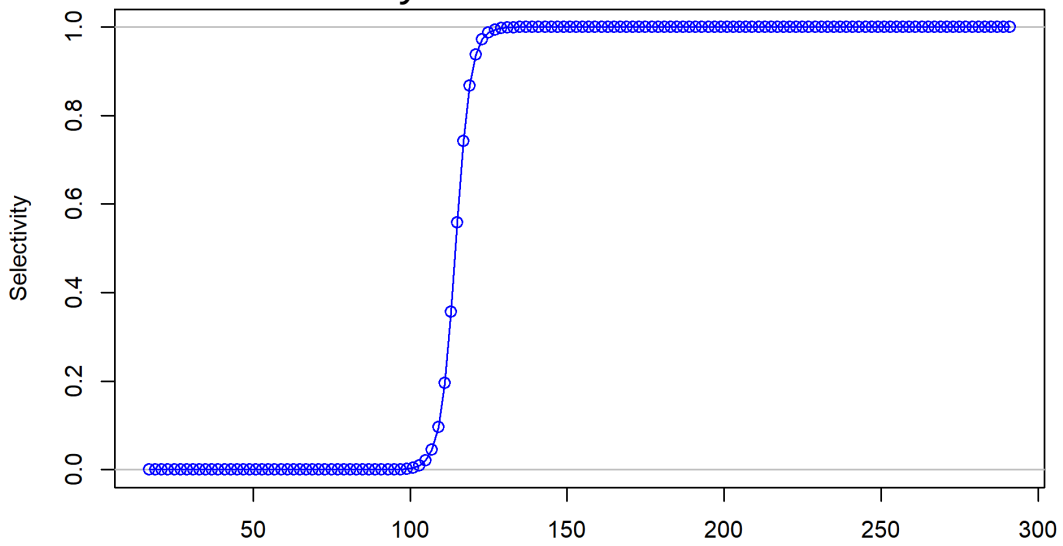
Area as Fleet Approach with time varying selectivity

- ❖ 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.

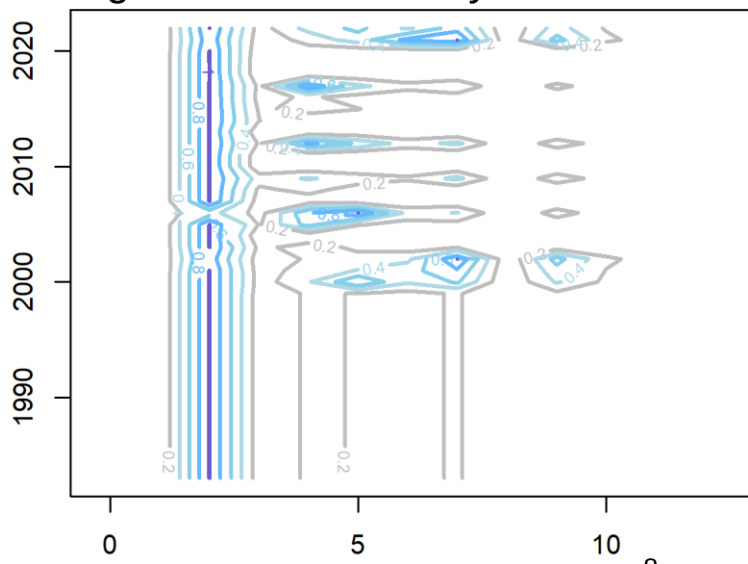
ex.) Jpn tuna Purse seine in SOJ



Gear selectivity

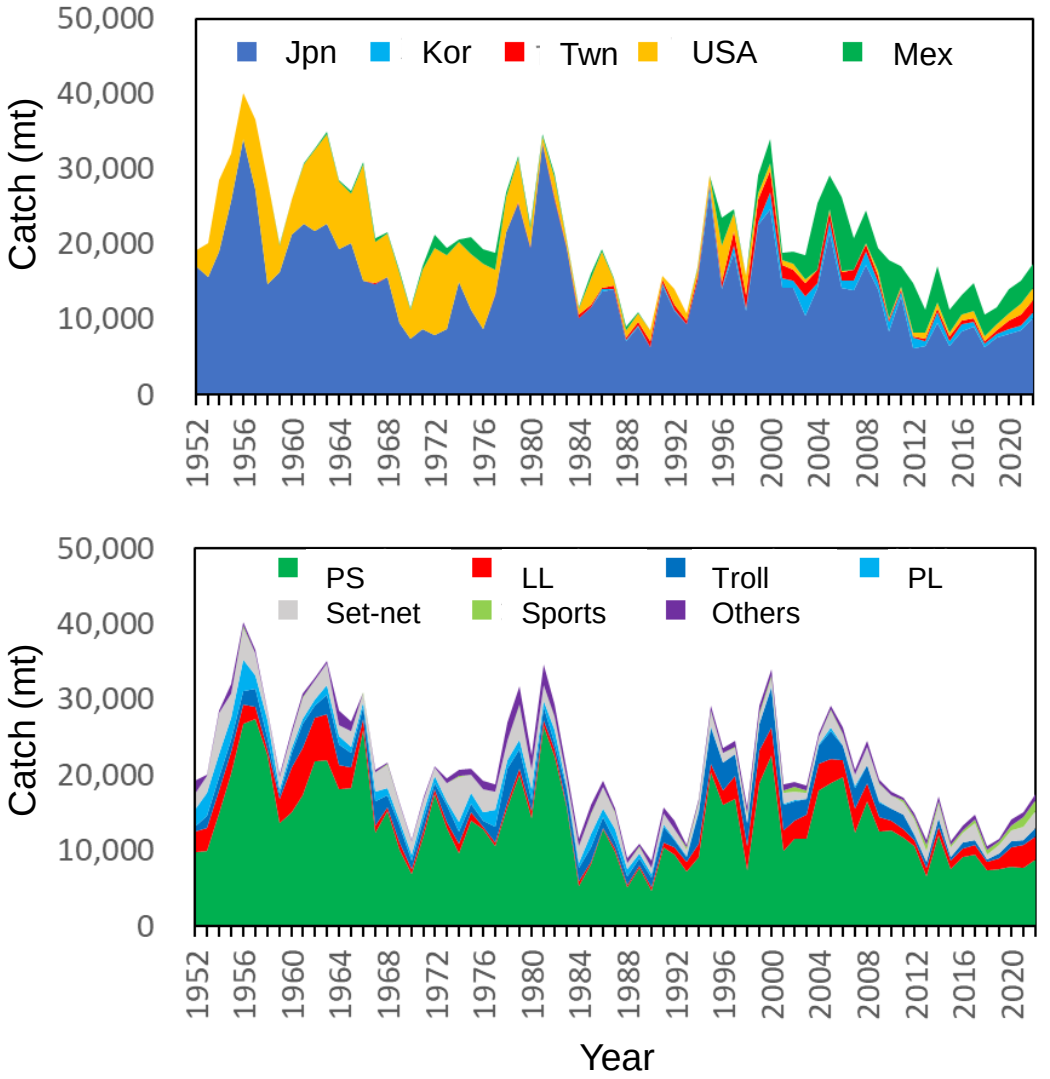


Age based availability



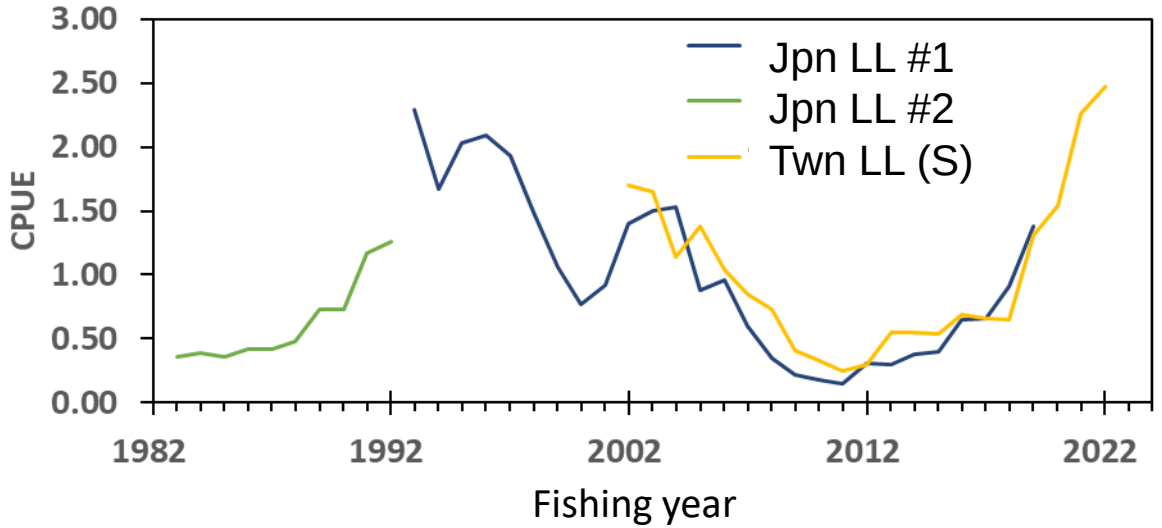
Catch

- 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.

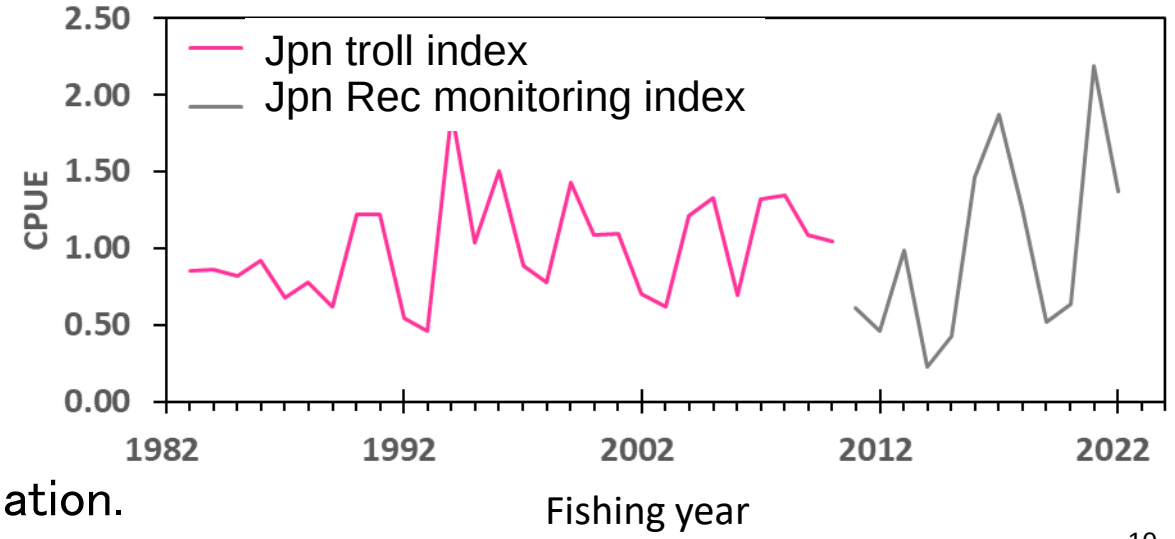


Abundance index

- 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.



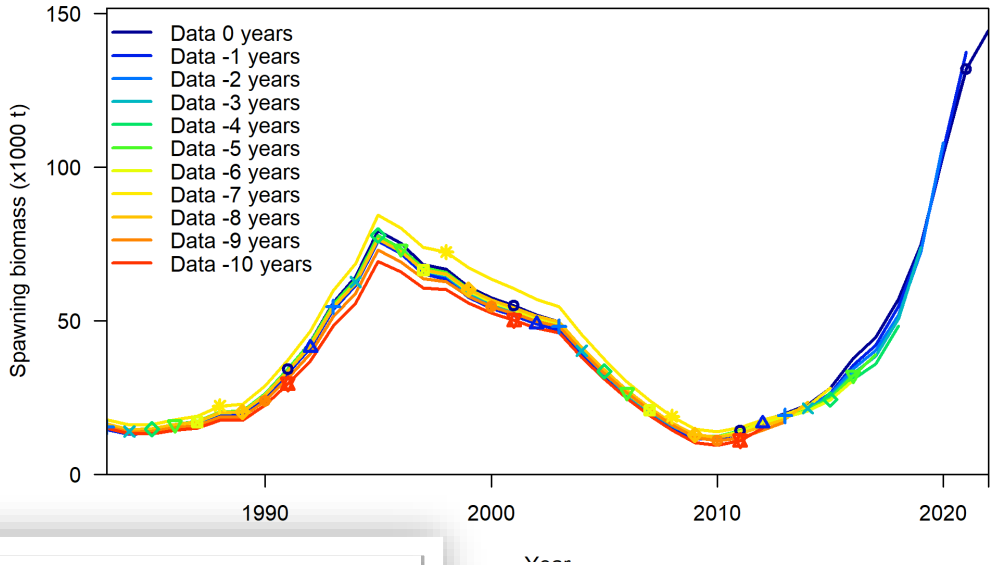
- Recruitment index
  - Japanese Troll CPUE index
    - ✓ Standardized by GLM.
    - ✓ Since this index caused pessimistic bias in the SSB estimation, this was terminated in 2010 FY.
  - Jpn recruitment monitoring survey index was used outside the model as a qualitative information.

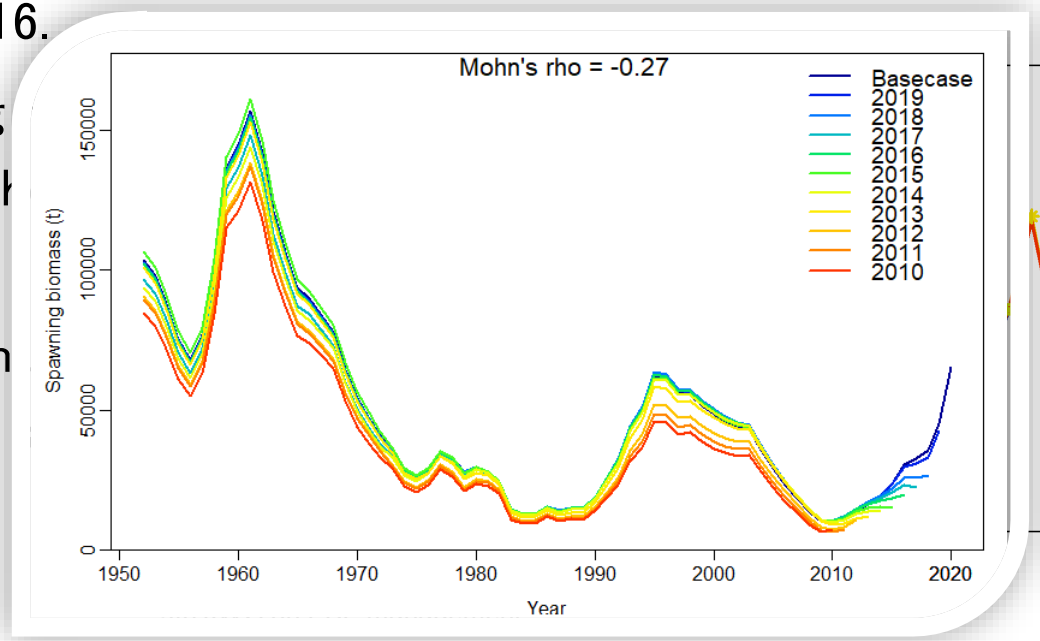


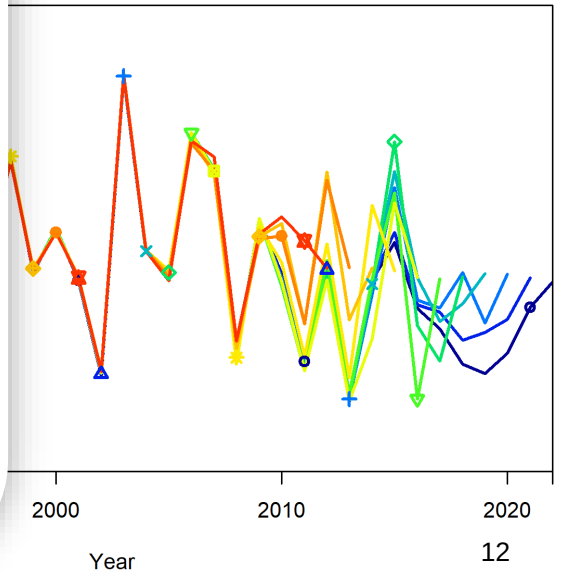
2. Model Diagnostics

Retrospective analysis

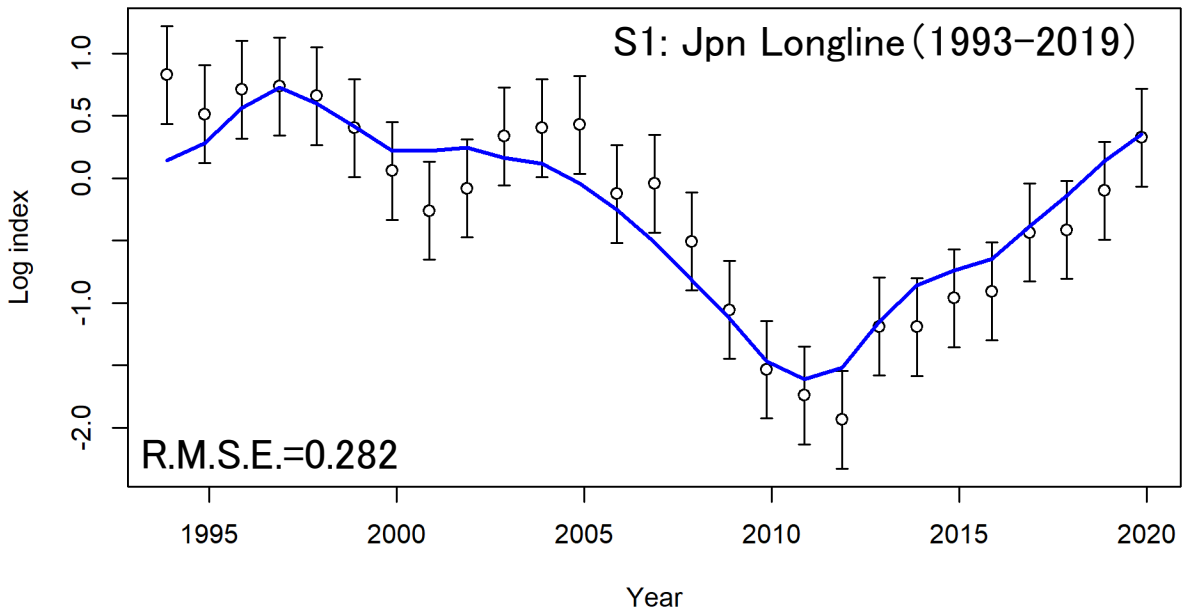
- Retrospective analysis showed a highly consistent estimation of terminal SSB over the past 10 years, with Mohn's rho = −0.06.
- This is a focal point for improvement in the previous assessment, and the PBFWG successfully resolved the negative systematic retrospective pattern by reducing the residuals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

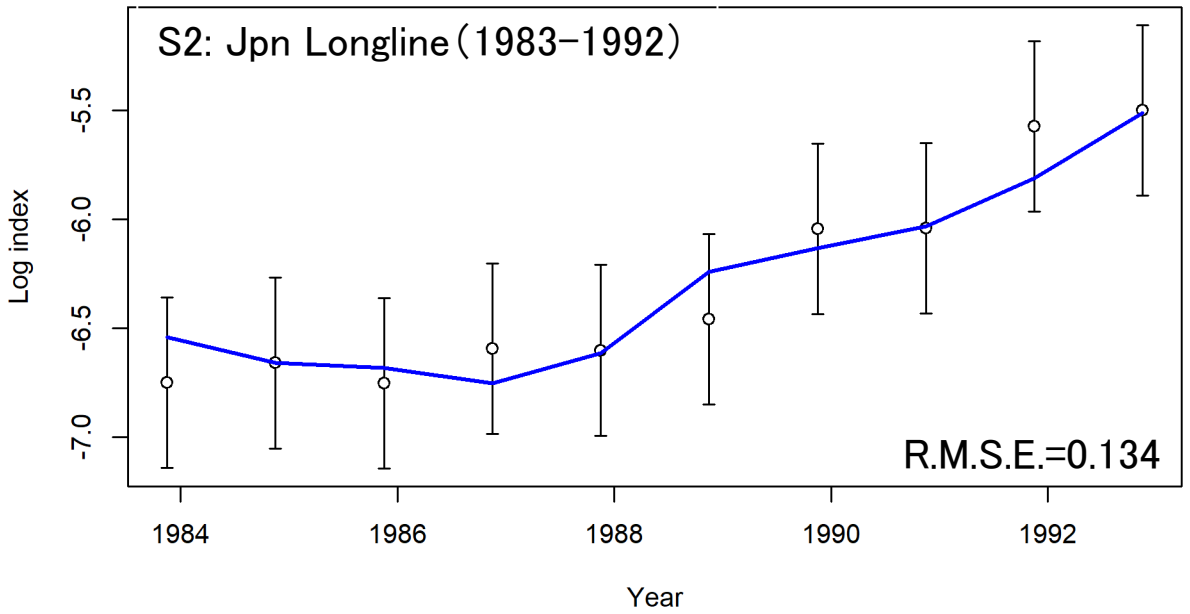


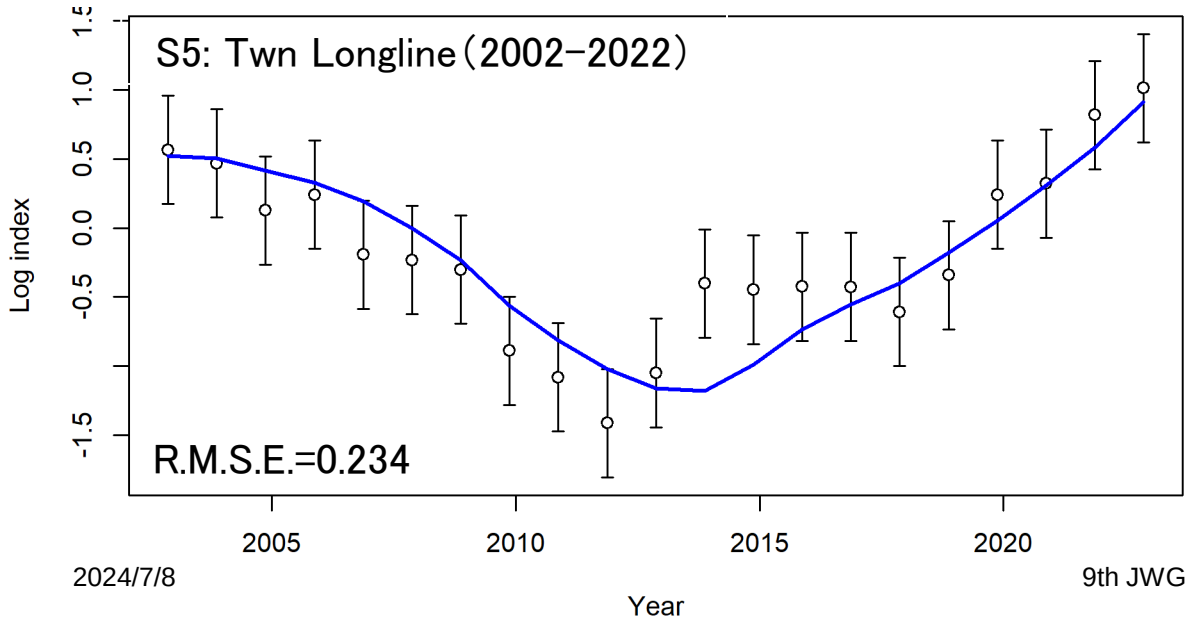


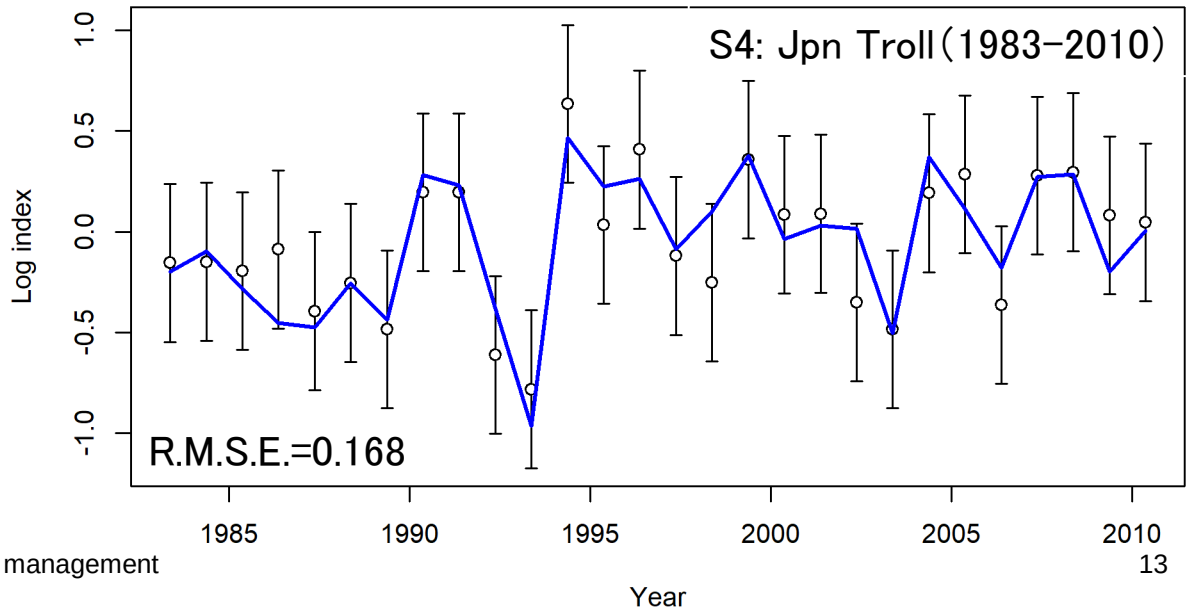


Goodness of fit to Abundance index

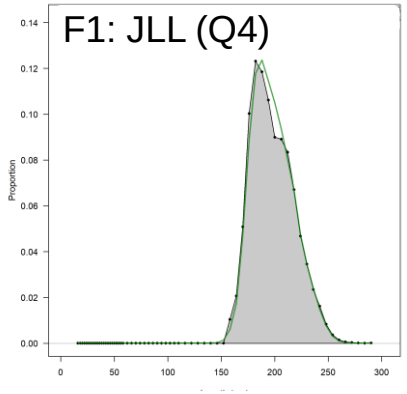


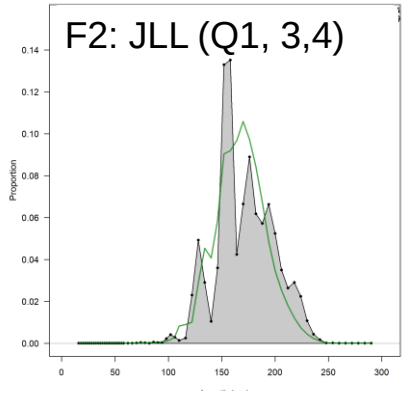


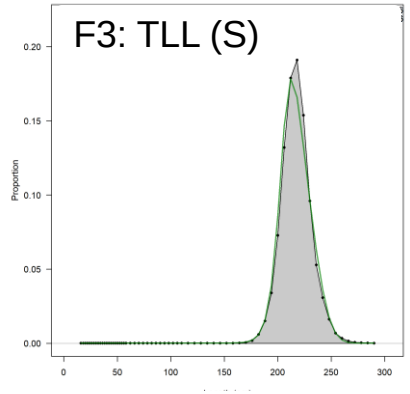


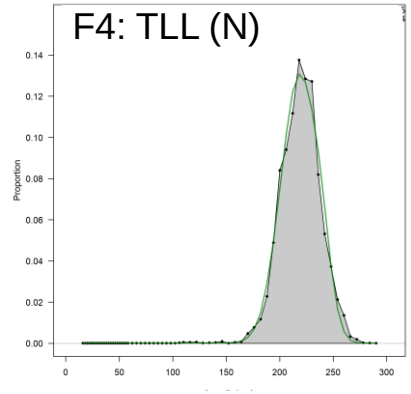


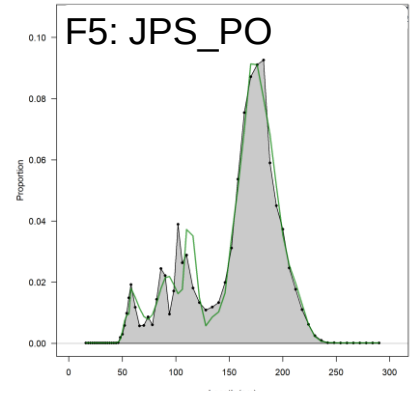
Average fits to the size composition data

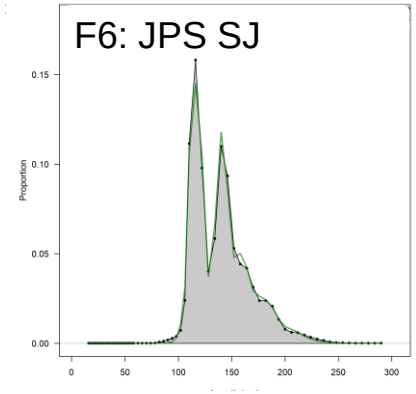


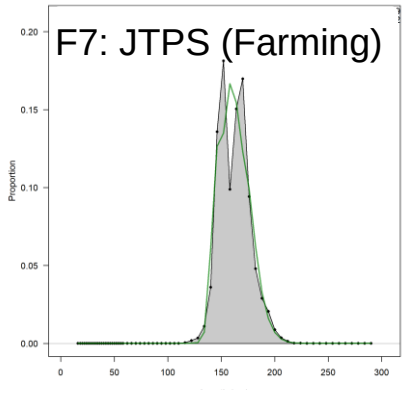


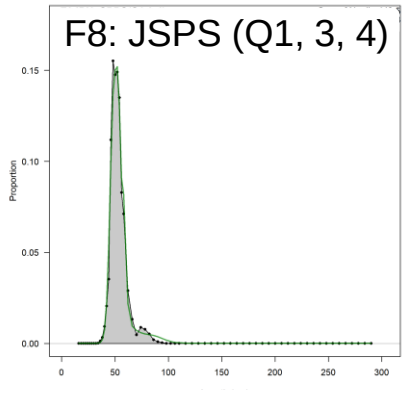


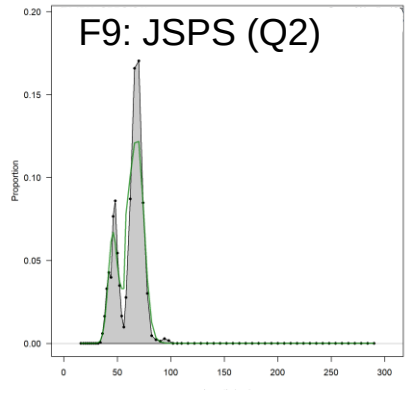


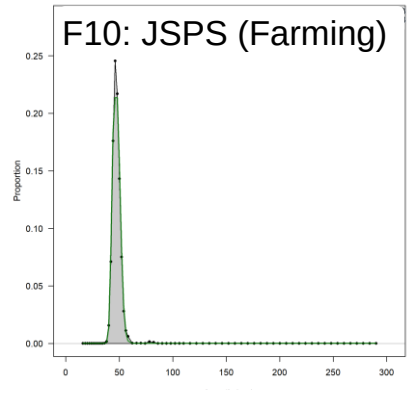


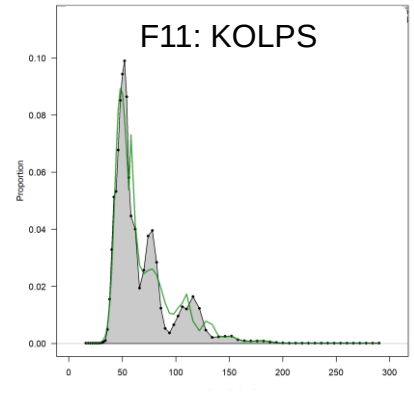


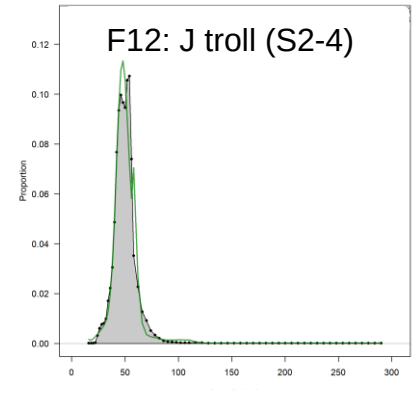


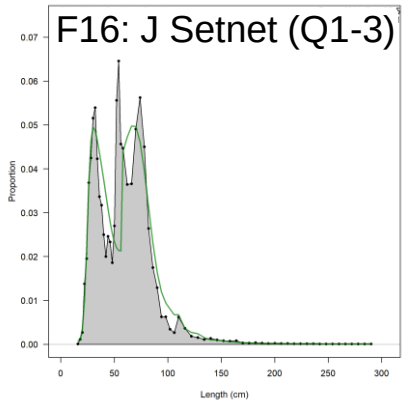


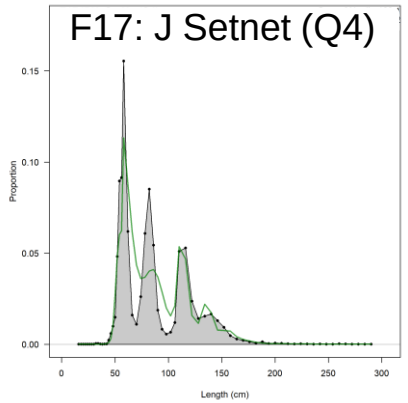


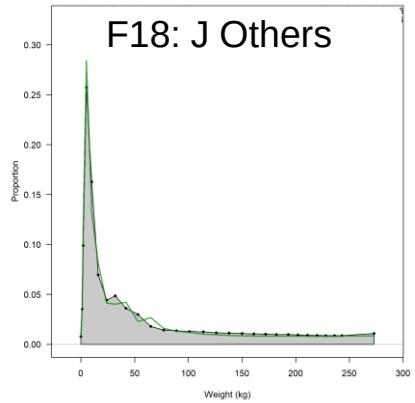


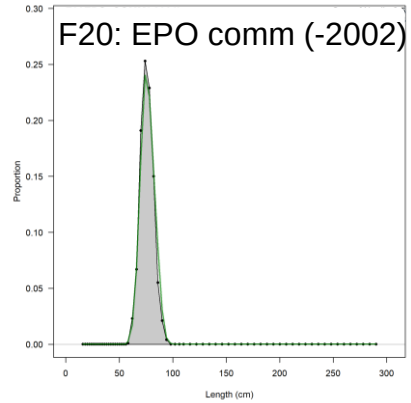


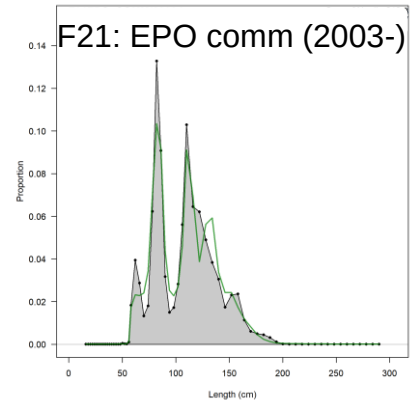


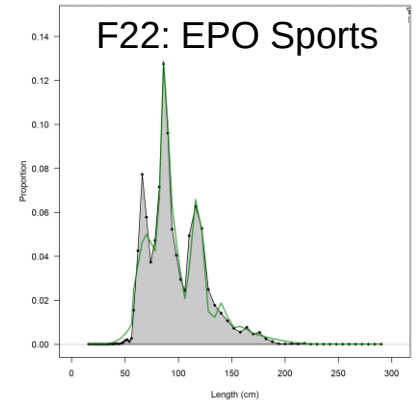








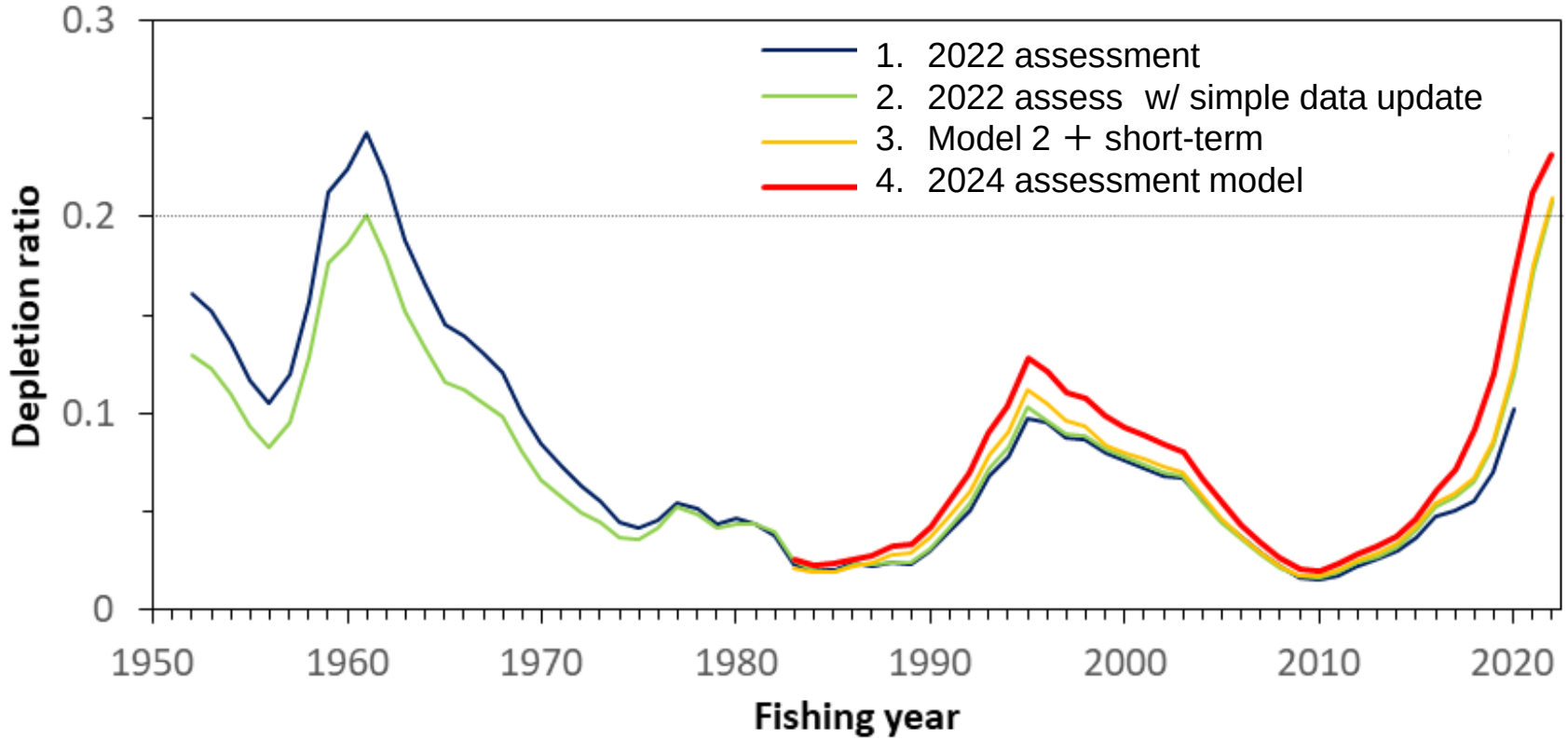




3. Assessment Results

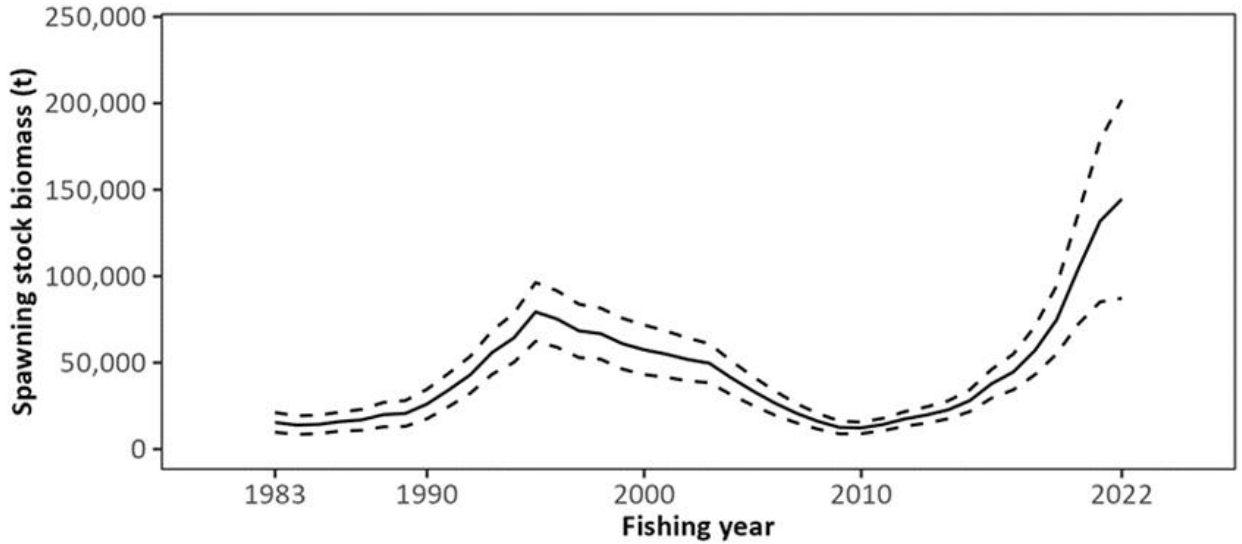
Results: Bridging analysis

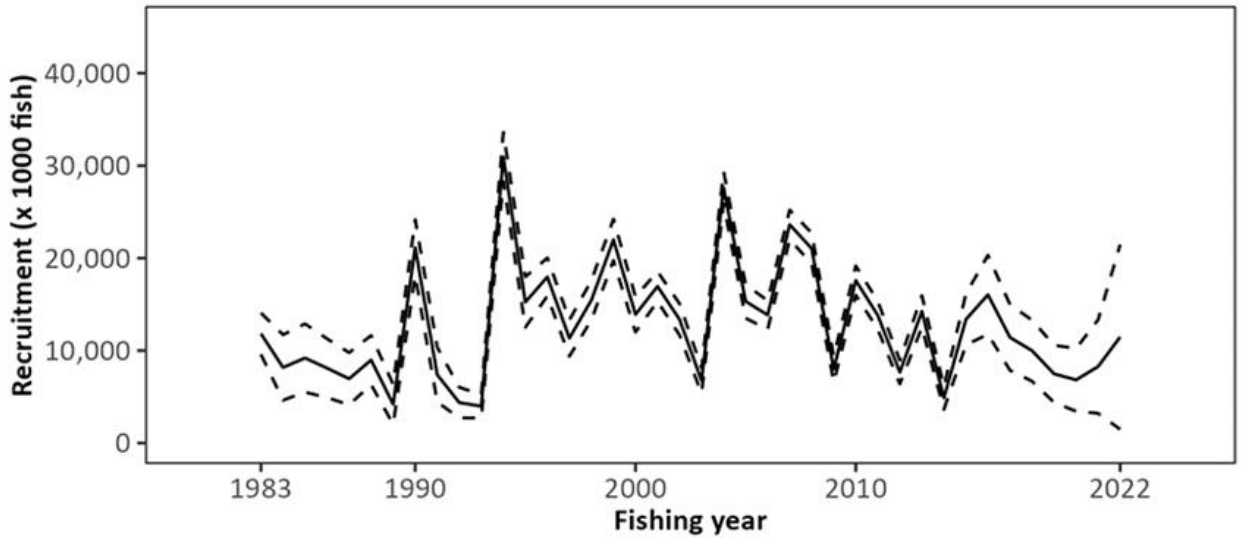
- Simple 2 years data update showed a rapid recovery to the level higher than 20%SSB0.
- Changing the model start year did not affect to the estimated trend of SSB.
- The 2024 base-case showed a slightly higher SSB than Model 3.
  - ✓The model has been revised to reduce the pessimistic retrospective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



Results: Biomass time series

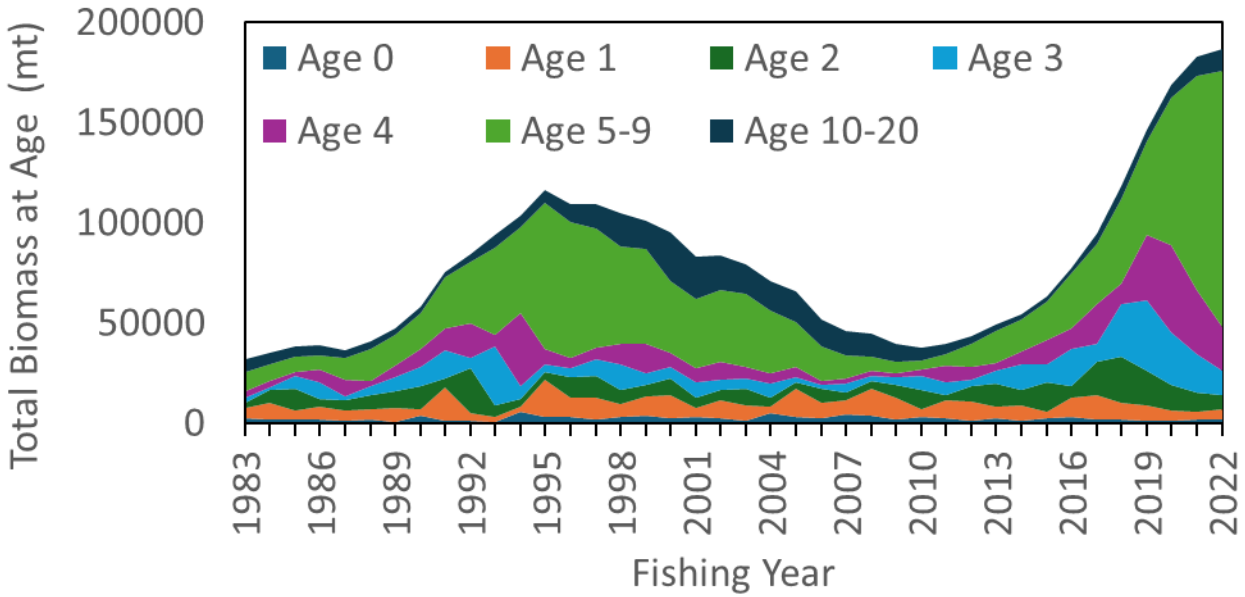
- SSB declined from 1996 to 2010 and has increased since 2011.
  - SSB at 2022 was about 144,000 mt (23.2% of SSB0).
  - Achieving the 2nd rebuilding target ($20\%SSB_0$) in 2021.
  - Relatively large confidence interval in a couple of terminal years.
- Recruitments have fluctuated since 1983.
  - 2016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

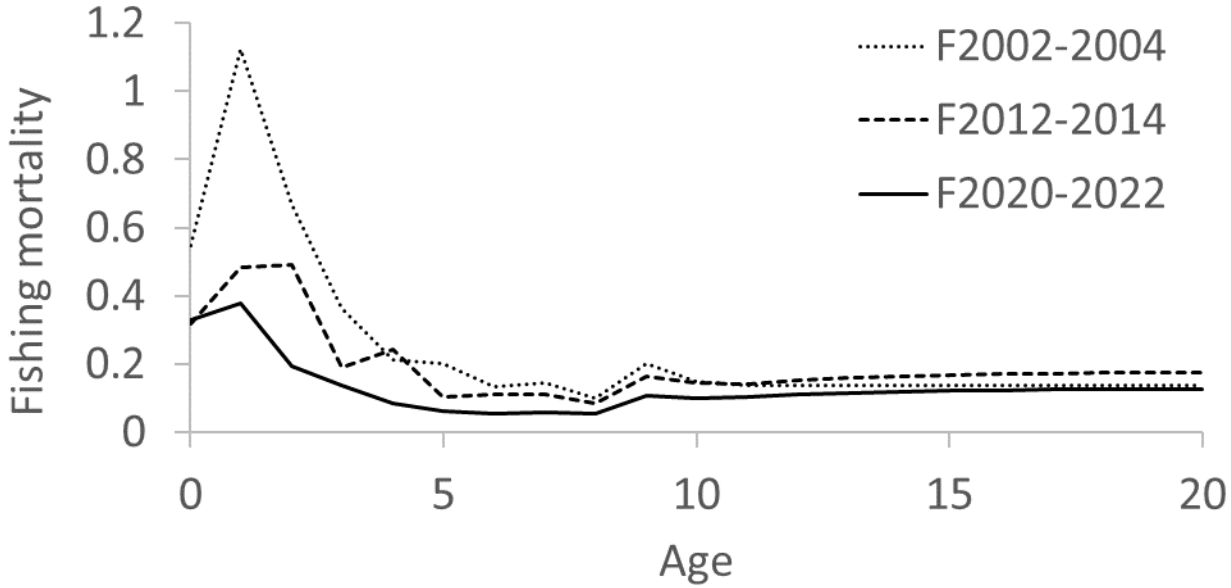




Results：Biomass and Fishing mortality at Age

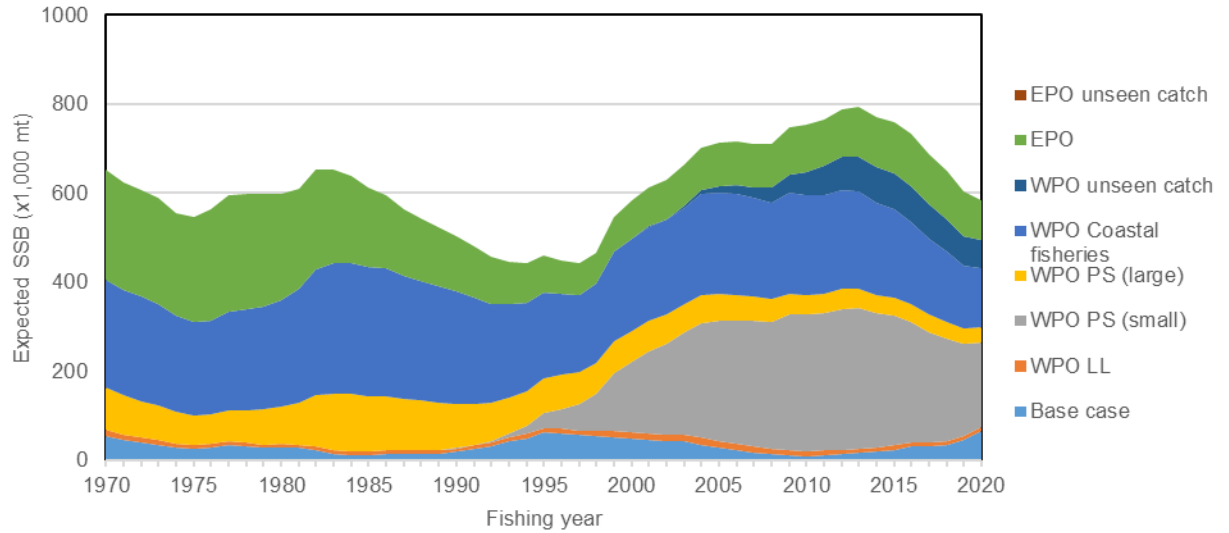
- Historically, the PBF has experienced a high fishing mortality in particular for fish for ages 0–2.
- After 2010, F gradually decreased, coinciding with the implementation of the first catch upper limits on both sides of the Pacific Ocean (2011 in the WCPFC and 2012 in the IATTC).
- A substantial decrease 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.

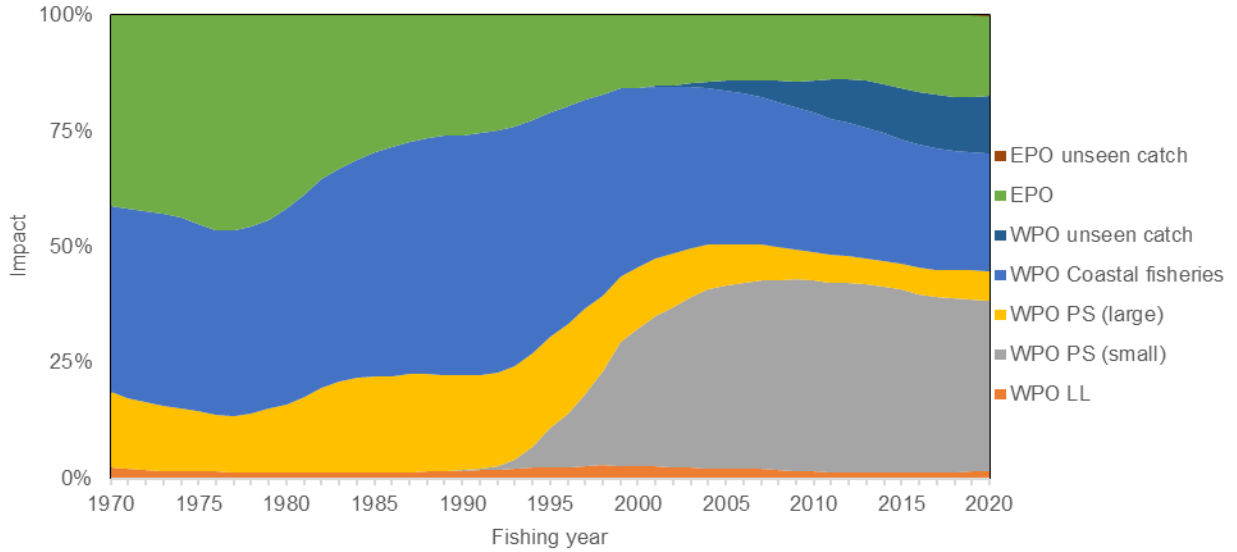




Results: Fishery Impact plot

- 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 2022 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 2022, the estimated cumulative impact proportion between WPO and EPO fisheries is about 83% and 17%, respectively.

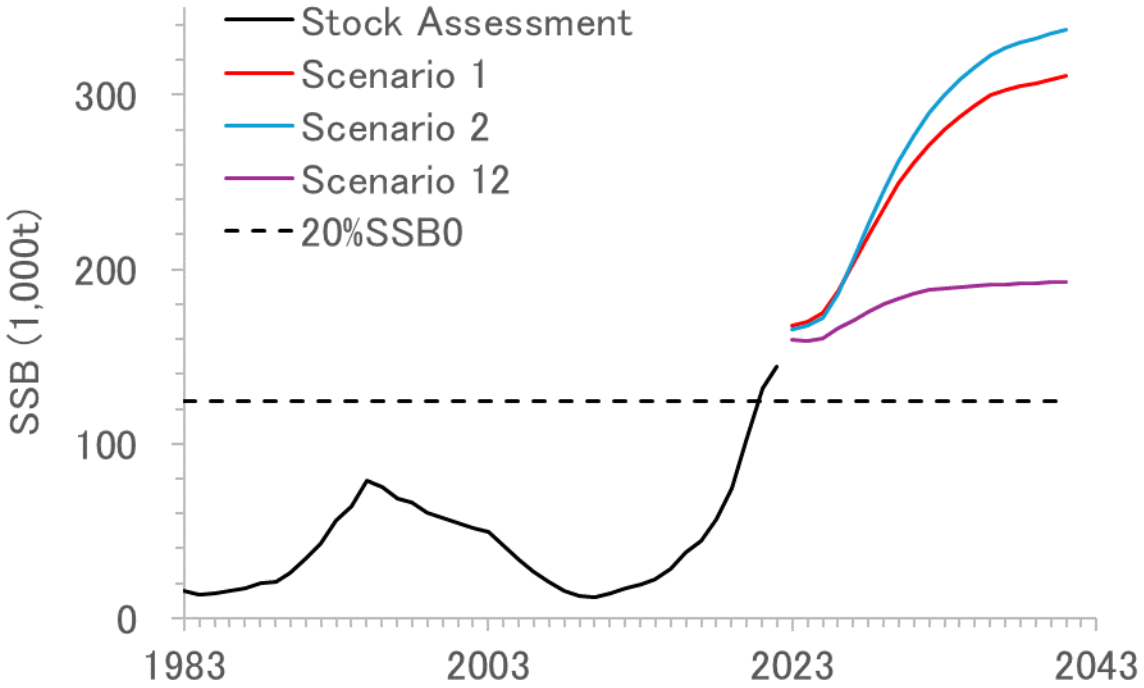




4. Future projection

Results: projection

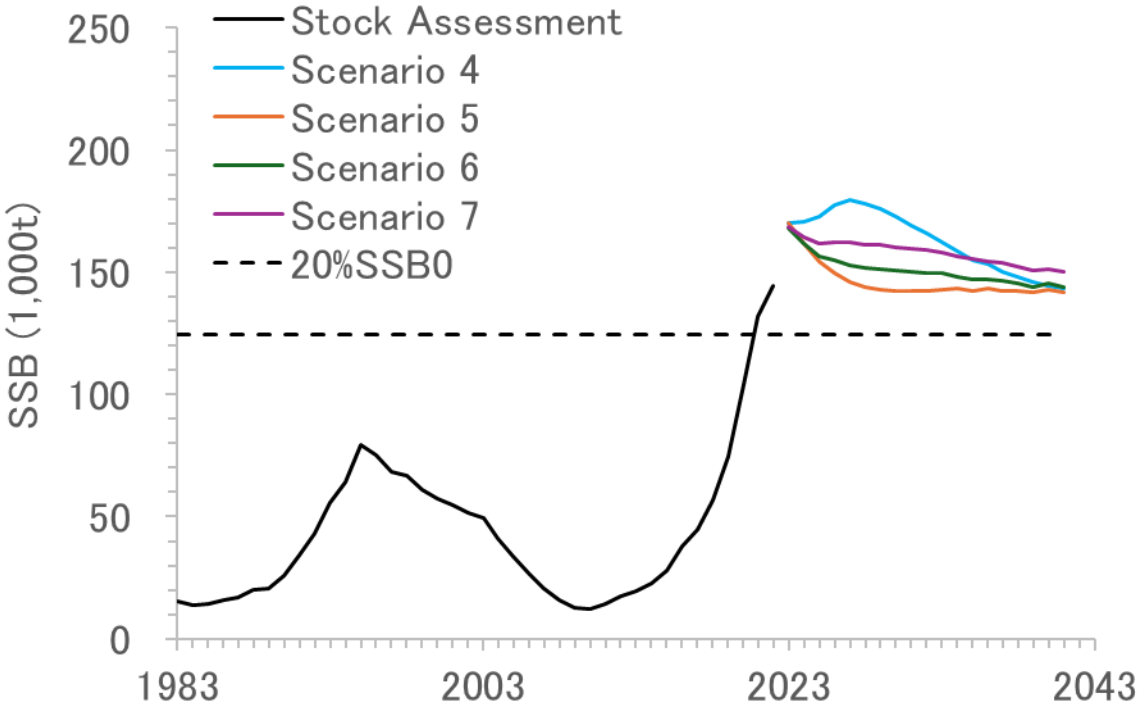
- Status quo (Scenario 1) projects the SSB in 2041 to be higher than 40% of SSB0.
- Scenario 2, which applies the conversion of small fish quota to large fish quota at the current conversion factor of 1.47, projects a similar trend but a higher SSB in 2034.
- Scenario 12, which applies a constant fishing 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)

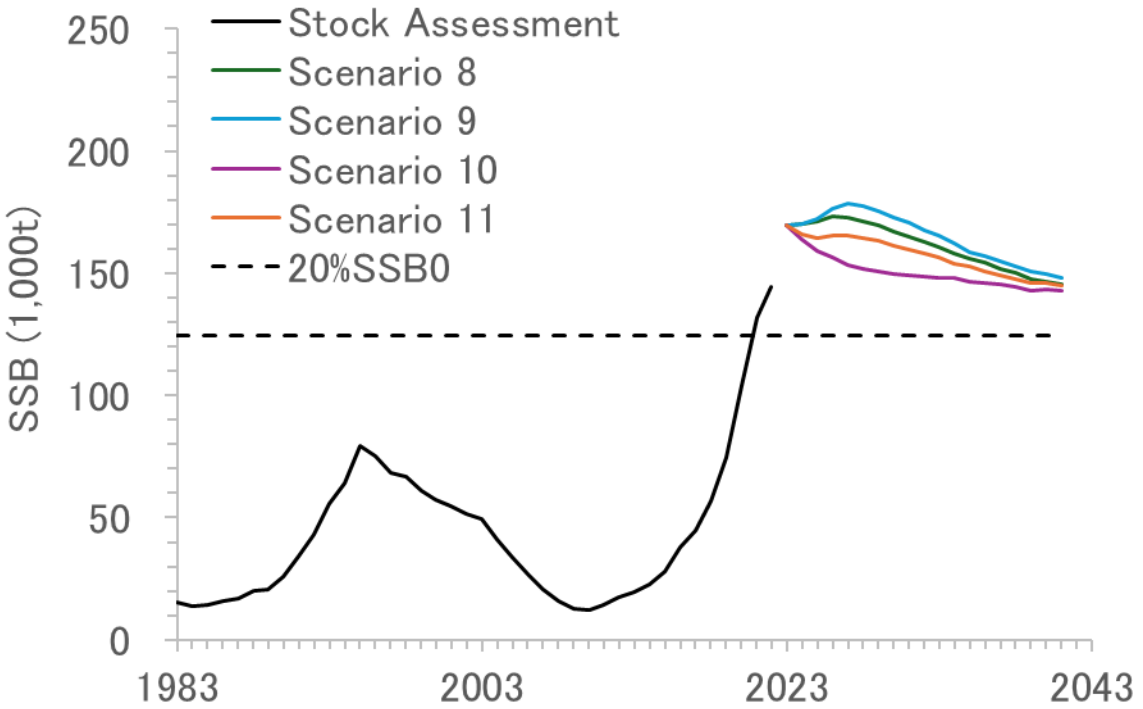
- Scenarios 4–11, which were fine-tuned to achieve the 20%$SSB_{F=0}$ with a 60% probability in 2041, resulted notably more aggressive catch, and those are exhibiting a decreasing trend from a peak biomass in the late 2020s to the end year of the projection.
  - Catching higher amounts of small fish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

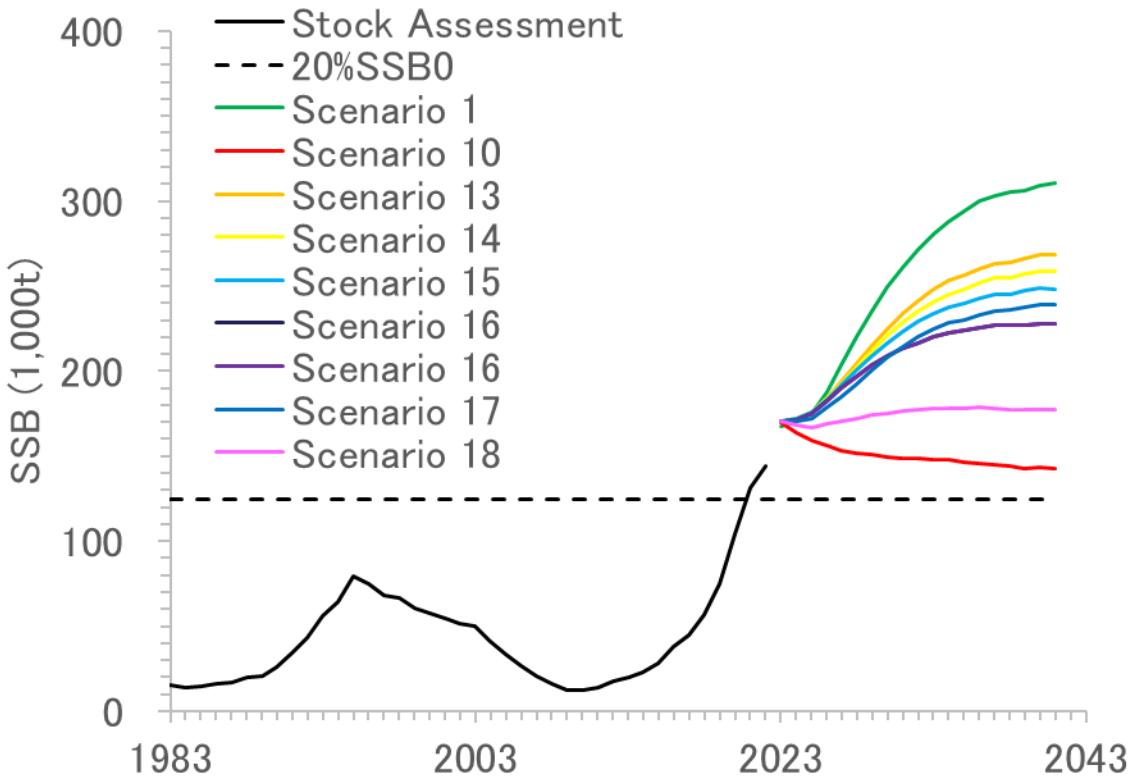


#	Scenario			Fishery impact ratio (2034)		Probability (stock > 20%SSB0 in 2041)	Expected catch in 2034				
	WCPO		EPO				WCPO		EPO		Total
	Small	Large	Comm	WCPO	EPO		Small	Large	Comm	Sp	
8	30% up	30% up	190% up	69%	31%	61%	5,508	10,420	11,556	950	28,434
9	55% up	55% up	80% up	79%	21%	63%	6,620	12,456	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

Results: projection (Additionally requested scenarios)

tRFMOs requested some additional harvesting scenarios to be analyzed by the future projection.

- ❖ SSB for All requested scenarios 13–18 were distributed between the scenario 1 (status quo) and scenario 10.
  - ○ The additionally requested harvesting scenarios were forecasted to show a continuous increase of future SSB throughout the projection period.



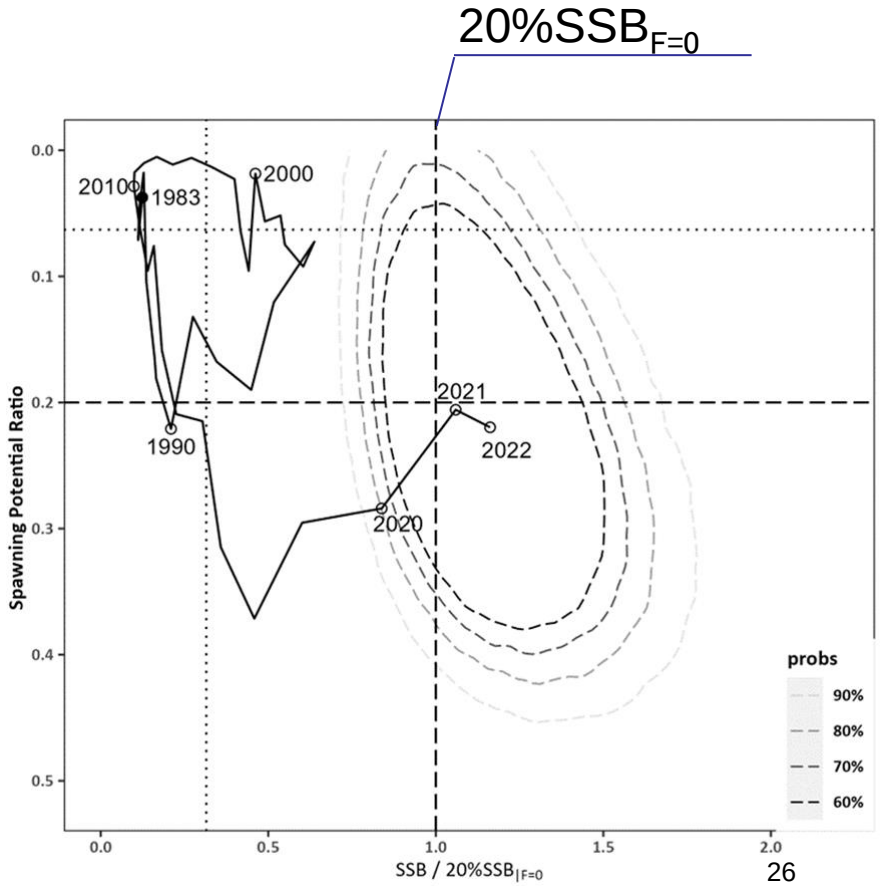
#	Scenario			Fishery impact ratio (2034)		Probability (stock > 20%SSB0 in 2041)	Expected catch in 2034				
	WCPO		EPO				WCPO		EPO		Total
	Small	Large	Comm	WCPO	EPO		Small	Large	Comm	Sp	
13	Status quo	+50% up	+50% up	77%	23%	98%	4,193	12,033	5,993	1,400	23,619
14	+5% up	+50% up	+50% up	78%	22%	97%	4,416	12,039	5,993	1,359	23,807
15	+10% up	+50% up	+50% up	79%	21%	96%	4,639	12,045	5,992	1,318	23,994
16	+20% up	+50% up	+50% up	82%	18%	92%	5,086	12,051	5,988	1,237	24,362
17	+5% up	+70% up	+70% up	78%	22%	94%	4,428	13,541	6,789	1,305	26,062
18	+20% up	+100 %up	+100% up	80%	20%	75%	5,118	15,884	8,001	1,144	30,146

5. 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 that it is 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 (SSB_{MED} = $6.3\%SSB_{F=0}$) in 2017, 7 years earlier than originally anticipated by the RFMOs, and its second rebuilding target ($20\%SSB_{F=0}$) in 2021; and**
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 be 23.6% and thus the PBF stock is not subject to overfishing relative to some of F-based reference points proposed for tuna species, including F20%SPR.**



Conservation information (preamble part)

After the steady decline in SSB from 1996 to the historically low level in 2010, the PBF stock has started recovering, and recovery has been more rapid in recent years, coinciding with the implementation of stringent management measures. The 2022 SSB was 10 times higher than the historical low and is above the second rebuilding target adopted by the WCPFC and IATTC, which was achieved in 2021. The stock has recovered at a faster rate than anticipated when the Harvest Strategy to foster rebuilding (WCPFC HS 2017-02) was implemented in 2014. The fishing mortality (F%SPR) in 2020-2022 is at a level producing 23.6%SPR. According to the requests from WCPFC and IATTC, future projections under various scenarios were conducted. The projection scenarios and their results, the figure of projection results, “future Kobe plot”, and “future impact plot” are provided as Tables 3-5, Figures 12, 13, and 14, respectively. In addition, the results of additional projections which were requested by the JWG of IATTC-WCPFC NC is provided in Appendix 2 of the stock assessment report (ISC 2024 Annex13).

Based on these findings, the following information on the conservation of the Pacific bluefin tuna stock is provided:

Conservation information (punch-line)

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%$SSB_{F=0}$ (interim LRP for tropical tunas in IATTC) at least once in 10 years is negligible;
2. The projection results show that increases in catches are possible. However, the risk of falling below 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.