WCPFC SC 14
Pacific Bluefin Tuna Assessment;
2018 Update Stock Assessment and Projections

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

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2018 PBF stock assessment

- Meeting logistics
  - March 5th to 12th at La Jolla, CA, USA.
  - Participants: 26 scientists from U.S.A., Japan, Korea, Mexico, Taiwan, IATTC, and SPC
- Update assessment
  - Up-to-date data until June 2017.
  - Basically the same demographic assumption (same model construction).
- Projection
  - A projection for the current measures.
  - Some projections under new HCR.
- Report
  - ISC 2018 Annex 14 (SA/WP/06)

Overview of 2018 assessment model

- A fully integrated model (Stock Synthesis–Version 3)
  - Length–based, age–structured (0–20+) model
  - From 1952 to 2016
- Pan–Pacific Assessment
  - No–spatially defined model (Area as Fleet approach)
- Fishery definitions
  - 19 Fisheries (Catch & Size comp (if available))
  - 3 CPUEs (TWN & JPN Longlines, JPN Troll)
- Given biological traits (Growth, Maturity, Natural mortality)
- Estimate initial conditions, population scale, recruitments, and fishery selectivity

Assumption of Population dynamics

- Age-specific Natural mortality
  - 1.6@age-0, 0.386@age-1, 0.25@age-2+
- Age-specific Maturity
  - 20%@age-3, 50%@age-4, 100%@age-5+
- Growth, Length-Weight relationship

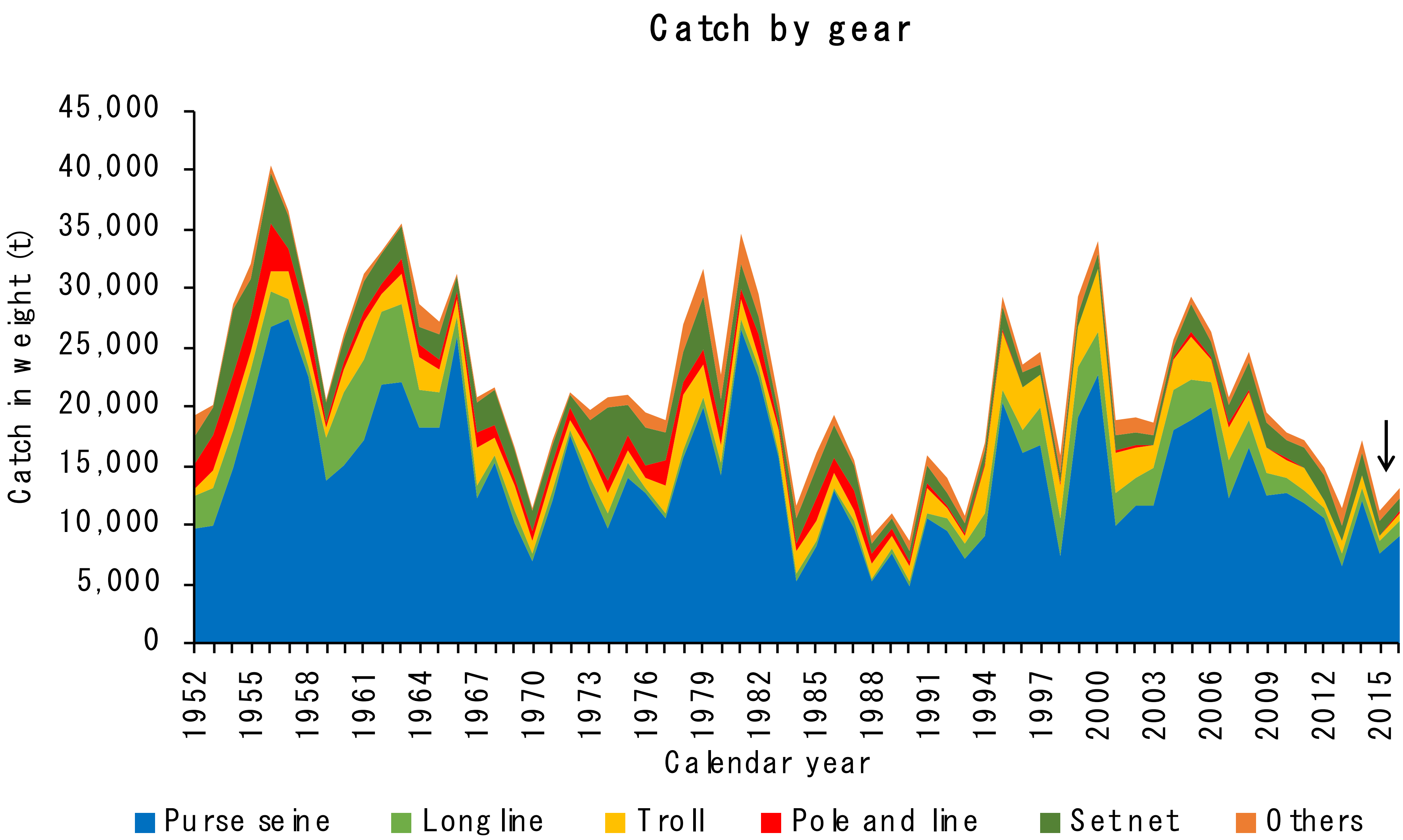
$$= 249.9 \times (1 - \quad \cdot \quad ^{\times(\quad \cdot \quad)})$$

- Stock Recruitment Relationship (S-RR)
  - Beverton-holt Relationship (h=0.999, S.D. of log Rec. =0.6)
- Selectivity of Fisheries
  - Time varying selectivity

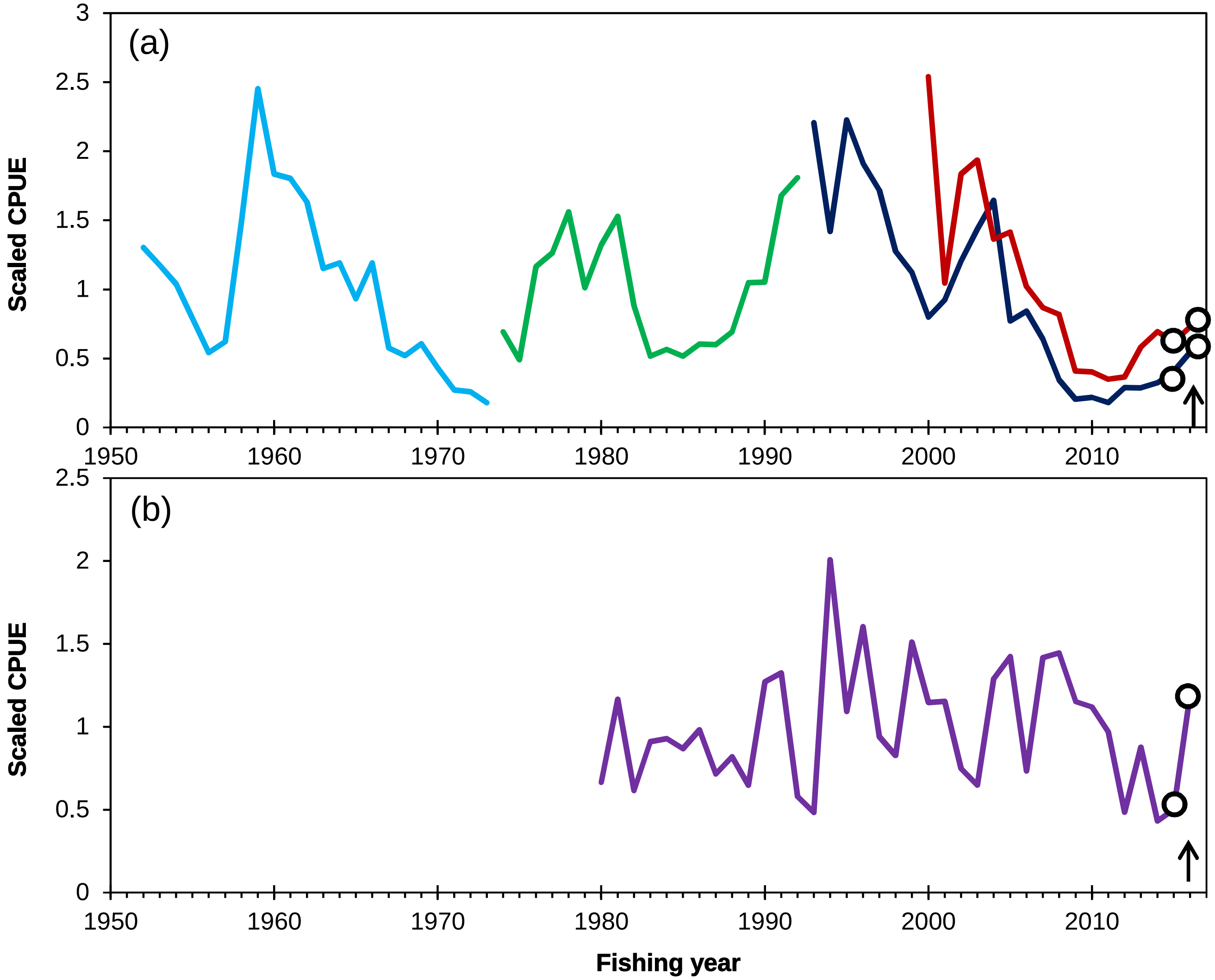
What are updated ?

- Input data were updated.
  - Catch (2015–2016)
  - CPUE (Whole time series, –2016)
    - ✓ TWN & JPN Longlines, JPN Troll.
      - The same standardization methods with previous assessment.
  - Size composition
    - ✓ 6 purse seines, 3 longlines, 3 set-nets, 2 trolls.
    - ✓ updated from 2014 (KOR PS, TWN LL, MEX PS) or 2015 (the rest of the fleets).
- Basically the same demographic assumptions.
  - Extend the last year of time varying selectivity.

Catch by gear

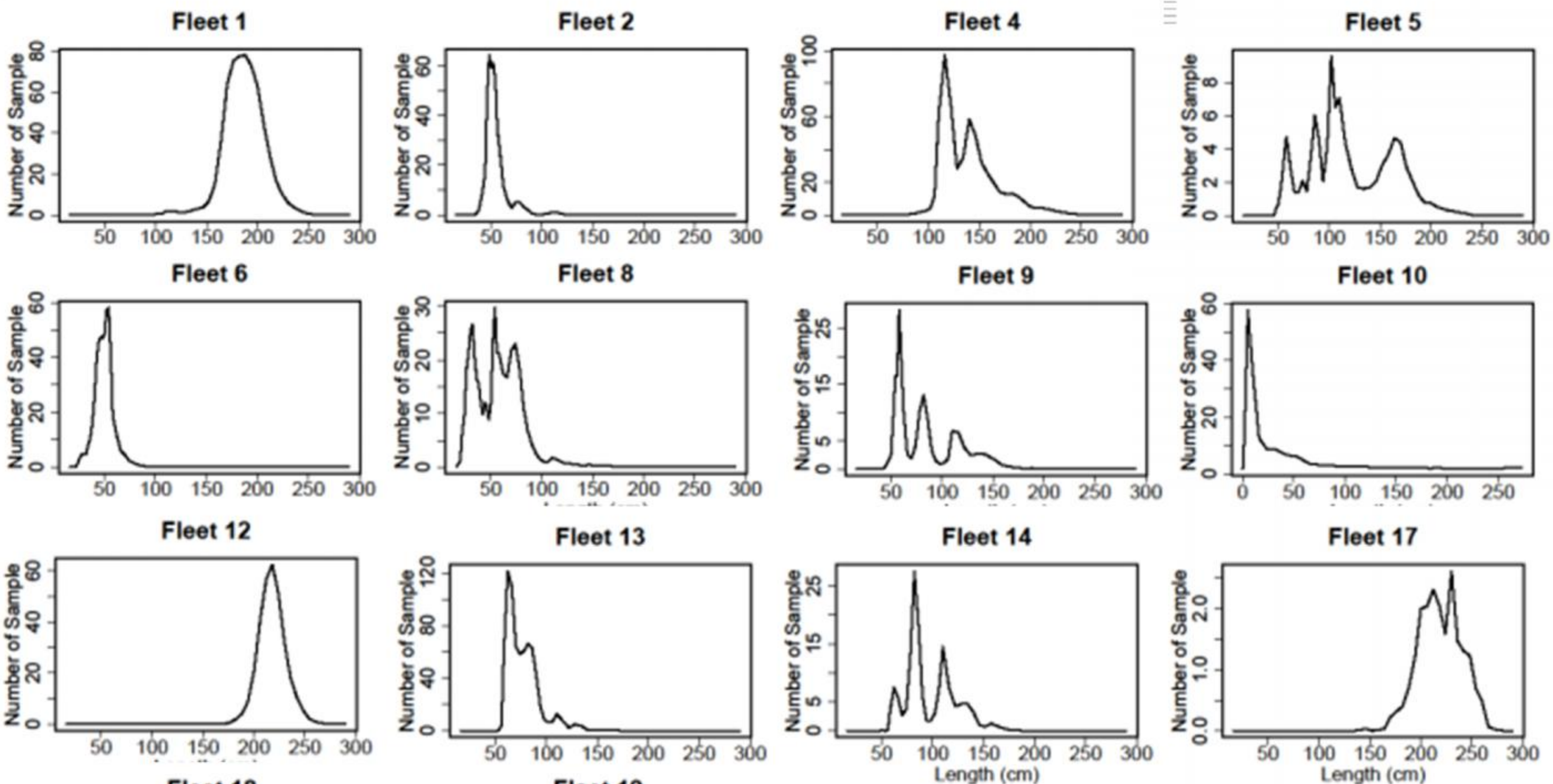


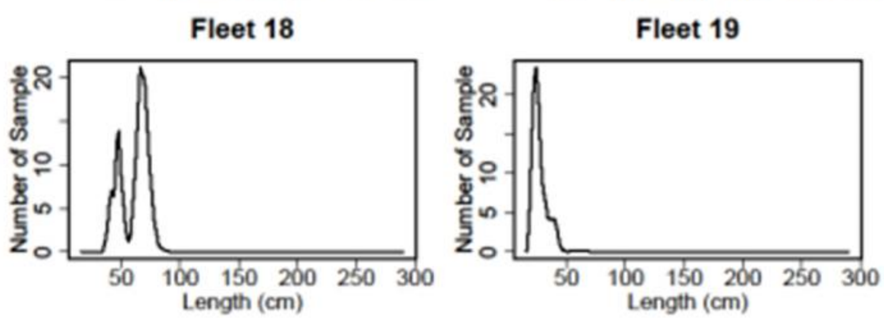
Catch per Unit of Effort based abundance index

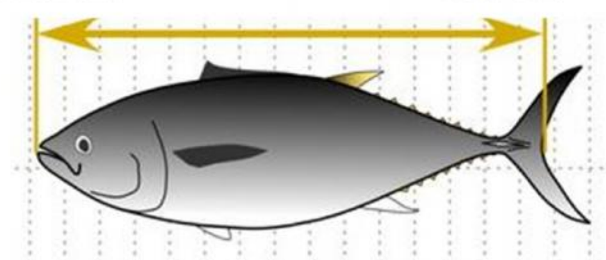


- a. Longline
  - Spawner index
    - JPN longline #1
    - JPN longline #2
    - JPN longline #3
    - TWN longline
- b. Troll
  - Age-0 index
    - JPN Troll

Size Composition data

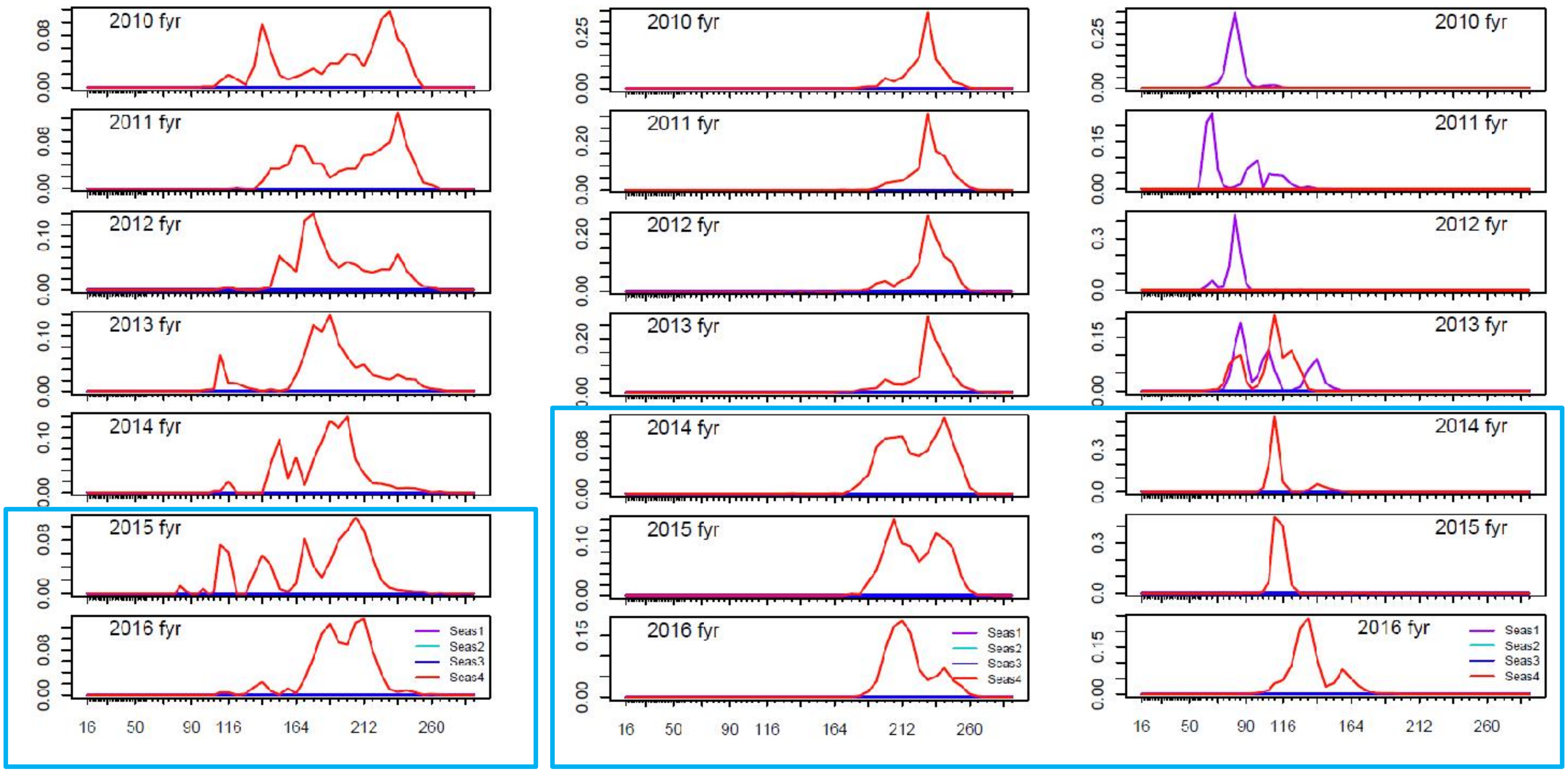






Example of the updated composition data

Fleet 1 JPLL | Fleet 12 TWLL South | Fleet 14 MXCOMM



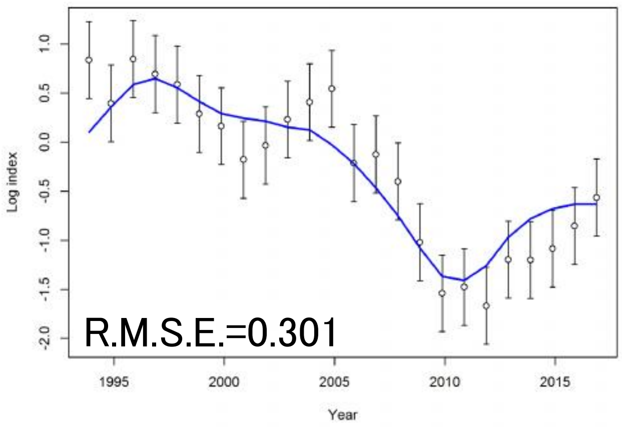
Updated

Results

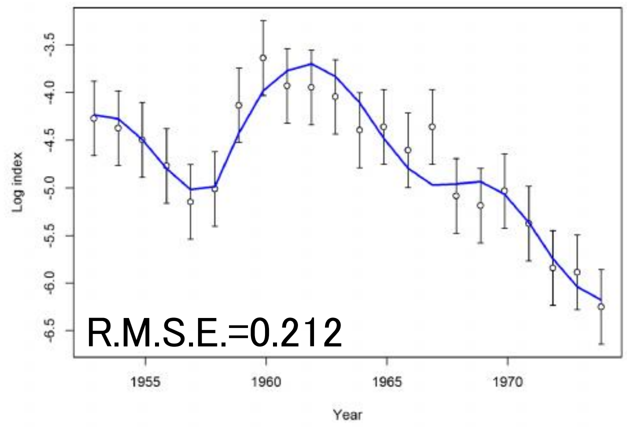
- Goodness of fit to
  - CPUE based abundance indices
  - Size composition
- Likelihood profile over population scale
- Retrospective diagnostics
- Assessment results
  - SSB and Recruitment
  - F at Age
  - Kobe plot
  - Impact plot

Goodness of fit to CPUEs

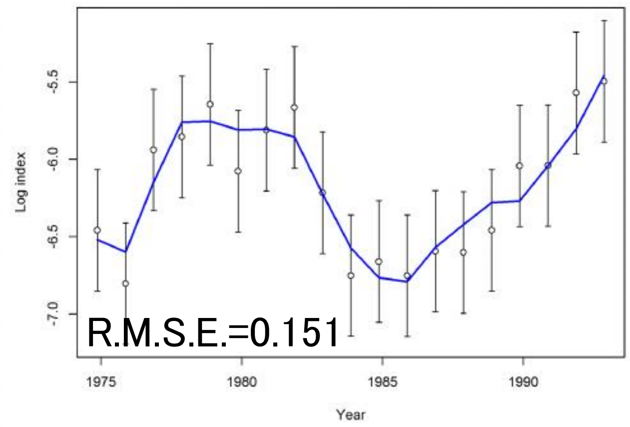
S1: Jpn Longline(1993–2016)



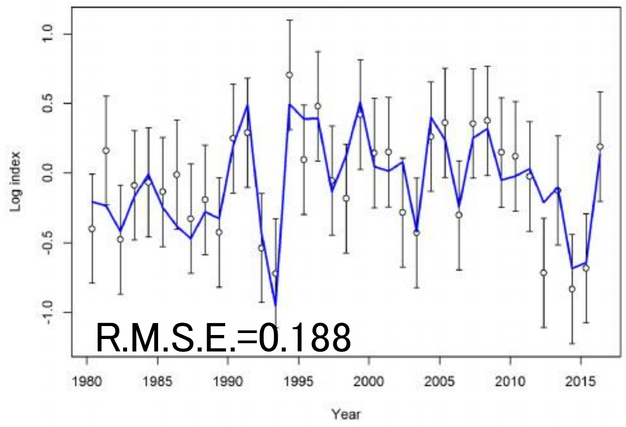
S2: Jpn Longline(1952–1973)



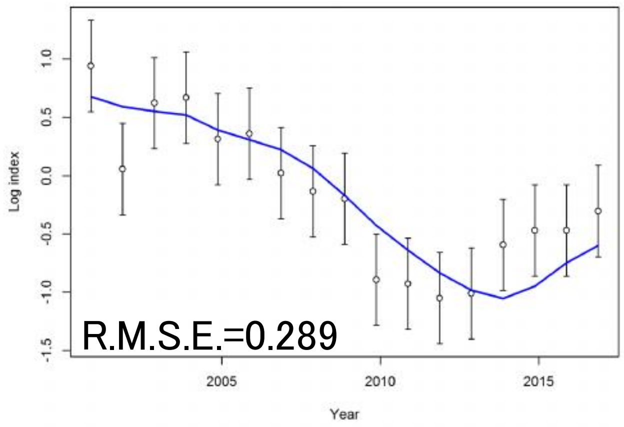
S3: Jpn Longline(1974–1992)



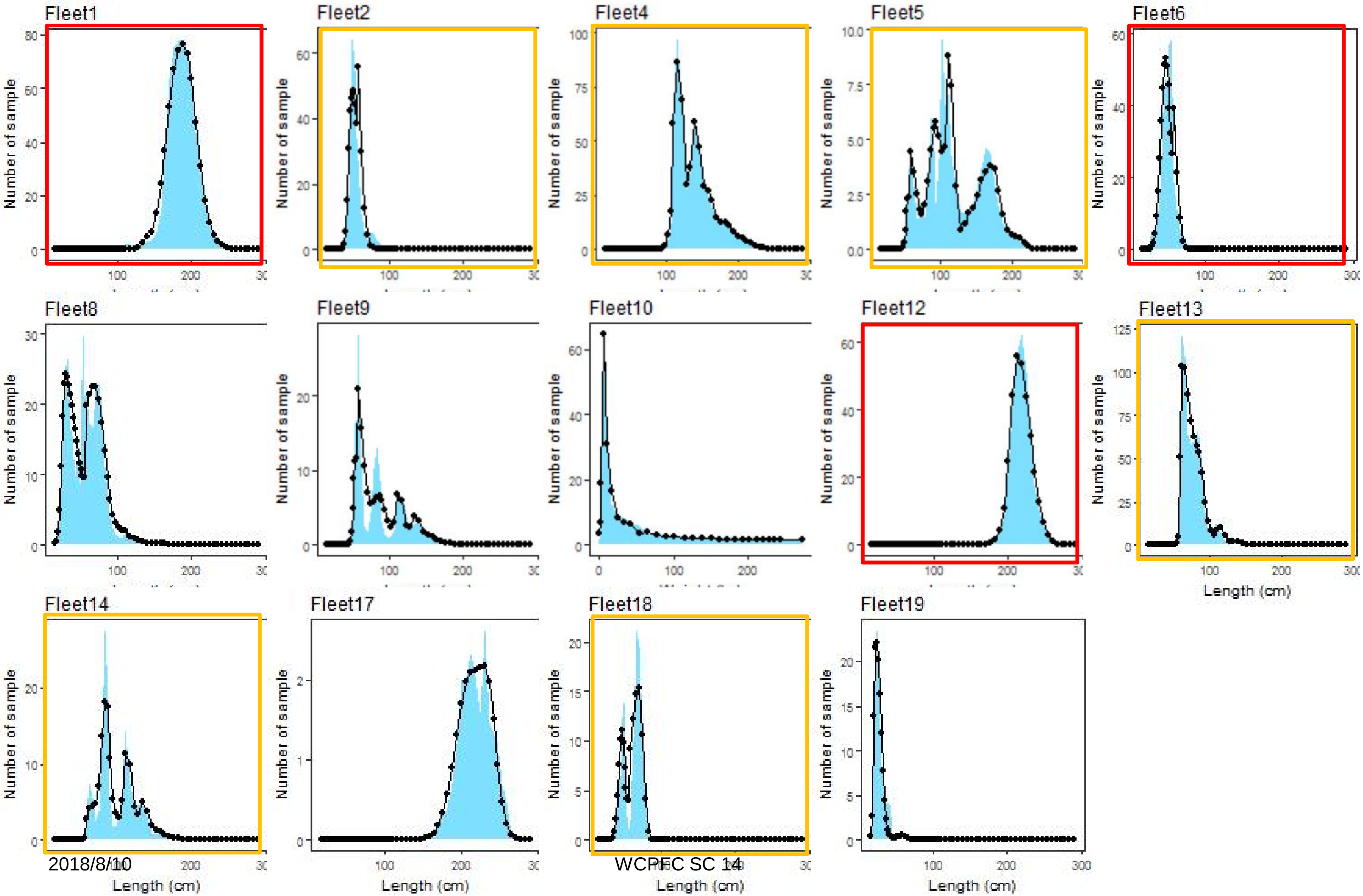
S5: Jpn Troll(1980–2016)



S9: Twn Longline(2000–2016)

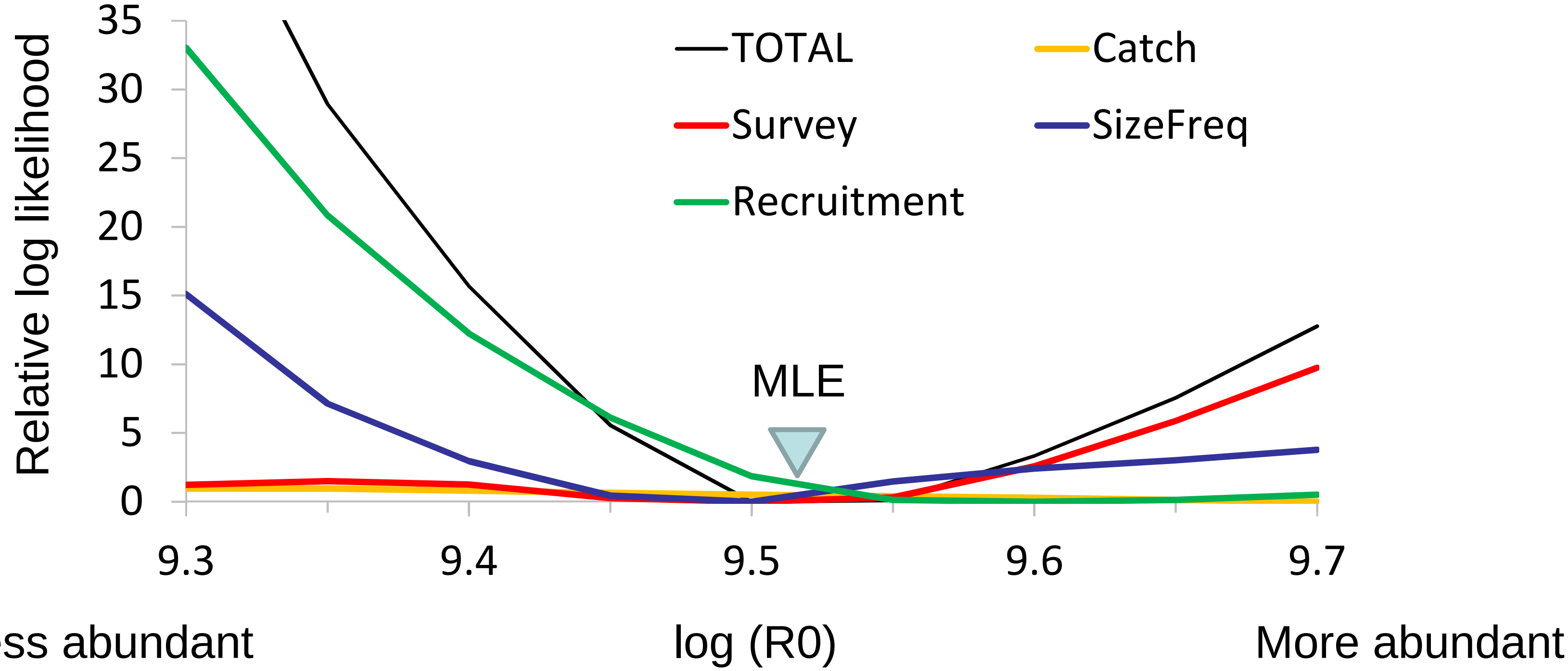


Average fits to Size Compositions



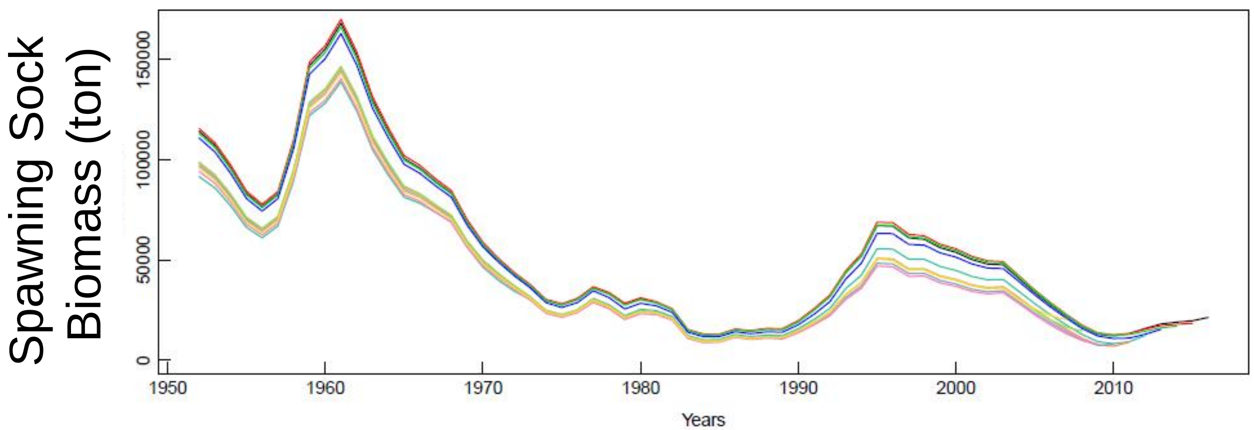
Likelihood profiles over fixed scaling parameter

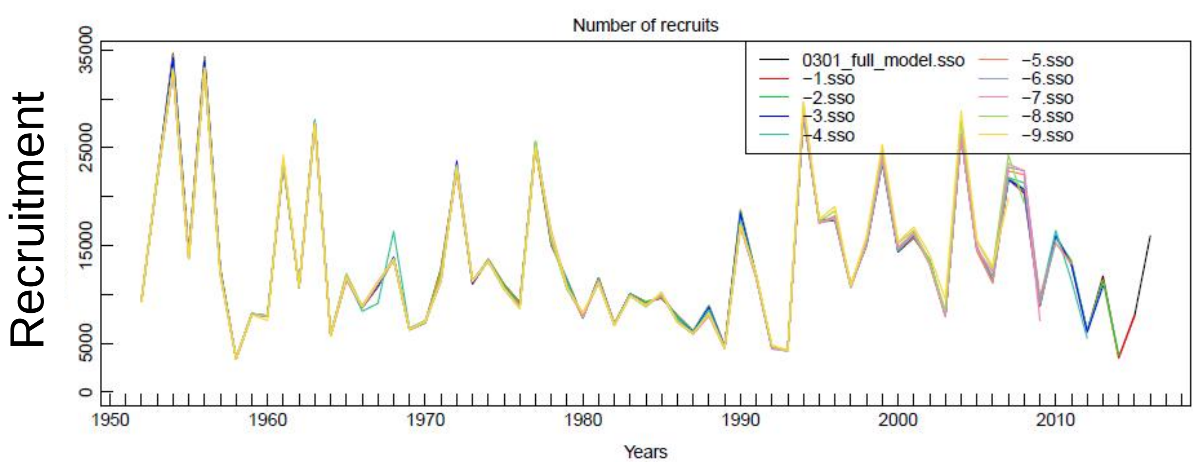
- Each component marked the lowest likelihood around at maximum likelihood estimate (MLE) of Log(R_0).
  - ○ CPUE (9.5), Size comp. (9.5), Recruitment Penalty (9.6)
  - ○ Consistency regarding the population scale estimates.



Retrospective Analysis

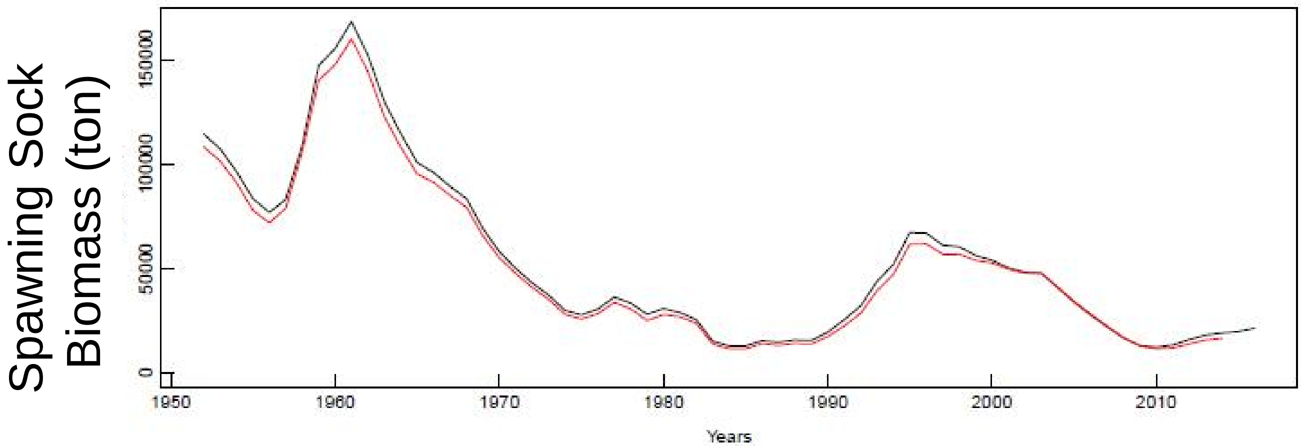
- No substantial pattern in recent 3–4 terminal years in the SSB estimates although those of 5 year and above might be slightly underestimated.
- Recruitment estimates are basically consistent.

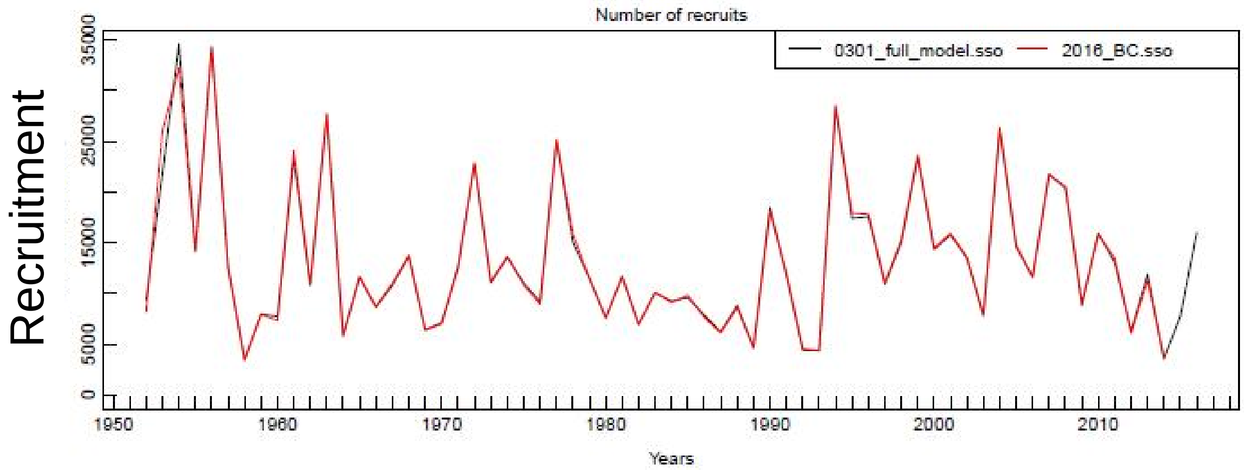




Assessment results

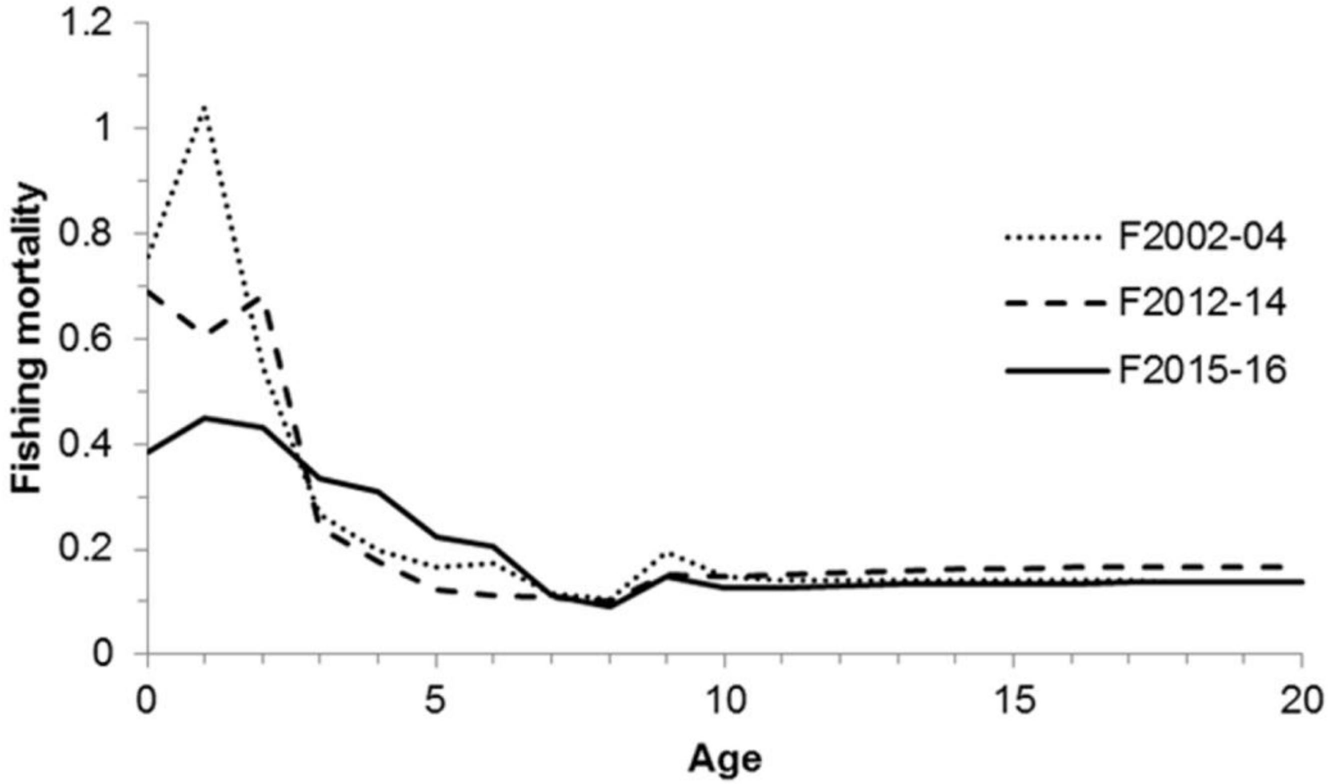
- Base case model derived consistent results with the previous assessment.
  - SSB fluctuated over time; declined during 1996–2010, and increased since 2011.
  - Recruitments in 2015 and 2016 are lower and higher than the historical average.





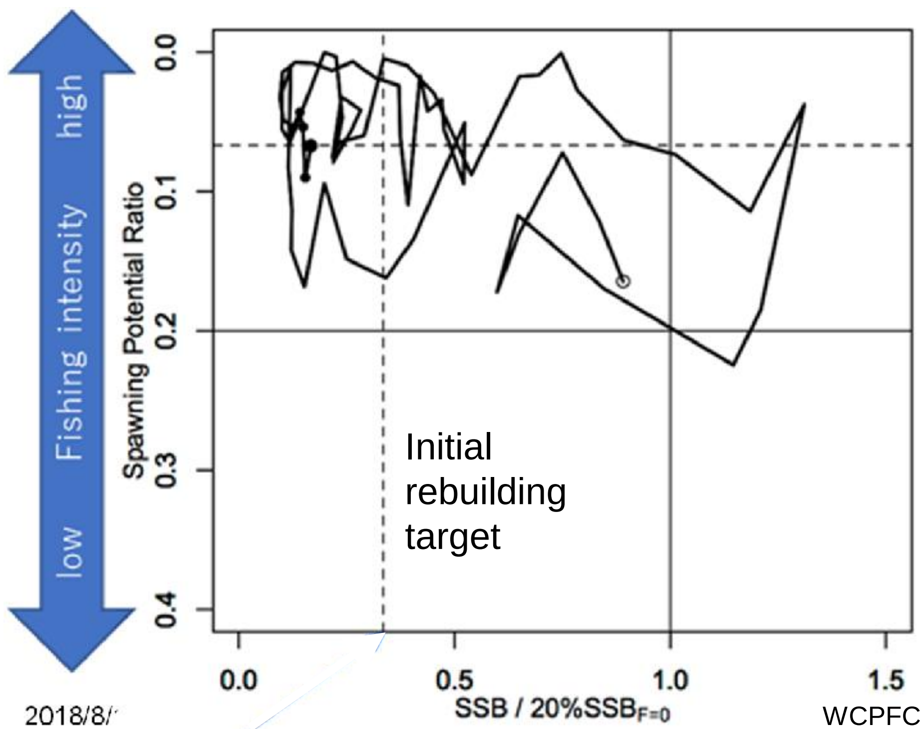
Age specific fishing mortality

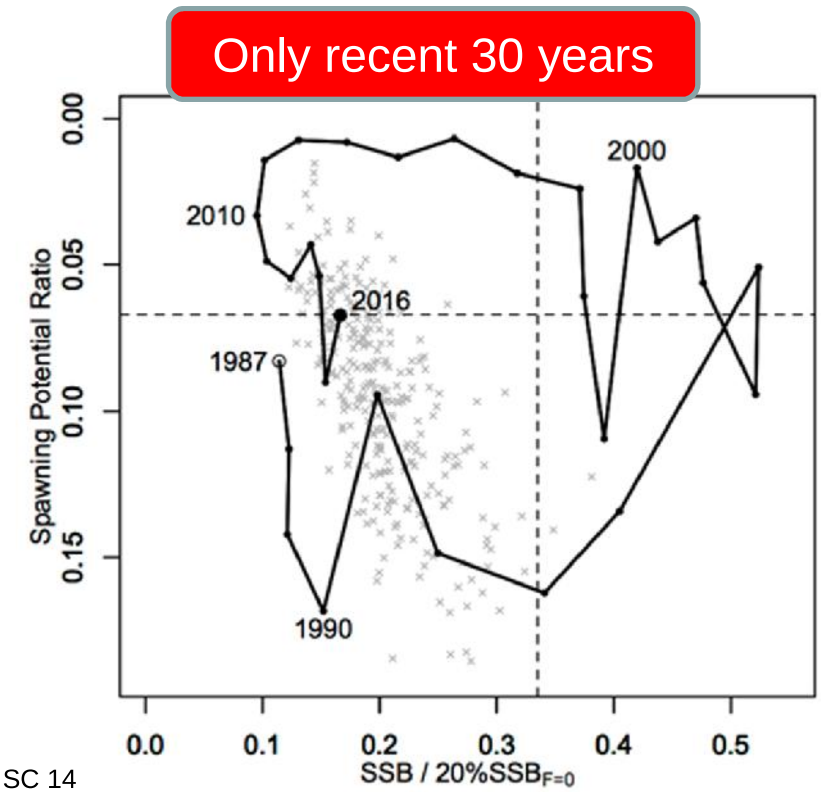
- Substantial decrease of F is observed in ages 0–2 in 2015–2016.
- Note that stricter management measures in IATTC and WCPFC have been in place since 2015.



Stock Trajectory

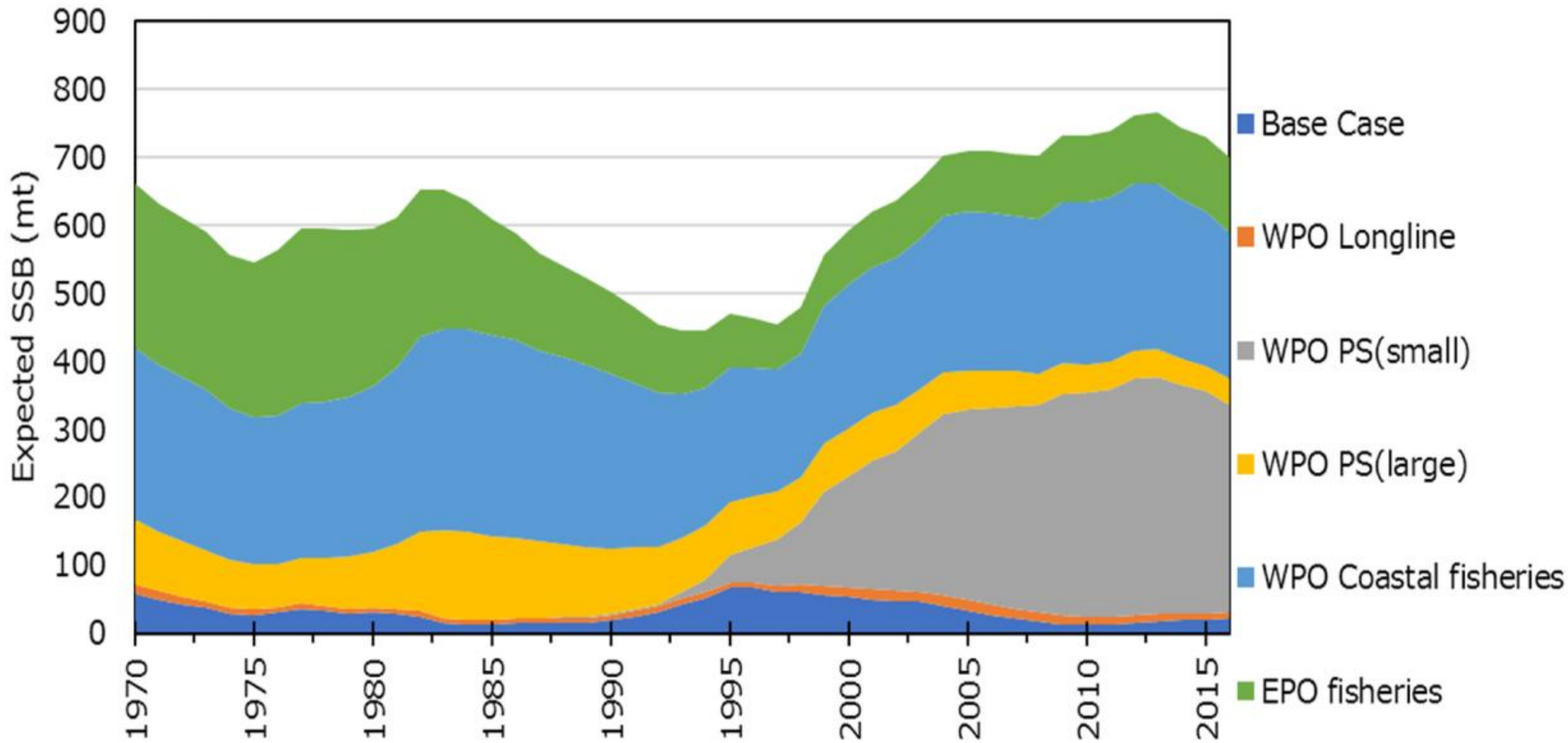
	Initial rebuilding target	Second rebuilding target	1995 (recent high)	2002-2004 (reference year)	2011 (5 years ago)	2016 (latest)
Biomass (%$SSB_{F=0}$)	$SSB_{med\ 1952\text{-}2014}$ = 6.7%	20%	10.4%	7.1%	2.1%	3.3%
fishing intensity (SPR)	6.7%	20%	5.1%	3.4%	4.9%	6.7%





Fishery impact plot

- Historically, the WPO coastal fisheries has had the greatest impact.
- Since about the mid-2000s, the WPO purse seine fleets targeting small PBF (age 0-1), have had the greatest impact.
- The impact of the EPO fishery was large before the mid-1980s, decreasing significantly thereafter.



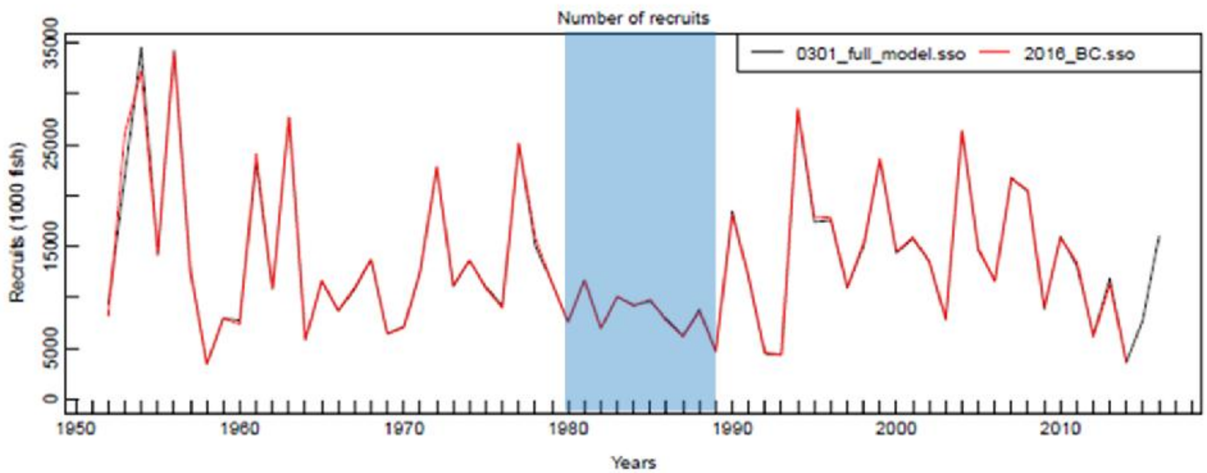
Projection

Projection model overview

- Age-structured forward projection model (*ssfuturePBF*)
  - Identical model structure with the stock assessment of PBF
  - Given growth, maturity and Natural mortality which are identical with those used in the stock assessment
  - Age-specific quarterly Fishing mortality of each fleet were assumed to be past particular year in the assessment (e.g. 2002-04).
  - Catch upper limit could be set to depict a management measure.
  - Two recruitment scenarios (low (1980-1989) and average (1952-2016))
- Projection time period
  - From 2016 to 2034
  - Initial condition (2016) was based on the stock assessment result.
- Uncertainty
  - 300 bootstrap replicates followed by 20 recruitments resampling.

Recruitment Scenario for Projection

- Specified by WCPFC HS-02.
- Low recruitment scenario until the initial rebuilding target being achieved and average recruitment thereafter.
- Recent 10-year recruitment is more optimistic than low recruitment scenario.

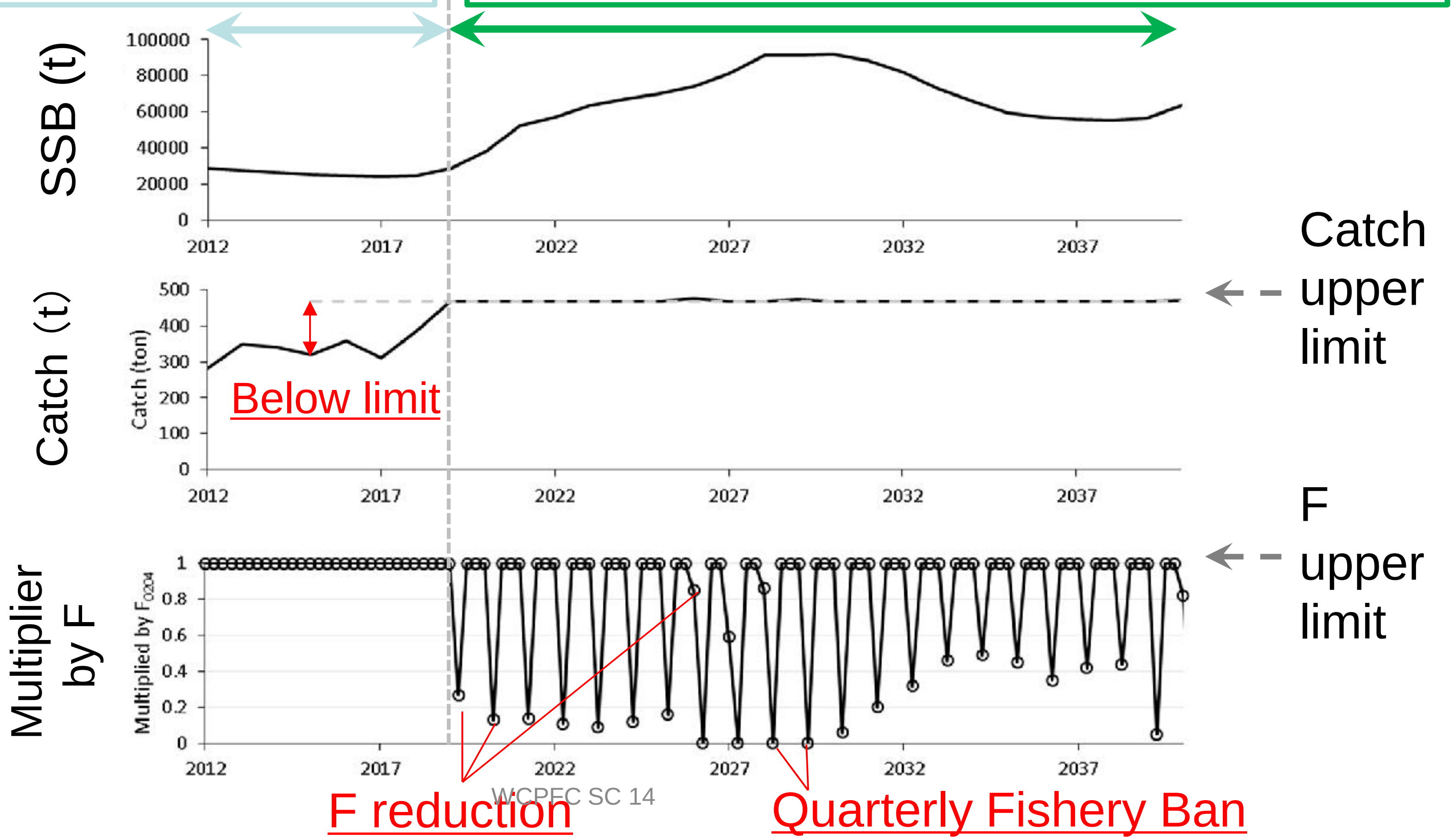


Fishing mortality and Catch controls in projection

When the stock remains at low, Catch does not meet its upper limit even fishery operates at given Fishing mortality (F).

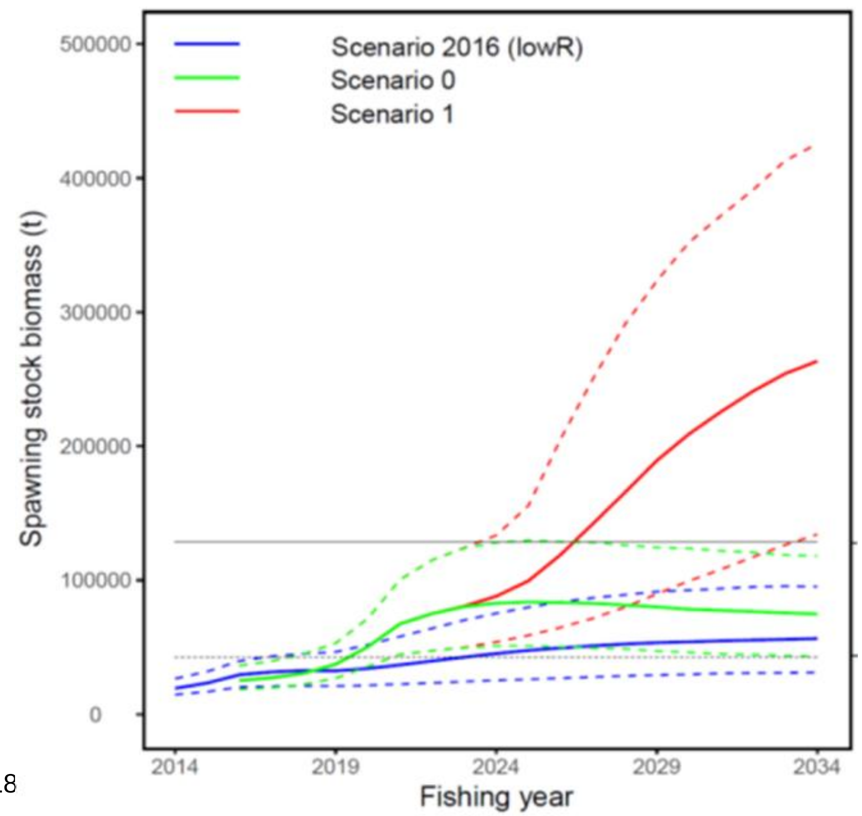
Once the stock gets recovery, fishery could get better yield with same given F. In the projection, when the catch approaches to its limit, F is adjusted or to be 0 (ban) to maintain catch limit.

【ex】



Projection with the current CMMs

- The projection of Status Quo (Scenario 0) resulted in an 98% probability of achieving the initial rebuilding target.
- More optimistic result than the 2016 projection is mainly due to the relatively good recruitment of 2016 year class.



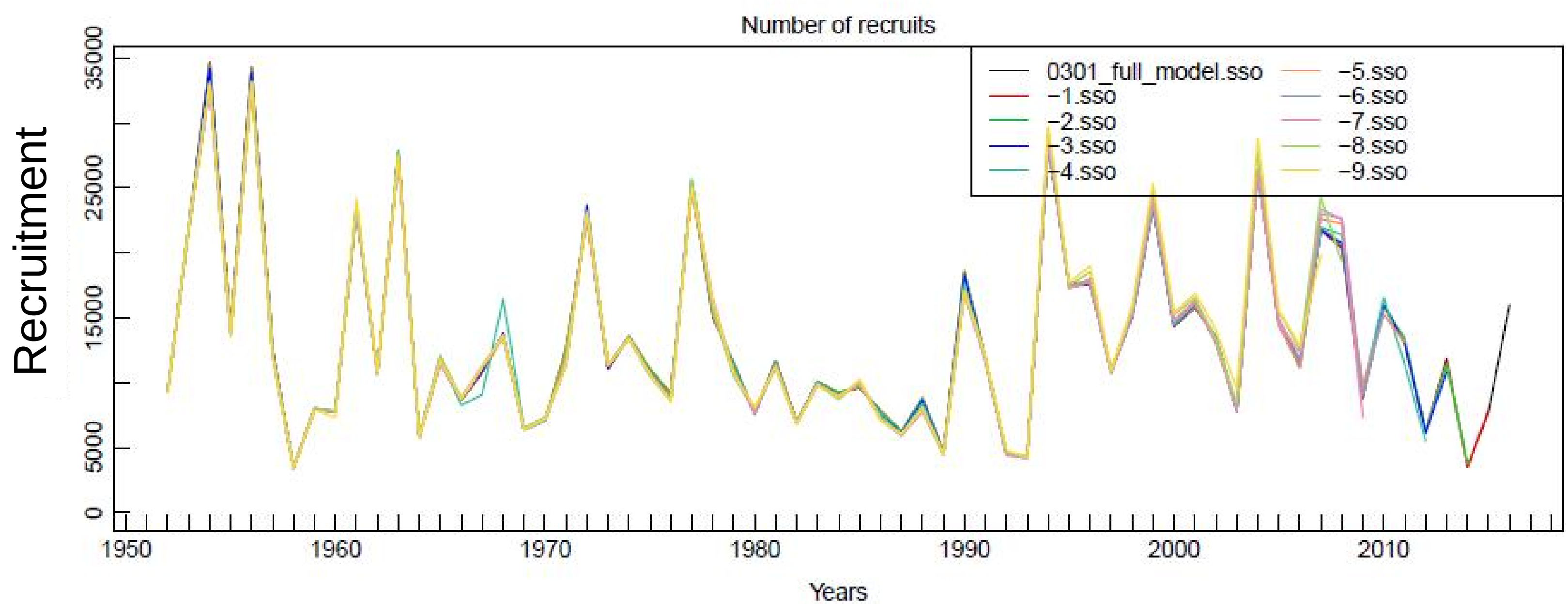
Scenario 2016 (2016 assessment)
Scenario 0 (low R)
Scenario 1 (R_switch_at SSBmed)

Second rebuilding target (20%SSB0)

Initial rebuilding target ($SSB_{med\ 1952-2014}$)

Retrospective Analysis for recruitment estimates

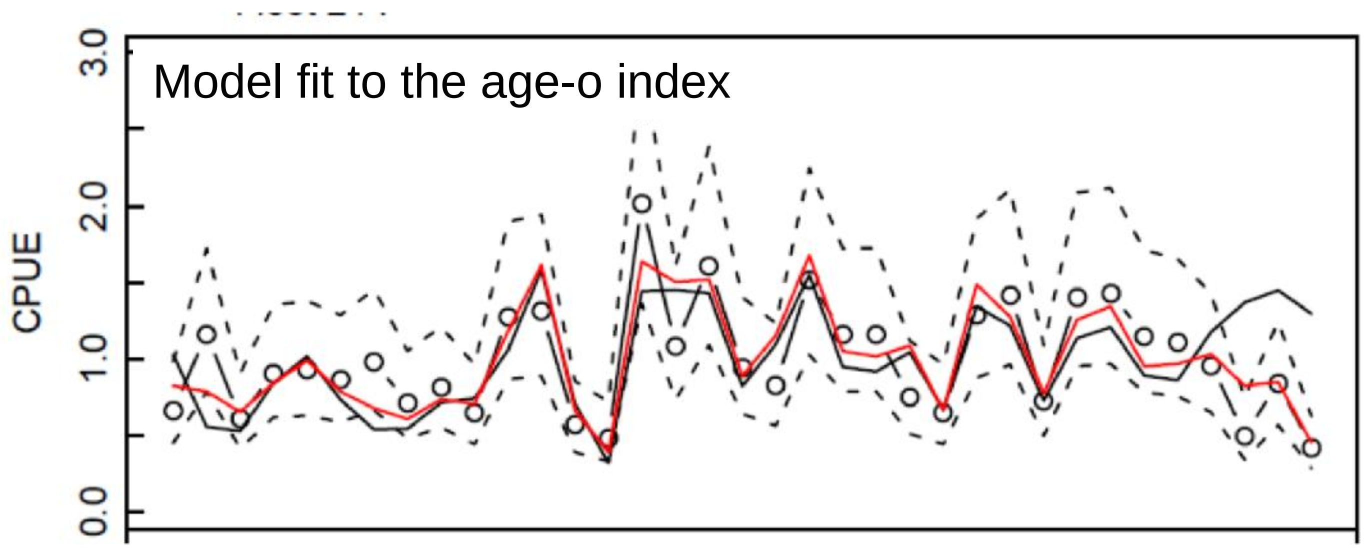
- Troll CPUE (Age-0 fishery) and size composition were main sources of information about recruitment strength.
- Recruitment estimates are basically consistent even when new size composition data is added.

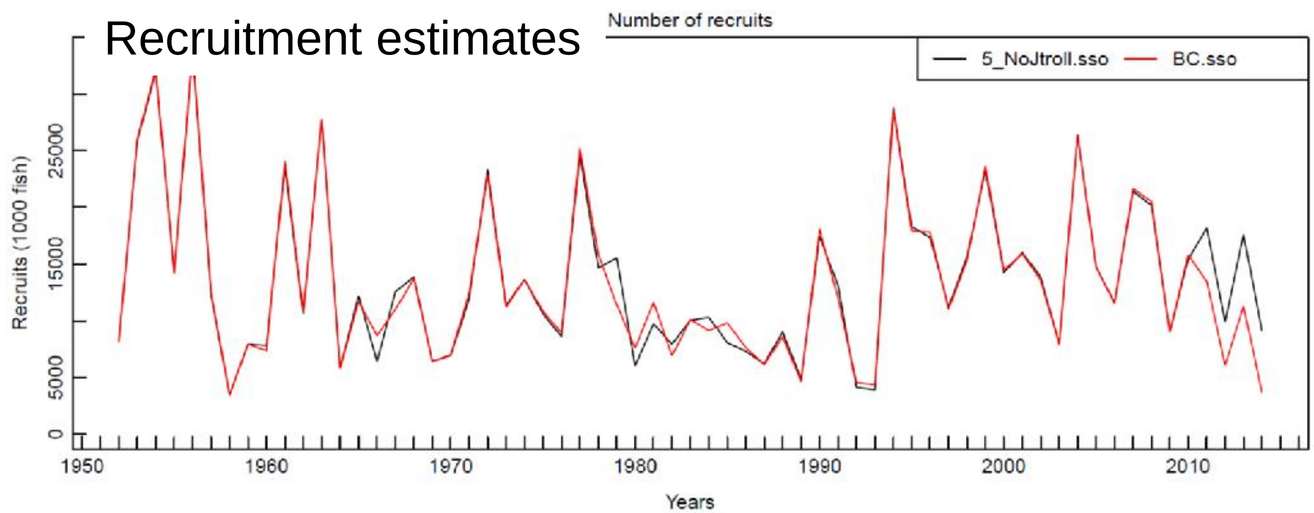


Sensitivity exercise for troll age-0 abundance index

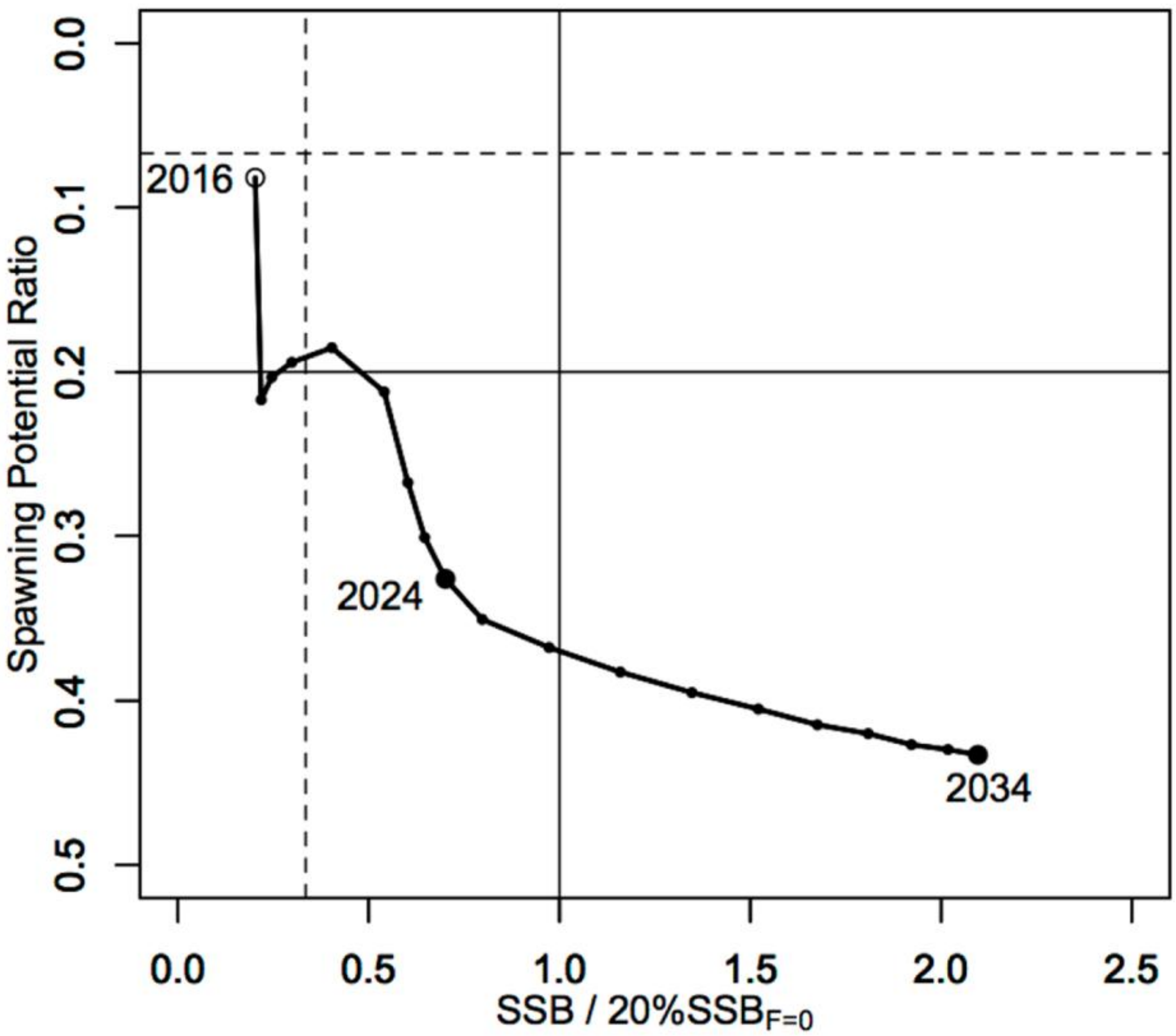
A model with age-0 index

A model without age-0 index





Kobe plot for the future periods (“La Jolla Plot”)



Summary of the assessment

- ISC conducted an update assessment with the up-to-date data until 2016 fishing year (–June, 2017).
- The model represents the data sufficiently and results were consistent with the 2016 assessment.
- ISC concluded that the 2018 assessment results were the best available science information.
- The 2018 projection results are more optimistic, mainly due to the relatively good recruitment in the terminal year (2016 YC).
- Based on the performance analyses of the recruitment estimates, 2016 recruitment was included in the projections.

Additional projections in response to the WCPFC Harvest Strategy 2017-02

What's described in the WCPFC HS-2017-02 ?

- WCPFC Harvest Strategy (HS-2017-02)
  - Be prepared by the WCPFC NC & IATTC joint WG.
  - Provided two rebuilding targets, a HCR, and an assumption for future recruitment.
  - Requested to conduct some projections based on the new HCR.

Request for Projections under new HCR

- If the projection indicates that the probability of achieving the initial rebuilding target is <u>**at 75% or larger**</u>, ISC will be requested <u>to provide relevant information</u> on potential catch limit increases.
  - as long as the probability of reaching the initial rebuilding target is maintained at 70% or larger, and the probability of reaching the 2nd rebuilding target by the agreed deadline remains at least 60%.
- Recruitment assumptions for projection
  - The Initial rebuilding period (until the stock meets $SSB_{med1952\text{-}2014}$); Resampling from the relatively low recruitment period (1980-1989).
  - The 2nd rebuilding period (from next year of initial rebuilding period); Resampling from the entire assessment period.

Scenarios with potential catch limit increase

Scenario 1: Approximation of the CMMs in force by the IATTC & WCPFC.

(Scenario 0): Same with the scenario 1, but low recruitment continues.

Scenario 2: Same catch limit with HS1, but no effort control (Constant Catch).

Scenario 3: 5% increase of catch limit for all fleets from scenario 2.

Scenario 4: 10% increase of catch limit for all fleets from scenario 2.

Scenario 5: 15% increase of catch limit for all fleets from scenario 2.

Scenario #	Fishing mortality*1	WPO Catch limit					EPO*3 Catch limit		Catch limit Increase			
		Japan*2		Korea		Taiwan	Commercial	Sports	WPO		EPO	
		Small	Large	Small	Large	Large	Small / Large		Small	Large	Small	Large
0*4	F	4,007	4,882	718		1,700	3,300	-	0%		0%	
1	F	4,007	4,882	718		1,700	3,300	-	0%		0%	
2	F x 2.0	4,007	4,882	718		1,700	3,300	-	0%		0%	
3	F x 2.0	4,207	5,126	754		1,785	3,465	-	5%		5%	
4	F x 2.0	4,408	5,370	790		1,870	3,630	-	10%		10%	
5	F x 2.0	4,608	5,614	826		1,955	3,795	-	15%		15%	

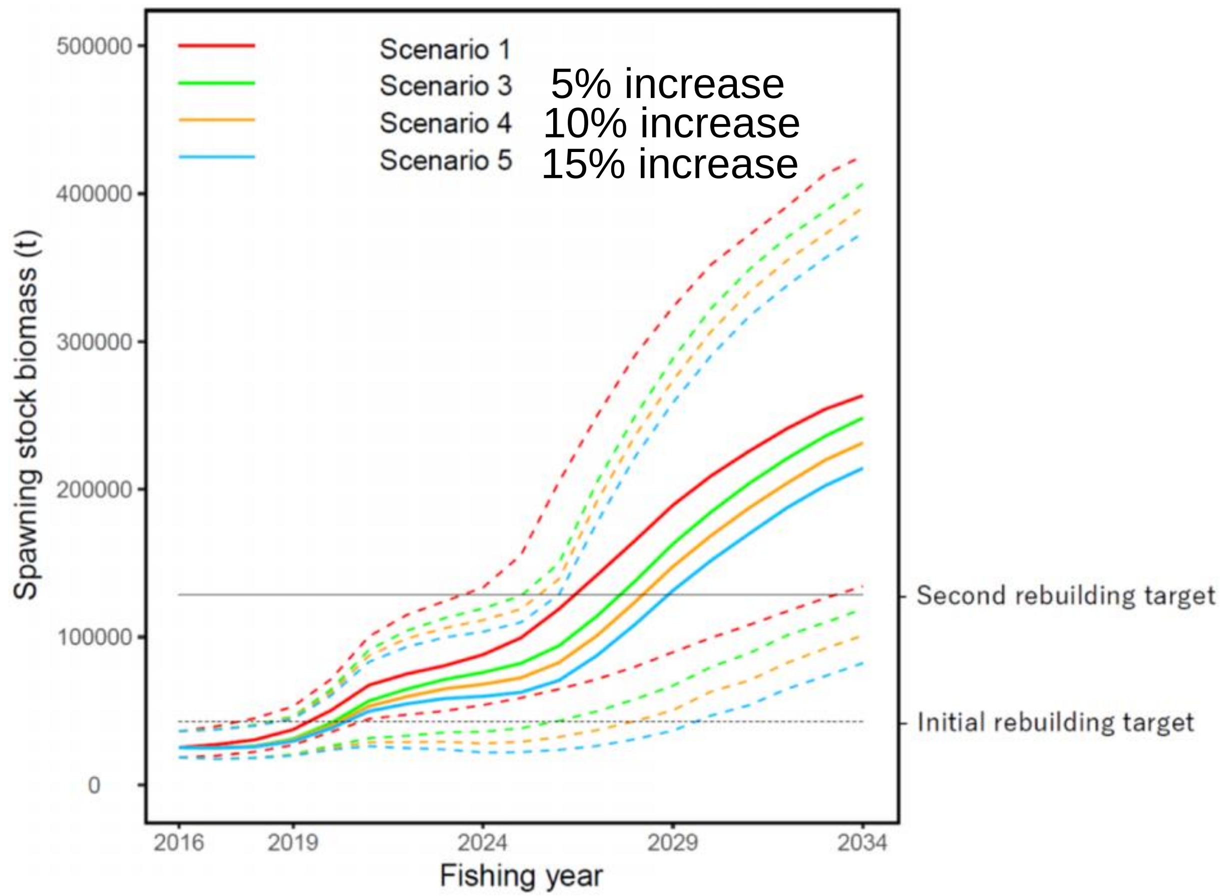
Results of the projections

Scenarios	Catch limit increase	Probability of achieving	
		Initial rebuilding target	2nd rebuilding target
Scenario 0	-	98%	3%
Scenario 1	-	99%	96%
Scenario 2	-	96%	96%
Scenario 3	5%	91%	93%
Scenario 4	10%	83%	90%
Scenario 5	15%	74%	85%

Scenario #	Catch limit Increase				Initial rebuilding target			Second rebuilding target		Median SSB (mt) at 2034
	WPO		EPO		The year expected to achieve the target with >60% probability	Probability of achiving the target at 2024	Probability of SSB is below the target at 2024 under the low recruitment	The year expected to achieve the target with >60% probability	Probability of achiving the target at 2034	
	Small	Large	Small	Large						
0[*1]	0%		0%		2020	98%	2%	N/A	3%	74,789
1	0%		0%		2020	99%	2%	2028	96%	263,465
2	0%		0%		2021	96%	4%	2028	96%	264,118
3	5%		5%		2021	91%	8%	2029	93%	248,295
4	10%		10%		2021	83%	15%	2029	90%	231,466
5	15%		15%		2021	74%	24%	2030	85%	255,085

Results of the projections for catch limit increase

○ All of the scenarios provided were confirmed to achieve the rebuilding targets with the probability prescribed in the WCPFC Harvest Strategy.



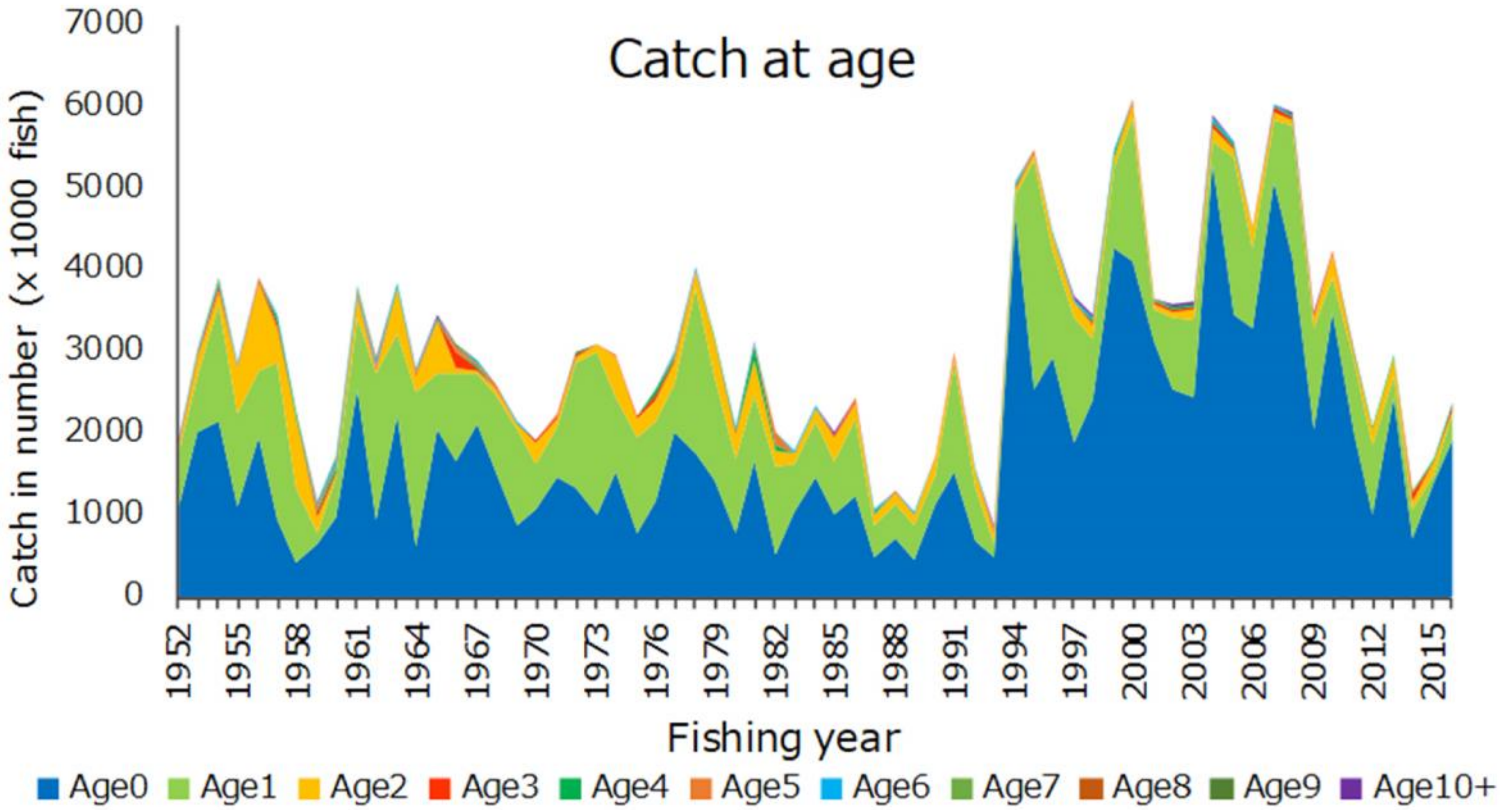
What did we do further?

- Investigating the possible effect if the increase of catch limit was differentiated between small and large fish.

Scenario #	WPO Catch limit					EPO Catch limit			Catch limit Increase			
	Japan		Korea		Taiwan	Commercial		Sports	WPO		EPO	
	Small	Large	Small	Large	Large	Small	Large		Small	Large	Small	Large
6	4,207	5,858	528	258	2,040	1,733	1,980	-	5%	20%	5%	20%
7	4,207	5,858	528	258	2,040	1,815	1,815	-	5%	20%	10%	10%
8	4,408	5,370	553	237	1,870	1,733	1,980	-	10%	10%	5%	20%
9	4,207	6,591	528	291	2,295	1,733	2,228	-	5%	35%	5%	35%
10	4,207	6,591	528	291	2,295	1,898	1,898	-	5%	35%	15%	15%
11	4,608	5,614	578	248	1,955	1,733	2,228	-	15%	15%	5%	35%
12	4,408	5,858	553	258	2,040	1,815	1,980	-	10%	20%	10%	20%
13	4,408	5,858	553	258	2,040	1,898	1,898	-	10%	20%	15%	15%
14	4,608	5,614	578	248	1,955	1,815	1,980	-	15%	15%	10%	20%
15	4,408	6,347	553	280	2,210	1,815	2,145	-	10%	30%	10%	30%
16	4,408	6,347	553	280	2,210	1,898	1,898	-	10%	30%	15%	15%
17	4,608	5,614	578	248	1,955	1,815	2,145	-	15%	15%	10%	30%

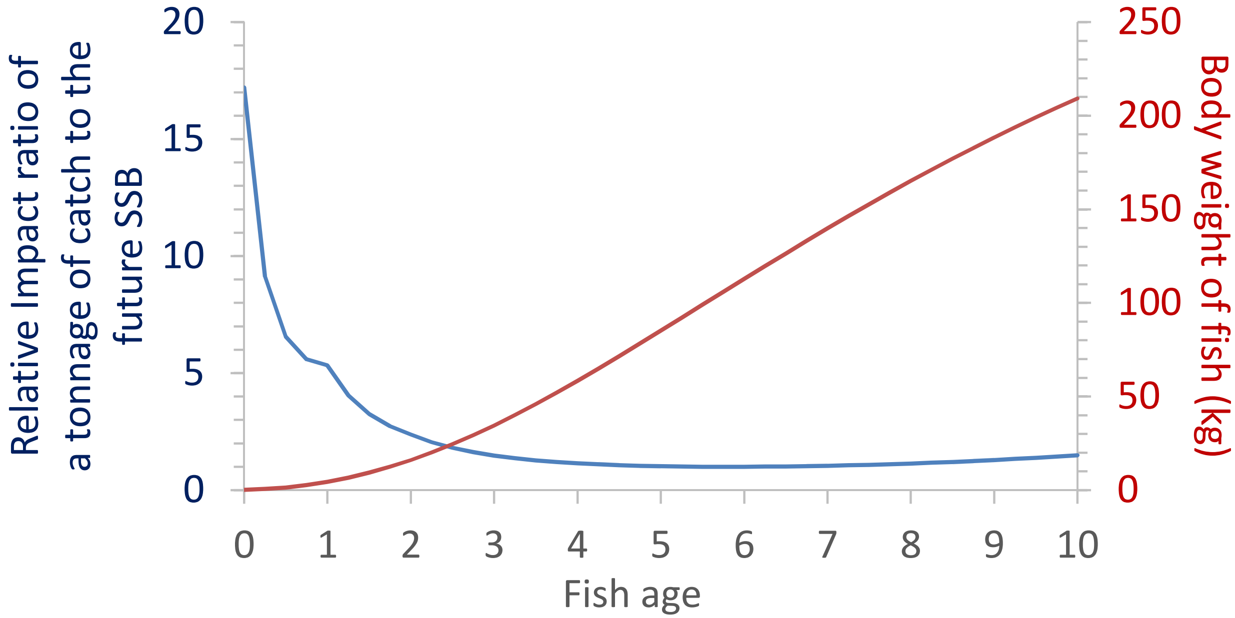
Why did we do that?

- The most of catch in number were occupied by ages 0-1 fish.



Difference of the Impact of fishery by catch at age

- Same weight of catch has different impact on the stock by age.
  - 1 ton of catch≒500 of age-0 (2 kg of body weight)≒20 of age-3 (49 kg).
  - Catching a high number of small fish can have a greater impact on future spawning stock biomass than catching the same weight of large fish.



Age	0	1	2	3	4	5	6	7
Body weight	2	11	27	49	75	102	130	156
Fish/ton	502	92	37	20	13	10	8	6

Results of the different increment fraction scenarios

○ All of the examined scenarios were confirmed to achieve the initial and second rebuilding targets given the recruitment assumption.

Scenario #	Catch limit Increase				Initial rebuilding target			Second rebuilding target		Median SSB (mt) at 2034
	WPO		EPO		The year expected to achieve the target with >60% probability	Probability of achiving the target at 2024	Probability of SSB is below the target at 2024 under the low recruitment	The year expected to achieve the target with >60% probability	Probability of achiving the target at 2034	
	Small	Large	Small	Large						
6	5%	20%	5%	20%	2021	94%	6%	2028	95%	255,672
7	5%	20%	10%	10%	2021	94%	6%	2028	95%	248,911
8	10%	10%	5%	20%	2021	92%	9%	2029	94%	214,278
9	5%	35%	5%	35%	2021	93%	9%	2029	94%	246,153
10	5%	35%	15%	15%	2021	93%	9%	2029	94%	247,409
11	15%	15%	5%	35%	2021	84%	16%	2029	91%	233,055
12	10%	20%	10%	20%	2021	89%	11%	2029	93%	243,491
13	10%	20%	15%	15%	2021	89%	11%	2029	93%	243,223
14	15%	15%	10%	20%	2021	85%	16%	2029	91%	234,203
15	10%	30%	10%	30%	2021	87%	14%	2029	92%	237,742
16	10%	30%	15%	15%	2021	88%	13%	2029	92%	238,957
17	15%	15%	10%	30%	2021	84%	17%	2029	90%	232,769

Results

- All of the examined scenarios were confirmed to achieve the initial and second rebuilding targets given the recruitment assumption.
- The results showed that the measures protecting small fish are more effective than those protecting large fish for rebuilding.

Scenario #	Catch limit Increase				Probability of achieving		Probability of SSB is below the initial target at 2024 under the low recruitment	Expected annual catch in 2024 (ton)
	WPO		EPO		initial rebuilding target	second rebuilding target		
	Small	Large	Small	Large				
5	15%	15%	15%		74%	85%	24%	16,641
12	10%	20%	10%	20%	89%	93%	11%	16,841

Summary for the projections under new HCR

- In accordance with WCPFC HS 02, ISC conducted additional projections with various combination of the increase of catch limit.
- All of the examined scenarios were confirmed to achieve the initial and second rebuilding targets given the recruitment assumption.
- The projection results also show that the measures protecting small fish are more effective than those protecting large fish to rebuild the stock.

1st ISC Pacific Bluefin tuna MSE Workshop

30-31 May 2018
Yokohama, Japan

- **72 participants:** fishery managers, stakeholders, NGOs, and scientists
- **Talks and discussions:**
  To learn about and understand the MSE process (Dinardo);
  Requirements to implement an MSE (Nakatsuka);
  Recent progress by ALBWG and other RFMOs (Holmes);
- **First step for PBF MSE**
- **Results will be presented for NC-IATTC Joint Meeting in Sept .**

Thank you