# WCPFC NC 14

# Pacific Bluefin Tuna Assessment;

# 2018 Update Stock Assessment and Projections


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ISC PBFWG


2018/9/4

# 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

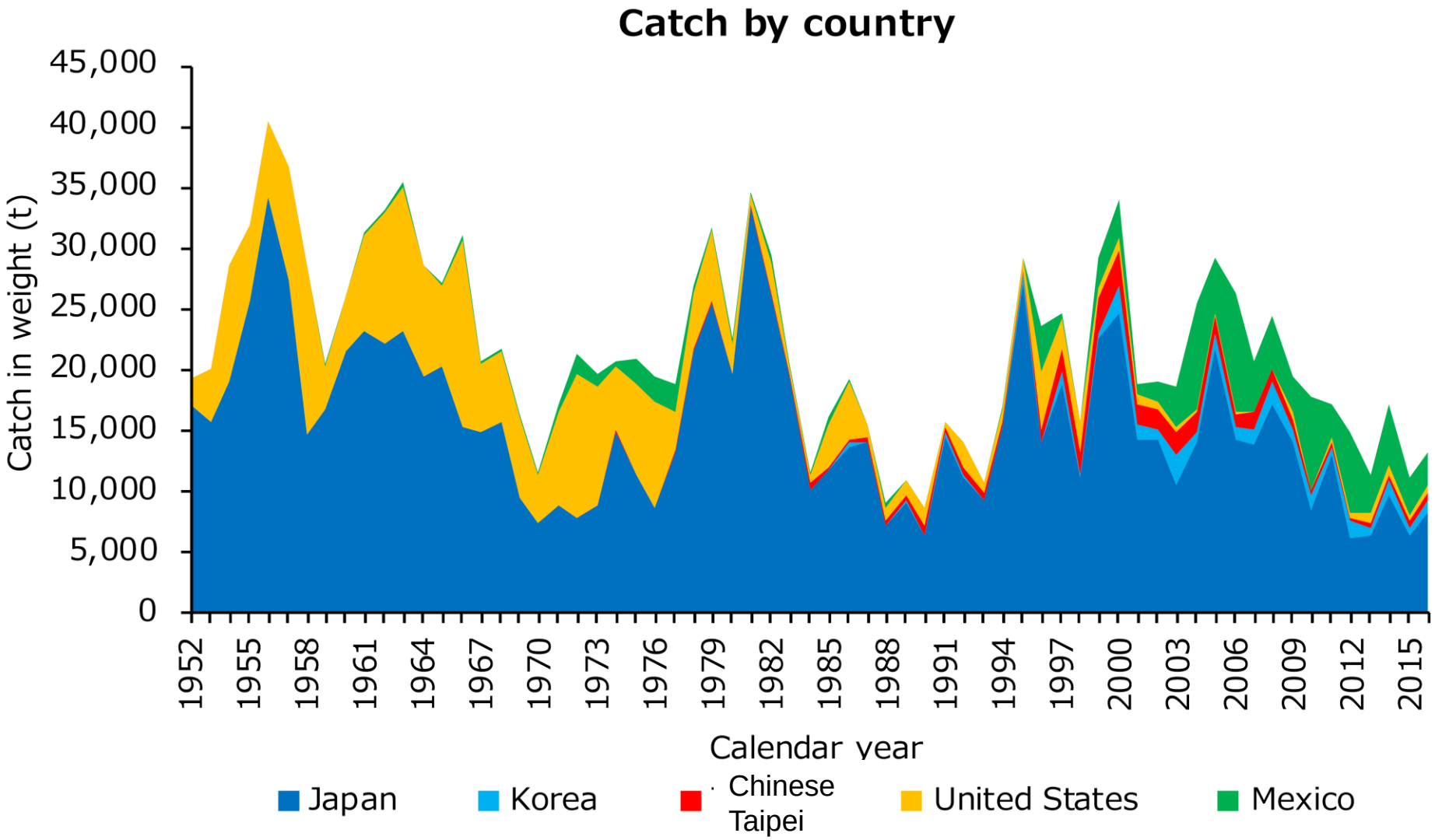
# Overview of 2018 assessment model

- 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

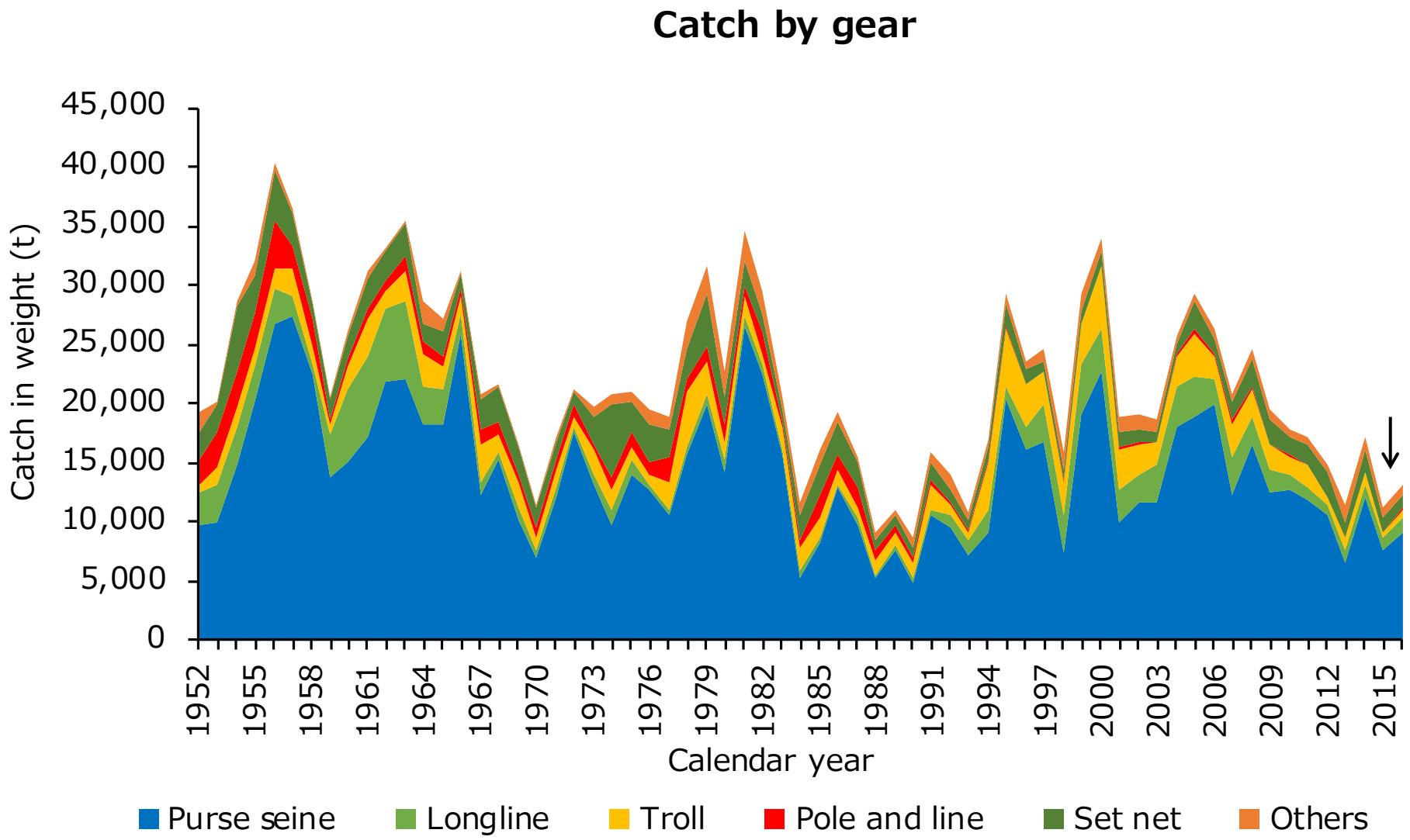
# What are updated ?

- 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.

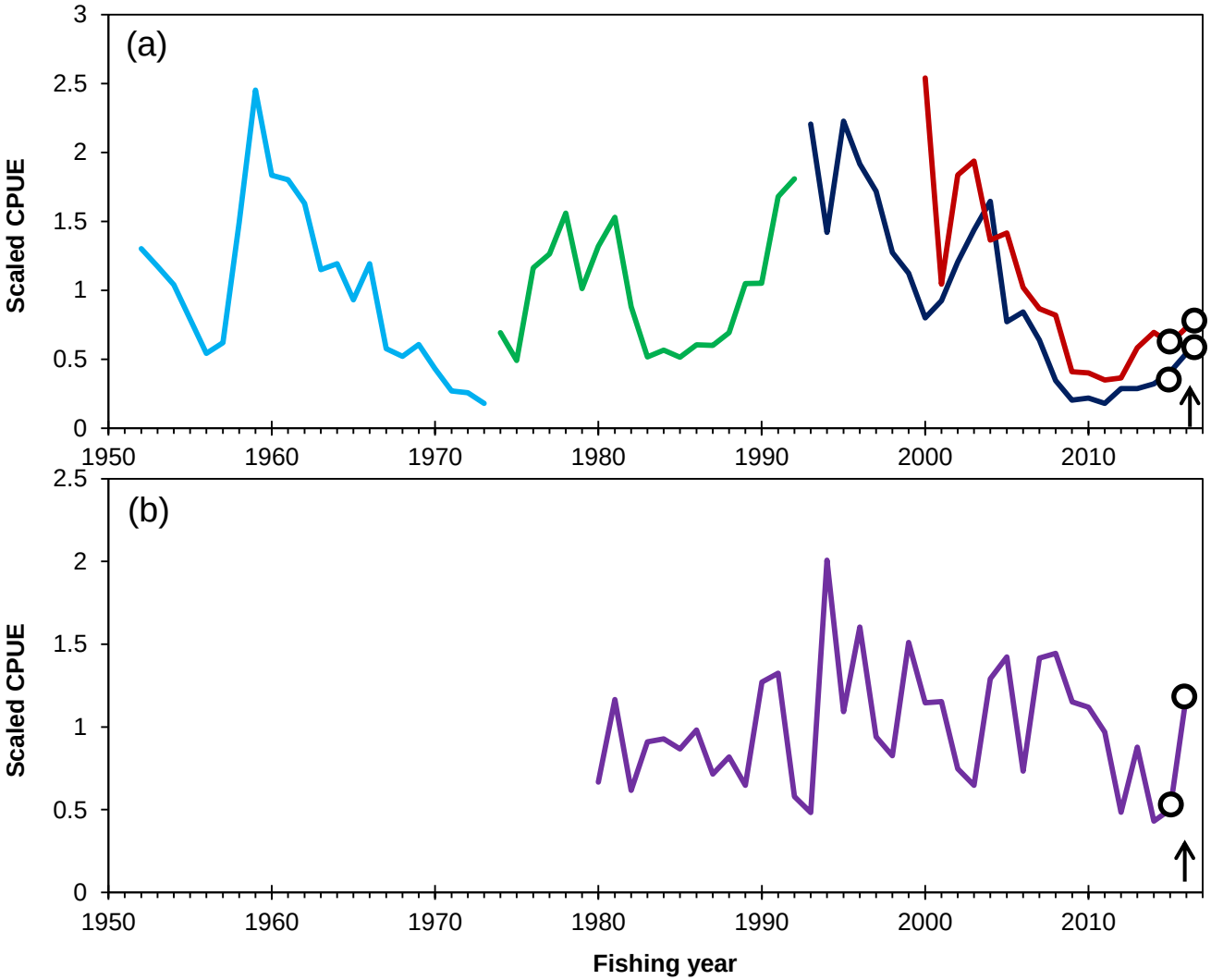
# Catch by country



# Catch by gear



# Catch per Unit of Effort based abundance index



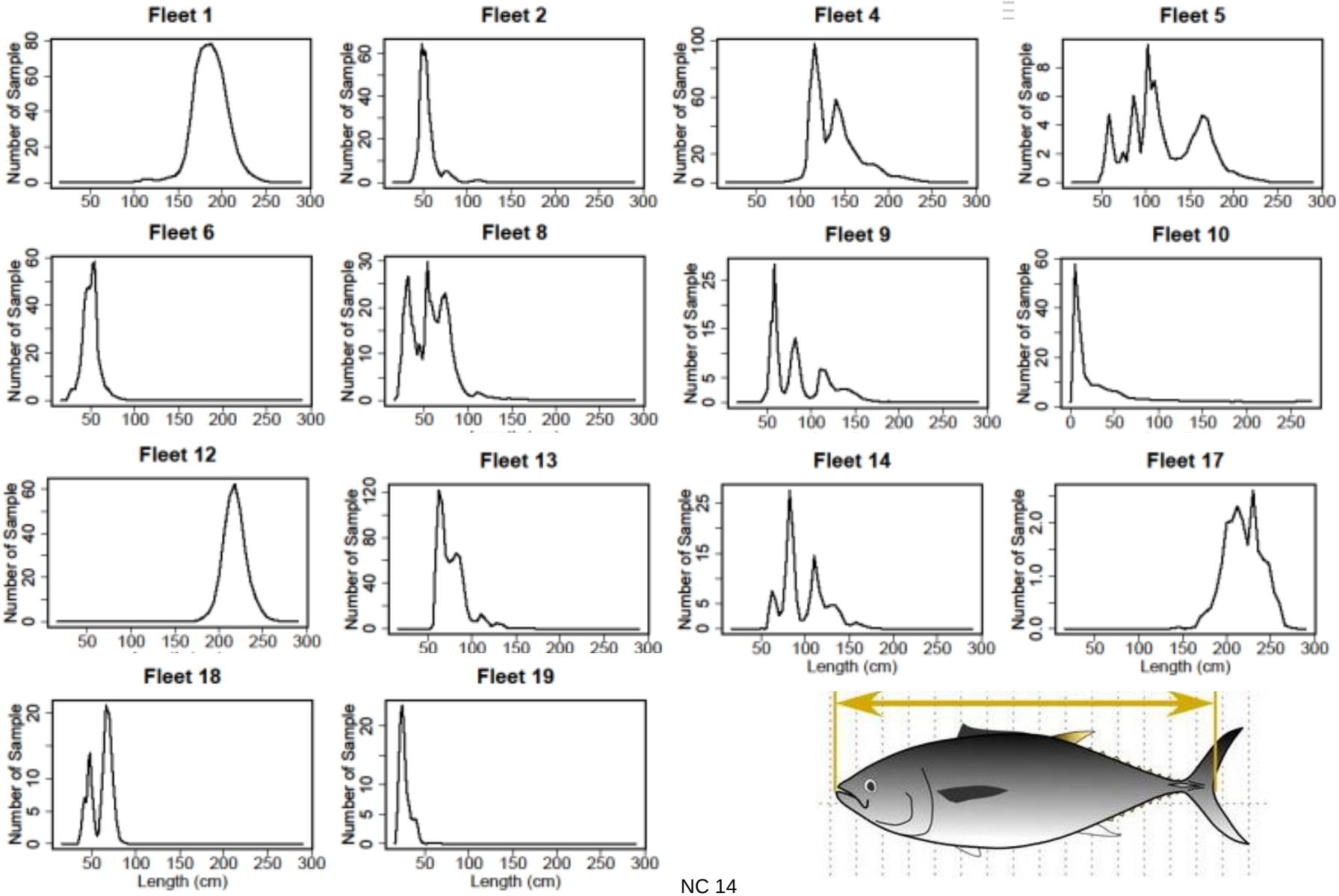

a. Longline

- Spawner index
  - JPN longline #1
  - JPN longline #2
  - JPN longline #3
  - TWN longline

b. Troll

- Age-0 index
  - JPN Troll

# Size Composition data

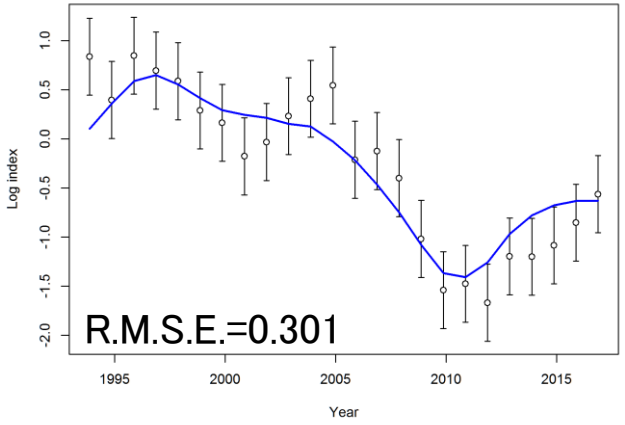


# Results

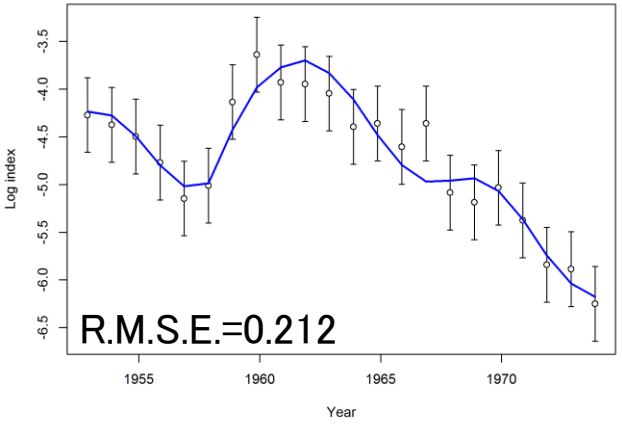
- Goodness of fit to
  - CPUE based abundance indices
  - Size composition
- Likelihood profile over population scale
- Retrospective diagnostics
- Assessment results
  - SSB and Recruitment
  - F at Age
  - Kobe plot
  - Impact plot

# Goodness of fit to CPUEs

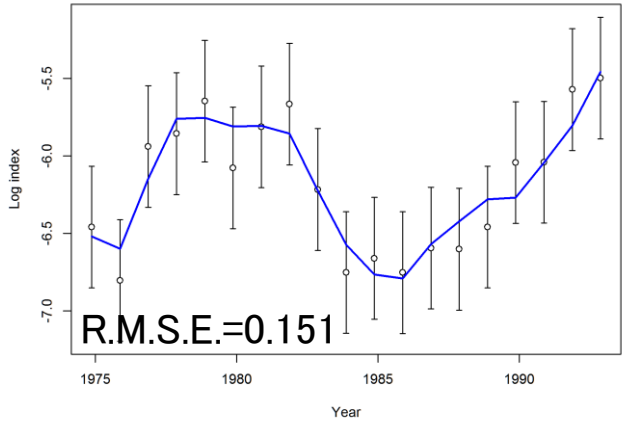
S1: Jpn Longline (1993-2016)



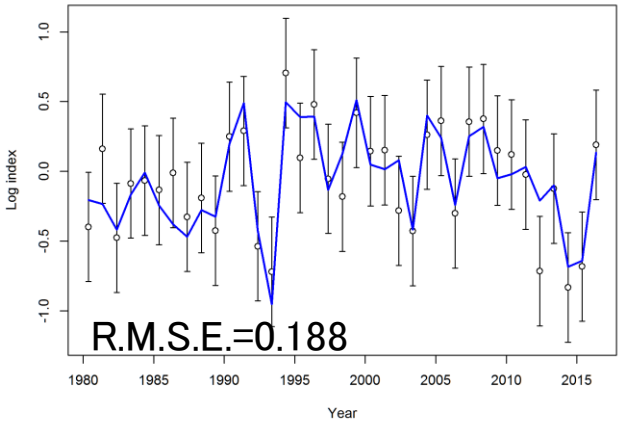

S2: Jpn Longline (1952-1973)



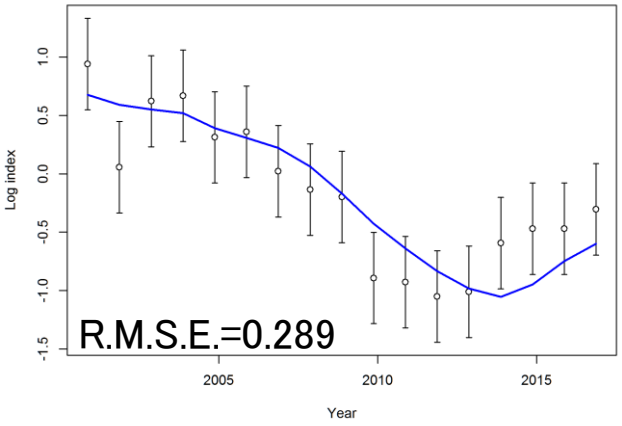

S3: Jpn Longline (1974-1992)



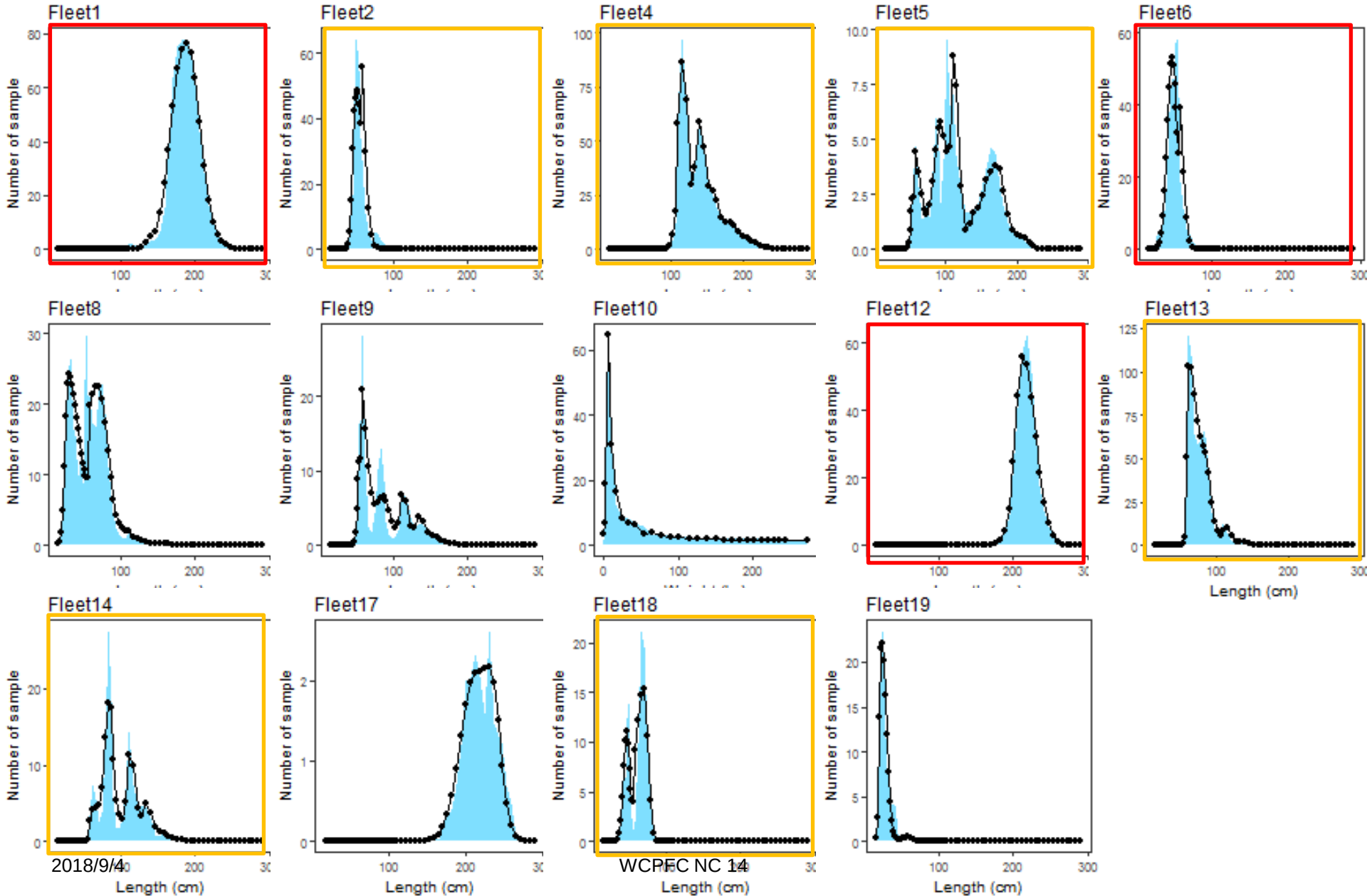

S5: Jpn Troll (1980-2016)




S9: Twn Longline (2000-2016)

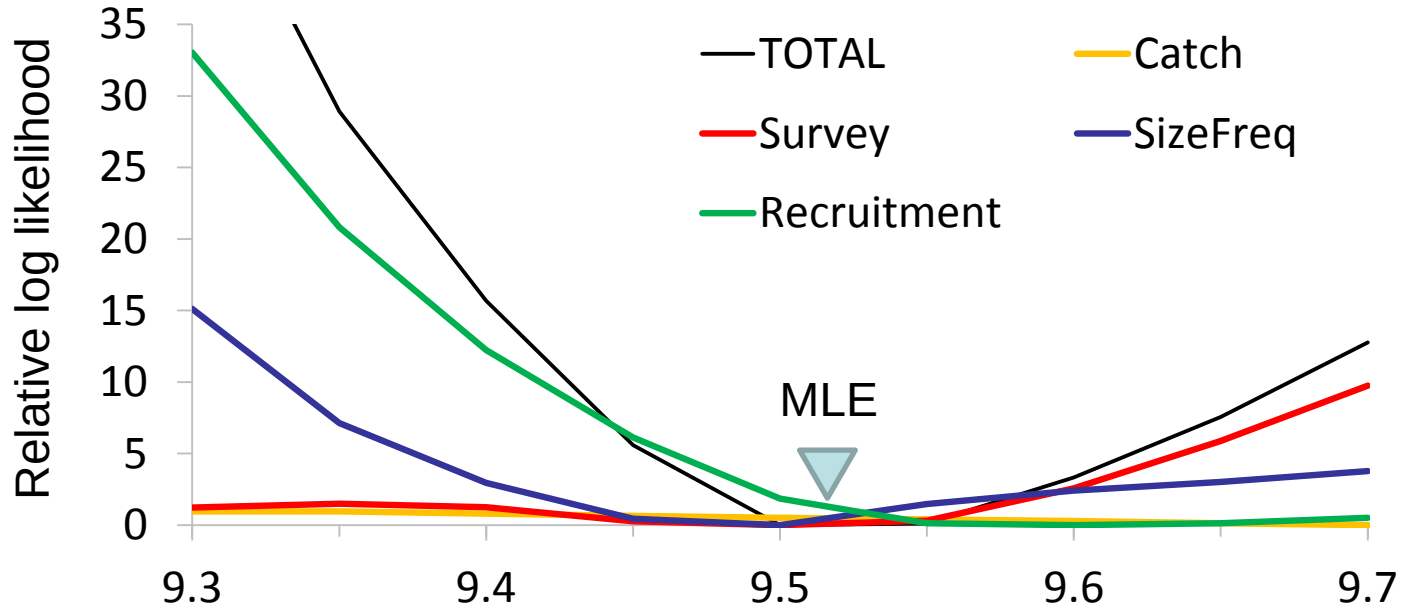


# Average fits to Size Compositions



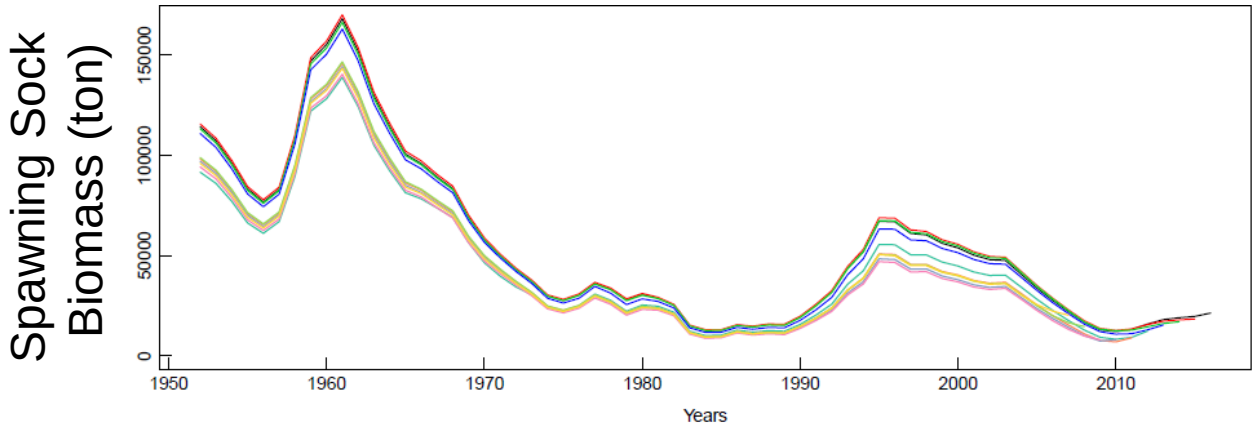
# Likelihood profiles over fixed scaling parameter

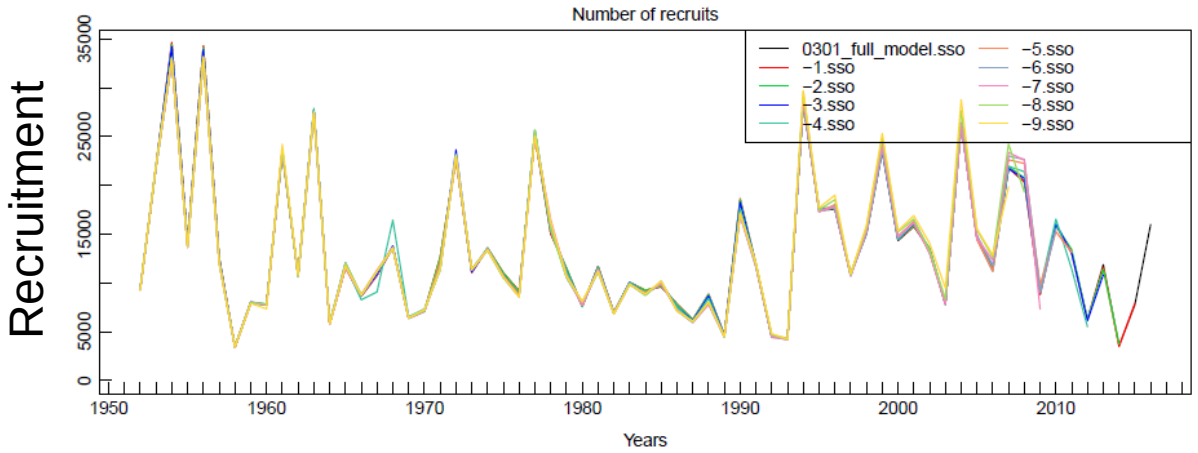
- Each component marked the lowest likelihood around at maximum likelihood estimate (MLE) of Log($R_0$).
  - CPUE (9.5), Size comp. (9.5), Recruitment Penalty (9.6)
  - Consistency regarding the population scale estimates.



# Retrospective Analysis

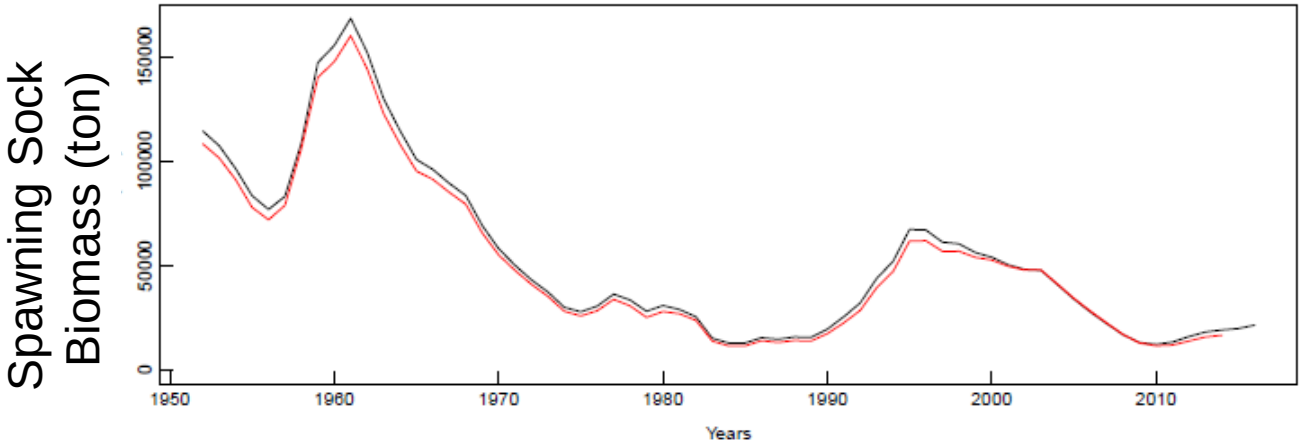
- No substantial pattern in recent 3–4 terminal years in the SSB estimates although those of 5 year and above might be slightly underestimated.
- Recruitment estimates are basically consistent.

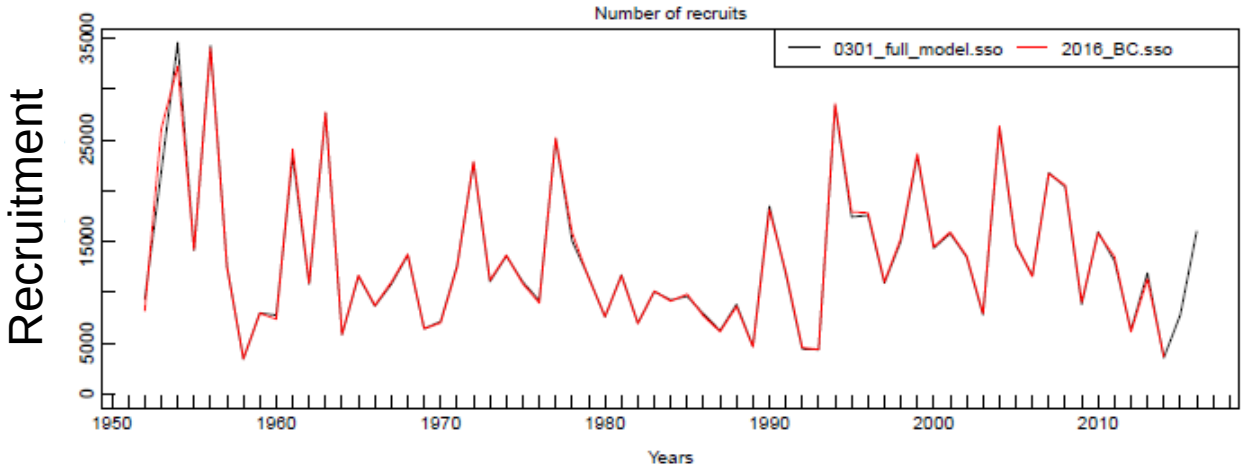


# Assessment results

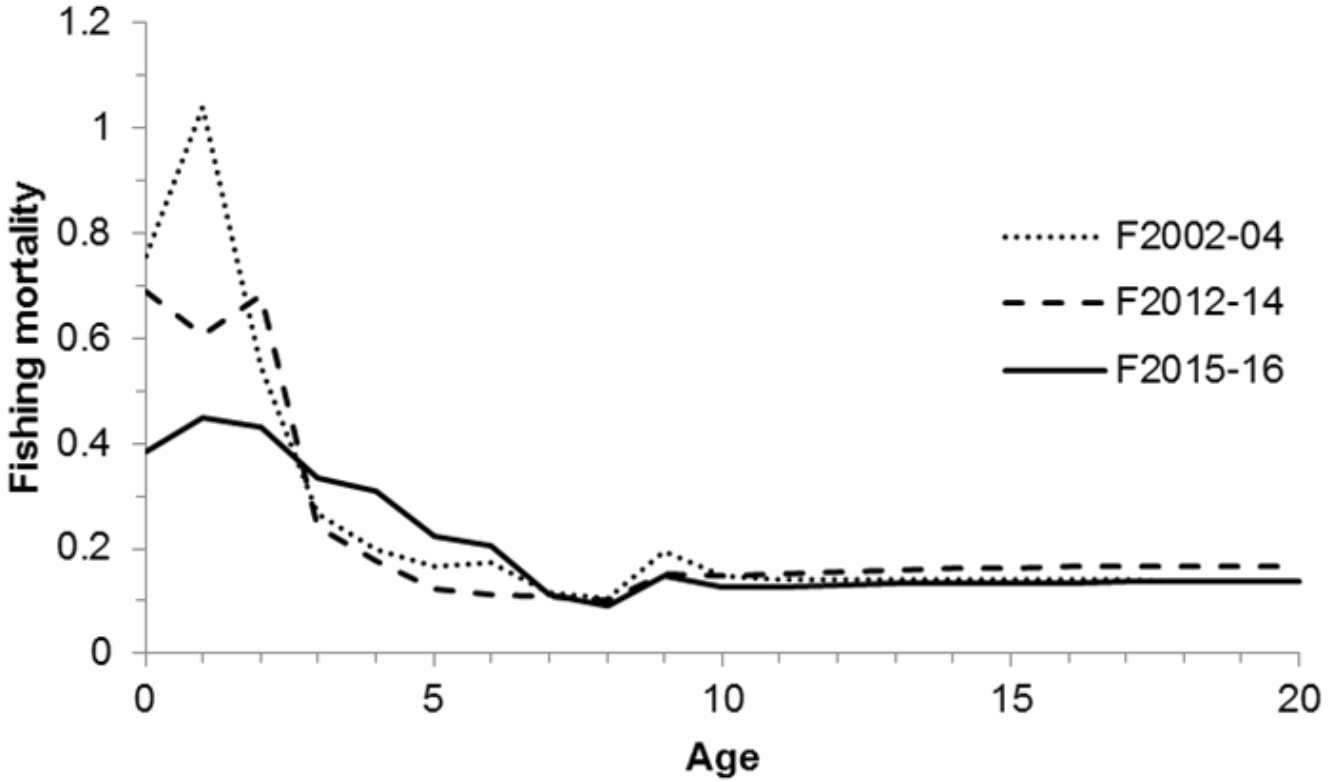
- Base case model derived consistent results with the previous assessment.
  - SSB fluctuated over time; declined during 1996–2010, and increased since 2011.
  - Recruitments in 2015 and 2016 are lower and higher than the historical average.



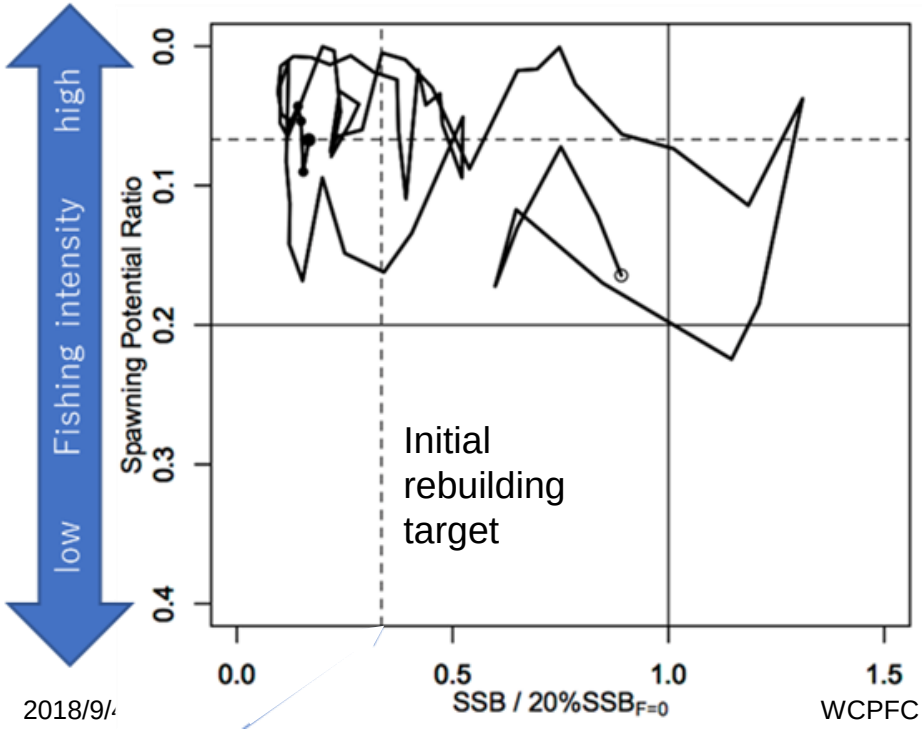
# Age specific fishing mortality

- 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.

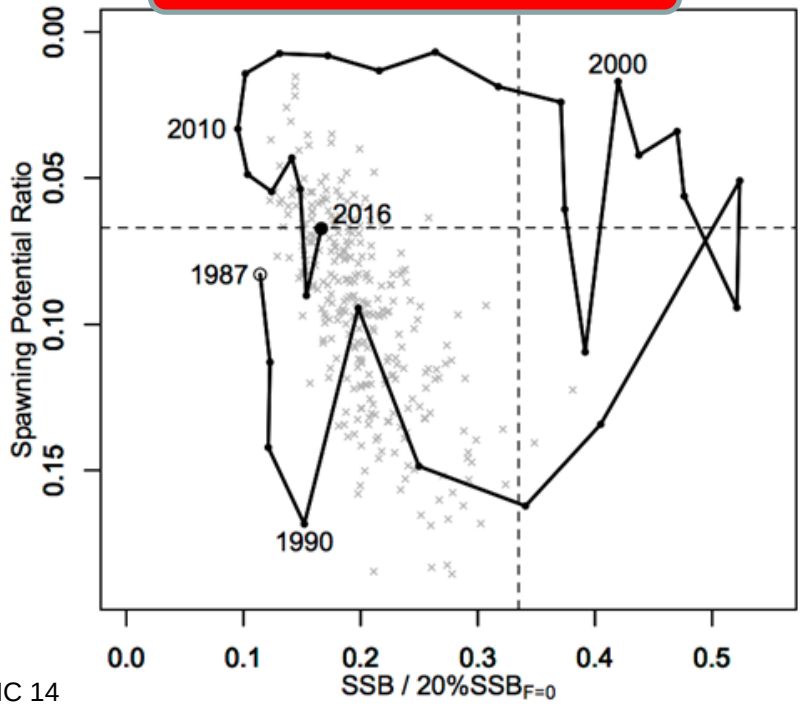


# Stock Trajectory

| | 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% |

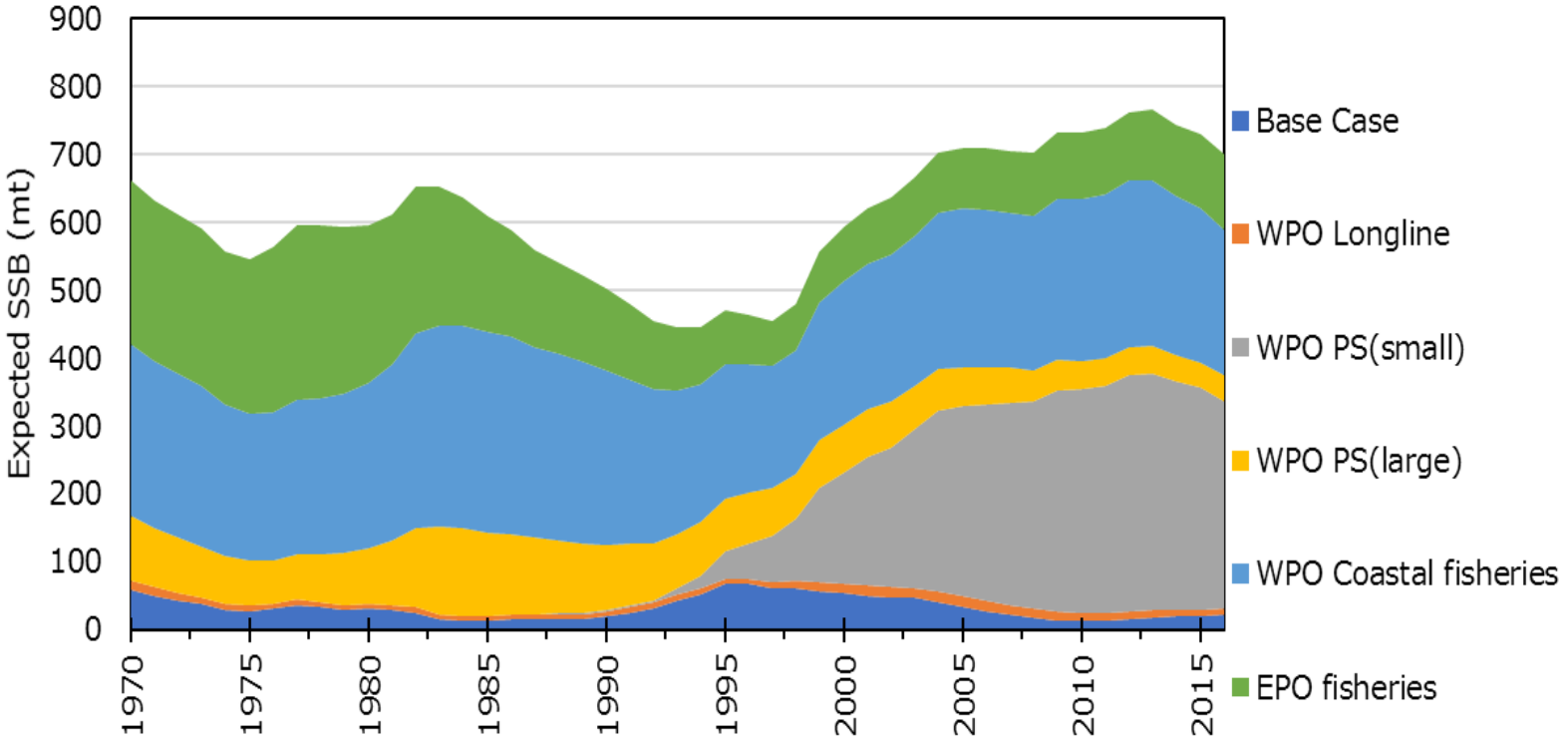



Only recent 30 years



# 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.



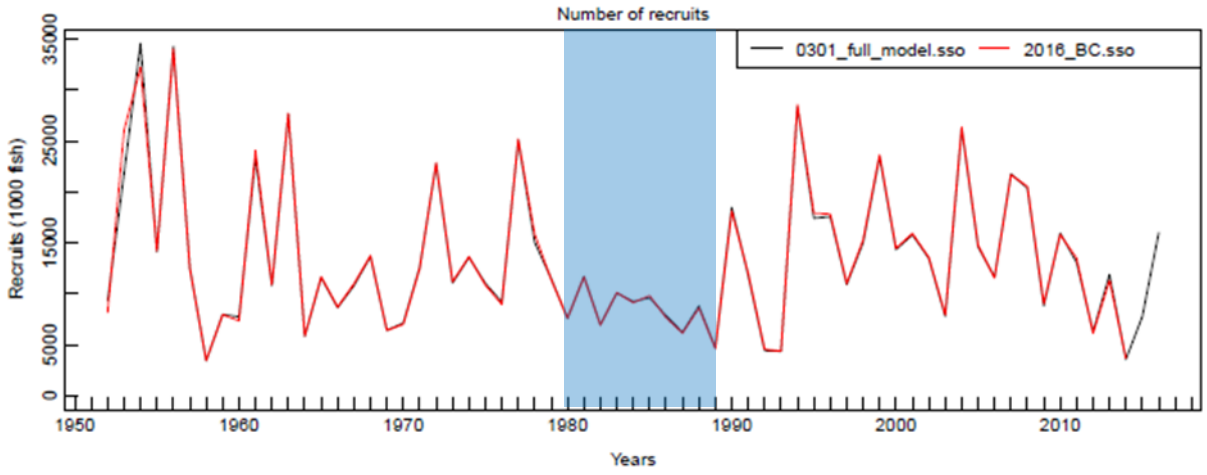
# Projection

# 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.

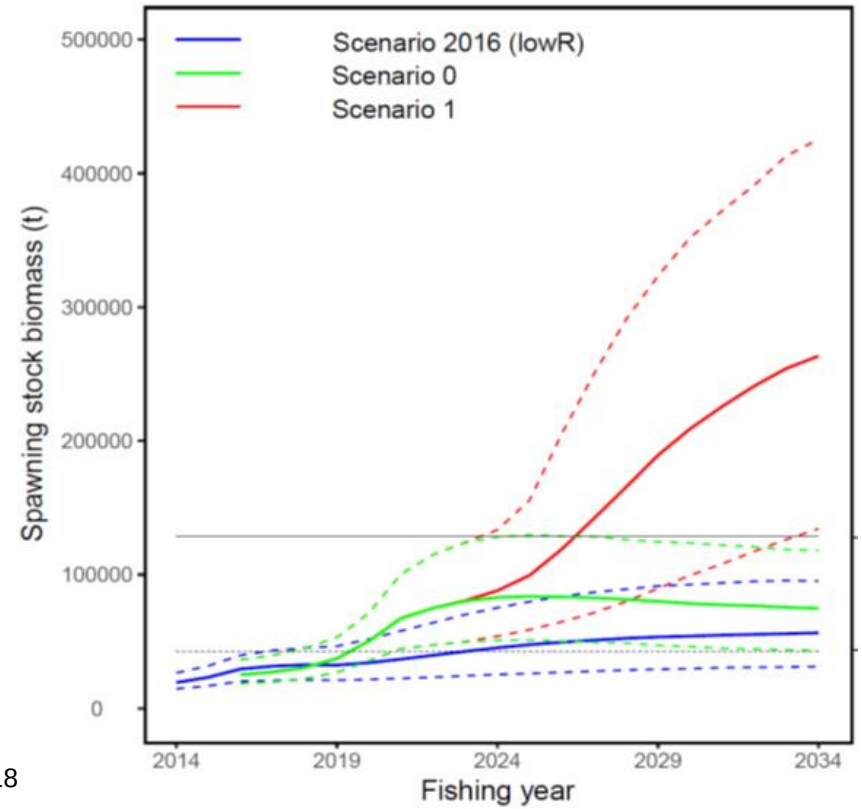
# Recruitment Scenario for Projection

- 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.



# 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.

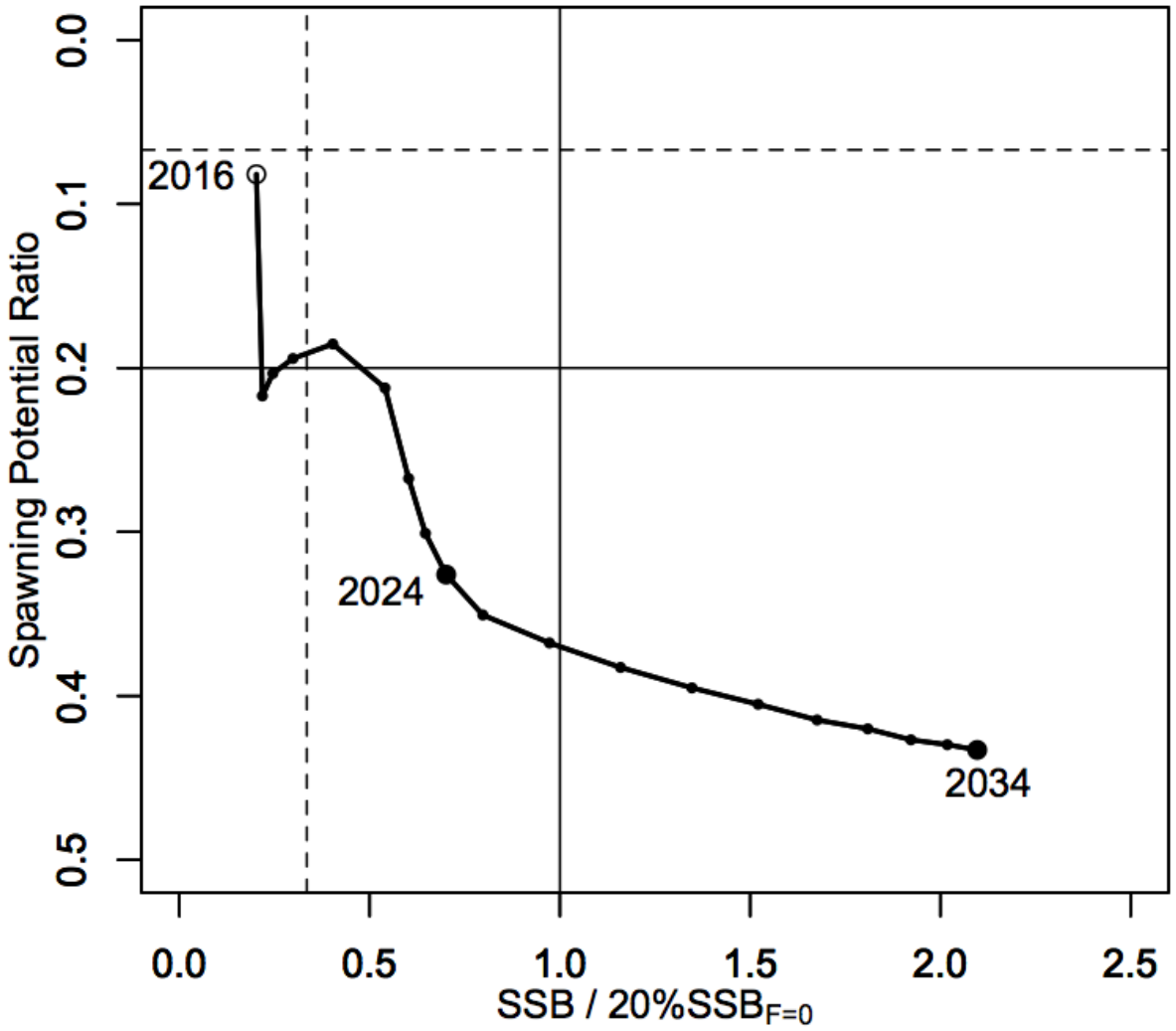



Scenario 2016 (2016 assessment )
Scenario 0 (low R)
Scenario 1 (R_switch_at SSBmed)

Second rebuilding target (20%SSB0)

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

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



# Stock Status

- No biomass-based limit or target reference points have been adopted to evaluate the overfished status for PBF. However, the PBF stock is overfished relative to the potential biomass-based reference points evaluated ($SSB_{MED}$ and $20\%SSB_{F=0}$).

- No fishing intensity-based limit or target reference points have been adopted to evaluate overfishing for PBF. However, the PBF stock is subject to overfishing relative to most of potential fishing intensity-based reference points.

# Conservation Information

- The projection based on the current management measures by the WCPFC and IATTC under the low recruitment scenario resulted in an estimated 98% probability of achieving the initial rebuilding target (6.7%$SSB_{F=0}$) by 2024. This is above the threshold (75% or above in 2024) prescribed by the WCPFC Harvest Strategy. The low recruitment scenario is more precautionary than the recent 10 years recruitment scenario.
- The estimated probability of achieving the second rebuilding target (20%$SSB_{F=0}$) 10 years after the achievement of the initial rebuilding target or by 2034, whichever is earlier, is 96% under the recruitment scenario prescribed by WCPFC Harvest Strategy. This is above the threshold (60% or above in 2034) prescribed by the WCPFC Harvest Strategy.

# Conservation Information

- It should be recognized that these projection results are strongly influenced by the inclusion of the relatively high, but uncertain recruitment estimate for 2016.

# 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)
  - Prepared by the WCPFC NC & IATTC joint WG.
  - Provides two rebuilding targets, a HCR, and an assumption for future recruitment.
  - Requested to conduct 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 **at 75% or larger**, ISC will be requested to provide relevant information 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 $SSB_{med1952-2014}$); 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% |

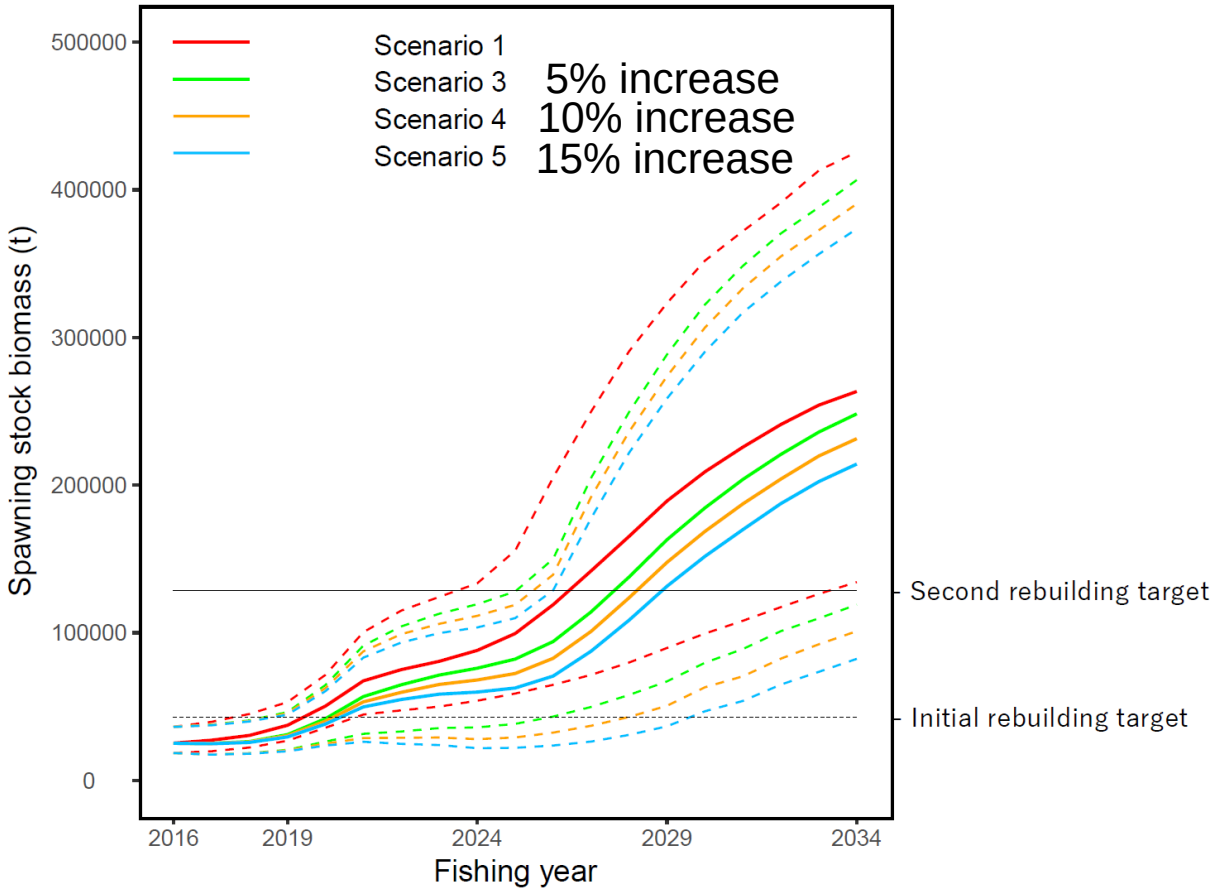
# Results of the projections

| 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.



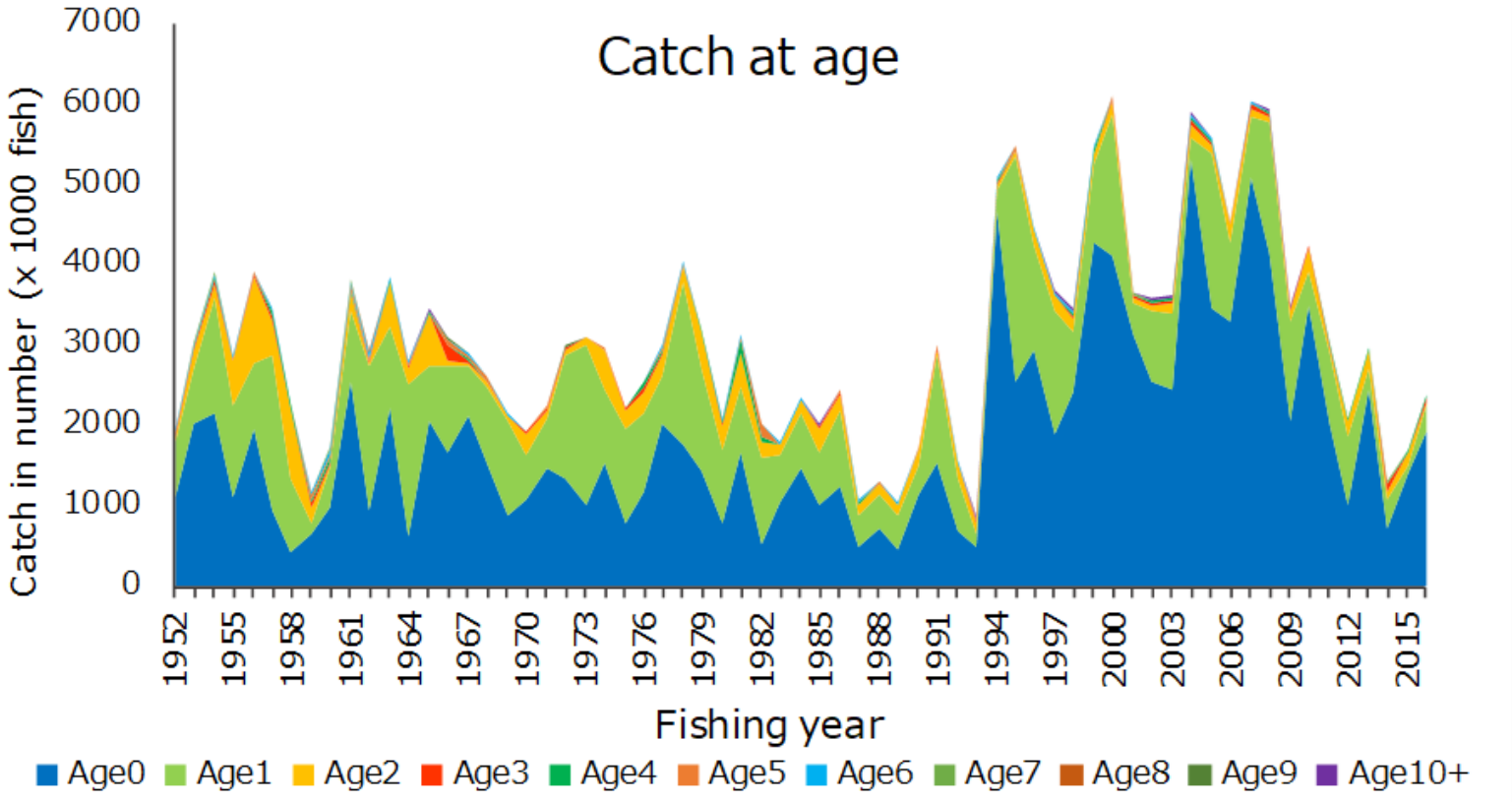
# What did we do further?

- 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% |

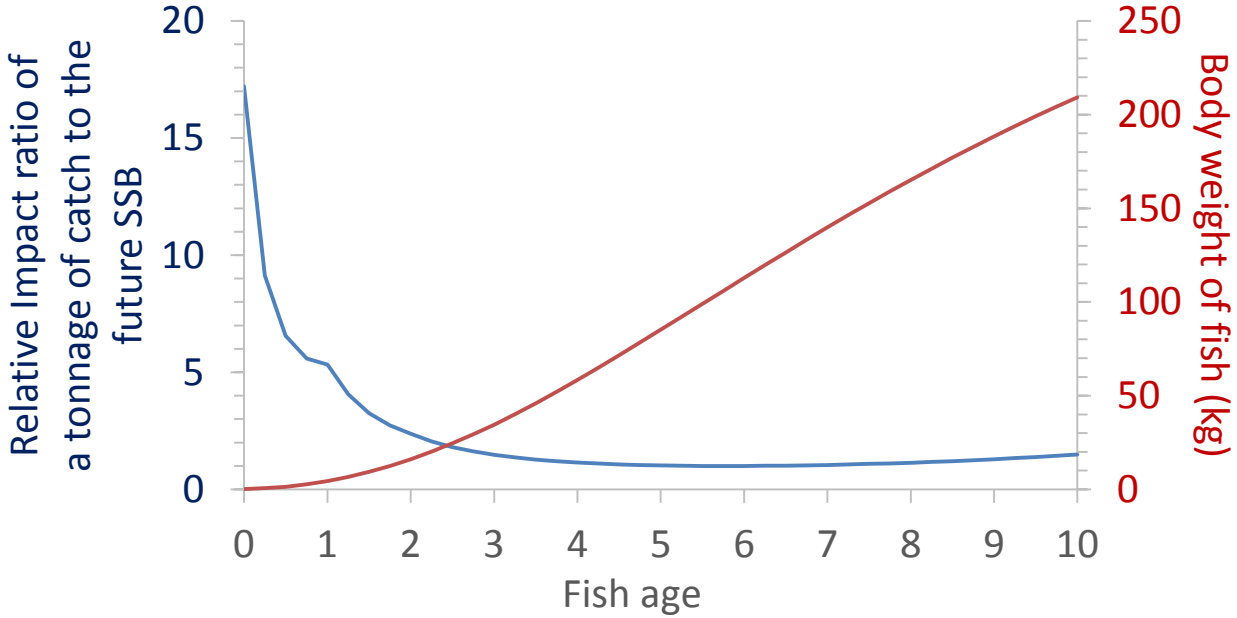
# Why did we do that?

- 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.

# ISC PBFWG Workplan

- Next assessment (benchmark assessment) is scheduled in 2020.
- In 2019, indices will be monitored and plan for 2020 assessment will be discussed.
- No assessment is scheduled in 2019 as no “drastic drop of recruitment” (WCPFC HS 02) is detected.

# 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