

ISC Pacific Bluefin tuna Stock Assessment 2016

Completed in 2016–Feb. 29th to 2016–Apr. 12th at La Jolla, USA



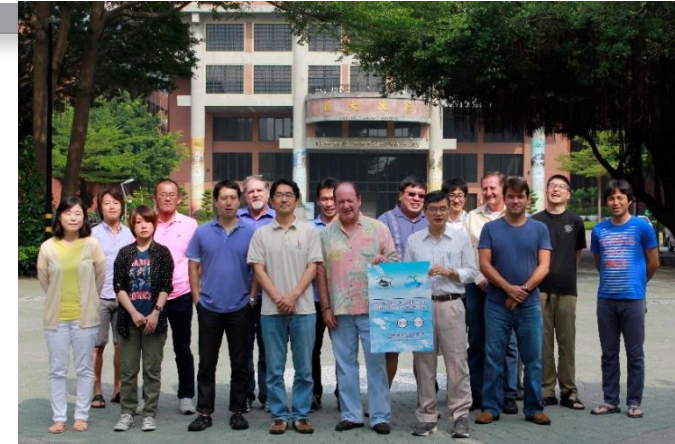
ISC Pacific Bluefin tuna Working Group



Schedule for PBF Stock Assessment in 2016

❖ ISC PBFWG Workshop

- Scientists from:
 - USA, Mexico, Korea, Chinese Taipei, Japan, and IATTC secretariat
- April 2015@Shizuoka
 - Reviewed the last stock assessment in 2014 to clarify the issues.
 - New idea for data preparation and assessment modeling.
- November 2015@Kaohsiung
 - Finalized data preparation methods.
 - Discussed about a simple model as a starting point of assessment modeling.
 - The future projection setting and scenarios.
- Feb.-March 2016@La Jolla
 - Established a benchmark assessment model.
 - Conducted future projections.
 - Concluded the Stock Status and Conservation Advice for PBF.



Outline

❖ Assessment model

- Data
- Assumptions for Biology and selectivity



❖ Results

- Fits to the data, diagnostics
- Biomass, Fishing mortality, Fishery impact
- Future projection

❖ Conclusion

Overview of assessment model

- ❖ A fully integrated model (Stock Synthesis–Version 3)
 - Length–based, age–structured (0–20+) model
- ❖ Fishery data (From 1952 to 2014)
 - 2013–2014 were updated.
- ❖ Fishery definitions: 19 fisheries (Fleets)
- ❖ No–spatially defined model
- ❖ Given Growth, Maturity, Natural mortality, Stock–Recruitment relationship

Main differences from the last assessment

- ❖ Fishery definition
 - From 14 fleets to 19 fleets.
- ❖ CPUE standardization methods
 - Jpn LL (targeting effect) and Twn LL (area effect)
- ❖ Size comp. data
 - Method to raise to the catch number at size
- ❖ Growth curve
- ❖ Initial weighting of size composition data
- ❖ Methods to estimate the selectivity of fishery
 - Implement more time variant processes.

Observation model

❖ Catch

- 19 Fleets (1952-2014)

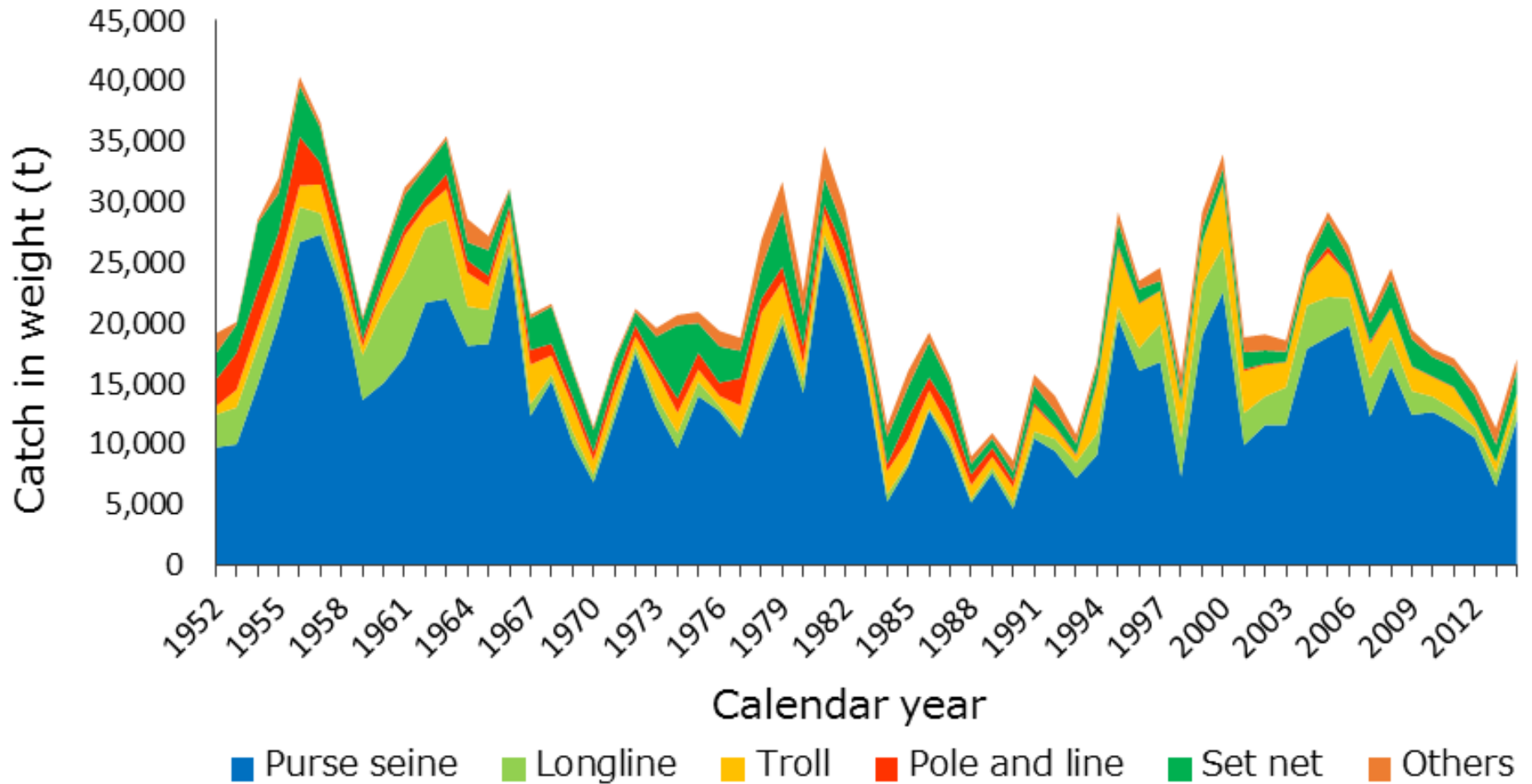
❖ Size composition

- Raised to the total number of fish caught (Catch# at size)
- 6 purse seines, 3 longlines, 3 set-nets, 2 trols.
- Enriched after 1990.

❖ CPUE based abundance indices

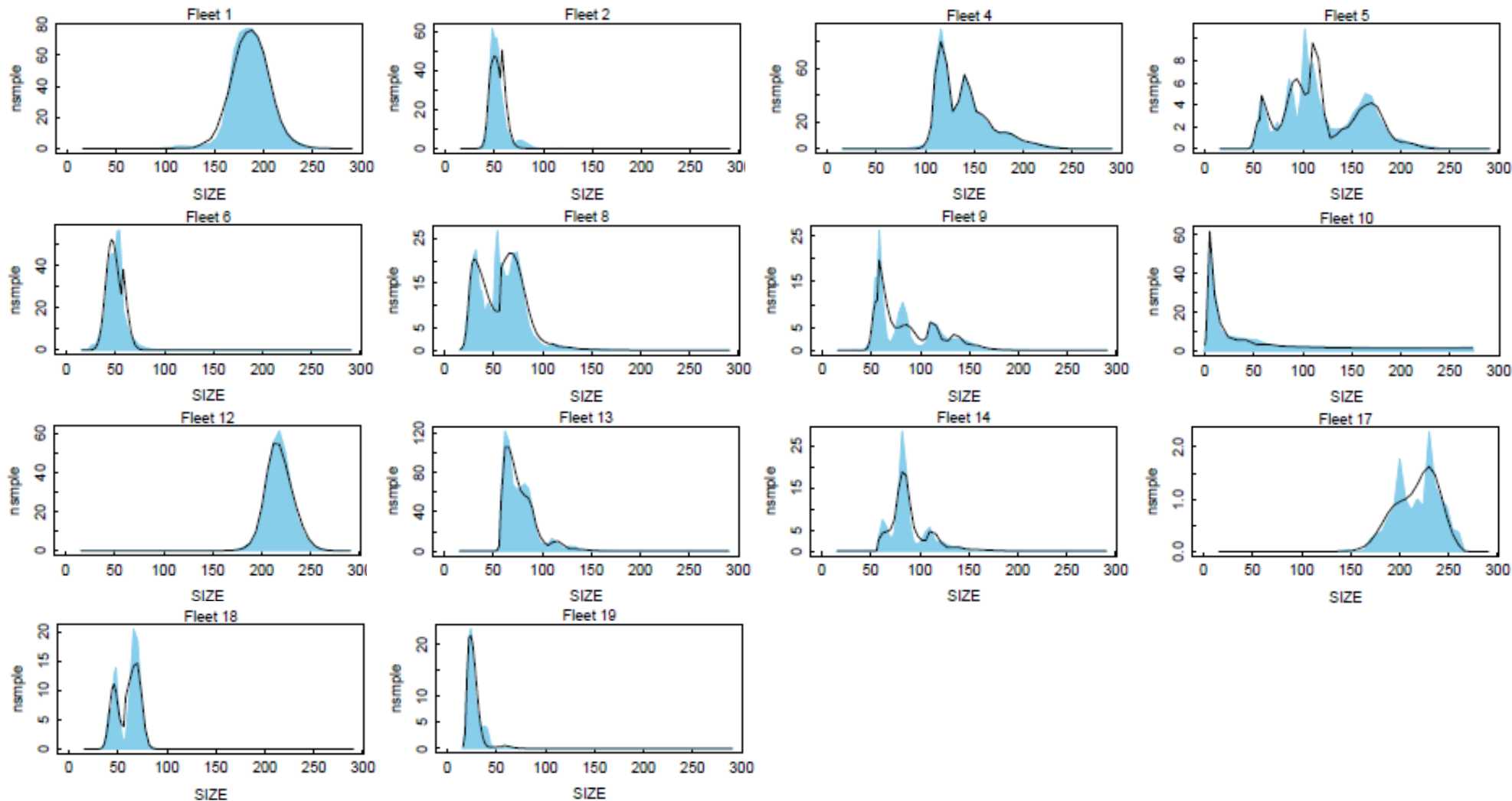
- 2 Fleets for large adult (Jpn and Twn longlines).
- 1 Fleet for age-0 fish (Japanese troll).

Catch by Fisheries



Size Compositions

@ SIZE fit (by fleet, lines: expected, polygon: observed)



CPUEs

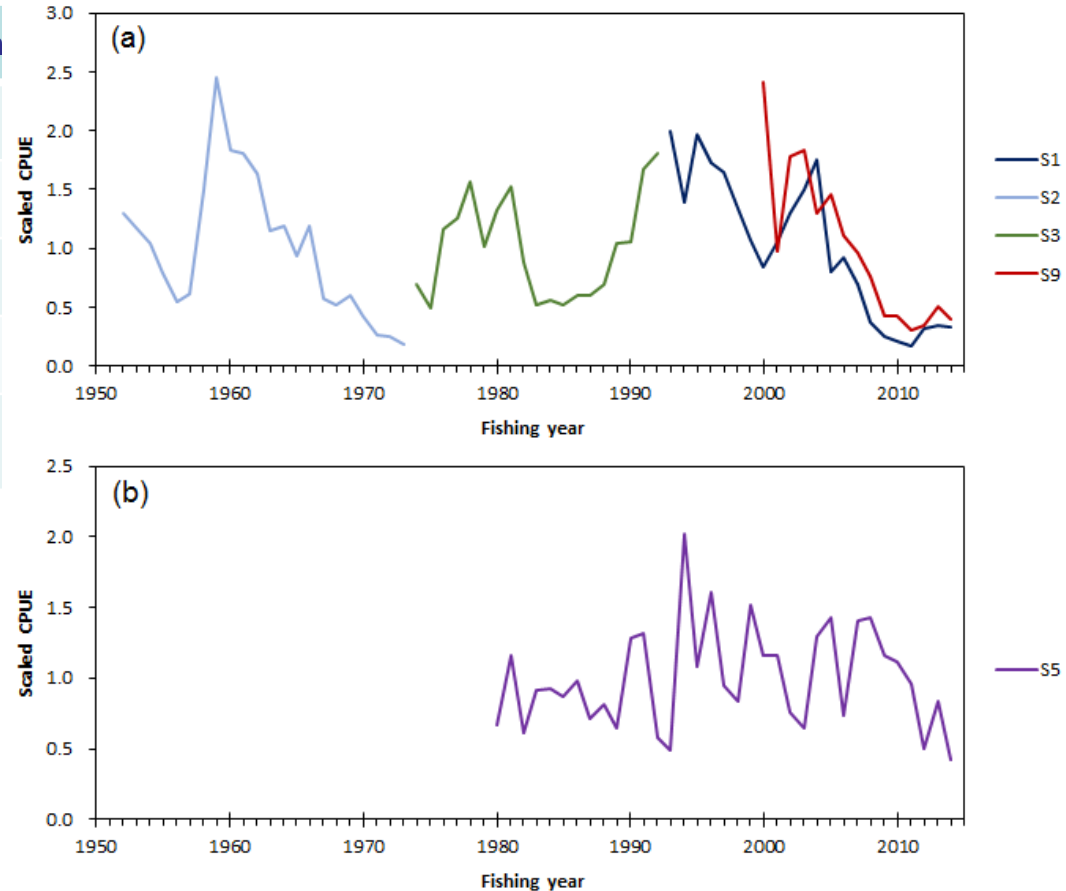
Survey#	Fisheries	Duration	Standardization
S1	Japanese Longline	1993-2014	ZINB
S2		1952-1973	GLM(LN)
S3		1974-1992	GLM(LN)
S5	Troll	1980-2014	GLM(LN)
S9	Taiwanese Longline (S)	2000-2014	GLMM

a. Longline CPUEs

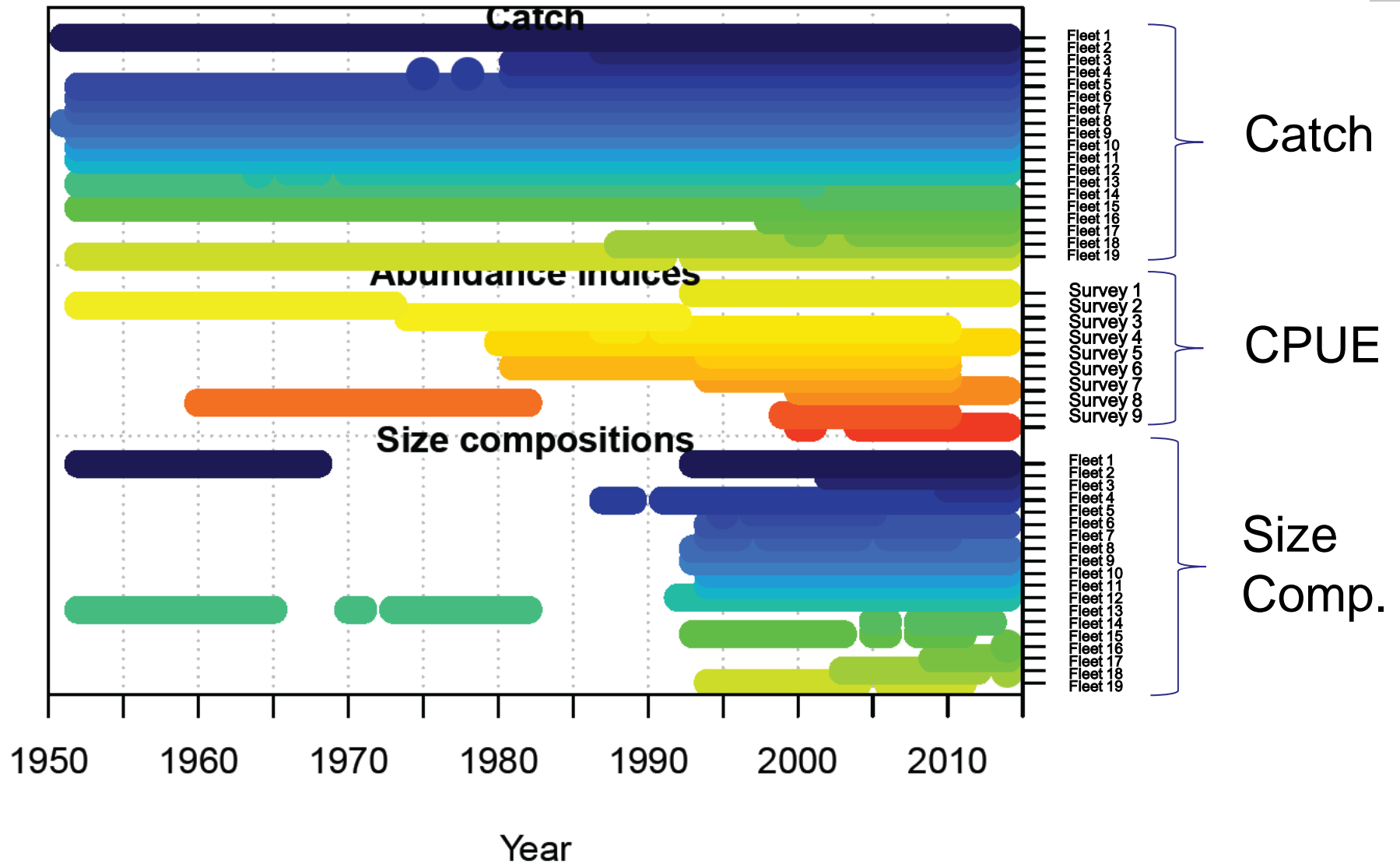
- Large adult (age 7+)

b. Troll CPUE

- Mainly age-0 fish



Data overview



Assumption of Population dynamics

❖ Natural mortality

- 1.6@age-0, 0.386@age-1, 0.25@age-2+

❖ Maturity

- 20%@age-3, 50%@age-4, 100%@age-5+

❖ Growth, Length-Weight relationship

- Von Bertalanffy growth function estimated externally.

❖ Stock Recruitment Relationship (S-RR)

- Beverton-holt Relationship ($h=0.999$, S.D. of $\log \text{Rec.} = 0.6$)

❖ Selectivity of Fisheries

- Constant throughout the assessment period
- Time varying selectivity

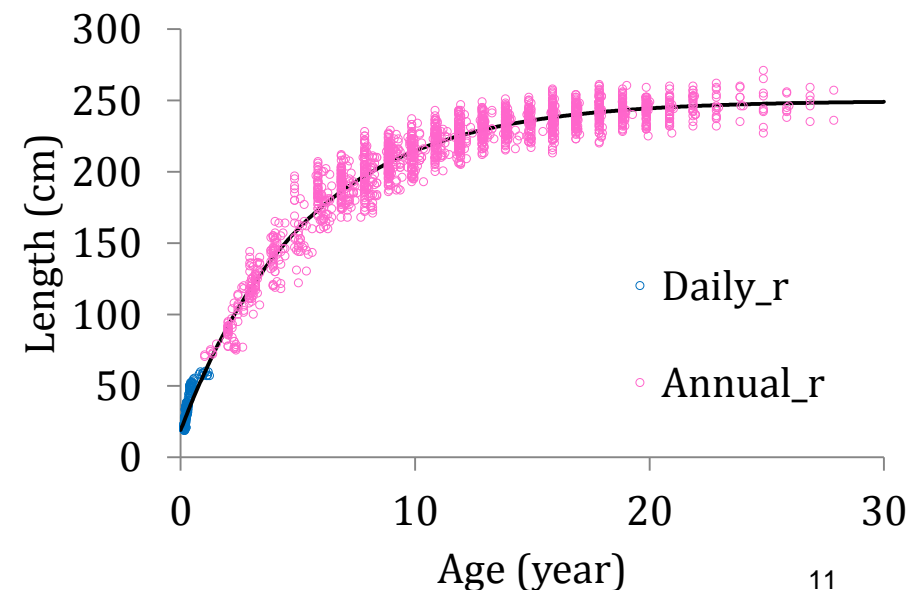
Age and Growth

❖ Von-Bertalanffy Growth Function

- VBGF parameters were re-estimated externally with otolith annuli and daily increments, which were obtained after ISC age determination WS at 2014.

$$L_t = 249.9 \times (1 - e^{-0.188 \times (t + 0.422)})$$

- Variability of length-at-age (CV_L) were estimated internally at preliminary run.



Selectivity (1) Constant during assess. period

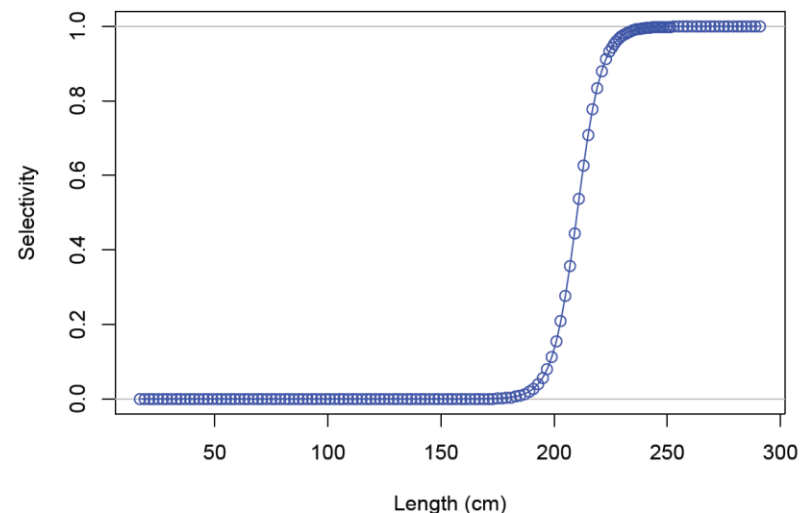
❖ Fleets associated with CPUEs

- Troll, and Twn LL (South)
- JLL (Time blocked)

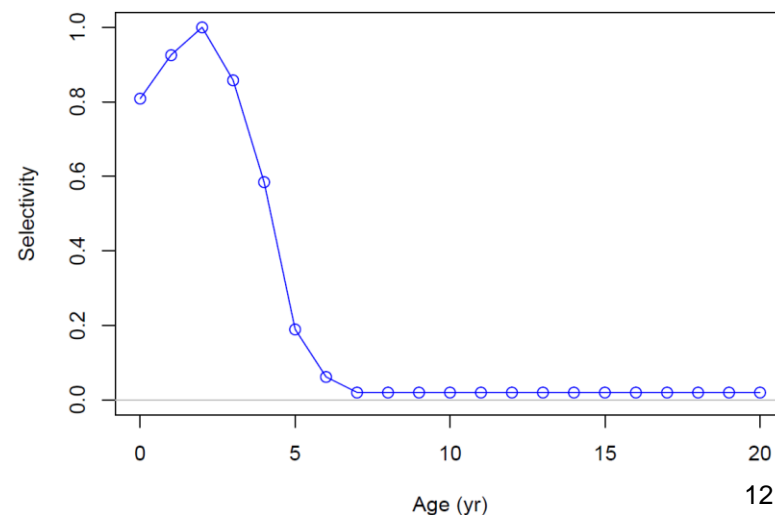
❖ Other Fleets

- Fleets with small number of fish caught (small sample size) .
- Fleets with no-substantial misfits.

Taiwanese LL (S)



Japanese Setnet (Season 2)

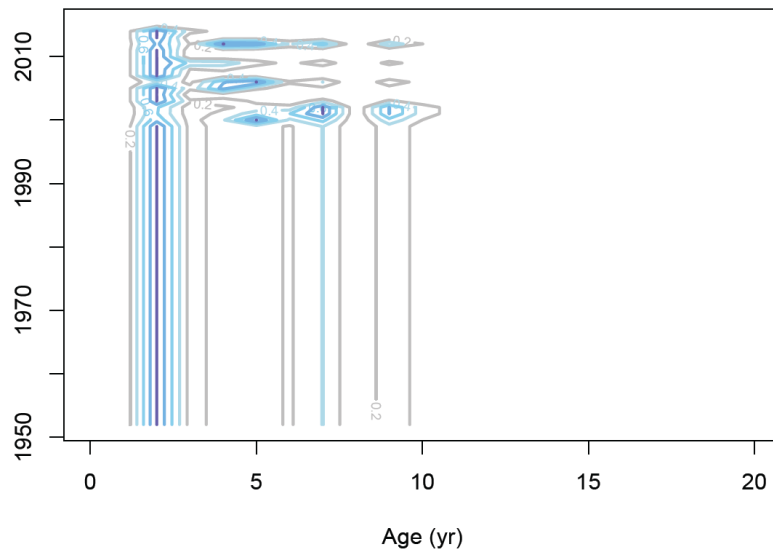


Selectivity (2) Time varying selectivity

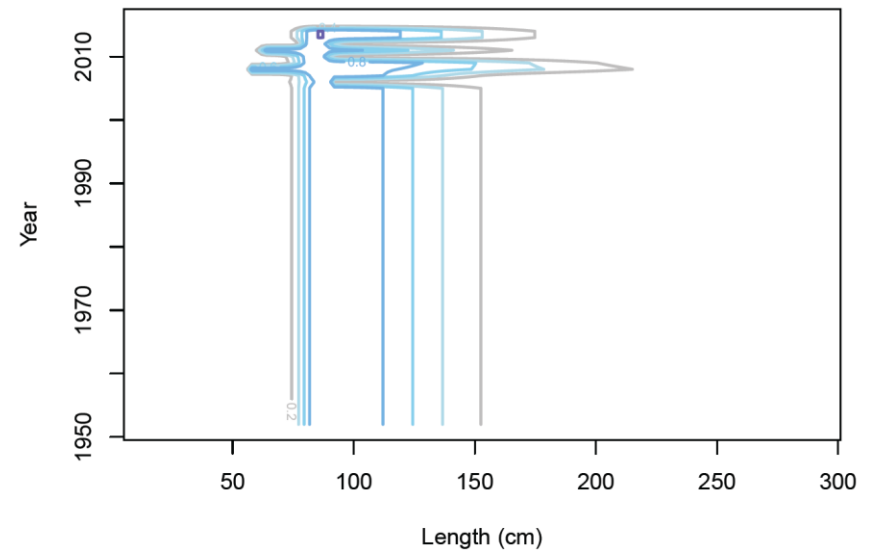
❖ Highly time varying selectivity

- Fleets which prioritized as high priority.
 - Large catch amount, reliable size comp. data.
- Japanese and EPO purse seine fleets.

Japanese Tuna Purse seine
in Sea of Japan



EPO Purse Seine (Mex dominant period)

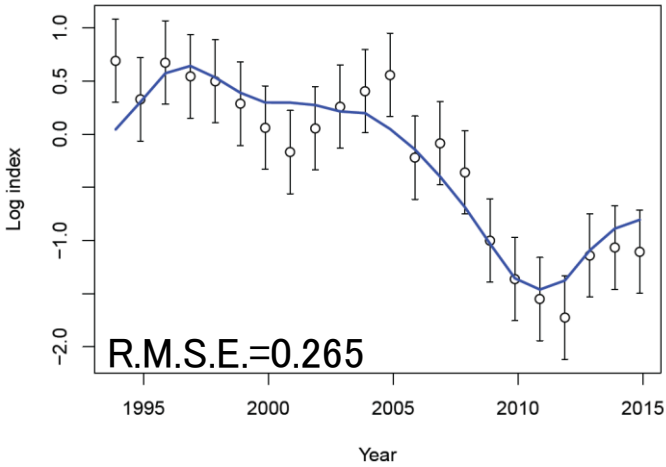


Results

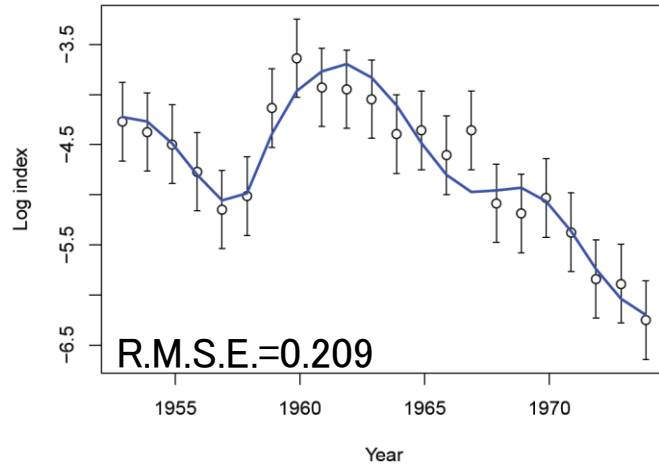
- ❖ Goodness of fit to
 - CPUE based abundance indices
 - Size composition
- ❖ Likelihood profile over $\text{Log}(R_0)$
- ❖ Biomass
- ❖ Recruitment
- ❖ Fishing mortality

Goodness of fit to CPUEs

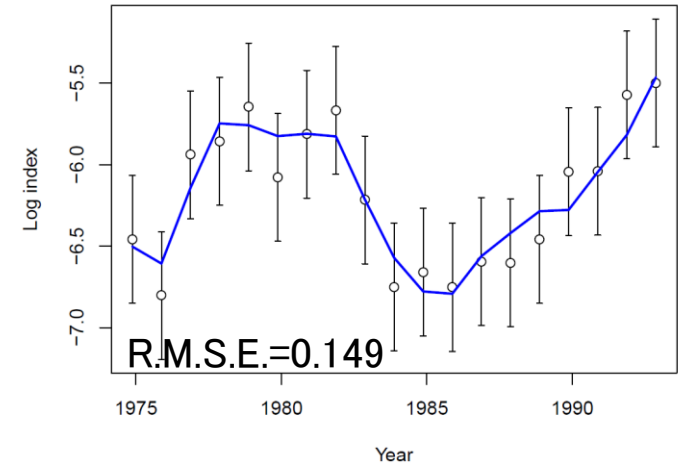
S1: Jpn Longline (1993–2014)



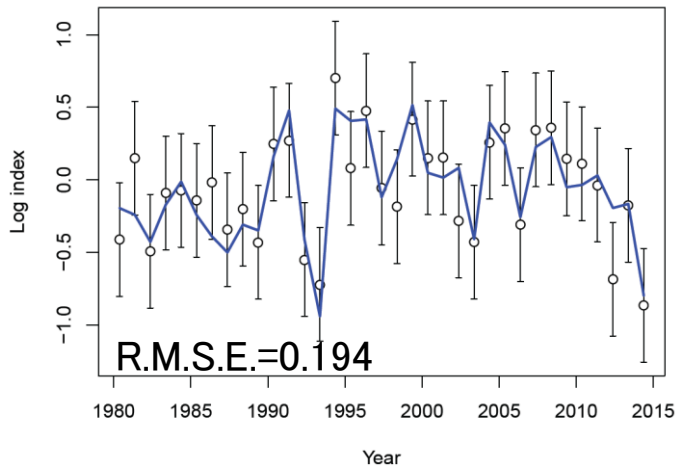
S2: Jpn Longline (1952–1973)



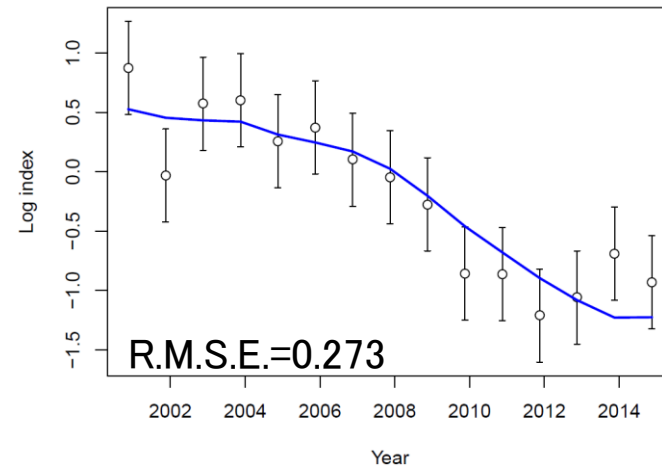
S3: Jpn Longline (1974–1992)



S5: Jpn Troll (1980–2014)

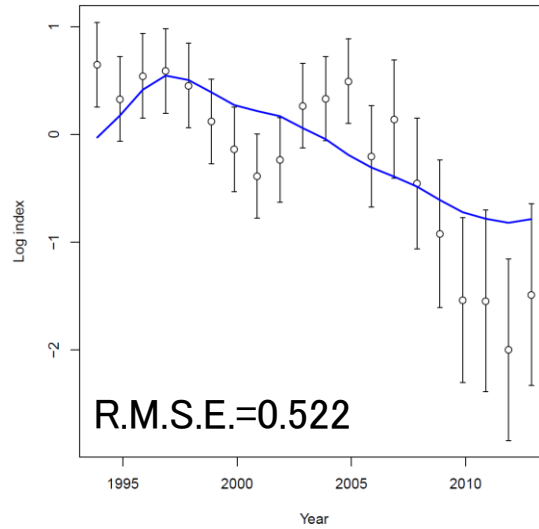


S9: Twn Longline (2000–2014)

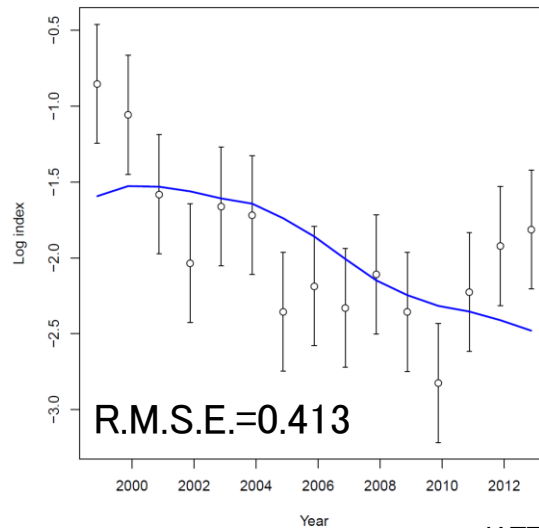


Comparison of model fit to terminal CPUEs

2014 Stock Assessment

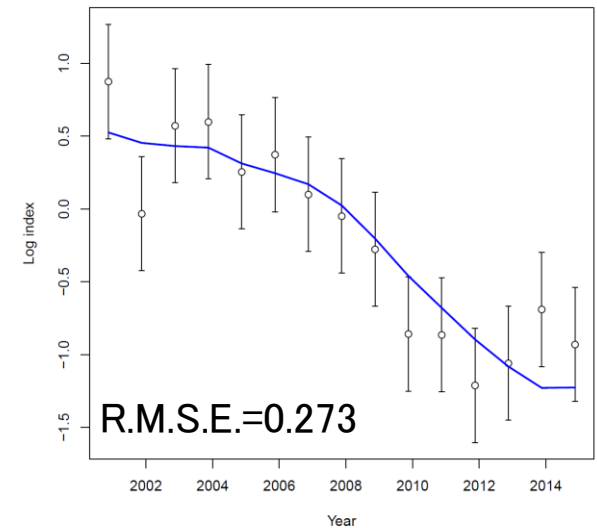
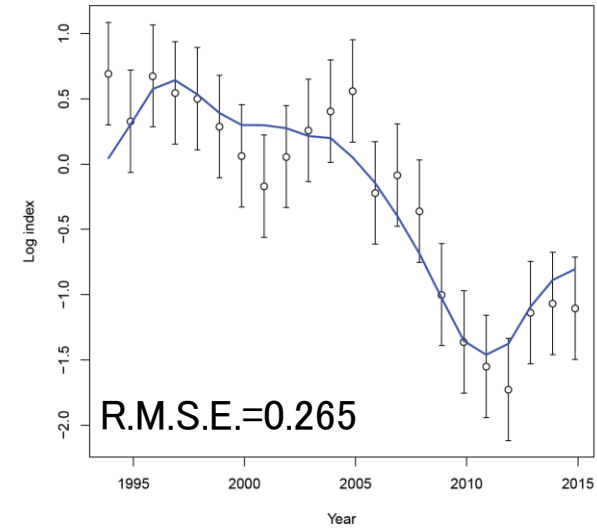


S1: Jpn Longline
(1993-2014)

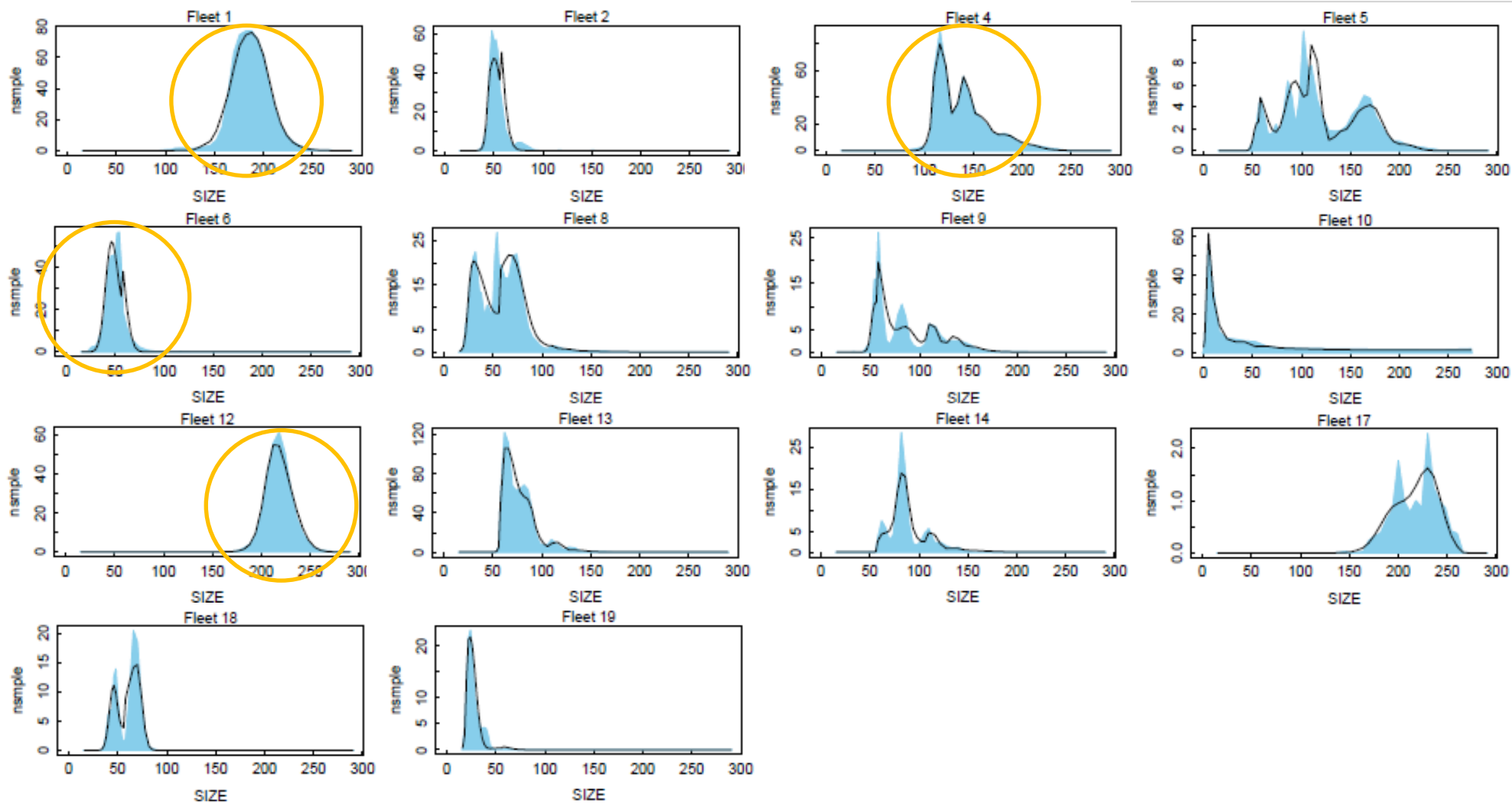


S9: Twn Longline
(2000-2014)

2016 Stock Assessment

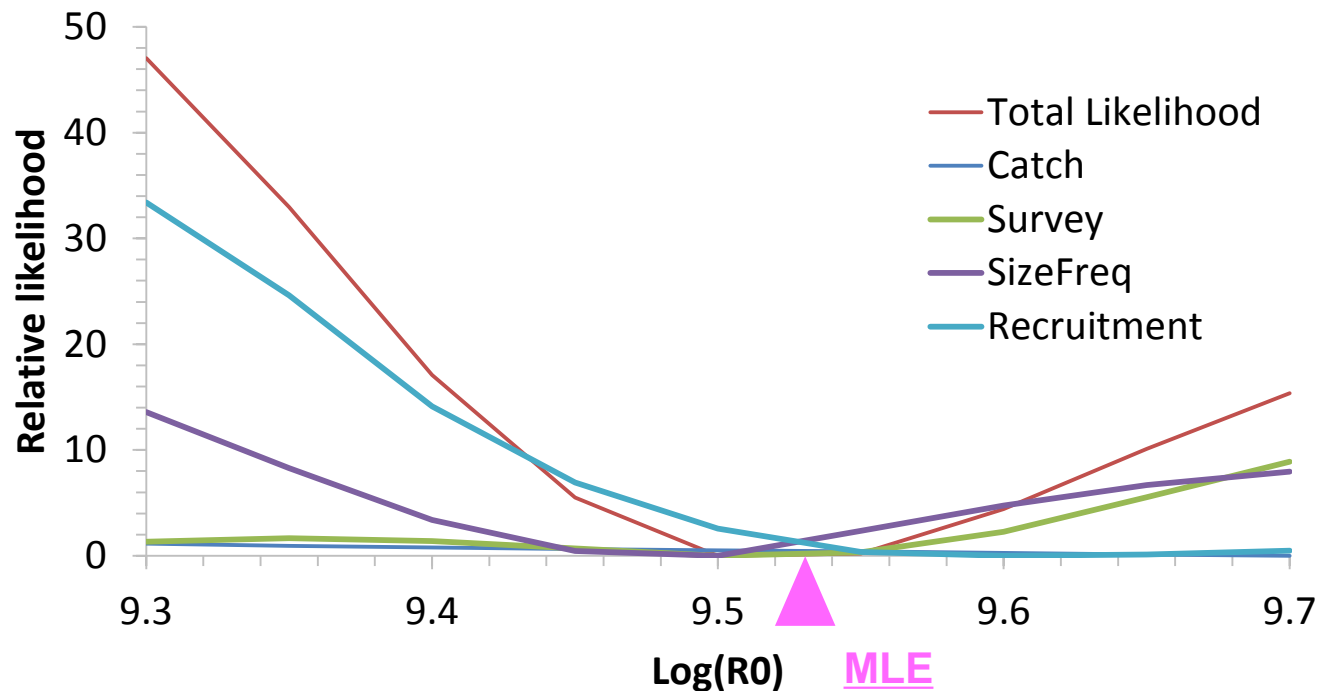


Average fits to Size Compositions



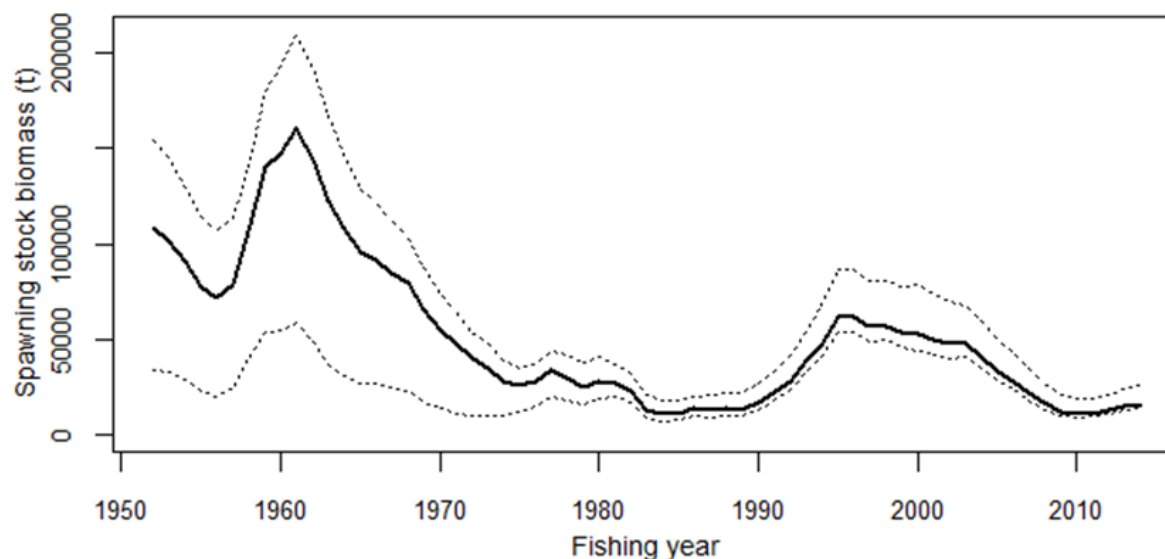
Likelihood profiles over fixed $\text{Log}(R_0)$

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



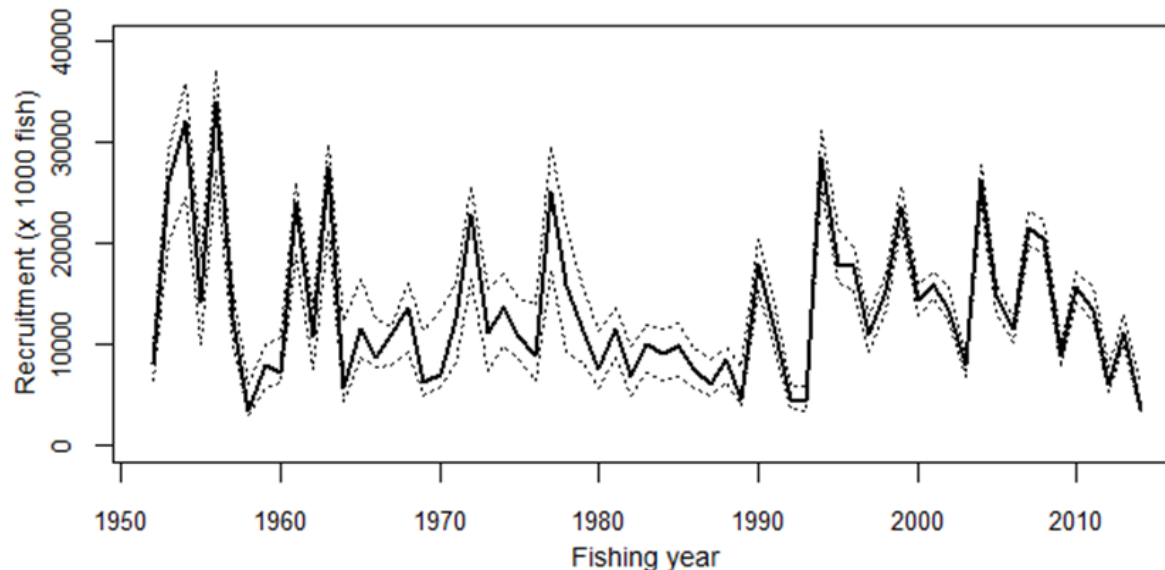
Spawning stock biomass

- Fluctuated ranging from 160,000 tons (1961) to 11,000 tons (1984).
- Declined from the second highest level of about 62,000 tons at 1996 to 12,000 tons at 2010.
- The decline appears to have ceased since 2010, and showed a tendency of slight increase.
- Terminal (2014) SSB was estimated to be 17,000 tons (2.6% SSB_0).



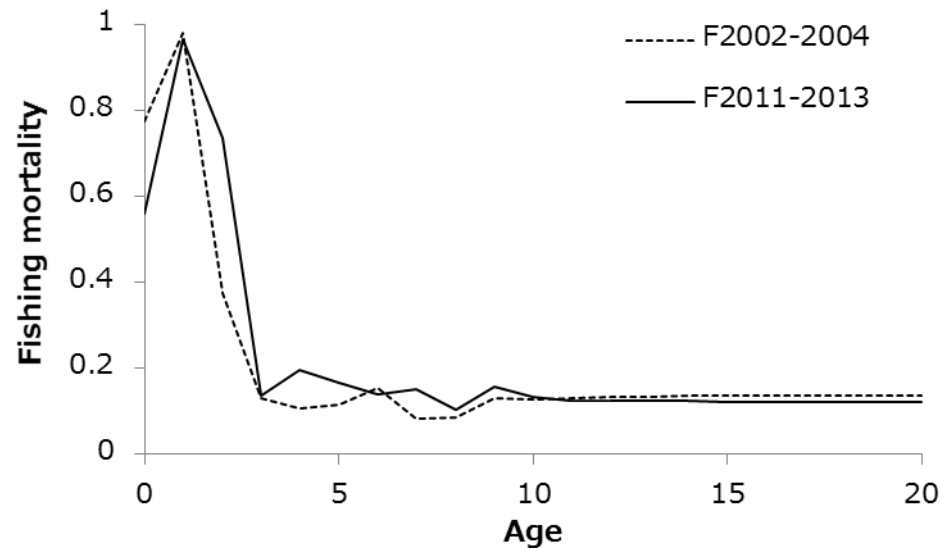
Recruitment

- Highly fluctuated with an average of 13.4 million fish.
- Recent strong cohorts occurred in 1994, 1999, 2004, and 2007.
- A low recruitment was estimated in the terminal year.
- The last 5 year's average might be below the historical average.



Fishing mortality (F)

- Throughout the stock assessment period, average fishing mortality for age 0–2 juveniles was higher than that for age 3+ .
- Most age-specific F for intermediate ages (2–10 years) in recent years (2011–2013) are above the 2002–2004 F while those for age 0 as well as ages 11 and above are lower.



Reference points

- No limit/target reference points have been established for the PBF stock under the auspices of the WCPFC and IATTC.
- 2011–2013 F exceeds the all calculated biological reference points except for F_{MED} and F_{loss} .
- Fishing mortality has decreased slightly in recent years.

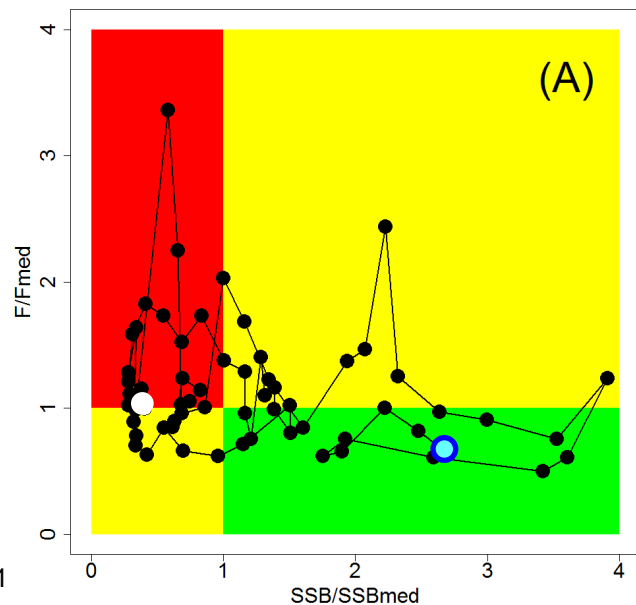
Year	F_{max}	$F_{0.1}$	F_{med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	Estiamted SSB for terminal year of each reference period	Depletion ratio for terminal year of each reference period
2002-2004	1.86	2.59	1.09	0.80	1.31	1.89	41,069	0.064
2009-2011	1.99	2.78	1.17	0.85	1.41	2.03	11,860	0.018
2011-2013	1.63	2.28	0.96	0.70	1.15	1.66	15,703	0.024

Stock Status (Summary 1)

- The base-case assessment model is a substantially improved from the 2014 assessment.
- The SSB steadily declined from 1996 to 2010; and the decline appears to have ceased since 2010, although the stock remains near the historic low.
- Estimates of recruitment showed large fluctuation though, the estimated recruitment level in 2014 was relatively low.
- The average recruitment level for the last five years may have been below the historical average level.

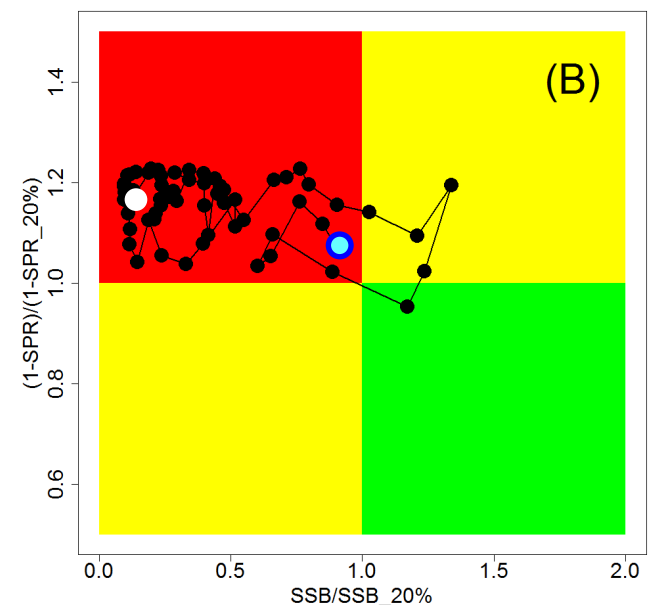
Stock Status (Summary 2)

- The current F (2011–2013) exceeds most of biological reference points commonly used by tRFMO except for F_{MED} and F_{loss} , although F level has decreased in recent some years.
- In summary, overfishing is occurring based on reference points, and the stock is overfished. If F_{MED} is considered the threshold, the current F is just at the threshold level.



2016/5/1

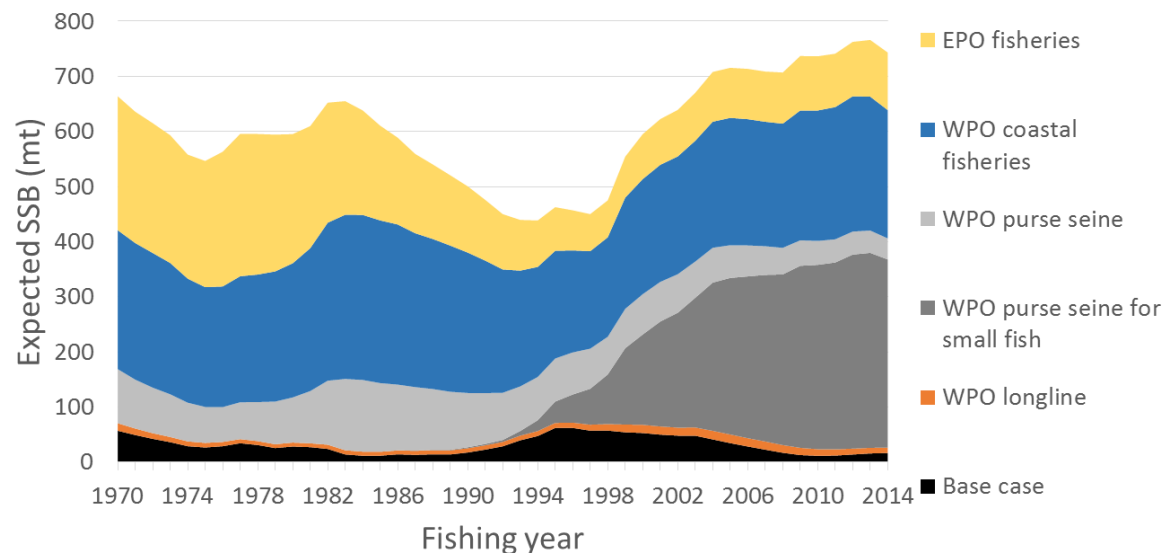
-IATTC SAC 07-



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Stock Status (Summary 3)

- Historically, the WPO coastal fisheries group has had the greatest impact on the PBF stock.
- Since about the early 1990s the WPO purse seine fleets, in particular those targeting small fish, has increased its impact.
- The impact of the EPO fishery was large before the mid-1980s, thereafter decreasing significantly.



Future Projection

Completed in 2016–Feb. 29th to 2016–Apr. 12th at La Jolla, USA



Projection Scenario

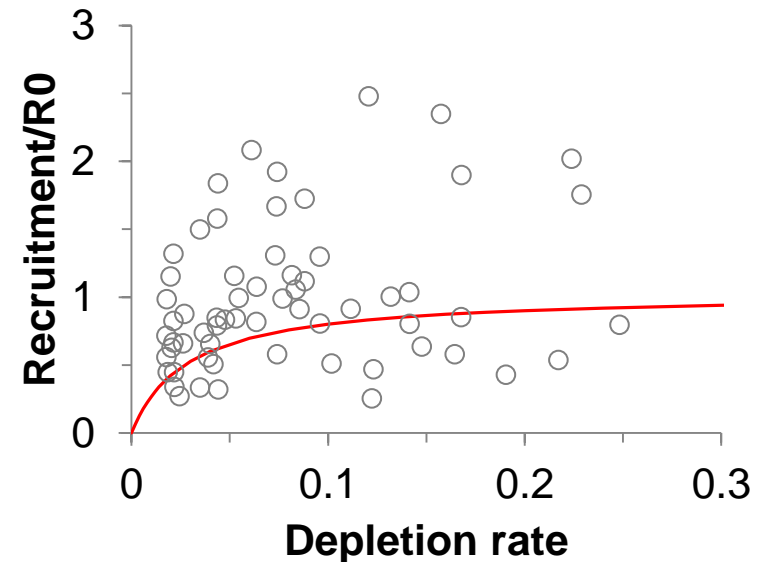
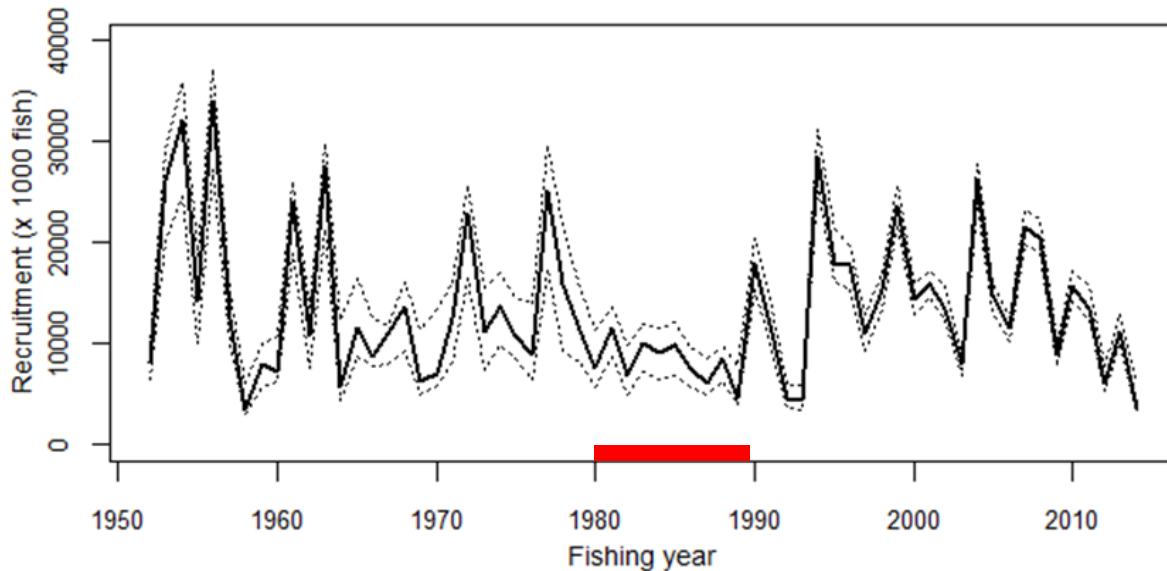
❖ Harvesting Scenario (11 scenarios)

- Same with the last assessment (Scenario 1)
- Approximation of the ‘WCPFC CMM 2015–04’ and ‘IATTC Resolution C–14–06’ (Scenario 2)
- Stricter Catch limit (Scenario 5–10)
 - 10/20 % reduction of catch limit for small fish/large fish/all sized fish.
- Different definition of the threshold of the small and large fish.
 - 50 kg/80kg (Scenario 3–4)
- Status Quo (Scenario 11)
 - Recent Fishing mortality (F2011–2013) and Current catch limit.

Projection Scenario

❖ Recruitment Scenario (3 scenarios)

- Historical average level
- Low recruitment level observed in past (1980–1989)
- Expected recruitment under Stock–recruit. relationship with steepness=0.9

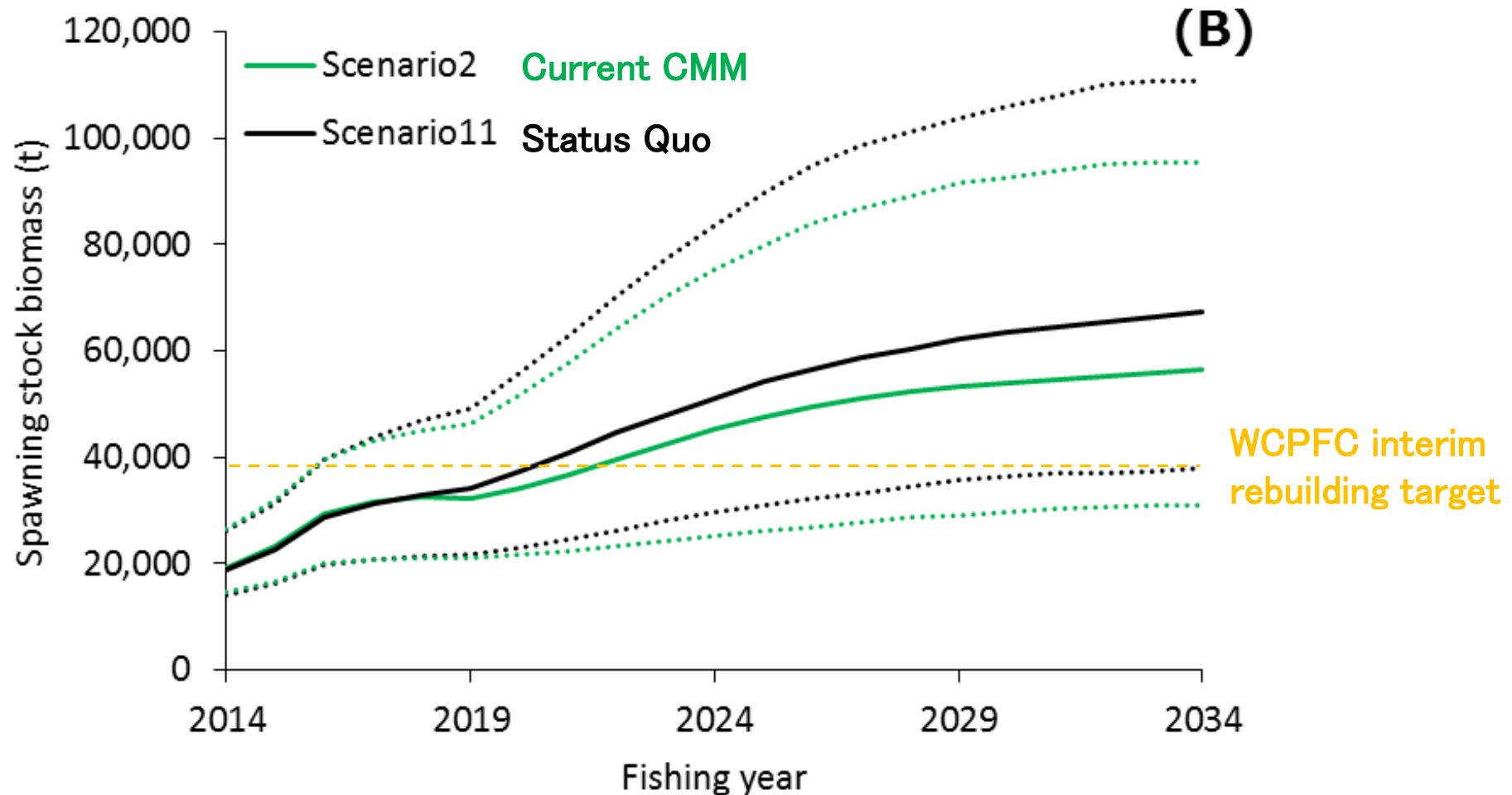


Results (Performance table)

Harvesting Scenario #	Fishing mortality	Catch limit		Threshold of Small/Large	Recruitment scenario	Probability that SSB is more than SSB median (38,000 tons)			Probability that SSB is more than 43,000 tons (SSB _{med} @last assessment)			Probability that SSB is more than 10%SSB ₀			Probability that SSB is more than 20%SSB ₀		
		Small	Large			2024	2029	2034	2024	2029	2034	2024	2029	2034	2024	2029	2034
Scenario1	F2002-2004	scenario 6 in 2014 assessment		30 kg	Low recruitment	77.0%	88.8%	89.9%	64.3%	79.3%	81.9%	14.7%	28.0%	31.8%	0.0%	0.0%	0.1%
Scenario2		50% of 2002-2004 average catch for WPO fisheries 3,300 tons for EPO commercial fisheries	2002-2004 average catch for WPO fisheries		Low recruitment	69.3%	83.7%	86.6%	56.1%	73.9%	79.0%	13.6%	29.3%	35.4%	0.1%	0.4%	0.6%
					Average recruitment	99.6%	100.0%	100.0%	99.3%	100.0%	100.0%	96.3%	99.8%	100.0%	73.8%	95.0%	98.0%
				Stock Recruit Relationship w/ h=0.9	98.2%	99.8%	99.9%	97.5%	99.7%	99.9%	93.5%	99.4%	99.9%	72.0%	97.3%	99.6%	
Scenario3		50% of 2002-2004 average catch		50 kg	Low recruitment	80.5%	91.5%	94.0%	69.1%	85.1%	88.5%	22.2%	43.6%	51.7%	0.2%	0.9%	1.3%
Scenario4				80 kg	Low recruitment	86.4%	94.6%	96.5%	76.6%	90.0%	93.0%	27.8%	51.8%	61.3%	0.2%	1.1%	1.6%
Scenario5		90% of scenario 2	same as Scenario 2	30 kg	Low recruitment	90.0%	96.5%	98.1%	81.5%	93.4%	95.9%	35.0%	61.7%	70.4%	0.3%	2.5%	3.7%
					Average recruitment	99.9%	100.0%	100.0%	99.9%	100.0%	100.0%	98.4%	100.0%	100.0%	82.2%	97.8%	99.3%
					Stock Recruit Relationship w/ h=0.9	99.4%	100.0%	100.0%	99.1%	100.0%	100.0%	97.0%	99.8%	100.0%	81.8%	99.0%	99.9%
Scenario6		same as Scenario 2	90% of scenario 2	30 kg	Low recruitment	75.3%	88.2%	90.2%	61.7%	78.6%	83.4%	15.7%	32.5%	38.7%	0.1%	0.5%	0.7%
			Average recruitment		99.7%	100.0%	100.0%	99.5%	100.0%	100.0%	96.8%	99.9%	100.0%	75.1%	95.2%	98.1%	
			Stock Recruit Relationship w/ h=0.9		98.9%	99.9%	100.0%	98.4%	99.9%	100.0%	95.0%	99.7%	100.0%	75.5%	98.0%	99.9%	
Scenario7	90% of scenario 2		30 kg	Low recruitment	90.3%	96.8%	98.3%	82.7%	94.2%	96.8%	39.4%	68.0%	77.4%	0.5%	3.5%	5.6%	
				Average recruitment	99.9%	100.0%	100.0%	99.9%	100.0%	100.0%	98.5%	100.0%	100.0%	83.5%	98.1%	99.6%	
				Stock Recruit Relationship w/ h=0.9	99.2%	100.0%	100.0%	99.0%	99.9%	100.0%	96.9%	99.8%	100.0%	81.6%	99.0%	99.9%	
Scenario8	80% of scenario 2	same as Scenario 2		Low recruitment	97.5%	99.6%	99.9%	94.8%	98.9%	99.5%	65.4%	89.2%	94.0%	1.9%	14.5%	22.8%	
Scenario9	same as Scenario 2	80% of scenario 2		Low recruitment	78.1%	89.9%	92.5%	65.0%	81.9%	86.3%	18.4%	37.1%	44.7%	0.2%	0.6%	0.9%	
Scenario10	80% of scenario 2		30 kg	Low recruitment	98.3%	99.8%	99.9%	96.3%	99.5%	99.8%	73.2%	93.8%	97.5%	3.1%	22.4%	34.1%	
				Average recruitment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.7%	100.0%	100.0%	91.0%	99.5%	100.0%	
				Stock Recruit Relationship w/ h=0.9	99.8%	100.0%	100.0%	99.7%	100.0%	100.0%	98.7%	100.0%	100.0%	90.0%	99.7%	100.0%	
Scenario11	F2011-2013	same as Scenario 2	same as Scenario 2		Low recruitment	82.6%	93.0%	95.0%	71.3%	86.4%	89.9%	23.6%	46.2%	56.0%	0.1%	1.2%	1.6%

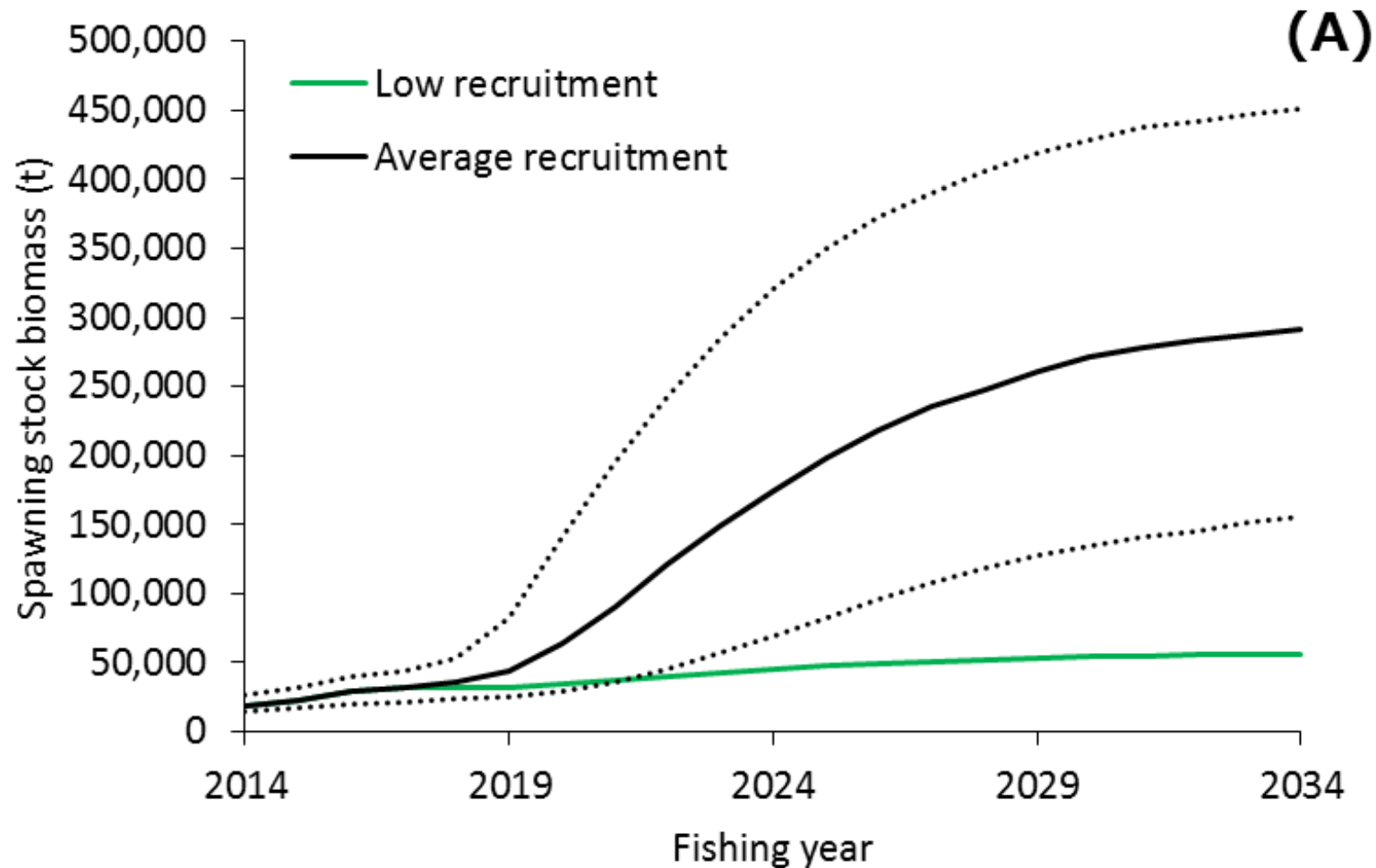
Results

- Current CMMs and Status Quo under low recruitment scenario.



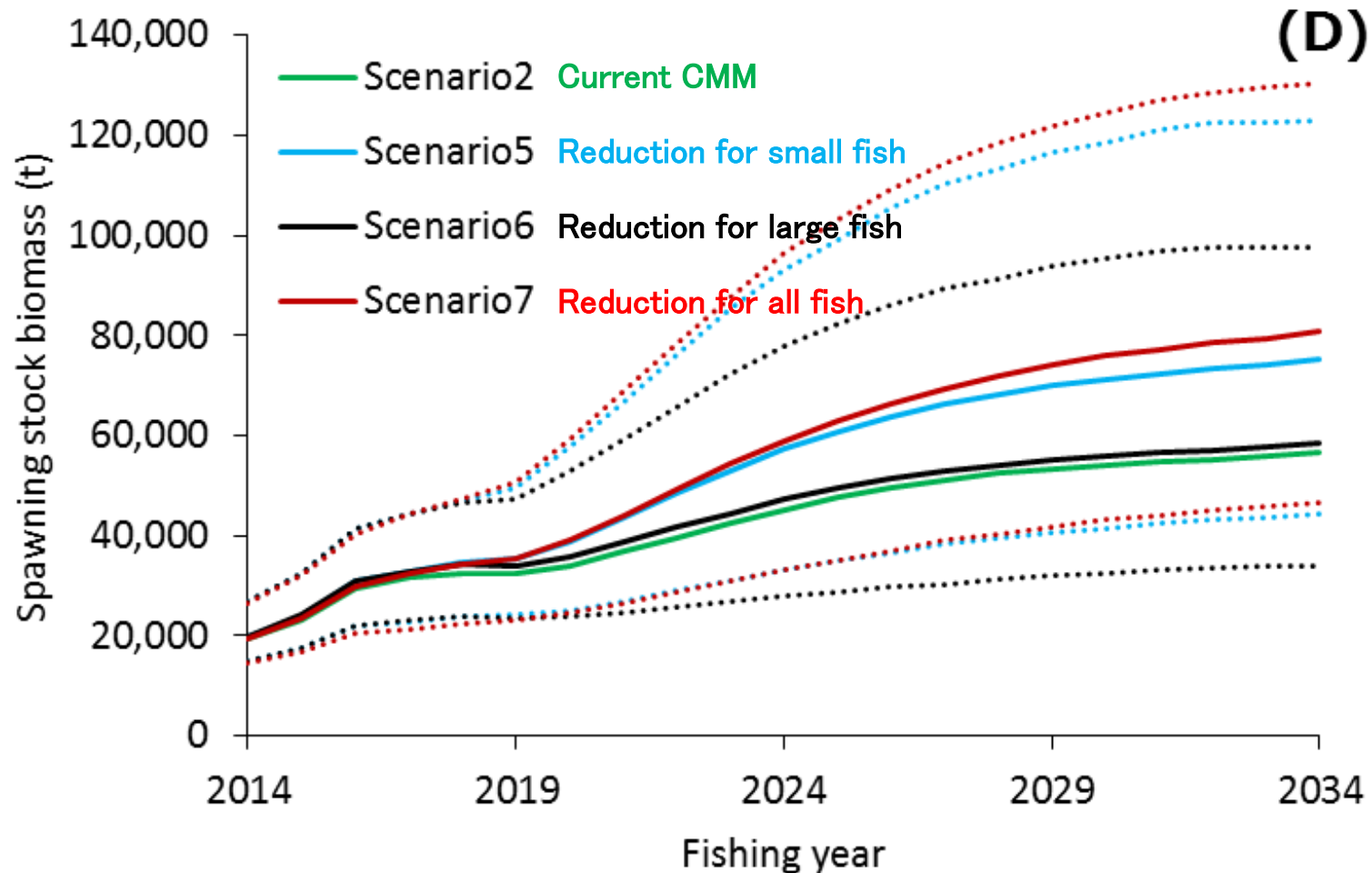
Results

- Current CMMs under Average and Low recruitment scenario.



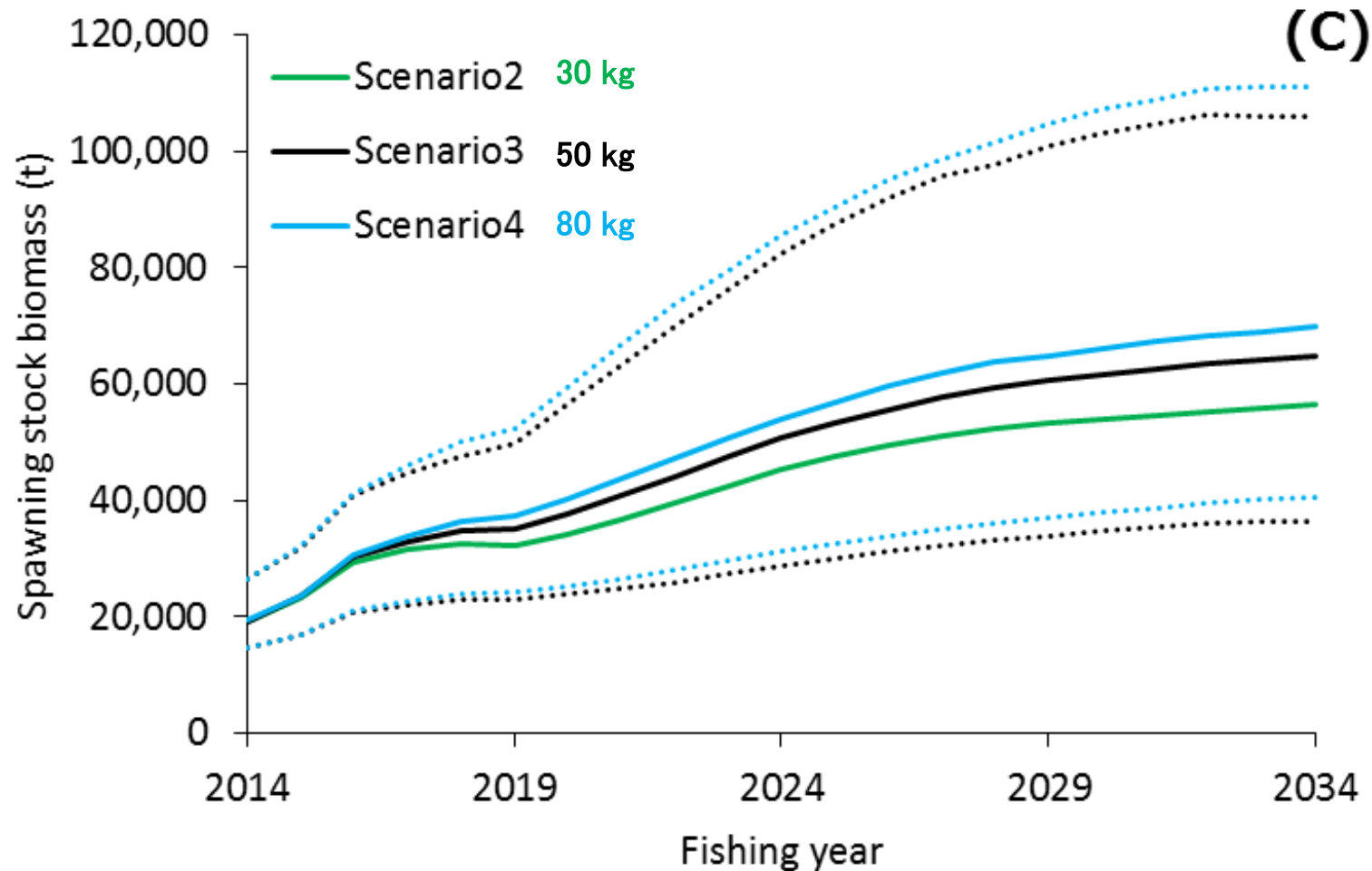
Results

- Comparisons of 10 % reduction scenarios under low recruitment scenario.



Results

- Comparisons of different of threshold for “small/large fish definition” under low recruitment scenario and current CMMs.



ISC PBF Conservation advice 2016 (summary)

- Under all examined scenarios, including a stronger stock–recruitment ($h=0.9$) scenario, the initial WCPFC rebuilding target would be achieved.
- The probability of achieving the initial WCPFC rebuilding target would increase if more conservative management measures were implemented, such as increasing the size in the definition of “small fish” or further reducing the catch limit.
- A 10% reduction in catch limit for small fish would have a larger effect on recovery than a 10% reduction for large fish.

Conclusion

- Stock assessment model was updated for the benchmark assessment 2016, and the base-case model is a substantially improved from the last assessment.
- Results are similar with the last assessment; the stock is still at near historic low and current fishing mortality is above the all reference points except F_{loss} and F_{med}
- The initial rebuilding target of WCPFC would be achieved by higher probability than the level prescribed in the WCPFC CMM, if current WCPFC CMM and IATTC Resolution are strictly complied.



Gracias

Thank you