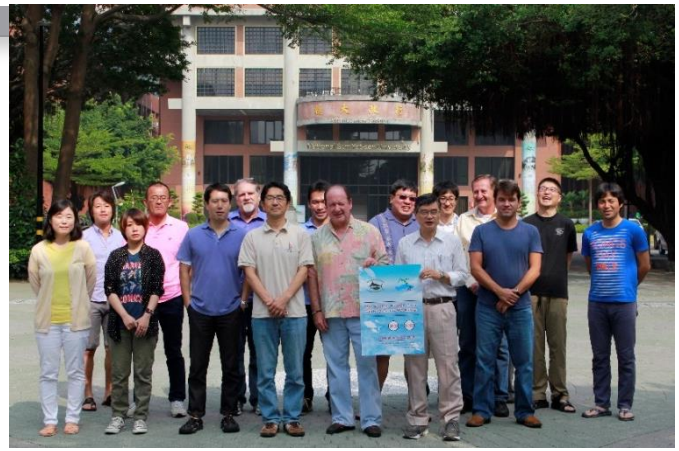
ISC Pacific Bluefin tuna Stock Assessment 2016 (SA-WP07)

Completed in 2016-Feb. 29th to 2016-Mar. 12th at La Jolla, USA

ISC Pacific Bluefin tuna Working Group

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

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

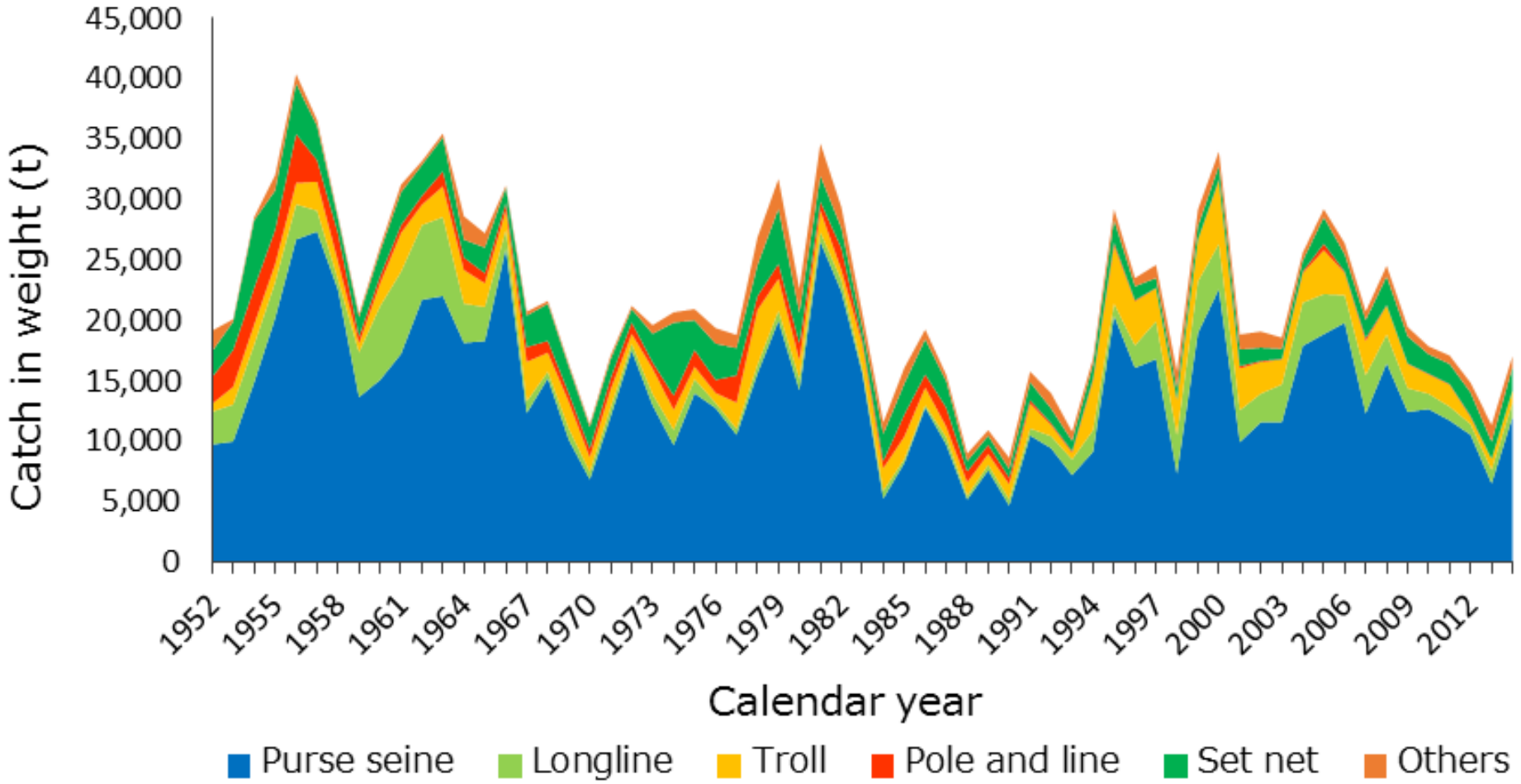
Main differences from the last assessment

- 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.

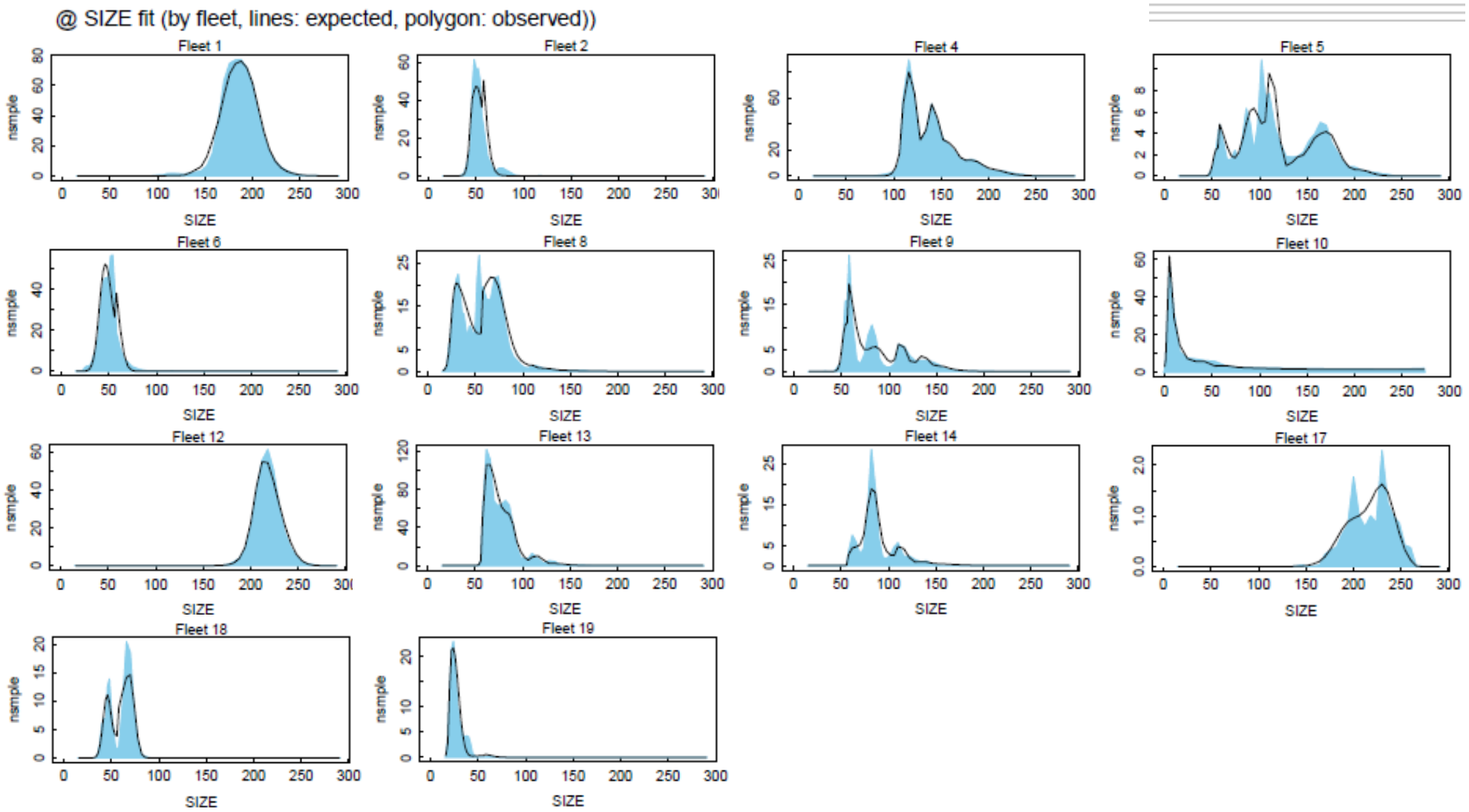
Assessment model

- 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 trolls.
  - More information 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

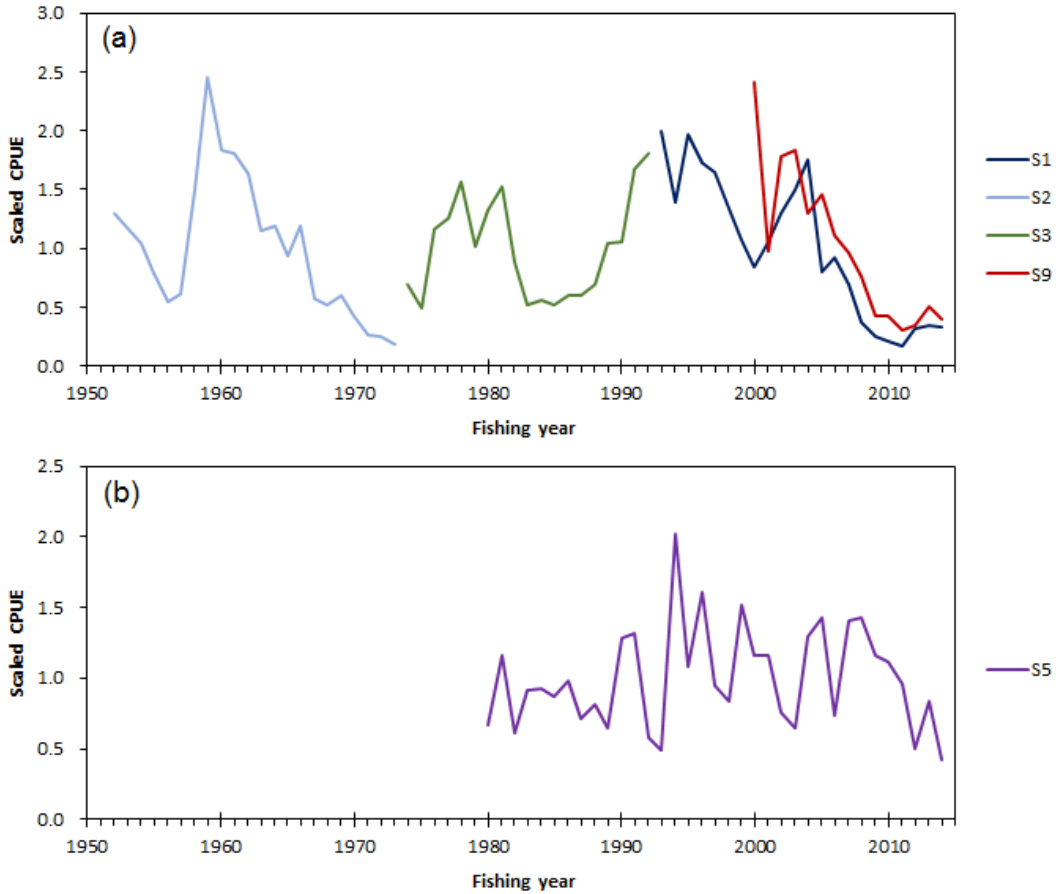


Size Compositions



CPUEs

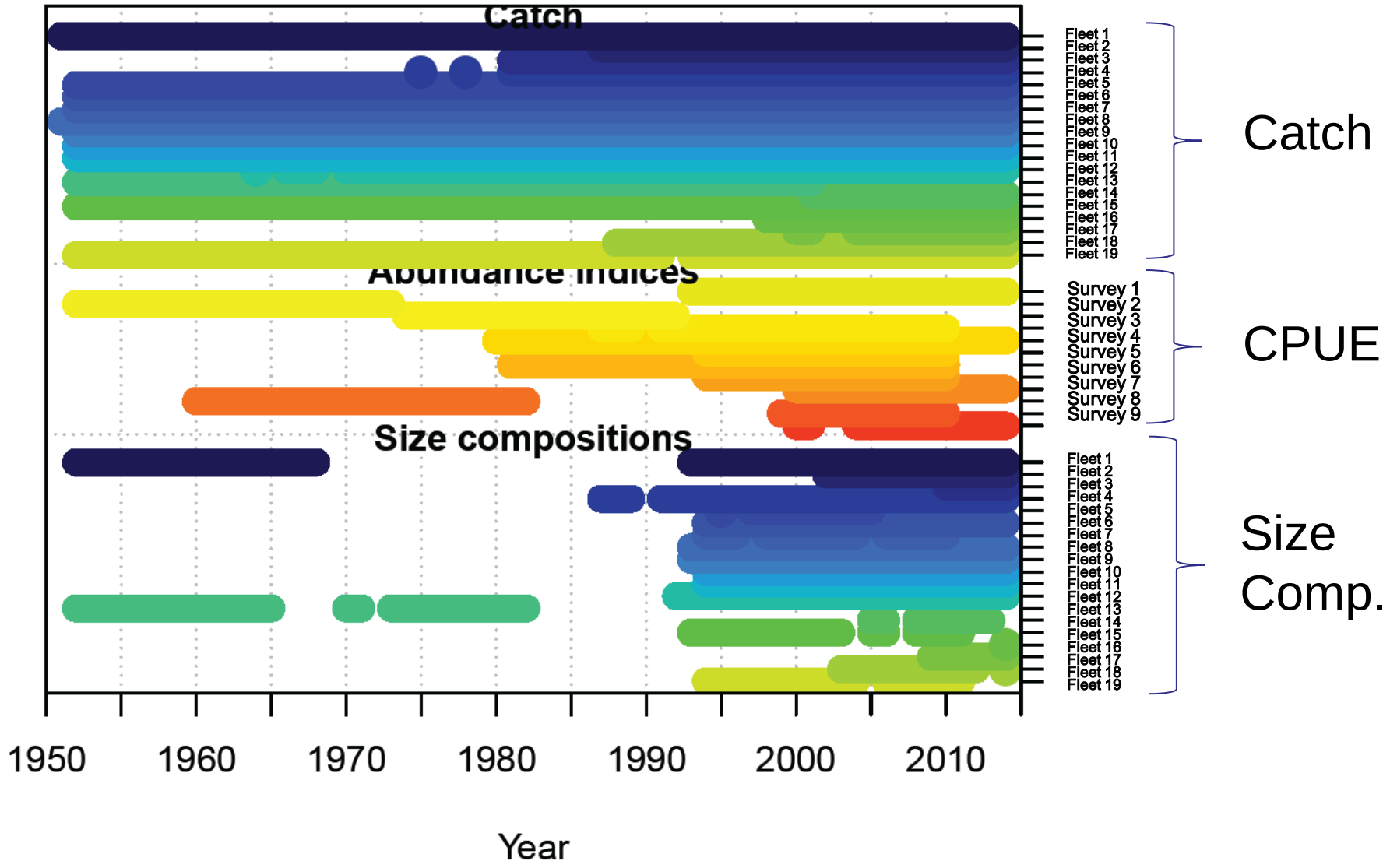
Survey#	Fisheries	Duration	Standardization
S1	Japanese Longline	1993-2014	ZINB
S2		1952-1973	GLM(LN)
S3		1974-1992	GLM(LN)
S5	Troll	1980-2014	GLM(LN)
S9	Taiwanese Longline (S)	2000-2014	GLMM



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 Rec. =0.6)
- Selectivity of Fisheries
  - Constant throughout the assessment period
  - Time varying selectivity

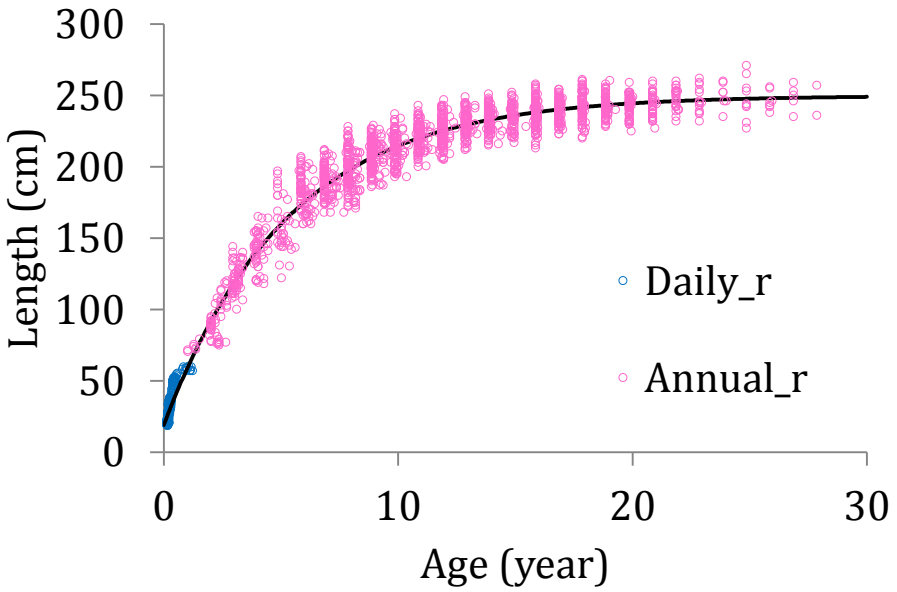
Age and Growth

❖ 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.

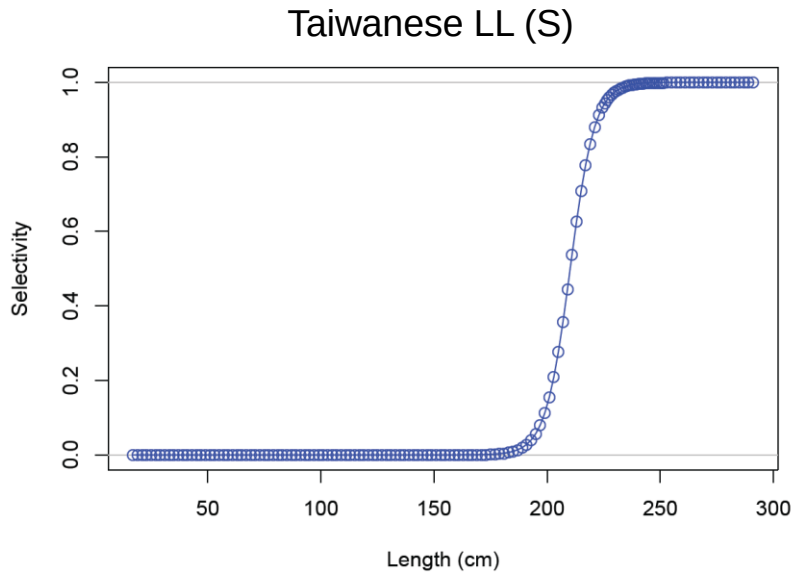
$$L_t = 249.9 \times \left(1 - e^{-0.188 \times (t + 0.422)}\right)$$

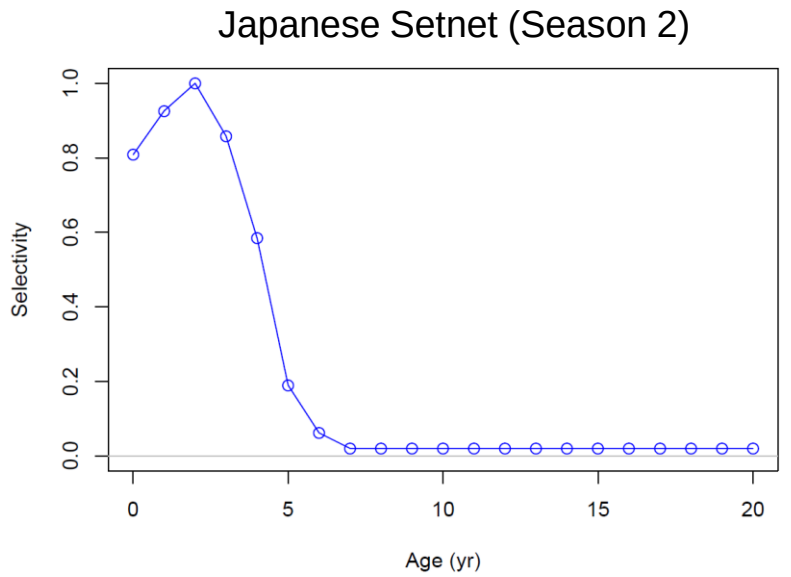
- Variability of length-at-age (CV_L) were estimated internally at preliminary run.



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.

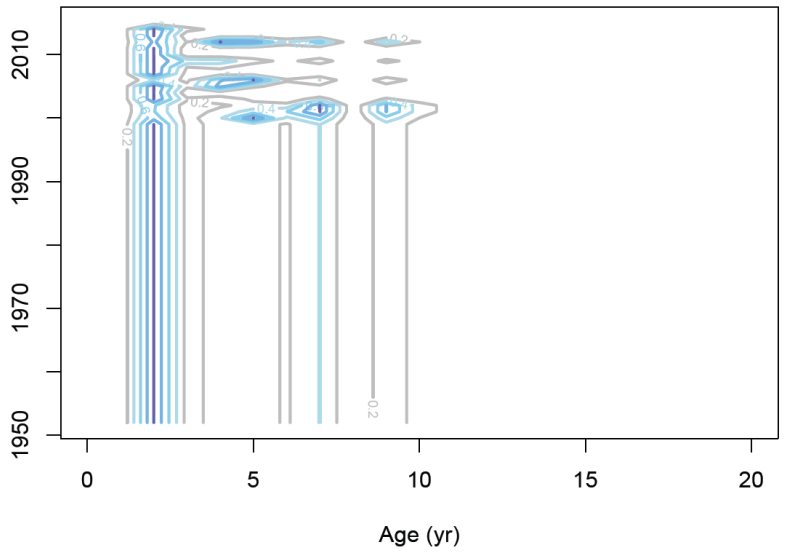




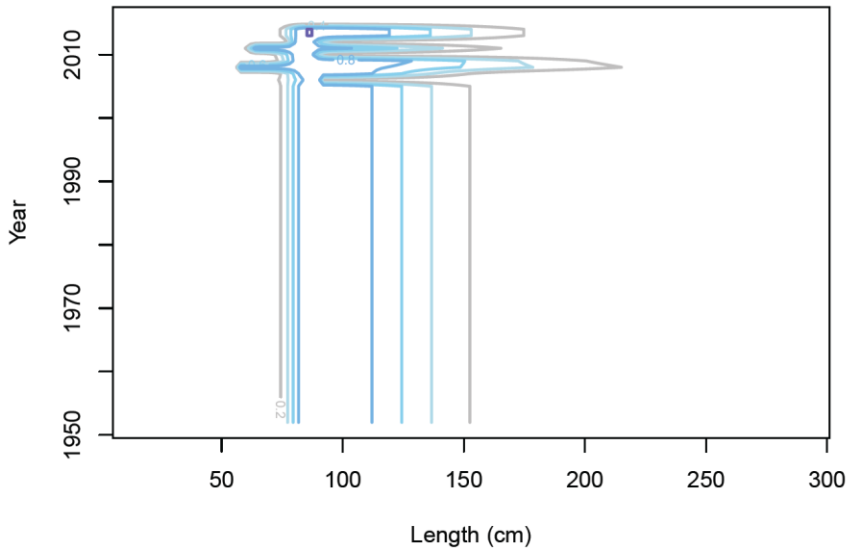
Selectivity (2) Time varying selectivity

- 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)

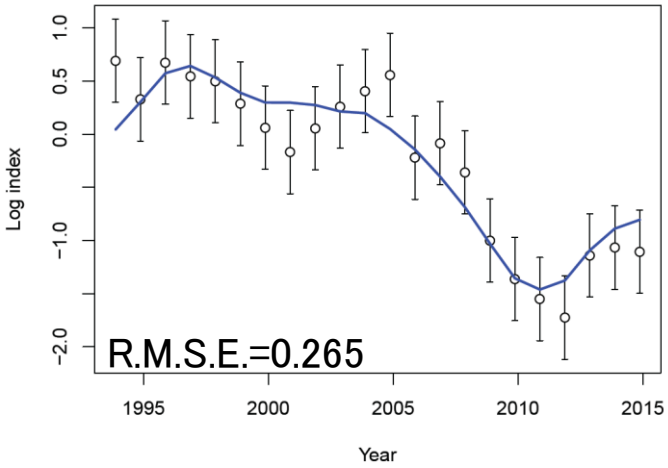


Results

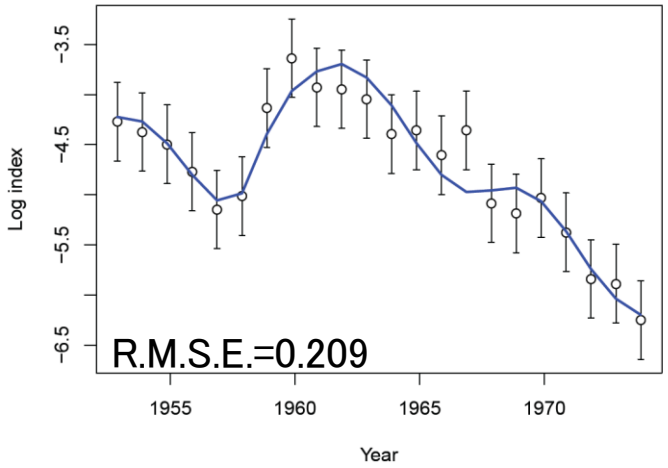
- Goodness of fit to
  - CPUE based abundance indices
  - Size composition
- Likelihood profile over Log(R0)
- Biomass
- Recruitment
- Fishing mortality

Goodness of fit to CPUEs

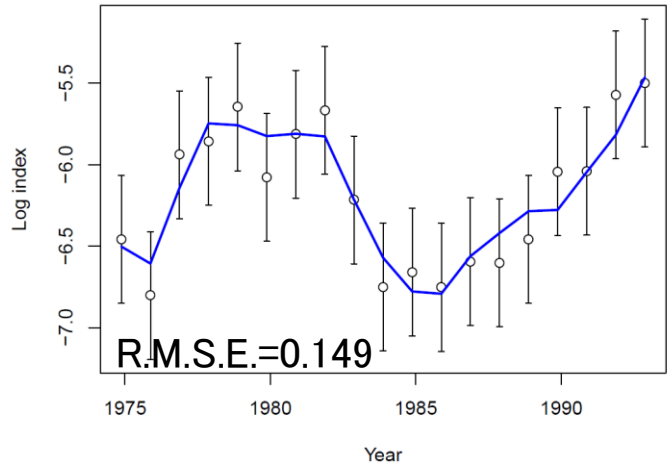
S1: Jpn Longline (1993–2014)



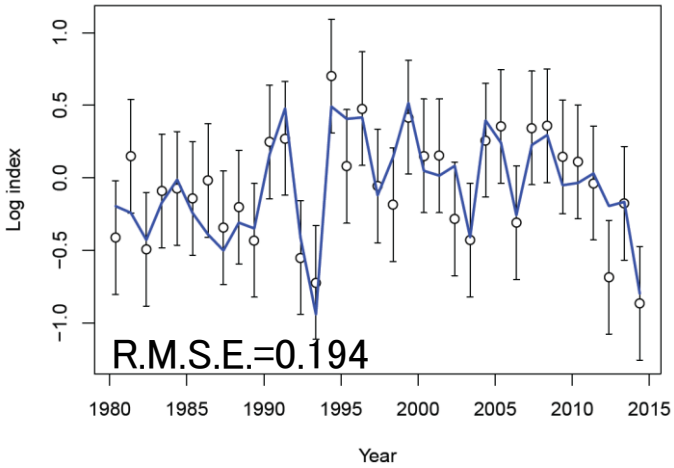
S2: Jpn Longline (1952–1973)



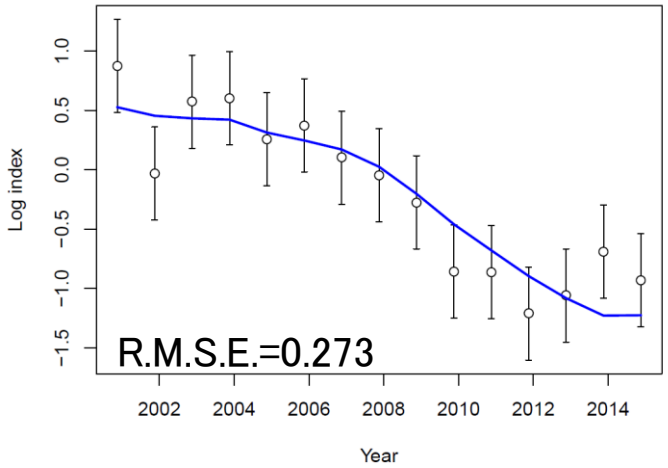
S3: Jpn Longline (1974–1992)



S5: Jpn Troll (1980–2014)



S9: Twn Longline (2000–2014)

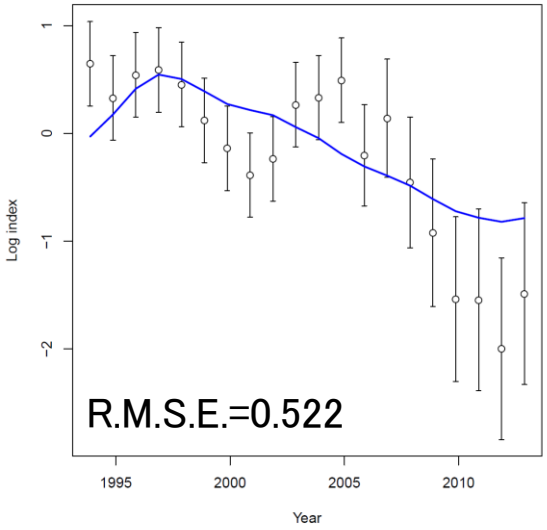


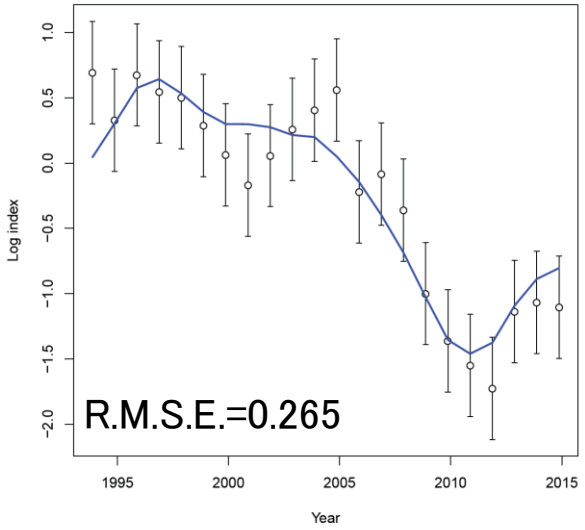
Comparison of model fit to terminal CPUEs

2014 Stock Assessment

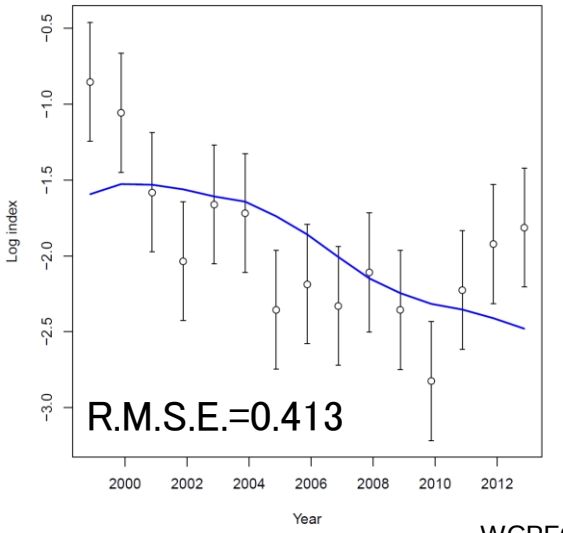
2016 Stock Assessment

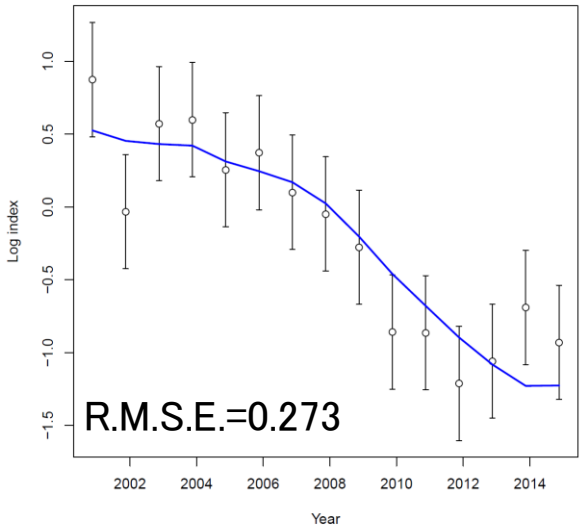
S1: Jpn Longline
(1993-2014)



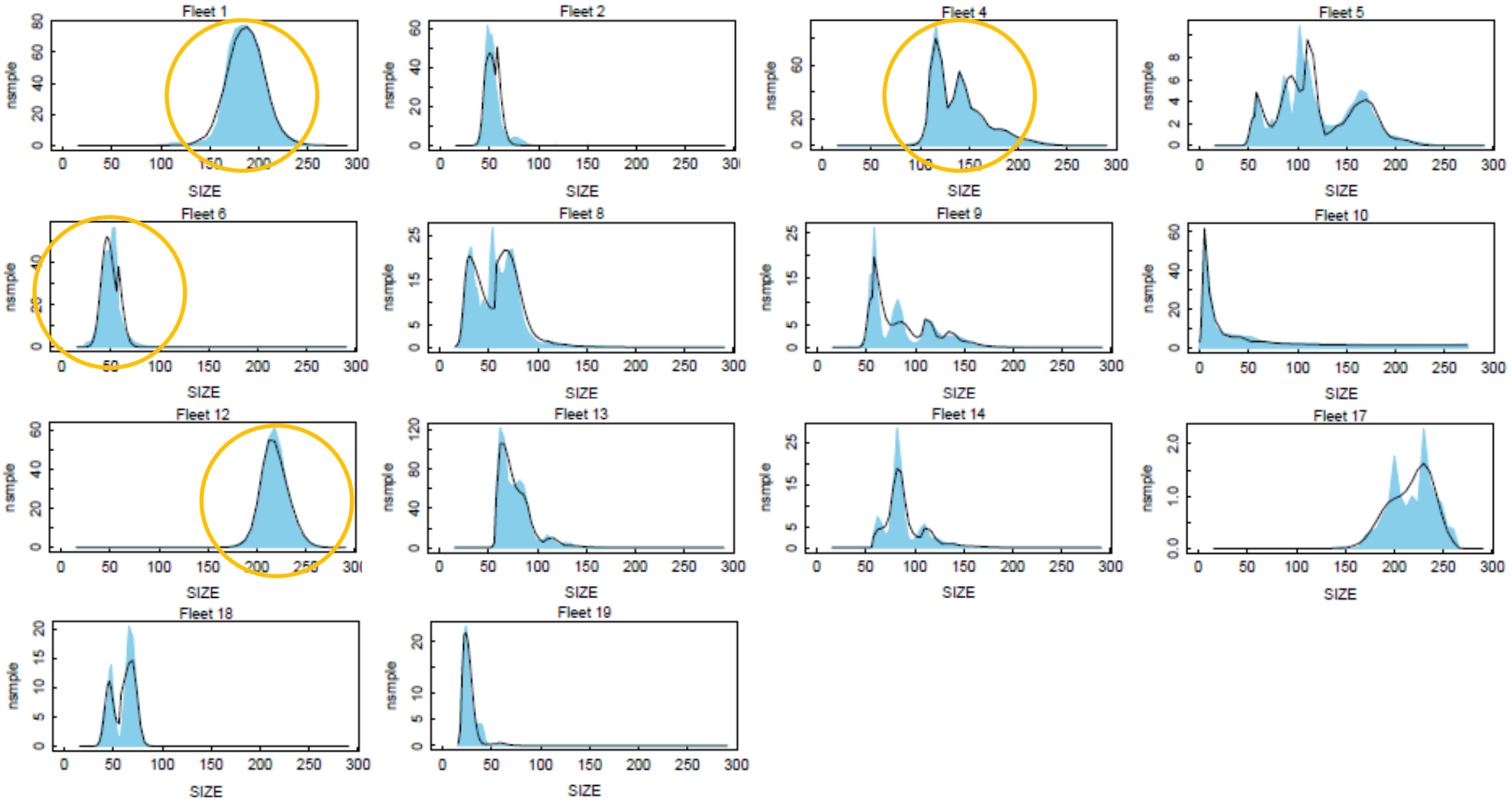


S9: Twn Longline
(2000-2014)



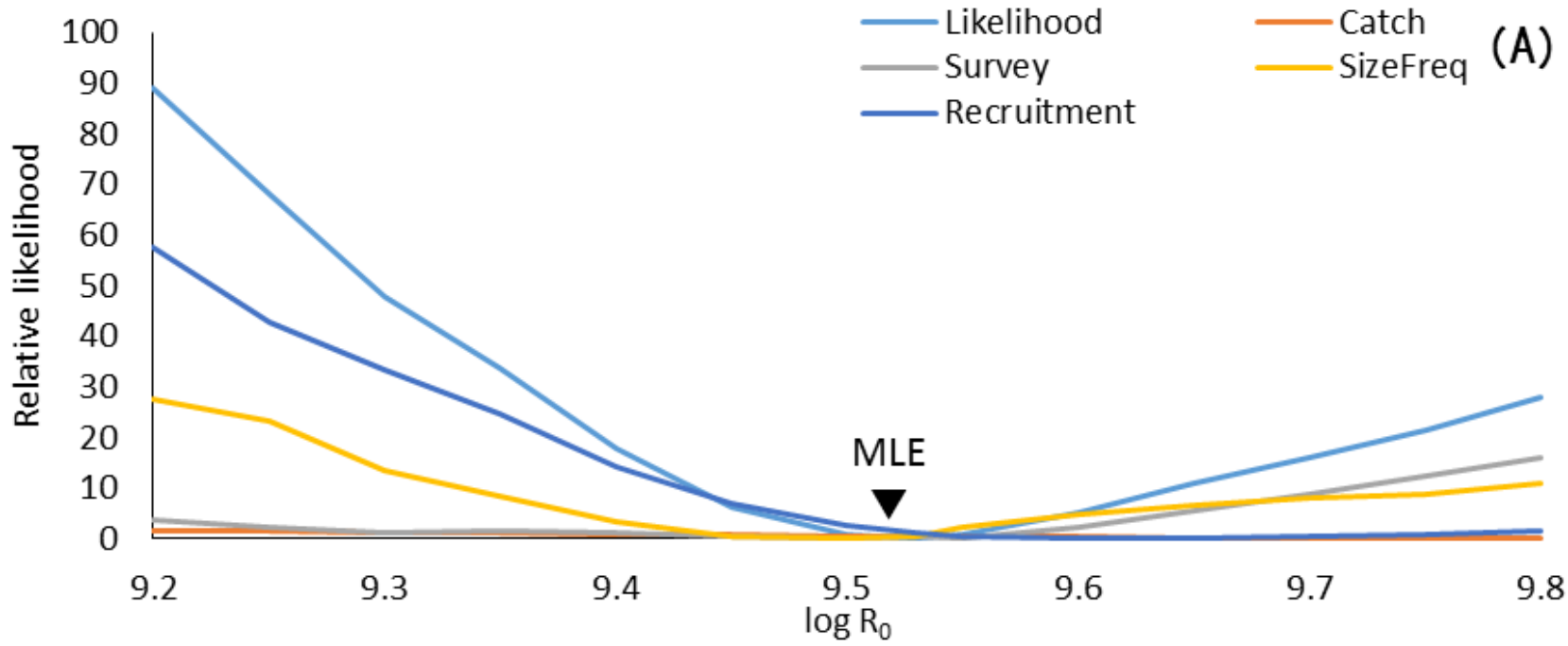


Average fits to Size Compositions



Likelihood profiles over fixed Log(R_0)

- Each component marked the lowest likelihood at a similar range of 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.

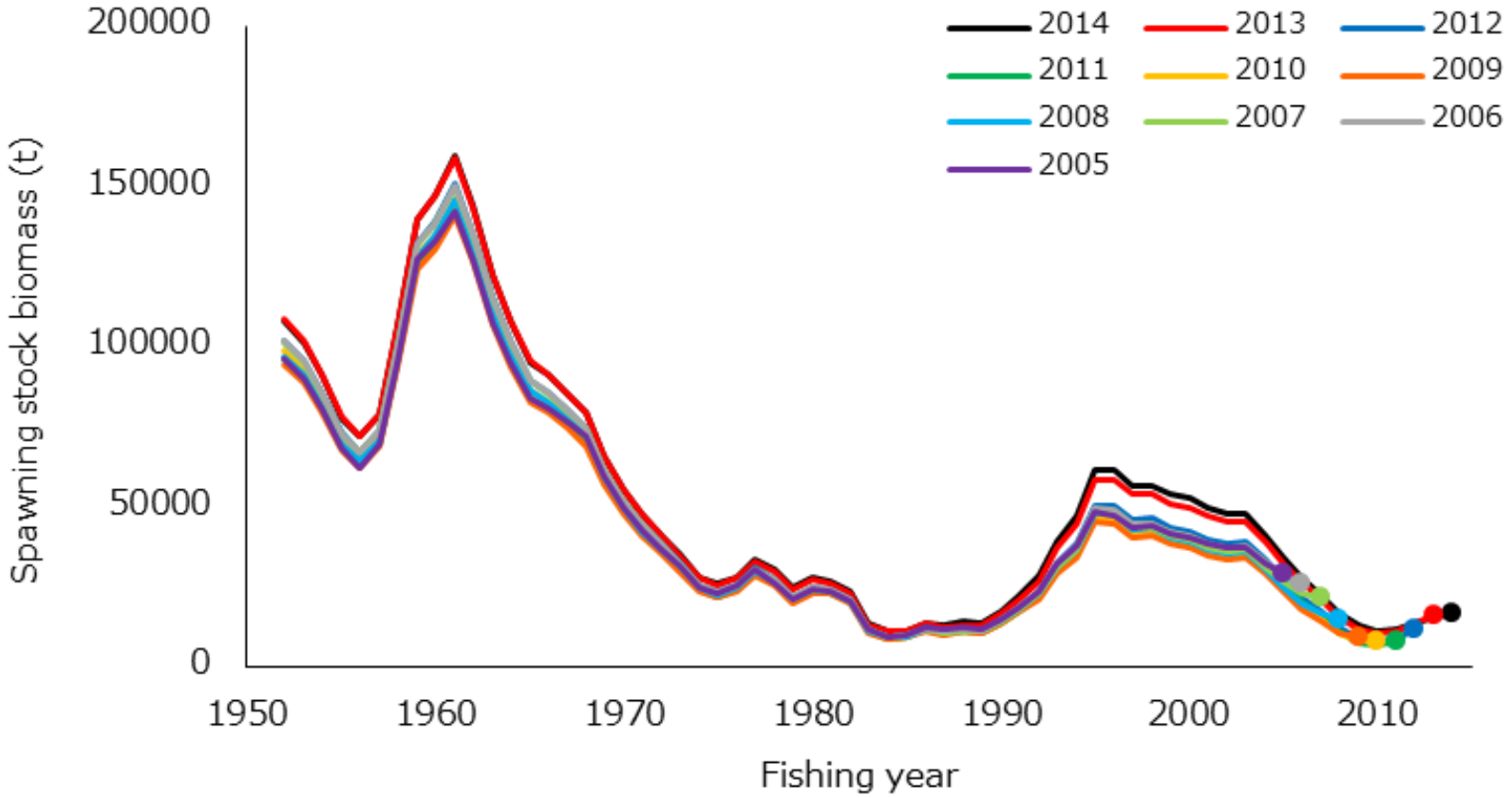


Alternative scenario (Sensitivity analysis)

- Higher/Lower M
- Steepness (h=0.9)
- Weighting (Harmonic mean EffN / Input N weighting)
- Variability of length at age (SD=f(length))
- Time varying selectivity for Japanese LL

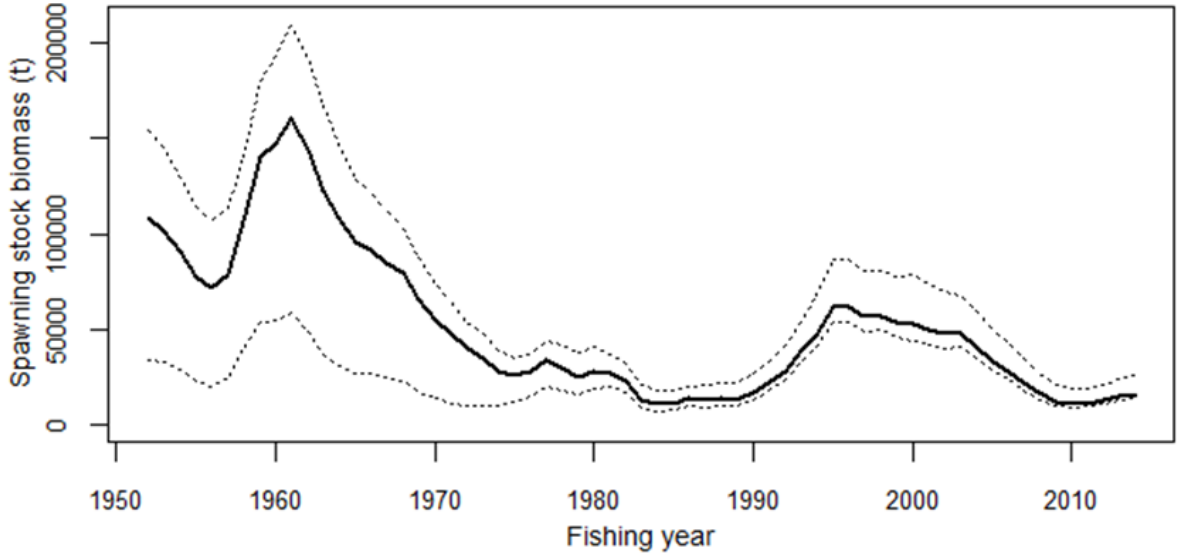
Retrospective Analysis

- No substantial tendency of estimation in the SSB for recent 9 terminal years



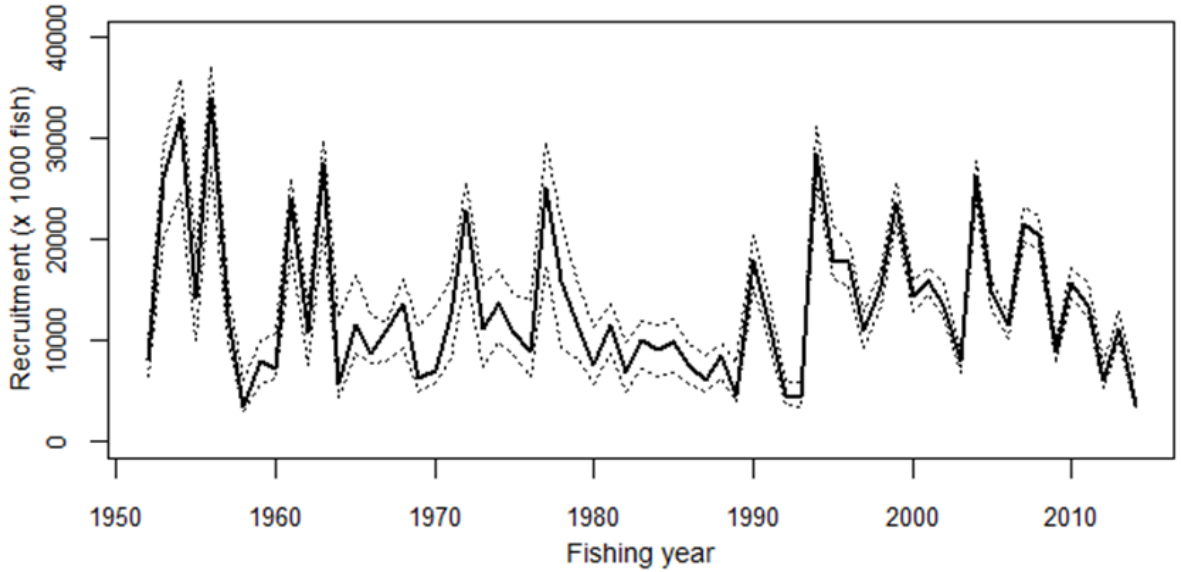
Spawning stock biomass

- 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).



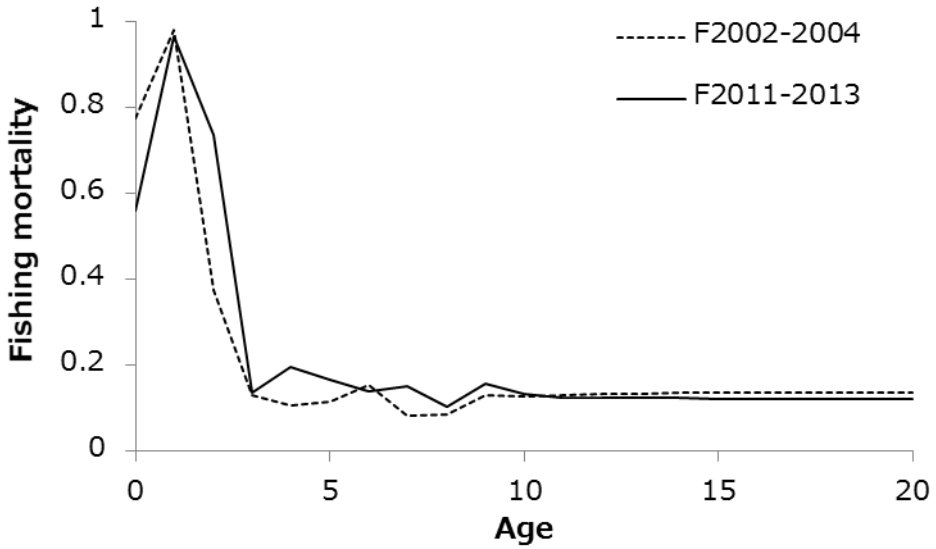
Recruitment

- 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+ .
- 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.

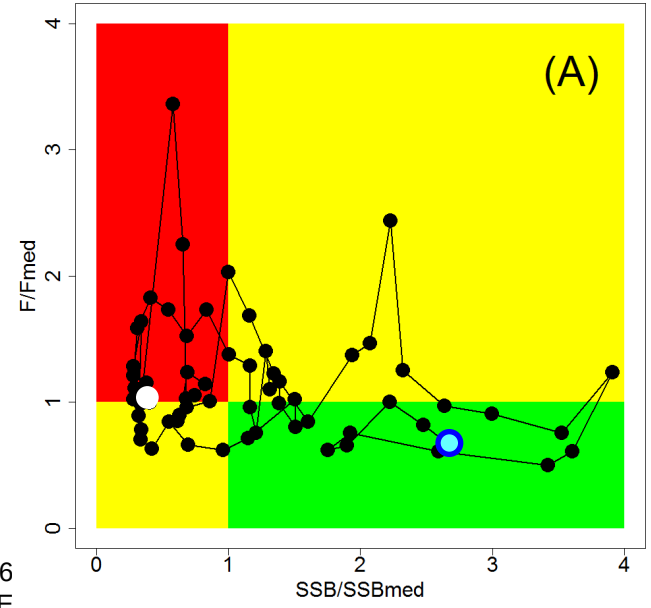
Year	F_{max}	$F_{0.1}$	F_{med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	Estiamted SSB for terminal year of each reference period	Depletion ratio for terminal year of each reference period
2002-2004	1.86	2.59	1.09	0.80	1.31	1.89	41,069	0.064
2009-2011	1.99	2.78	1.17	0.85	1.41	2.03	11,860	0.018
2011-2013	1.63	2.28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

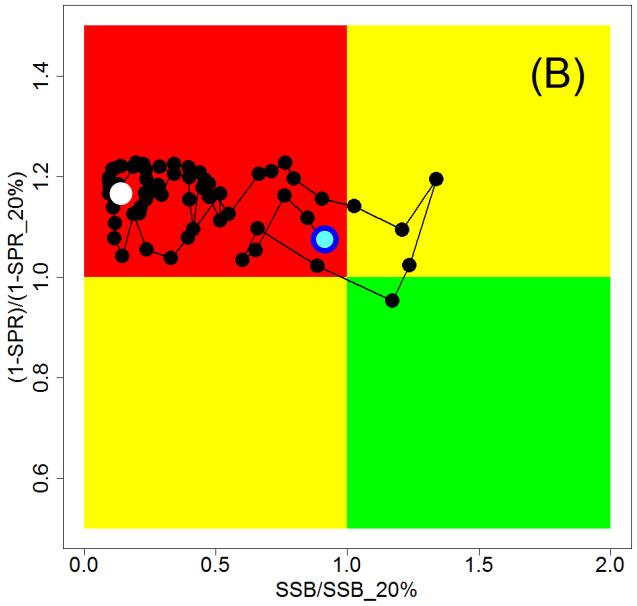
Stock Status (Summary 1)

- The base-case assessment model is 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)

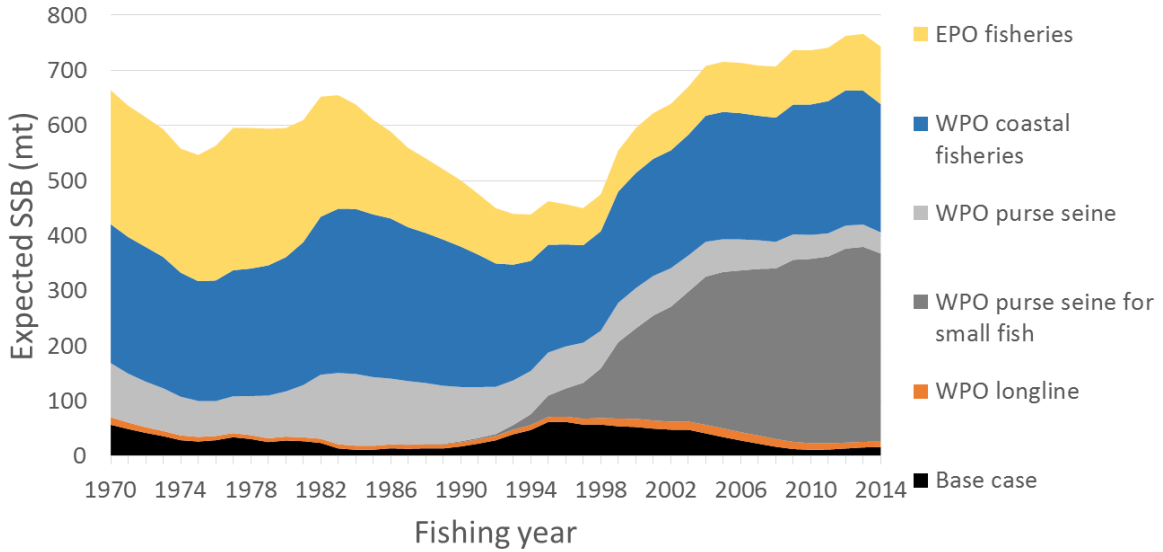
- The current F (2011–2013) exceeds most of biological reference points commonly used by tRFMO except for F_{MED} and F_{loss}, although F level has decreased in recent some years.
- In summary, overfishing is occurring and the stock is overfished. If F_{MED} is considered the threshold, the current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





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-Mar. 12th at La Jolla, USA

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

-WCPFC SC12-

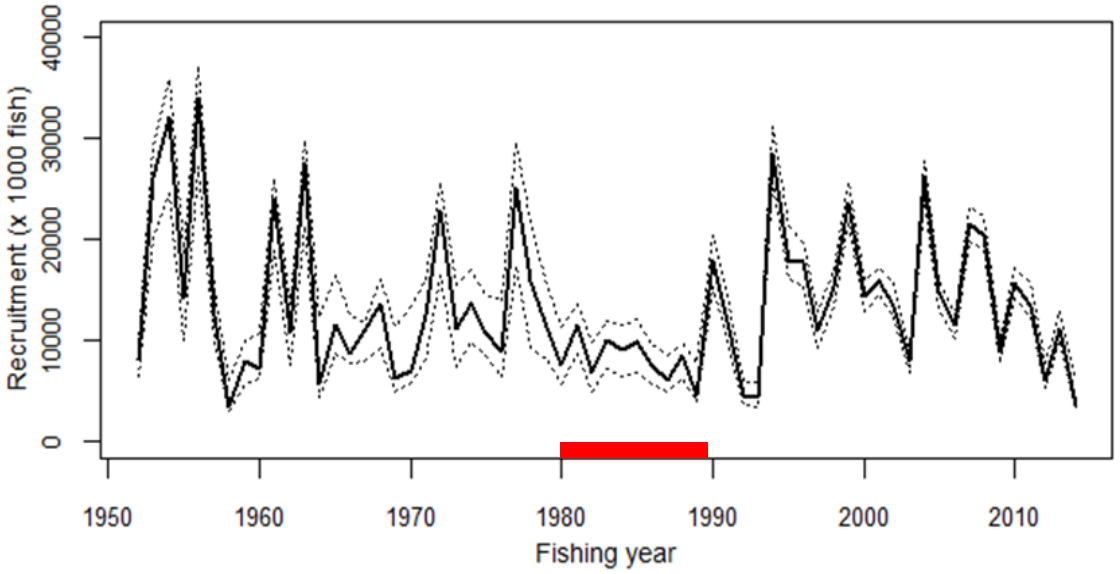
2016/8/6 Stones Hotel,
Bali, INDONESIA

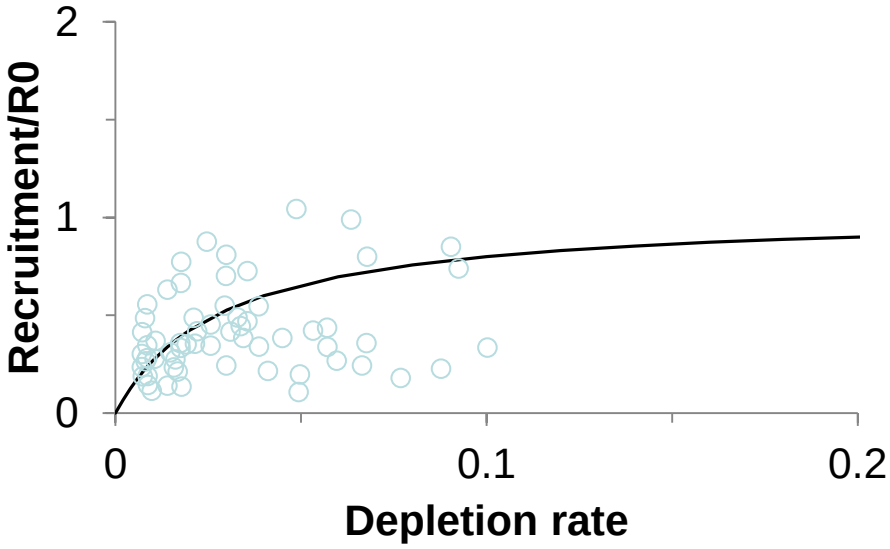
Projection Scenario

- Harvesting Scenario (11 scenarios)
  - Same with the last assessment Scenario 6 (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



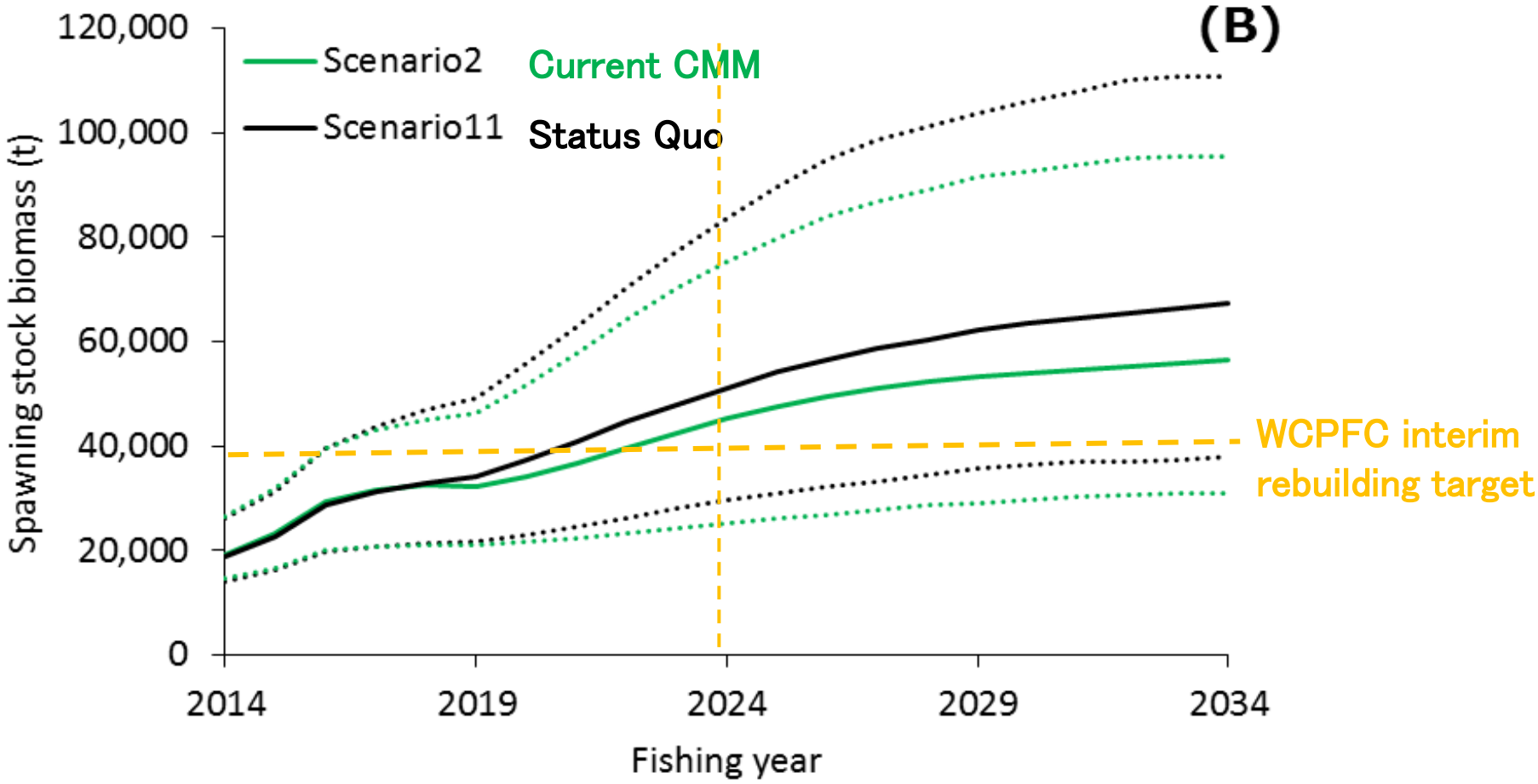


Results (Performance table)

Harvesting Scenario #	Fishing mortality	Catch limit		Threshold of Small/Large	Recruitment scenario	Probability that SSB exceeds 38,000 tons (SSB median of Bootstrap analysis runs)			Probability that SSB exceeds 41,000 tons (SSB median of Basecase model)			Probability that SSB is more than 43,000 tons (SSBmed@last assessment)			Probability that SSB is more than 10%SSB0			Probability that SSB is more than 20%SSB0			Average Catch	
		Small	Large			2024	2029	2034	2024	2029	2034	2024	2029	2034	2024	2029	2034	2024	2029	2034	2019	2024
Scenario1	F2002-2004	scenario 6 in 2014 assessment		30 kg	Low recruitment	77.0%	88.8%	89.9%	69.7%	83.3%	85.2%	64.3%	79.3%	81.9%	14.7%	28.0%	31.8%	0.0%	0.0%	0.1%	11619.2	13574.9
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%	61.5%	77.8%	82.3%	56.1%	73.9%	79.0%	13.6%	29.3%	35.4%	0.1%	0.4%	0.6%	11749.7	12994.2
					Average recruitment	99.6%	100%	100%	99.3%	100%	100%	99.3%	100%	100%	96.3%	99.8%	100%	73.8%	95.0%	98.0%	12958.4	14750.8
					Stock Recruit Relationship w/ h=0.9	98.2%	99.8%	99.9%	97.7%	99.8%	99.9%	97.5%	99.7%	99.9%	93.5%	99.4%	99.9%	72.0%	97.3%	99.6%	13087.3	15020.1
Scenario3		50% of 2002-2004 average catch		50 kg	Low recruitment	80.5%	91.5%	94.0%	73.8%	87.9%	90.7%	69.1%	85.1%	88.5%	22.2%	43.6%	51.7%	0.2%	0.9%	1.3%	11404.4	12672.3
Scenario4				80 kg	Low recruitment	86.4%	94.6%	96.5%	80.6%	91.9%	94.7%	76.6%	90.0%	93.0%	27.8%	51.8%	61.3%	0.2%	1.1%	1.6%	11292.6	12542.7
Scenario5		90% of scenario 2	same as Scenario 2	30 kg	Low recruitment	90.0%	96.5%	98.1%	85.3%	94.8%	97.0%	81.5%	93.4%	95.9%	35.0%	61.7%	70.4%	0.3%	2.5%	3.7%	11306.4	12881.3
					Average recruitment	99.9%	100%	100%	99.9%	100%	100%	99.9%	100%	100%	98.4%	100%	100%	82.2%	97.8%	99.3%	12442.0	14126.3
					Stock Recruit Relationship w/ h=0.9	99.4%	100%	100%	99.2%	100%	100%	99.1%	100%	100%	97.0%	99.8%	100%	81.8%	99.0%	99.9%	12576.4	14448.2
Scenario6		same as Scenario 2	90% of scenario 2		Low recruitment	75.3%	88.2%	90.2%	67.2%	82.9%	86.5%	61.7%	78.6%	83.4%	15.7%	32.5%	38.7%	0.1%	0.5%	0.7%	11496.2	12632.4
					Average recruitment	99.7%	100%	100%	99.6%	100%	100%	99.5%	100%	100%	96.8%	99.9%	100%	75.1%	95.2%	98.1%	12686.3	14071.5
					Stock Recruit Relationship w/ h=0.9	98.9%	99.9%	100%	98.6%	99.9%	100%	98.4%	99.9%	100%	95.0%	99.7%	100%	75.5%	98.0%	99.9%	12761.0	14379.7
Scenario7		90% of scenario 2		30 kg	Low recruitment	90.3%	96.8%	98.3%	86.2%	95.4%	97.6%	82.7%	94.2%	96.8%	39.4%	68.0%	77.4%	0.5%	3.5%	5.6%	11231.0	12607.1
					Average recruitment	99.9%	100%	100%	99.9%	100%	100%	99.9%	100%	100%	98.5%	100%	100%	83.5%	98.1%	99.6%	12139.4	13461.7
					Stock Recruit Relationship w/ h=0.9	99.2%	100%	100%	99.1%	100%	100%	99.0%	99.9%	100%	96.9%	99.8%	100%	81.6%	99.0%	99.9%	11227.3	12461.8
Scenario8		80% of scenario 2	same as Scenario 2		Low recruitment	97.5%	99.6%	99.9%	96.1%	99.3%	99.7%	94.8%	98.9%	99.5%	65.4%	89.2%	94.0%	1.9%	14.5%	22.8%	10922.8	12688.4
Scenario9		same as Scenario 2	80% of scenario 2		Low recruitment	78.1%	89.9%	92.5%	70.4%	85.6%	88.8%	65.0%	81.9%	86.3%	18.4%	37.1%	44.7%	0.2%	0.6%	0.9%	11327.0	12329.9
Scenario10		80% of scenario 2			Low recruitment	98.3%	99.8%	99.9%	97.4%	99.6%	99.9%	96.3%	99.5%	99.8%	73.2%	93.8%	97.5%	3.1%	22.4%	34.1%	10585.9	11586.4
					Average recruitment	100%	100%	100%	100%	100%	100%	100%	100%	100%	99.7%	100%	100%	91.0%	99.5%	100%	11194.1	12104.9
					Stock Recruit Relationship w/ h=0.9	99.8%	100%	100%	99.7%	100%	100%	99.7%	100%	100%	98.7%	100%	100%	90.0%	99.7%	100%	11227.3	12461.8
Scenario11	F2011-2013	same as Scenario 2	same as Scenario 2		Low recruitment	82.6%	93.0%	95.0%	75.9%	89.9%	92.1%	71.3%	86.4%	89.9%	23.6%	46.2%	56.0%	0.1%	1.2%	1.6%	12266.8	13587.4

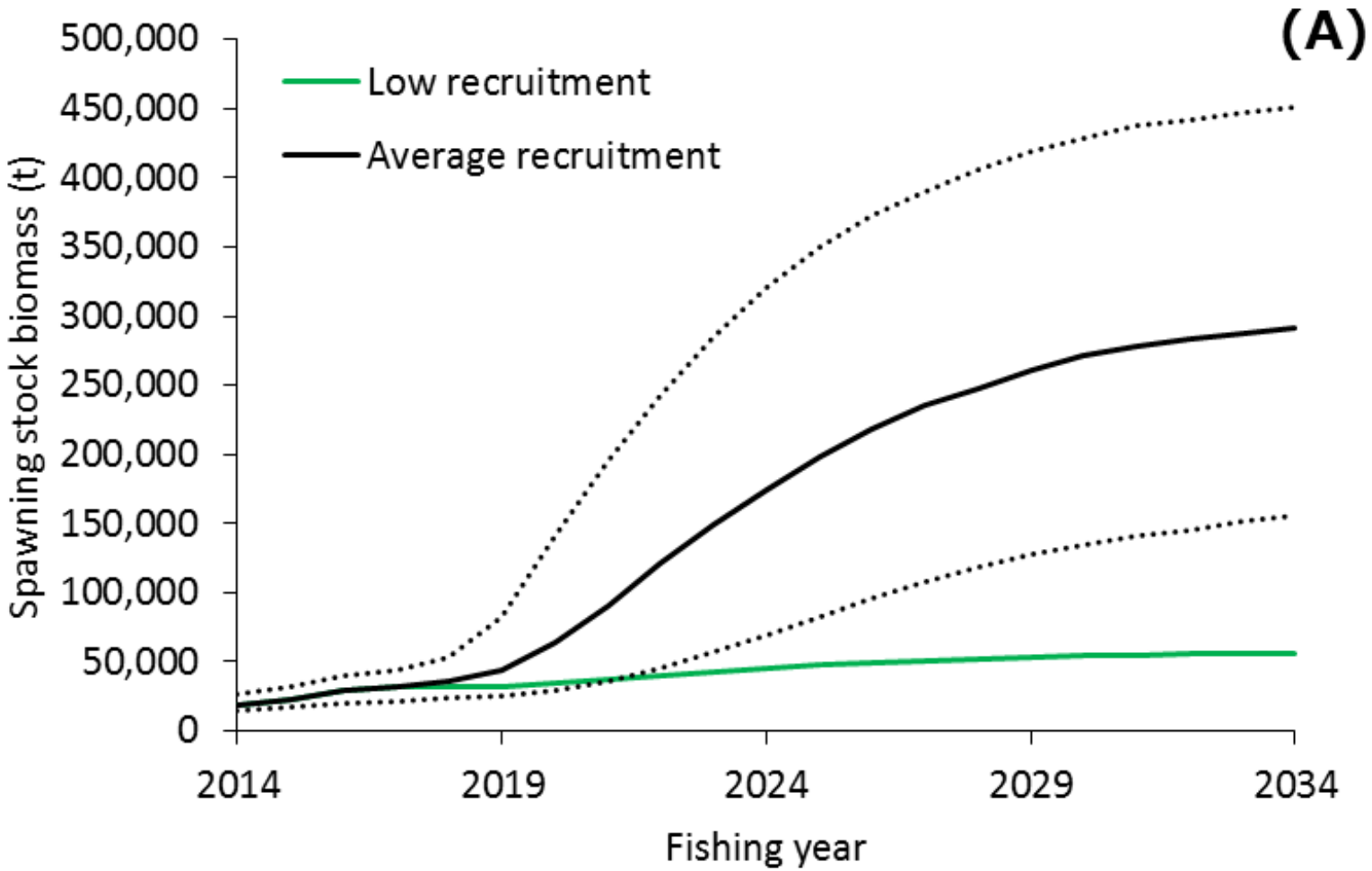
Results

○Current CMMs and Status Quo under low recruitment scenario.



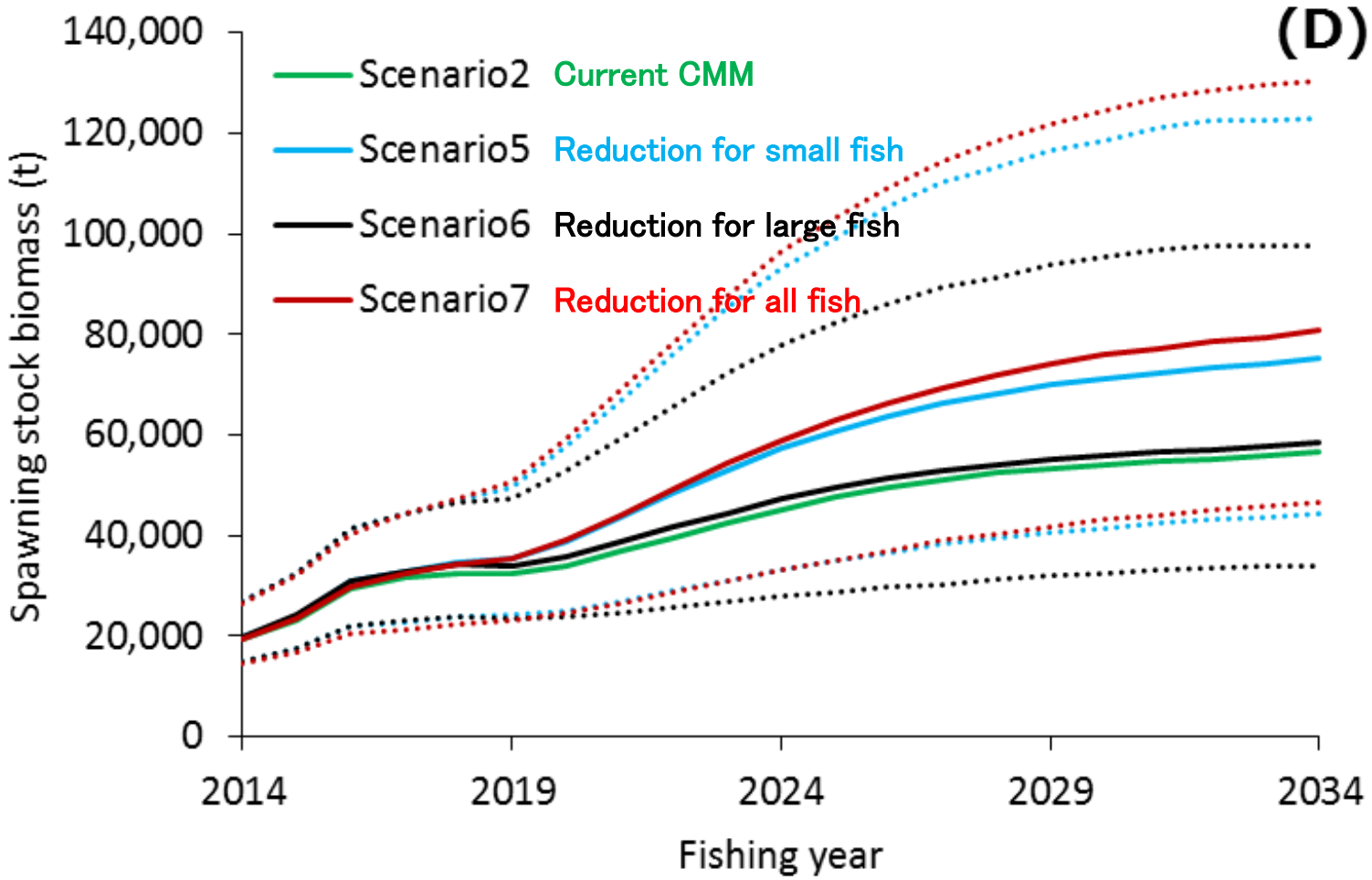
Results

○ Current CMMs under Average and Low recruitment scenario.



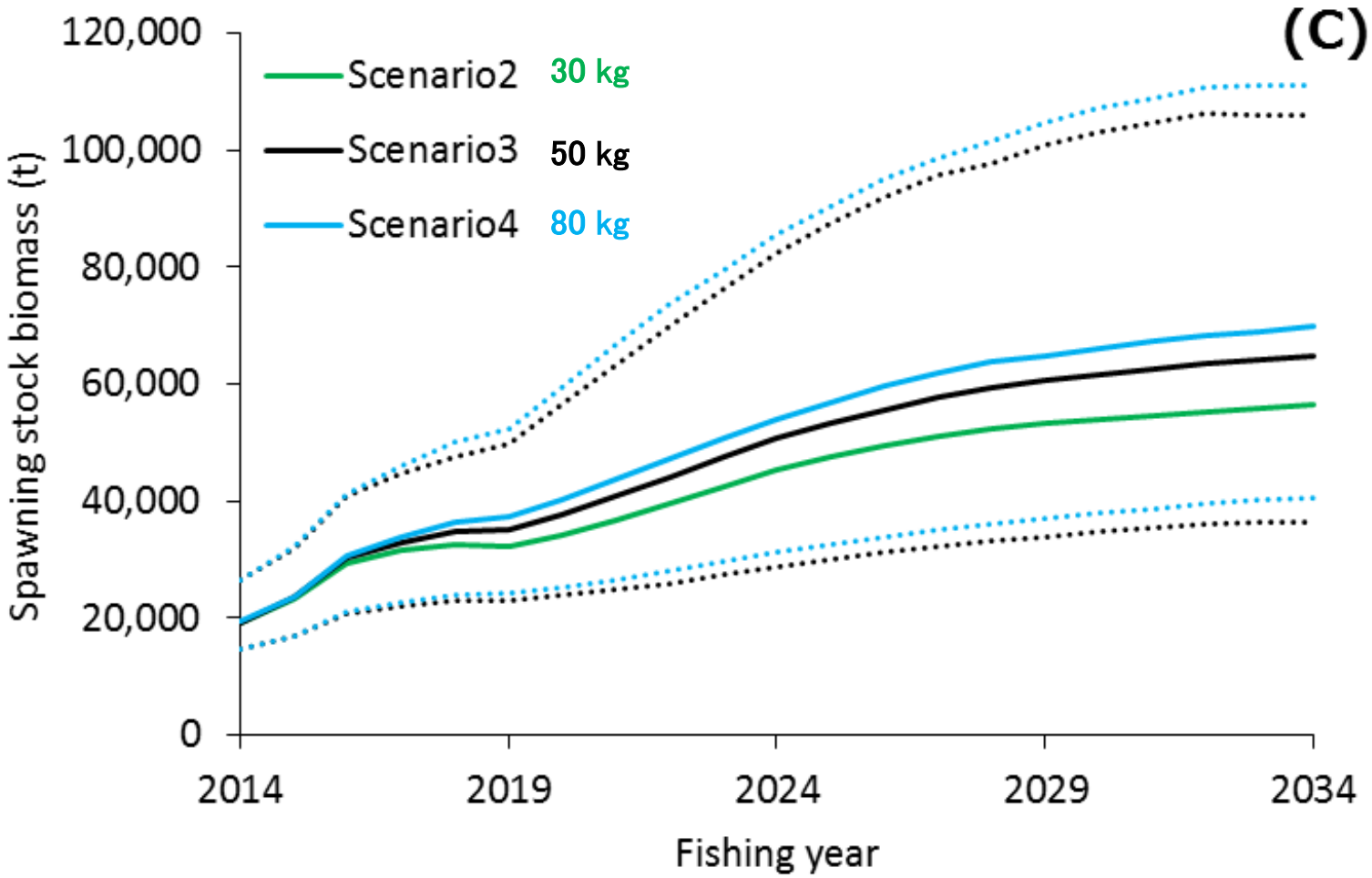
Results

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



Results

○ Comparisons of different of threshold for small/large fish 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 threshold 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.
- Recommended to fix the period to calculate initial rebuilding target of SSB_{MED}.

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.

Thank you

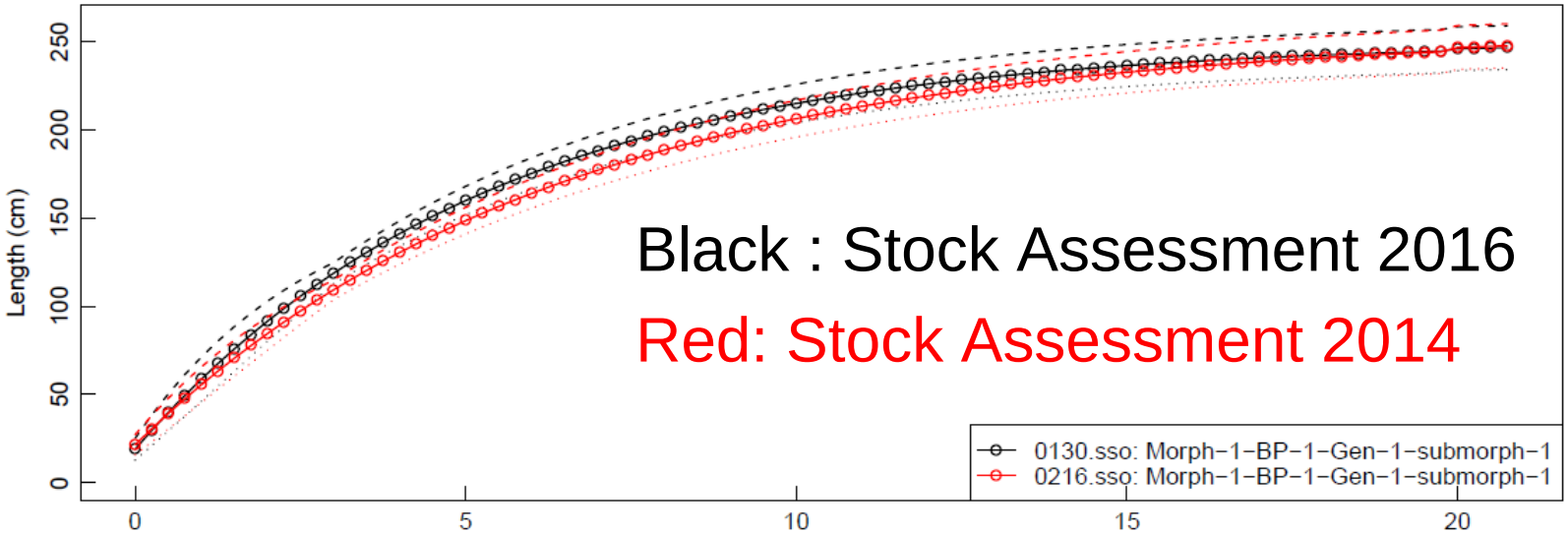
Future research plan prioritized by ISC

Attachment 6 REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP WORKSHOP Feb-March 2016

Item	Specific plan	Priority	Time frame
Stock-recruitment relationship		high	short term
Population structure	Genetic population structure inferred from Close-Kin data	high	short term
Better understanding of fishery data	New CPUE indices for intermediate age between recruit and large adult	high	short term
	cause of change in the trend of Japanese longline CPUE with focus on geostatistical modeling	highest	short term
	Improve Taiwanese index with focus on spatio-temporal change	high	short term
	Improvements of recruitment index	high	short term
Independent estimate of spawning biomass	Close-kin genetics	high	longer term
Evaluation of growth to improve length frequency fitting	Seasonal timing, annual variation, regional and sex-specific change of growth	second highest	short term

Comparison of Growth curve

- VBGF at Stock Assessment 2014
  - Based on Shimose (2009) with Ad-hoc adjustment for the length of age 0.125 fish.
- VBGF at current base case (2016)
  - Based on otolith annuli and daily increments obtained after "Age determination workshop"



Fleet #	Fleet name	Unit of Comp data (Size bin definition)	Size data included		Available period (Fishing year)	Source of sample size
			Component 1	Component 2		
Fleet1	JPLL	Length	JPLL		1952-1968, 1993-2014	Scaled Number of fish measured
Fleet2[*1]	JPSPPS (Seas1, 3, 4)	Length	JPSPPS (Season 1, 3, 4)	KROLPS	2002-2014	Number of landing well measured
Fleet3[*1]	KROLPS	Length	KROLPS		2010-2014	
Fleet4	JPTPSJS	Length	JP TPSJS		1987-1989, 1991-2014	same velue with the last assessment
Fleet5	JPTPSPO	Length	JP TPSPO		1995-2006	Number of landing well measured
Fleet6	JPTroll (Seas2-4)	Length	JP Troll (Season 2-4)		1994-2014	Total month of well sampled port
Fleet7[*2]	JPPL	Length	JP Pole-and-Line		1994-1996, 1998-2004, 2006-2010	
Fleet8	JPSetNet (Seas1-3)	Length	JP Setnet (Season 1-3)		1993-2014	Total month of well sampled port
Fleet9	JPSetNet (Seas4)	Length	JP Setnet (Season 4)		1993-2014	Total month of well sampled port
Fleet10[*3]	JPSetNet_HK_AM	Weight	JP Setnet in Hokkaido and Aomori	JP Handline & Tsugaru Longline	1994-2014	Total month of well sampled port
Fleet11[*3]	JPOthers	Weight	JP Handline & Tsugaru Longline		1994-2014	Total month of well sampled port
Fleet12	TWLL (South)	Length	TWLL (South area)		1992-2014	Scaled Number of fish measured
Fleet13	USCOMM (-2001)	Length	US Commercial Fisheries (PS)		1952-1965, 1969-1982	Number of haul well measured
Fleet14	MXCOMM (2002-)	Length	MX Commercial Fisheries (PS)		2005-2006, 2008-2013	Number of haul well measured
Fleet15[*4]	EPOSP	Length	US Recreational Fisheries		1993-2003, 2005-2006, 2008-2011	
Fleet16[*5]	Troll4Pen					
Fleet17	TWLL (North)	Length	TWLL (North area)		2009-2014	Scaled Number of fish measured
Fleet18	JPSPPS (Seas2)	Length	JPSPPS (Season 2)		2003-2012, 2014	Number of landing well measured
Fleet19	JPTroll (Seas1)	Length	JP Troll (Season 1)		1994-2004, 2006-2011	Total month of well sampled port

ones Hotel, Bali,