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Domestic Stock Assessment of Blue Mackerel in Japan

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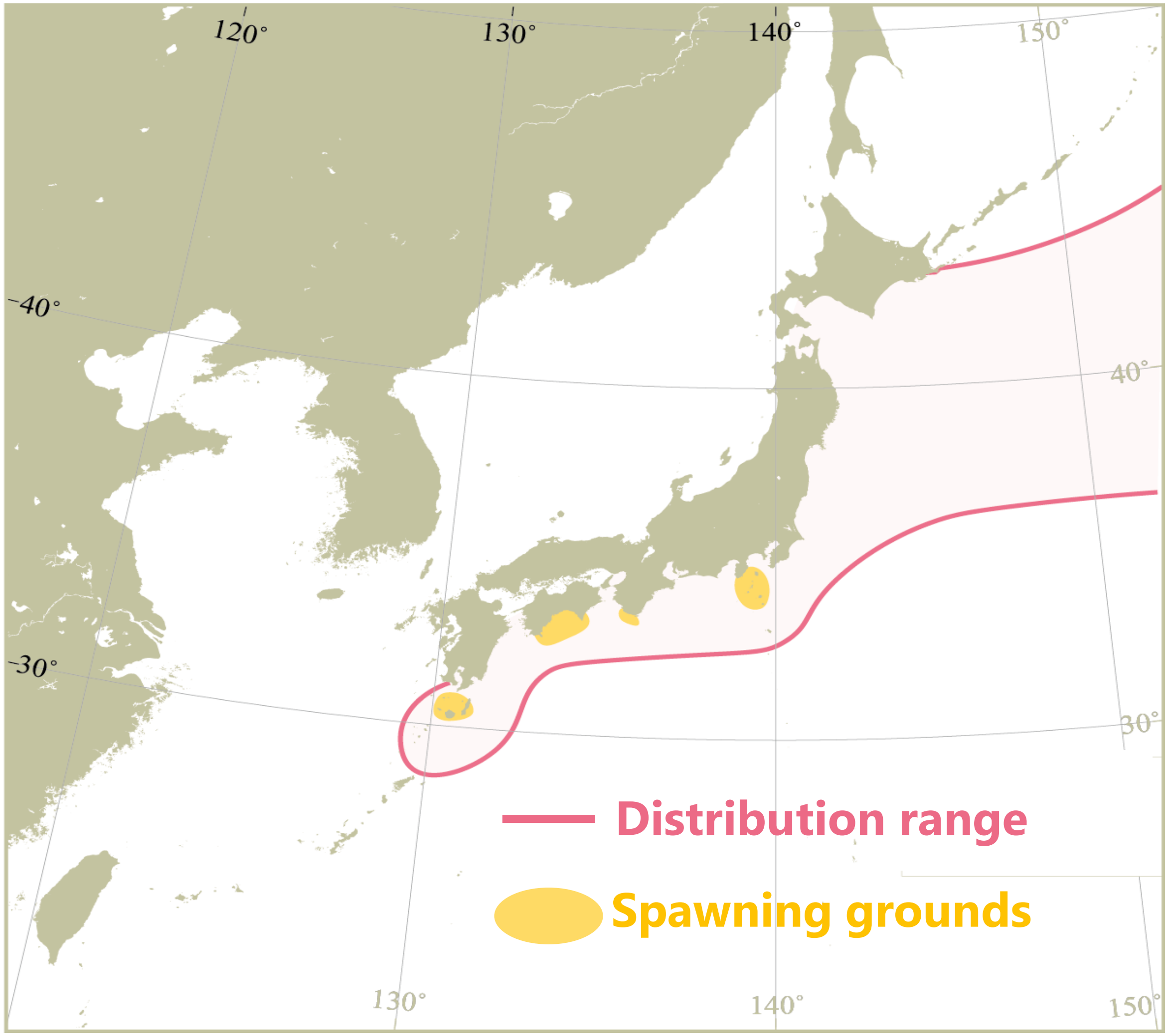
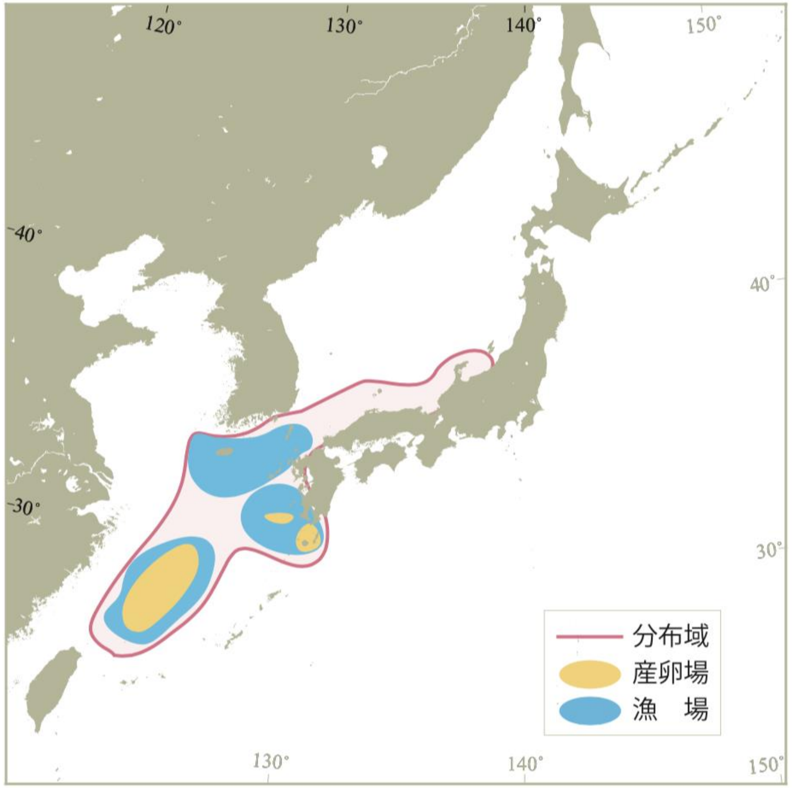
Spatial Structure of BM Stocks

Pacific stock

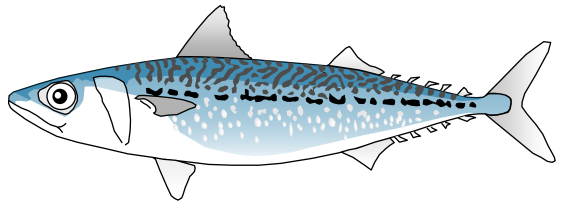


East China Sea stock

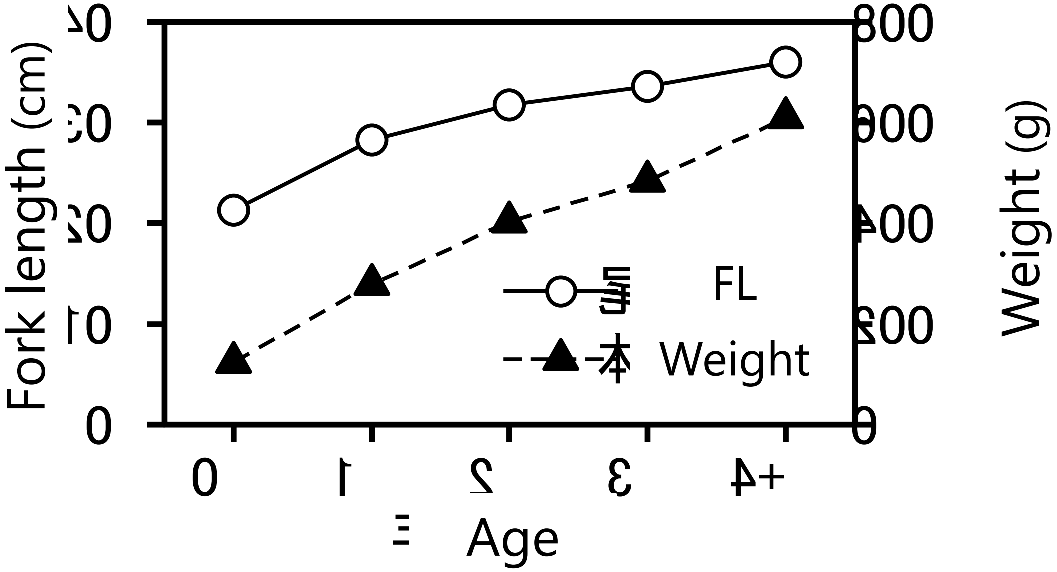


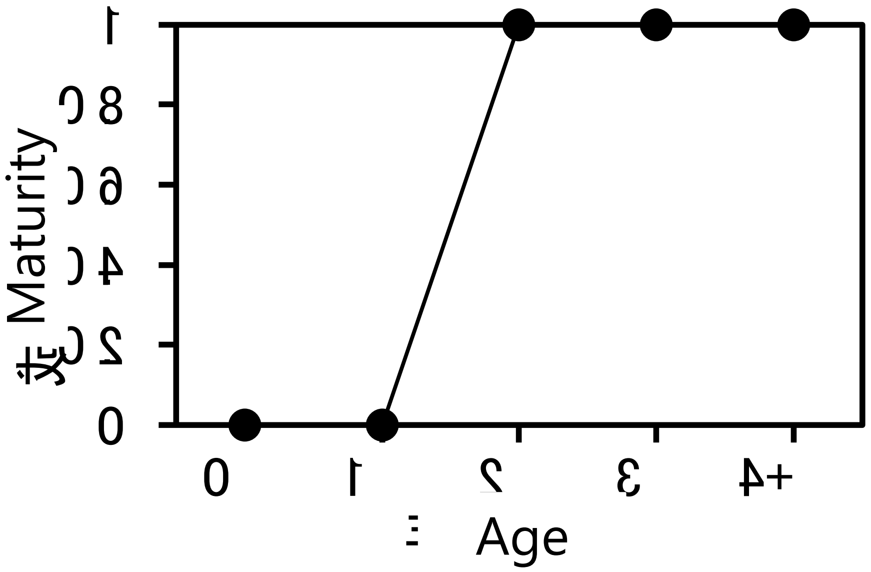
- There are two stocks depending on distributions and biology
- Only the Pacific stock is distributed in the NPFC Convention Area

Biological Characteristics



Average of fished individuals during the most recent 5 years（2017-2021）





Longevity: about 6 YO

Maximum fork length (FL)：about 45 cm

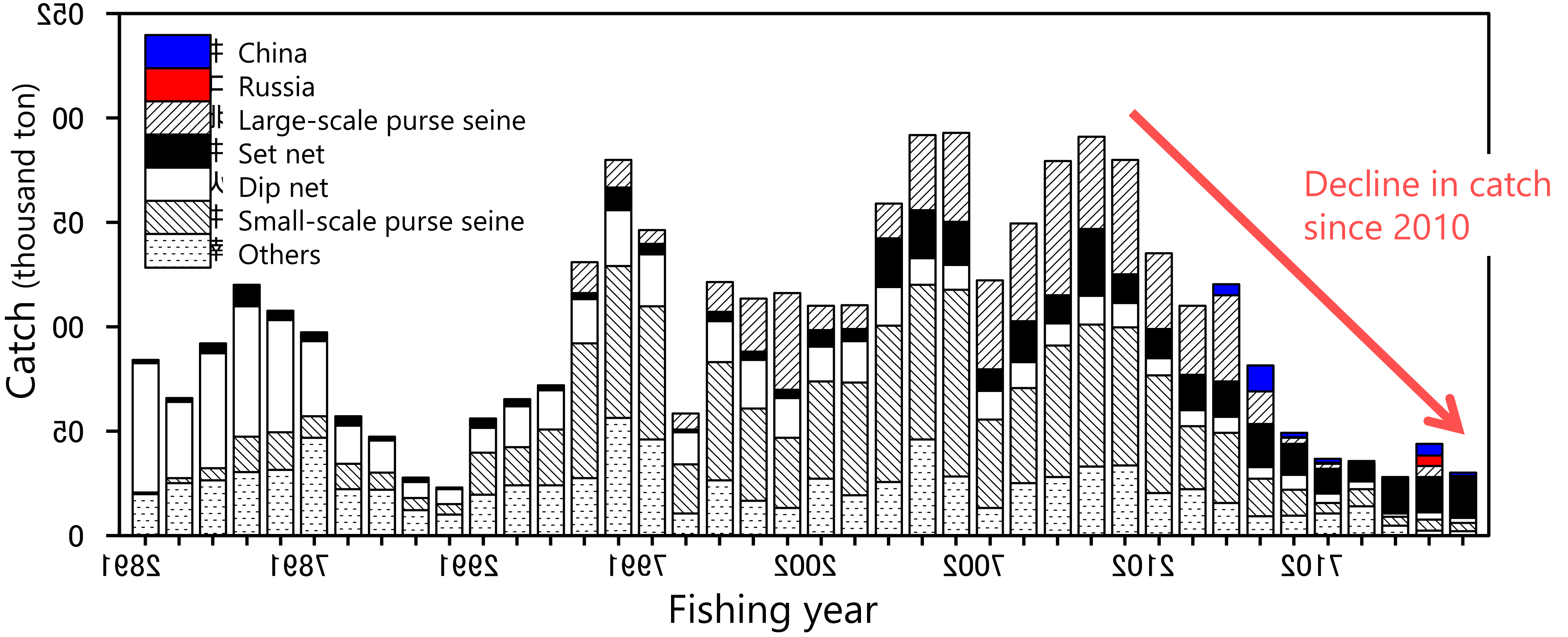
Maturity: Longer than 30 cm of FL（age 2+）

Spawning: From December to June in Kuroshio Current area west of the Izu Islands

Feeding: Planktonic crustaceans, whitebait, etc. in the juvenile stage. Squids and small fishes after immature stage.

Predator: Large fish such as skipjack and sometimes baleen whales

Catch Statistics



Fishing year is from July to June in the next year

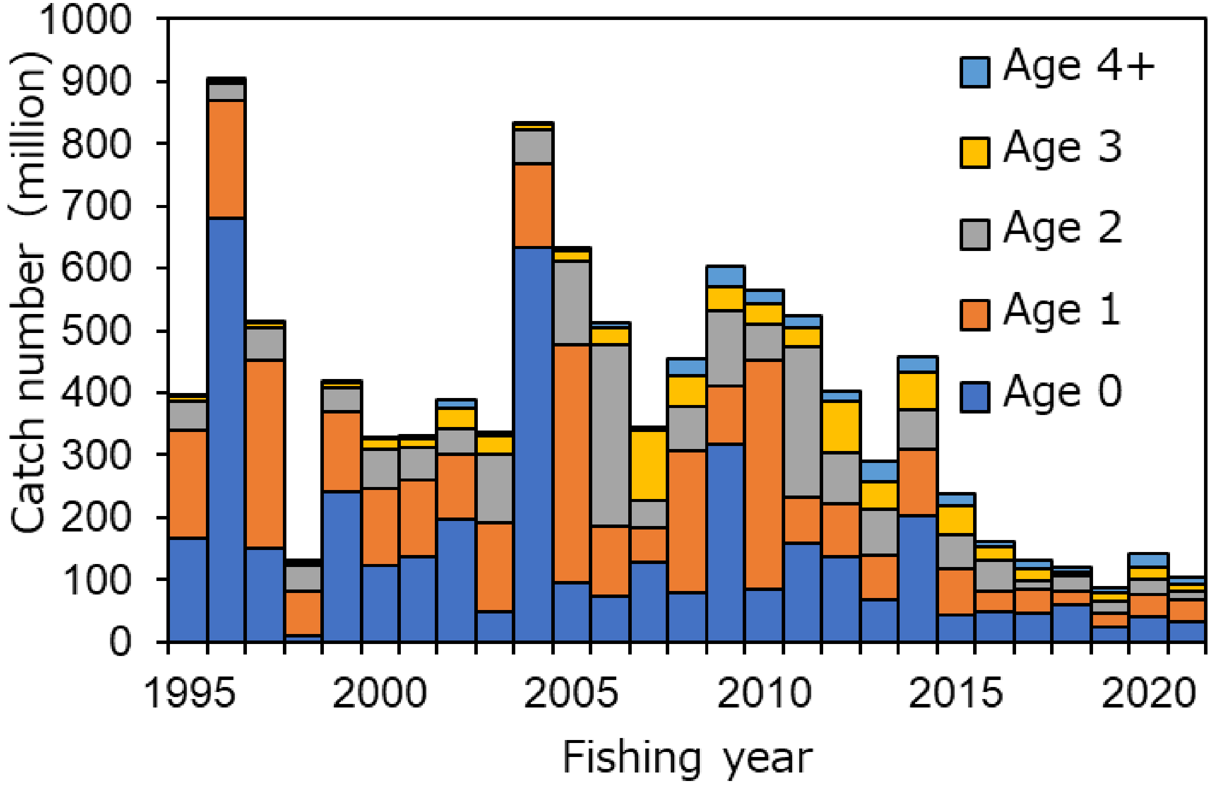
The NPFC official statistics report the aggregate of chub mackerel and BM catch as 'mackerel' catch

The proportions of BM and CM were assumed to those of northern large-scale purse seine fishery from July to December

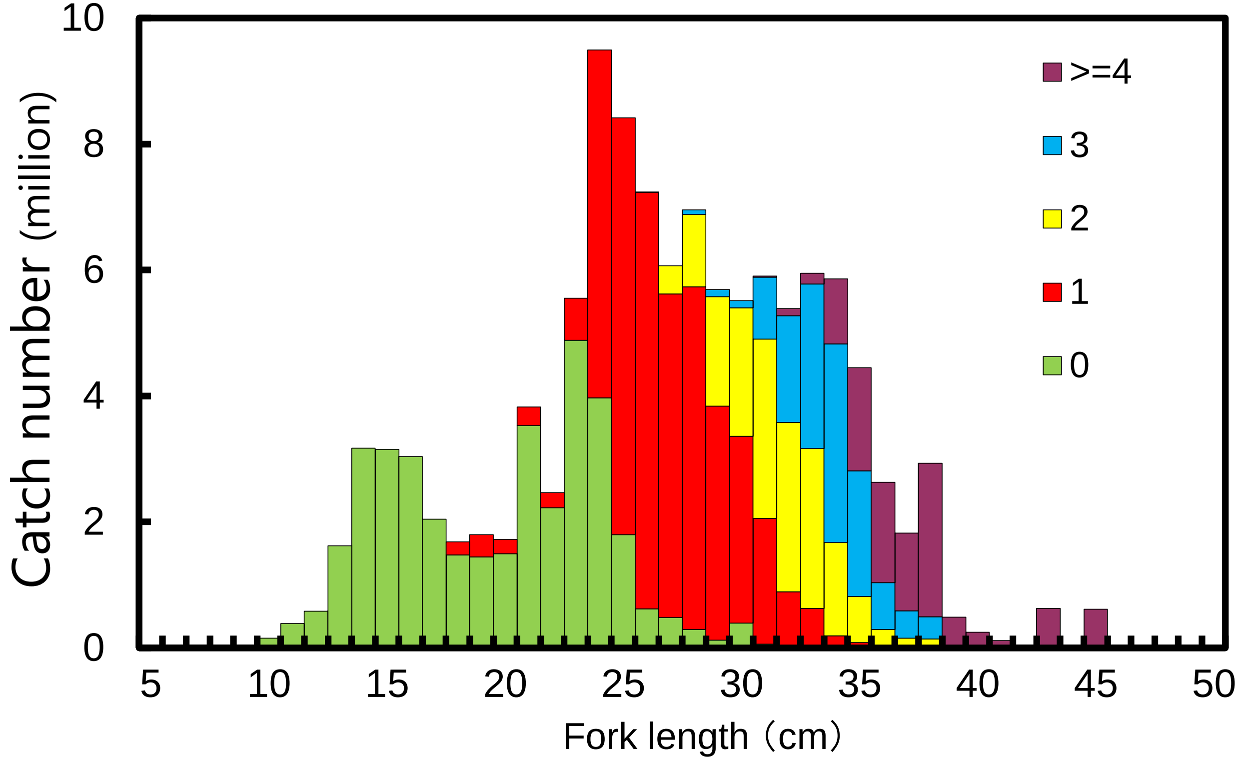
FY2020: 33 thousand ton, FY2021: 27 thousand ton (Russia: 1.2 thousand ton, China: 1.5 thousand ton)

Catch Number by Age and Length

Time series of catch at age



Catch at length in FY2021



The almost same method as JS was used for the estimation of catch at age for BM (see also a working paper for TWG CMSA: NPFC-2020-TWG CMSA03-WP02)

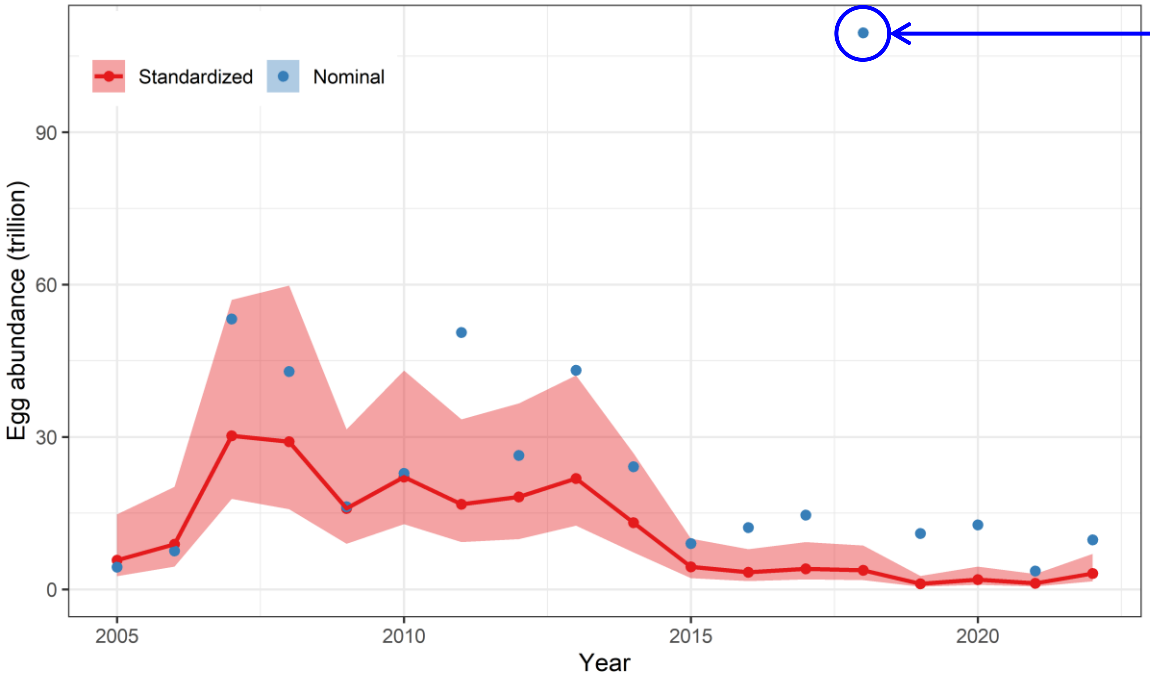
The age compositions were assumed to those of northern large-scale purse seine fishery from July to December

A wide range of age classes has recently been caught

Egg Abundance Standardized by VAST

The standardized egg abundance has been used as an abundance index for SSB

The standardization was conducted using the seasonal Vector Autoregressive Spatio-Temporal (VAST) model (Thorson et al. 2020, ICES JMS) with consideration for the effect of misidentification of mackerel eggs



An extremely high value was observed in 2018 probably due to the misidentification of chub mackerel eggs as BM eggs

Temporal, Spatial, Spatio-Temporal, Catchability

Binomial $$p_1(i) = \beta_1(t_i) + \omega_1(s_i) + \varepsilon_1(s_i, t_i) + \lambda_1 Q(i)$$

Gamma $$p_2(i) = \beta_2(t_i) + \omega_2(s_i) + \varepsilon_2(s_i, t_i) + \lambda_2 Q(i)$$

Catchability covariate $$Q(i) = \log(\text{CM egg density} + 0.1) - \log(0.1))$$

Effect of CM eggs

Seasonal effect of temporal term $$\beta(t) = \underbrace{\mu_\beta + \beta_m(m_t) + \beta_y(y_t)}_{\text{Fixed effect}} + \underbrace{\beta_t(t)}_{\text{AR(1)}}$$

(Mean, Month, Year, Year× Month)

The yearly trend was much smoothed by the standardization

Reduced Retrospective Bias by VAST

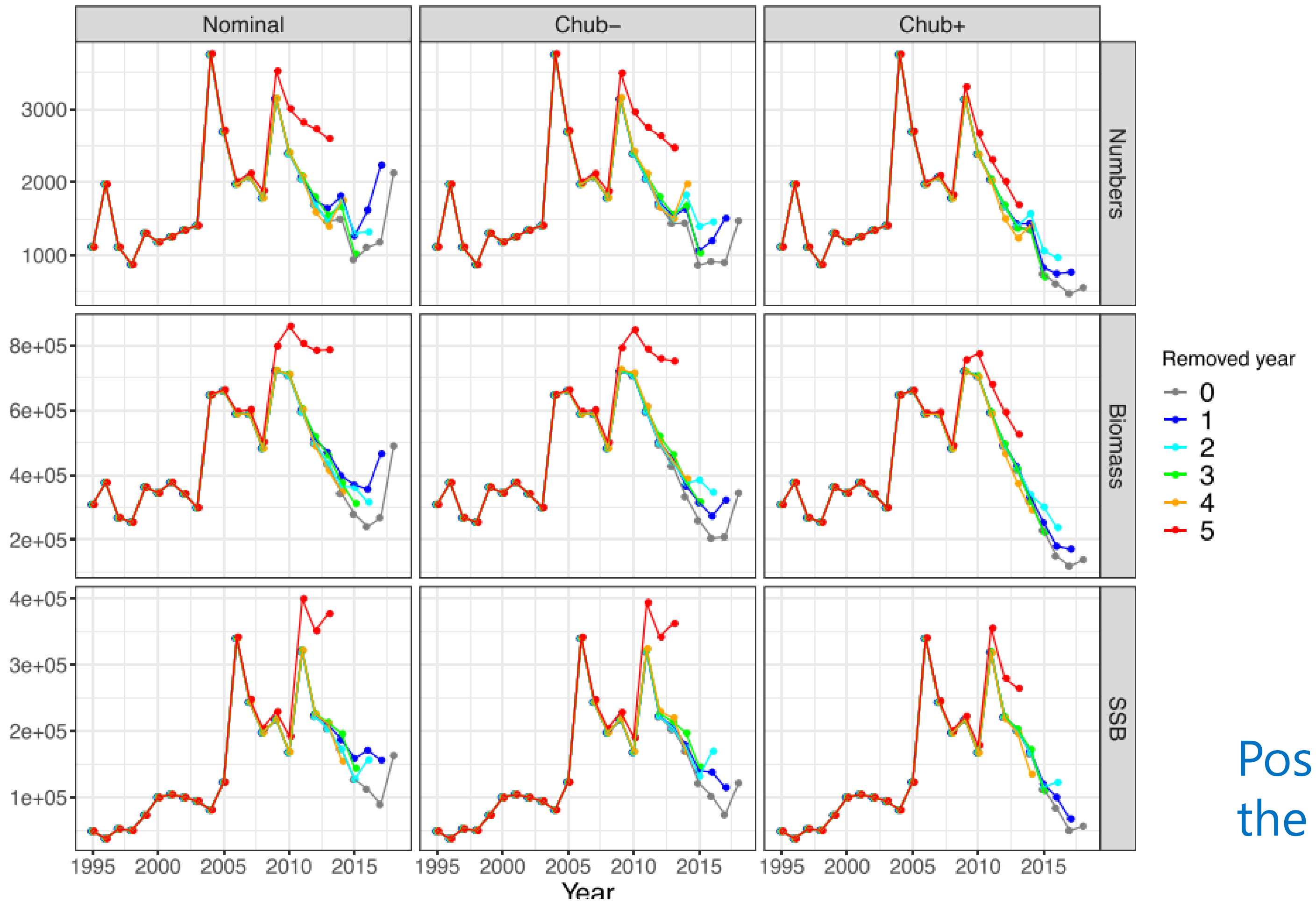


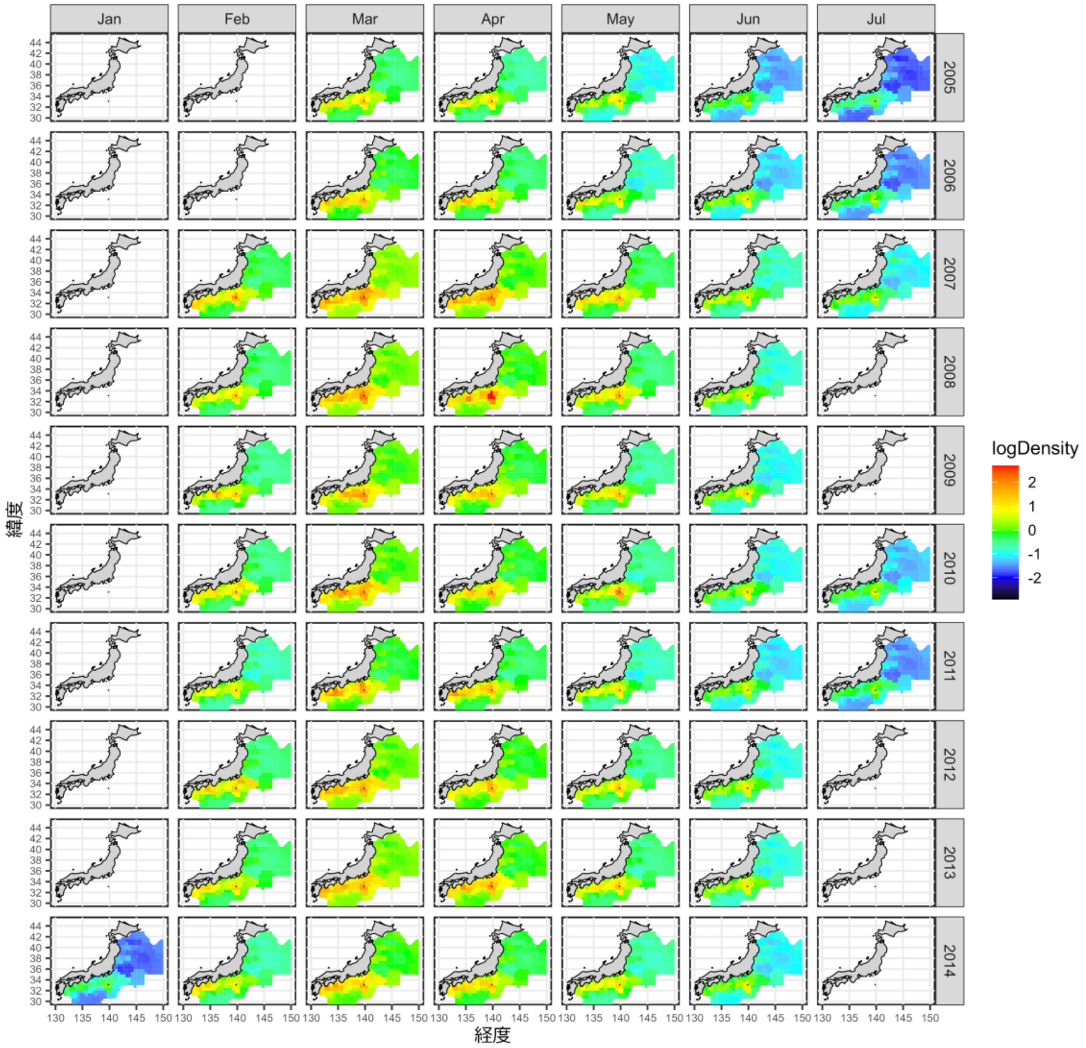
Table 1
Mohn's rho for each index of total numbers of individuals, total biomass, and spawning stock biomass (SSB).

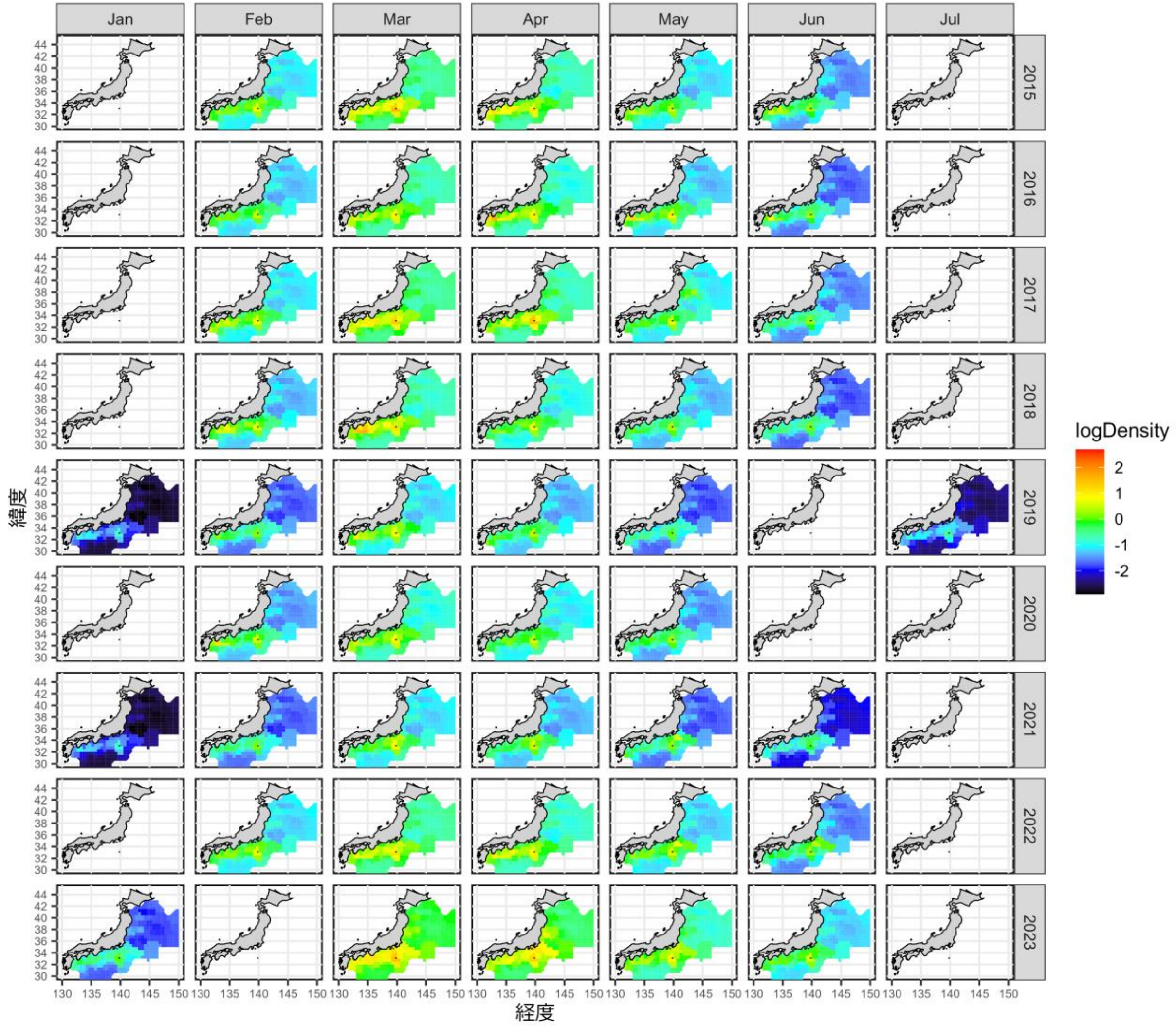
Index	Mohn's rho		
	Numbers	Biomass	SSB
Nominal	0.42	0.40	0.41
Chub−	0.51	0.48	0.45
Chub+	0.28	0.24	0.33

Positive retrospective biases were reduced by the VAST model with the chub mackrel effect

(Kanamori et al. 2021, Fish.Res.)

Egg Distributions by Month by Year





The egg abundance was high from March to May

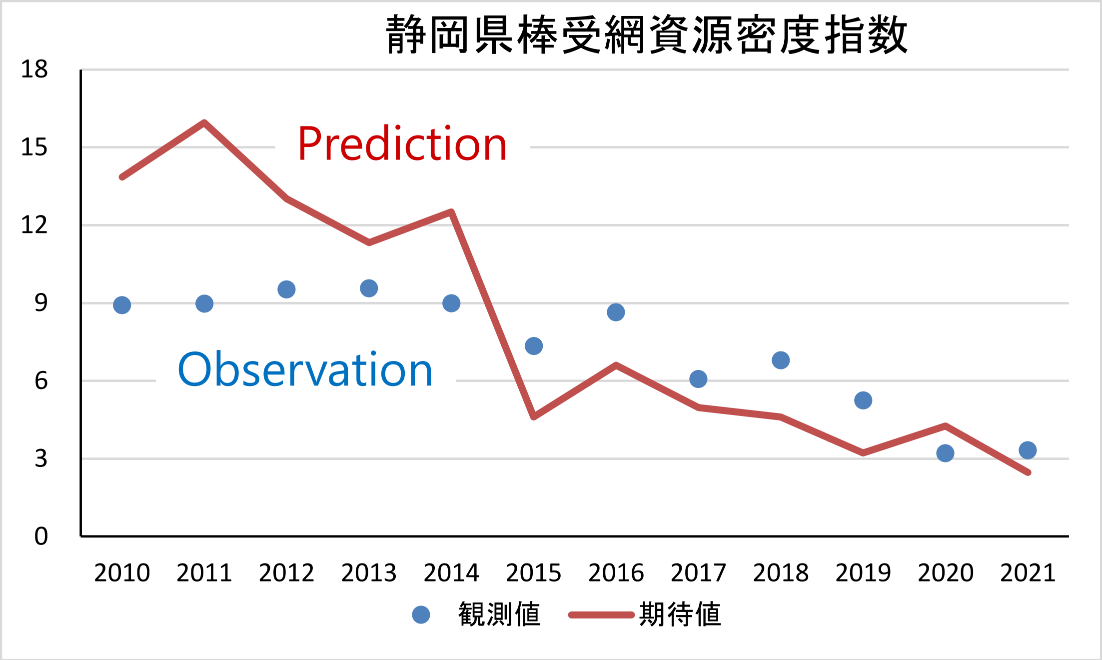
Spatial distributions little varied depending on month and year

Methods of tuned VPA

- The age classes are 0 to 4+
- The time span is from 1995 to 2021 fishing year
- Use the Pope's approximation
- Assume $F_{3,y} = F_{4+,y}$
- Natural mortality: M = 0.4 (from Tanaka's equation)
- The maturity rate is 0 for age 0 and 1 for older
- Estimate terminal F by two steps
    1. Conduct untuned VPA to estimate the selectivity at age in the terminal year under the constraint that the terminal F at age is identical to the average of F from 2017 to 2020
    2. Estimate the terminal F with the two abundance indices (for recruitment and SSB) under the constraint that the selectivity in the terminal year is identical to that obtained from the step 1

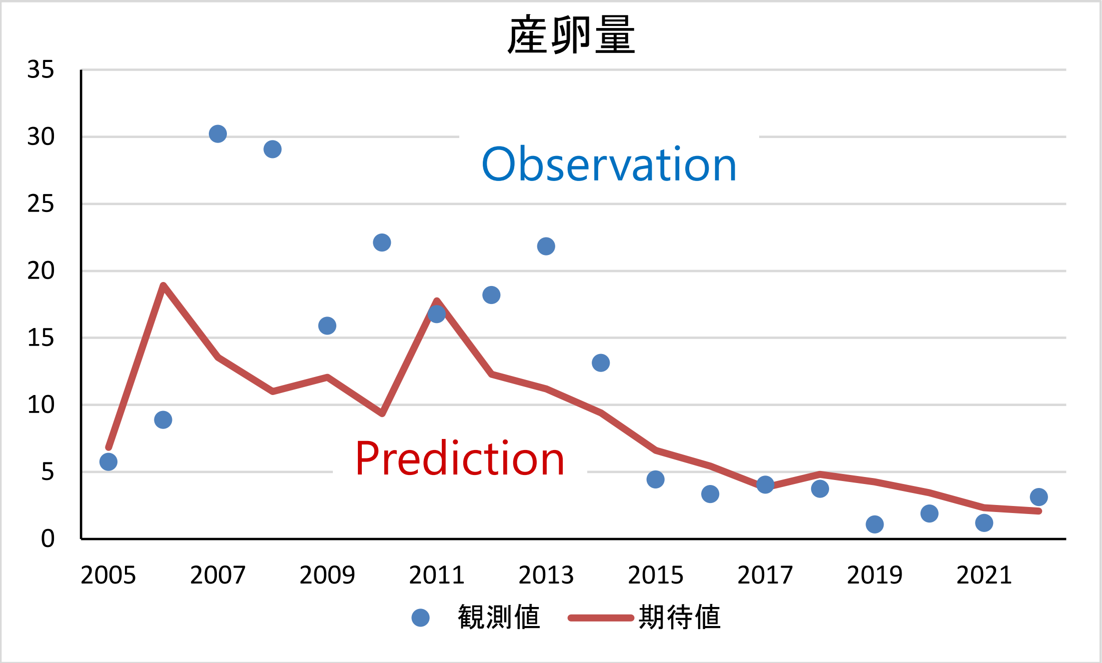
Residual plot as a model diagnostic

Dipnet fishery index for age 0



Negative → Positive

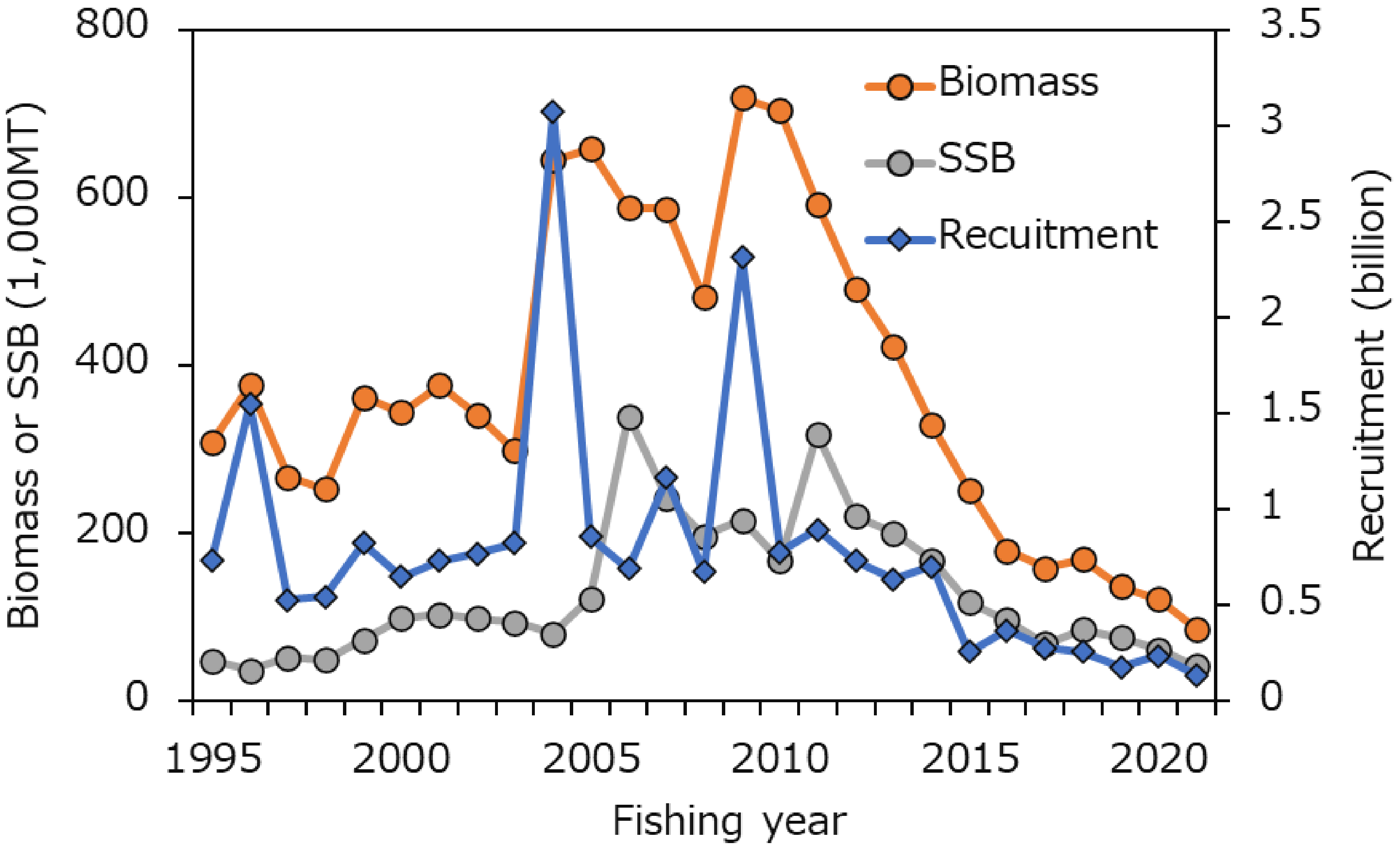
Standardized egg abundance for SSB



Positive → Negative

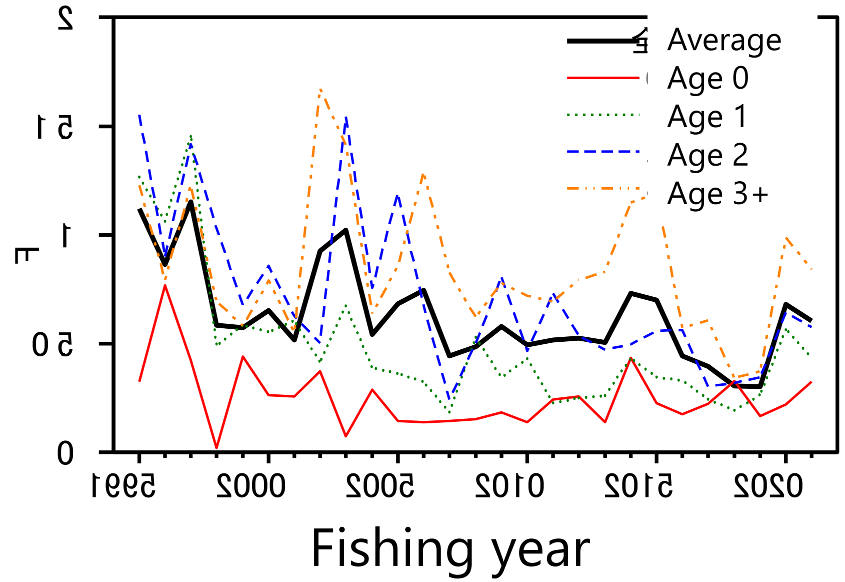
Temporal patterns of residuals were found

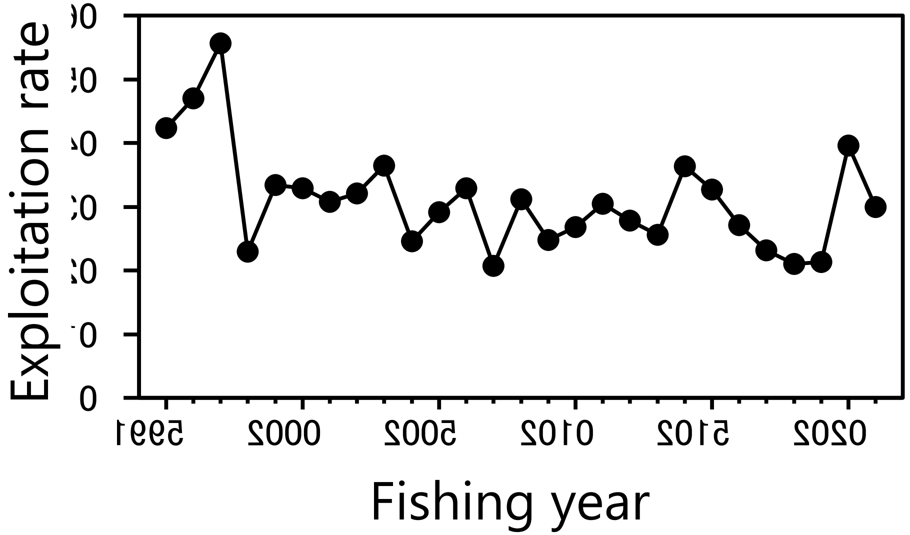
Total Biomass, SSB, and Recruitment

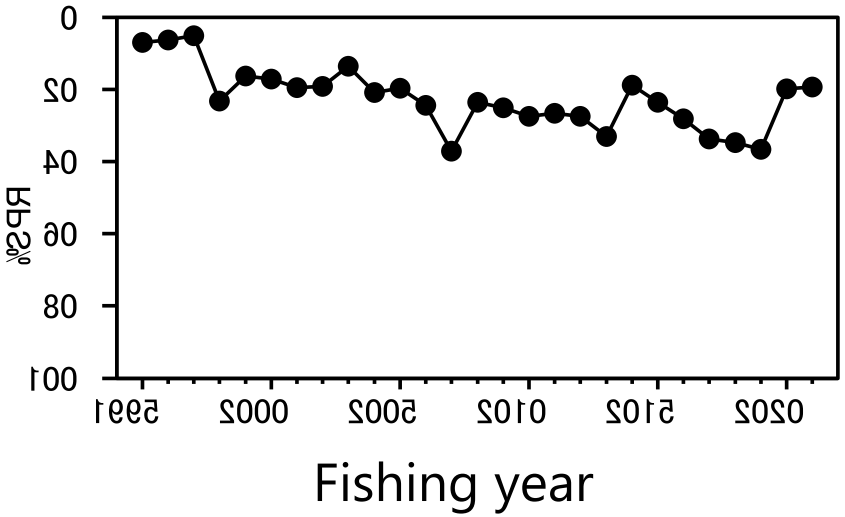


- The total biomass was kept at high levels (600~700 thousand ton) from 2004 to 2011 because of continuous relative high recruitment
- The total biomass, SSB, and recruitment showed a decreasing trends since 2011
- Biomass in 2021: 87 thousand ton, SSB in 2021: 42 thousand ton

F at Age, Exploitation rate, and %SPR

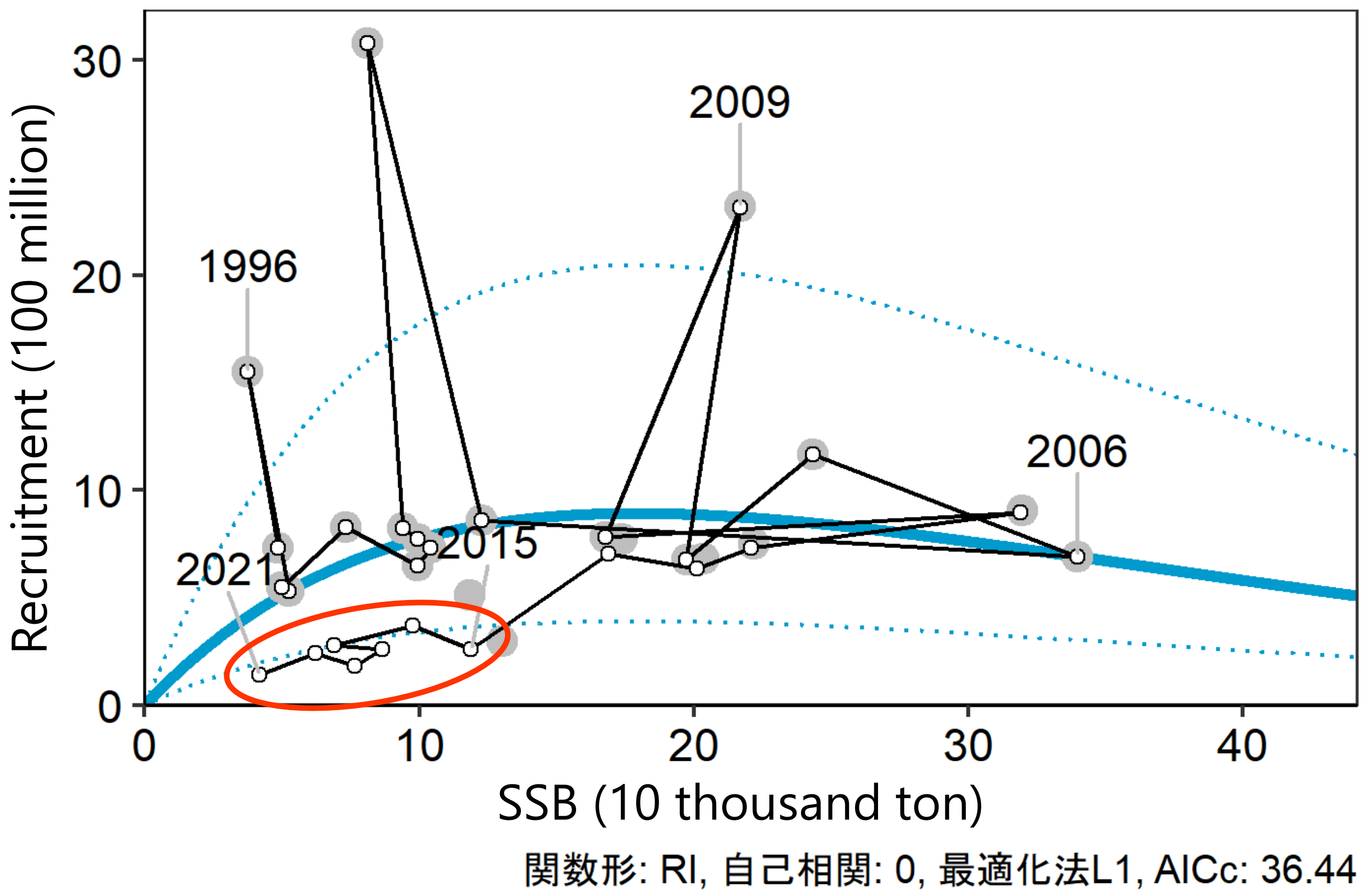






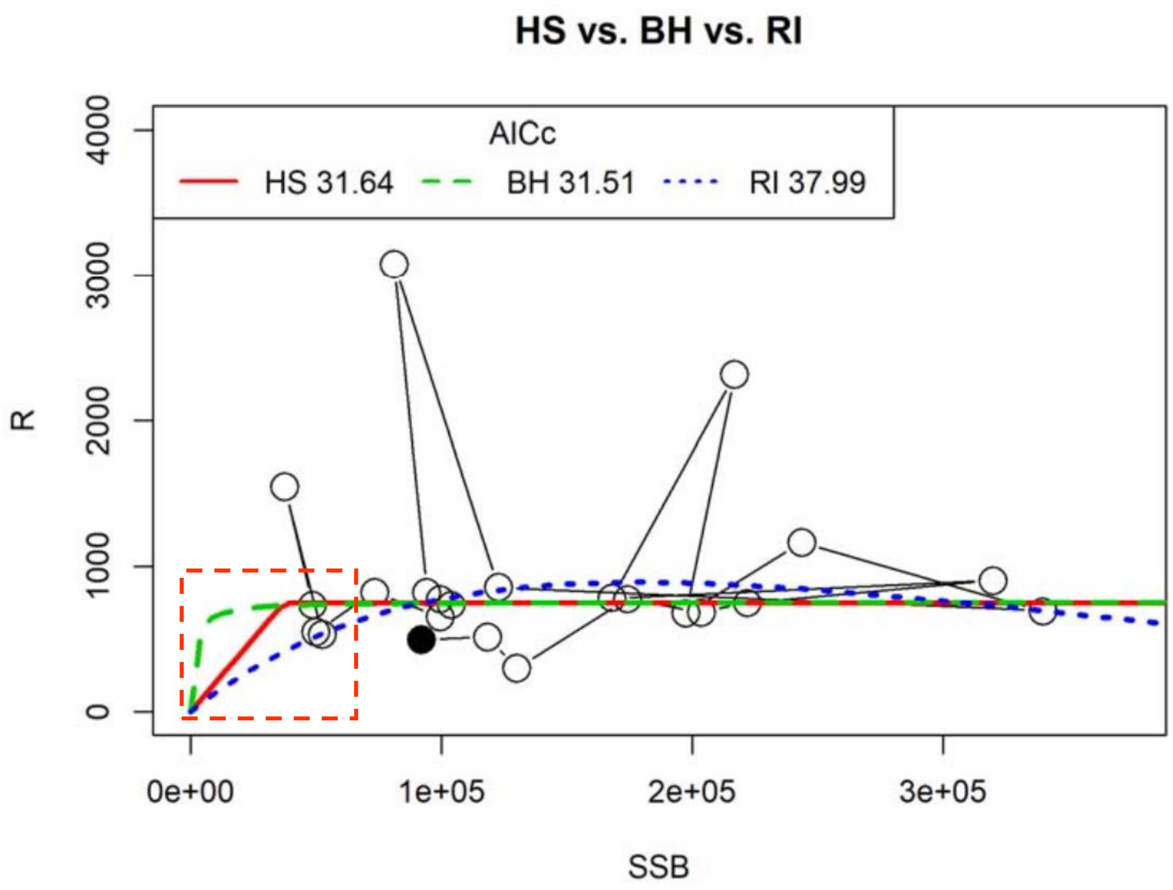
The fishing pressure had gradually decreased until 2019
It increased in 2020 and 2021

Stock-Recruitment relationship



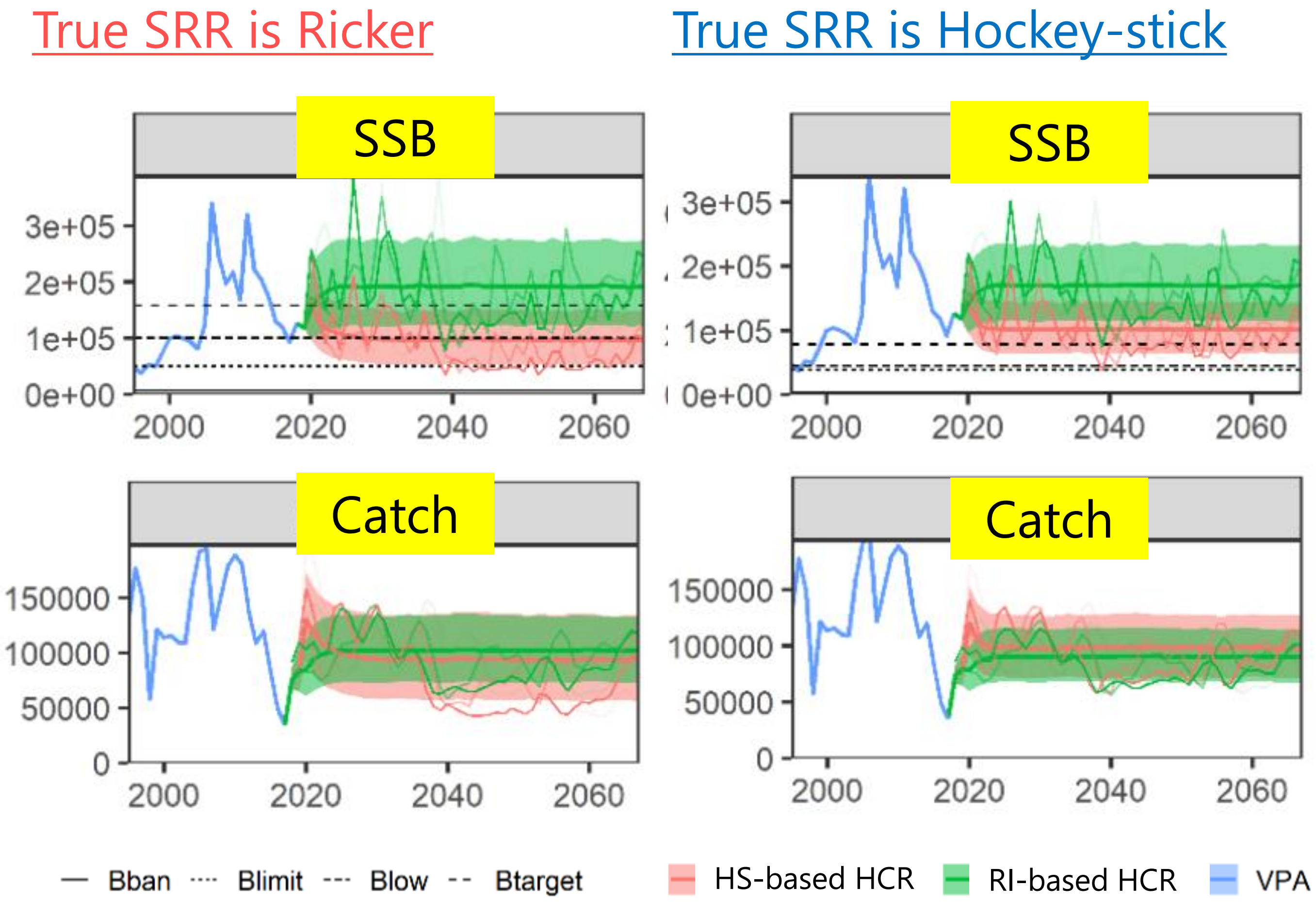
- Ricker SR relationship
- This was estimated at the benchmark stock assessment in 2019
- Recruitment has been greatly lower than the prediction from the SR relationship since 2015
- Its reason is unknown…

Why using the Ricker?



- AICc was lower for Beverton-Holt (BH) and Hockey-stick (HS) than Ricker (RI)
- Slopes in low SSB levels were different among function types
- The slope of BH was too steep and unrealistic (steepness is almost 1)
- The management performance between HS and RI was compared by a simple MSE

Why using the Ricker?



Ricker was selected with respect to the risk analysis

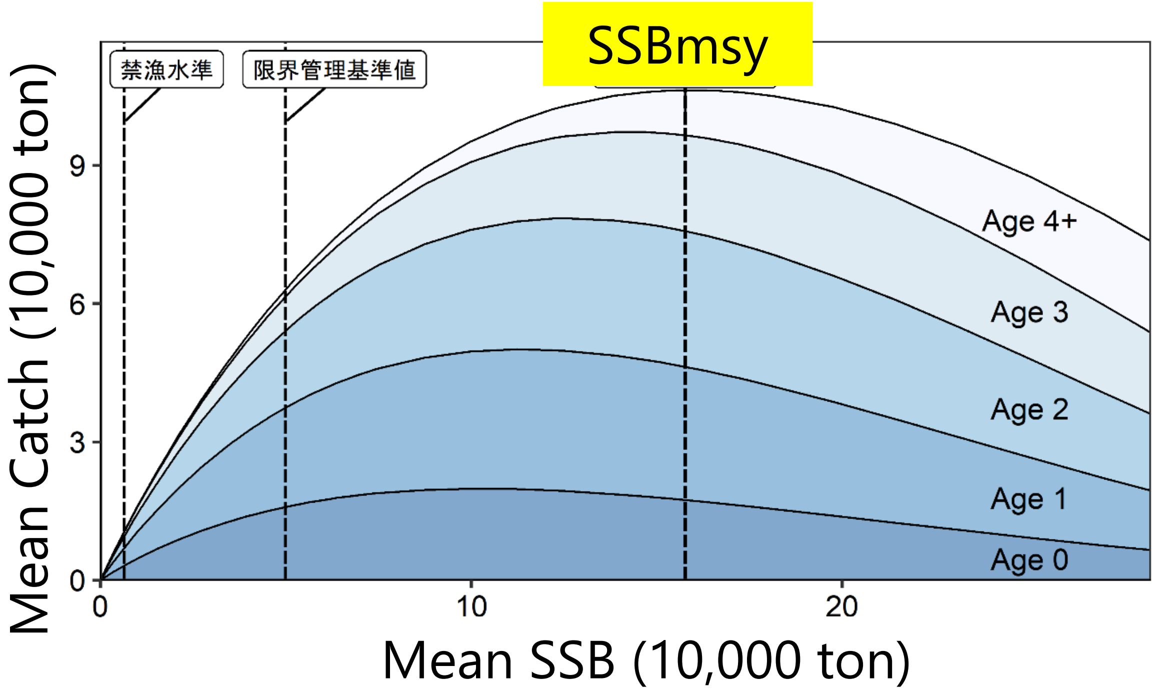
When the true SR was assumed to be Ricker…

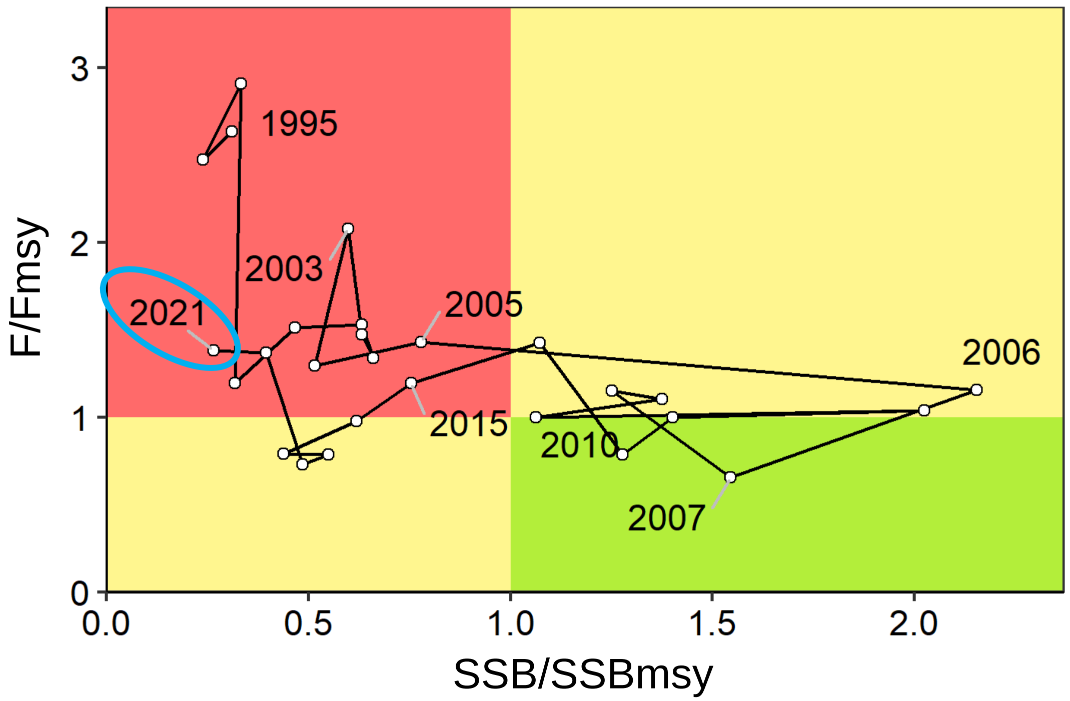
- Applying a HS-based HCR had higher risk of SSB reduction than applying a RI-based HCR (e.g., SSB < its historical minimum)
- The mean catch from the HS-based HCR was slightly lower than that from the RI-based HCR

When the true SR was assumed to be HS…

- Applying the RI-based HCR could keep SSB at a higher level than applying the HS-based HCR
- The mean catch from the RI-based HCR was not much lower than that from the HS-based HCR

Yield Curve and Kobe Plot

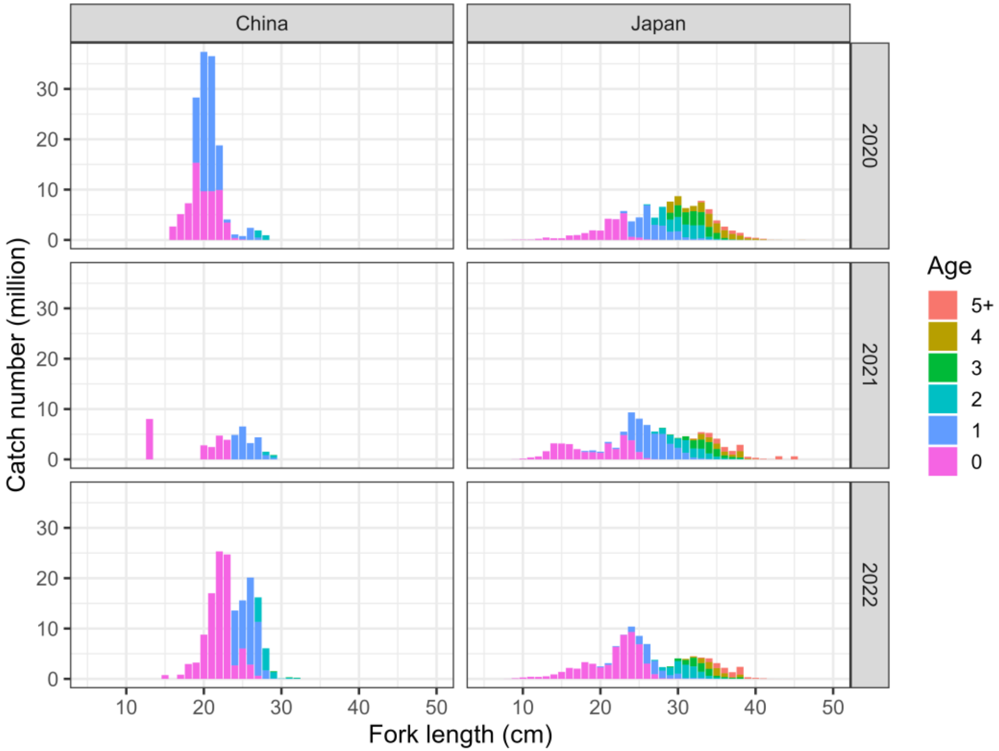




- MSY reference points were estimated by a stochastic simulation with a random recruitment variability from the normal-regime SR relationship (see Ichinokawa et al. 2017, ICES JMS, for details)
- The current status (FY2020-2021) is in the red zone (overfishing and overfished)

Summary

- Japan conducts the BM stock assessment by the tuned VPA
- The MSY-based reference points were estimated from the stochastic simulation from the Ricker SR relationship
- Biomass and SSB has been decreasing since 2011 and recruitment has been greatly lower than the expectation from the SR relationship
- The current status is overfishing (F > Fmsy) and overfished (SSB < SSBmsy)



Future Issues

- It is necessary to reflect actual age composition in the outside of Japanese EEZ
- Should conduct the development and standardization of abundance indices