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Agenda Item 6.3
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6.3 Domestic Stock Assessment of Japanese Sardine in Japan in 2023 FY (January-December)

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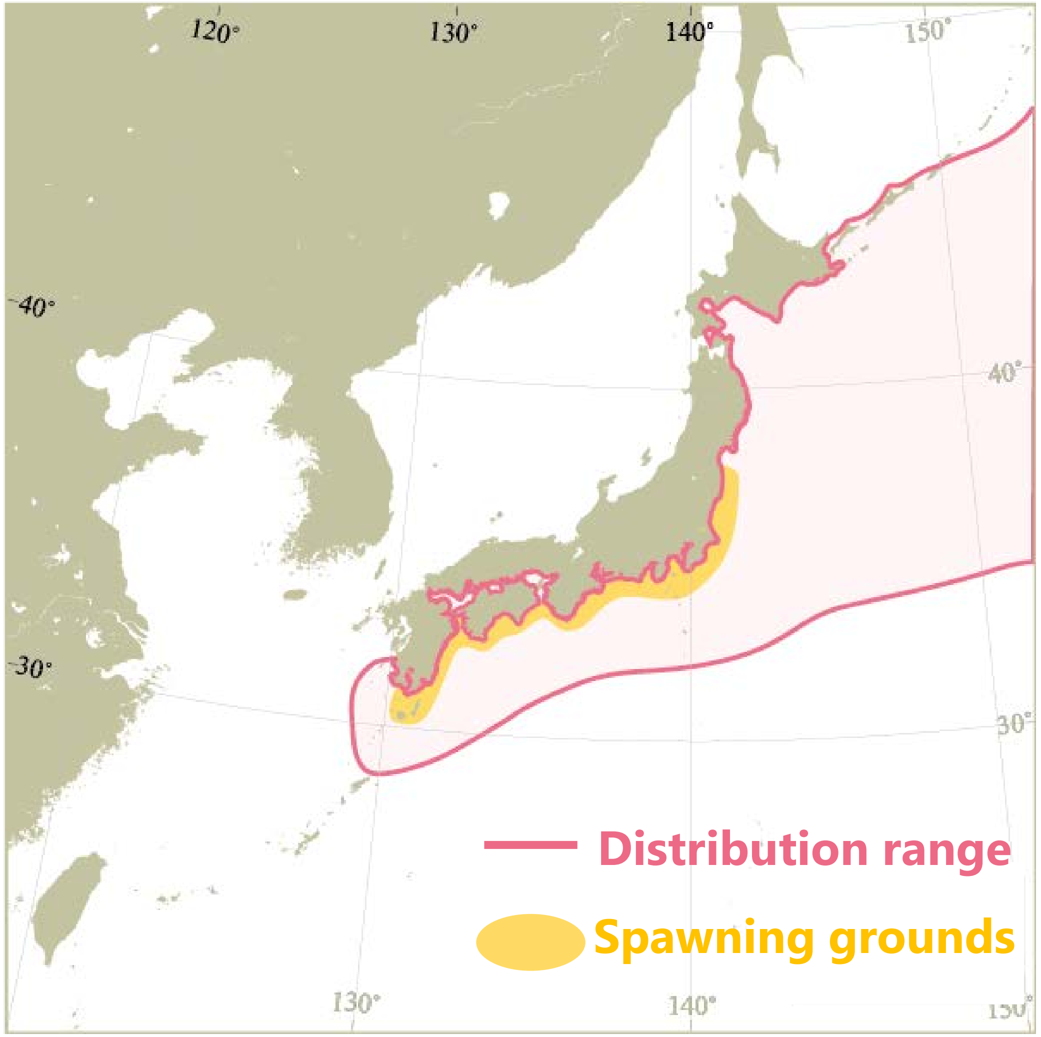
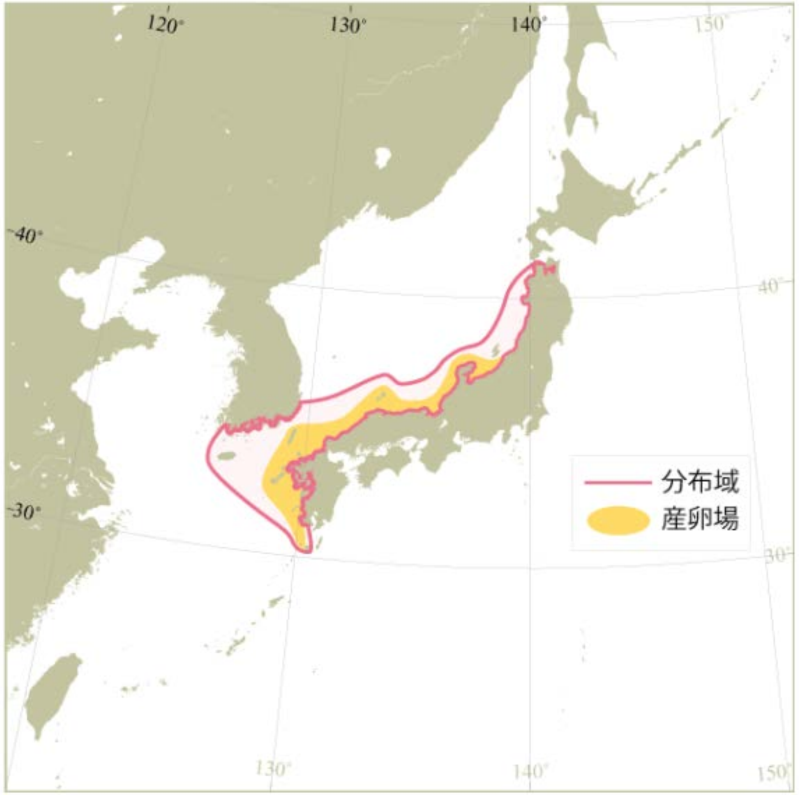
Spatial Structure of JS Stocks

Pacific stock



Tsushima Warm Current stock

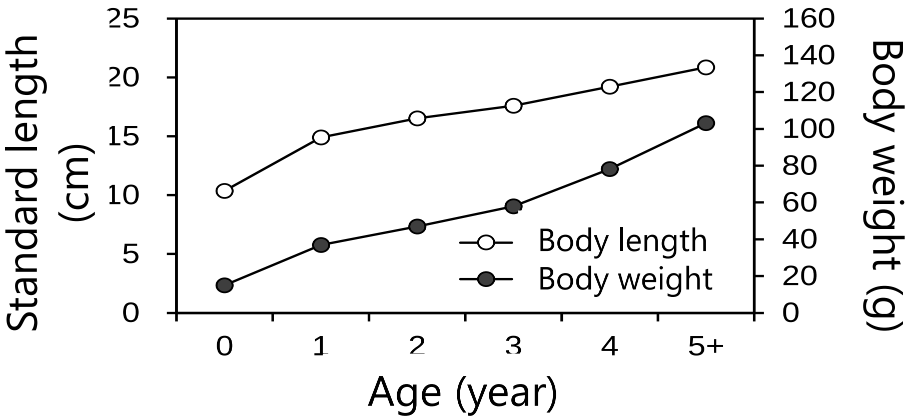


- There are two stocks depending on distributions and biology
- Only the Pacific stock is distributed in the NPFC Convention Area

Biological information for Japanese sardine

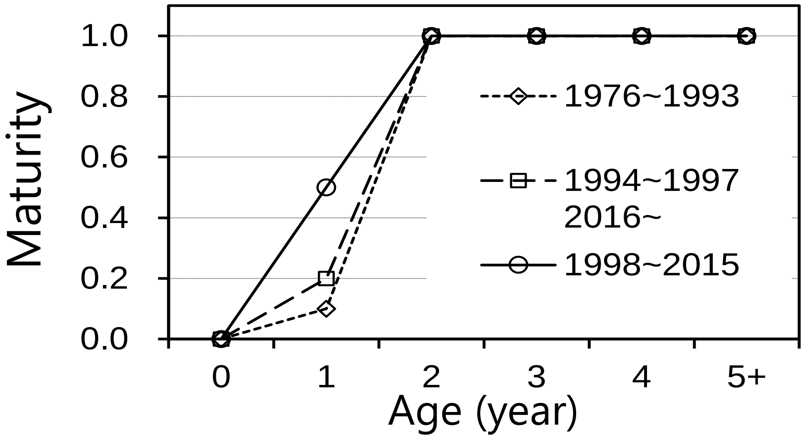
Scientific name: *Sardinops melanostictus*

Body length and weight by age



- The Longevity is about 7 years old
- The maximum body length is 22-24 cm
- The maximum body weight is 110 g

Maturity by age

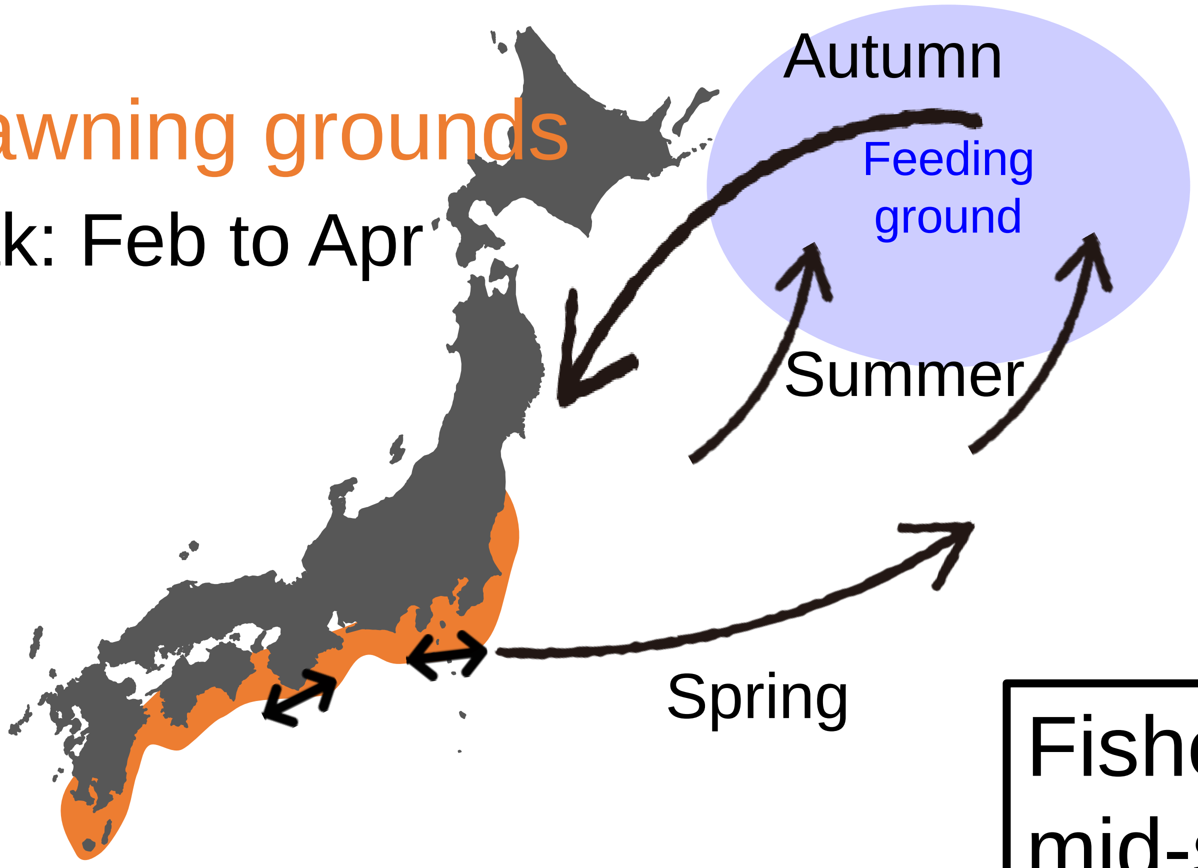


- Begin to mature from age 1
- The maturity rate at age 1 depends on the stock abundance
- Almost all fish at age 2 mature

Distribution and migration

Spawning grounds

Peak: Feb to Apr



2 migration patterns;

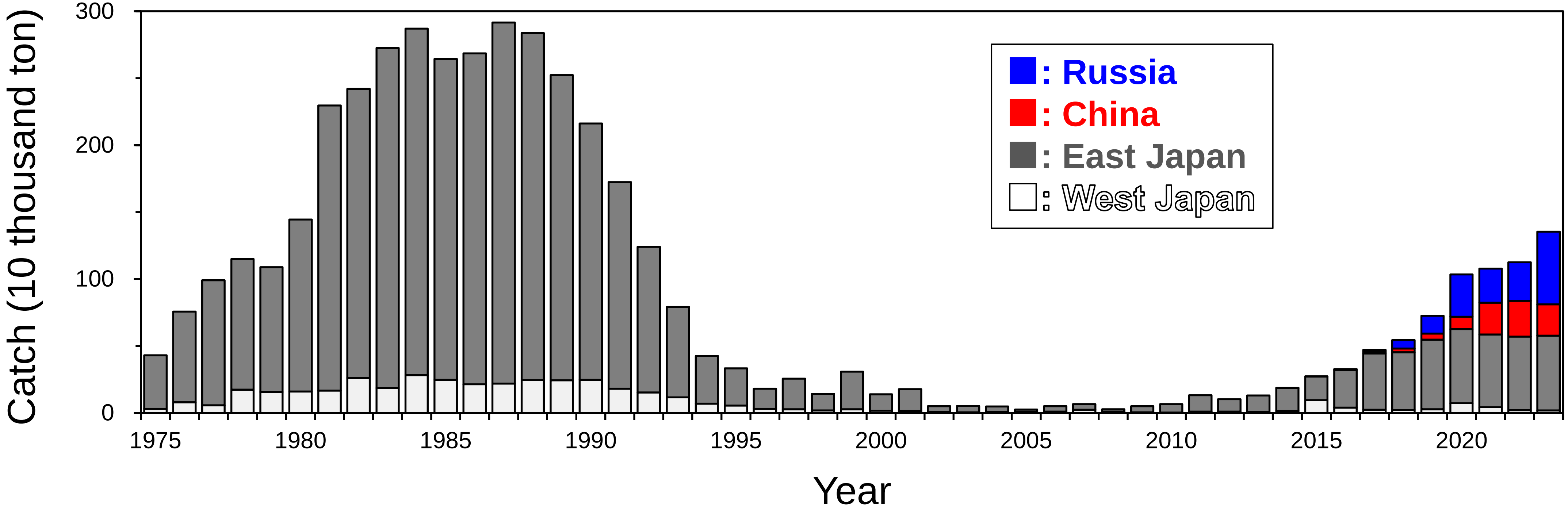
- **Offshore group**:
  The biomass fluctuates greatly
- **Coastal group**:
  The biomass is table over years

Fished by large-scale purse seine, mid-scale purse seine, set net, and other fisheries on many coastal areas

Catch statistics

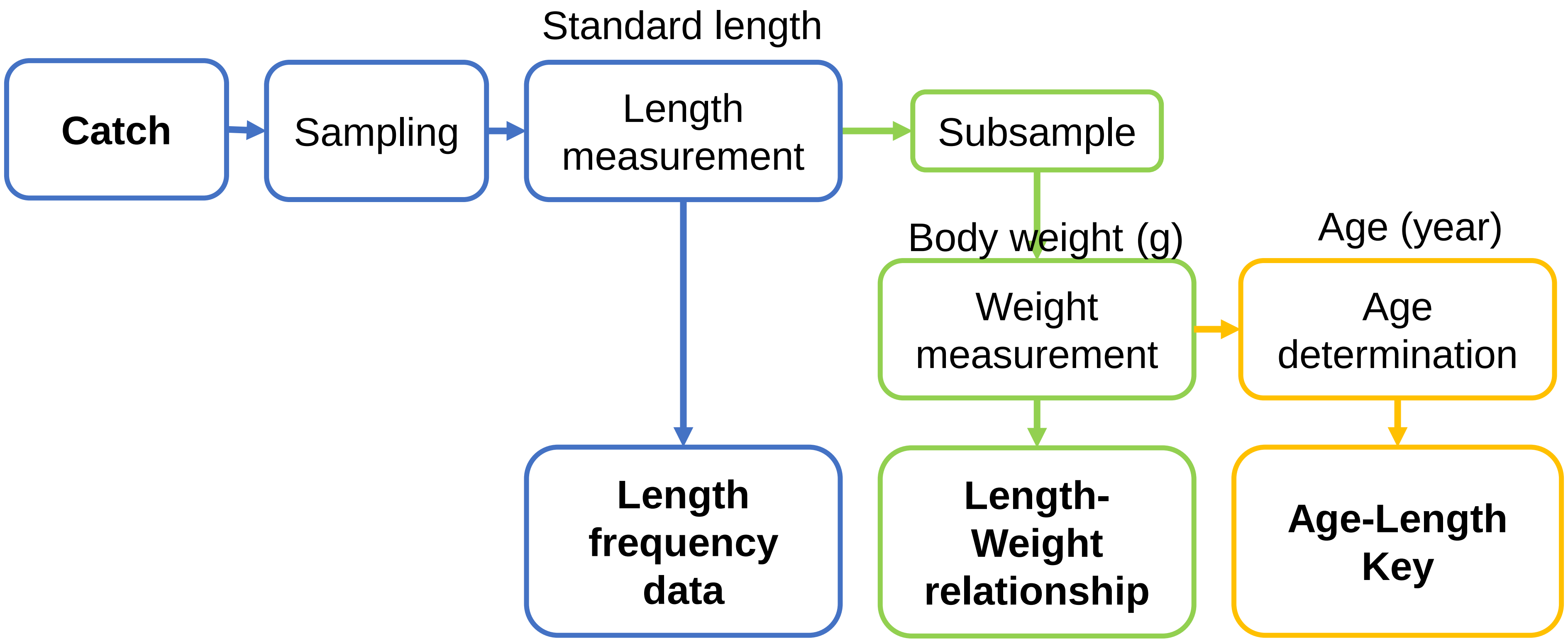
- Catch weights by Japan were taken from the national official statistic
- Data in Japan were originally collected from 18 coastal prefectures by month by gear
- Catch weights by China and Russia were taken from the NPFC statistics

Increase in East Japan catch
Increase in foreign catch since 2020



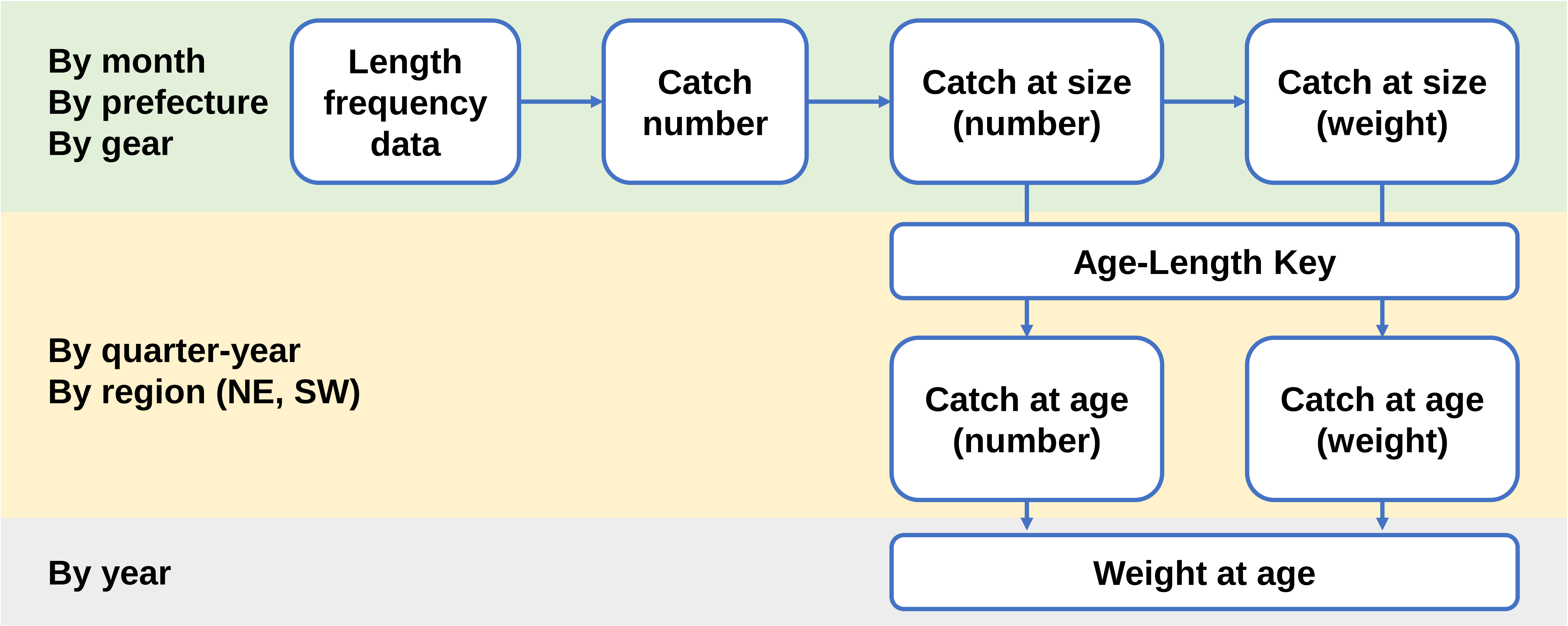
Length, Weight and Age Data

- Measurement data are collected from all 18 prefectures
- Data are treated by month and by fishing gear
- Age is estimated by otolith or scale reading



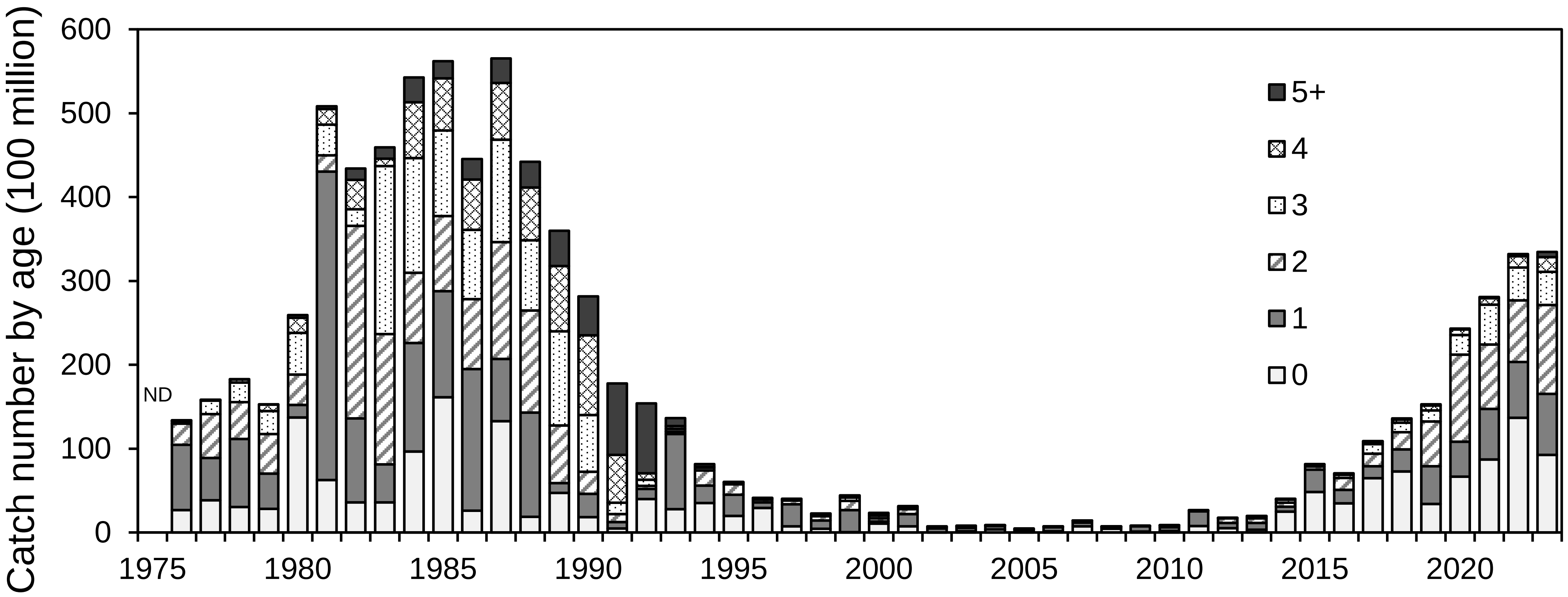
Catch at Age and Weight at Age in Japan

- Catch at size is derived from length frequency and L-W relationship
- ALK is applied to derive catch at age
- Weight at age is estimated from catch at age (weight)/catch at age (num)



Age composition for
China: Japanese ALK was applied for Catch at Length submitted by Chinese colleague
Russia: Assumed to be identical to that of the purse seine fishery in north of Miyagi pref. from Jul. to Dec.

Catch at Age



- Wide age classes were caught recently
- The catch of 0 age fish is increasing since 2020

Abundance indices for JS stock assessment

Three time series of abundance indices are used
for JS stock assessment (ridge VPA);

- **Egg abundance of East Japan**: spawning stock biomass
- **Autumn (Sep-Oct) survey**: age 0 (recruitment)
- **Summer (Jun-Jul) survey**: age 0 (recruitment) and 1 fish

Introduced from this year

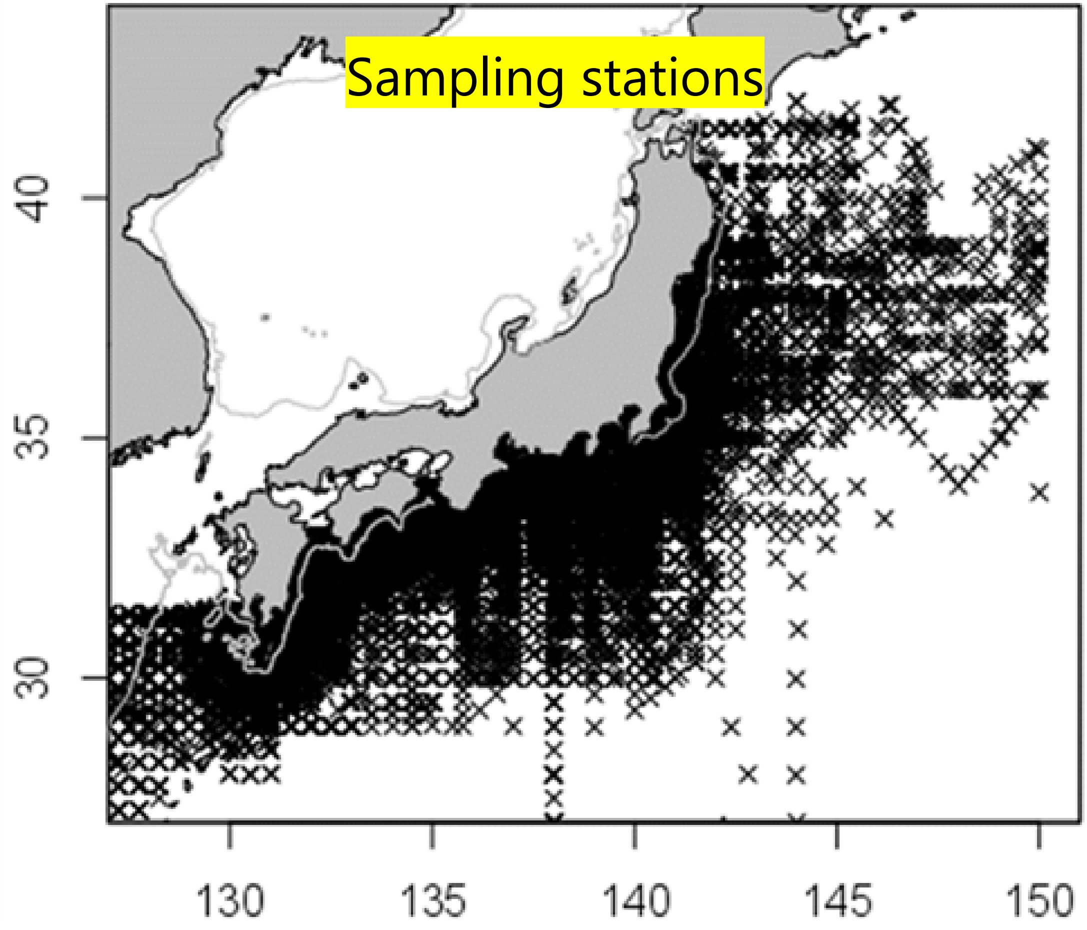
***abundance indices by last year;**

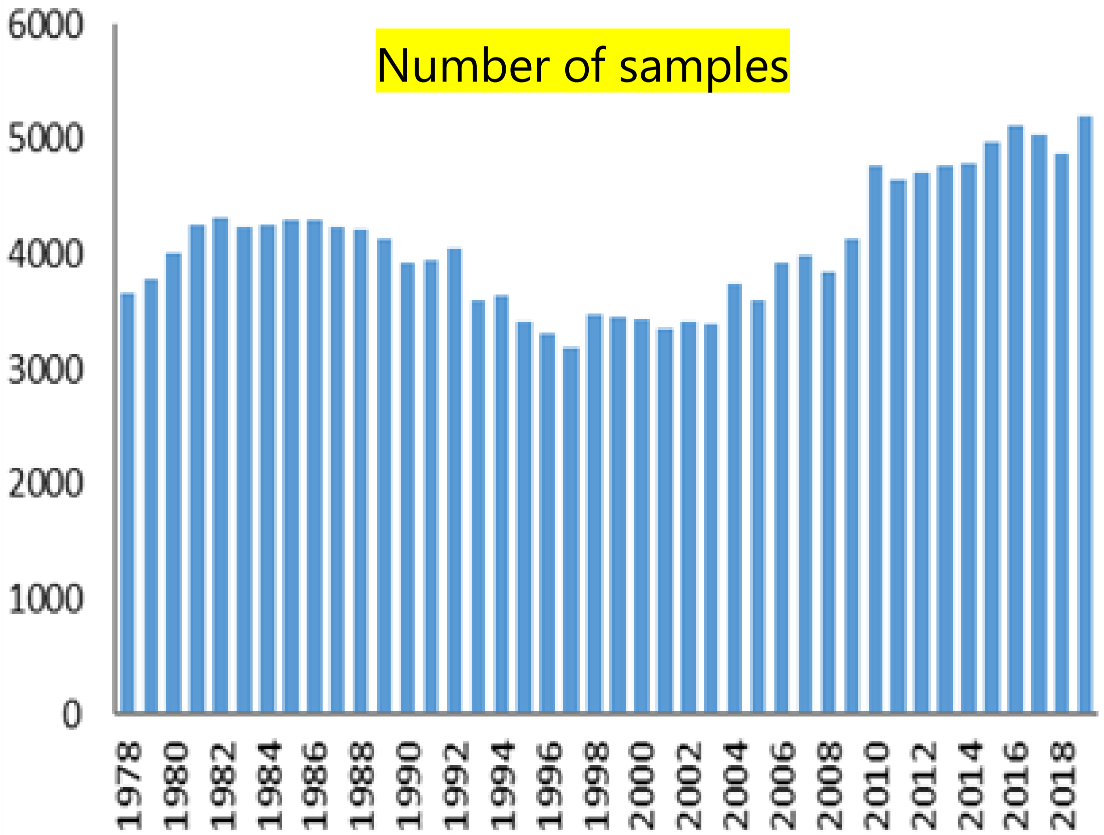
- **Egg abundance of East Japan**
- **Autumn (Sep-Oct) survey (age 0)**
- Winter fishery-dependent index (Dec.-Apr. Large-scale purse seine)

All abundance indices applied this year were obtained from **fishery-independent surveys**

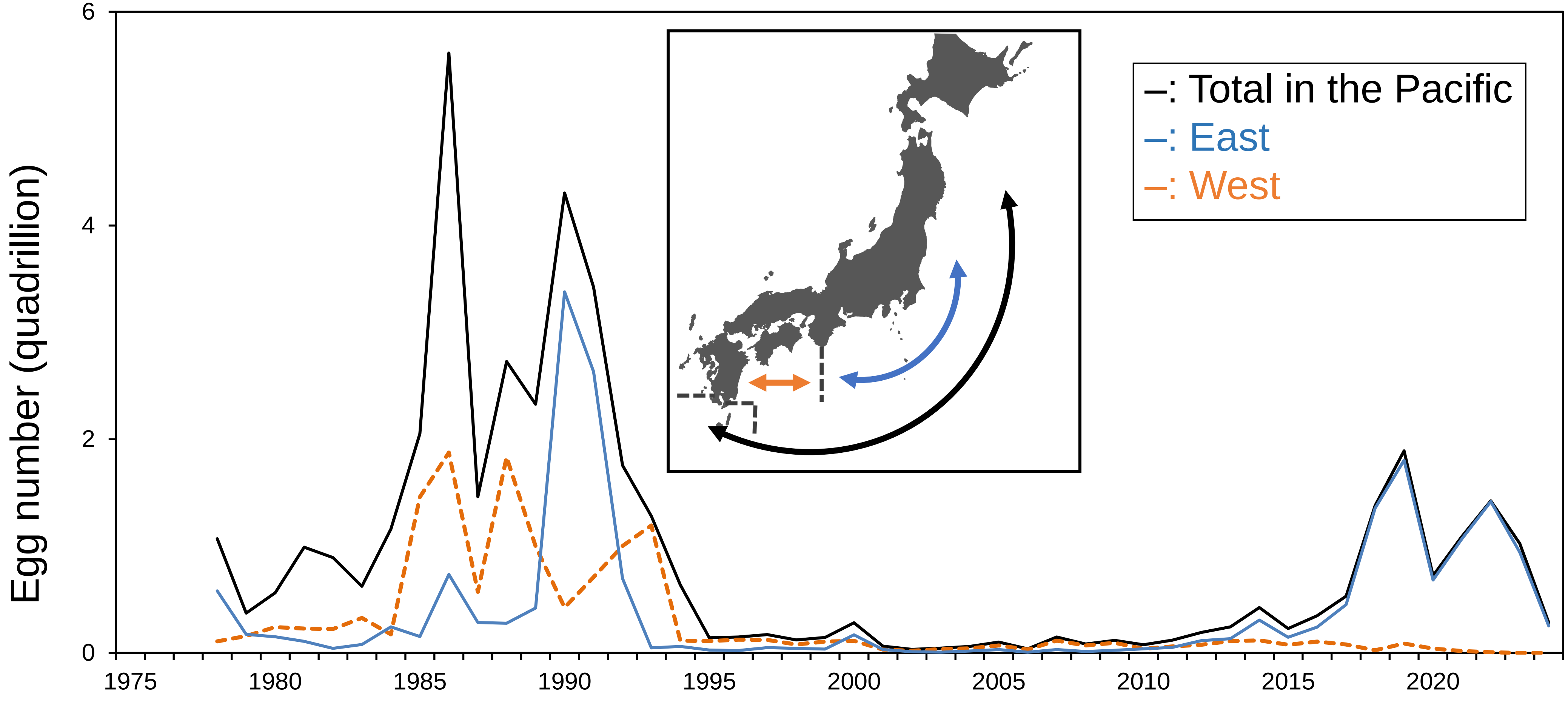
Egg abundance of East Japan (survey)

- The Egg and Larval survey is conducted by 19 prefectural fisheries institutes and FRA in every month along the Pacific coast of Japan using NORPAC net
- Number of samples per year is approximately 5,000 (depends on the oceanographic condition)





Egg abundance of East Japan



Almost all of eggs were observed in East Japan
→ Egg abundance of East Japan was adopted as the index

Autumn (September-October) survey

Based on the result of the autumn survey in September to October, total density of age 0 fish was estimated by acoustic survey and sea surface temperature (SST)

Sampling method

- Approximately 40 sampling stations
- Sampling range
  - Latitude: 37.0 °E–50.0 °E
  - Longitude: 141.5 °E–179.0 °W
- Net mouth: 30 m × 30 m
- Sampling depth : less than 40 m
- Sampling duration: 15–60minutes

Density estimation method

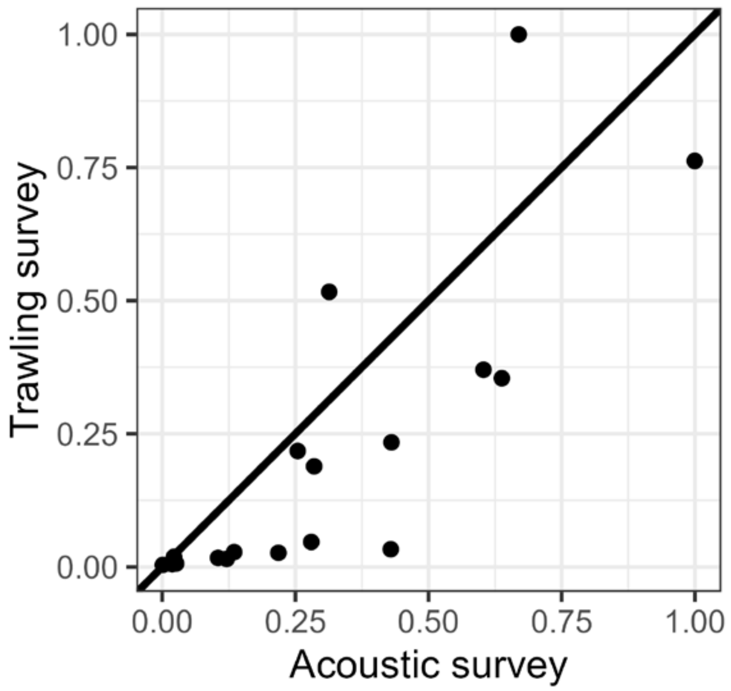
(Estimated area in the Northwest Pacific with SST of 10–15 °C)

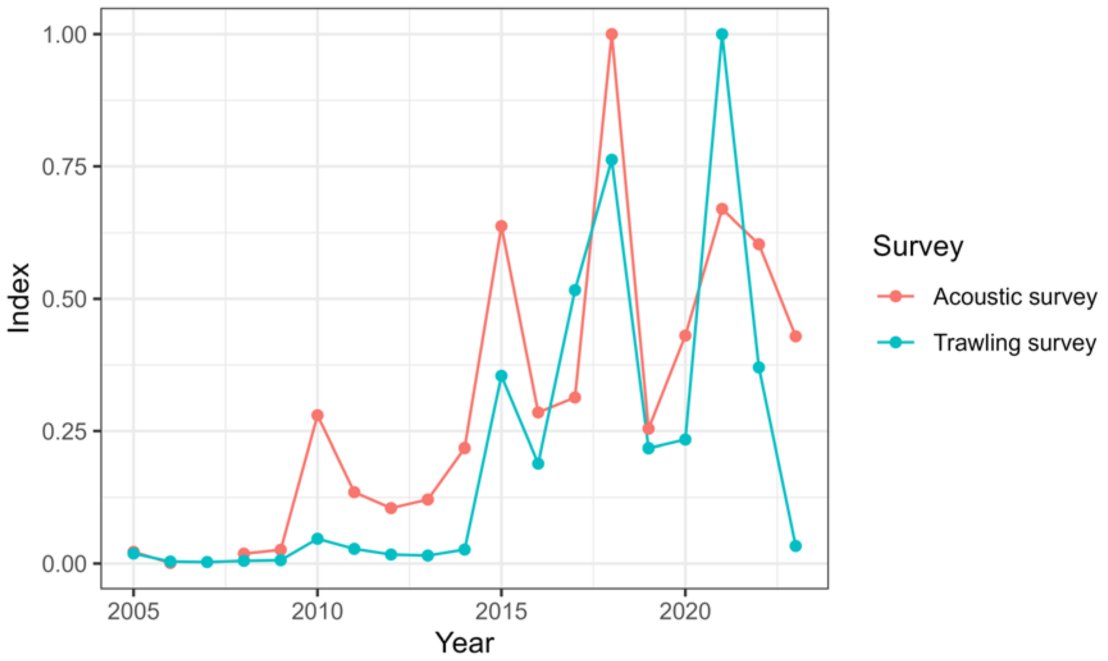
×

(Mean density estimated by acoustic and trawling survey)

Comparison between acoustic surveys and trawling survey

Standardized acoustic survey vs Standardized trawling survey





Both indices show a similar trend

Acoustic survey tends to produce overestimated results

→Necessary to carefully evaluate which index to use

Summer (June-July) survey

Based on the result of the summer survey in June to July, standardized CPUE was adopted as the indices for age 0 and 1 fish

Sampling method

- Approximately 150 sampling stations
- Sampling range
  Latitude: 32.0 °E–48.5 °E
  Longitude: 141.0 °E–165.0 °W
- Net mouth: 30 m × 30 m
- Sampling depth : less than 40 m
- Sampling duration: 15–60minutes

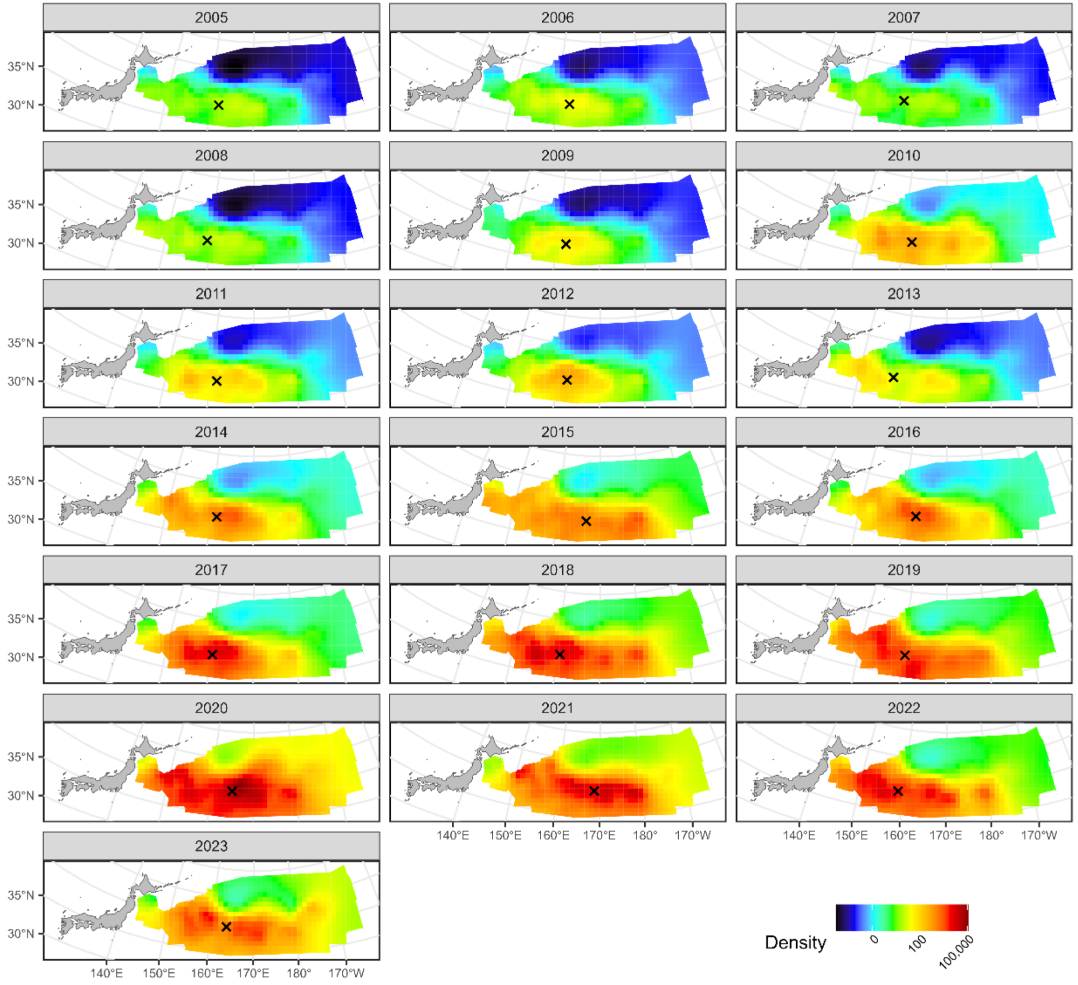
CPUE standardization method

To eliminate sampling bias, we used **vector autoregressive spatio-temporal (VAST) model** (Thorson, 2018)

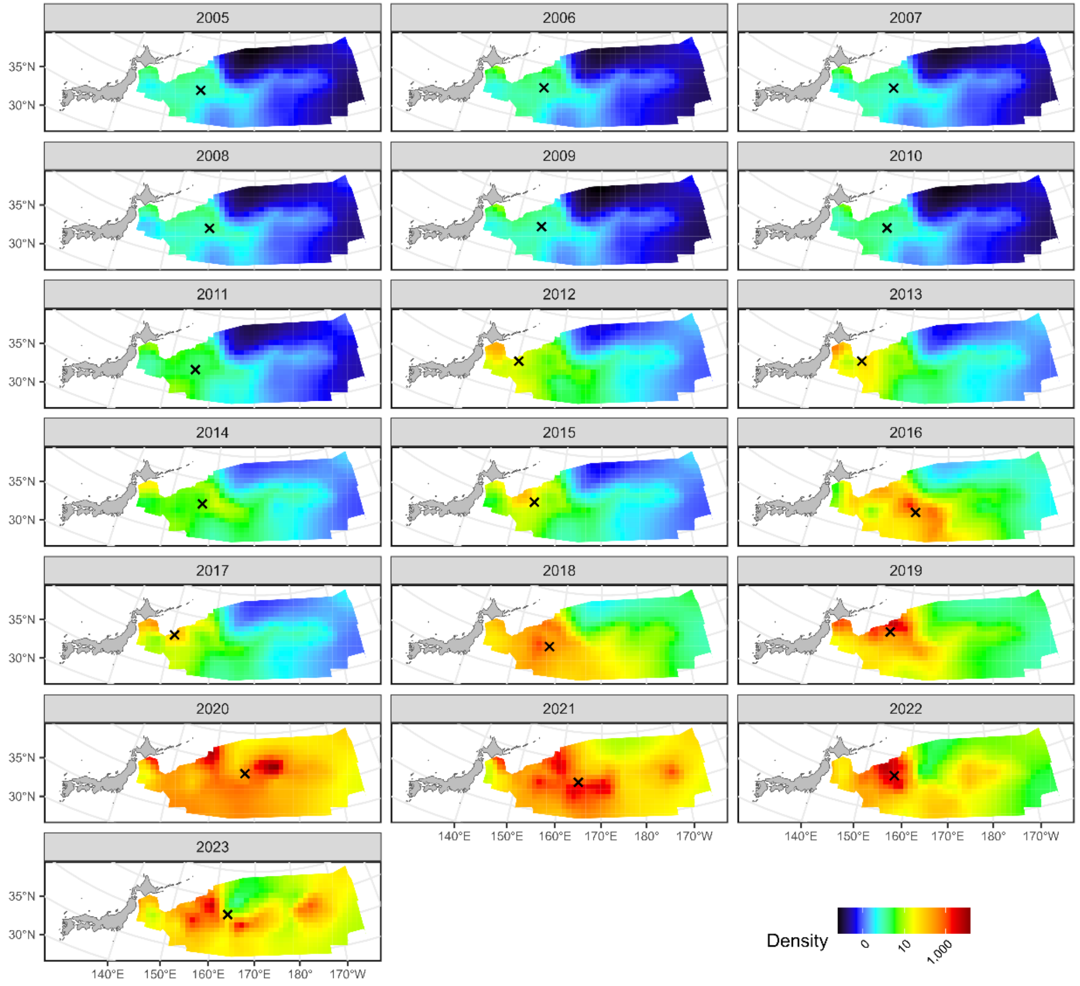
- Probability distribution: binominal × Gamma
- Knot number: 100
- Assumed effects
  Temporal effect: random effect
  Spatial effect: random effect
  Spatio-temporal effect: random effect
- Anisotropy: not adopted
- Covariations: not adopted

Summer (June-July) survey

Age 0 fish (recruitment)

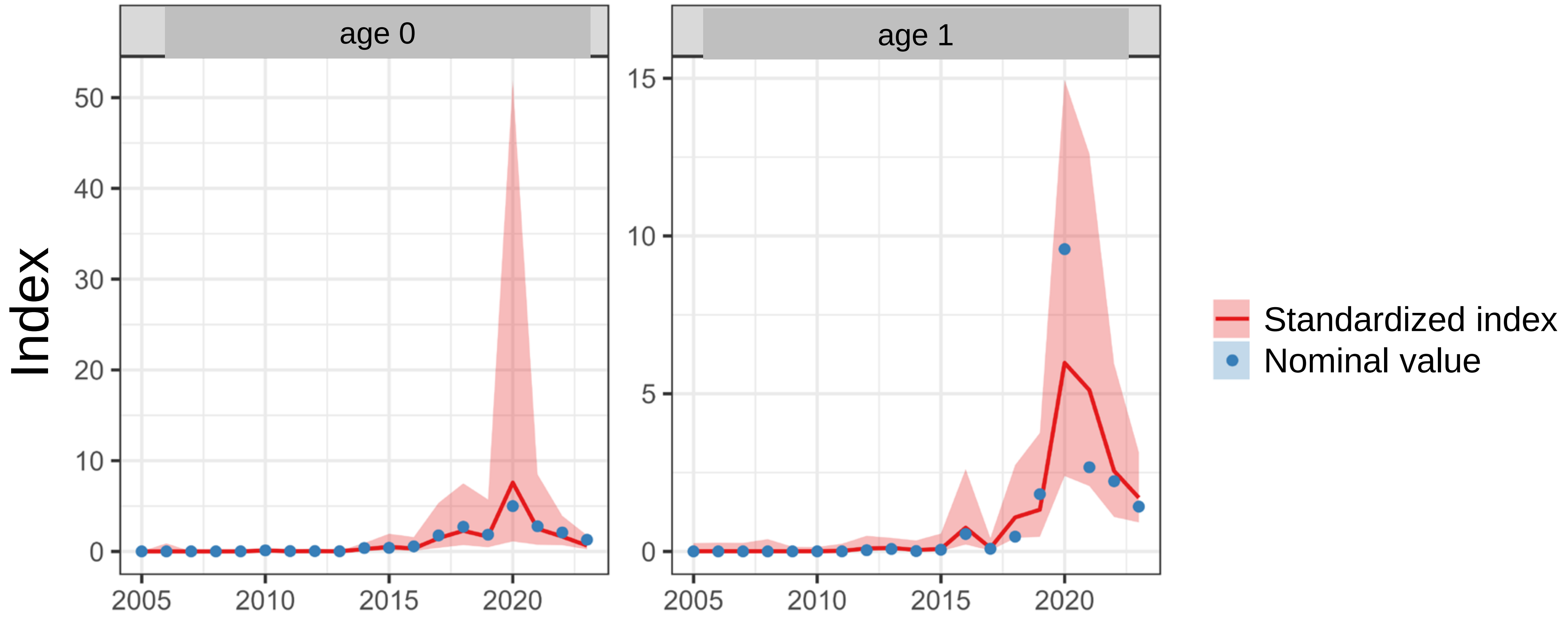


Age 1 fish



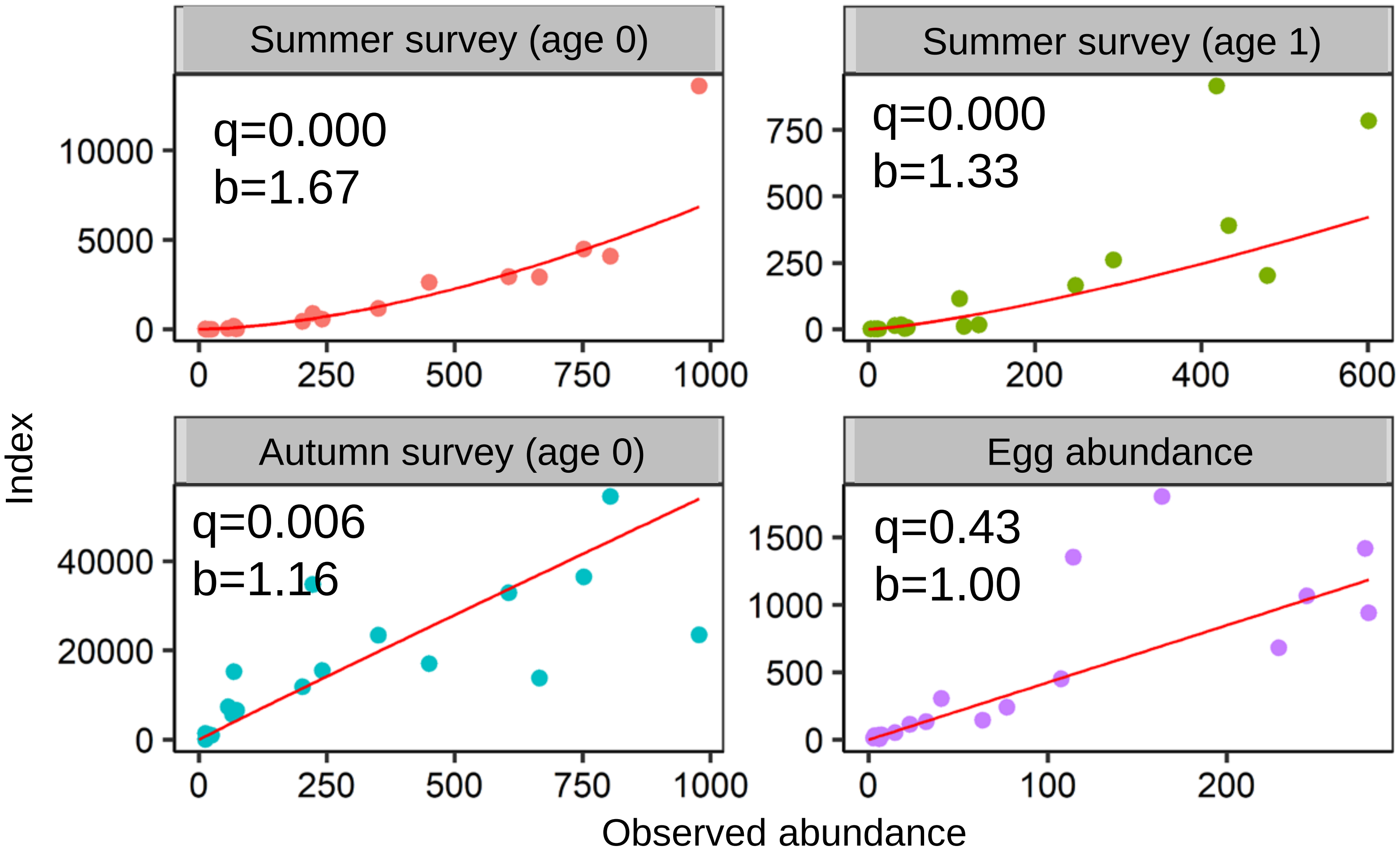
The abundance is increasing in recent years

Summer (June-July) survey



The standardized indices reflect the biomass trend (nominal value) broadly

Relationships between index and abundance



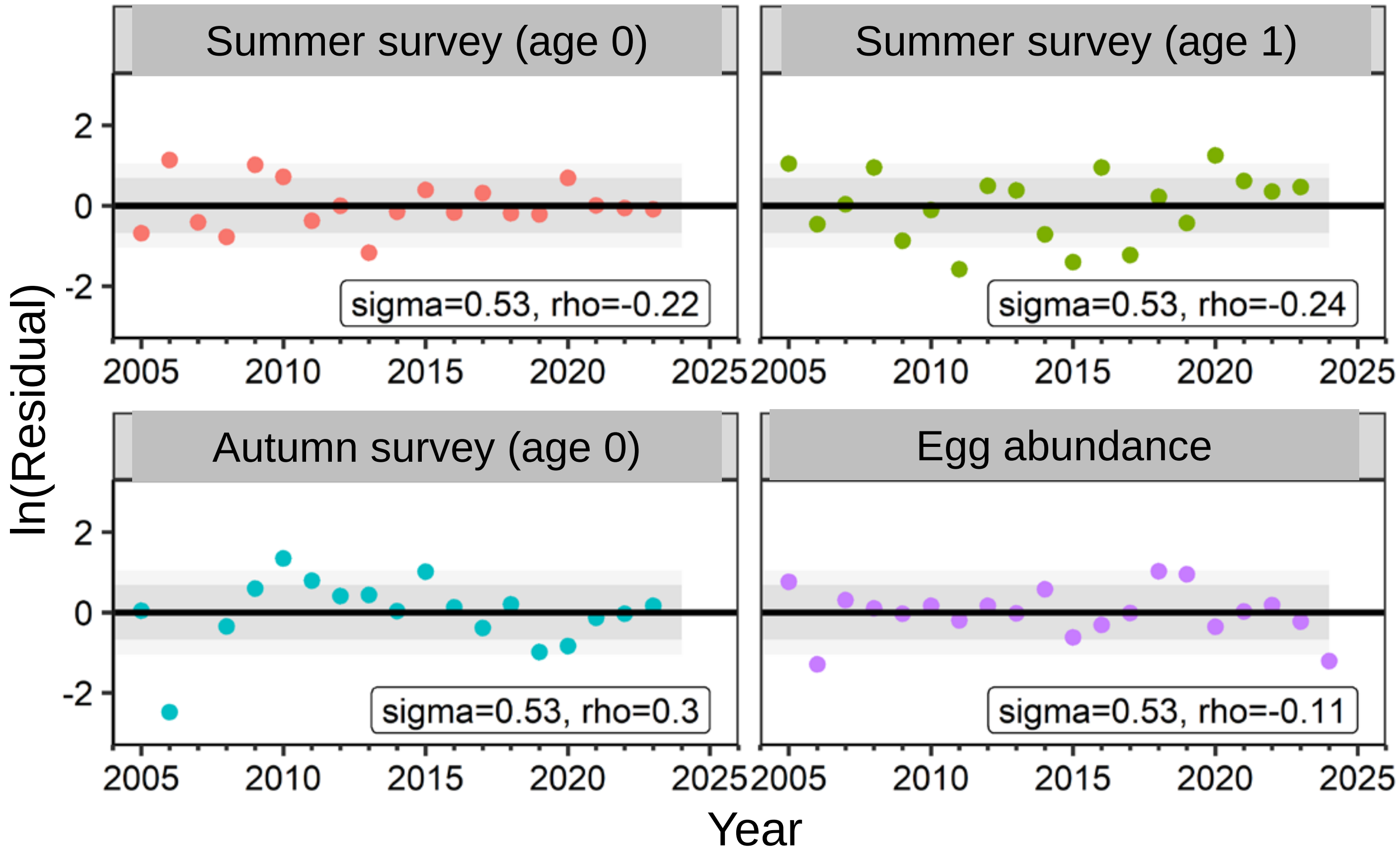
$$q_k = \exp\left\{\frac{1}{n_k}\sum_y \ln\left(\frac{I_{k,y}}{X_y^{b_k}}\right)\right\}$$

$$b_k = \frac{Cov[\ln(\boldsymbol{I_k}), \ln(\boldsymbol{X_k})]}{V[\ln(\boldsymbol{X_k})]}$$

I: index, *X*: Observed abundance,
Cov: covariance, *V*: variance

Neither significant autocorrelation nor deviation were observed

Residual plot



: 80% confidence intervals

: 95% confidence intervals

sigma: standard deviance of indices

rho: autocorrelation coefficient

Neither significant autocorrelation nor deviation from normal distribution for all the indices

Stock assessment model

Stock assessment model: **tuned VPA**

Age classes: 0 ~ 5+

Natural mortality: M = 0.4
from Tanaka's equation: M = 2.5/maximum age (Tanaka 1960)
2.5/7 = 0.357 ≈ 0.4

Use the Pope's approximation

Assume $F_{4,y} = F_{5+,y}$

Estimate nonlinear coefficients for the recruitment and age 1 indices

Ridge VPA (Okamura et al. 2017, ICES JMS)

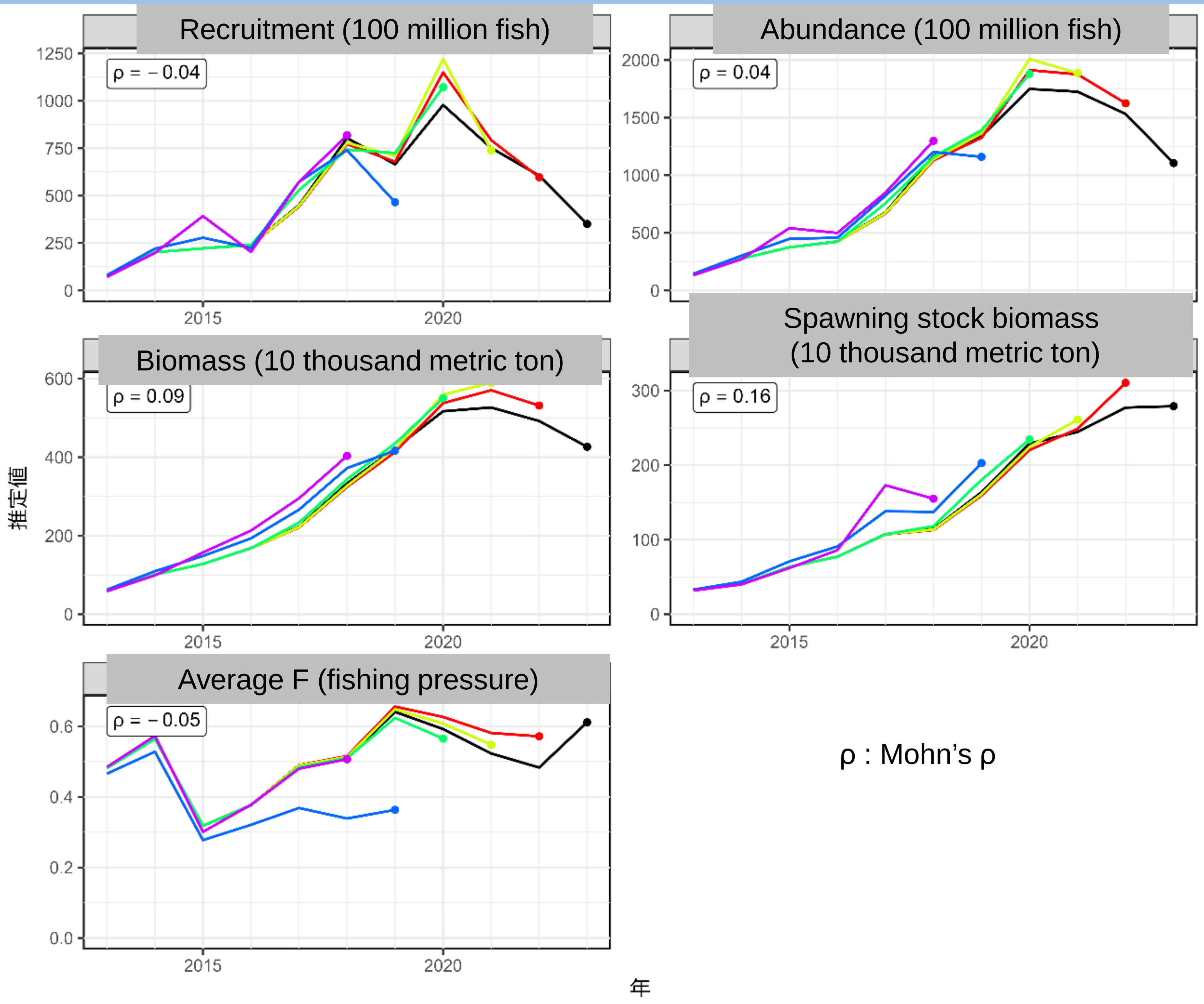
$$(1-\lambda)\sum_{k=1}^{3}\sum_{y}\left[\ln(I_{k,y})-\ln\left(q_k X_{k,y}^{b_k}\right)\right]^2+\lambda\sum_{a=0}^{4}F_{a,2022}^2$$

Select λ so that a retrospective bias is minimized

Pose a penalty for squared F to avoid divergence of F

$I_{k,y}$: Index values
$X_{k,y}$: Corresponding abundance estimate
(SSB, N at age 0, or N at age 1)
q_k: Proportional constant
b_k: Nonlinear coefficient

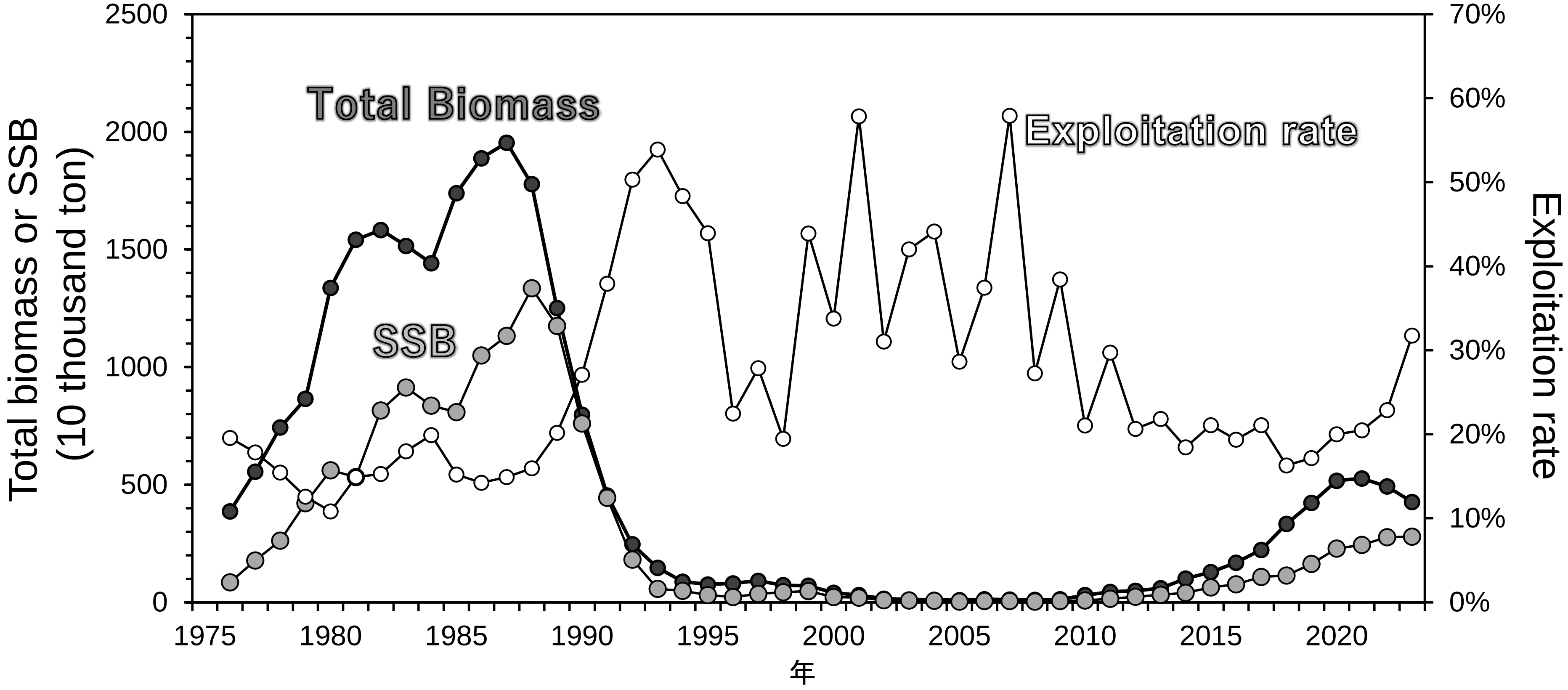
Retrospective analysis as a model diagnostic



ρ : Mohn’s ρ

No severe retrospective biases

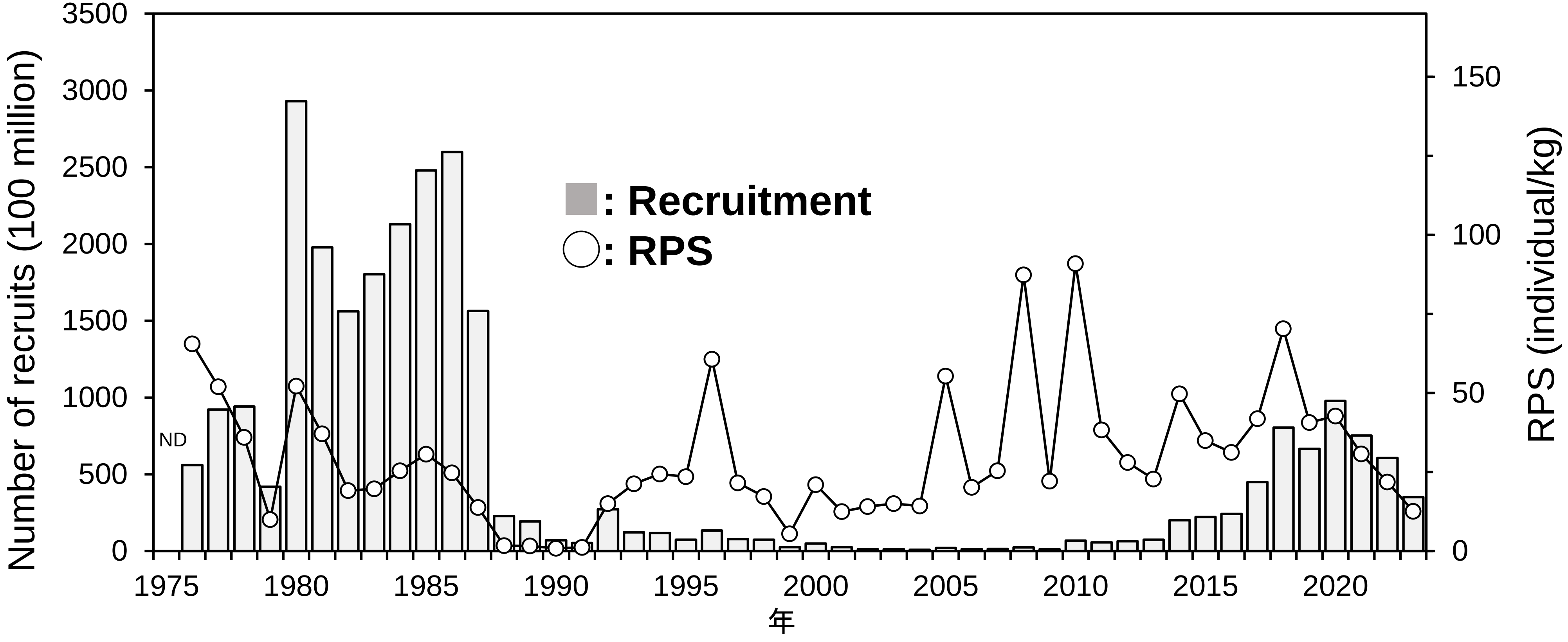
Biomass and Exploitation Rate



Total biomass and SSB increased since 2010s, remained flat since 2020
However, total biomass is declining since 2020
(Biomass in 2023: 4.24 million mt, SSB in 2023: 2.79 million mt)

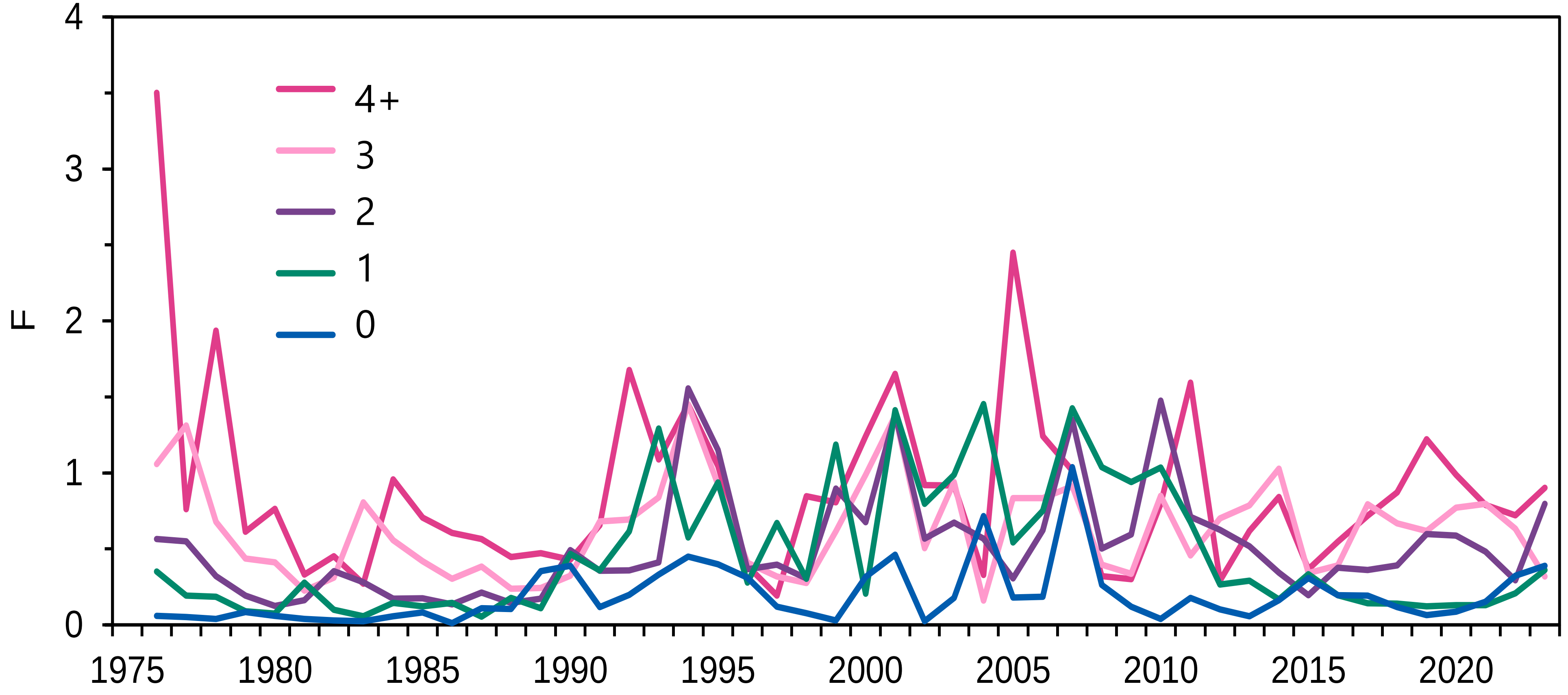
Catch rate declined in the late 2000s and remained low in the 2010s
However, it has increased from 2020 to 2023, especially in 2023

Recruitment and RPS



A high value of RPS increased recruitment in 2010
The increase in SSB and moderate RPS caused high recruitments since 2011
RPS and recruitment is declining since 2020

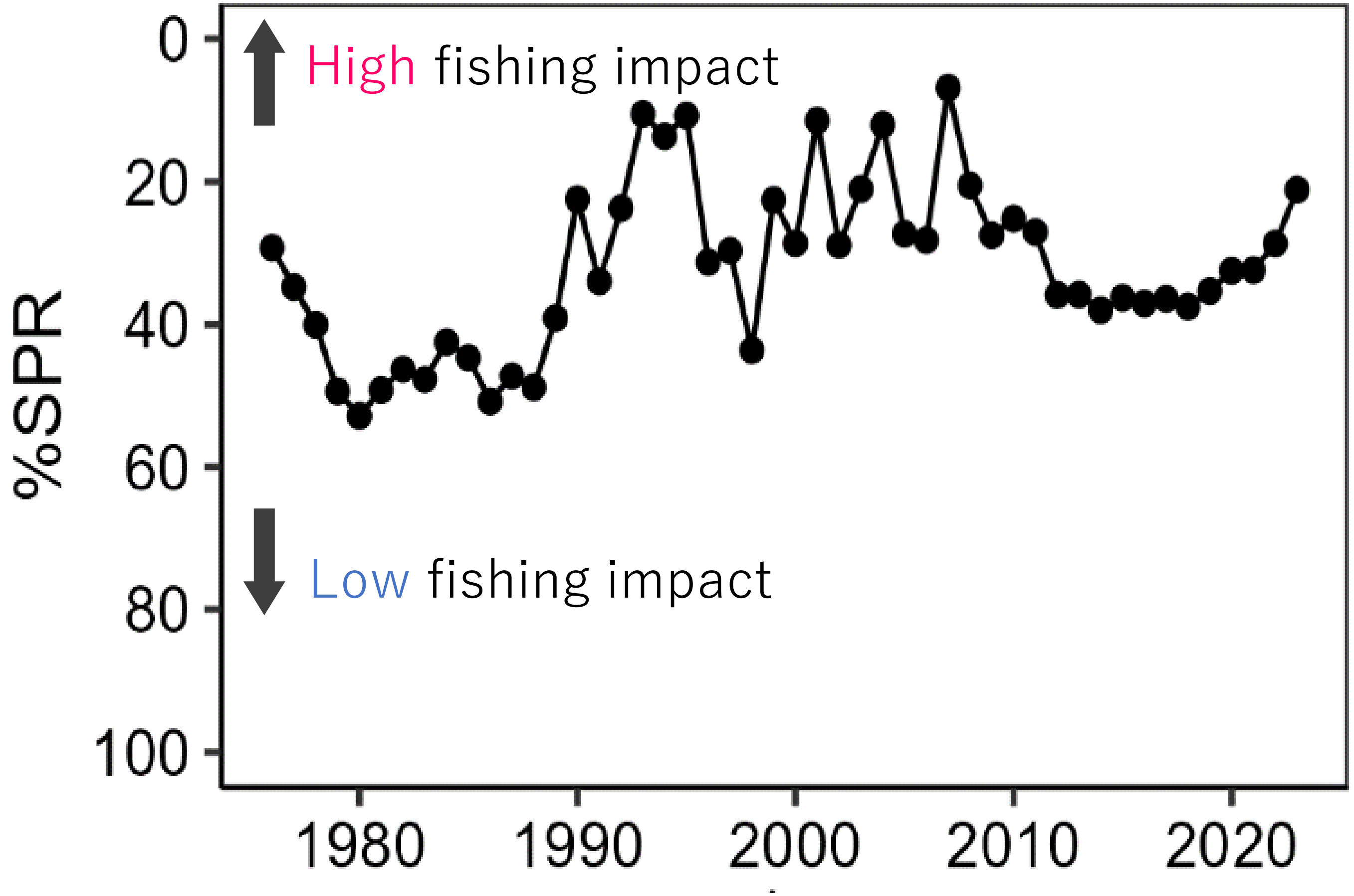
Fishing Mortality by Age



F at age 3 is declining
F at the other age is increasing

Fishing Mortality (%SPR)

%SPR：Ratio of SPR (SSB/R) with fishing to SPR without fishing

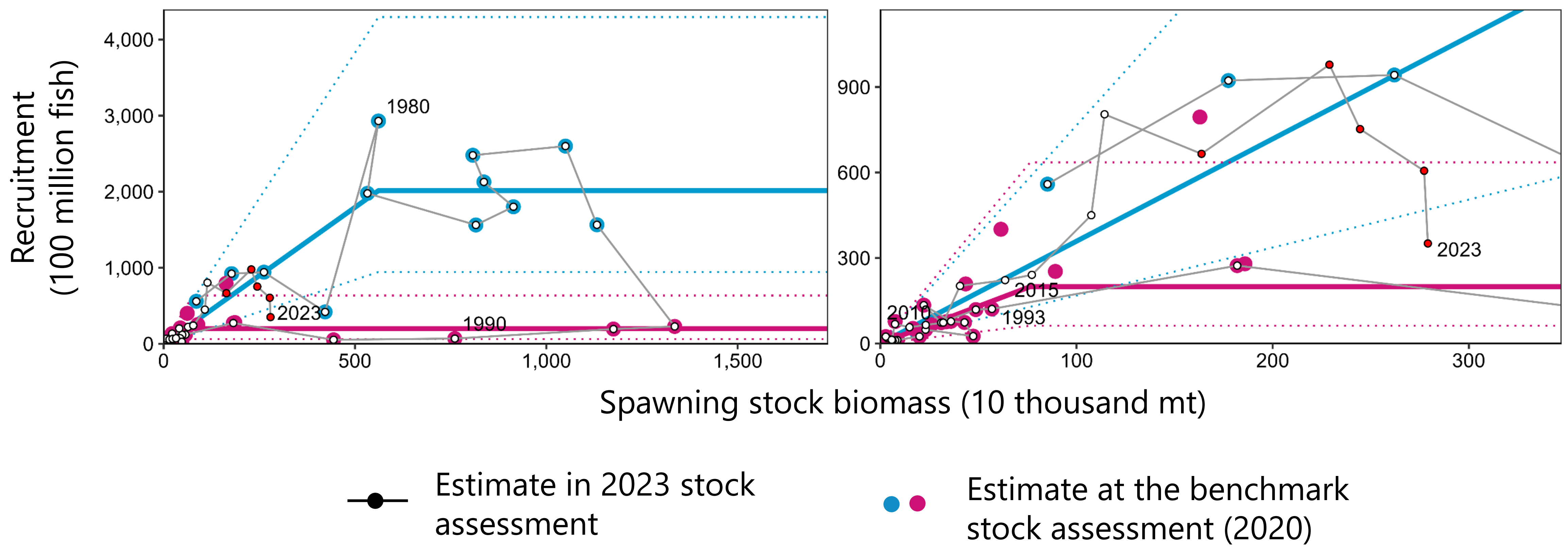


Fishing pressure in the 2010s is maintained at low levels (≈ 40%SPR)

Fishing pressure in 2020-2022 increased (≈ 25%SPR)

Stock-Recruitment Relationship

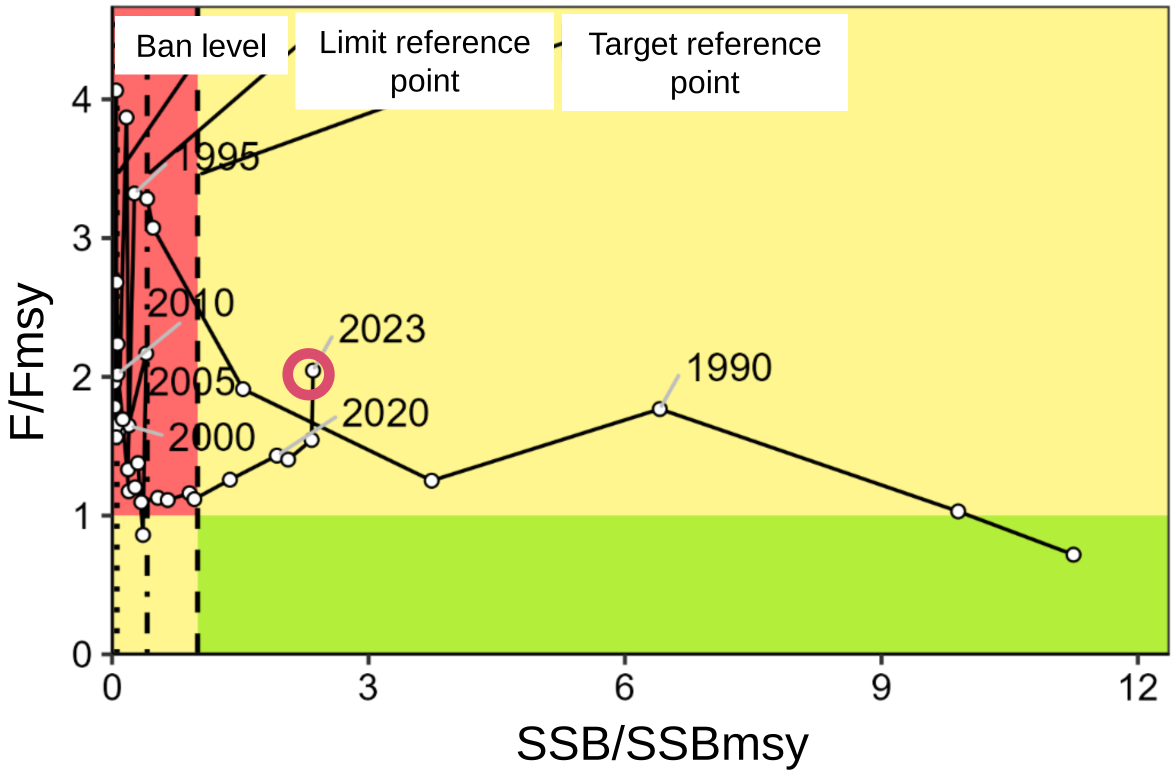
- Post-hoc estimation of the hockey-stick (HS) relationship from VPA outputs
- Separate regimes between 1987 and 1988

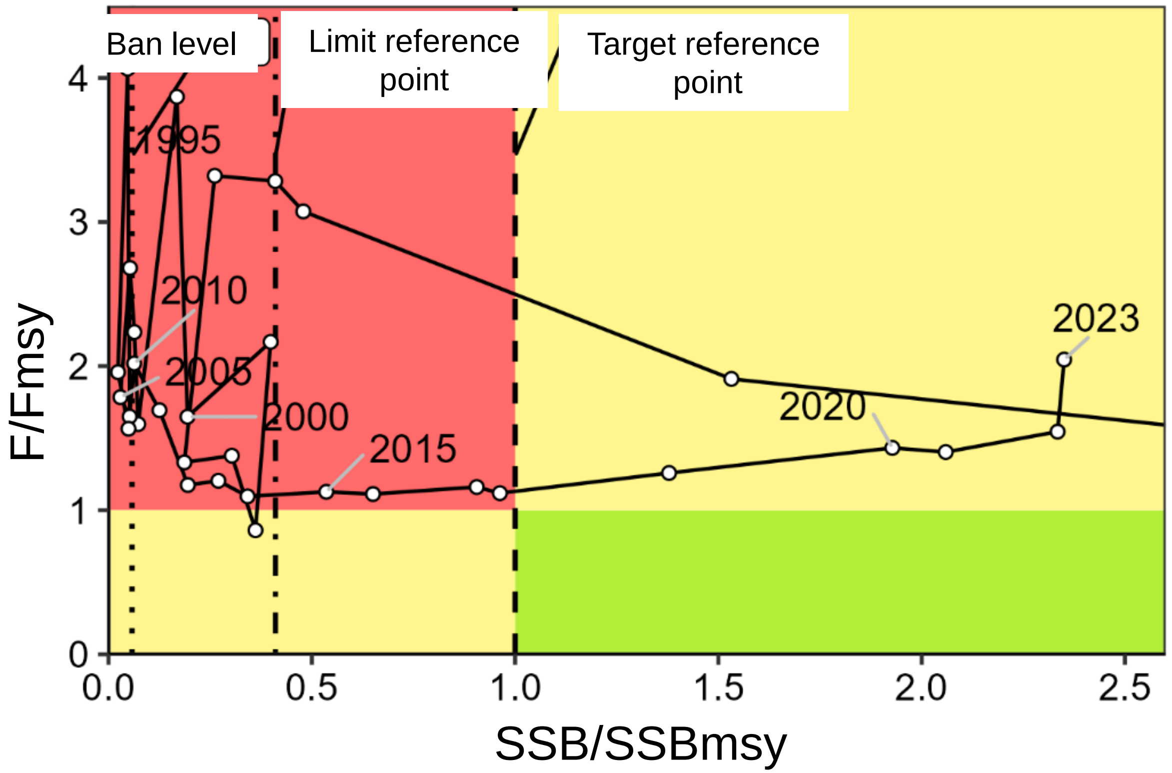


High recruitment in recent years

But slow increase in SSB (probably due to decline in weights)

Kobe plot





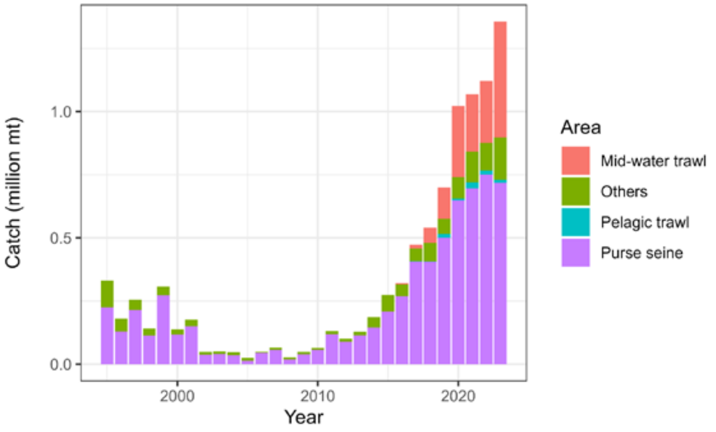
- MSY reference points were estimated by a stochastic simulation with a random recruitment variability from the normal-regime SR relationship (see Ichinokawa et al. 2017, ICES JMS, for details)
- SSB in 2023 exceeded SSBmsy
- F in 2023 exceeded Fmsy

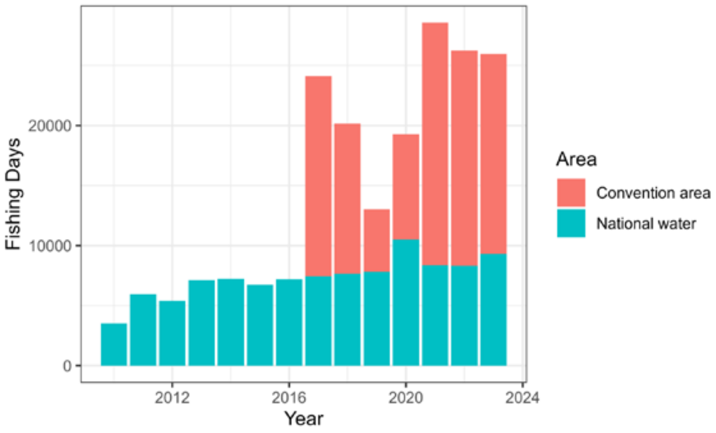
Small Working Group on Japanese sardine (SWG JS)

Lead: Dr. Kazunari Higashiguchi (Japan)

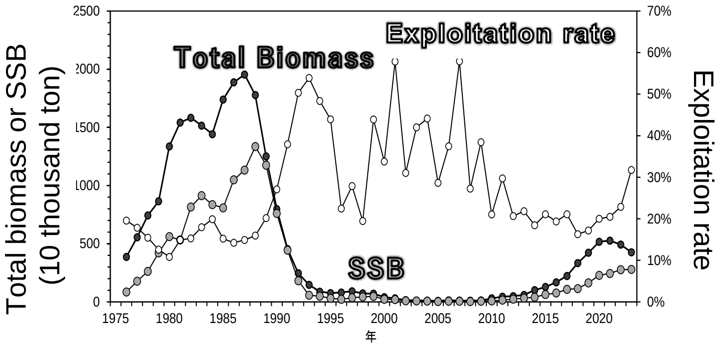
Japanese sardine

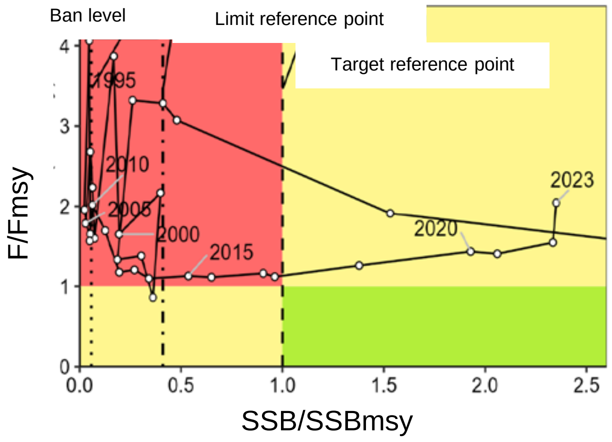
Convention Area





Domestic Assessment





Comments on Status

- SSB is **above SSBmsy**
- Fishing mortality is **above Fmsy**
- Japanese catch and majority of Russian catch are from their national waters.
- Chinese catch is from CA

Summary

- Japan conducts the JS stock assessment by the tuned VPA with ridge penalty
- The MSY-based reference points were estimated from the stochastic simulation from the normal-regime SR relationship of the hockey stick function
- In 2023, estimated total biomass was 4.24 million mt and SSB was 2.79 million
- It exceeded SSBmsy
- The current F (F2021-2023) exceeded Fmsy

Future Issues

- It is necessary to reflect actual age composition in the outside of Japanese EEZ
- Should consider more how to treat regimes for future projection and BRP