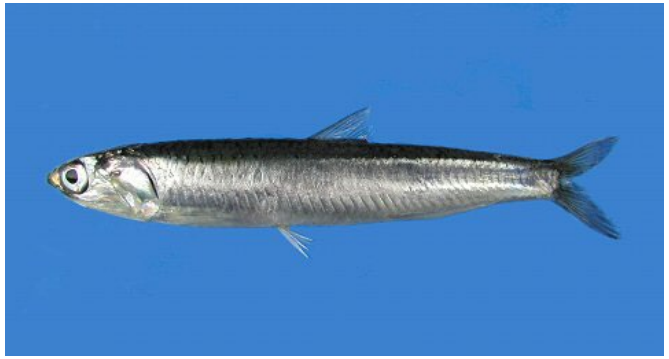
Peer Review on Stock Assessment and Evaluation Japanese Anchovy (Seto Inland Sea)

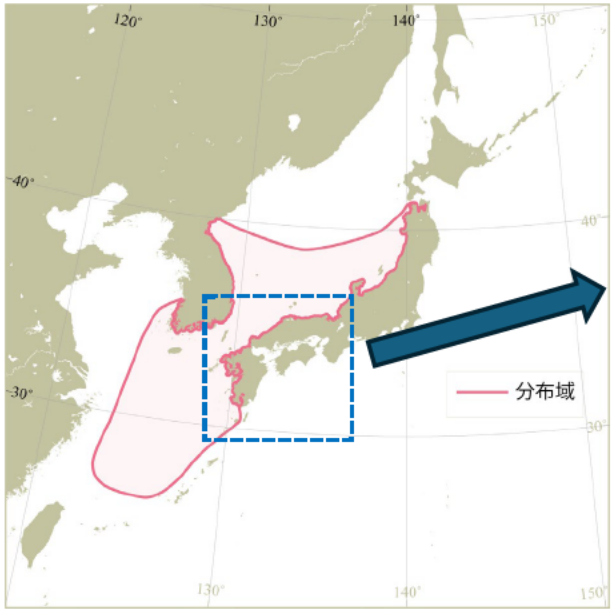
- Overview: Japanese Anchovy Stock in the Seto Inland Sea
- Responses to Questions and Comments from Prof. Yamakawa
- Responses to Questions and Comments from Prof. McAllister
- Future Work

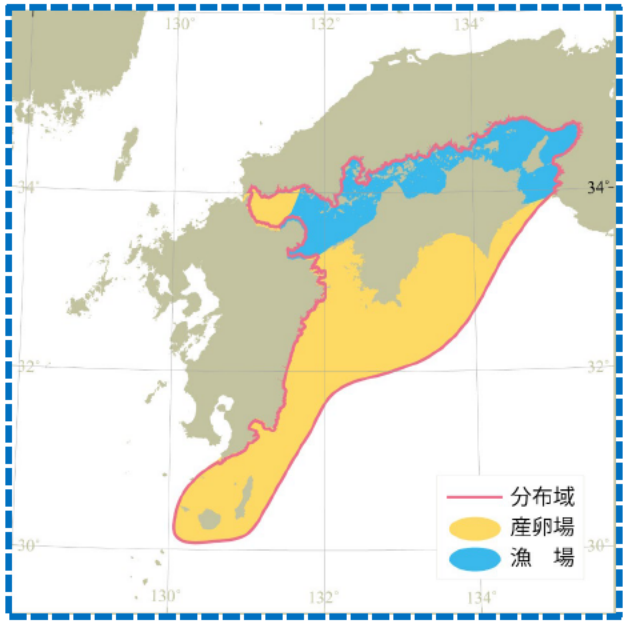


National Research and Development Agency,
Japan Fisheries Research and Education Agency

Naoaki Kono, Masanori Takahashi, Tohya Yasuda,
Mikio Watai, Haruhiko Hino, Junji Kinoshita,
Yuga Kisara, Akiha Tsukada, Shota Nishijima

Three Japanese anchovy stocks around Japan





Pacific stock

Tsushima warm current stock

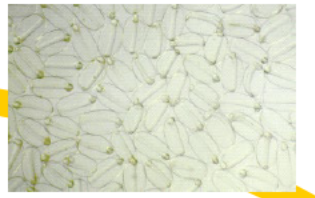
Seto Inland Sea stock

Peer review in 2023

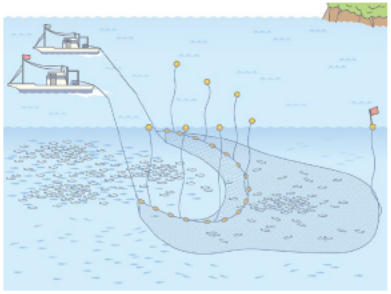
https://www.fra.go.jp/shigen/fisheries_resources/meeting/peer_review_meeting/peer_review_2023.html

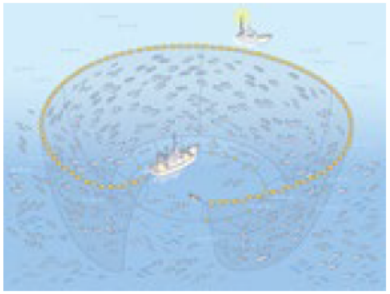
Subject of this peer review

Adult

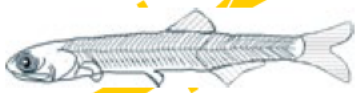


Natural mortality & Fishing mortality





Natural mortality

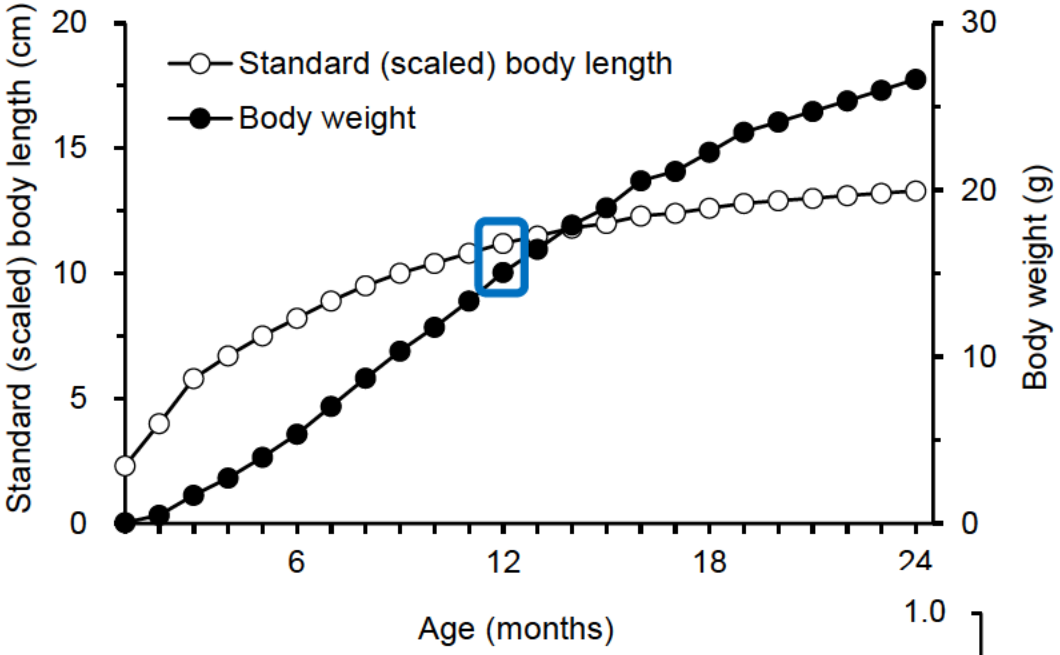


Larvae (ca. 1 to 4 cm)
Growth stage
at fishing start

Juvenile (≥ ca. 4 cm in body length)

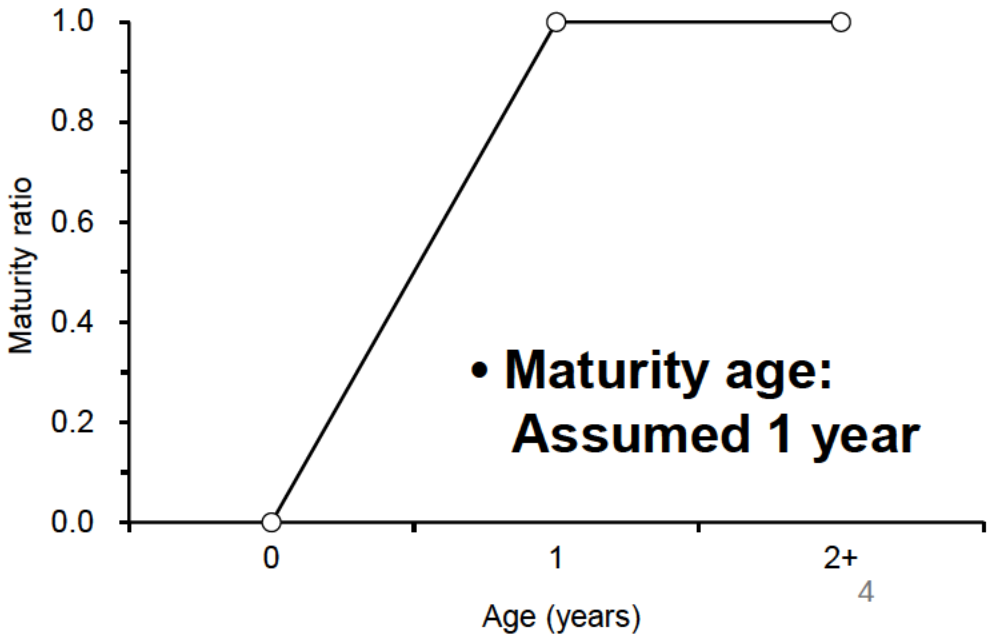
Life history of Japanese anchovy

Growth, maturity age and lifespan of the Seto Inland Sea stock



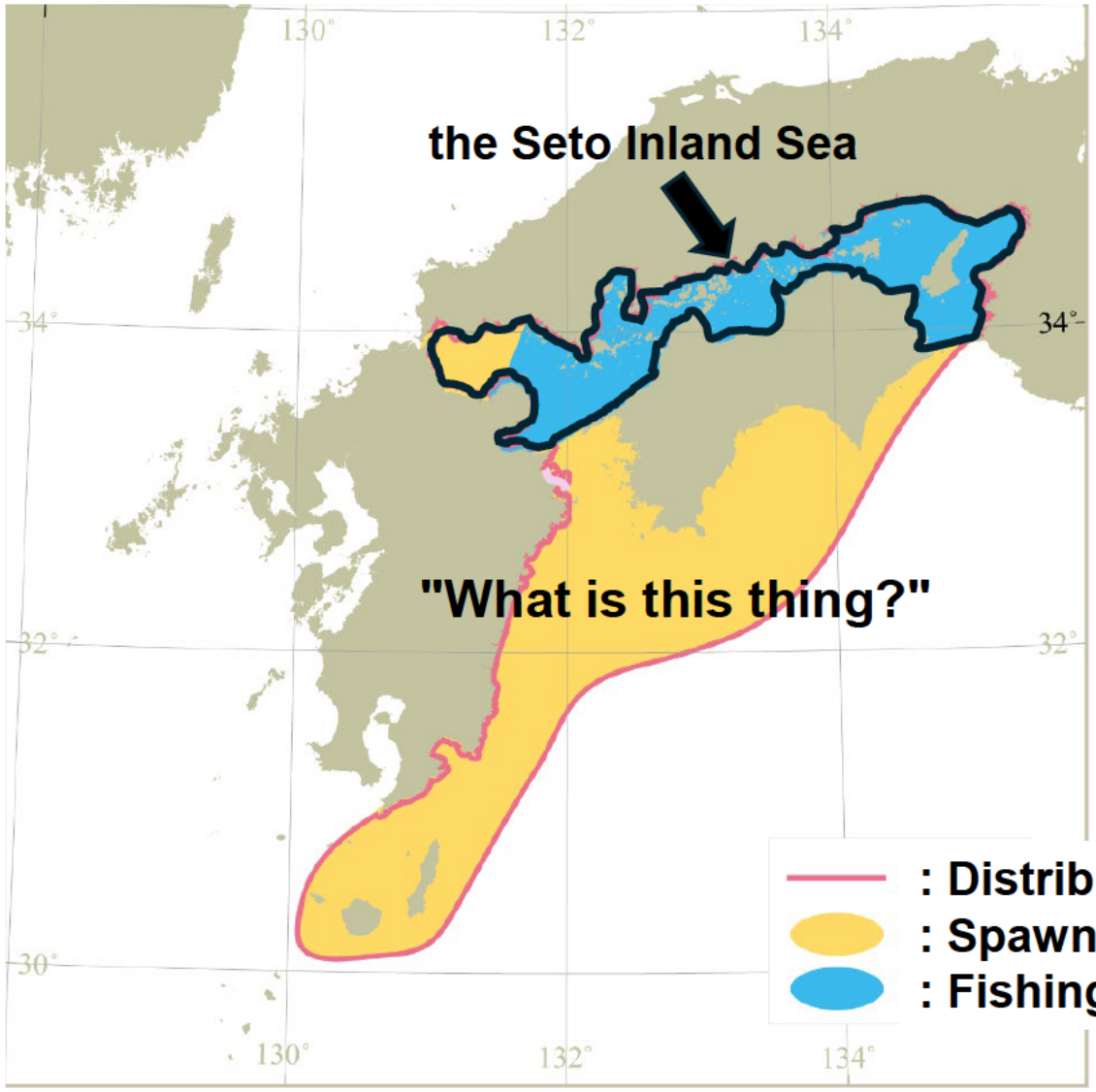
- **Growth in first year:**
  ca. 10 cm length
  ca. 10 g weight

- **Estimated lifespan:**
  ~2 years



- **Maturity age:**
  Assumed 1 year

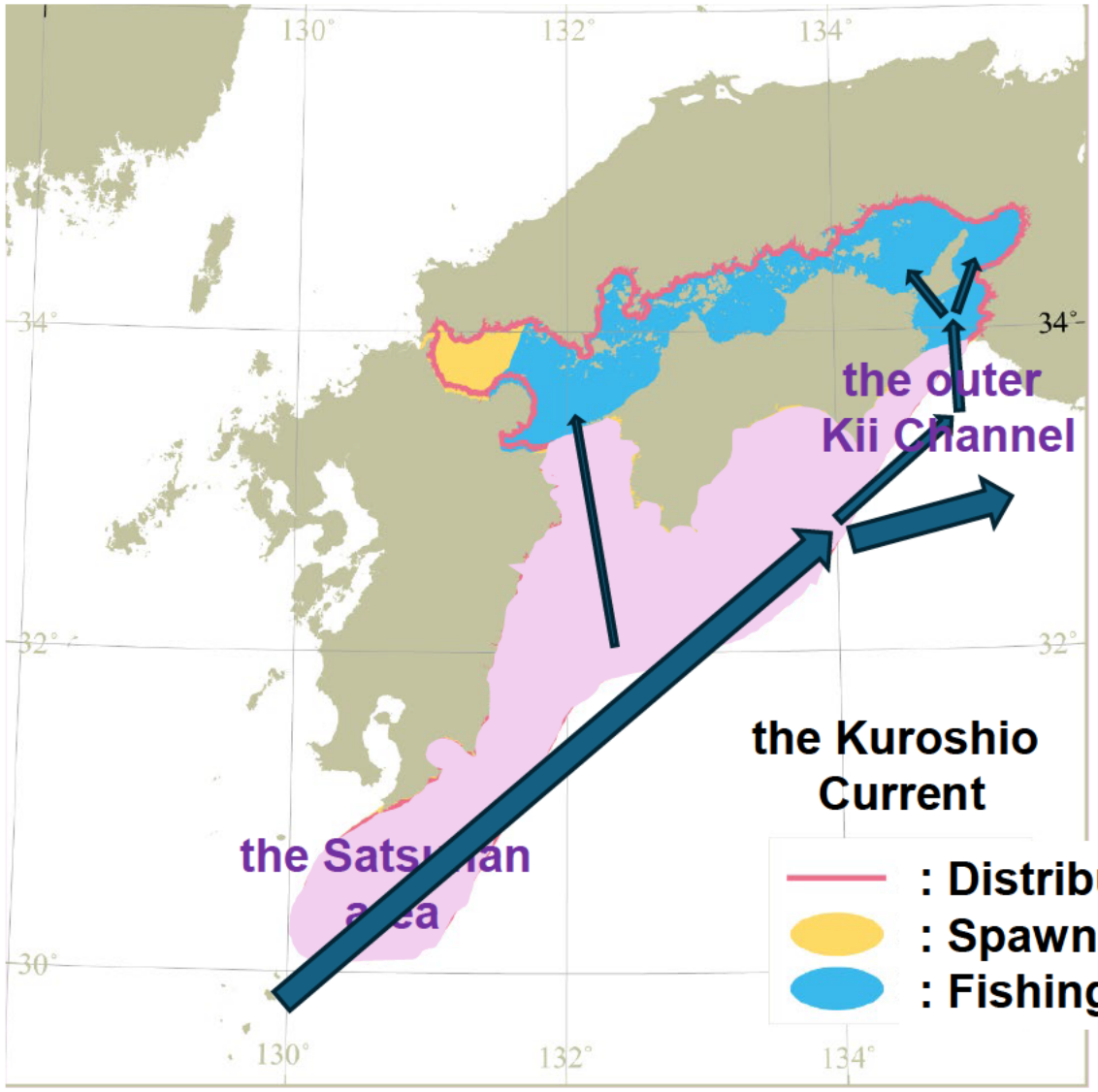
Distribution range, spawning ground, and fishing ground of the Seto Inland Sea stock



Stock assessment and evaluation for Japanese anchovy of Seto Inland Sea stock:

The target is the Japanese anchovy caught in the Seto Inland Sea.

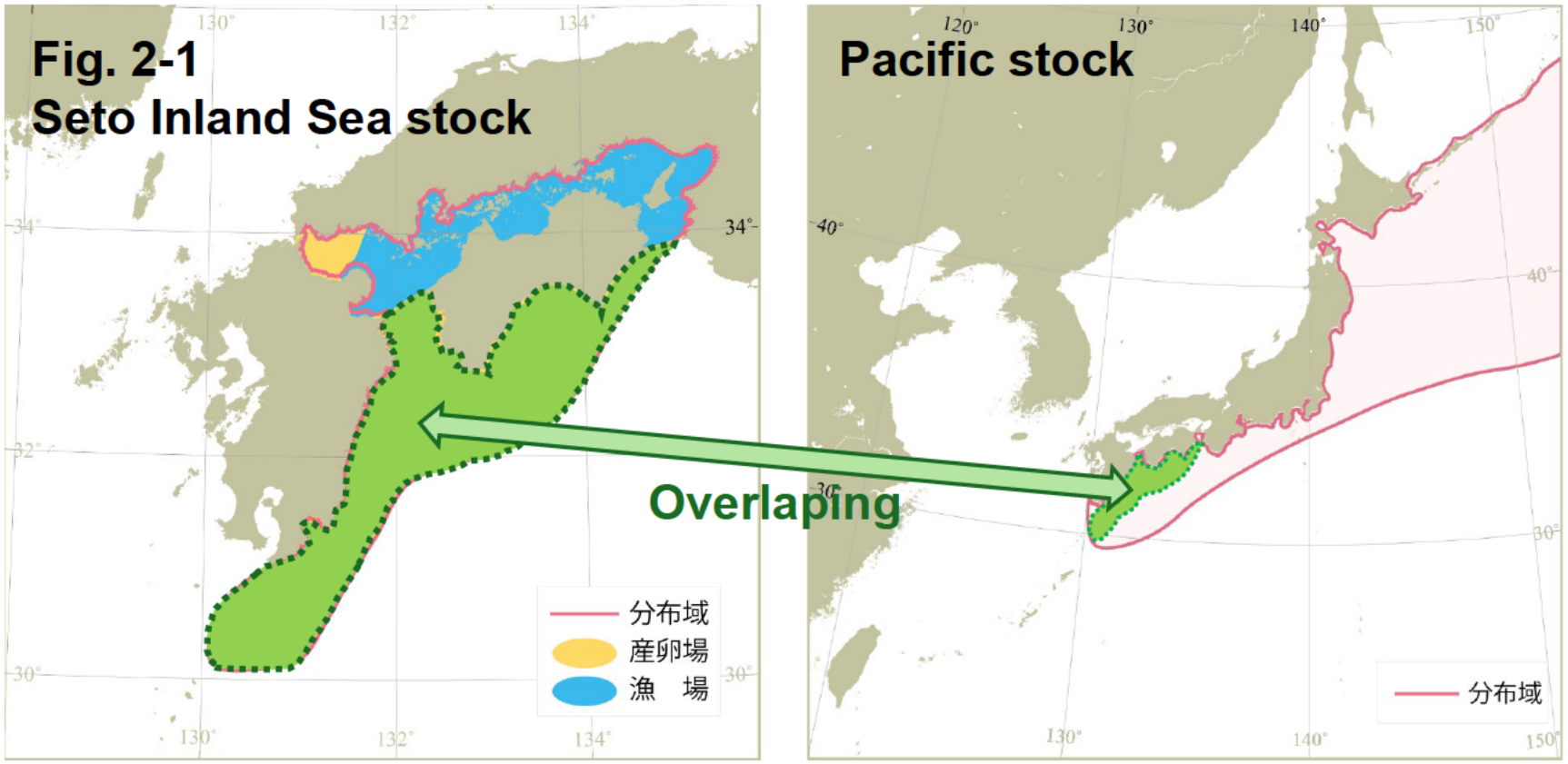
Distribution range, spawning ground, and fishing ground of the Seto Inland Sea stock



Some early life stages of anchovy spawned in the area from the Satsunan region to the outer Kii Channel are transported by the Kuroshio Current and drift into the Seto Inland Sea.

Including this meaning, spawning grounds and distribution areas are also shown beyond the Seto Inland Sea.

- **Related question from Prof. Yamakawa on spawning survey**
  The spawning ground in Fig. 2-1 overlaps with the distribution area of the Pacific stock. What spatial range of egg production is included in Fig. 4-1?



- **Related question from Prof. Yamakawa on spawning survey**
  The spawning ground in Fig. 2-1 overlaps with the distribution area of the Pacific stock. What spatial range of egg production is included in Fig. 4-1?
  → Egg production was estimated using data from the Seto Inland Sea (Fig. S7-1).

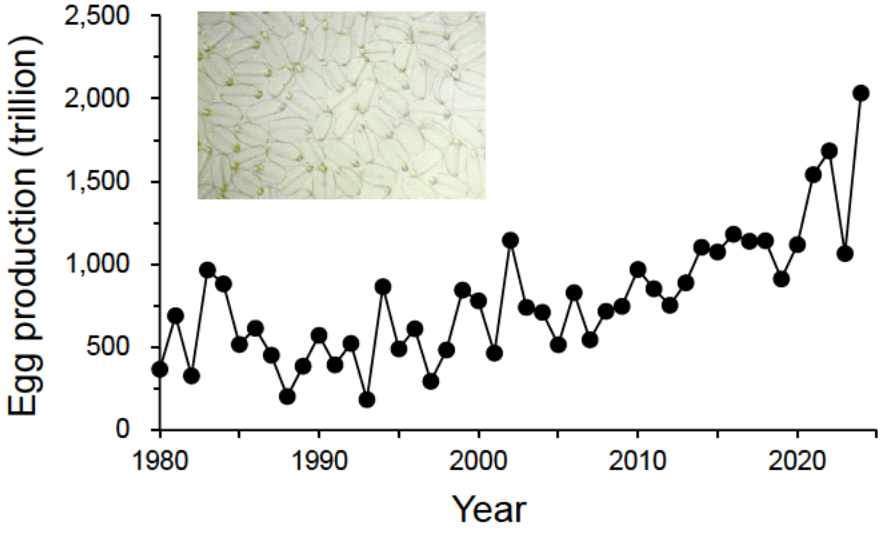


Fig. 4-1. Trend of egg production in the Seto Inland Sea

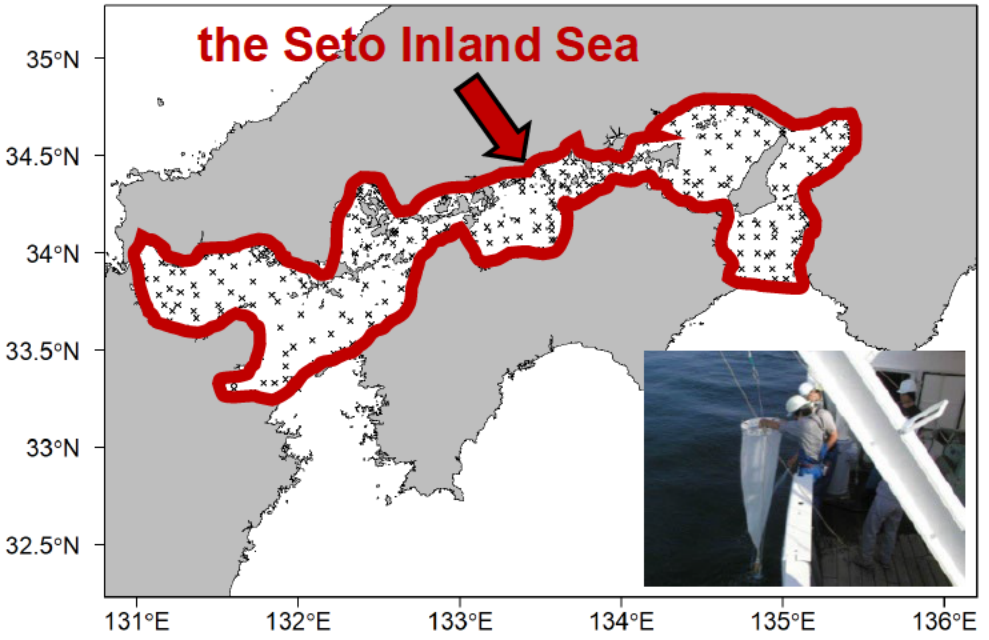


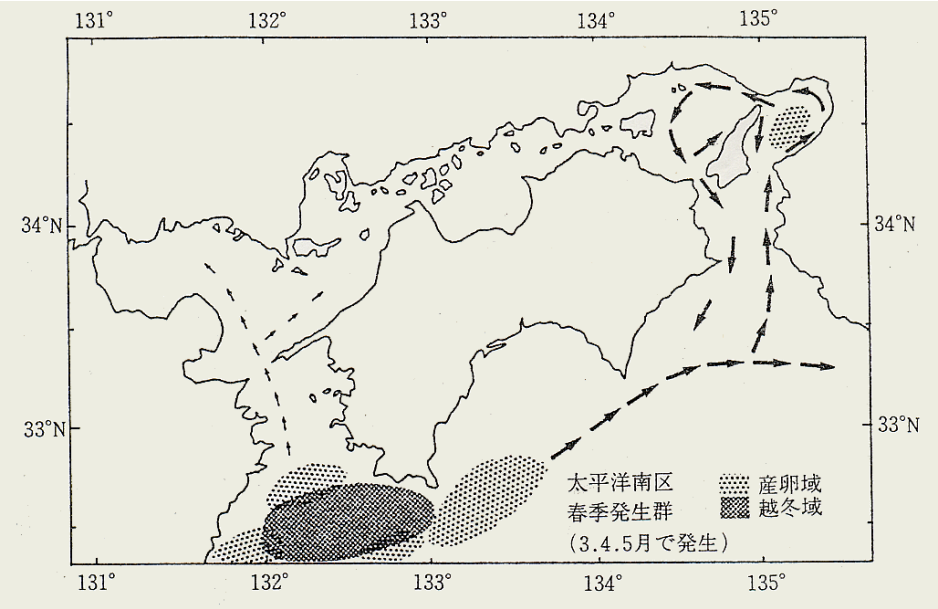
Fig. S7-1. Layout of survey stations (×) for egg survey in the Seto Inland Sea

- **Related question from Prof. Yamakawa on interaction with Pacific**

  Clarify interaction with Pacific stock. To what extent is the interaction with the Pacific stock considered to occur?

  → Previous studies indicate interaction with the Pacific coast.

1. Migration patterns for Japanese anchovy of Southern Pacific spring spawning group



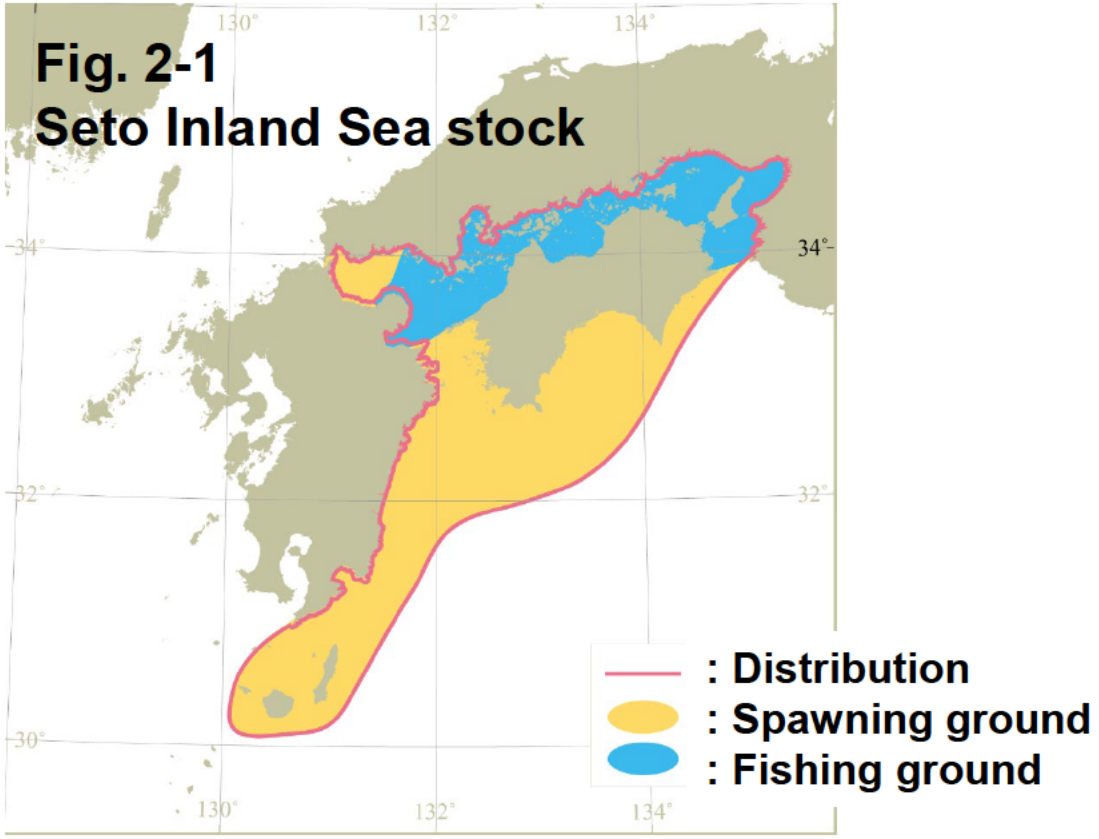
: Spawning ground

: overwintering area

Figure reproduced from Takao (1990)

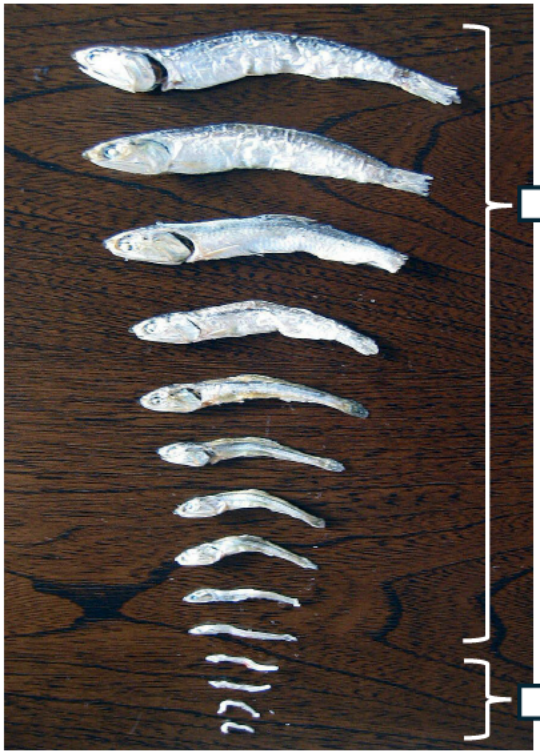
2. Changes in shirasu fishing grounds suggest that larval anchovies enter from the Pacific coast. (Horiki 1971, Takao 1975, Saiura & Takeda 2001, Gosho 2003)

- **Related question from Prof. Yamakawa on spawning survey**
  The spawning ground in Fig. 2-1 overlaps with the distribution area of the Pacific stock. What spatial range of egg production is included in Fig. 4-1?
  → Fig. 2-1 illustrates the migration of eggs to larvae from the Pacific coast to the Seto Inland Sea.



Characteristics of the catch of Japanese anchovies in the Seto Inland Sea

- Various developmental stages are caught
- Mainly used as a raw material for dried anchovies (Ni-boshi and Shirasu-boshi)

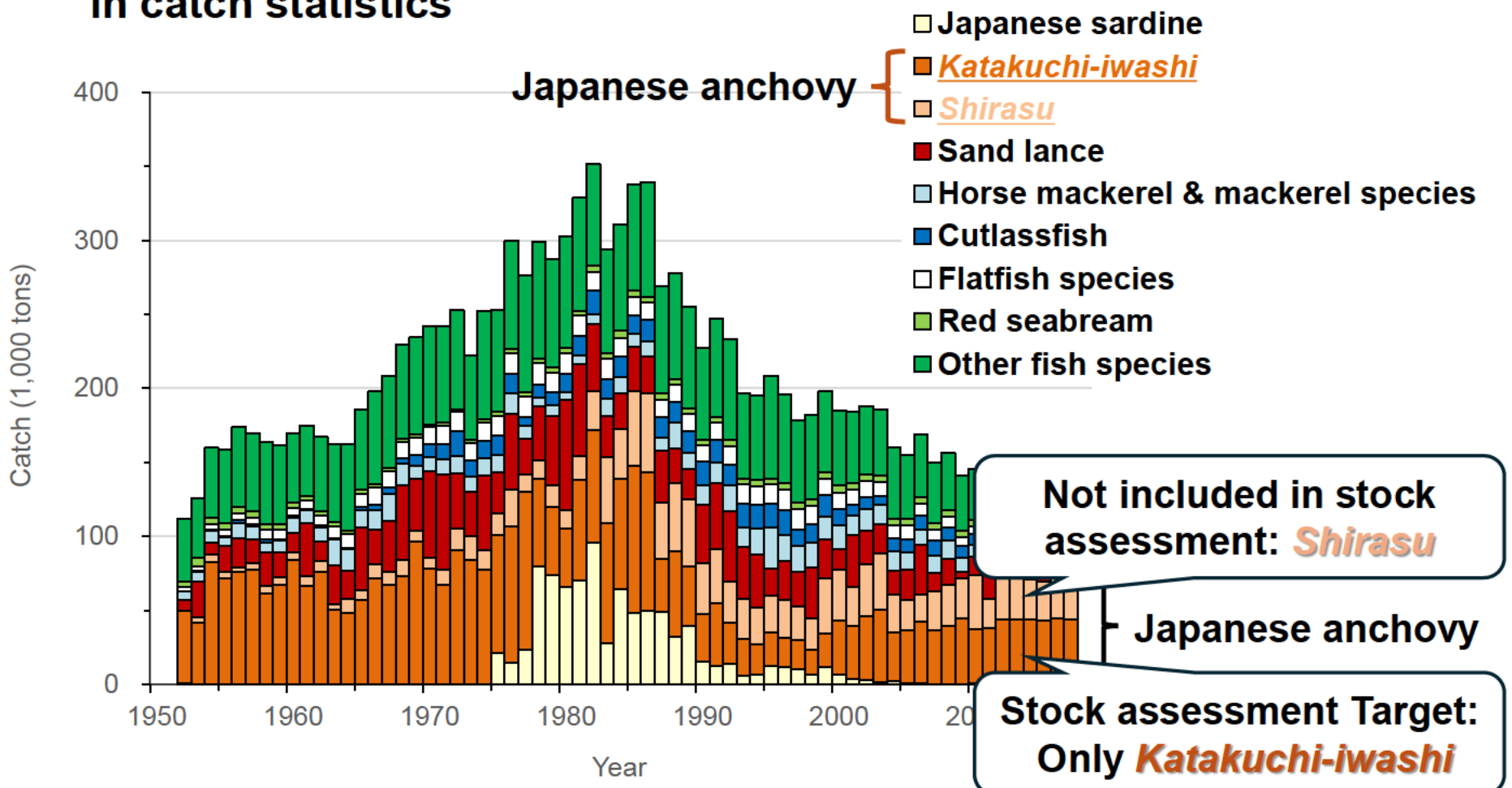


★***Shirasu*** **are not included in stock assessment.**

Additional information: Catch in the Seto Inland Sea

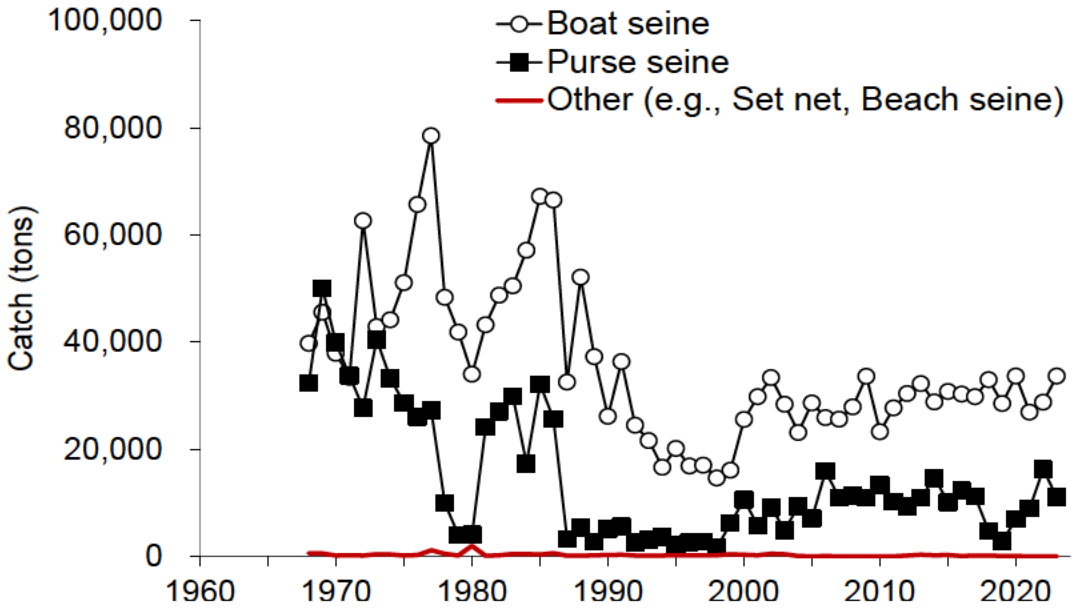
Japanese anchovy:

- Most abundant species in catch
- Recorded under two categories (*Katakuchi-iwashi* and *Shirasu*) in catch statistics



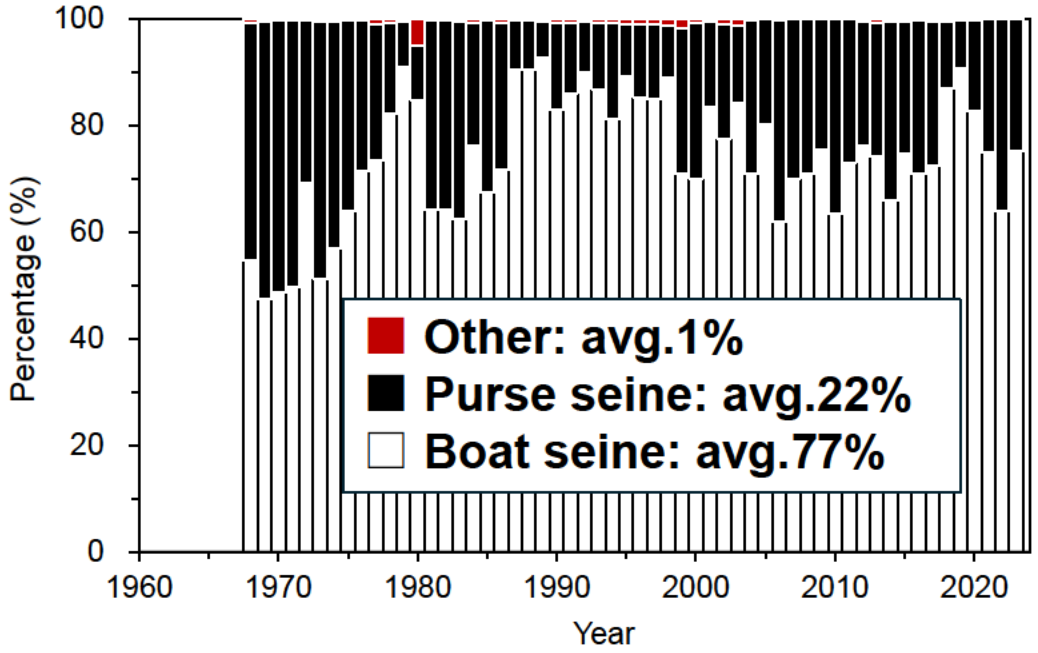
Annual trends in fish catch by species

Catch of *Katakuchi-iwashi* in the Seto Inland Sea



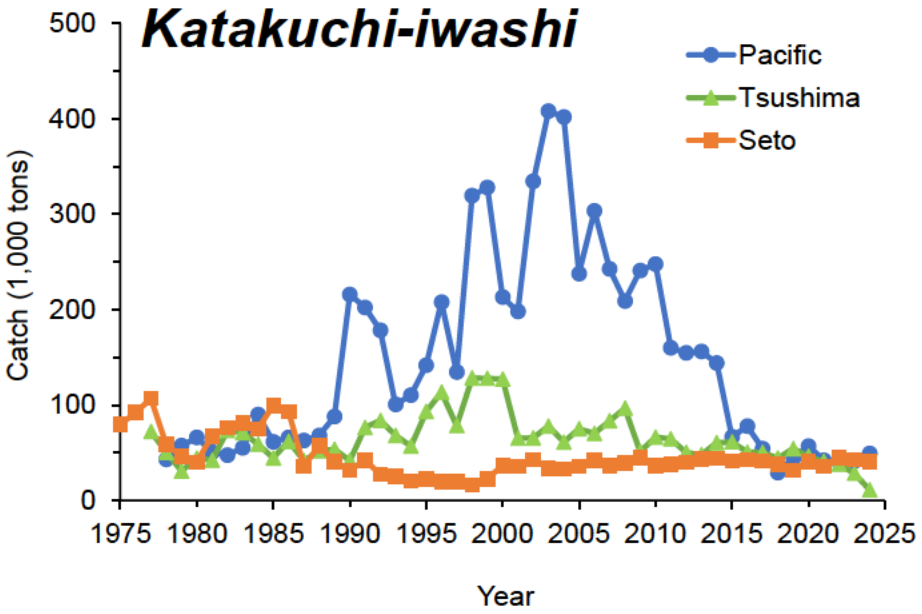
Catch weight by fishing method

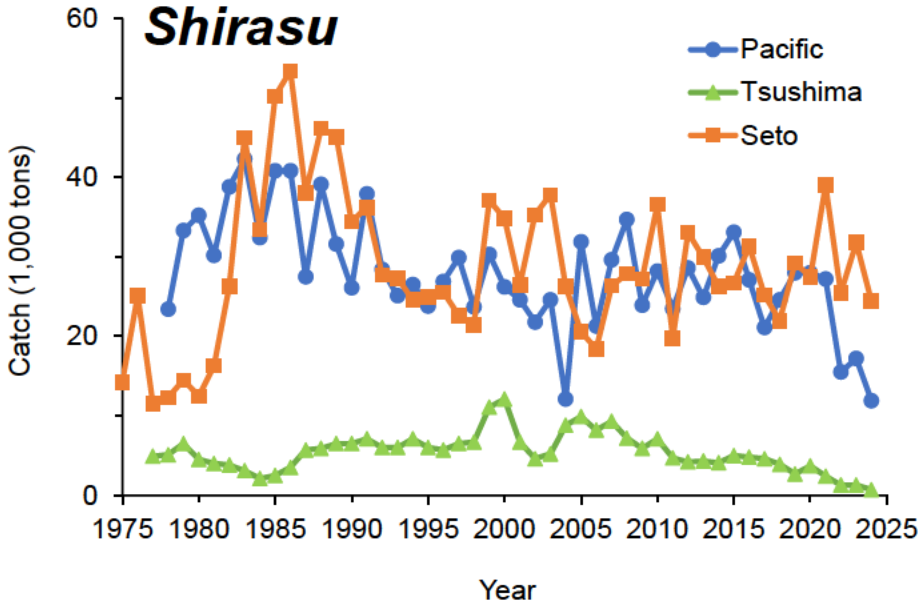
Mainly caught by

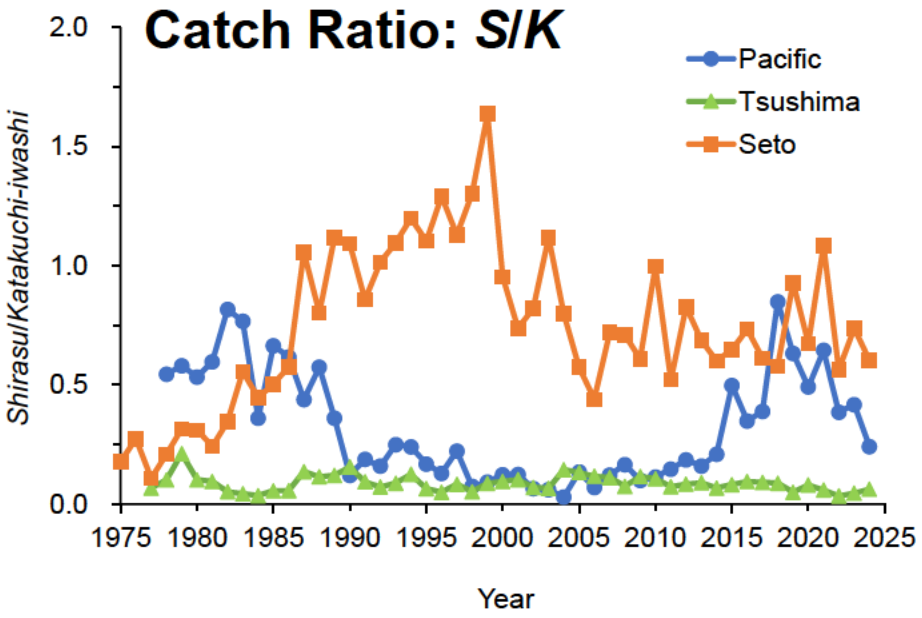


Catch composition by fishing method

Catch characteristics by stock



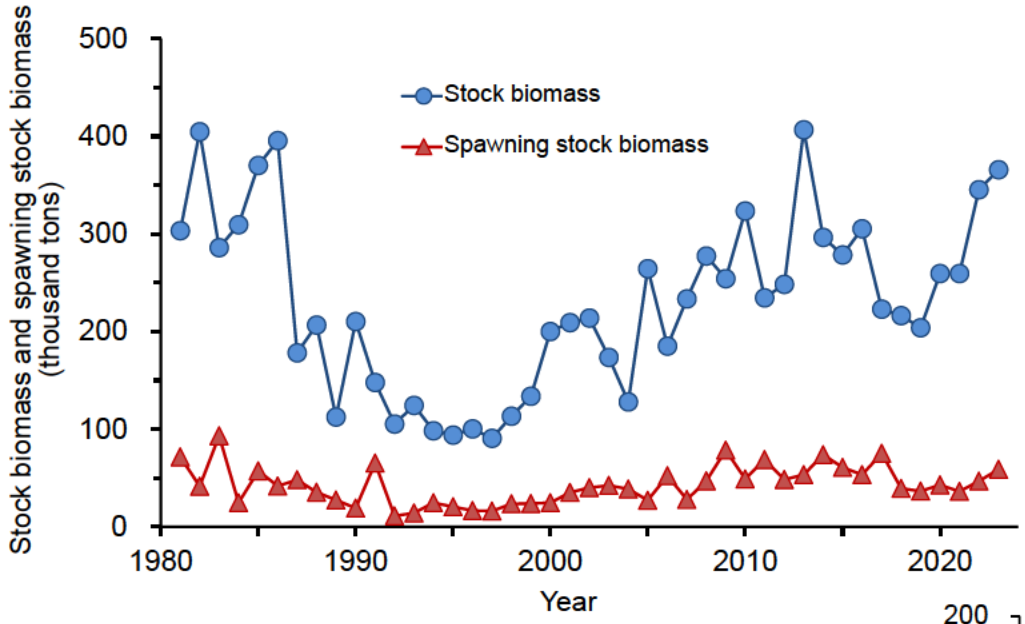




High *Shirasu/Katakuchi-iwashi* catch ratio in Seto Inland Sea

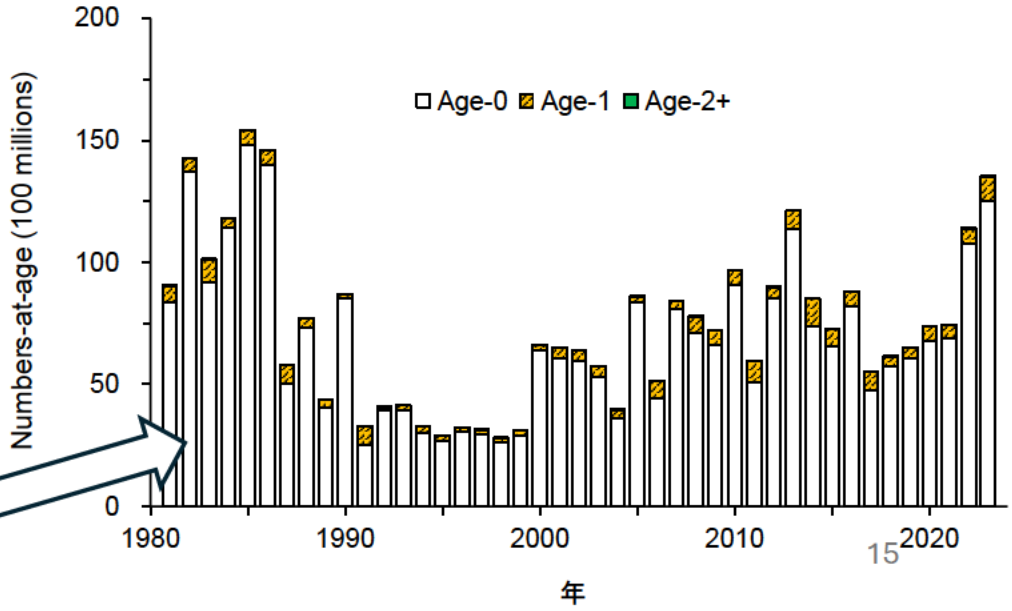
➢ Overview of Stock Assessment Results

Trends in stock biomass, spawning stock biomass and recruitment



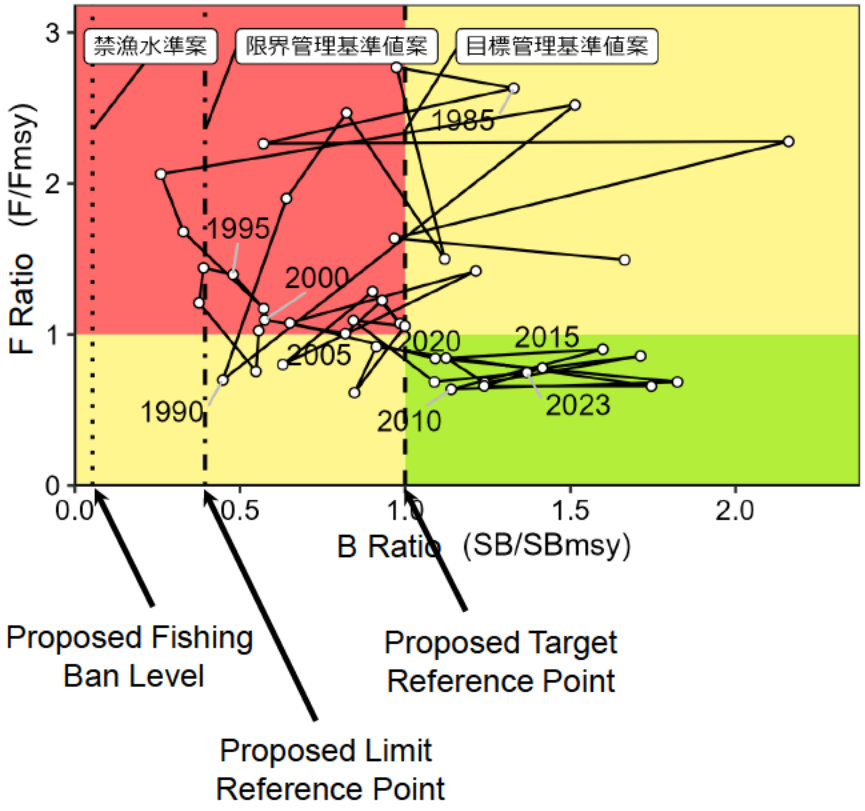
They were
- high in the 1980s,
- low in the 1990s,
- increased in the 2000s
- have remained stable in recent years

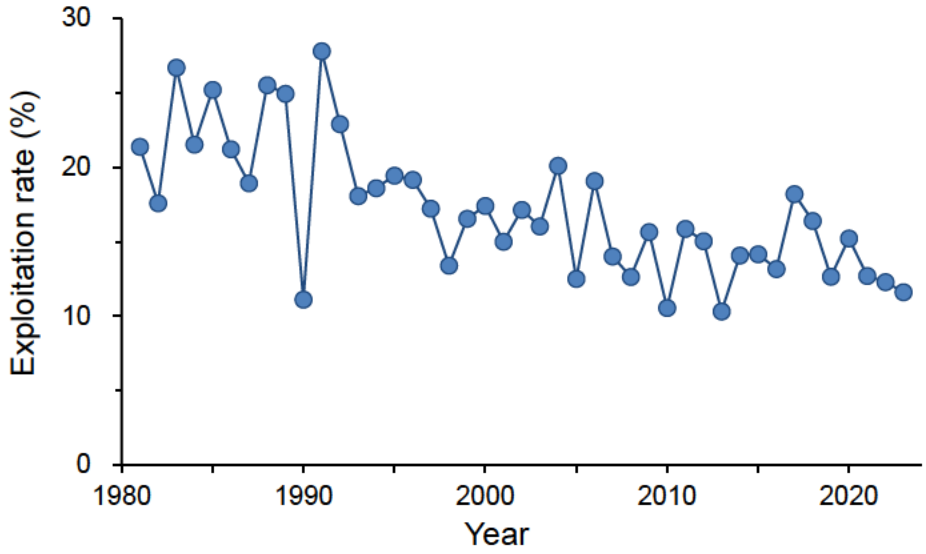
Recruitment (Age-0)

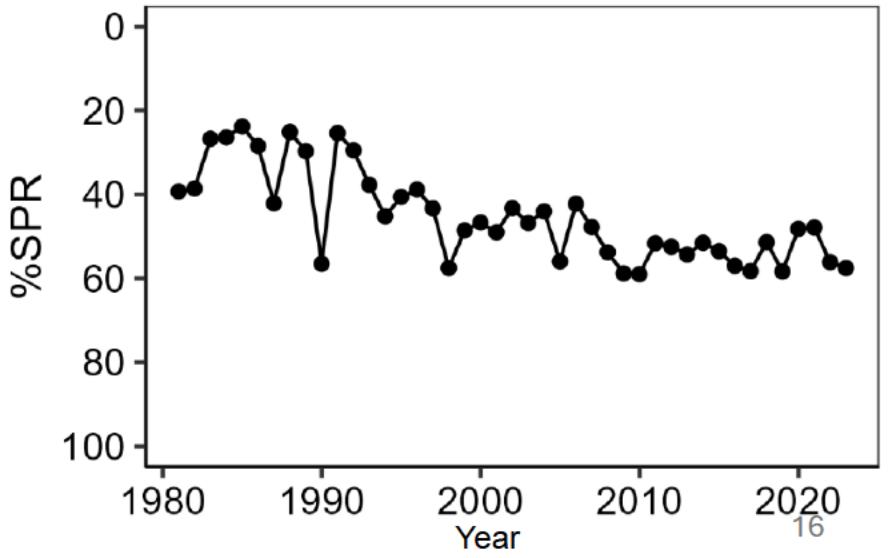


➢ Overview of Stock Assessment Results

Kobe plot, trends in trends in exploitation rate and %SPR

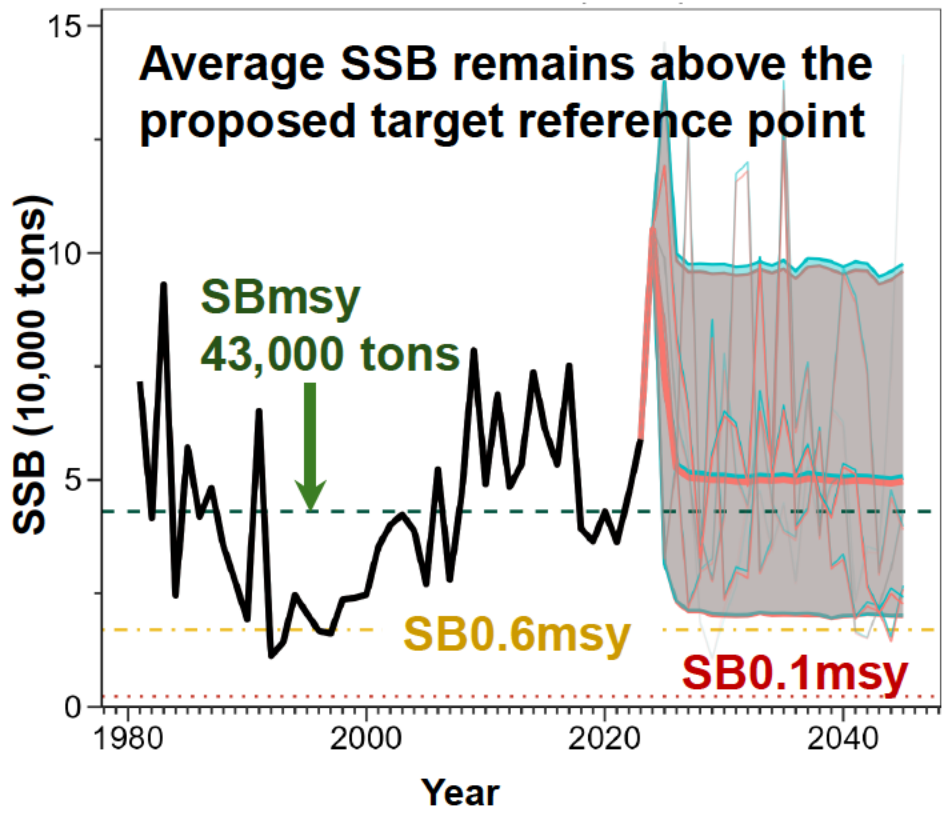


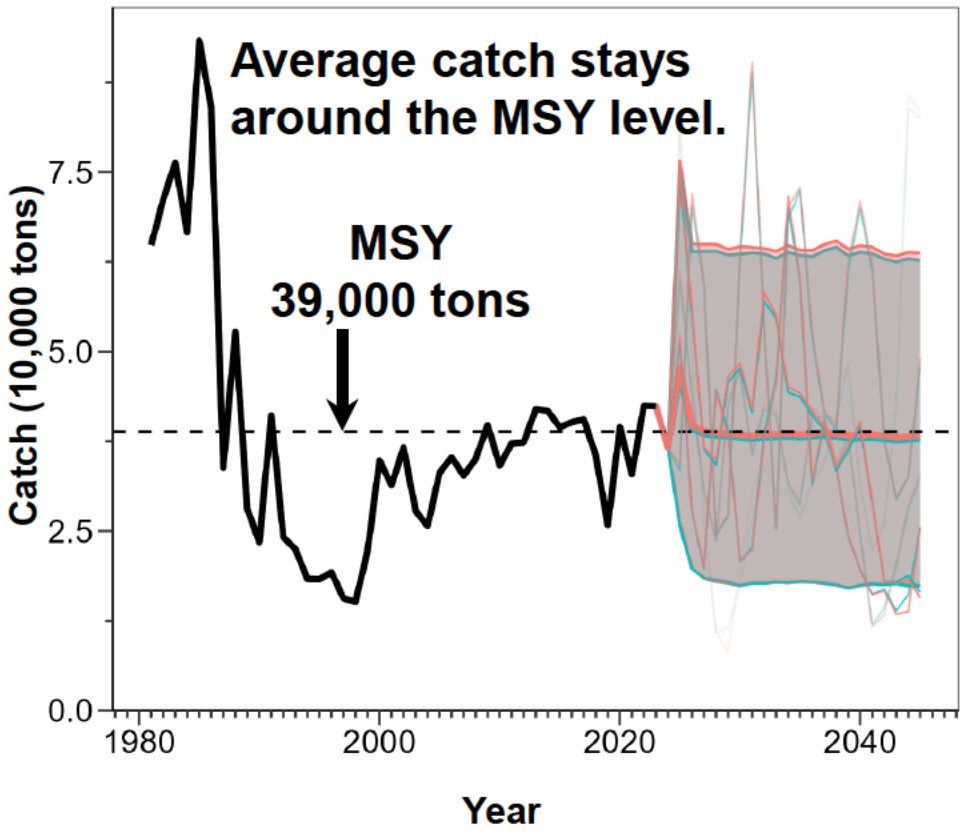




➢ Overview of Stock Assessment Results

Future projections





Proposed HCRs (β = 0.8)

Current fishing pressure (F2018-2022)

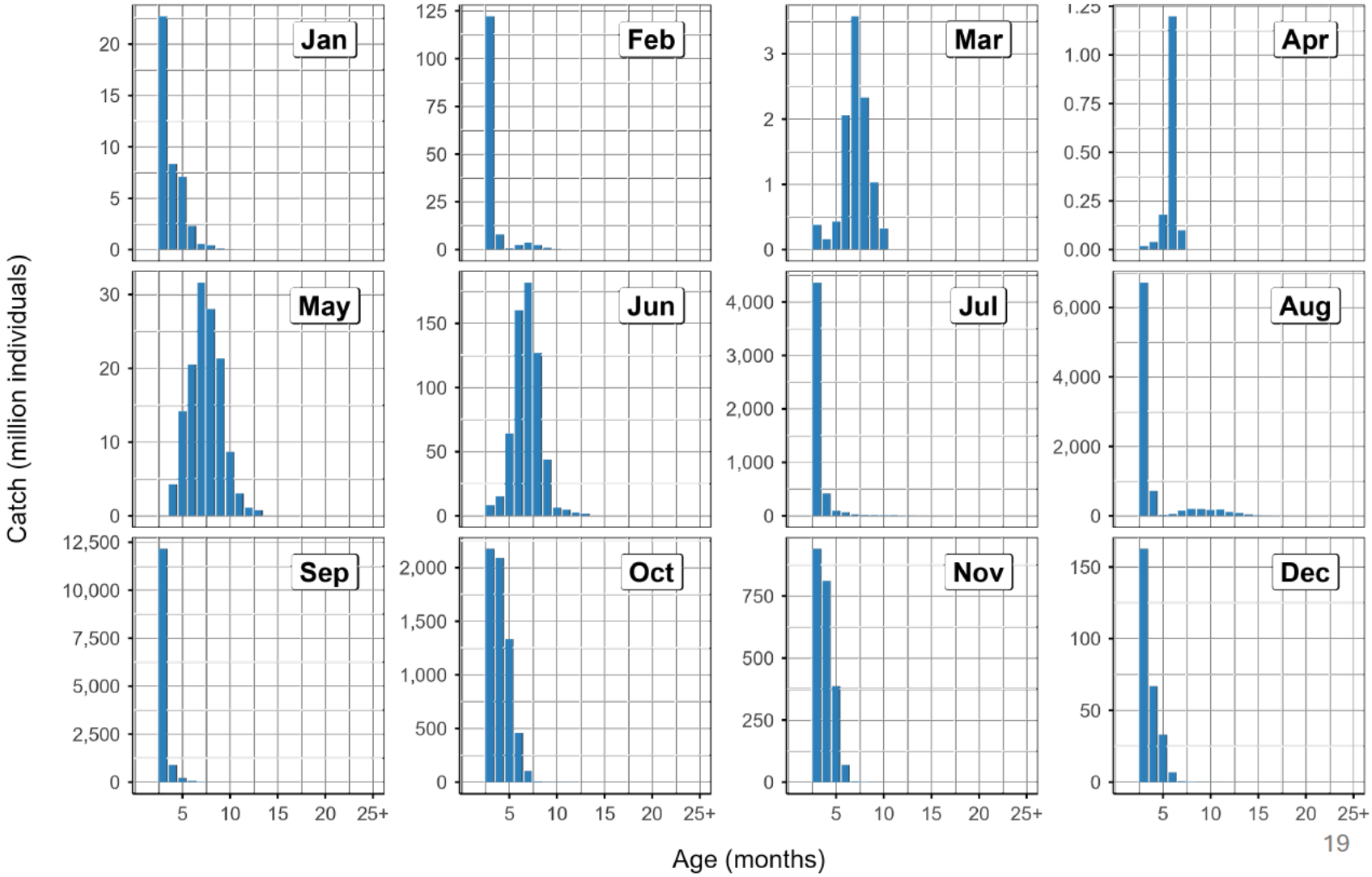
Solid line: average
Thin lines: 5 future projections
Shaded area: prediction interval (90% of simulation results)

➢ Responses to Questions and Comments from Prof. Yamakawa

1. **Add graphs for monthly catch trends; check seasonal/historical changes.**
2. **Show monthly spawning trends; validate weighted M calculation.**
3. **Clarify interaction with Pacific stock; compare fluctuation patterns.**
4. **Why was stock biomass high in the 1980s even though spawning was similar to the 1990s?**
5. **Why was recruitment high in 1980s despite low spawning? Survival or bias?**
6. **Causes of systematic bias in retrospective analysis; effect of excluding 1980s.**
7. ***Shirasu* catch > SSB: need to review estimates, M, and possible Pacific.**

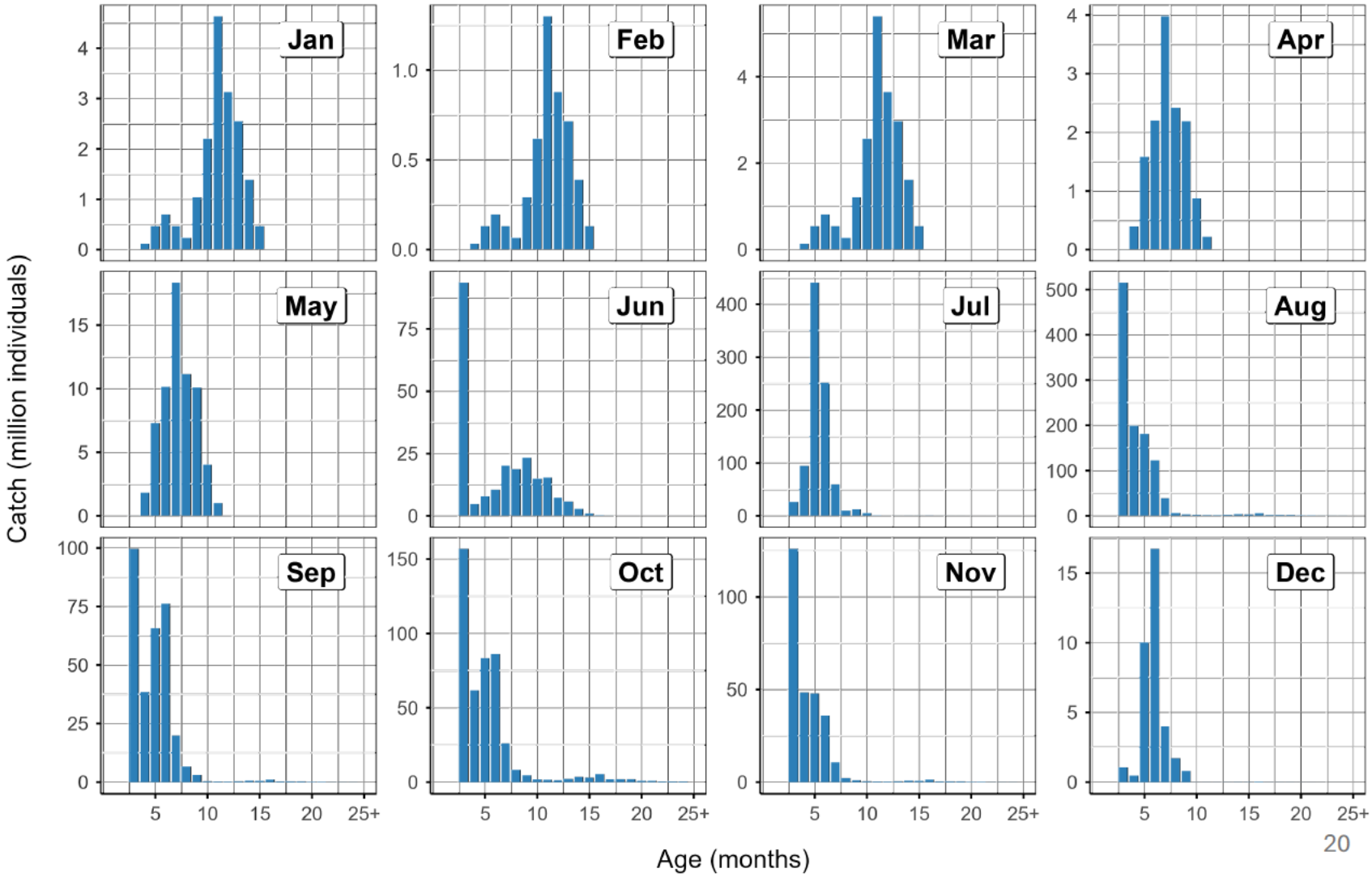
➢ Responses to Questions and Comments from Prof. Yamakawa

1. Add graphs for monthly catch trends; check seasonal/historical changes. → 1985: Maximum Catch of *Katakuchi-iwashi*



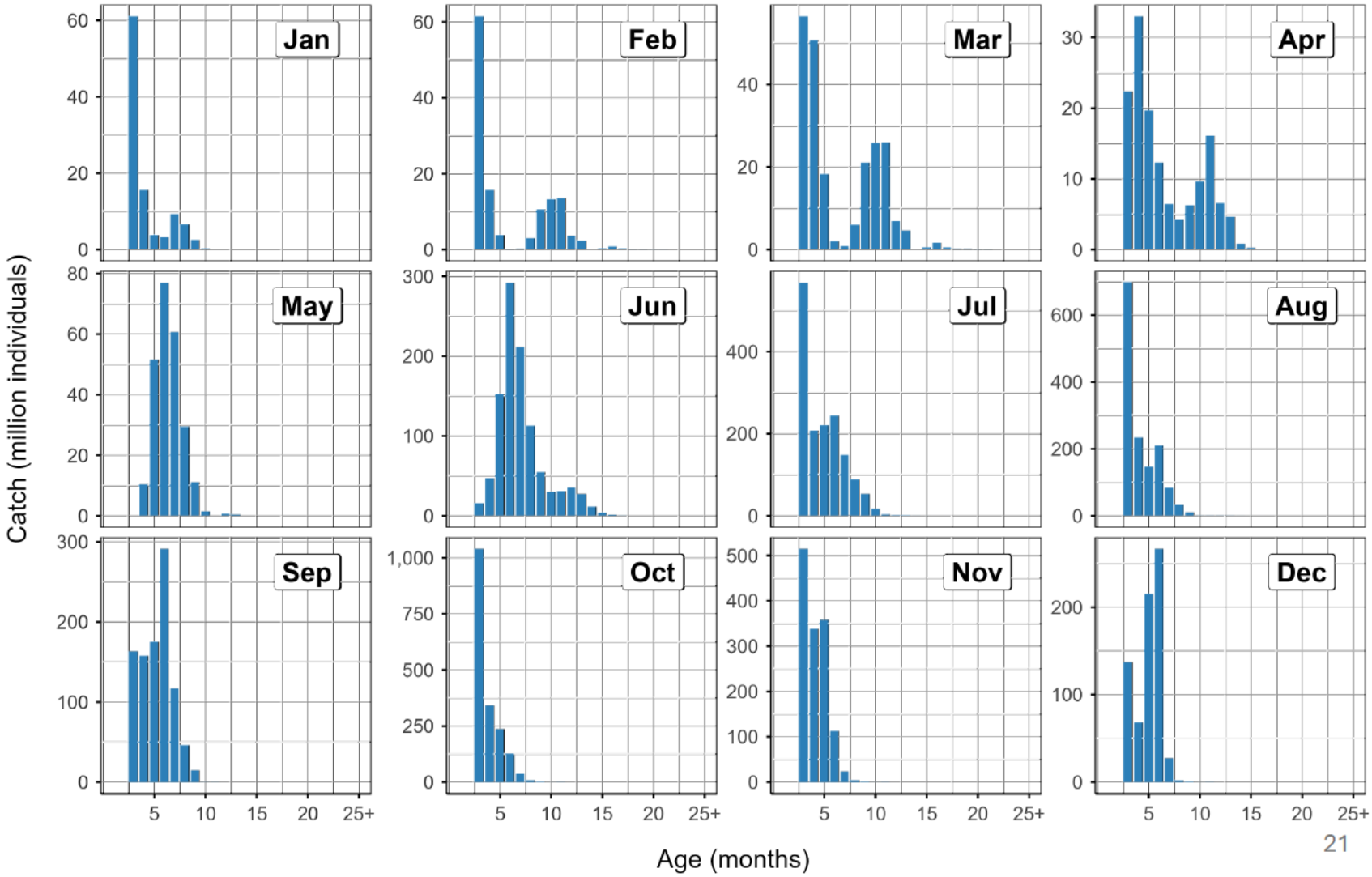
➢ Responses to Questions and Comments from Prof. Yamakawa

1. Add graphs for monthly catch trends; check seasonal/historical changes. → 1998: Minimum Catch of *Katakuchi-iwashi*



➢ Responses to Questions and Comments from Prof. Yamakawa

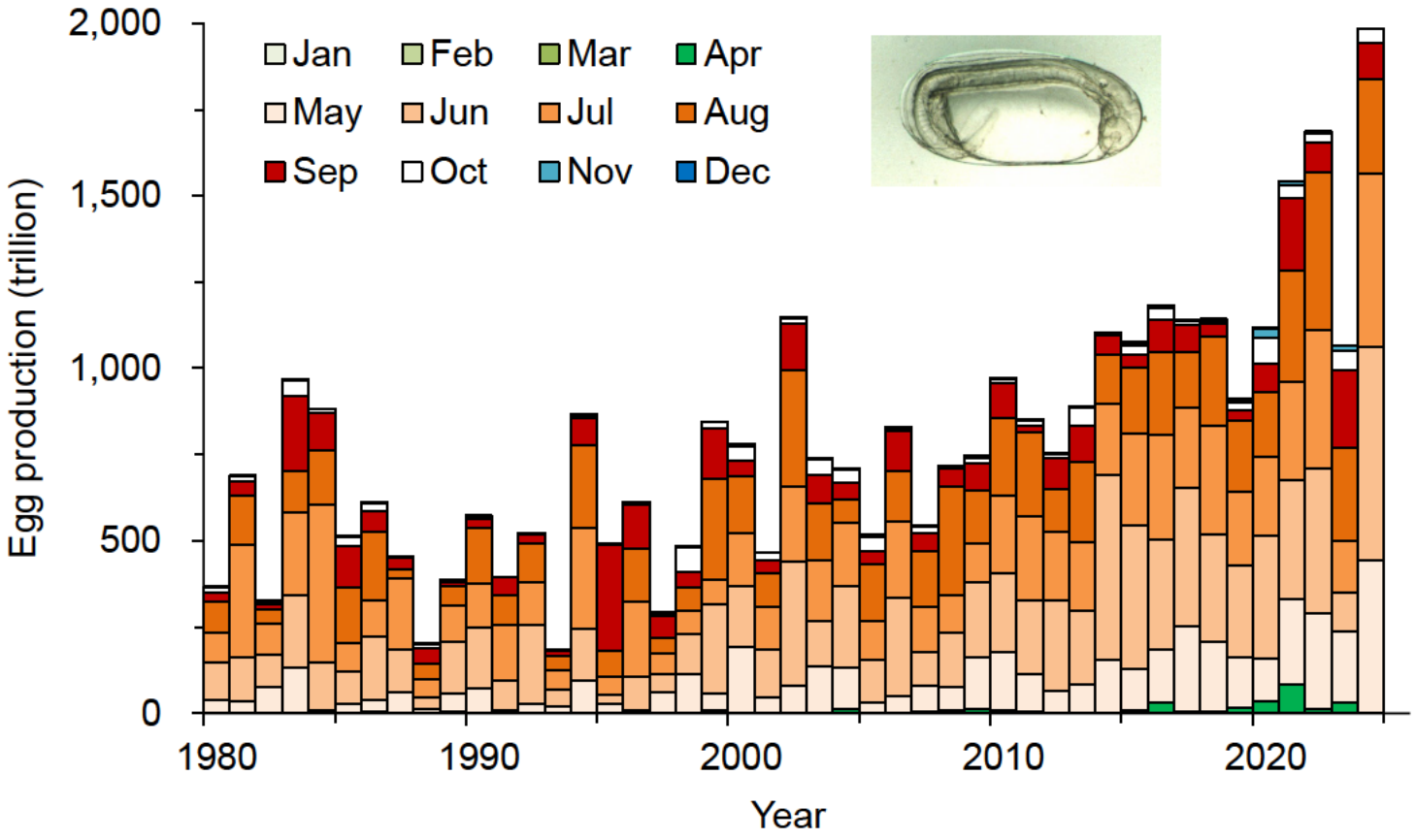
1. Add graphs for monthly catch trends; check seasonal/historical changes. → 2020: Stable Catch of *Katakuchi-iwashi* Since 2000



➢ Responses to Questions and Comments from Prof. Yamakawa

2-1. Show monthly spawning trends

→ **Main spawning season is from May to September.**



Planned to be included as a figure in next fiscal year's stock assessment report.

➢ Responses to Questions and Comments from Prof. Yamakawa

2-2. Validate weighted M calculation.

There are no available resource index values by month and age.
→ We will estimate using weighted M values based on the number of catches for each year from 1981 to 2023.

The formula is as follows:

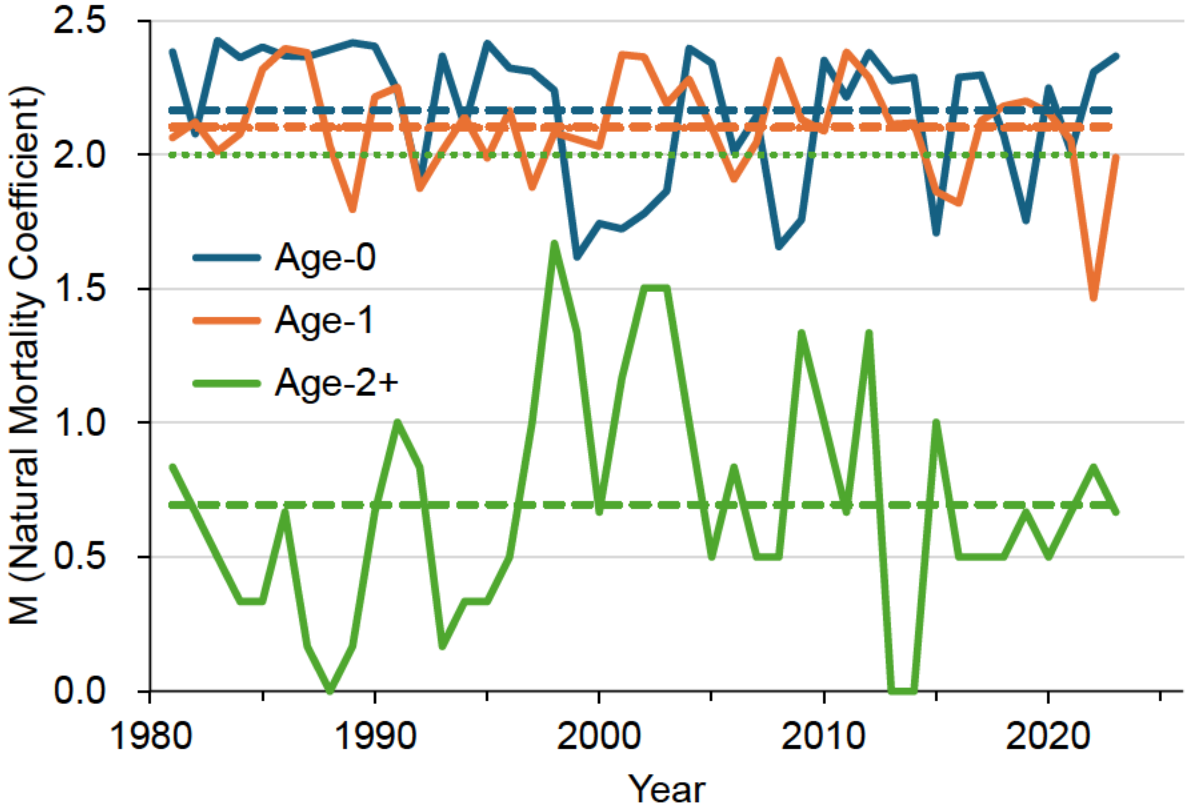
$$\text{Weighted Average} = \sum (w_i \times x_i) / \sum w_i$$

Where:

- x_i: M values for each month and month-age group
- w_i: number of catches for each month and month-age group

➢ Responses to Questions and Comments from Prof. Yamakawa

2-2. Validate weighted M calculation



Weighted M ——

Ages-0 and Ages-1: nearly equal to current setting

Age-2+: values differ greatly → Impact on stock estimates: to be examined

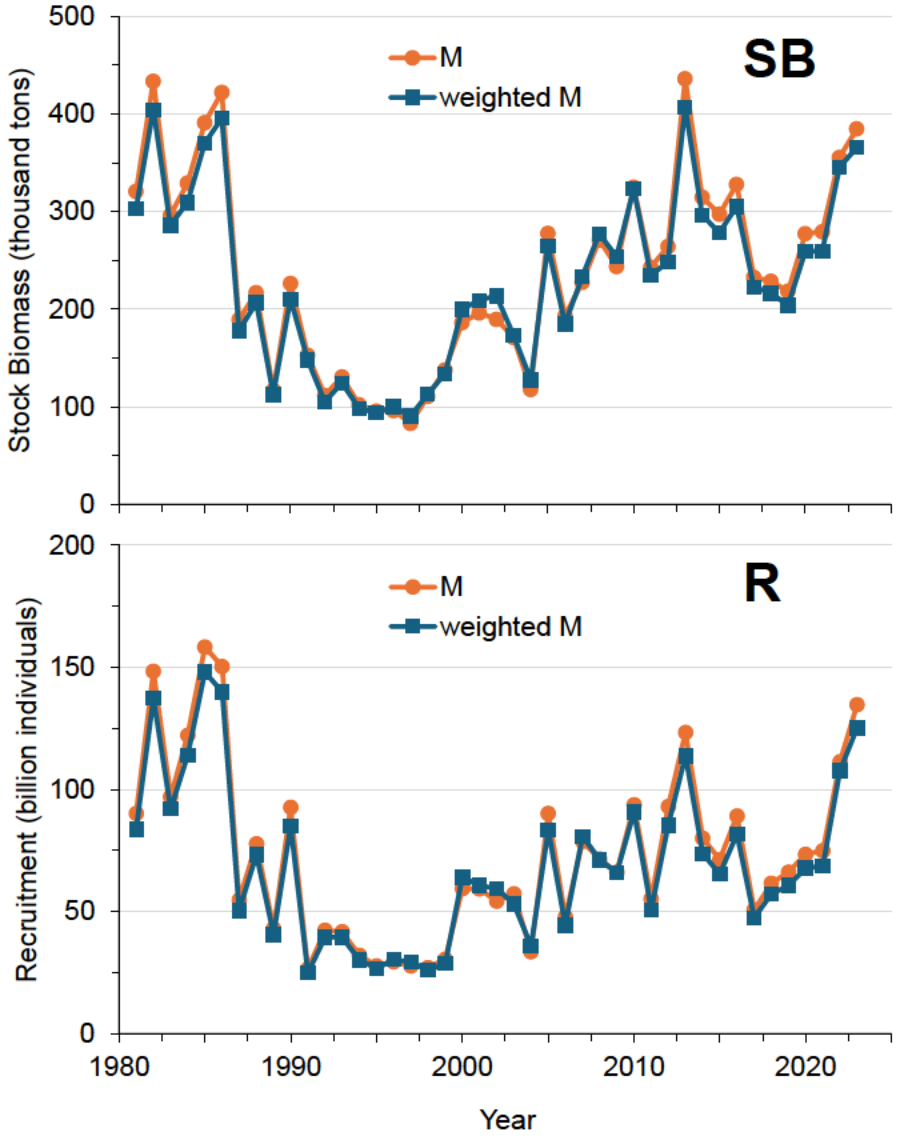
		Age-0	age-1	age-2+
Simple average	·····	2.1	2.1	2.0
Weighted average	----	2.2	2.1	0.7

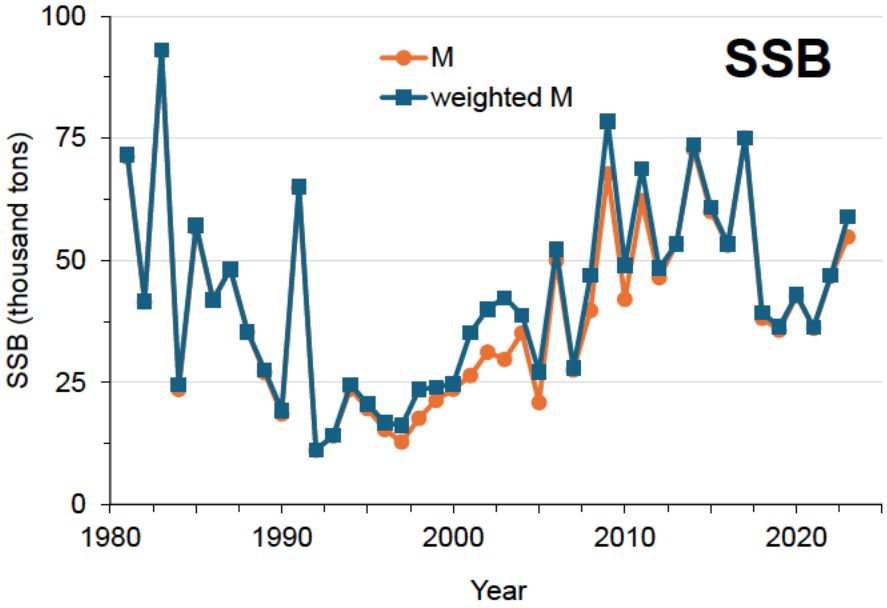
Comparison of M values

(Simple average: Current setting vs Catch-at-number weighted)

➢ Responses to Questions and Comments from Prof. Yamakawa

2-2. Validate weighted M calculation





Ages-0, 1 and 2+

Simple M : 2.1, 2.1 and 2.0

Weighted M : 2.2, 2.1 and 0.7

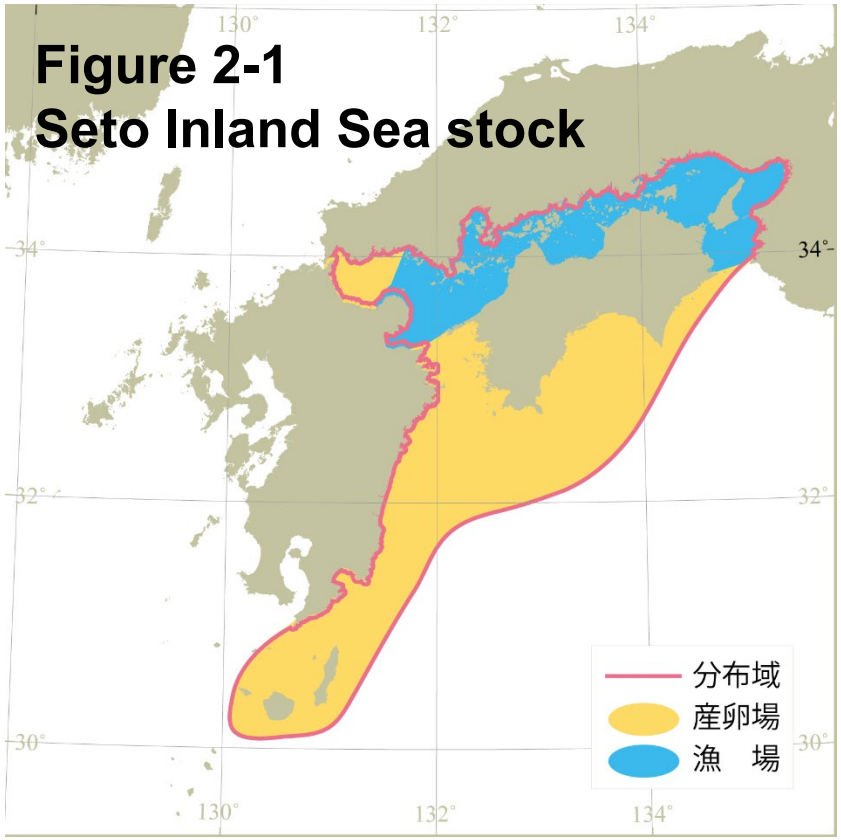
→ VPA results: No major differences

Comparison of VPA results by differences in M

➢ Responses to Questions and Comments from Prof. Yamakawa

3-1. Clarify interaction with Pacific stock. To what extent is the interaction with the Pacific stock considered to occur?

→ The degree of exchange with the Pacific stock is unclear, and no quantitative assessment is available.

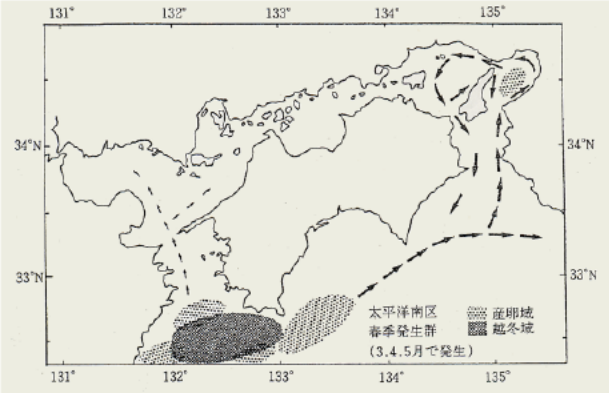


➢ Responses to Questions and Comments from Prof. Yamakawa

3-1. Clarify interaction with Pacific stock. To what extent is the interaction with the Pacific stock considered to occur?
→ As mentioned on the previous slide

➢ **Related question from Prof. Yamakawa on interaction with Pacific**
Clarify interaction with Pacific stock. To what extent is the interaction with the Pacific stock considered to occur?
→ Previous studies indicate interaction with the Pacific coast.

1. Migration patterns for Japanese anchovy of Southern Pacific spring spawning group



: Spawning ground

: overwintering area

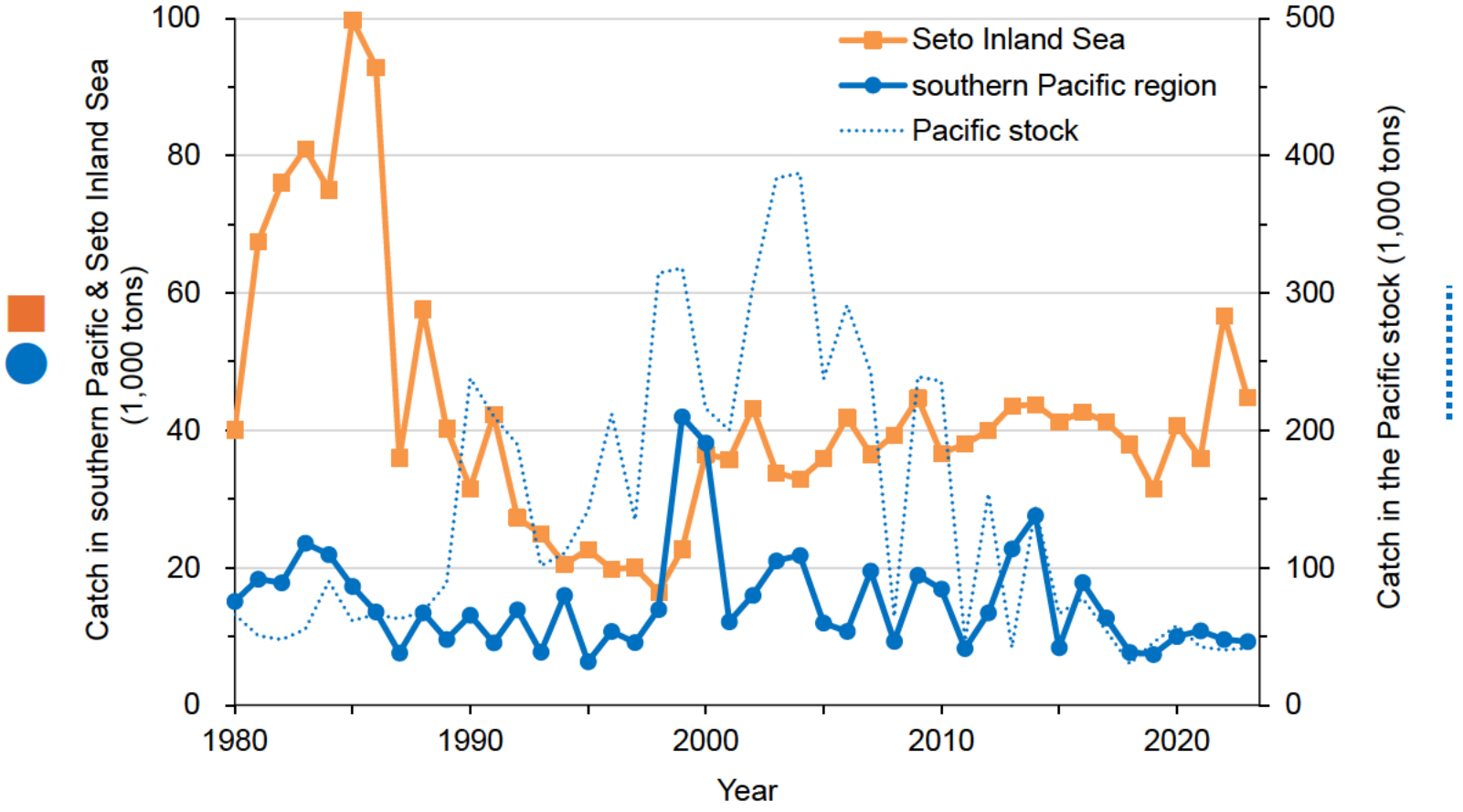
Figure reproduced from Takao (1990)

2. Changes in shirasu fishing grounds suggest that larval anchovies enter from the Pacific coast. (Horiki 1971, Takao 1975, Saiura & Takeda 2001, Gosho 2003)

➢ Responses to Questions and Comments from Prof. Yamakawa

3-2. Compare fluctuation patterns.

→ Stock biomass *in the southern Pacific* is unknown, so comparison is not possible. Instead, a comparison was made using catch data.

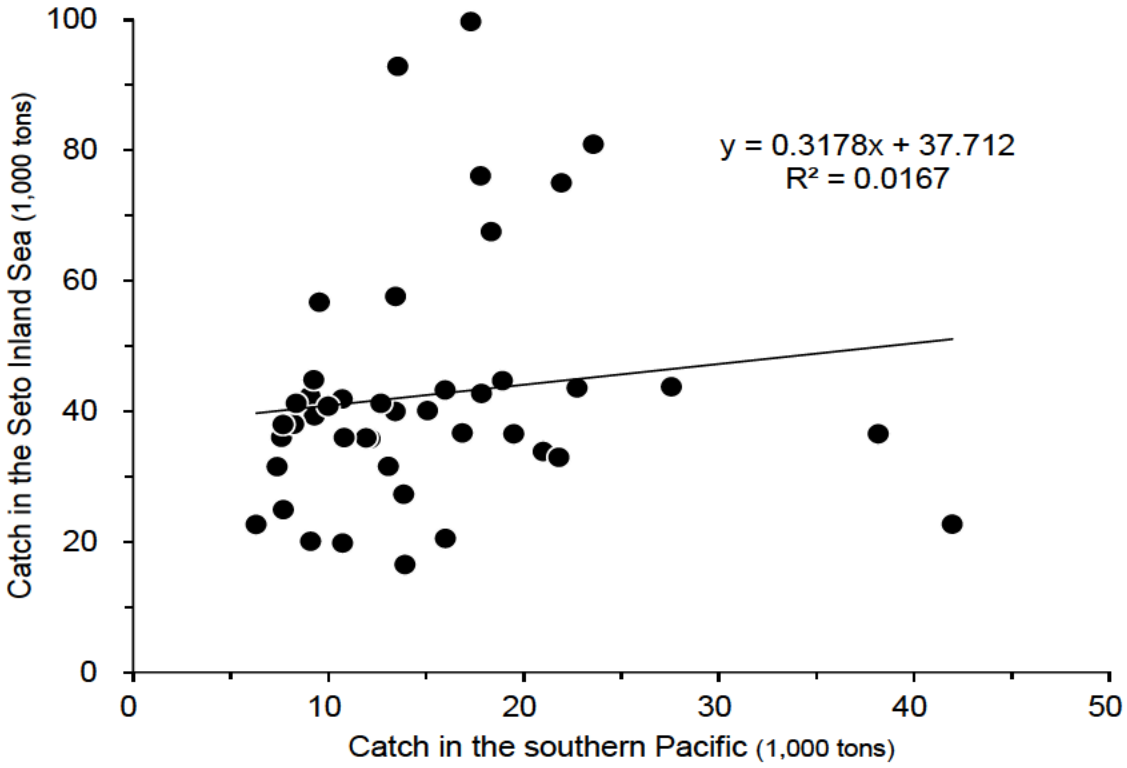


***Southern Pacific* catch is part of the Pacific stock.**

➢ Responses to Questions and Comments from Prof. Yamakawa

3-2. Compare fluctuation patterns.

→ Stock biomass *in the southern Pacific* is unknown, so comparison is not possible. Instead, a comparison was made using catch data.

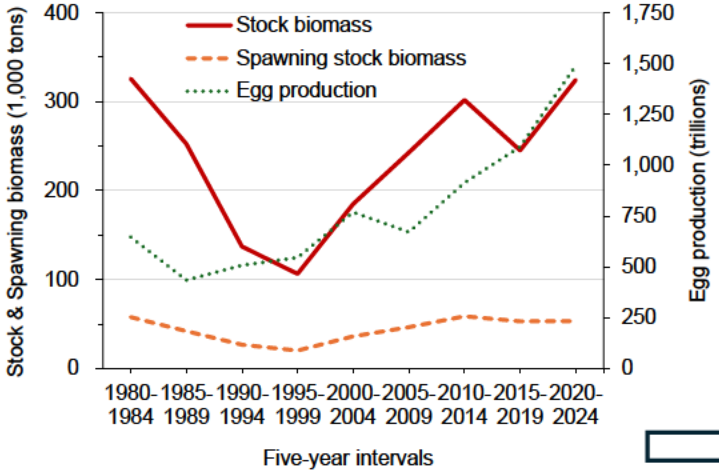


Catch fluctuations in the southern Pacific and Seto Inland Sea seem inconsistent.

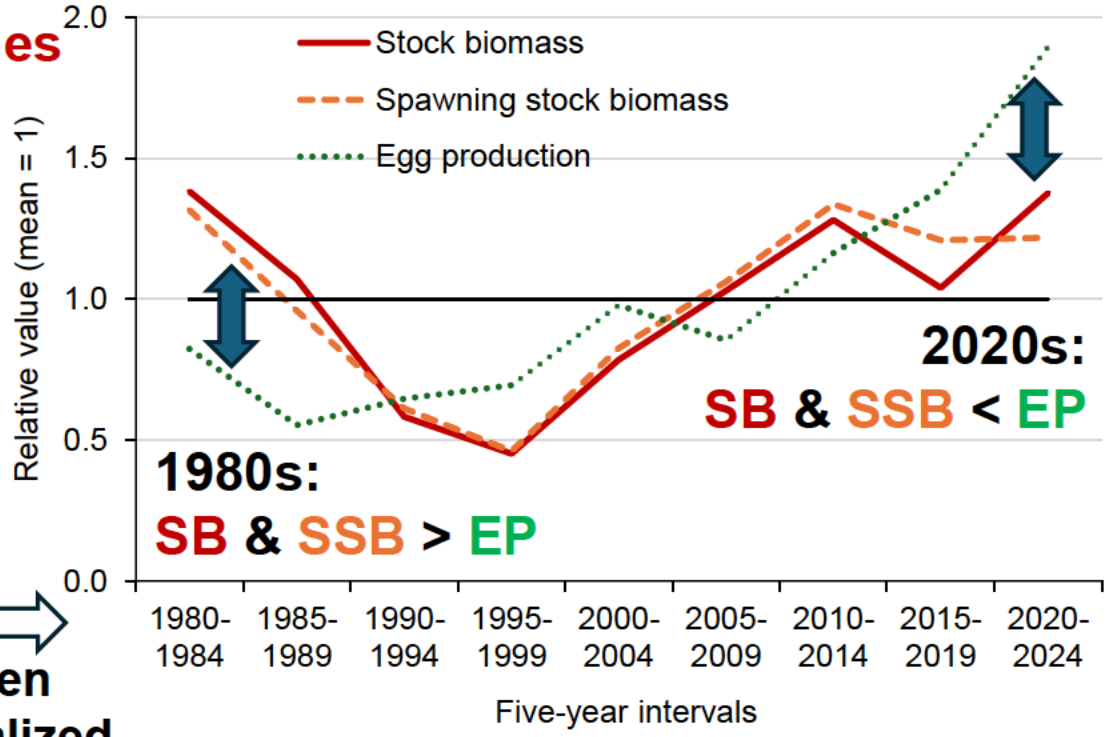
➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?

→ Compare the individual values based on five-year averages.



When normalized



→ Similar trends in stock biomass (SB) and spawning stock biomass (SSB), different from egg production (EP).

➢ Responses to Questions and Comments from Prof. Yamakawa

4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

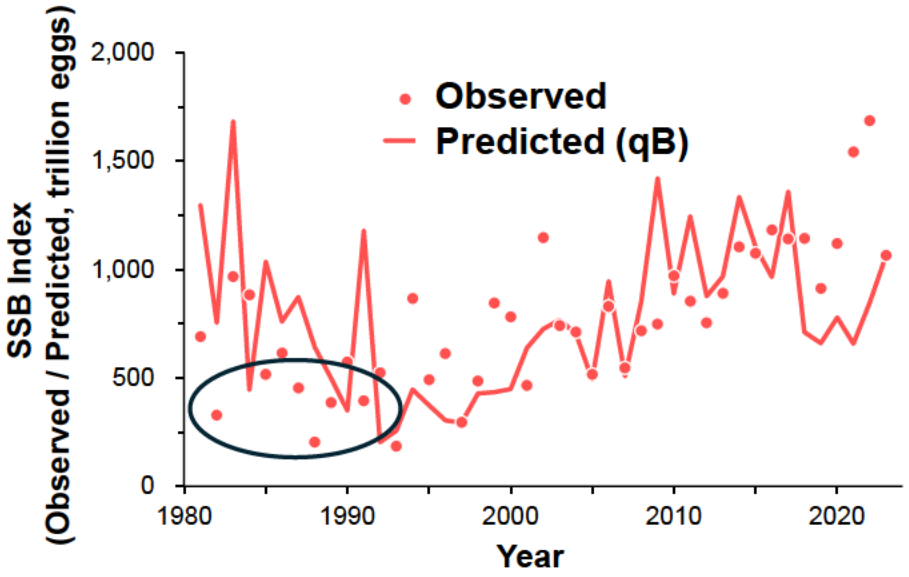


Fig. S2-5. SSB index

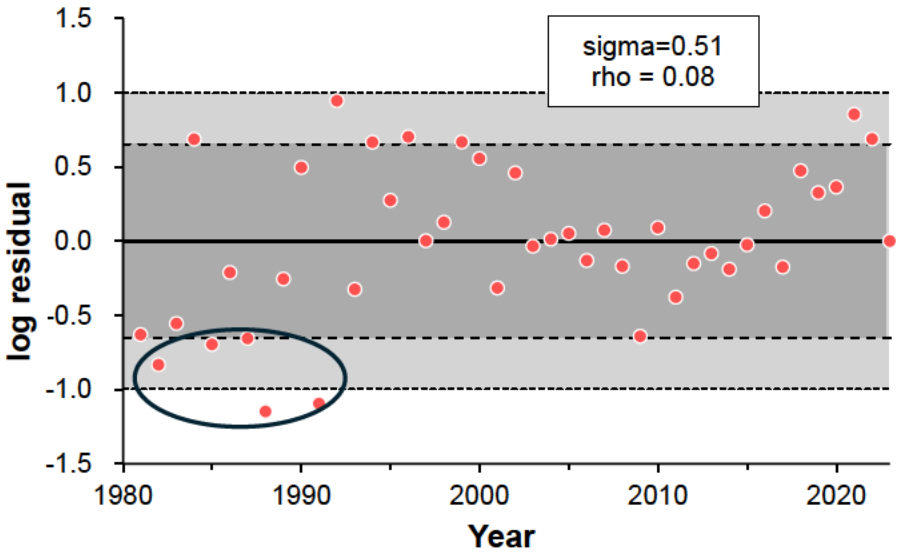


Fig. S2-6. Log residuals

Prof. Yamakawa presented five hypotheses to address this question.

➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?

4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Prof. Yamakawa's Five Hypotheses

1) Overestimation of age-1 and age-2+ catch in the 1980s

2) Bias from fishing practices and effort

3) Pacific stock interactions & distribution/migration shifts

4) Poor spawner condition (food shortage, high sardine abundance)

5) Higher natural mortality (age-0) in 1980s

➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?
4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Prof. Yamakawa's Five Hypotheses
1) Overestimated age-1 and age-2+ catch in 1980s
Catch estimates for age-1 and age-2+ in the 1980s may have been overestimated.

→ The estimation method itself—for age-specific catch numbers and catch weight—was applied consistently using all available information.
→ The likelihood of methodological issues does not appear to be high.
→ Further examination may still be possible.

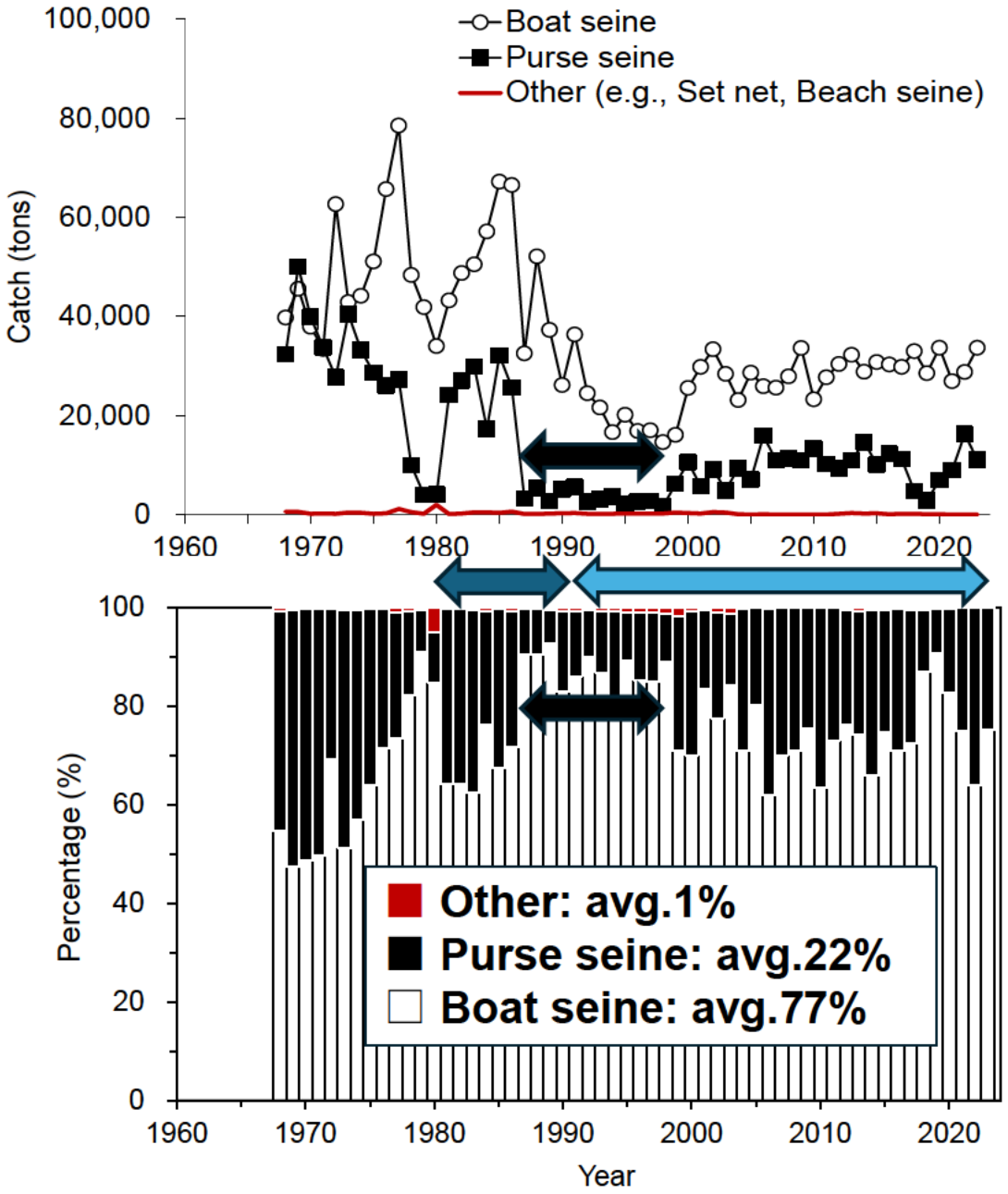
➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?
4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & 2-6)

Prof. Yamakawa's Five Hypotheses
2) Bias from fishing practices and effort
Fishing practices and fishing effort were significantly different in the 1980s compared to later decades. The differences in fishing practices and effort may have led to misestimated stock size and exploitation rate.

→ Unfortunately, no data is available to show changes in fishing effort for *Katakuchi-iwashi* fishery. Changes in fishing practices shown earlier; repeated in next slide.

Catch of *Katakuchi-iwashi* in the Seto Inland Sea



Catch weight by fishing method (tons)

- **Catch by purse seine declined temporarily around 1990;**

but

- **Timing does not match the mismatch between SB/SSB and EP**

Catch composition by fishing method

➢ Responses to Questions and Comments from Prof. Yamakawa

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4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Prof. Yamakawa's Five Hypotheses
3) Pacific stock interactions & distribution/migration shifts
Interactions with the Pacific stock and possible changes in distribution/migration patterns affected estimates.

→ Unfortunately, no data are available on changes in spatial distribution or migratory behavior.
This stock is likely influenced by the Pacific stock. However, the reason for low spawning output despite high stock and spawning stock biomass in the 1980s remains unclear.

➢ Responses to Questions and Comments from Prof. Yamakawa

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4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Prof. Yamakawa's Five Hypotheses
4) Poor spawner condition (food shortage, high sardine abundance)
Poor nutritional condition of spawners in the 1980s due to food shortage caused by high sardine abundance.
Were poor condition, slow growth, delayed maturation, or low fecundity observed?

➢ Responses to Questions and Comments from Prof. Yamakawa

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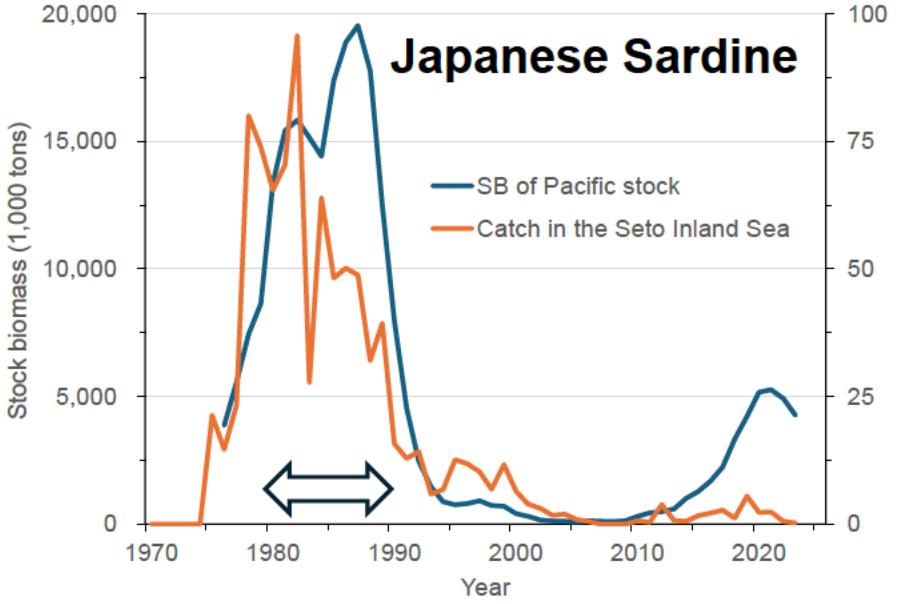
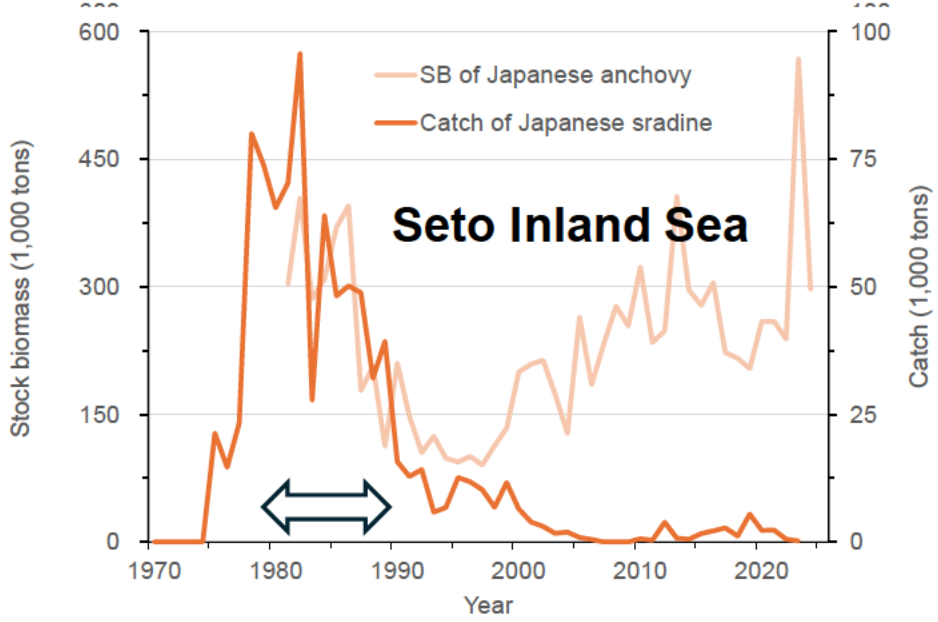


1980s Japanese Sardine: High Pacific SB & Seto Catch



1980s Seto Inland Sea: High Anchovy SB & Sardine Catch

In the 1980s, Japanese sardines were abundant in the Seto Inland Sea and may have competed with anchovies there.

➢ Responses to Questions and Comments from Prof. Yamakawa

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Prof. Yamakawa's Five Hypotheses
4) Poor spawner condition (food shortage, high sardine abundance)
Poor nutritional condition of spawners in the 1980s due to food shortage caused by high sardine abundance.
Were poor condition, slow growth, delayed maturation, or low fecundity observed?

→ Unfortunately, these declines have not been fully examined; body condition may be verifiable. This is an interesting research aspect but left for future work.

➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?
4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Prof. Yamakawa's Five Hypotheses
5) Higher natural mortality (age-0) in 1980s
Higher natural mortality of age-0 fish in the 1980s vs later decades (*related to Hypothesis 4*).

→ No data on long-term age-0 mortality.
→ Even if true, it doesn't explain low egg production.

➢ Responses to Questions and Comments from Prof. Yamakawa

4-1. Why did spawning remain similar in the 1980s and 1990s despite high stock in the 1980s?

4-2. 1980s: Systematic gap between index and predictions — why? (See Fig. S2-5 & S2-6)

Possible Explanations

1. Accuracy issues in catch-at-number calculations
2. Changes in fishing pressure/practices
3. Changes in spawning ecology

Future Work

1. Re-examine data and estimation methods
   - ALK using Multinomial Logistic Regression
2. Investigate changes in fishing practices and effort dynamics
   - Identify their drivers
3. Analyze historical variation in body condition

➢ Responses to Questions and Comments from Prof. Yamakawa

5. Why high recruitment with low spawning in 1980s? Survival or bias?

- It is possible that survival rate until recruitment was high, but the details remain unclear.

- In addition, high fishing pressure on age-0 fish and the large catch of age-0 fish may also explain why recruitment is estimated to be high (based on retrospective VPA calculations).

- Both possibilities remain; details unclear.

➢ Responses to Questions and Comments from Prof. Yamakawa

6. Causes of systematic bias in retrospective analysis; effect of excluding 1980s.

- Catch has not increased despite very high SSB in recent years.
- SSB-based VPA tuning inflates recent SSB and previous cohorts.
- Tuning effect fades the next year
  → estimates rely on catch
  → SSB was overestimated.
- Known issue; no effective solution.
- Excluding 1980s data does not remove this systematic bias.

➢ Responses to Questions and Comments from Prof. Yamakawa

7. *Shirasu* catch > SSB: need to review estimates, M, and possible Pacific

- Intensive *Shirasu* fishing; Age-0 fish account for a large share of the catch.
  → Strong fishing pressure on early life stages.

- Given this stock structure, cases where *Shirasu* catch exceeds SSB can occur.

Future Work

- Underestimation of SSB cannot be ruled out.
  → Further review of M values is needed; evaluation is difficult and requires an FRA-wide approach.

- If SSB is not underestimated:
  → Possible contribution of *Shirasu* originating from the Pacific stock must be considered.

➢ Responses to Questions and Comments from Prof. McAllister

1. **VPA confidence intervals:** Recommended to present

2. **Stock–recruitment relationship:**
   Use non-HS models or include autocorrelation

3. **Probabilistic statements:** e.g., 2023 F vs. Fmsy, stock trends

4. **SSB–egg production relationship**
   - Include equation & R-squared (R^2)
   - Check log-residual autocorrelation; $\rho = 0.08$—too small?

5. **Other points**
   - Predation: Any seabird predation?
   - Fishing effort: Why not measurable?
   - SPR definition: spawning per recruit vs. spawning potential ratio
   - Add numbering to Kobe plot & summary tables
   - Key considerations when applying VPA/SCA

➢ Responses to Questions and Comments from Prof. McAllister

1. VPA confidence intervals: Recommended to present

→ As noted in the response to My initial response 1:

- **Not mandatory in current FRA assessments; inclusion is left to each stock assessor.**

- **For this stock, egg production is used as the tuning index, and CIs can be shown with the suggested method.**

→ To be considered in next year's assessment.

➢ Responses to Questions and Comments from Prof. McAllister

2. Stock–recruitment relationship:

Use non-HS models or include autocorrelation

→ According to the response to My Initial Questions 2

• Followed the FY2024 SR Relationship Guidelines (FRA-SA2024-ABCWG02-05)

• Examined: HS, RI, and BH models

• Evaluated with/without autocorrelation

Analysis for this Stock (Kono et al. 2022, FRA-SA2024-ABCWG02-05)

• Conducted in 2022, using data up to 2021

• Compared 15 SR models

• Final selection:

Hockey-Stick model

Two-step estimation

No autocorrelation

➢ Responses to Questions and Comments from Prof. McAllister

2. Stock–recruitment relationship:

No AR

Least Absolute Deviations

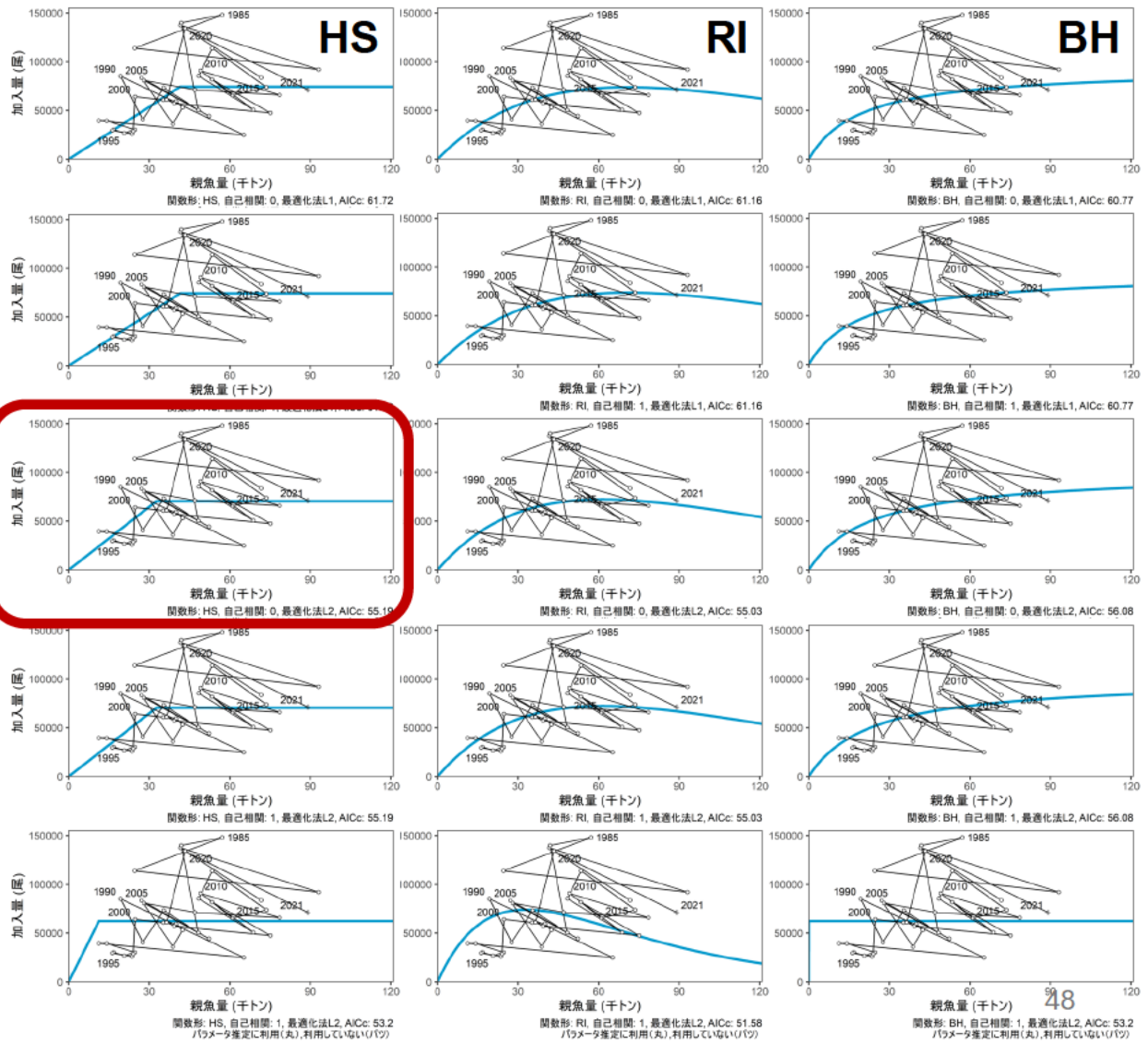
AR_two-step method

No AR

Least Squares

AR_two-step method

AR_joint method



➢ Responses to Questions and Comments from Prof. McAllister

2. Stock–recruitment relationship:

Use non-HS models or include autocorrelation

No.	SR Type	Optimization Method	Auto-correlation	ρ Estimation Method	ρ	AICc	a	b	SD	Recruitment at Low SSB
1	HS	LAD	No	-	0.00	61.72	1.790	41477	0.454	OK
2	HS	LAD	Yes	Two-step	-0.14	61.72	1.790	41477	0.444	OK
3	RI	LAD	No	-	0.00	61.16	2.834	1.41.E-05	0.446	OK
4	RI	LAD	Yes	Two-step	-0.01	61.16	2.834	1.41.E-05	0.440	OK
5	BH	LAD	No	-	0.00	60.77	4.836	5.19.E-05	0.449	OK
6	BH	LAD	Yes	Two-step	0.09	60.77	4.836	5.19.E-05	0.442	OK
7	HS	LS	No	-	0.00	55.19	2.158	32678	0.444	OK
8	HS	LS	Yes	Two-step	0.02	55.19	2.158	32678	0.438	OK
9	HS	LS	Yes	Joint	0.55	53.20	5.551	11225	0.418	NG
10	RI	LS	No	-	0.00	55.03	3.197	1.63.E-05	0.443	OK
11	RI	LS	Yes	Two-step	0.09	55.03	3.197	1.63.E-05	0.436	OK
12	RI	LS	Yes	Joint	0.63	51.58	6.104	3.04.E-05	0.409	NG
13	BH	LS	No	-	0.00	56.08	4.345	4.33.E-05	0.449	OK
14	BH	LS	Yes	Two-step	0.04	56.08	4.345	4.33.E-05	0.443	OK
15	BH	LS	Yes	Joint	0.55	53.20	1.95.E+09	31286	0.418	NG

SR type: Hockey-stick model (HS), Ricker model (RI), Beverton–Holt model (BH)

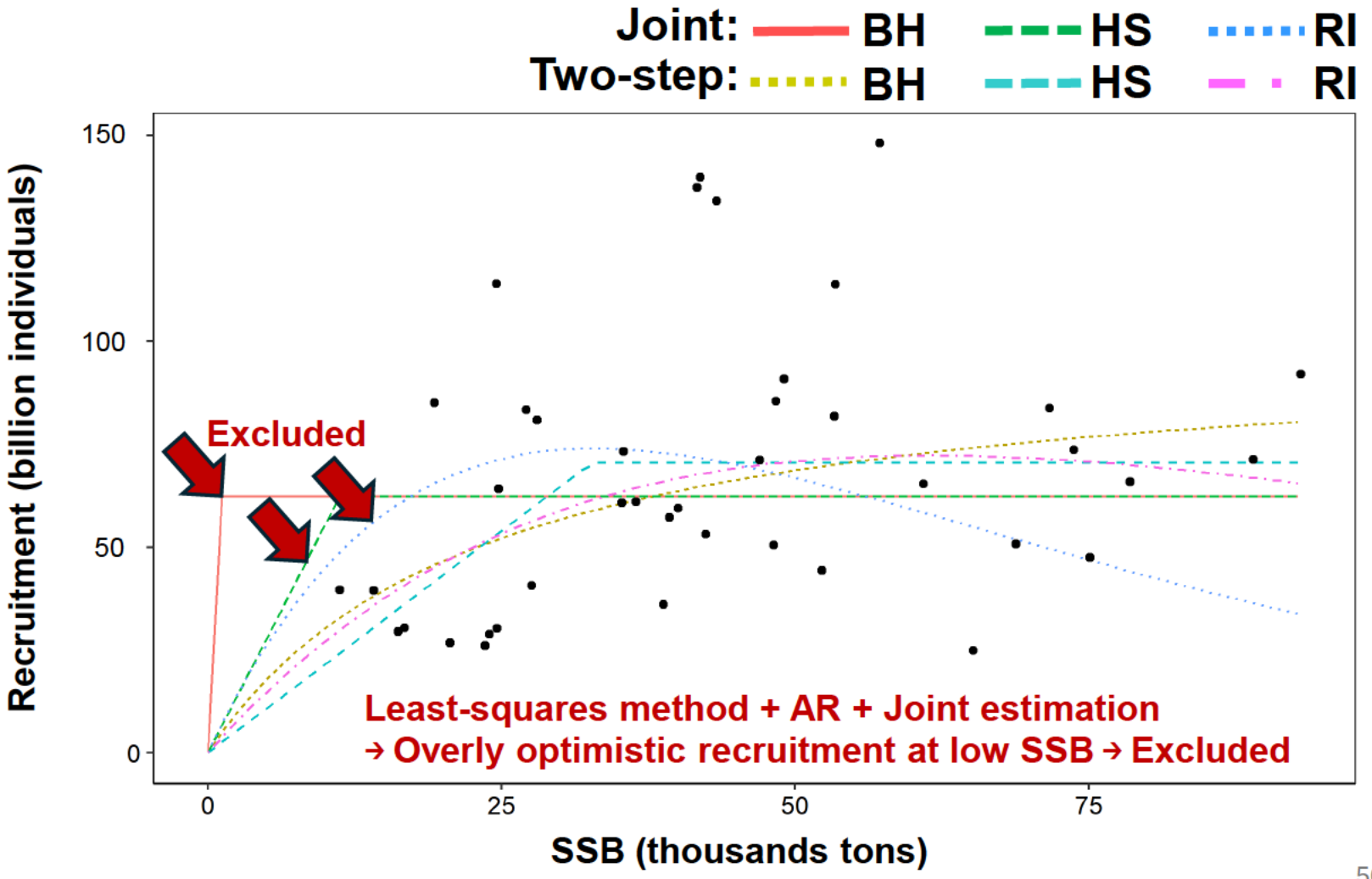
Optimization method: Least Absolute Deviations (LAD), Least Squares (LS)

ρ: Autocorrelation coefficient

➢ Responses to Questions and Comments from Prof. McAllister

2. Stock–recruitment relationship:

Use non-HS models or include autocorrelation



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➢ Responses to Questions and Comments from Prof. McAllister

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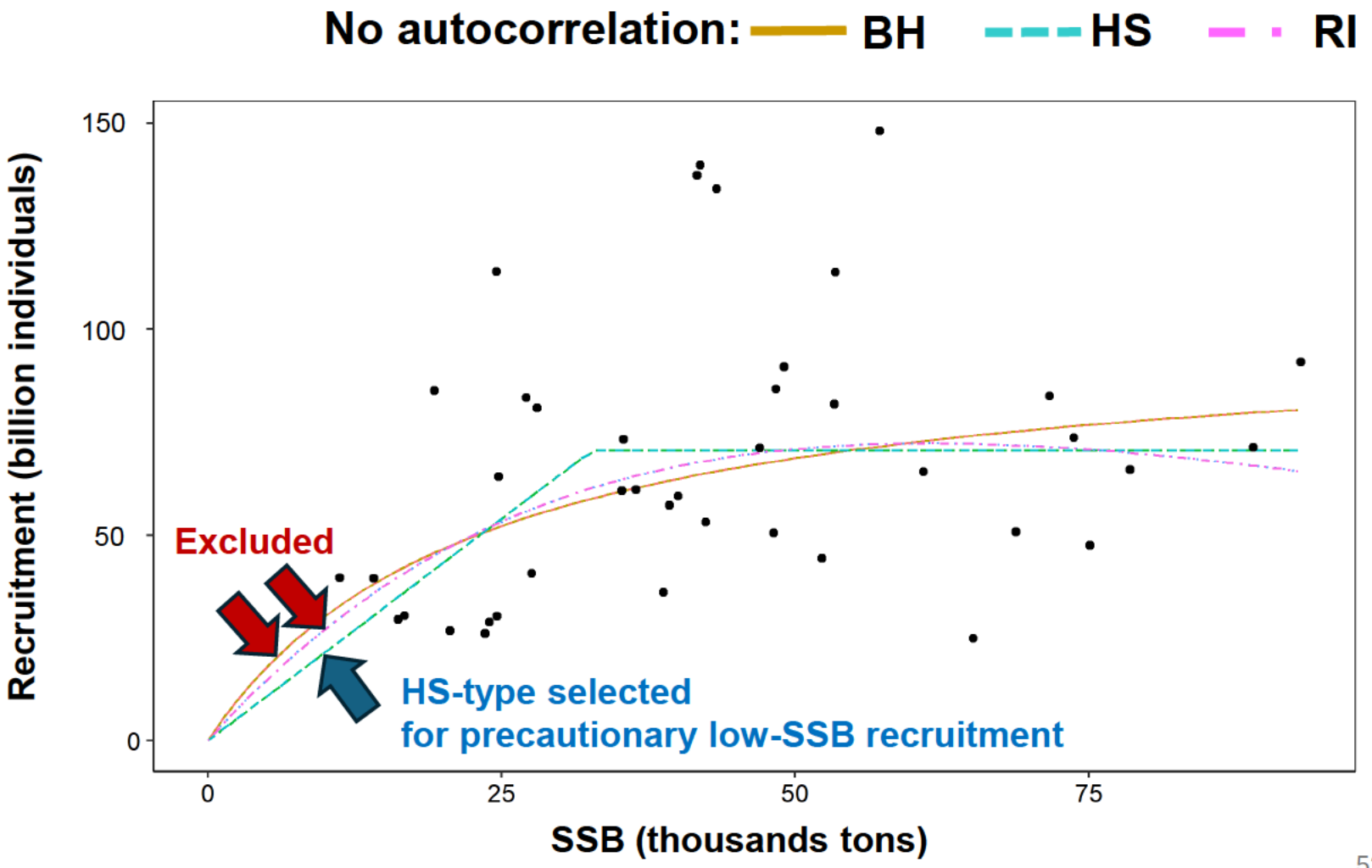


➢ Responses to Questions and Comments from Prof. McAllister

3. Probabilistic statements: e.g., 2023 F vs. Fmsy; stock trends

- **Present results as probabilities, not as point estimates.**

- **Present the probability that F (2023) is above or below Fmsy, rather than simply stating whether it is higher or lower.**

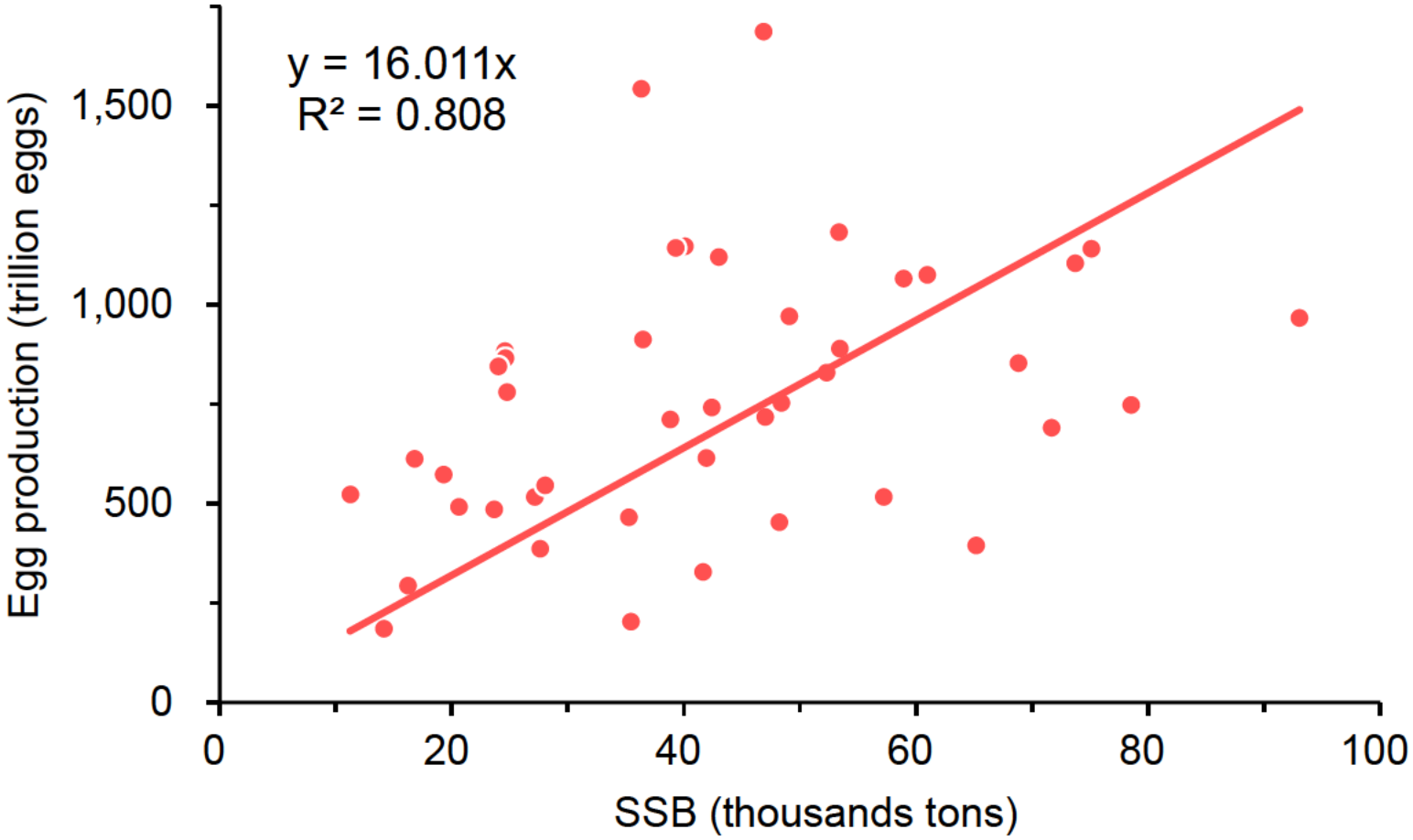
→ Current stock assessment: reports only point estimates
→ Future direction: requires discussion across the entire FRA

➢ Responses to Questions and Comments from Prof. McAllister

4-1. SSB–egg production relationship:

Include equation & R-squared (R^2)

→ As shown below, this will be included starting from next report.



➢ Responses to Questions and Comments from Prof. McAllister

4-2. SSB–egg production relationship:

Check log-residual autocorrelation; ρ = 0.08—too small?

→ Rechecked: no error and no autocorrelation

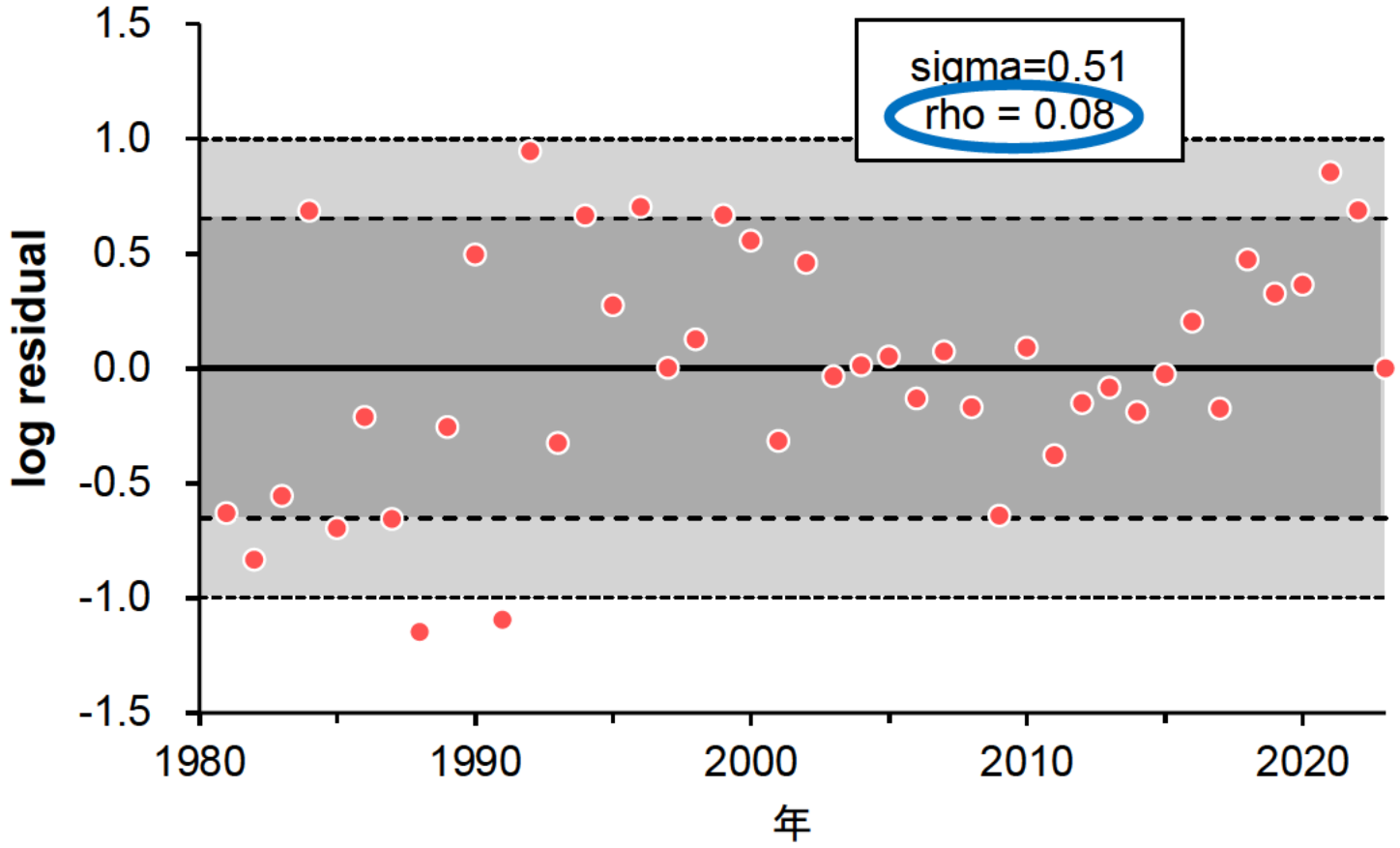


Fig. S2-6. Log residuals

➢ Responses to Questions and Comments from Prof. McAllister

5. Other points

- **Predation: Is avian predation observed?**

→ **Avian predation is also expected in the Seto Inland Sea; I will search for references.**

- **Fishing effort: Why can it not be identified?**

→ **There is no system to collect effort data; This point will be added to the report.**

- **SPR definition: spawning per recruit vs spawning potential ratio**

→ **Same answer as for Pacific Alfonsino.**

- **Numbering for the Kobe plot / summary table at the beginning.**

→ **To be considered across the Agency. This will be considered across the FRA.**

- **Comments on VPA/SCA (Statistical Catch-at-Age) and their application → Will consider them.**

➢ Future Work (Revisited)

- **Further review of natural mortality coefficient (M); requires a coordinated FRA-wide approach**

- **Incorporate re-examination of data; review estimation methods (e.g., creating ALK using Multinomial Logistic Regression)**

- **Assess changes in fishing practices and investigate underlying factors; Explore fishing effort dynamics**

- **Conduct historical analysis of body condition**

Thank you for your time and attention.