Stock Assessment for the Southwestern Sea of Japan Stock of Shotted Halibut (Fiscal Year 2024)

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Table of contents

General introduction

Ecology of shotted halibut

Distribution

- Widely distributed on the continental shelf waters around Japan; Mainly southwestern Sea of Japan

Maturation and Spawning

- Two years for males and three years for females
- Spawning season are almost from late Jan. to early Mar.

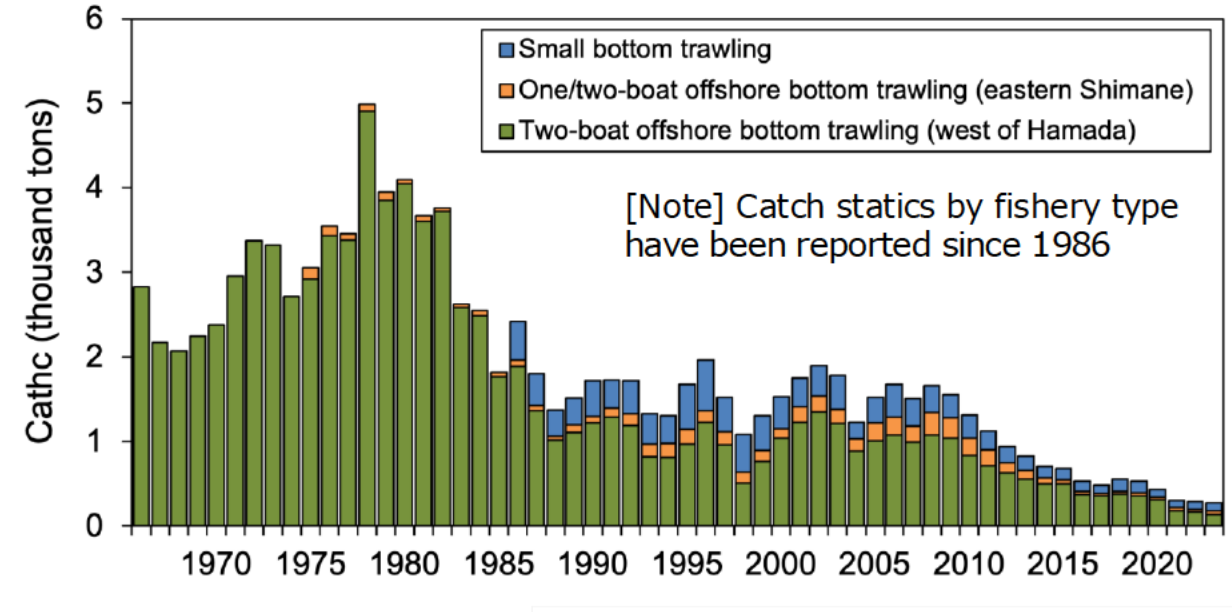
Lifespan

- Up to seven years

General introduction

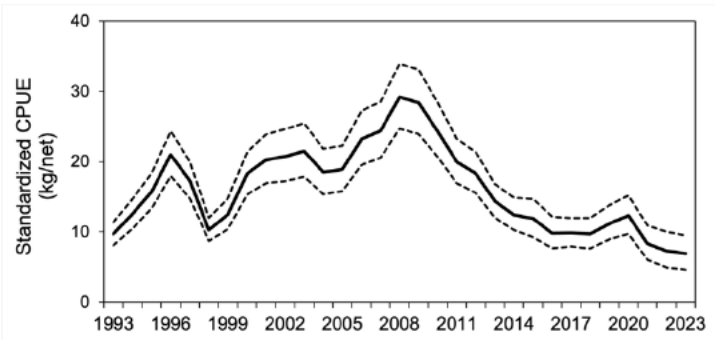
Fishery status

Trend in catch by fishery type



Standardized CPUE

Two-boat offshore bottom trawling in west of Hamada (1993–2023)



- Culturally popular fish in southwestern JP.
- Recruitment begins at age 1 (TL 15–18 cm)
- Age 3 and 4 are the primary targets
- Mainly caught by **offshore bottom trawling**, followed by **small bottom trawling**

Trend in catch

- Peaked at 5,000 ton in 1978
- **Declining trend over the long term**
- In recent years, the catch has declined to under 300 ton (275 ton in 2023)

Overview of stock assessment

Flow of stock assessment

Catch at age of stock (1993–2023)*1

*1: Data for calculating the catch at age is available from 1993.

↓ **Normal VPA** (M=0.35)

- Abundance at age
- Fishing mortality at age

↓ **Forward calculation**

- Abundance at age and SSB in 2024 ← **Stock recruit model**

↓ **Forward calculations, stock recruit model**

- Abundance at age and SSB after 2025, **Future forecast**

Overview of stock assessment

■ Catch at age

Commercial size category:
Uniform-sized fish, packed in fixed quantities per box

Monthly number of boxes by Commercial size category
(Offshore bottom trawl catches landed at Hamada Port*1)

*1: One of the major landing ports for stock

- Commercial size category-length key (annually updated)
- Age-length key (previously developed)
- Scaling up to the total **offshore bottom trawling** catch
- Weight correction

Provisional catch at age
(Catches for offshore bottom trawling)

- Scaling up, including **small bottom trawling** catch
- Weight correction

[Note]
CAA for small bottom trawling remains uncalculated owing to data limitations.

Catch at age
(Total catch for target fishery)

⟹ **VPA**

Overview of stock assessment

VPA results

Fig. 4-3. Stock biomass at age

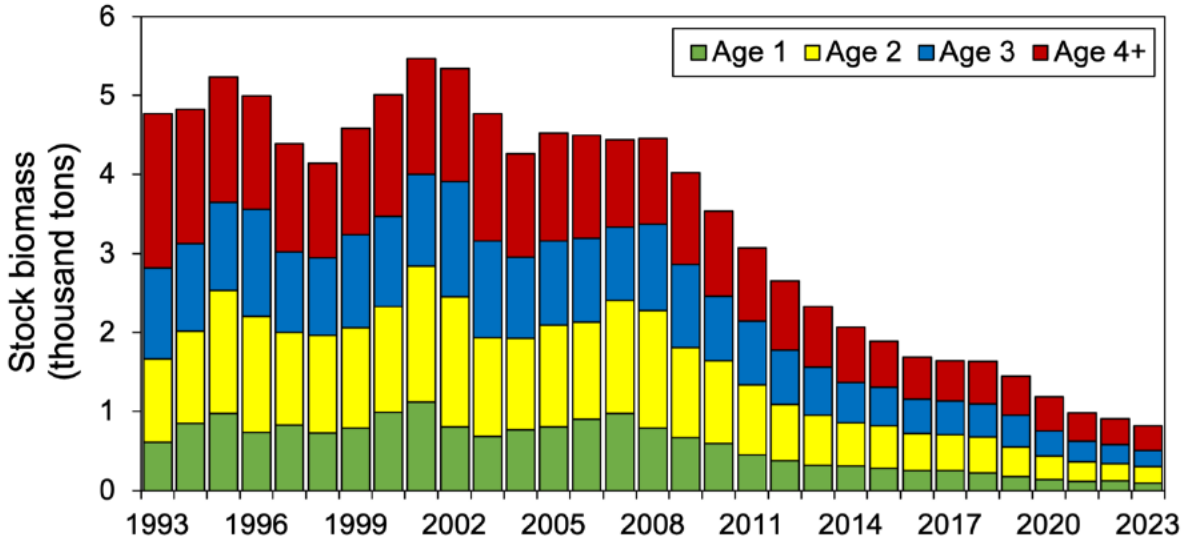
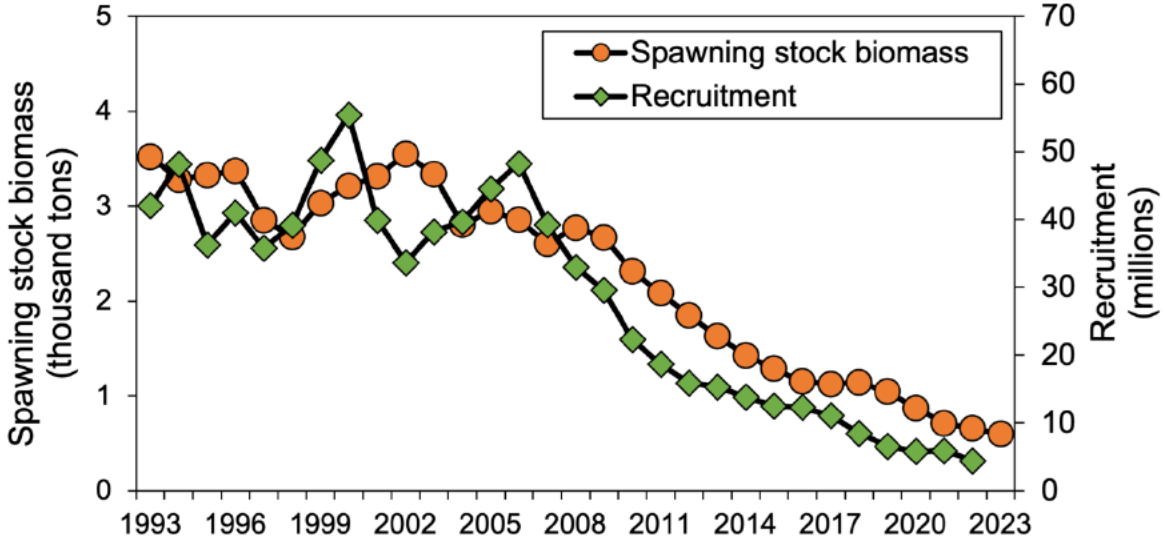


Fig. 4-4. SSB and Recruitment (age 1)

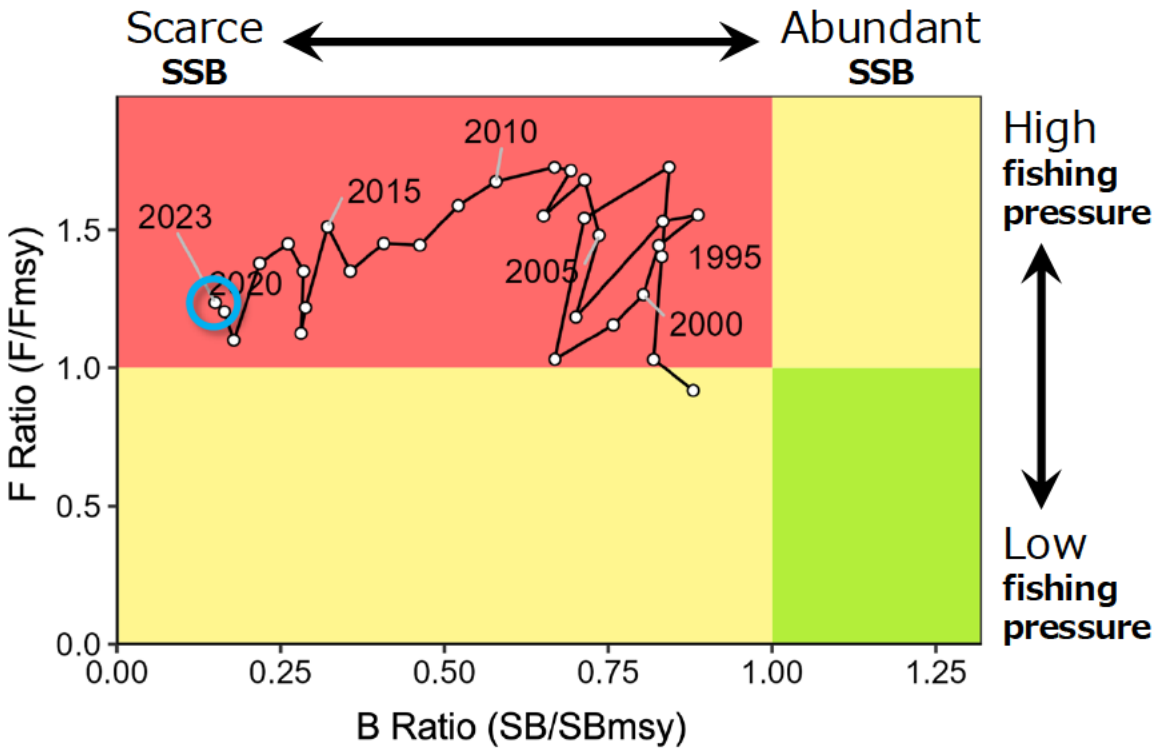


- Stock biomass at age that calculated by multiplying the abundance at age by average weight at age showing a decreasing trend
- SSB and Recruitment also showing a decreasing trend
- Even looking at recent years, the trend remains one of decline

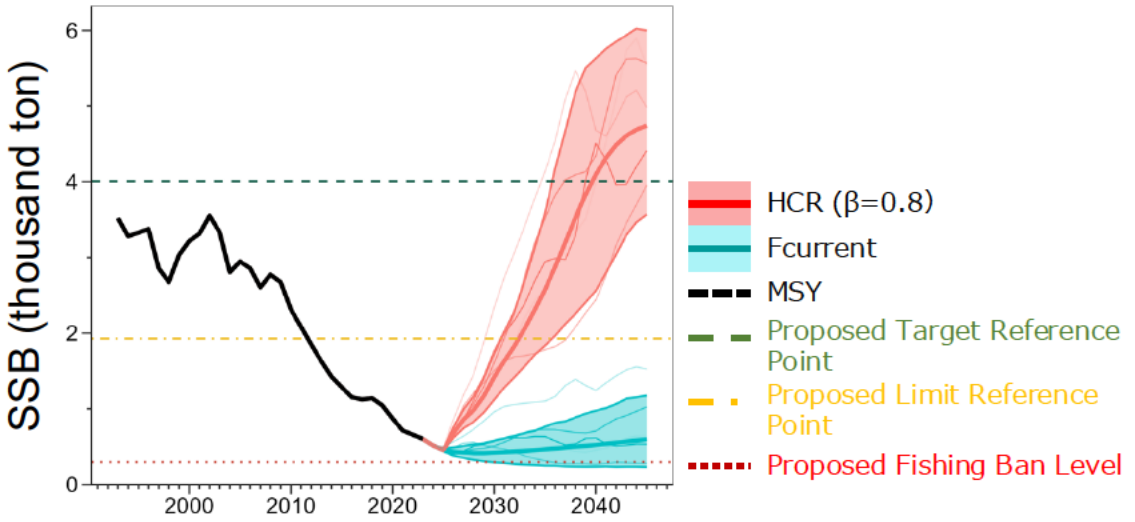
Overview of stock assessment

VPA results

Fig. 4-11. Kobe plot (modified)



Future projection (excerpt)



- Stock condition is **extremely poor**
  - High fishing pressure, and scarce SSB
- **MSY cannot be achieved under the current fishing pressure**

Response to Review

Overview of questions and comments

- *"Confidence intervals should also be provided for stock estimates."*
  + several similar comments.

- *"It is recommended that either the Beverton-Holt or Ricker stock recruit models be considered to replace the Hockey stick stock recruit model."*

- *"The use of a 4+ group in the VPA when the life span is 7 could lead to some inaccuracies in the stock assessment."*

- *"(Kobe plot) The first year in the time series should also be given a year label also."*
  + Comments on how to write the report.

- And more

Thank you for making the corrections to words and grammar.

Response to Review

Question

- *Is this referring to predation on shotted halibut?*

Reviewed report

(4) Predator-Prey Relationships

... The extent of predation is unknown (sic).

- Mistake in the translation.
- Correct: "**The predator of shotted halibut has not been identified.**"
- While the potential predators (*e.g.* cod, pinniped) has been reported in other areas, little is known about the predators of shotted halibut.

Response to Review

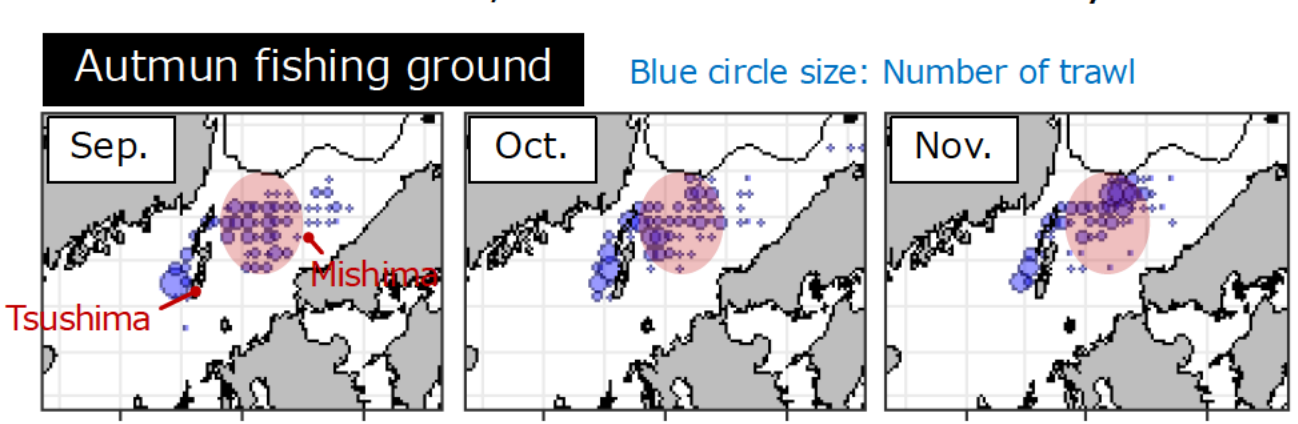
Question

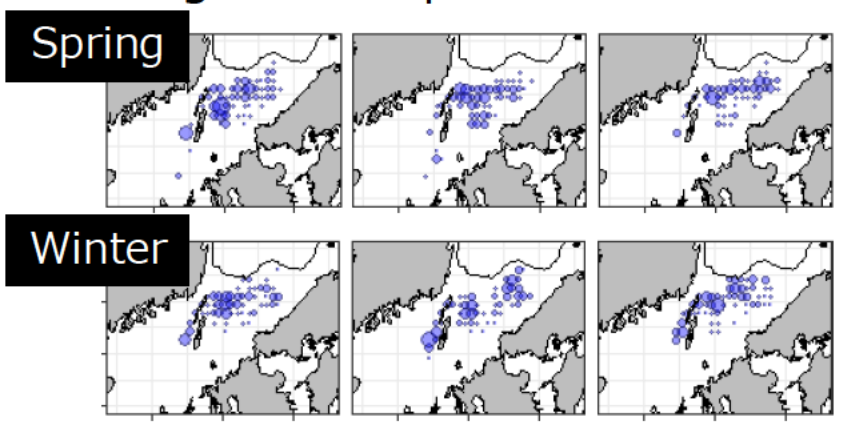
- *What types of sampling methods were used to draw these inferences about fish stock movements?*

Reviewed report

2. Ecology
(1) Distribution and Migration
… In areas east of Tsushima, they concentrate in northeastern Tsushima and northwestern Mishima waters in autumn, dispersing during other seasons.

- **We assume that stock movement can be monitored through fishery dataset**
- Fishing ground in autumn (main season for fishing) overlap with the main distribution of this stock
- In other seasons, this stock is landed as bycatch with no significant spatial bias.





Summer:
closed to fishing

Response to Review

Comments

- *Confidence intervals should also be provided for stock biomass estimates. This can be accomplished by bootstrapping the VPA.*
- *This and the next two statements of stock status could be made as probability statements if a bootstrap VPA method was applied.*

- **Normal VPA (*i.e.* without tuning by indices) was used in fiscal year 2024**
  - **It is challenging to provide confidence intervals using normal VPA models**

- It is possible to show the confidence interval using **Tuning VPA** via bootstrap method for abundance indices.
- Even though confidence interval via bootstrapping by assuming multinominal error in CAA is calculable in Normal VPA, the implementation remains preliminary.

Response to Review

- **Applicable to other similar comments as well.**

Comment

- *It may be preferable to revise the VPA method so that it allowed probabilistic statements to be made, e.g., here the probability that the SSB was declining could be stated.*

Reviewed report

Based on trends observed over the last five years (2019–2023), the SSB is determined to be in a "declining" trend .

Comments

- *Coefficients of variation could be added for estimated quantities in this table but would require the use of a bootstrap VPA method.*

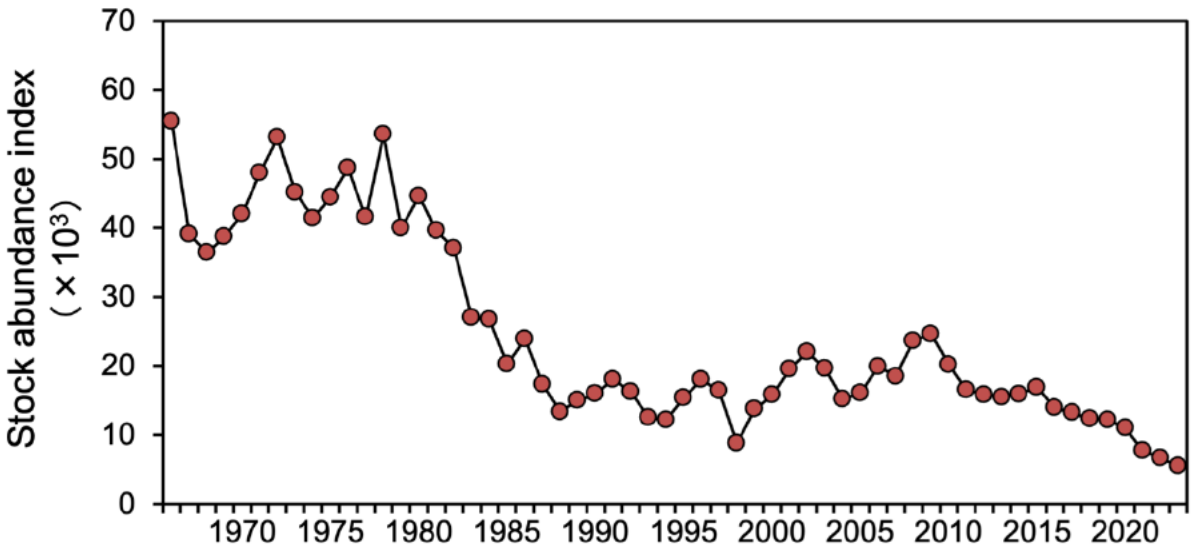
- *As noted above, it would be preferable to report also coefficients of variation (CVs) or confidence intervals alongside estimates of stock biomass, abundance, recruitment and fishing mortality rates from the VPA.*

Response to Review

Question

- *Could confidence intervals be provided for this abundance index also?*

Fig. 4-1. Trend in stock abundance index
(two-boat offshore bottom trawling, west of Hamada)



$$CPUE_{i,j} = \frac{C_{i,j}}{X_{i,j}}$$

$$Index = \sum_{i=1}^{I} \sum_{j=1}^{J} CPUE_{i,j}$$

where
C is catch weight,
X is number of tow,
i is month,
j is sub-fishing area

- **Non-model based index**
- It is technically possible to estimate the confidence intervals through random sampling of sub-fishing areas
- However, we must carefully consider their biological or statistical implications

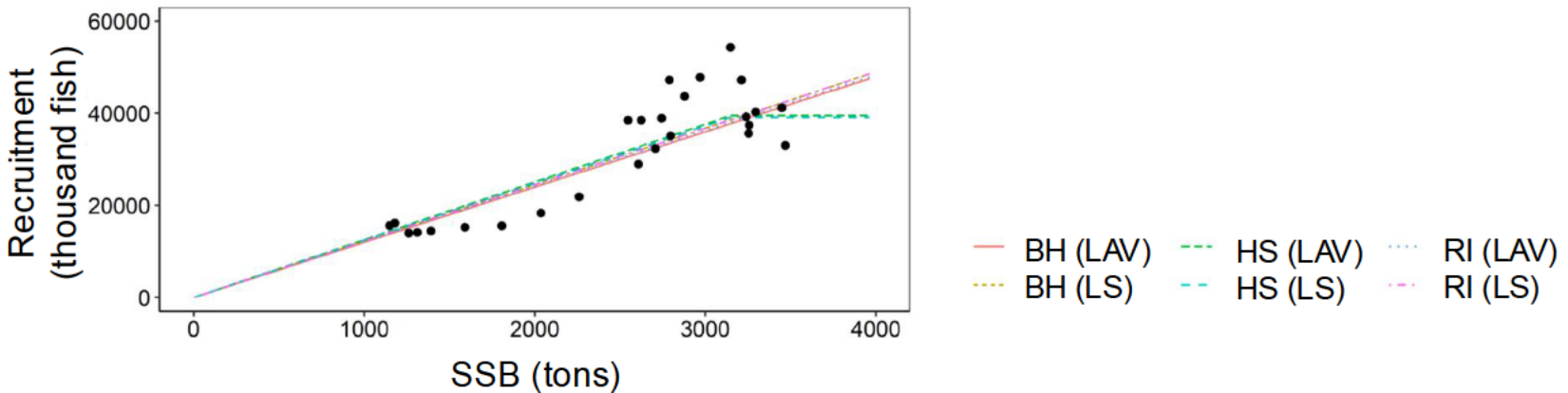
Response to Review

Comment

- *As noted for the other stock assessments, it is recommended that either the Beverton-Holt or Ricker stock recruit models be considered to replace the Hockey stick stock recruit model. These other two models have been found to have several advantages and superior attributes compared to the Hockey stick model.*

- **We selected HS model based on the results of applying and reviewing all three models**
- Current model had been selected by Yagi et al., 2021
  - No density dependence observed in dataset (SSB and Recruitment during 1993-2018)
  - For stocks with no apparent density dependence, the use of HS model is recommended to obtain realistic stock-recruitment relationships (Ichinokawa et al. 2017)

Result of the model reviewing (modified Yagi et al., 2021)

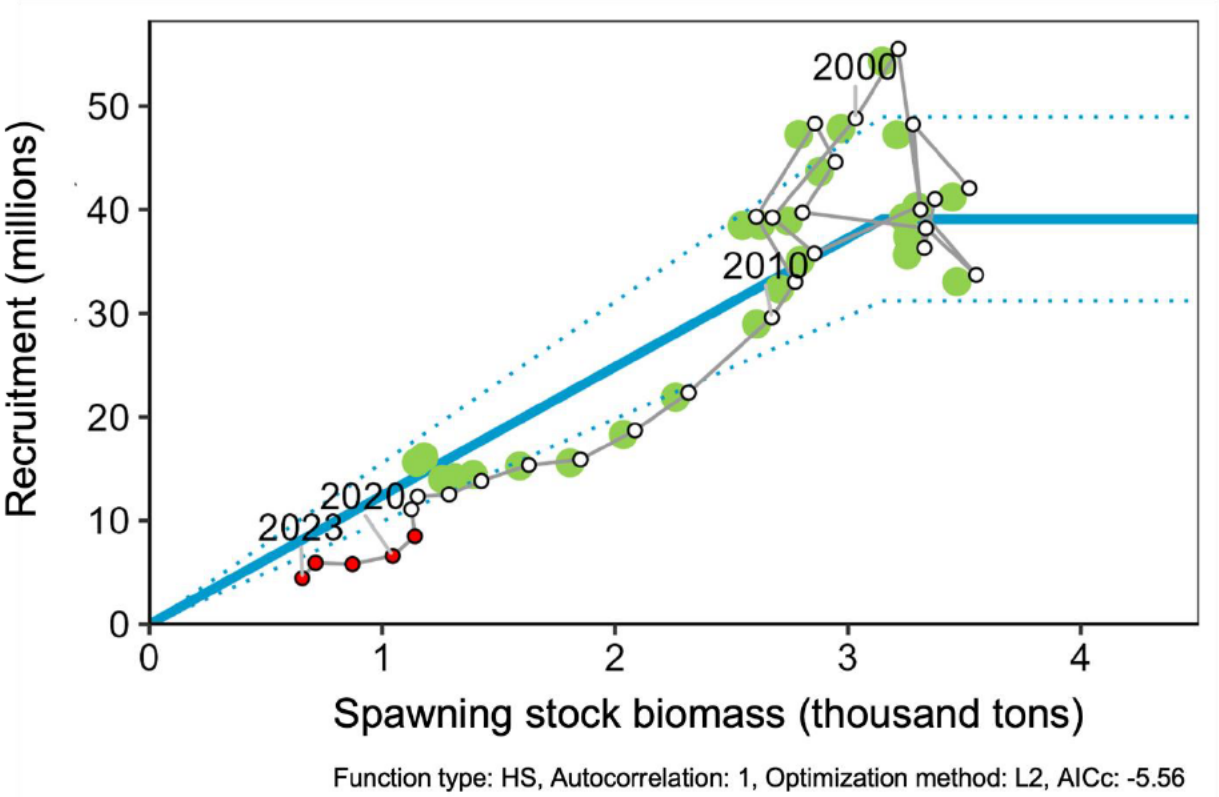


Response to Review

Comment

- *This is not a correct definition of confidence interval. If it is a 90% CI for the stock-recruit function, then it would be fine to call it a 90% confidence interval for the stock recruit function.*

Fig. 4-10. Relationship between SSB and Recruitment



- Mistake in the original text
- **The dotted lines show the 90% prediction interval for SSB and recruitment under the assumed stock-recruitment model**

Response to Review

Comments

- *A row could be added that gave the estimated Fmsy for this fish stock.*

- As you pointed out, including *Fmsy* makes the content much easier to follow
- However, the information to be included in summary table is **fixed by format for multiple stocks**
- The format has been renewed each year to make it easier to understand.

Metric	Value
SBmsy (Spawning Stock Biomass to achieve MSY)	4,000 tons
2023 SSB Level	Below SBmsy
2023 Fishing Pressure Level	Above Fmsy
2023 SSB Trend	Declining
Maximum Sustainable Yield (MSY)	1,500 tons
2025 Allowable Biological Catch	-

Age	Fmsy
Age 1	0.12
Age 2	0.36
Age 3	0.46
Age 4+	0.46

Additional information based on comments

Renewed report (Fiscal Year 2025)

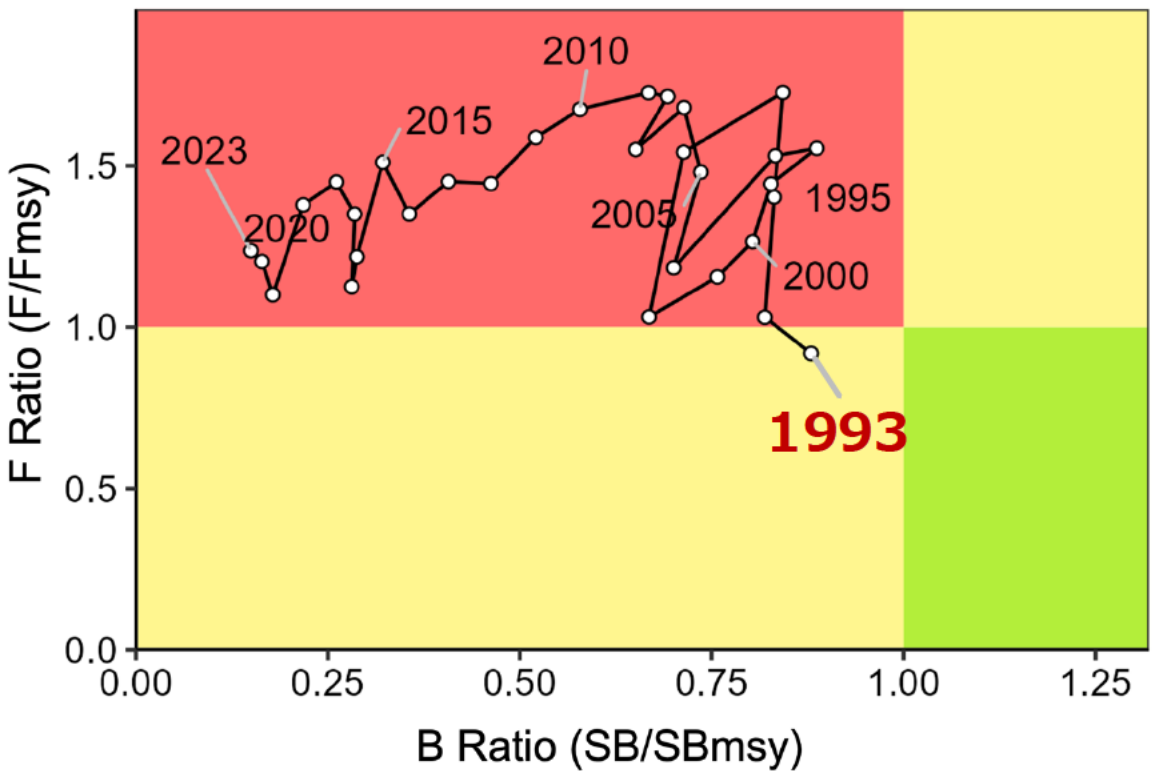
MSY, SSB Levels and Trends, and ABC	
SSB required for MSY (SBmsy)	4,000 tons
Level of SSB in 2024	Under the level to achieve MSY (0.21 times SBmsy)
Level of Fishing Pressure in 2024	Under the level to achieve SBmsy **(0.67 times Fmsy)**
Trend in SSB in 2024	Decreasing
Maximum Sustainable Yield (MSY)	1,500 tons
ABC for 2025	-

Response to Review

Comment

- *The first year in the time series should also be given a year label also.*

Fig. 4-11. Kobe plot



- **Year labels are fixed by format** (5-year increment and Latest year labels).

[Note]

- First year of this stock assessment is 1993.
- Detailed fishery dataset for VPA is available from 1993.
- 1993 is not at the initial biomass (B_0).

Response to Review

Comment

- *The use of a 4+ group in the VPA when the life span is 7 could lead to some inaccuracies in the stock assessment. Estimates of total fishing mortality rate on fully recruited fish could be challenged by having such a low aged plus group.*

- As you pointed out, **re-examining the age composition is crucial for accurate assessment**.
- However, we have set age 4+ group for this stock, based on the following background:
- Stock assessment was performed the use of 5+ group until fiscal year 2005.
- [2005–2006] Age+ group in stock assessment has changed.

  1) The maximum age of bottom trawl catch was 4-years (information from joint venture).
  2) Fishing pressure for age 4 group had the potential to be over estimated due to the low proportion of 5+ group in CAA.

Catch at age around 2005 (thousand fish)

	2003	2004	2005	2006	2007
Age 1	4,596	5,477	8,095	7,945	10,108
Age 2	7,528	5,739	7,708	8,235	9,438
Age 3	4,689	3,008	3,466	4,058	2,996
Age 4	2,759	1,617	1,909	2,135	1,560
Age 5+	594	418	475	509	364

Response to Review

Comment

- *The use of a 4+ group in the VPA when the life span is 7 could lead to some inaccuracies in the stock assessment. Estimates of total fishing mortality rate on fully recruited fish could be challenged by having such a low aged plus group.*

- Proportion of 5+ group in CAA has been increasing in recent years.
- **[Note] We might need to revise the age+ group in the VPA.**

Catch at age (thousand fish)

	2003	2004	2005	2006	2007	~	2019	2020	2021	2022	2023
Age 1	4,596	5,477	8,095	7,945	10,108	~	966	524	345	549	344
Age 2	7,528	5,739	7,708	8,235	9,438	~	2,208	1,648	1,063	1,100	1,068
Age 3	4,689	3,008	3,466	4,058	2,996	~	1,478	1,225	873	779	702
Age 4	2,759	1,617	1,909	2,135	1,560	~	766	661	473	415	405
Age 5+	594	418	475	509	364	~	214	192	146	140	148

(Proportion of 5+ group: **1.5–2.9%**)　　(Proportion of 5+ group: **3.8–5.6%**)

Response to Review

Question

- *How are the plus group equations set up in this VPA? What assumptions are made to do the plus group calculations, e.g., about selectivity, M and F in the plus group by year?*

Supplementary Table 5-1.
Parameters used to calculate future projections

	Selectivity*1	Fmsy*2	F2020-2022*3	Average weight (g)	Natural mortality	Maturity ratio
Age 1	0.27	0.12	0.10	20	0.35	0
Age 2	0.79	0.36	0.42	58	0.35	0.4
Age 3	1.00	0.46	0.65	115	0.35	1.0
Age 4+	1.00	0.46	0.65	226	0.35	1.0

*1: Selectivity used to estimate the level to maintain MSY at the FY 2021 Research Institute Meeting (i.e., selectivity of Fcurrent in the FY2020 stock assessment).

*2: Fmsy estimated at the FY 2021 Research Institute Meeting (i.e., Fmsy/Fcurrent multiplied by Fcurrent in the FY2020 stock assessment).

*3: The average F value for 2020 to 2022 was used as the current fishing pressure of this stock. This F value was used as the assumption for the catch in 2023.

Number at age

- $N_{4+,y} = N_{3,y-1}exp(-M_{3,y-1} - F_{3,y-1}) + N_{4+,y-1}exp(-M_{4+,y-1} - F_{4,y-1})$

Natural mortality (*M*):

- Assuming that M is constant across all ages.
- M=0.35 based on M=2.5/lifespan (Tanaka 1960; Tauchi & Tanaka's equation).

Fishing mortality (*F*):

- Assuming that *F* for plus group and one year younger are equal. $F_{+group} = F_{+group-1}$

Selectivity:

- Relative values are calculated for each age, with the age of highest *F* set as selectivity=1.0

Response to Review

Comment

- *A sensitivity run on the VPA could be considered which applied a credible hypothesized discard rate for fish smaller than marketable size. If not, then authors should list some potential biases in the VPA that could result from not including dead discards of smaller than marketable size fish.*

Reviewed report

It is possible that small fish smaller than marketable size are being discarded (Ishikawa Prefectural Fisheries Center et al. 1994), so resource management measures aimed at protecting small fish will need to be considered in the future.

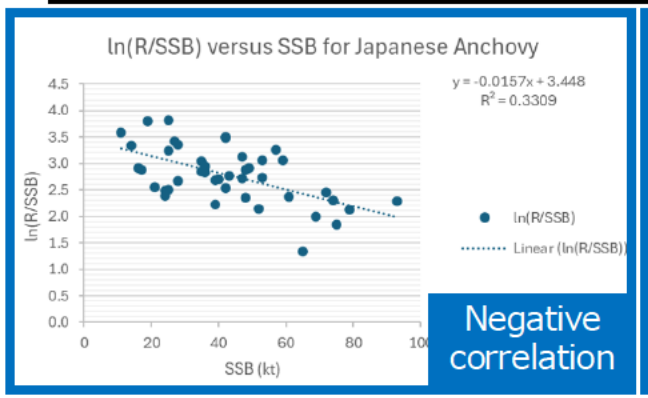
- Considering discards is crucial for stock assessment
- **We assume that the limited bottom trawl activity in shallow nursery grounds likely prevents the underestimation of *F***
- However, as your suggestion is significant, we intend to incorporate the consideration of discards through sensitivity analyses that vary the CAA for age-1 fish
- Additionally, it is necessary to start with fisher interviews to obtain the information on discards

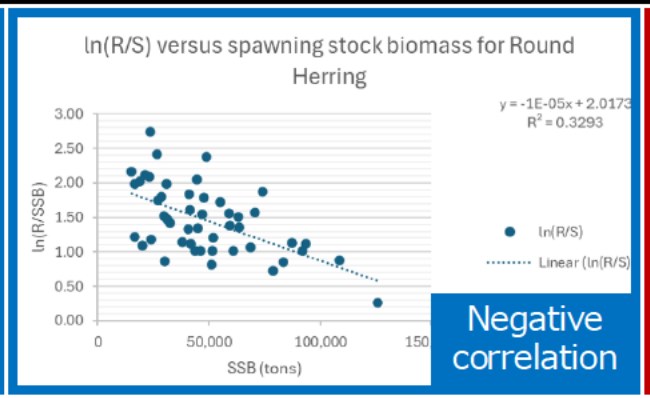
Response to Review (Additional Question)

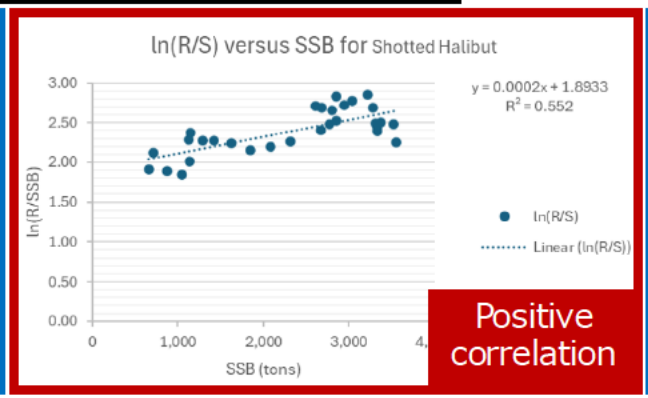
Question

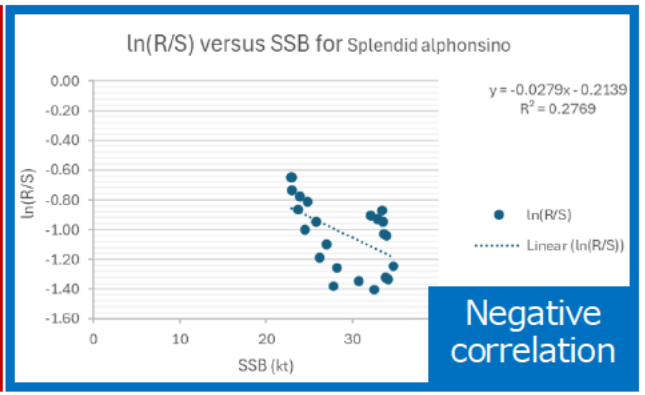
- *What reasons can the assessment scientists offer for why the relationship between ln(R/S) and SSB for shotted halibut is strongly positive over the range of SSB when ecological theory would most commonly predict a negative relationship between ln(R/S) and SSB?*

Modified Fig. 1 in Additional comment sheet. Plots of ln(R/S) versus SSB







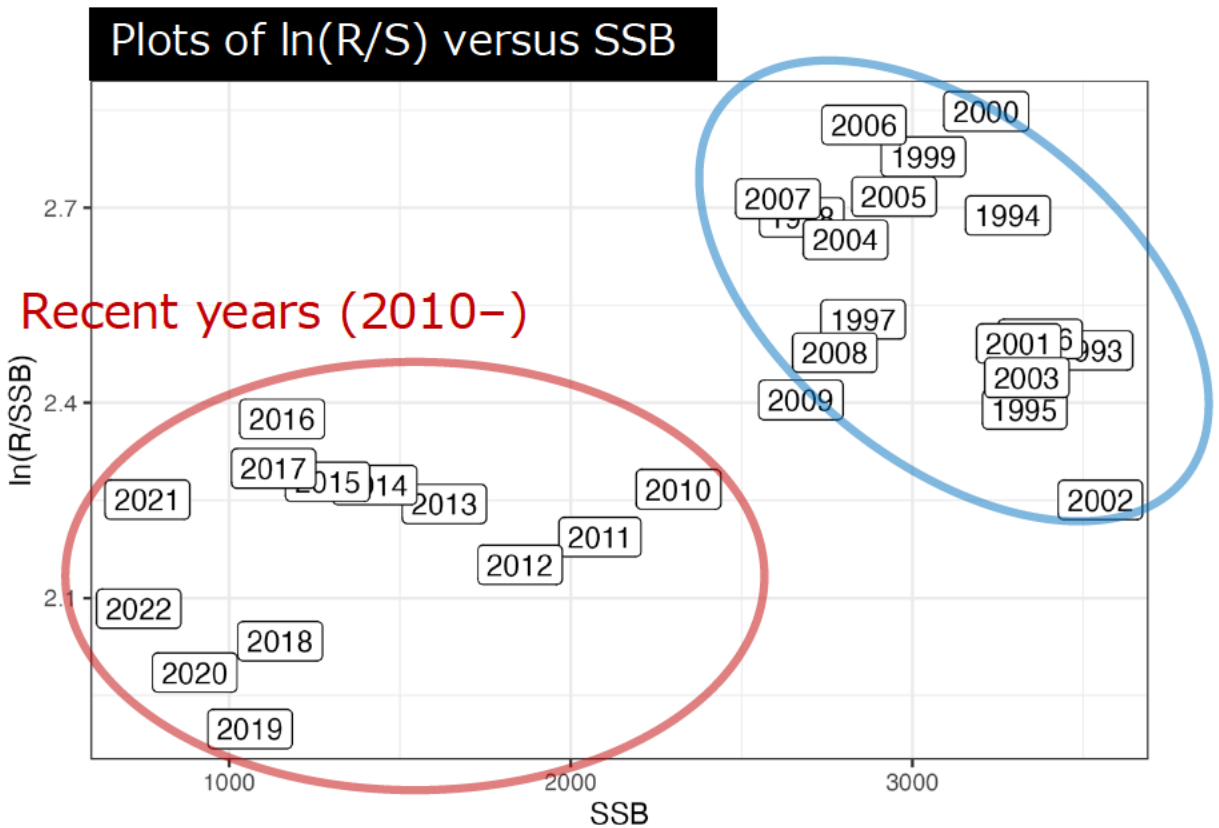


- The results might be biased because the dataset are derived from low-abundance state
- This stock likely deteriorated during the late 1980s; consequently, the dataset only covers the period from 1993 onwards
- Data are unavailable for periods when the stock was abundant enough to exhibit density-dependent effects

Response to Review (Additional Question)

Question

- *What reasons can the assessment scientists offer for why the relationship between ln(R/S) and SSB for shotted halibut is strongly positive over the range of SSB when ecological theory would most commonly predict a negative relationship between ln(R/S) and SSB?*



Another interpretation:

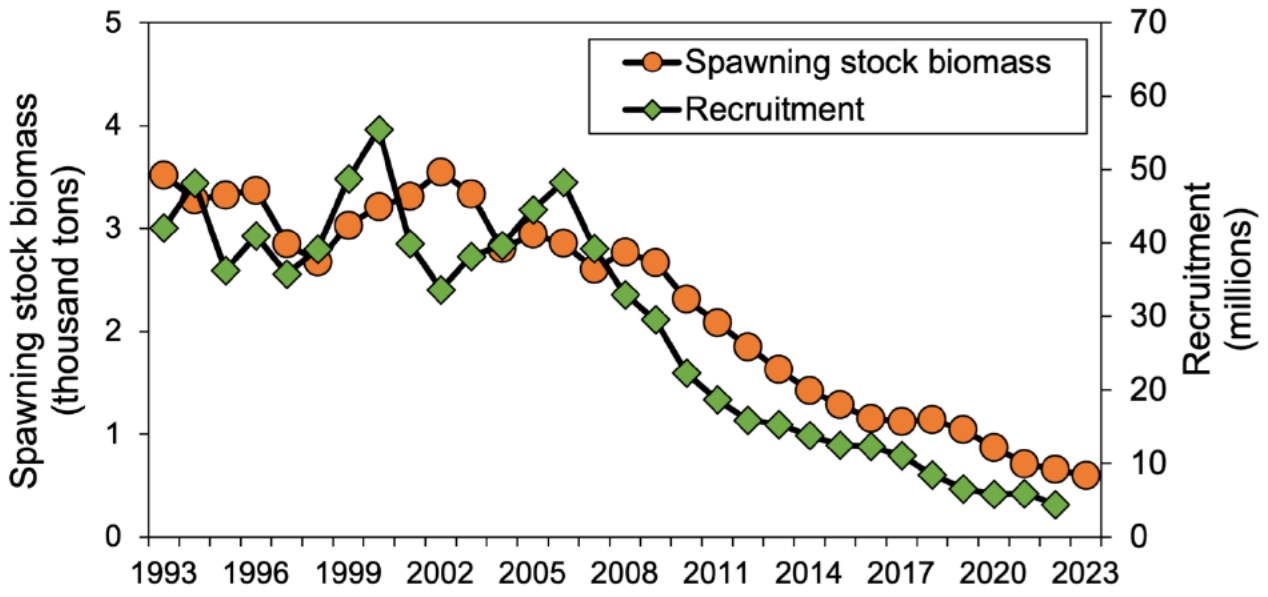
- This may be attributed to the low-abundance state in recent years.
- Data prior to 2009 shows a negative correlation (circled in blue)
- Recent trends may be driven by density-independent factors (*e.g.* warm temperature)

Response to Review (Additional Question)

Question

- *Why are the time trajectories for estimated recruitment for shotted halibut (Fig. 4-4) and splendid alfonsino (Sup. Fig. 2-4) so remarkably smooth while those for Japanese Anchovy (Fig. 4-6) and round herring (Figure 4-5) far more variable between years?*

Fig. 4-4. Trend in SSB and Recruitment (age 1 in following year)



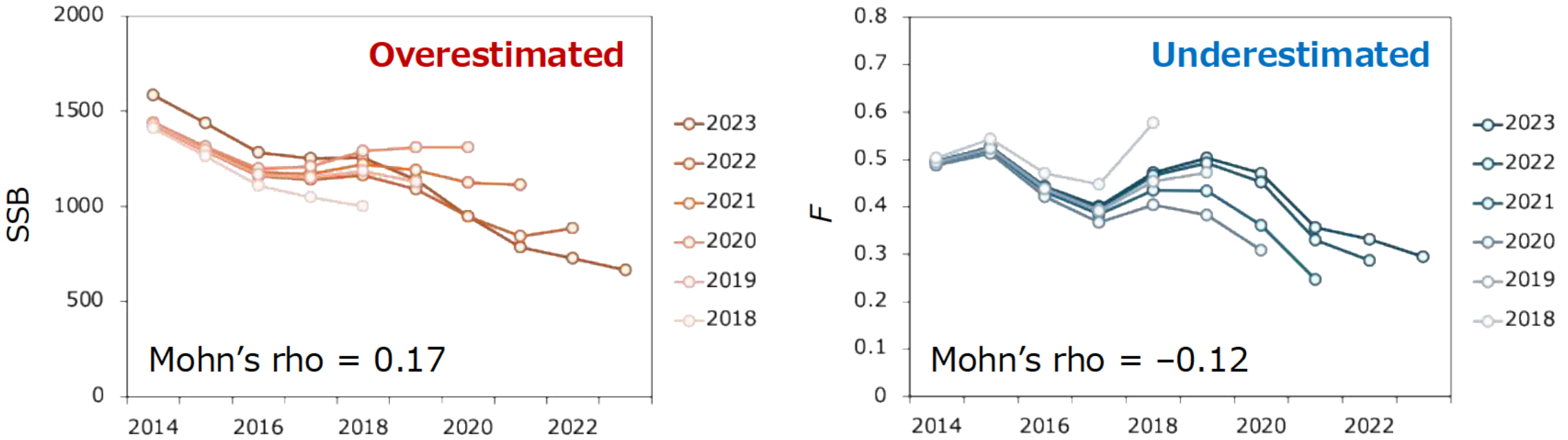
- **This results may be attributed to the smoothing effect of the ALK.**
- The ALK in use was derived from data pooled over a 4–5 years period from the past
- As there are other issues arising from the current ALK, we are currently working on updating ALK

Issues in stock assessment for shotted halibut

Retrospective pattern in VPA

- The FY2024 assessment reviewed this time was based on the Normal VPA result
- Previously, we used the Tunning VPA; however, due to the retrospective bias, we switched to normal VPA for the FY2024 assessment

Result of SSB and F estimations via Tuning VPA



Issues in stock assessment for shotted halibut

Retrospective pattern in VPA

- The FY2024 assessment reviewed this time was based on the Normal VPA result
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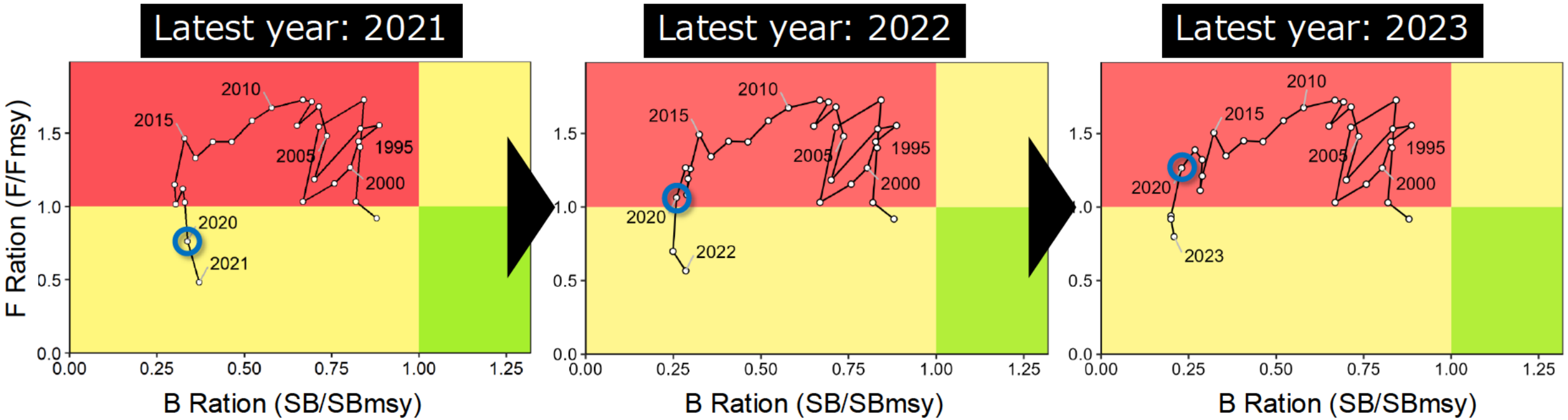
- **Stock status was revised downward (yellow to red zones) year by year**



Issues in stock assessment for shotted halibut

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- **Stock status was revised downward (yellow to red zones) year by year**

Expert comments

"There have been ongoing criticisms that the stock assessments have remained overly optimistic. Need to shift toward a more precautionary approach"

Issues in stock assessment for shotted halibut

Approach for improvements

1) Review of the calculation process for CAA

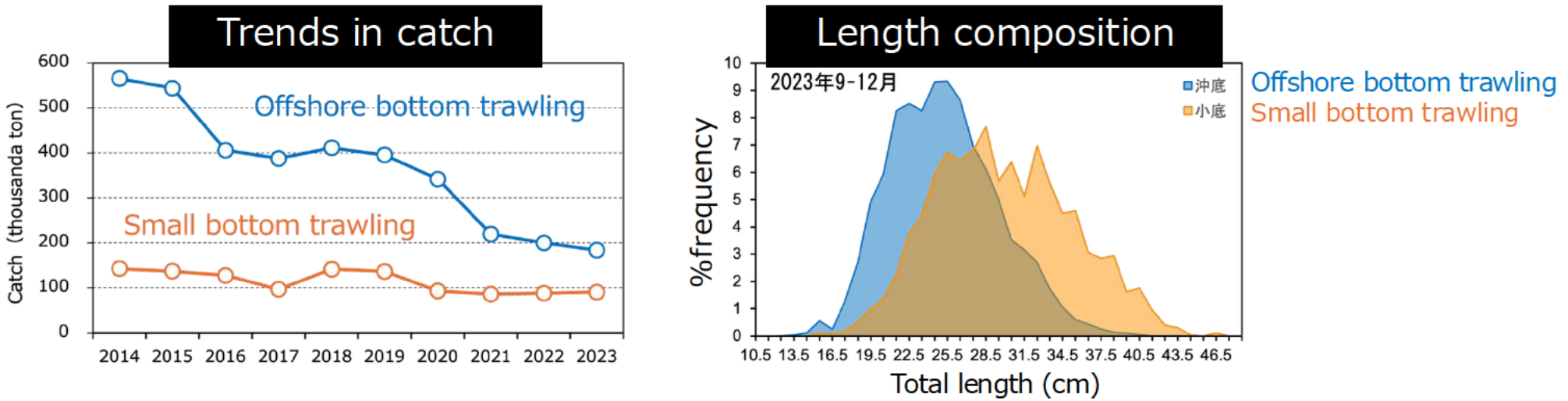
- Consideration of catch characteristics of small bottom trawling – [Underway]
- Updating the Age-length key – [in progress]
- Review of the age plus group setting – [in progress]

Issues in stock assessment for shotted halibut

Approach for improvements

1) Review of the calculation process for CAA

- Consideration of catch characteristics of small bottom trawling – [Underway]



- We estimated the total stock CAA by scaling up the CAA data from the offshore bottom trawl
- **Market survey suggested that differences in length composition**
- A trial calculation of the CAA was conducted, incorporating the differences in length composition

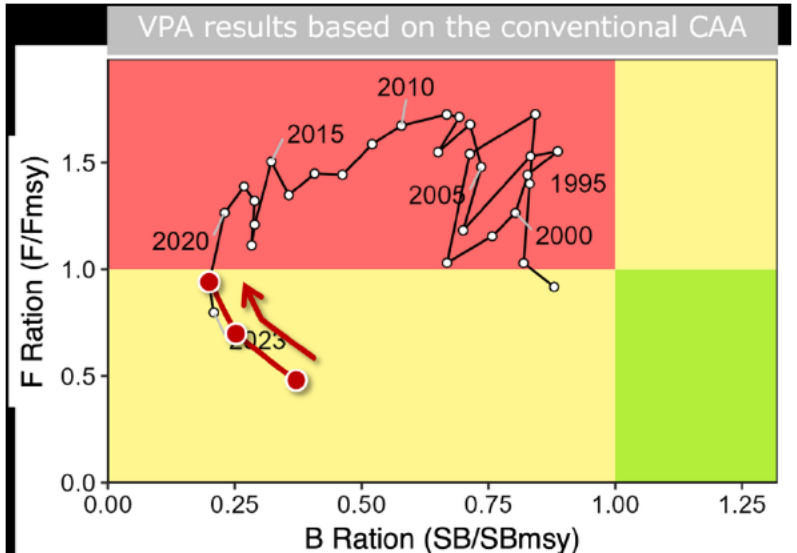
Issues in stock assessment for shotted halibut

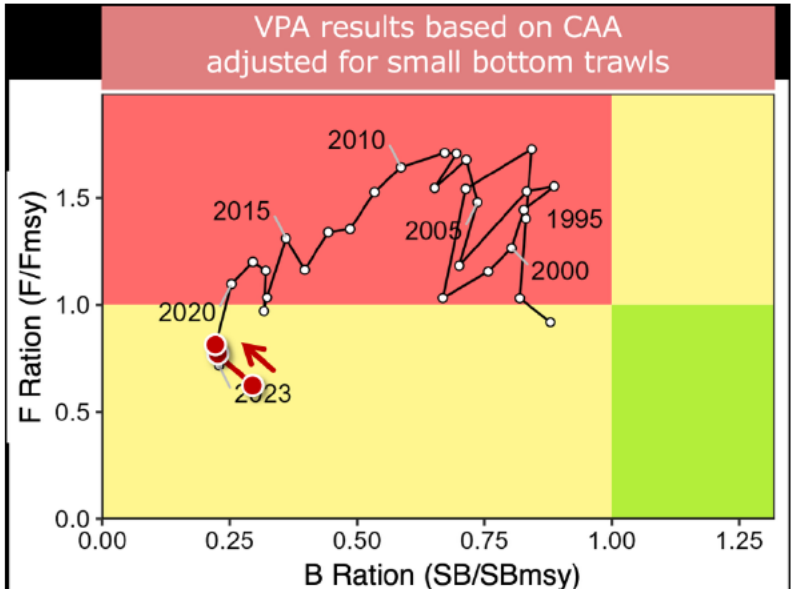
Approach for improvements

1) Review of the calculation process for CAA

- Consideration of catch characteristics of small bottom trawling – [Underway]

- CAA was revised because the small bottom trawls catch was seasonally biased toward older fish (3 and 4+ years fish)
- **The use of the revised CAA led to a reduction in retrospective bias, resulting in a more stable assessment.**

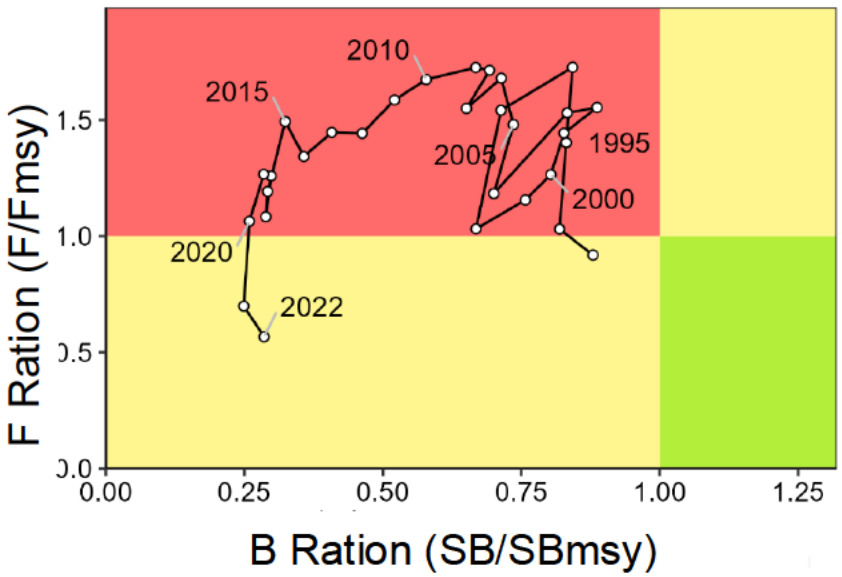




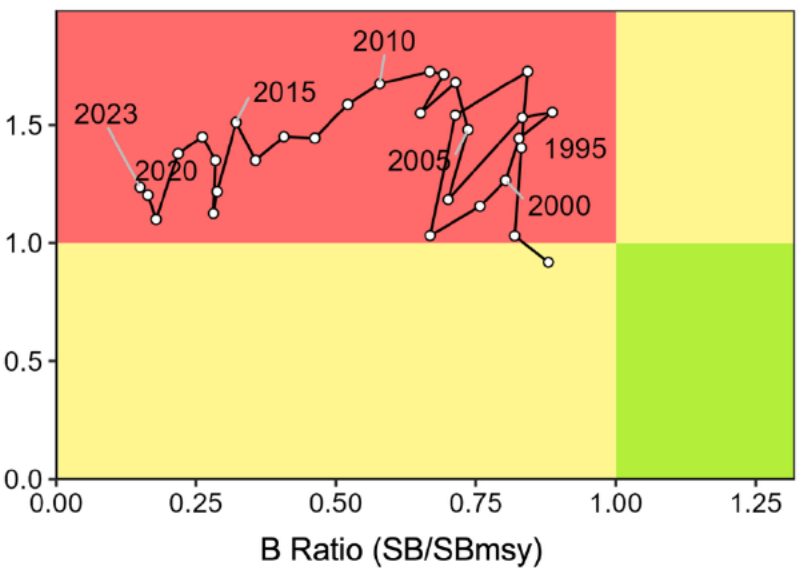
Appendix information

- **Comparison of VPA results**

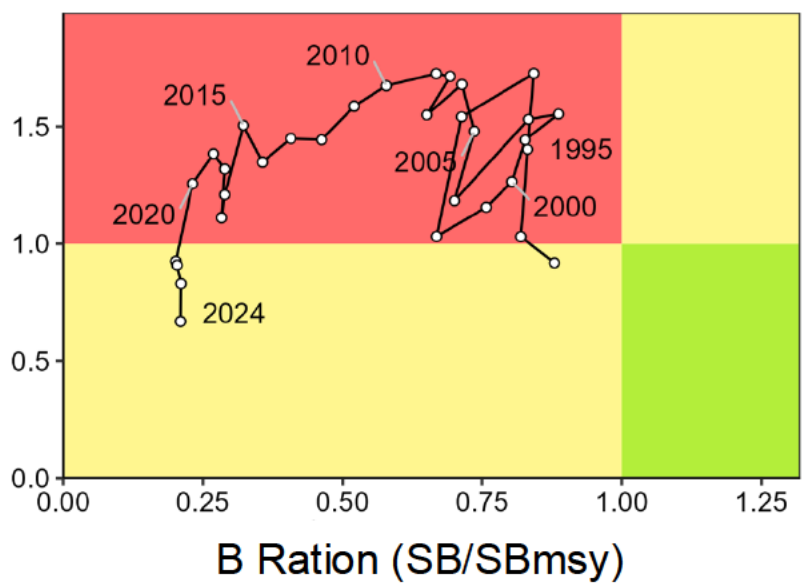
2023 (Tuning VPA)



2024 (Normal VPA)



2025 (Tuning VPA)

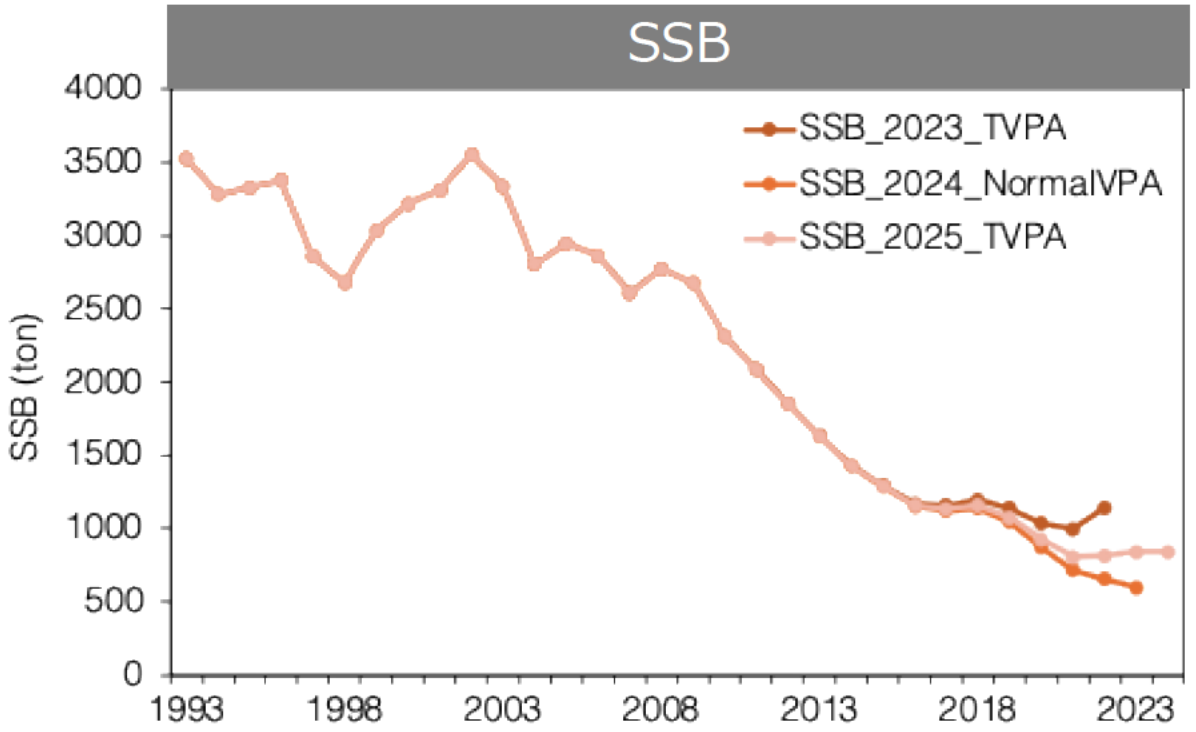


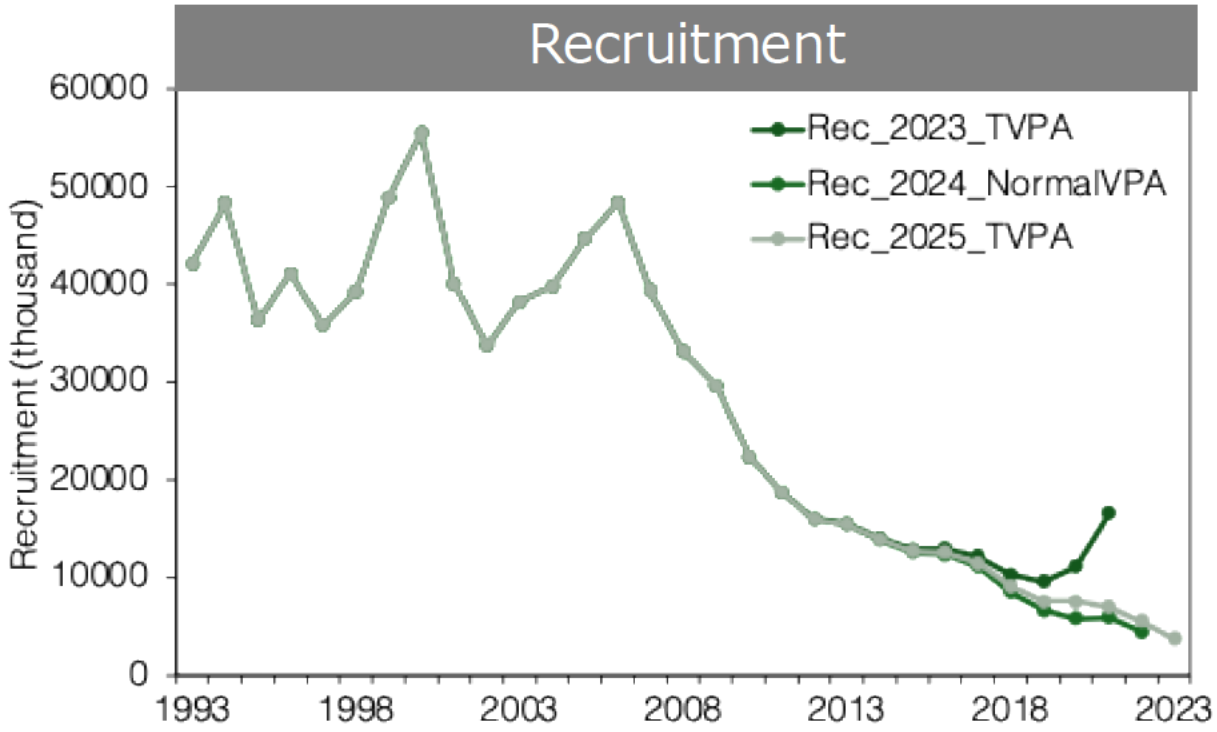
Appendix information

Comparison of VPA results

- Estimations of SSB and Recruitment

[Note] 2023: Tuning VPA
2024: Normal VPA
2025: Tuning VPA





Appendix information

- **Fratio at age**