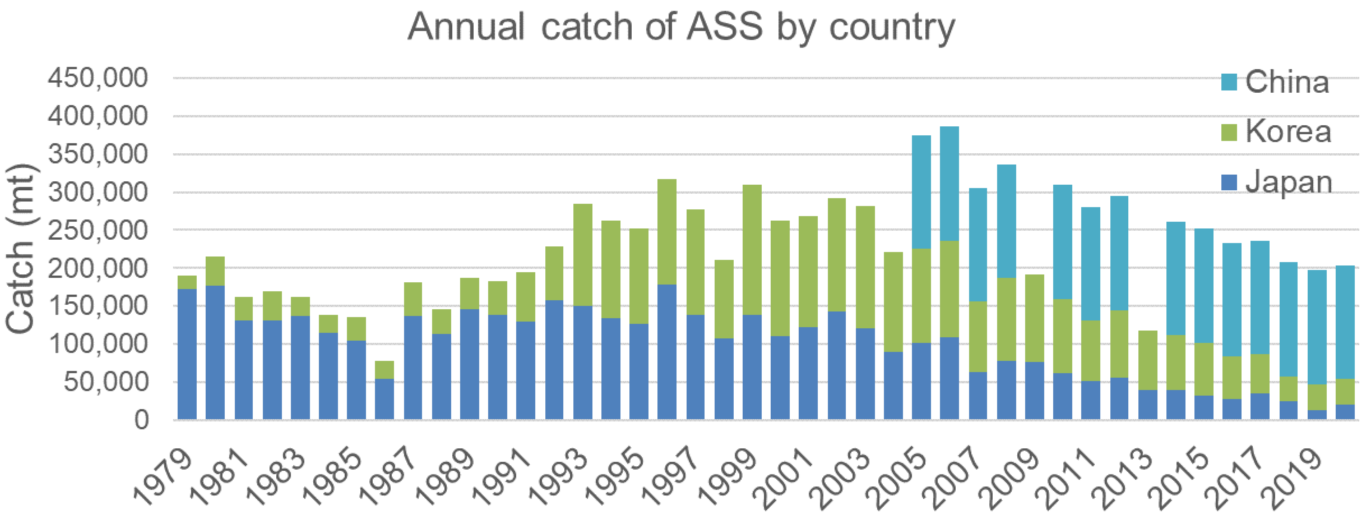
Autumn-spawning stock (AS) Japanese flying squid

Contents

1. Catch data

1. Catch data

Annual catch by country



Catch statistics by country

- Japan: Official statistics published by the Japanese government
- Korea: Official statistics published by the South Korean government
- China
  - Unknown
  - Constant catch of 150 thousand ton per year assumed to 2005-2020 except for 2009 and 2013.

Question

Catch from China is clearly critical and one important assumption is that China catch is a constant 150,000 t per year. There is some explanation in Appendix 5 but I am not sure I understand it. Please explain in more detail.

Assumption of Chinese catch

Cause of this assumption

Chinese trawlers targeting JFS started operations in North Korean waters in the Sea of Japan in 2004 and number of vessels steeply increased in 2005 onward (Jo et al 2016).

Problems

- IUU fishery
- Total catch is not able to be utilized directly.
- The catch is probably too large to ignore.

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

Illuminating dark fishing fleets in North Korea

Jaeyoon Park[1*†], Jungsam Lee[2†], Katherine Seto[3,4], Timothy Hochberg[1], Brian A. Wong[1,5], Nathan A. Miller[1,6], Kenji Takasaki[7], Hiroshi Kubota[7], Yoshioki Oozeki[7], Sejal Doshi[8], Maya Midzik[8], Quentin Hanich[3], Brian Sullivan[1], Paul Woods[1], David A. Kroodsma[1]

Illegal, unreported, and unregulated fishing threatens resource sustainability and equity. A major challenge with such activity is that most fishing vessels do not broadcast their positions and are "dark" in public monitoring systems. Combining four satellite technologies, we identify widespread illegal fishing by dark fleets in the waters between the Koreas, Japan, and Russia. We find >900 vessels of Chinese origin in 2017 and >700 in 2018 fished illegally in North Korean waters, catching an estimated amount of *Todarodes pacificus* approximating that of Japan and South Korea combined (>164,000 metric tons worth >$440 million). We further find ~3000 small-scale North Korean vessels fished, mostly illegally, in Russian waters. These results can inform independent oversight of transboundary fisheries and foreshadow a new era in satellite monitoring of fisheries.

최종보고서

중국어선 북한수역조업 피해조사 연구

2016. 6.

강원도환동해본부

Literatures about Chinese catch

Reference	Estimated catch
Kang et al. (2006) Song et al. (2008)	100-185 thousand ton for 2005
Jo et al. (2016)	44-426 thousand ton for 2007-2012
Park et al. (2020) estimated catch via some procedures	101-260 thousand ton for 2017 63-207 thousand ton for 2018
Trading company information (Japanese fishery industry press)	140-150 thousand ton for 2018 150 thousand ton for 2019 Note: those value are not estimates.

- Low expectation of future continuous taking of estimated catch from four papers.
- 150 thousand ton was intermediate value.
- Constant value of 150 thousand ton per year was applied in 2005 onward.
  - No evidence available to set year variation in Chinese catch.
- Due to very low fishing effort in 2004, 2009 and 2013, zero was set in those years.

1. Catch data

Reviewers' question about Chinese catch

Question

In Appendix 4, there was some interesting work to estimate China fishing effort in the Sea of Japan using satellite observations. This could be a useful way of estimating effort and subsequently catch, and likely better than assuming a fixed constant catch. Why not use those estimates?

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Response

- Since 2020, fishing effort of Chinese fleet has decreased.
- We try to adjust the recent Chinese catch according to quasi-fishing effort obtained via satellite observations in the upcoming update of stock assessment in Dec.
  - Constant catch of 150 thousand ton could be changed based on recent trend in fishing effort.

Problems to estimate catch via satellite observations

- Catch or CPUE information is required to obtain reliable estimate.
- Those information are not able to take from the Chinese fleet.

Reviewers' question about Chinese catch

Question

What is a reasonable range of China catch?

Response

- Table in slide 6 provides possible range of Chinese catch based on past study.
- Applying a constant catch of 300 thousand ton from the Chinese fleet, catch in number exceeded recruitment in 2019.

Reviewers' question

Question

An alternative option is to assume that total catch is largely unknown and catch free methods be used to assess and manage the stock.

Response

- We appreciate your informative advice regarding alternative assessment method under large uncertainty in catch data.
- At this moment, we could grasp annual catch from Japan and Korea.
- As mentioned for WS, the prime candidate of alternative SA model is SAM, where observation errors in catch and indices can be driven.

2. Estimation of abundance

Estimation of recruitment

- In common with WSS, annual recruitment is directly calculated with recruitment abundance index.

$$R_t = qU_t$$

- U_t is obtained from recruitment estimation survey in the Sea of Japan.

Question

Please explain the survey in more detail and how well it captures the distribution of the squid.

Recruitment estimation survey in SOJ

- Duration

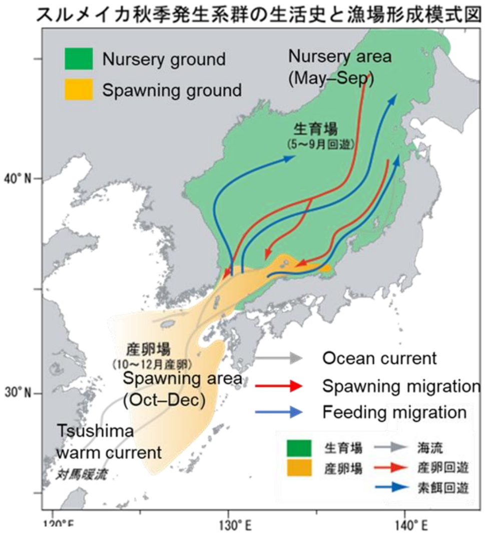
  1979 to 2021 (Terminal year is updated annually)

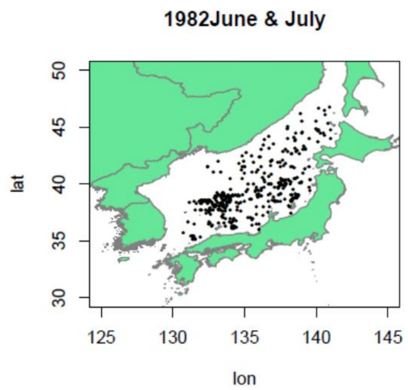
- Area
  - Potential distribution area in Japanese EEZ
  - Sampling points had been set in the Russian waters up to approx. 10 years ago.
- Season

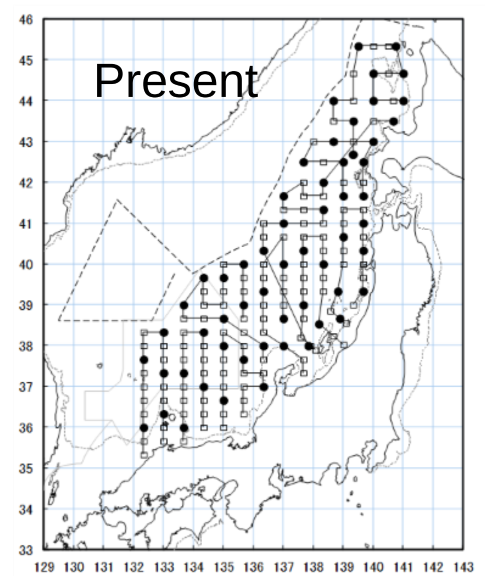
  June to July

- Fishing gear

  Squid-jigging





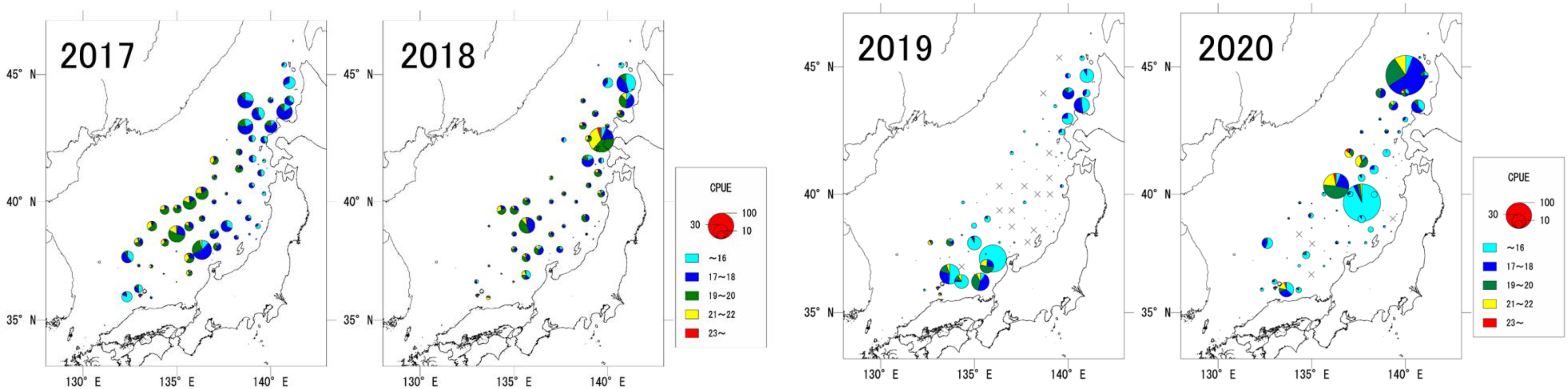


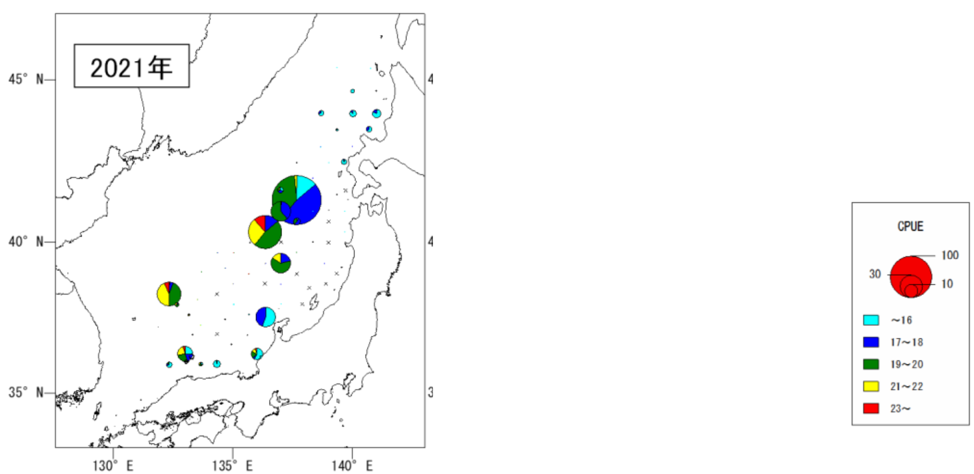
<u>Catch & effort data from survey were used for CPUE standardization to provide recruitment abundance index.</u>

Reviewers' question on recruitment abundance index

<u>Question</u>

In Appendix 2, it is explained that the index for 2019 and 2021 were not usable but I am not sure I understand the explanations. Please explain in more detail.





Reviewers' question on recruitment abundance index

Question

The small jigging index appeared to be quite consistent with the survey index (Appendix Fig 5-5), and less variable. Why not use this index? Especially when the survey index was not appropriate.

Response

- Not only small jigging (coastal jigging) but also offshore jigging could be used as abundance indices in future JFS stock assessment.
  - We need Korean CPUE.
- Issue of time-lagged data collection of logbook
  - Squid is 1yr-lived species so that time-lag in data collection become fatal issue.
  - Conventionally, survey-based recruitment abundance indices have been used for AS.

Reviewers' question on recruitment abundance index

Question

- Similar to the assessment for winter-spawning squid, it would be useful to calculate and report uncertainty in the standardized CPUE index. This could be used to propagate uncertainty into quantities of interest to management (Fig. 5 in the "CPUE Standardization / Model Diagnostic Results" document).
- What were the uncertainties in the indices?

Response

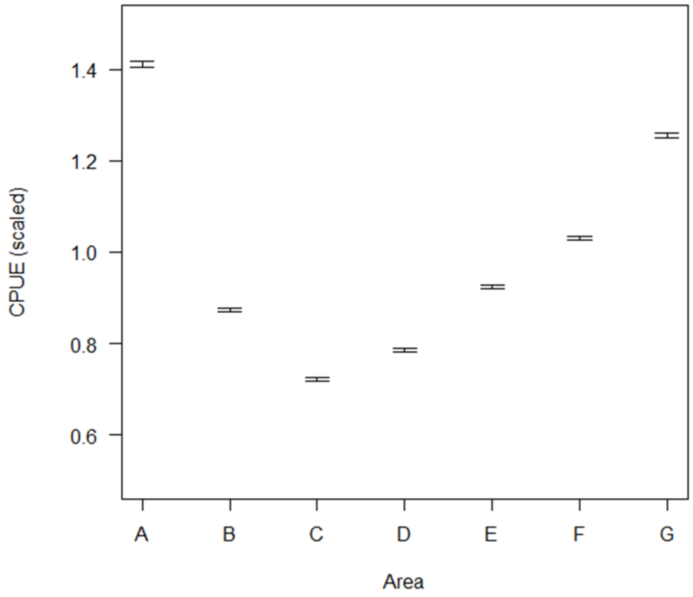
- In general, we can calculate standard errors for recruitment index for each year via CPUE standardization
  - At this moment, the standard errors are not reflected in the JFS stock assessment results.
  - In future JFS stock assessment, uncertainty in the recruitment abundance indices could be considered.

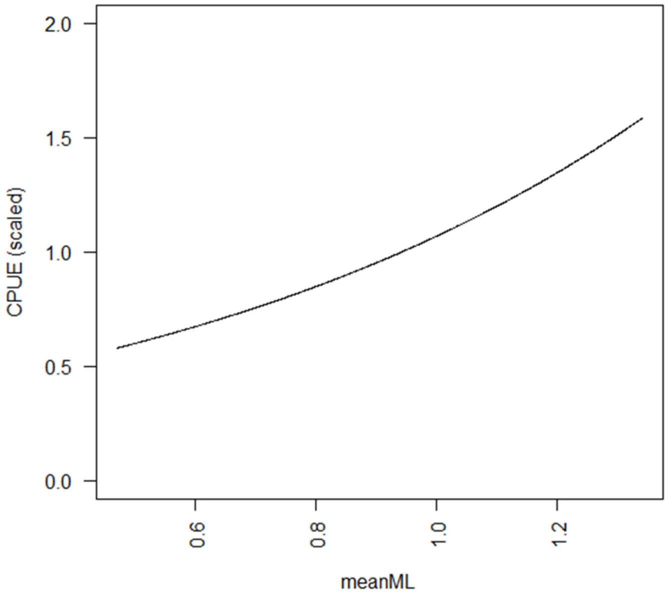
- Potential uncertainty would lie in (recent) changes in distribution pattern of JFS.

Reviewers' question about standardized CPUE

<u>Question</u>

In addition to the ROC and Q-Q plots provided for the standardized index, please show the estimated relationships between predicted CPUE and temperature, area, and mantle length.





Estimation on recruitment

- Each recruitment index value was scaled up with the proportional constant *q*.

  $$N_t = qU_t$$

- This constant *q*
  - is critical to determine annual recruitment.
  - has been traditionally used in the stock assessment of AS.

<u>Question</u>

Please explain how q is estimated in more detail. I do not understand the method in Appendix 2.

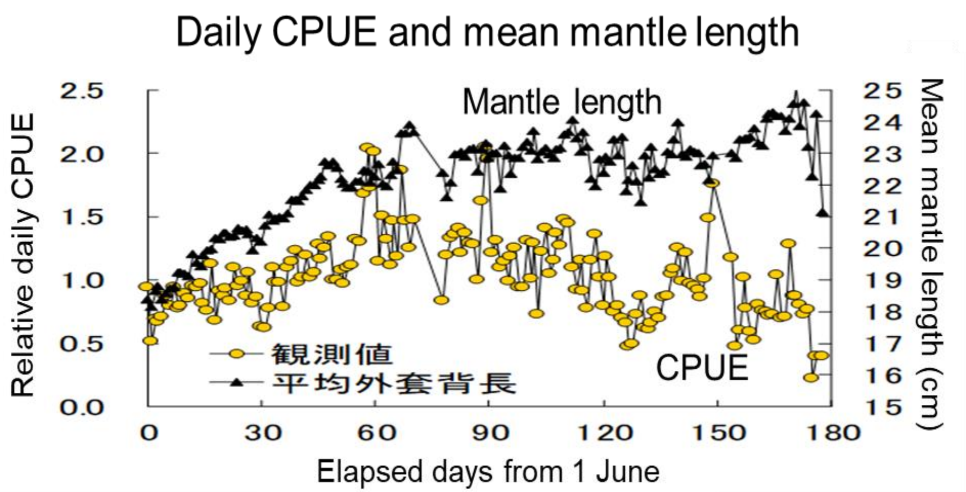
How to calculate *q*

Assumption

☐ Mean fishing mortality (1979-2001) $F^* = 0.447$

How to estimate F^*

- Squid-jigging survey (1979-2001, May-Nov) provided daily CPUE.
- Daily total mortality z^* was estimated based on daily decrease rate of survey CPUE.



$$u_d = a \cdot exp(bx_d - z^* d) \quad \text{Eq.3}$$

u_d: Relative daily CPUE
x_d: Daily mean mantle length
d: Erapsed days from 1 June

Estimation of F* and q

- Parameters a, b and z* were estimated with the least square method.
  - z^* = 0.00582 per day
- Six-month total mortality Z* was calculated as 1.047.
- Given that M = 0.6 per six-month,

F^* = Z^* − 0.6 = 0.447 per six-month

- $F_t = -\ln\left(1 - \frac{C_t e^{-0.5M}}{qU_t}\right) \quad Eq\ 2$

C_t: Catch in year t
U_t: Recruitment abundance index for year t

- q was estimated under the condition that average F_t corresponded to F^*
- q was estimated to be 3.51*10^9

2. Estimation of abundance

Reviewers' question about estimation of *q*

Question

To estimate average fishing mortality, is the daily decrease in CPUE obtained by a survey that is operating simultaneously with the fishery, and in the same area, to monitor total mortality? This is what I understood from reading the report, but please correct me if I'm mistaken.

Response

- Yes. Total mortality was monitored via daily decrease in relative CPUE obtained by survey.

Reviewers' question about estimation of *q*

Question

If the survey monitors daily changes in relative CPUE, how much variability is there in the rate of decline across years and areas? In other words, if the data are subset by time period or area, how much do the estimates of daily total mortality differ from the estimates derived from the entire time period (1979-2000)?

Response

- At this moment, there are no information on differences in monitored total mortality by time period and by area.

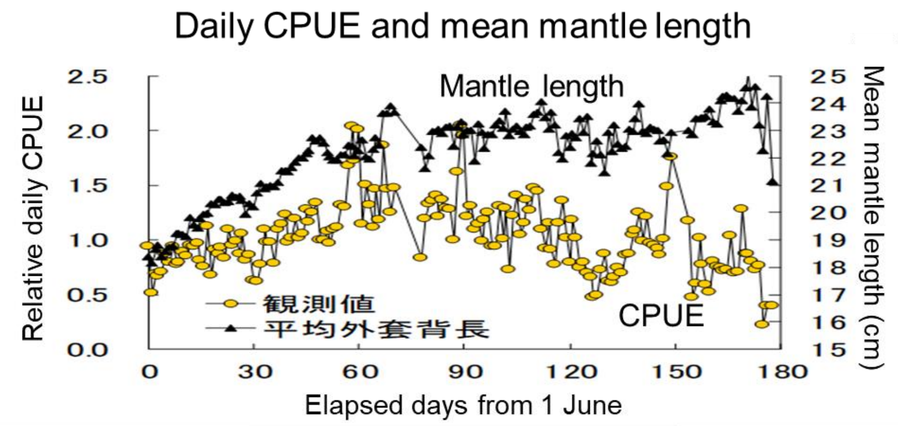
Reviewers' question about estimation of *q*

<u>Question</u>

The calculation for relative CPUE was revised to incorporate catchability as a function of average mantle length. Does the assumed exponential relationship reflect how size affects vulnerability of squid to the gear? I am wondering if vulnerability increases with size at first, but may asymptote beyond a certain size.

<u>Response</u>

- Daily CPUE increased as increase in mantle length up to about 60 days-old.
- The CPUE show decrease trend at age older than 60 days-old.



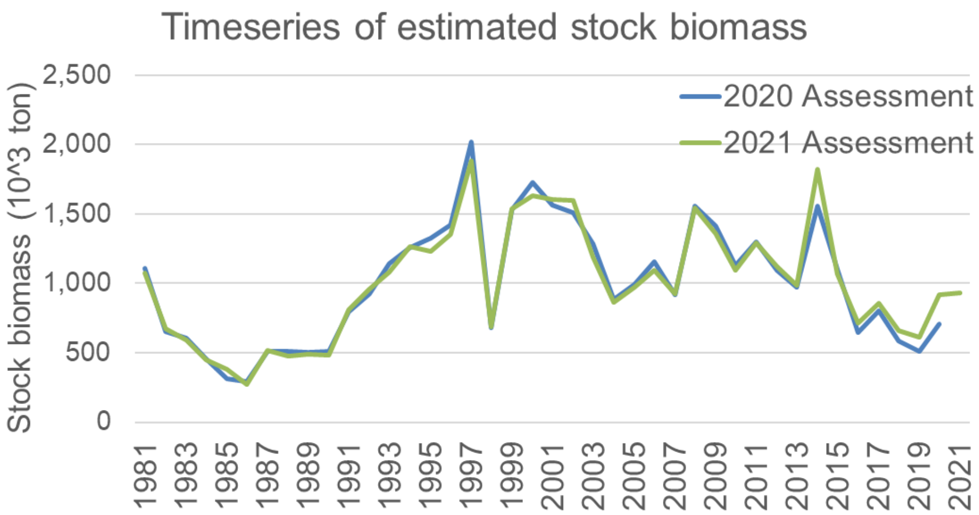
Reviewers' question about estimation of *q*

Question

In Appendix 2, you note that the proportionality constant, q, changed by an order of magnitude (from 2.96 x 10^8 to 3.51 x 10^9). Is this simply due to an arbitrary scaling change during the CPUE standardization? I'm assuming there was not a 10-fold change in the biomass estimates.

Response

- *q* has been re-estimated annually according to the result from CPUE standardization.
- Absolute and relative CPUE were used to scale up in the 2020 and 2021 assessments.



Reviewers' question about estimation of recruitment

<u>Question</u>

Similar to the winter stock, the critical assumptions for the abundance estimates are that recruitment is assumed to be directly proportional to the survey CPUE and that the proportion (q) is known and constant (except for one year?).

<u>Response</u>

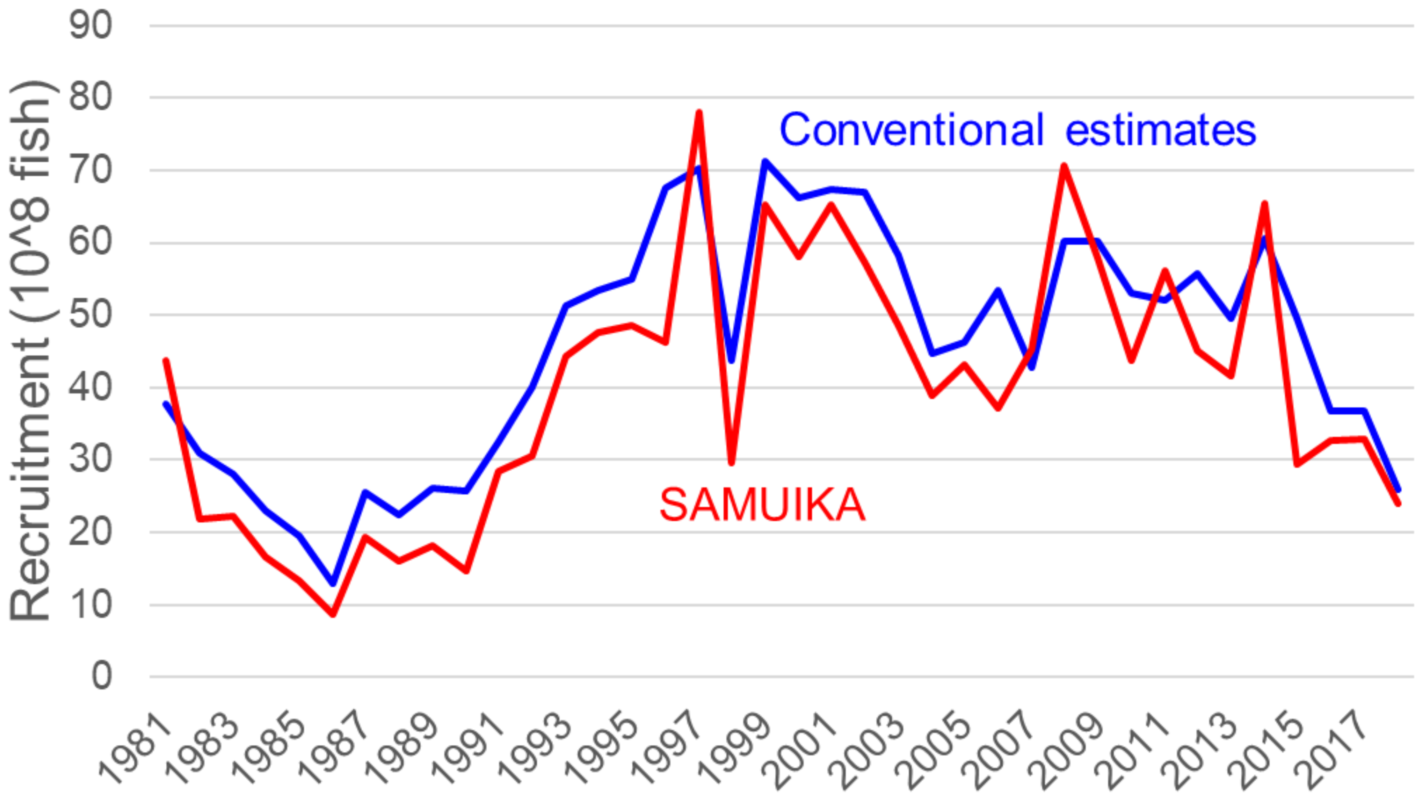
- Critical assumption that q is constant.
- Difficult to conduct direct validation of this assumption.

- As reference information, alternative assessment model was tested to AS data.
  - SAMUIKA

Application of SAM

- Nishijima-san published a paper of stock assessment of JFS with SAM.
  - SAMUIKA (State-space Assessment Model Used for IKA).
- SAM is a prime candidate of the future stock assessment models to apply to JFS.
- <u>*q* was estimated and worked as a constant catchability.</u>

SAM − Comparison of recruitments estimates

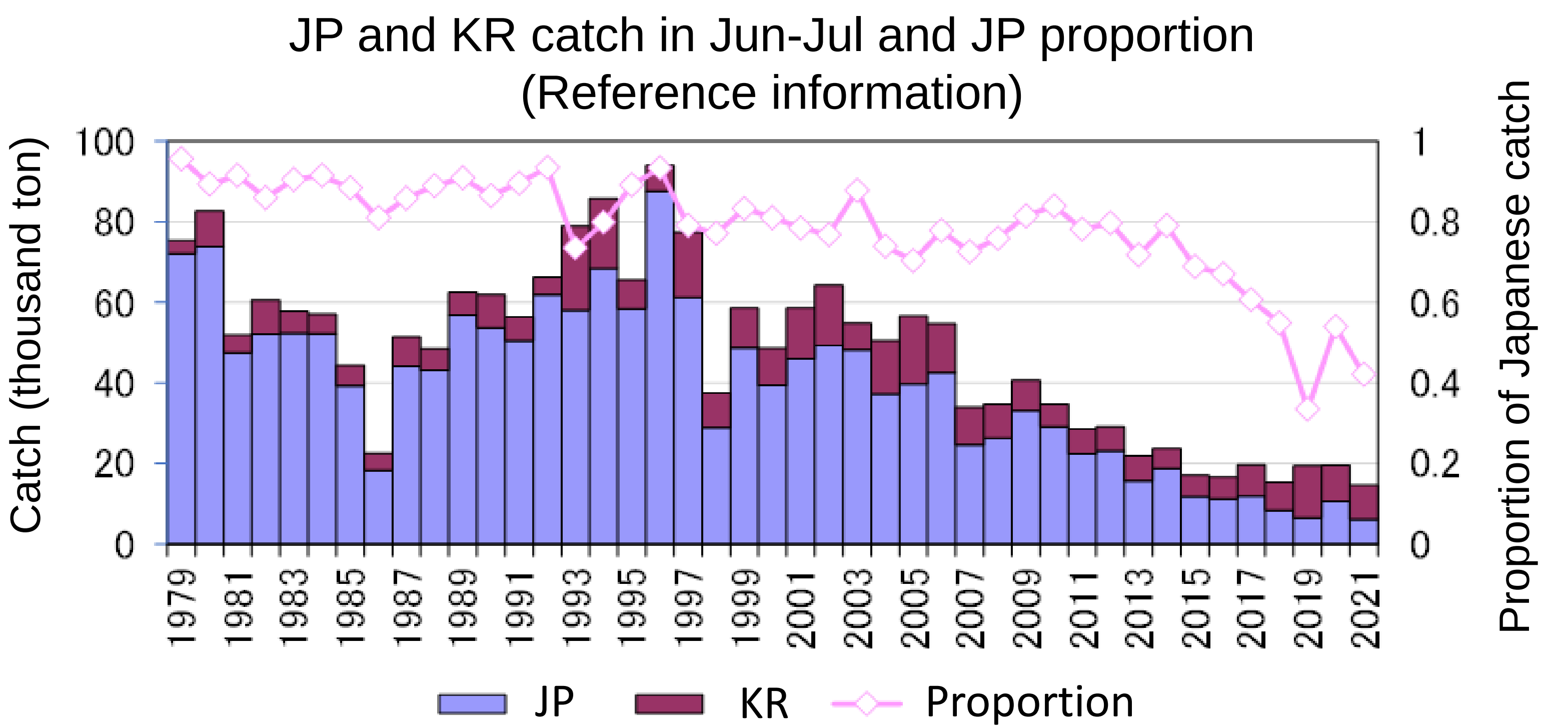


- Mean recruitment over the year from SAMUIKA was 13% smaller than that of conventional estimate.

Reviewers' question about estimation of recruitment

Question

Given that the survey does not cover the entire distribution of the stock in the Sea of Japan, this assumes that the proportion of the stock covered by the survey is also constant (i.e., distribution is constant). Please provide evidence that this assumption is reasonable.



Reviewers' question about sensitivity to M setting

Question

In the sensitivity test to alternative values of M, can you describe why the 2021 biomass does not change, while the 2021 Spawning Stock Biomass (SSB) changes? Is this change in M applied to all steps in the assessment that rely on M? Looking at Equation 2, a change in M would affect the estimate of q, which would affect the biomass estimate in Equation 1.

Response

- Direct estimation of the 2021 biomass (recruitment) with the index.
- SSB estimates can be changed according to assumption on M.

$$S_t = \left(N_t \cdot \exp^{-\frac{\mathrm{M}}{2}} - C_t\right) \cdot \exp^{-\frac{\mathrm{M}}{2}}$$

- M value also does not affect *q*.

Reviewers' question about estimation of recruitment

Question

- Was uncertainty considered and incorporated into the estimation process?
- Was uncertainty in the SB and R estimates considered?

Response

- There is no consideration of uncertainty in estimation process of abundance.
- In future JFS stock assessment, possible uncertainty would be incorporated.

3. Stock-recruitment and management quantities

Reviewers' question

Question

The reasoning for using a hockey stick is unclear but it appears to be set at a meeting and may be based largely on management concerns. Is that correct?

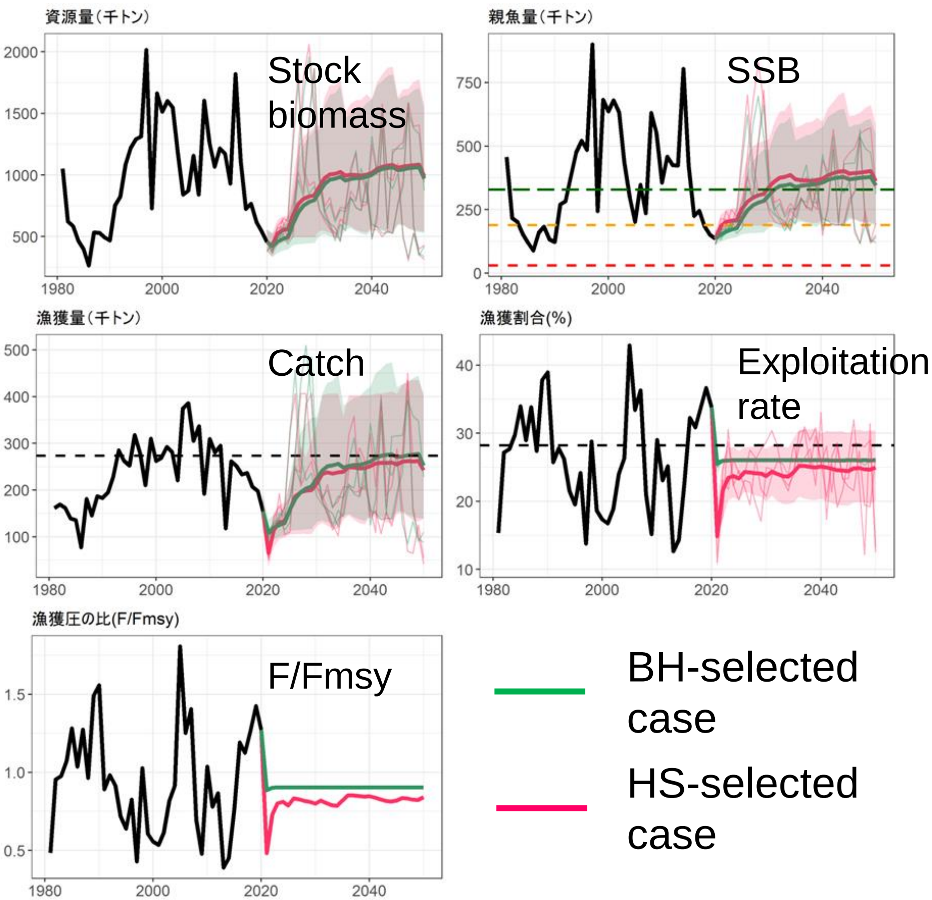
Response

- HS, BH and RI are designated as candidates of S-R relationship to be used for estimation of reference point in the Japanese stock assessment.
- It was impossible to select the S-R relationship based on AICc.
    - RI was rejected with taking in consideration of biological characteristic of JFS.
- HS was employed via simple MSE (HS vs. BH).
    - Evaluation of performance when a wrong S-R relationship was chosen.

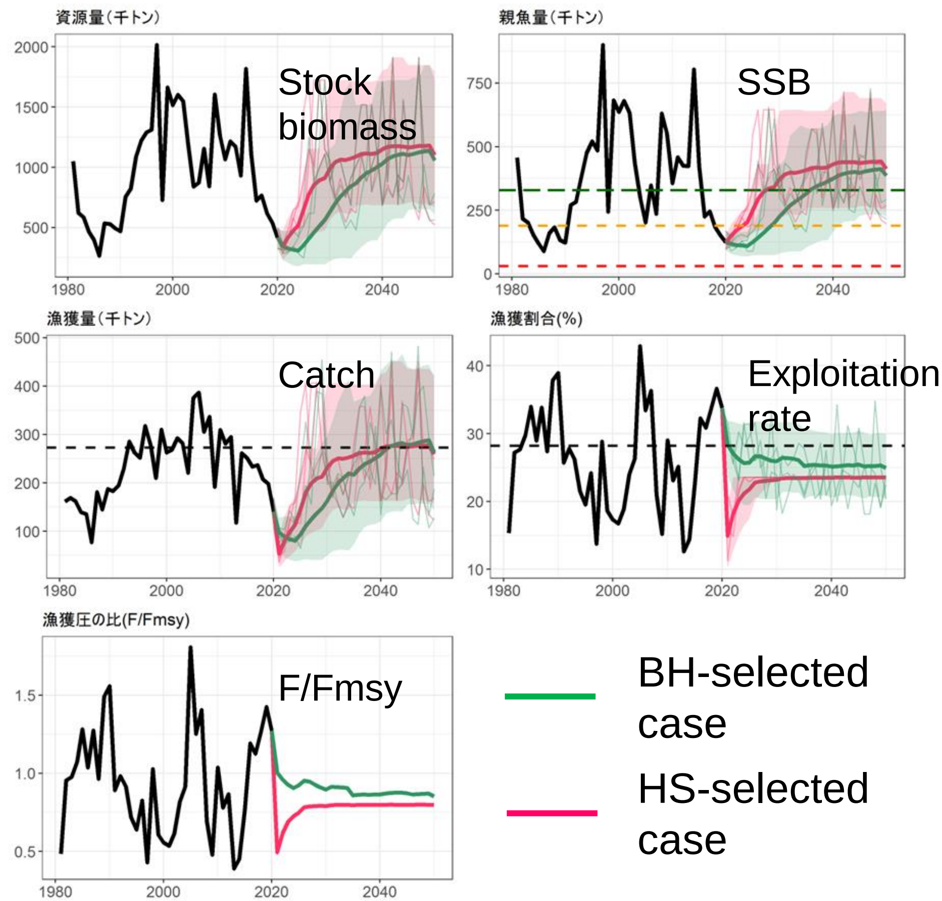
-> See next slide

3. Stock-recruitment and management quantities
Simple MSE

True SR: BH



True SR: HS



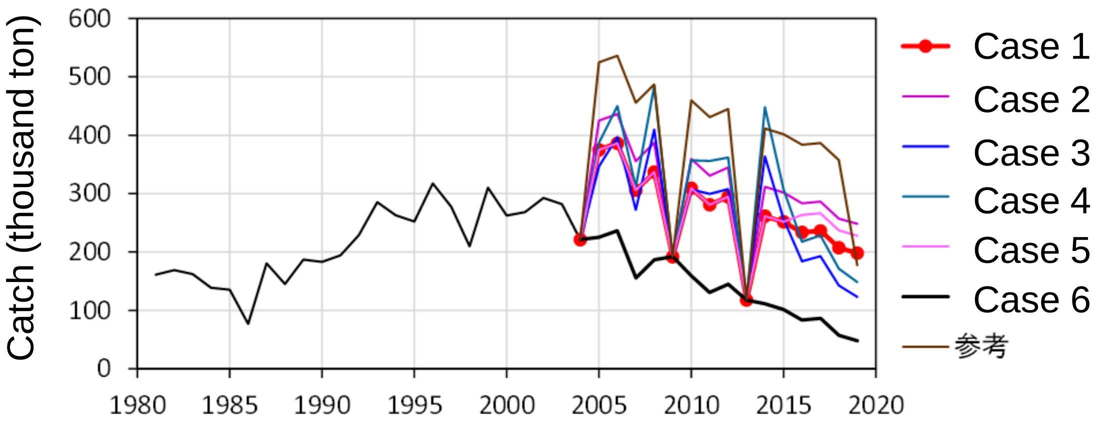
Reviewers' question on sensitivity to Chinese catch assumption

<u>Question</u>

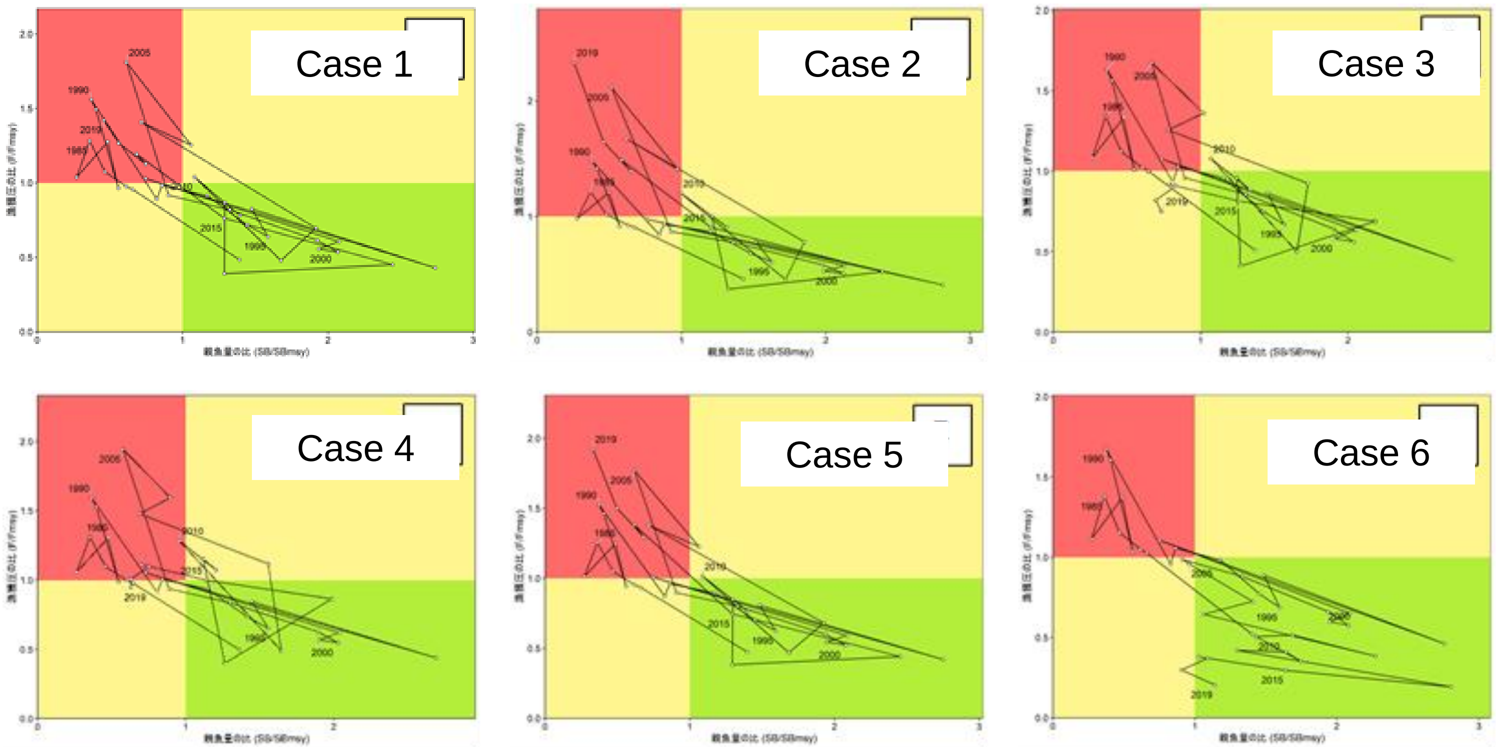
- How sensitive are the model results to the assumed level of Chinese catch?

<u>Response</u>

- Sensitivity test was conducted regarding several settings of Chinese catch
  - Case 1 (base case): Constant catch of 150 thousand ton
  - Case 2: Constant catch of 200 thousand ton
  - Case 3: Mean catch of 150 thousand ton under constant F
  - Case 4: Mean catch of 200 thousand ton under constant F
  - Case 5: Constant catch of 150 thousand ton until 2015 and annual increment of 30 thousand ton in 2016 onward
  - Case 6: Zero



Literatures about Chinese catch



S-R relationship and reference point did not change largely among cases except for case 6