Estimation of the length composition for the Japanese tuna purse seine with new data collected at PBF farming operation using stereoscopic camera

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Summary

In the Sea of Japan, purse seiners operate targeting Pacific Bluefin tuna from May to July. They mainly land PBFs for fresh consumption, but they also farm PBFs in recent years. We estimate size composition from measurement data from stereo-camera and raised by number of farming PBFs. We also calculated models including estimated size composition.

Introduction

Japanese tuna purse seines which operated in the Sea of Japan (JPS-SOJ) is the fisheries targeting large size Pacific Bluefin tuna (PBF). This fishery is one of the biggest fleets in 2000's until the catch quota was firstly introduced in 2011 as unilateral measure of Japan. Tuna purse seine in the Sea of Japan introduced self-regulated IQ in 2017 and governmental IQ in 2022. A part of PBF caught by this fishery has been farmed since early 2010's, and the ratio of the farming of large PBF over the catch by JPS-SOJ has been increased in recent year (Figure 1). This operation also occurred in early summer (June to July) and captured PBF was carried to Ine in Kyoto prefecture or Oki islands in Shimane prefecture (Figure 2) from the operation points and fattened until winter.

In the stock assessment model, fleet 4 is assigned for JPS-SOJ. For this fleet, catch in weight, which included farming operation, and length composition data, which collected by the port sampling, were used.

In this document, we firstly present the measurement data from JPS-SOJ farming operation using stereoscopic camera, and method to raise the measurement data to the total catch in number of fish at size. We also provide some results of the test run using the PBF stock assessment model for adding the new size composition.

Number of farming PBF by JPS-SOJ

The number of PBF for farming was recorded in the logbook. We also collected an engagement document between the fishermen and farming company since 2021. This document included contracted date, farming place and number of farmed PBF. We used logbook data during 2017-2020 and the engagement document during 2021 and 2022.

Catch in weight and number, and coverage of the measurement, which is the number of fish measured over the total number of fish farmed, were summarized in Table 1.

Size composition

The farms were encouraged to measure the folk length for 20% of farmed fish or at least 100 fish of caged fish using stereoscopic camera at the time of transfer from moving pen by the guideline of the industry themselves. Those measurement data using the stereo-camera system (AM100, AQ1 systems) were provided from the fishery or farming company. This system has been validated its precision of the measurement by 100 PBF individuals in Fukuda and Nakatsuka (2019) and it showed similar results between the stereo-camera measurement and the direct measurement. Large PBF for farming has been also measured by the stereo-camera in EPO (Dreyfus and Da Silva 2015), and this measurement data have been used since 2012 stock assessment (ISC PBFWG 2012).

Based on the newly available measurement data by the stereo-camera system, the size composition was estimated and raised by numbers of farming PBF.

$$N_{iy} = \sum_{k=1}^{k} m_{iyk} \times C_{yk}$$

where, N_{iy} is the estimate of the number of fish in size bin i for year y, m_{iyk} is proportion at the length bin of i in the operation (k) and C_{iyk} is catch number in the operation.

Figure 3 shows the raised size compositions. The size composition from the farming operation showed a peak value at larger size than that for the landing to the port (Figure 4).

Farming measurement data to Stock assessment model

We tried 3 options to apply this size composition data for the stock assessment model.

1. Simply add the farming data to the size composition of fleet 4 (JPS-SOJ)

   In the stock assessment model, the catch in weight for fleet 4 have included both the catch for farming and that for market landing. In the logbook, the catch amount for farming was recorded in both units of number and weight. However, catch at size (CaS) for fleet 4 was composed by only landed PBF measured by port sampling. For this option, the raised size composition for farming were simply added to the composition of fleet 4 and catch time series was remained as it was in the 2022 base case.

   Spawning stock biomass (SSB) and Recruitment result are the green line in Figure 5. Observed and estimated size compositions show good fit (Figure 6).

2. Develop a new fleet for farming operation (fleet 26)

   To explain catch and the size composition for JPS-SOJ farming operation individually, a new fleet 26 was constructed in the stock assessment model. Catch in weight for farming were removed from the fleet 4 and catch in number for farming was assigned to fleet 26. The second option was the model sharing the selectivity with fleet 4. For this model, we estimated the size and age selectivity of the fleet 4 (JPS-SOJ) based on the composition data of the fleet 4 and fleet 26 (lambda of those fleets were 1.0), and the estimated size and age selectivity was shared by the fleet 26.

3. Develop a new fleet for farming operation with time varying selectivity

   The third option was the model estimating the time varying selectivity for fleet 26 based its own composition data. A length-based time invariant asymptotic selectivity and age-based non-parametric time varying selectivity was estimated.

SSB and Recruitment result are in Figure 5. The option-2 and option-3 models with new fleet shows higher SSB than the 2022 base case model and the option-1 model. The models with new fleet showed bigger fish in their predicted size composition than that of the 2022 base case model and the option-1 model. Thus, the catch in bigger fish in the option-2 and option-3 models might lead a lower number of fish caught and eventually those estimated SSB become higher than the 2022 base case and option-1 model. Figure 7 shows observed and predicted aggregated size composition (fleet 4 and 26) for the models option-2 and option-3. Predicted size compositions in each year have same trends with observed size compositions. Also, predicted combined size composition data for both models are similar to each other except 2018 fishing year.

Conclusion

In the PBF stock assessment model, catch by tuna purse seine for farming operation in the Sea of Japan has been included in the fleet 4, which is the tuna purse seine in the Sea of Japan for port landing. Before mid-2010's, the farming operation by tuna purse seine occupied only limited part of the catch by the fleet, but it occupied 36% of catch in 2022. The importance of the measurement data for farming operation is increased.

The stock assessment model calculates population dynamics by number, thus catch based on number is more direct information for the model than catch in weight. So the changing the unit of catch from weight to number could be an advantage for the assessment model. From the raised size composition in this document, fish for farming shows a distribution for bigger size than that of landed PBF (fleet 4). There is a possibility that it occurs due to demands for the larger fish for farming.

Recent stock assessment model has many parameters to estimate. When we add the new fleet to estimate time varying selectivity, the model requires 29 more parameters than the base case model for additional 4 quarters of size composition data. On the other hand, there are no additional parameter in the model sharing the size and age selectivity between fleet 4 and fleet 26.

It is likely that operations for farming in the Sea of Japan would be continued in similar scale. We suggest adding a new fleet for farming in the Sea of Japan and using sharing selectivity with fleet 4. The estimated SSB as well as the predicted size composition for combined fleets (4 and 26) between the models for option-2 and option-3 shows similar results so that choosing a model, which had smaller number of the parameter estimated could be reasonable.

Reference

Dreyfus M. and A. Aires-da-Silva, 2015, PBF catch size-composition of the Mexican purse seine fishery from data collected at pen rearing operations: an update for 2013-2014., ISC/15/PBFWG-2/05

Fukuda H. and S. Nakatsuka, 2019, Estimation of the PBF length-composition for the Japanese purse seine with new data collected at young PBF farming operation using stereoscopic camera., ISC/19/PBFWG-2/02

ISC PBFWG, 2012, Stock Assessment of Pacific Bluefin Tuna in 2012., Available at: https://isc.fra.go.jp/pdf/Stock_assessment/PBF_stock_assessment_report_2012.pdf

Tables and Figures

Table 1 Catch amount, number and coverage by year

	Total catch amount (mt) caught by PS in SoJ	Catch amount (mt) for farming	number of farming fish	Number of measured fish	Coverage
2011	1797.1	12.0	150	-	-
2012	589.6	52.0	736	-	-
2013	1570.0	45.0	450	-	-
2014	2052.3	56.0	1220	-	-
2015	1626.3	96.7	1560	-	-
2016	1773.7	138.1	2180	-	-
2017	1697.8	279.4	2911	1000	34.4%
2018	1388.5	185.6	2139	400	18.7%
2019	1607.9	491.9	6400	2631	41.1%
2020	1606.0	302.7	4142	784	18.9%
2021	1646.0	490.6	4983	962	19.3%
2022	1821.8	525.7	5397	1900	35.2%

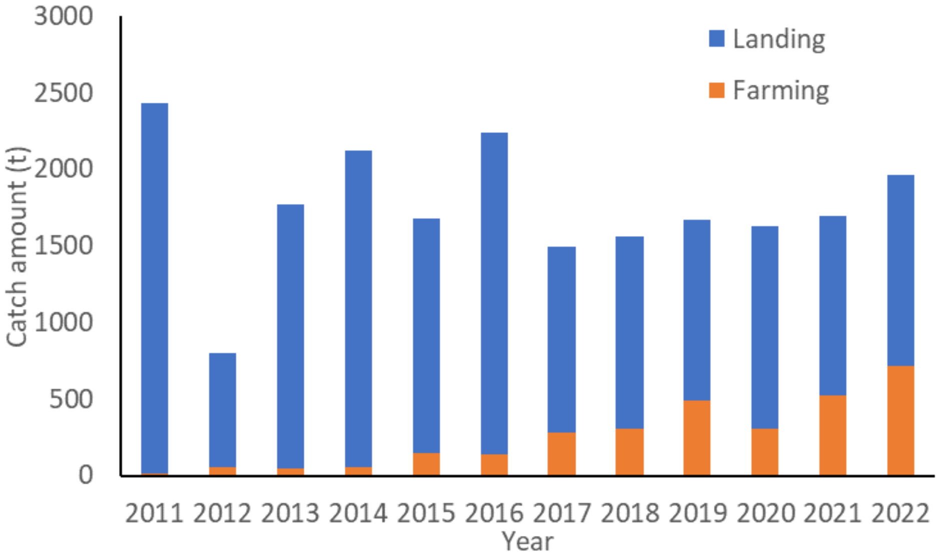


Figure 1. Annual catch amount of PBF caught by Purse seiners operated in SOJ.

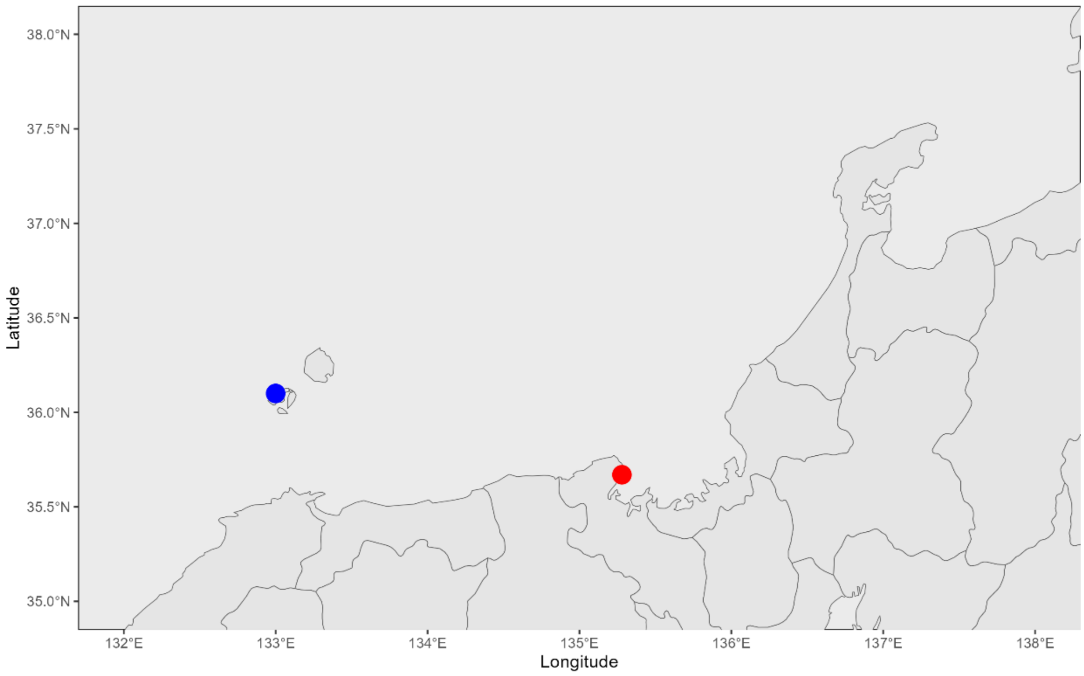


Figure 2. Location of farming place Ine in Kyoto (red) and Oki islands (blue).

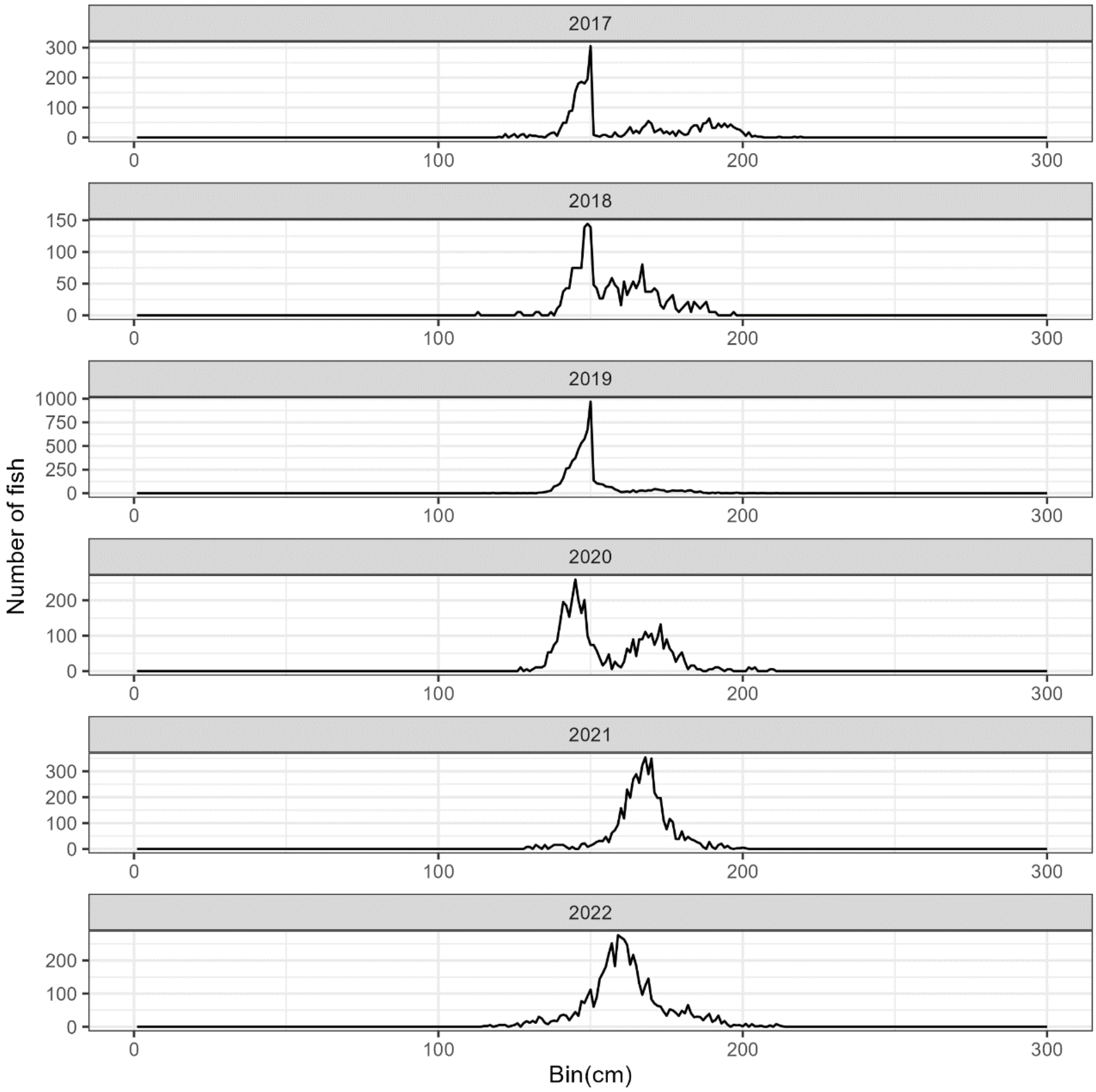


Figure 3. Raised size composition.

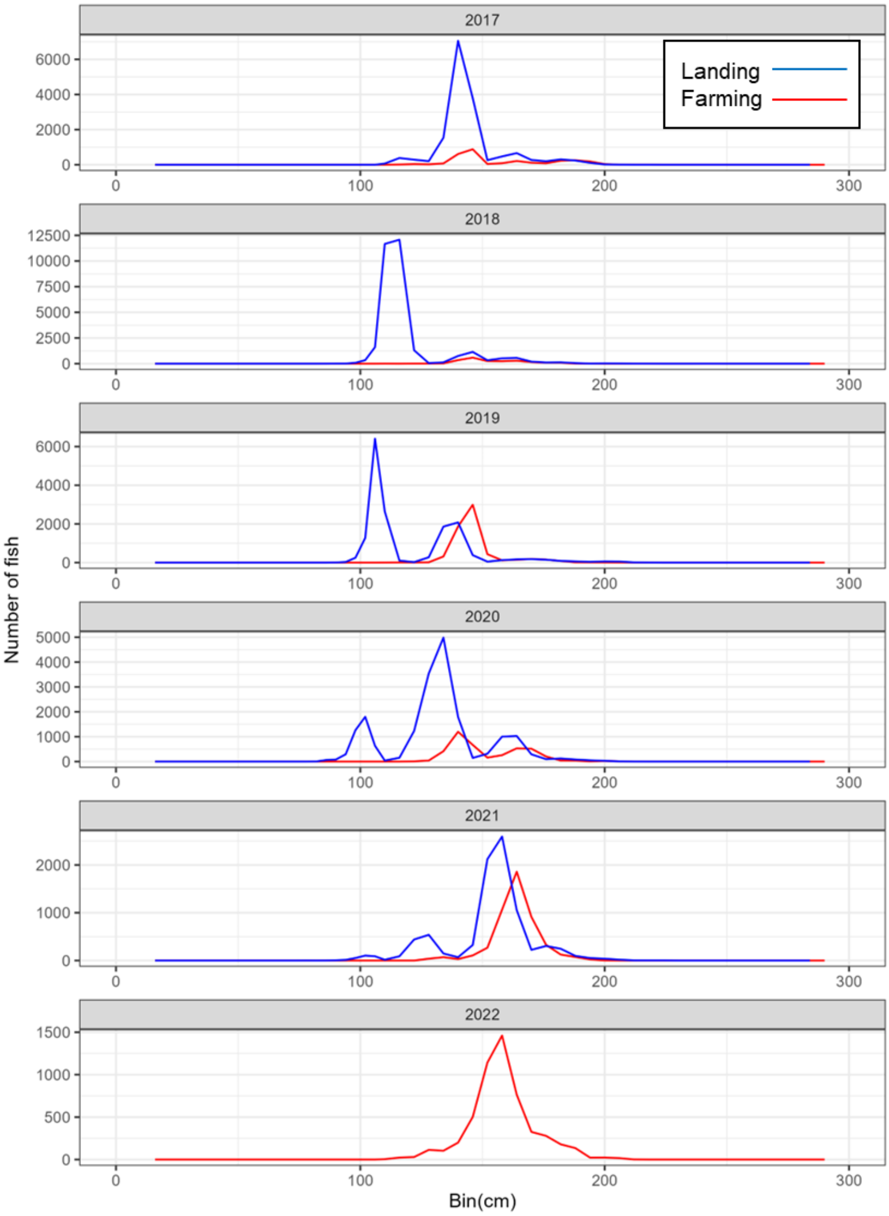


Figure 4. Comparison size compositions between farming (red line) and landing (blue line).

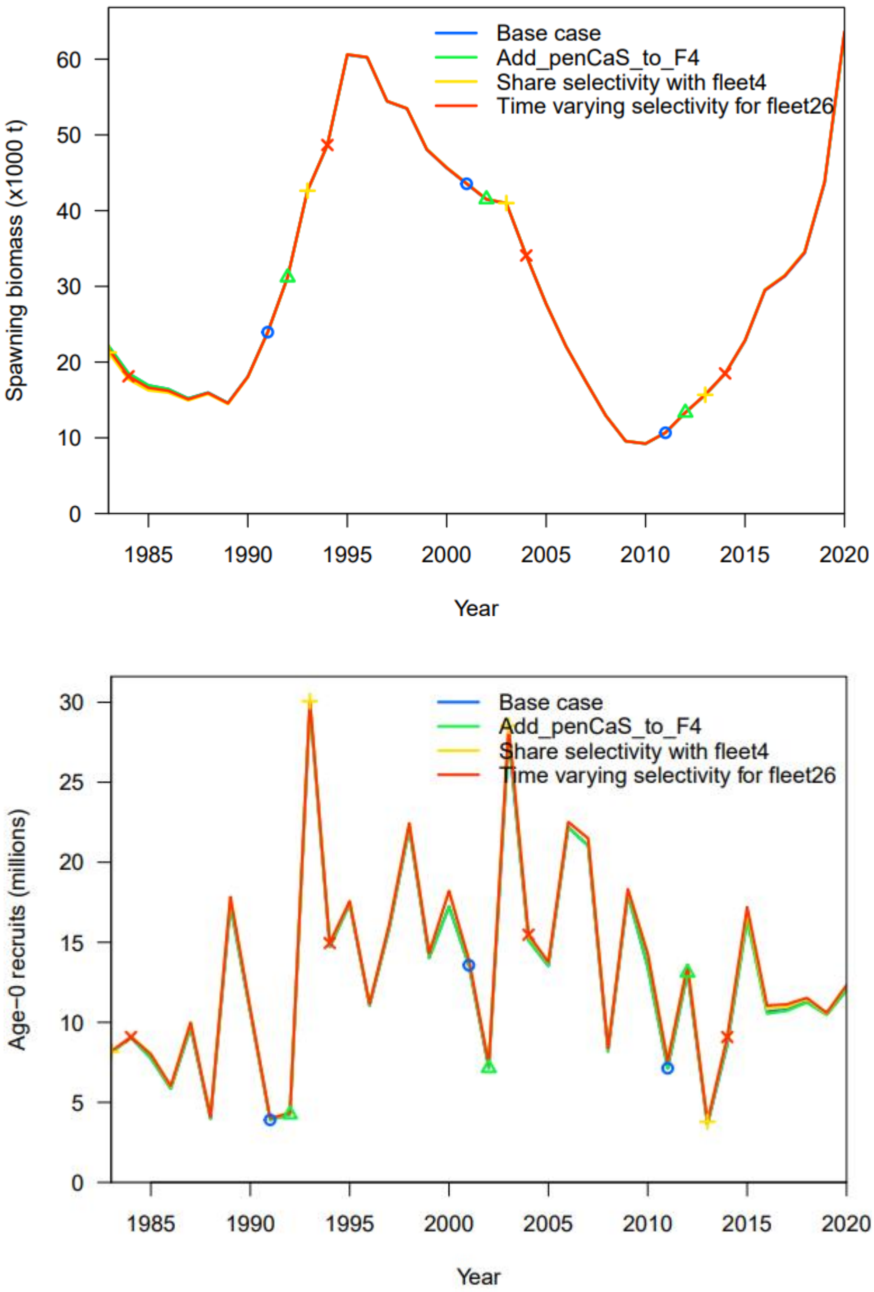
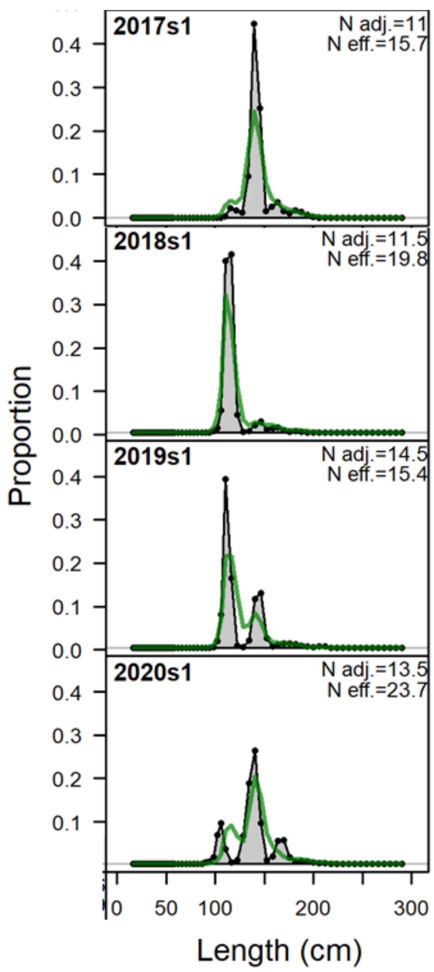


Figure 5. Comparison SSB (top) and Recruitment(bottom) between short base case(blue), the model adding farming CaS to fleet (green), the model adding new fleet with sharing selectivity with fleet 4 (orange) and the model adding new fleet with time varying selectivity (red).



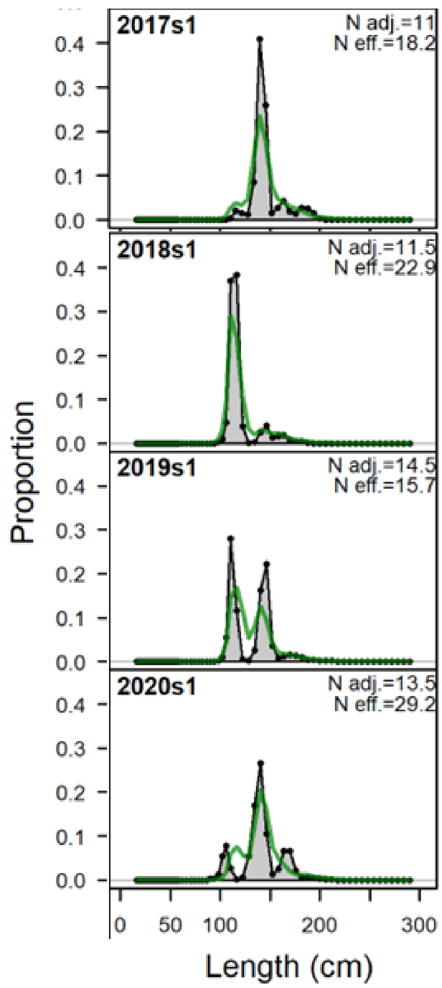


Figure 6. Observed (grey) and predicted(green) size composition for Fleet 4. Left panel is the result from base case model and right panel is the result from the model adding farming CaS to fleet.

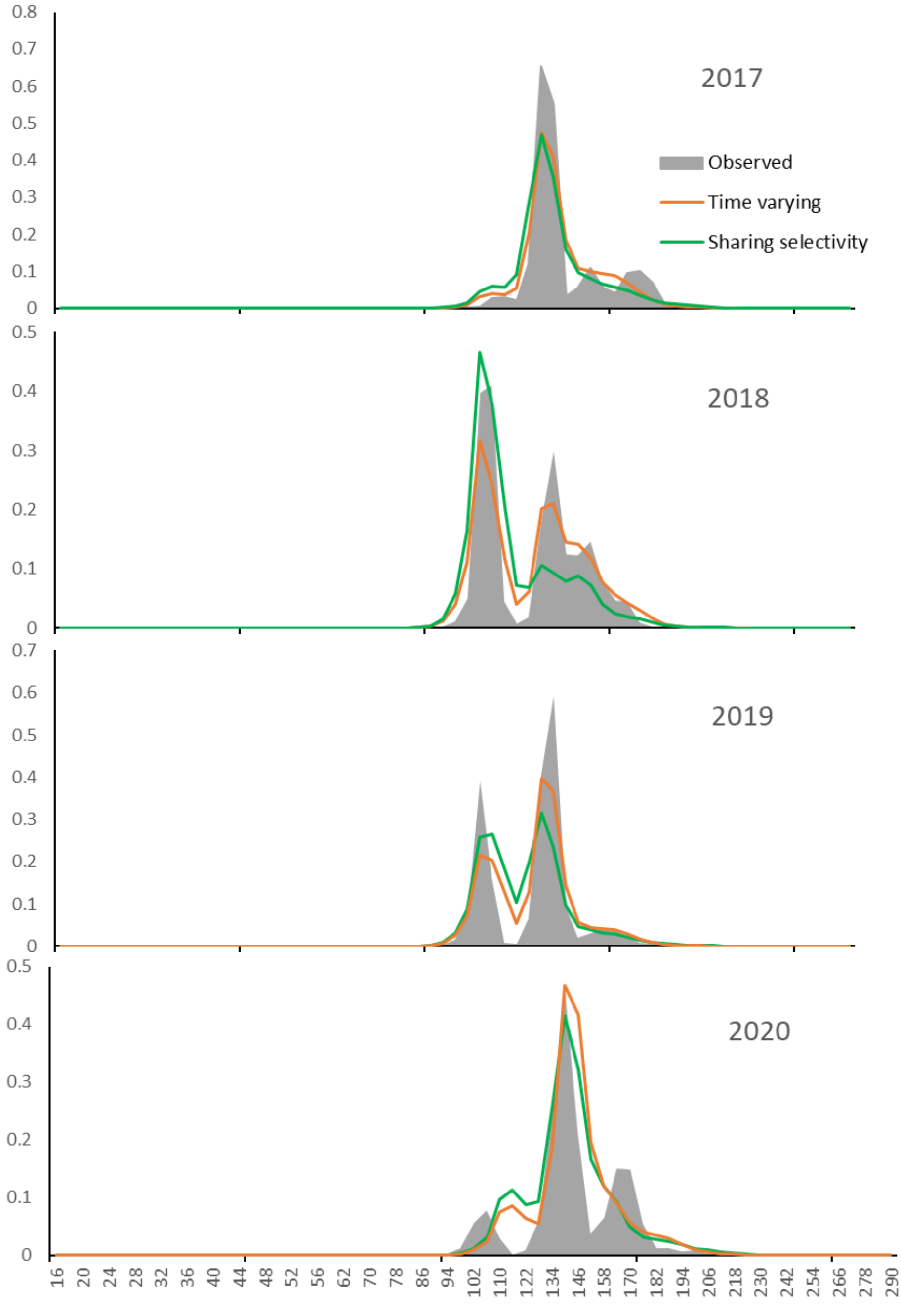


Figure 7. Observed and Estimated size composition estimated from the model adding new fleet with sharing selectivity with fleet 4 (left) and from the model adding new fleet with time varying selectivity(right).