



Seto Inland Sea stock of Bastard halibut *Paralichthys olivaceus*

Peer Review Meeting for Japanese Fish Stock Assessment
7-10 November 2023

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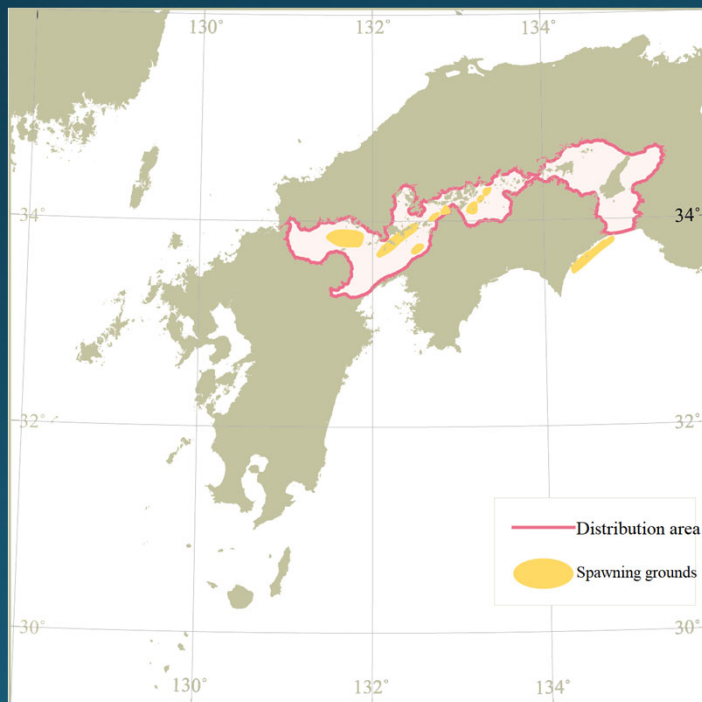
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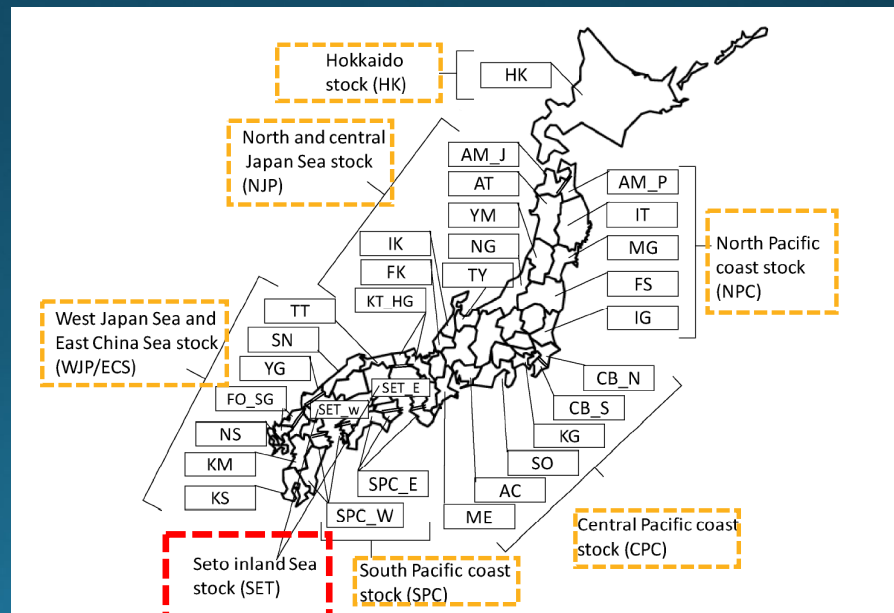
1. Biology and Stock Assessment

> Distribution

- Seto Inland Sea stock of Bastard halibut *Paralichthys olivaceus* is distributed mainly along the coast of the Seto Inland Sea.
- After reaching maturity, some migrate out to the open sea. (Ehime Prefecture 1995, Tokushima Prefecture 1995).



↓ Distributions of other stocks



(Kidokoro et al., 2021) 3

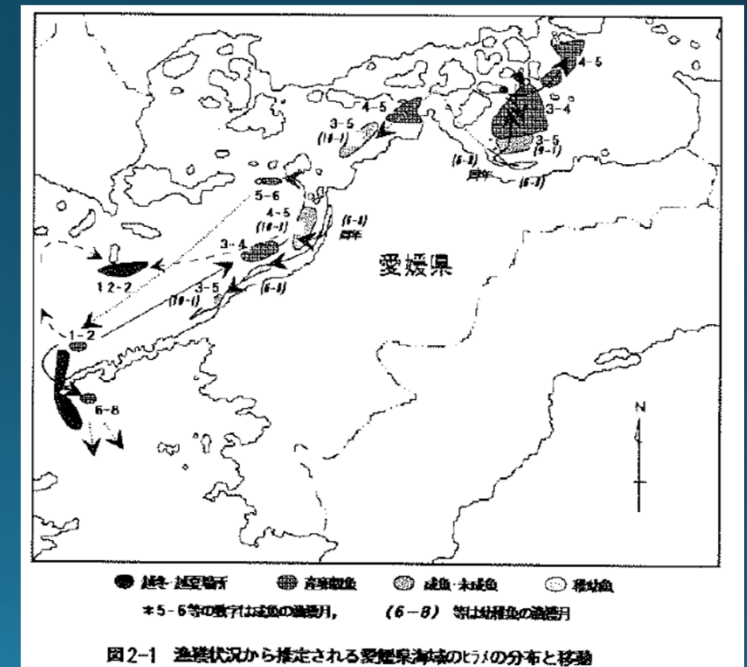
1. Biology and Stock Assessment Reviewer's Comments

- Q1: It was stated that some of the stock, after maturity, migrate out into the open ocean. Do these fish in the open ocean return to the Inland Sea? (ST Q7)
- Q2: Do these fish in the open ocean contribute to the SSB and recruitment of Inland Sea stock? (ST Q8)

Response

There is no direct evidence of returning back to the Seto-Inland Sea however immigration/migration is considered to be limited.

In the stock assessment, catches within the Seto-Inland Sea region are considered as the Seto-Inland Sea stock.



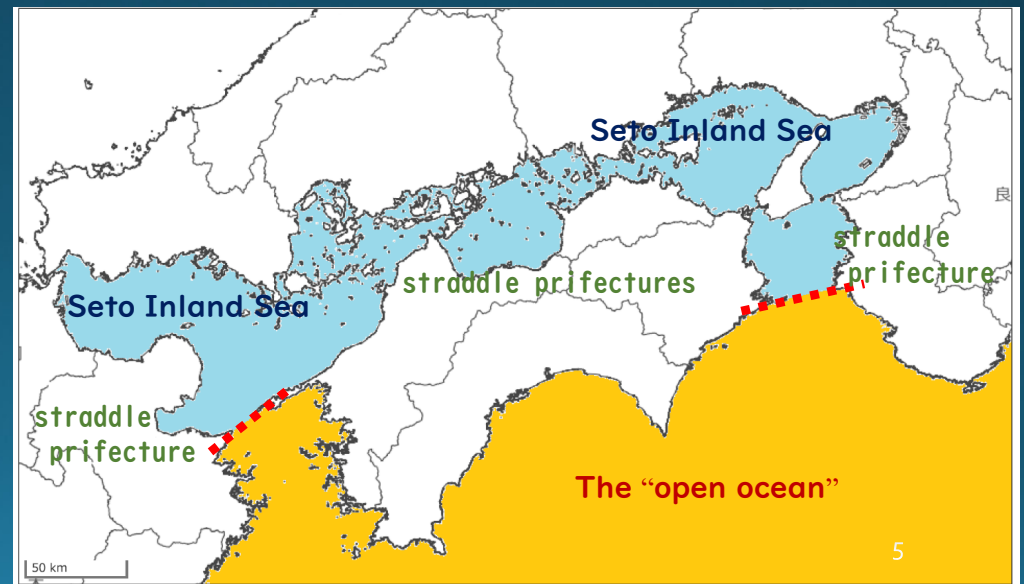
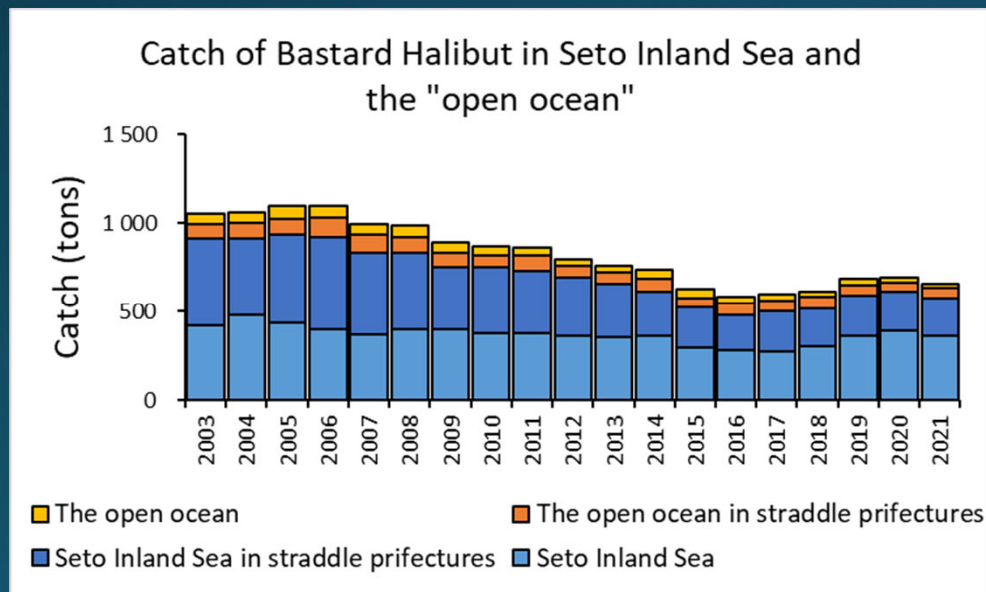
(Ehime Prefecture⁴ 1995)

1. Biology and Stock Assessment Reviewer's Comment

- Q₃: Are there fisheries that catch these fish in ? (ST Q₉)

Response

- Yes, halibuts are caught by offshore bottom trawl other than gears similar to the Seto-Inland Sea.
- Catch in the open ocean is considered in the southern Pacific coast stock, however the catch is significantly low compared to the Seto-Inland Sea stock.



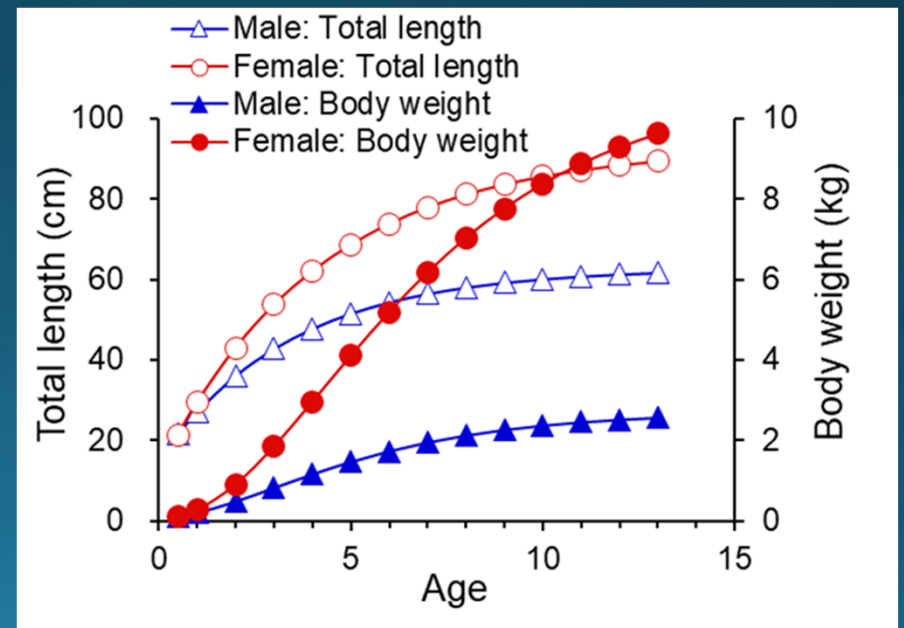
1. Biology and Stock Assessment

> Growth

- Difference in growth between the sexes.
- The lifespan is unknown (The oldest was 16 years old)
- Ages were determined using otolith (for PTK Q1b)
- The von Bertalanffy growth curve was;

Male: $L_t = 62.78 (1 - \exp(-0.29(t + 0.96)))$

Female: $L_t = 92.94 (1 - \exp(-0.24(t + 0.59)))$



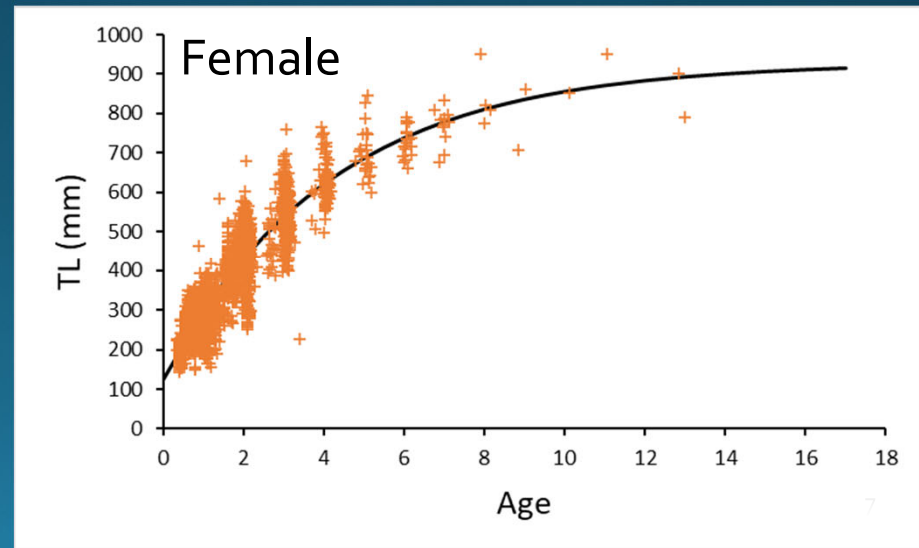
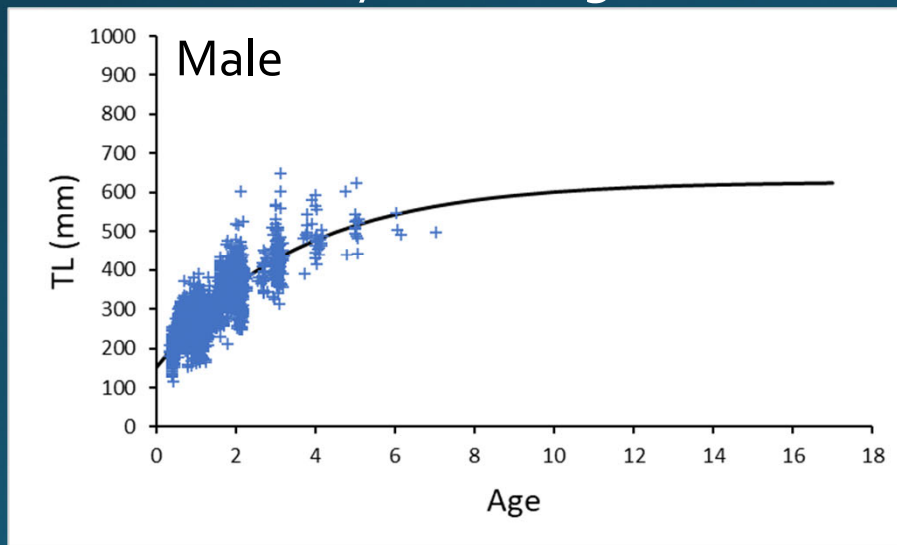
1. Biology and Stock Assessment

Reviewer's Comment

- Q₄: Where are the values for older fish (>age5) coming from? Are these fish outside of the Seto Sea? (PTK Q₅)
- Q₅: There was aging done during 1995-2004. How variable was the growth from year to year during this period? (ST Q₁₀)

Response

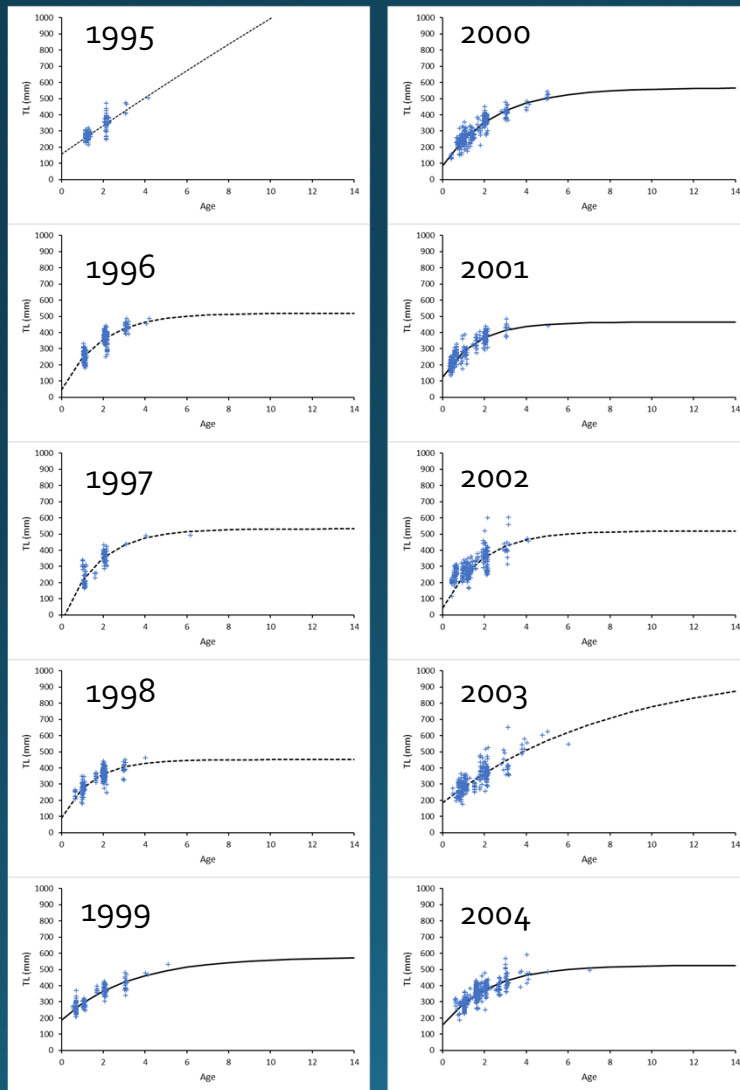
All measured samples originate from the Seto-Inland sea.
Yearly samples are limited therefore analysis is conducted on a pooled data.
The data analyzed and growth curves:



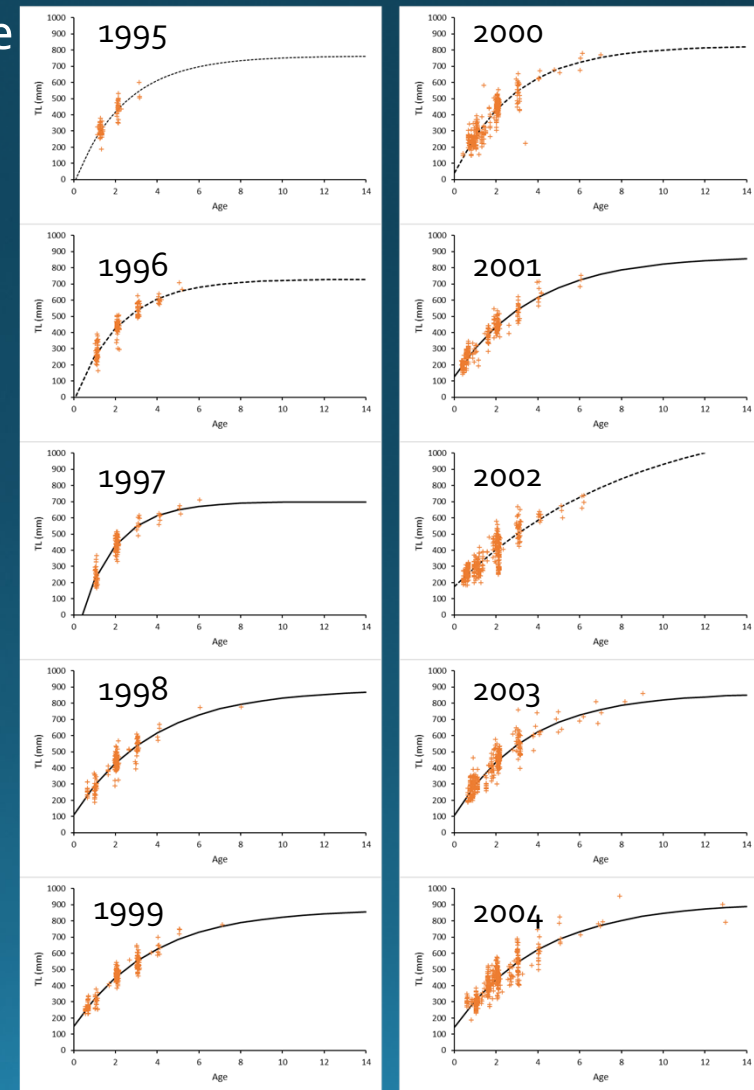
1. Biology and Stock Assessment Reviewer's Comment

Response Data and estimated growth curve

Male



Female

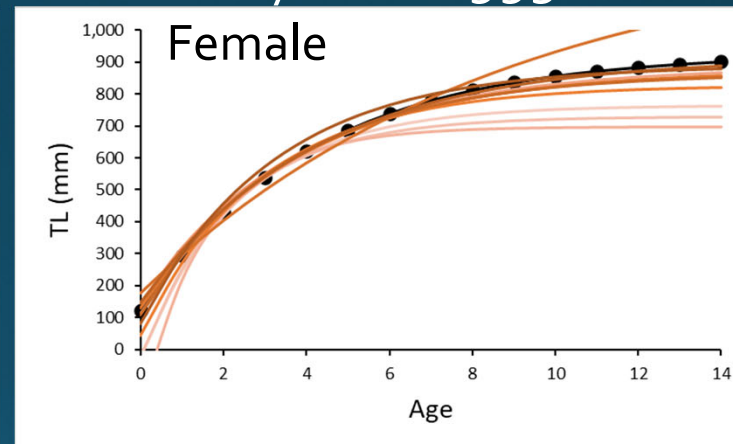
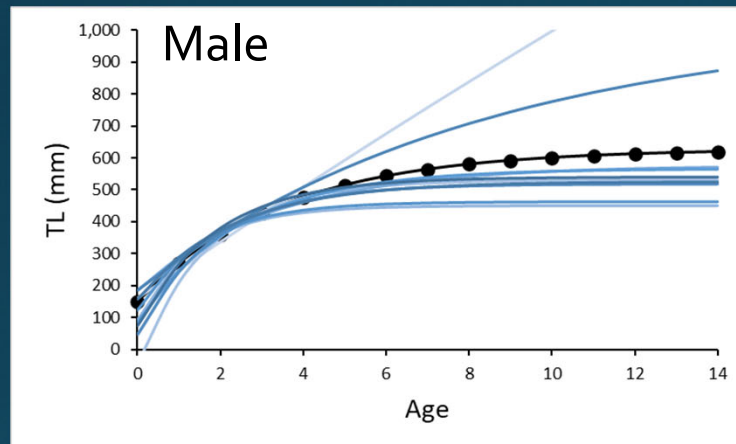


1. Biology and Stock Assessment

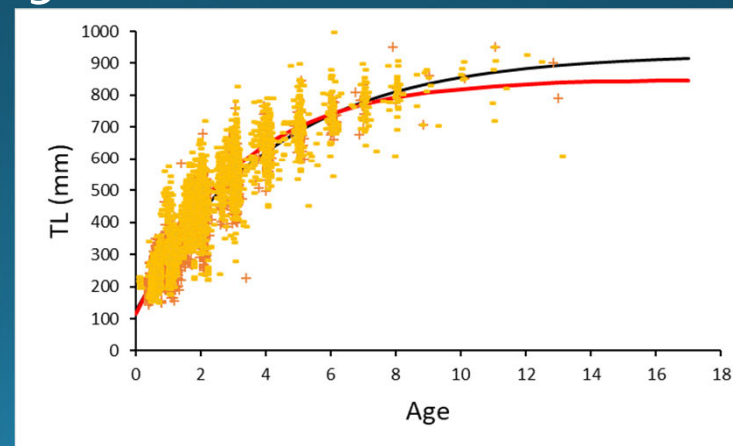
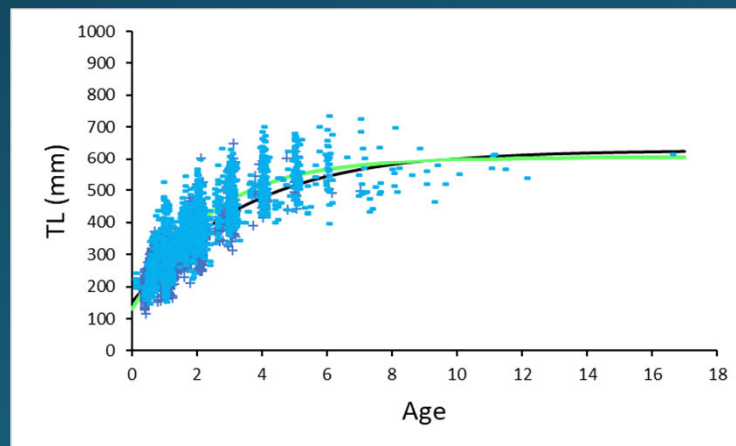
Reviewer's Comment

Response

There is no significant dynamics between yearly growth trajectories
> Growth curve estimated from data for each year in 1995 to 2004



> Growth curve estimated from 2005-2022 data



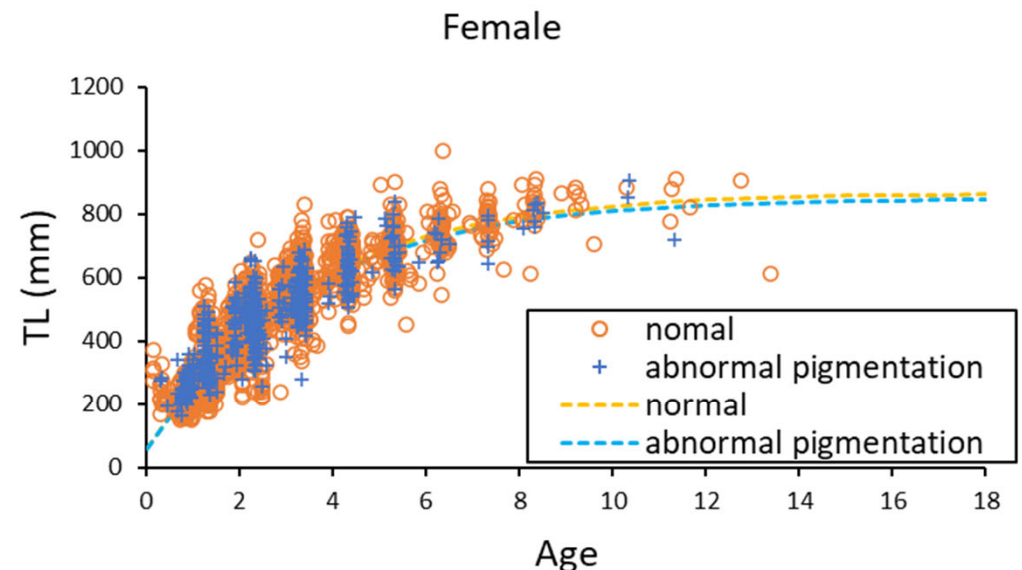
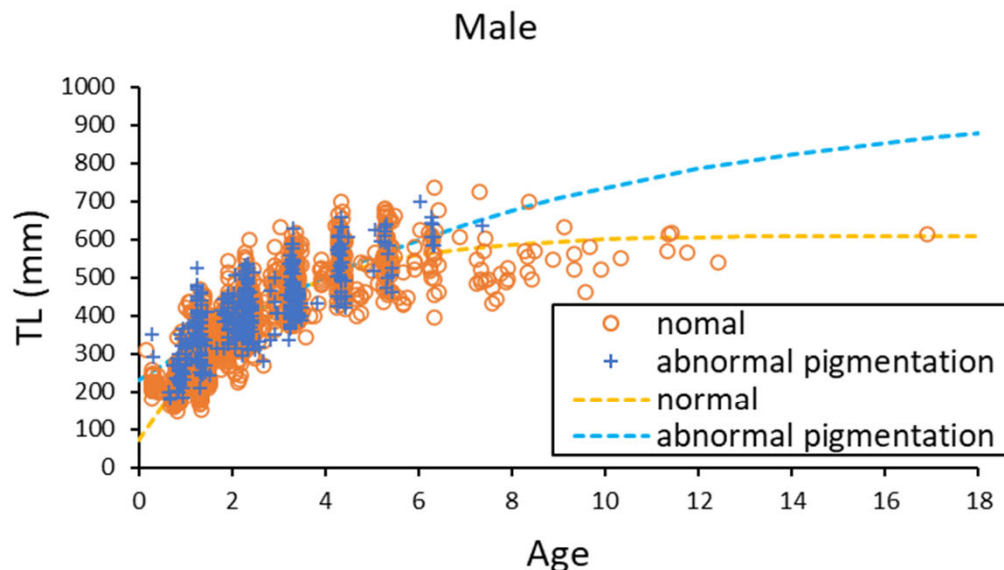
1. Biology and Stock Assessment

Reviewer's Comment

- Q6: Is there evidence of a different age-length relationship for hatchery fish? (PTK Q2a)

Response

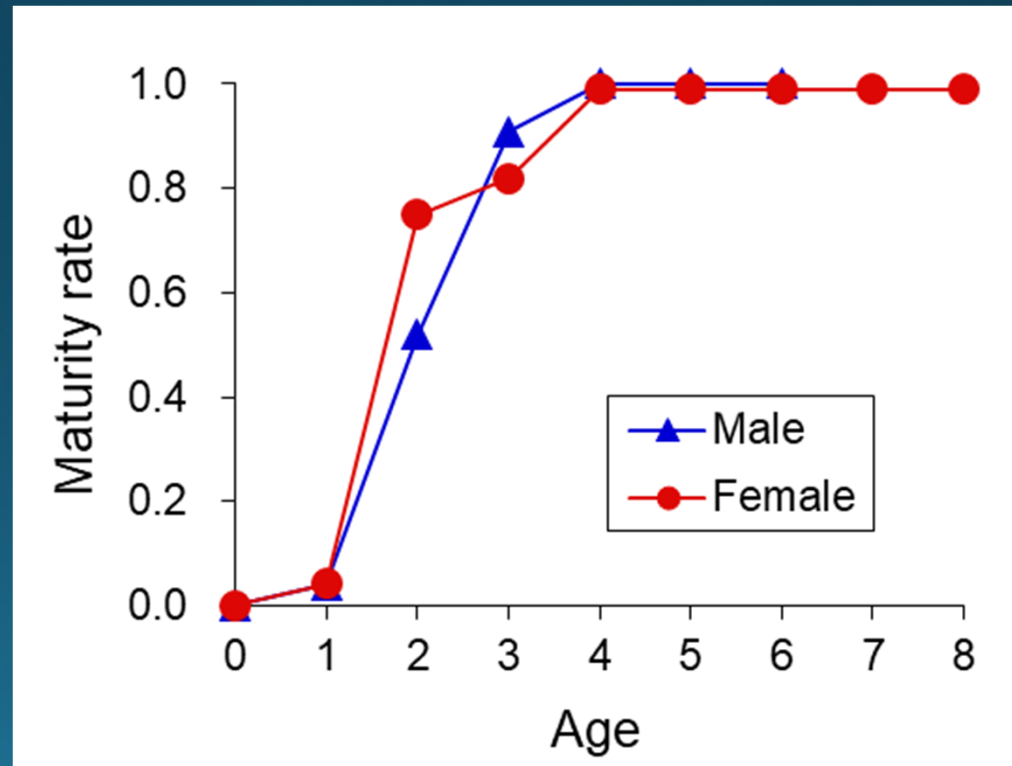
NO: We don't assume any difference between Hatchery fish (abnormal pigmentation) and Wild fish (normal).



1. Biology and Stock Assessment

> Maturation / Spawning

- Spawning season:
 - > February to May in the eastern waters
 - > March to June in the central and western waters
- Maturity rate at age as;



1. Biology and Stock Assessment

Reviewer's Comments

- Q7: Please provide additional details on the number of samples used to calculate maturity rate at age. How was maturity determined from the samples? Was visual assessment of maturity stage or histological analysis used? (PTK Q2c)
- Q8: There is no difference in age at maturity between male and females in this stock. Is other stocks treat age at maturity as similar? For example, male matures at age-2 and female at age-3 according to Minami (1997) (TYQ1)

Response

Maturity-at-age is based on a reported data (Ehime prefec, 1995)

> sample size is unknown, maturity is based on the GI in April

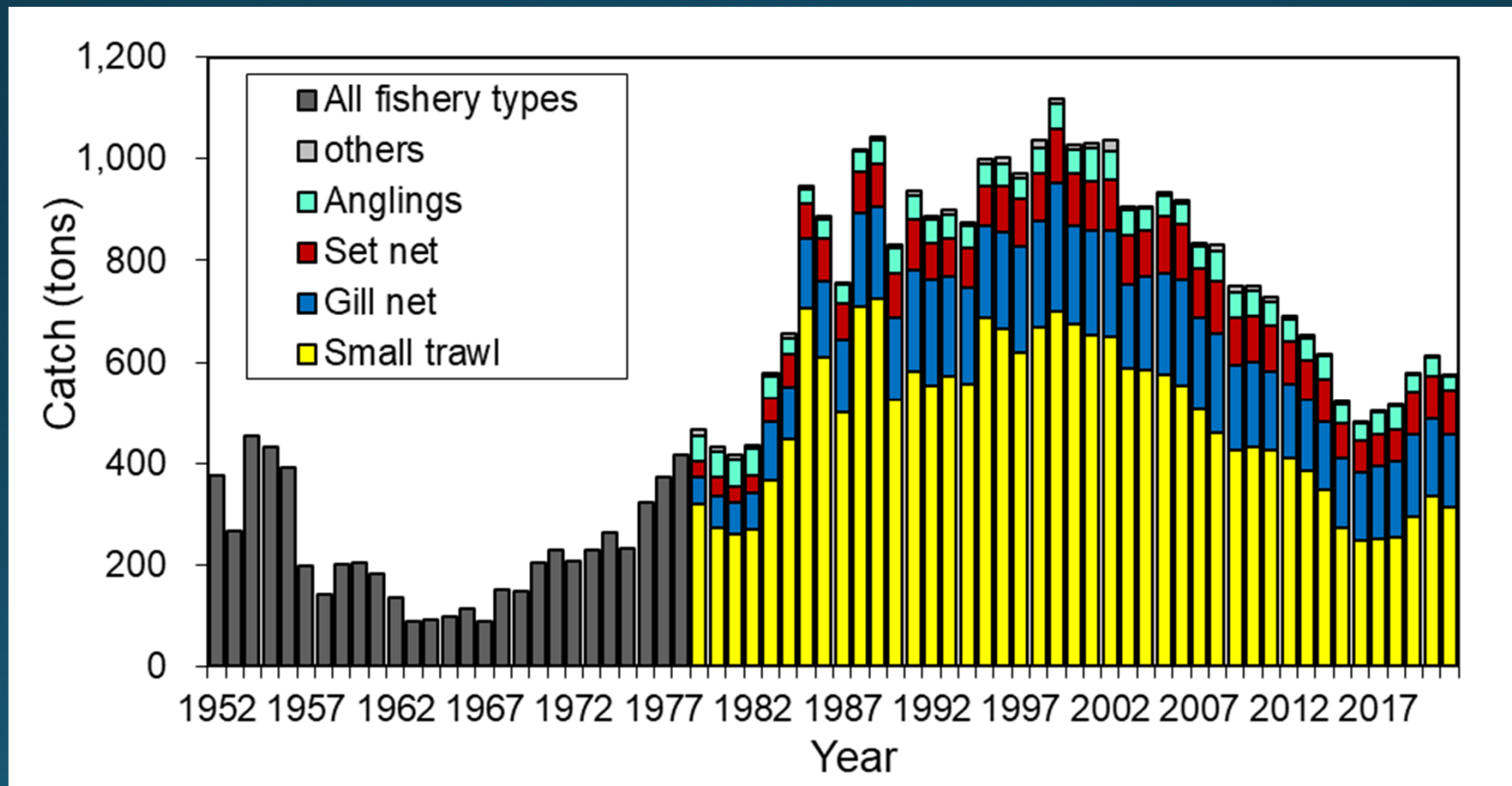
> $GI = (GW/TL^3)10^7$, GW : g, TL : mm

- ✓ Age of maturity of female is greater than males' in other stocks
- ✓ Female and males are treated as a whole in the stock calculation
- ✓ The points are correct from the biological perspective, we are going to consider those features.

1. Biology and Stock Assessment

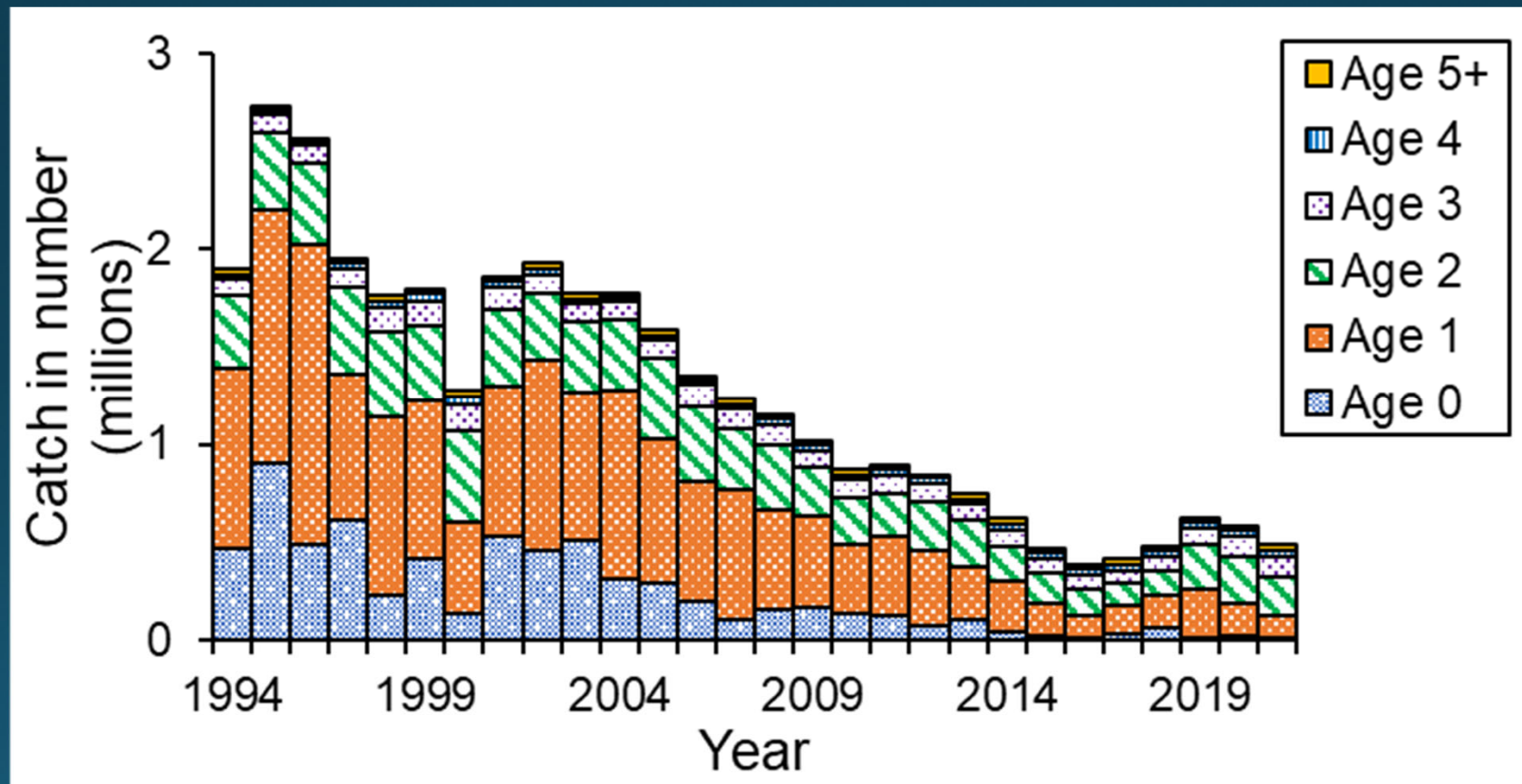
> Catch

- Mainly caught by Small trawl fishery, Gill net fishery, Set net fishery, and Anglings (including Long line fishery)



1. Biology and Stock Assessment > Catch

- Data : 1994 to 2021
- Age composition: 0, 1, 2, 3, 4 and 5+ (plus group)



1. Biology and Stock Assessment

Reviewer's Comments

- Q9: Please provide details on the catch compositions if available. Details such as dates of sampling, number of individuals measured, protocols for assessing age. (PTK Q1a)
- Q10: For a cohort analysis, it is assumed that catch-at-age is known. It is important that this is a reasonable assumption. Please explain in detail how the catch-in-weight is converted into catch-at-age in numbers. (ST Q16)

Response

Age assessment: observing the cross section of otolith.
Calculation methods for catch in number at age (CAA) are shown on following slides.

1. Biology and Stock Assessment

- > Estimation of Catch Number at Age

Fdofxowlrgr#iru#Edwfk#lg#pxp ehudw#lj h#FDD,#

- ## ① Sampling for each $\dots$

- fishing season
 - ✓ Jan. to Apr., May to Aug., Sep. to Dec.
- sample fisheries cooperatives
 - ✓ 6 prefectures
- fishery type
 - ✓ Small trawl, Gill net, Set net, Others

- ## ② Measurement of samples:

- Total length composition measurement
- Precision measurement
 - ✓ total length, body weight, sex, age etc.

- ### ③-a; Estimate the length composition of annual catch for each season

- ### ③-b; Estimate the Age-length key for each season and sex

- #### ④ Estimate the catch in number at age (CAA)

1. Biology and Stock Assessment

> Estimation of Catch Number at Age

① Sampling for each...

- fishing season (3 seasons)
- sample fisheries cooperatives
- fishery type

② Measurement of samples:

- Total length composition measurement
- Precision measurement (total length, body weight, sex, age etc.)

			>100			>20			>10			>0			0		
Year			2019			2020			2021								
Fishery type: Prefecture			Jan. to Apr.	May to Aug.	Sep. to Dec.	Jan. to Apr.	May to Aug.	Sep. to Dec.	Jan. to Apr.	May to Aug.	Sep. to Dec.	Jan. to Apr.	May to Aug.	Sep. to Dec.	Jan. to Apr.	May to Aug.	Sep. to Dec.
Small trawl	Osaka	Number of samples	213	66	35	109	72	46	268	79	74						
		Number of aged	0	0	0	0	0	0	0	0	0						
	Hyogo	Number of samples	293	110	155	65	80	30	198	40	39						
		Number of aged	2	3	0	0	2	0	4	6	0						
	Ehime	Number of samples	238	59	21	160	86	66	131	61	72						
		Number of aged	81	23	0	49	34	35	46	38	1						
Gill net	Ehime	Number of samples	26	45	22	24	18	23	14	5	6						
		Number of aged	4	0	0	0	11	14	0	4	0						
Set net	Ehime	Number of samples	33	31	0	0	0	0	48	0	0						
		Number of aged	0	0	0	0	0	0	0	0	0						
	Kagawa	Number of samples	18	63	21	47	58	0	31	61	11						
		Number of aged	18	63	21	47	57	0	31	61	11						
Small trawl and others	Yamaguchi	Number of samples	533	181	148	467	137	207	389	242	88						
		Number of aged	0	0	0	0	0	0	0	0	0						
	Oita	Number of samples	611	331	397	878	442	355	458	297	160						
		Number of aged	0	0	0	0	0	0	0	0	0						

1. Biology and Stock Assessment

> Estimation of Catch Number at Age

- ③-a; Estimate the length composition of annual catch for each season
- ③-b; Estimate the Age-length key for each season and sex
- ④ Estimate the catch in number at age (CAA)

e.g. 2021 data

Total length measurement
Number of measured;

Fishery types	Prefecture	Jan. to Apr. (ind)	May to Aug. (ind)	Sep. to Dec. (ind)
Small trawl	Osaka, Hyogo, Ehime	601	186	185
Gill net	Ehime	14	5	6
Set net	Ehime, Kagawa	79	61	11
Small trawl and others	Oita	458	297	160
	Yamaguchi	389	242	88

×

Catch

Total (tons)
173
35
21
43
33



length composition

TL	Jan. to Apr.	May to Aug.	Sep. to Dec.
<4	0.00	0.00	0.00
8	0.00	0.00	0.00
12	0.00	0.00	0.00
16	0.00	0.00	0.00
20	0.26	0.07	0.59
24	1.50	0.62	2.93
28	3.61	1.52	4.63
32	5.26	16.08	6.64
36	6.83	4.85	9.35
40	12.45	11.33	7.37
44	13.72	7.87	8.63
48	15.25	15.68	16.99
52	20.42	13.85	12.28
56	8.37	9.57	12.59
60	5.63	9.16	10.31
64	2.67	5.37	5.24
68	1.37	2.04	2.21
72	1.23	1.41	0.14
76	0.82	0.43	0.00
80	0.50	0.07	0.00
84	0.10	0.00	0.10
88	0.00	0.08	0.00
92	0.00	0.00	0.00
96	0.00	0.00	0.00
100	0.00	0.00	0.00

1. Biology and Stock Assessment

> Estimation of Catch Number at Age

- ③-a; Estimate the length composition of annual catch for each season
- ③-b; **Estimate the Age-length key for each season and sex**
- ④ Estimate the catch in number at age (CAA)

Supplementary Table 2-1.

Age-length key (Female)

Female	January to April					May to August					September to December					
TL class	1	2	3	4	5	1	2	3	4	5	0	1	2	3	4	5
0 40	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
40 80	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
80 120	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
120 160	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
160 200	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
200 240	1	0	0	0	0	0.92	0.06	0.02	0	0	1	0	0	0	0	0
240 280	0.98	0.02	0	0	0	0.91	0.09	0	0	0	0.95	0.05	0	0	0	0
280 320	0.85	0.15	0	0	0	0.85	0.15	0	0	0	0.7	0.27	0.02	0	0	0
320 360	0.49	0.48	0.03	0	0	0.69	0.31	0	0	0	0.26	0.68	0.07	0	0	0
360 400	0.16	0.79	0.05	0	0	0.27	0.68	0.04	0	0	0	0.94	0.04	0.01	0	0
400 440	0.06	0.85	0.09	0	0	0.03	0.87	0.1	0	0	0	0.88	0.11	0.01	0	0
440 480	0.03	0.83	0.13	0.01	0	0.01	0.86	0.12	0.01	0	0	0.73	0.27	0	0	0
480 520	0.02	0.64	0.33	0.01	0	0	0.64	0.32	0.05	0	0	0.65	0.32	0.03	0	0
520 560	0.01	0.33	0.61	0.04	0.01	0	0.3	0.58	0.11	0.01	0	0.31	0.53	0.13	0.03	0
560 600	0.01	0.18	0.6	0.17	0.04	0.01	0.18	0.6	0.17	0.04	0	0.01	0.18	0.6	0.17	0.04
600 640	0	0.06	0.49	0.35	0.1	0	0.06	0.49	0.35	0.1	0	0	0.06	0.49	0.35	0.1
640 680	0	0.01	0.29	0.42	0.27	0	0.01	0.29	0.42	0.27	0	0	0.01	0.29	0.42	0.27
680 720	0	0.01	0.13	0.39	0.47	0	0.01	0.13	0.39	0.47	0	0	0.01	0.13	0.39	0.47
720 760	0	0	0.05	0.25	0.7	0	0	0.05	0.25	0.7	0	0	0	0.05	0.25	0.7
760 800	0	0	0.01	0.1	0.88	0	0	0.01	0.1	0.88	0	0	0	0.01	0.1	0.88
800 840	0	0	0.03	0	0.97	0	0	0.03	0	0.97	0	0	0	0.03	0	0.97
840 880	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
880 920	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
920 960	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
960 1000	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1

(male)

Male	January to April					May to August					September to December					
Total length	1	2	3	4	5	1	2	3	4	5	0	1	2	3	4	5
0 40	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
40 80	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
80 120	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
120 160	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
160 200	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
200 240	0.99	0.01	0	0	0	0.99	0.01	0	0	0	0.99	0.01	0	0	0	0
240 280	0.86	0.14	0	0	0	0.87	0.13	0	0	0	0.88	0.12	0.01	0	0	0
280 320	0.61	0.38	0.01	0	0	0.7	0.29	0.01	0	0	0.42	0.54	0.04	0	0	0
320 360	0.19	0.77	0.04	0	0	0.23	0.69	0.07	0	0	0.06	0.84	0.1	0.01	0	0
360 400	0.04	0.85	0.1	0	0	0.04	0.83	0.1	0.02	0	0.01	0.76	0.18	0.01	0.02	0
400 440	0.05	0.61	0.31	0.02	0.01	0.02	0.53	0.4	0.04	0.01	0	0.71	0.22	0.01	0.01	0.04
440 480	0.01	0.36	0.52	0.09	0.02	0	0.38	0.38	0.14	0.1	0	0.33	0.44	0.04	0.11	0.07
480 520	0.01	0.16	0.41	0.22	0.2	0	0.18	0.26	0.32	0.23	0	0.14	0.36	0.36	0	0.14
520 560	0	0.09	0.42	0.22	0.28	0	0.03	0.35	0.3	0.32	0	0.1	0.1	0.2	0.1	0.5
560 600	0.01	0.03	0.31	0.37	0.28	0.01	0.03	0.31	0.37	0.28	0	0.01	0.03	0.31	0.37	0.28
600 640	0	0.02	0.08	0.4	0.51	0	0.02	0.08	0.4	0.51	0	0	0.02	0.08	0.4	0.51
640 680	0	0	0.05	0.24	0.71	0	0	0.05	0.24	0.71	0	0	0	0.05	0.24	0.71
680 720	0	0	0	0.33	0.67	0	0	0	0.33	0.67	0	0	0	0	0.33	0.67
720 760	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1

sex ratio

Jan.-	May-	Sep.-
0.5	0.5	0.5
0.5	0.5	0.5
0.5	0.5	0.5
0.5	0.5	0.46
0.3	0.25	0.52
0.47	0.34	0.58
0.38	0.47	0.59
0.35	0.47	0.46
0.33	0.39	0.32
0.23	0.31	0.4
0.49	0.53	0.57
0.77	0.71	0.76
0.79	0.76	0.83
0.77	0.78	0.76
0.76	0.76	0.76
0.83	0.83	0.83
0.89	0.89	0.89
0.96	0.96	0.96
0.98	0.98	0.98
1	1	1
1	1	1
1	1	1
1	1	1
1	1	1
1	1	1

1. Biology and Stock Assessment

Reviewer's Comment

- Q11: Was a pooled (across all years) age-length key used for each of the three seasons? Were there sufficient samples to use year-specific age-length keys for the three seasons? (PTK Q_{4a})

Response

YES, pooled age-length key was used. The sample is too little to construct yearly key.

									>100	>20	>10	>0	0
Number of measurements		Male						Female					
		Age	0	1	2	3	4	5+	0	1	2	3	4
1995-2018	Jan. to Apr.		728	1117	276	83	78		596	1064	506	186	187
	May to Aug.		633	576	164	61	51		596	738	264	101	94
	Sep. to Dec.	654	401	74	9	7	15	803	378	90	26	8	6
2019	Jan. to Apr.		14	13	5	4	2		23	11	15	5	14
	May to Aug.		12	15	11	10	3		10	6	12	7	5
	Sep. to Dec.	64	2	5	1	0	0	87	3	7	0	2	2
2020	Jan. to Apr.		2	25	14	1	6		5	18	16	4	5
	May to Aug.		2	16	11	5	4		10	28	11	9	10
	Sep. to Dec.	128	4	3	2	1	1	206	10	15	6	0	3
2021	Jan. to Apr.		4	7	14	3	3		6	18	23	4	5
	May to Aug.		4	16	19	7	5		2	18	28	11	5
	Sep. to Dec.	21	3	1	0	0	0	67	0	6	1	0	0
Total	Jan. to Apr.		748	1162	309	91	89		630	1111	560	199	211
	May to Aug.		651	623	205	83	63		618	790	315	128	114
	Sep. to Dec.	867	410	83	12	8	16	1163	391	118	33	10	11

Note: This number includes those not used in CAA calculations

1. Biology and Stock Assessment

Reviewer's Comment

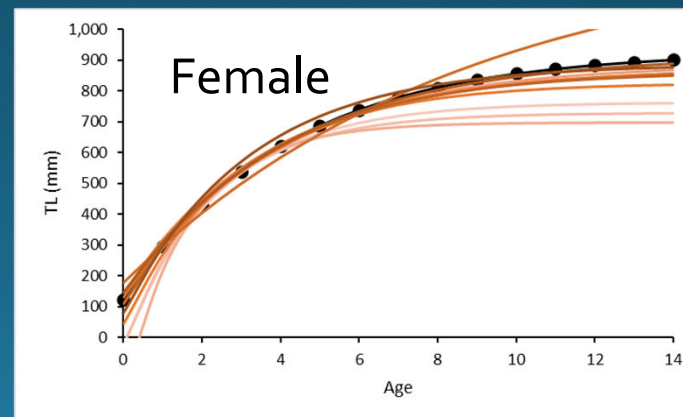
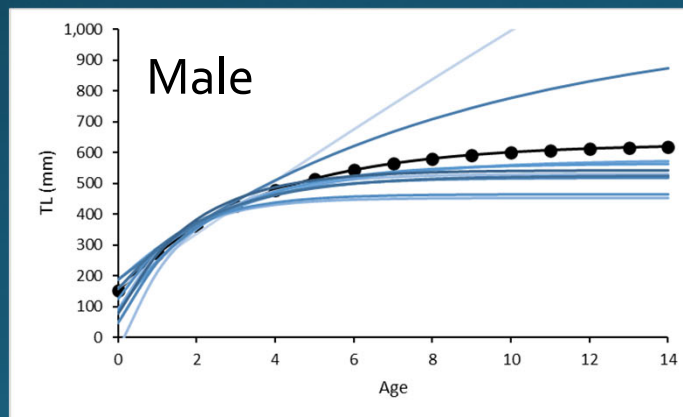
- Q12: It appears that the same seasonal ALK was used between years and there was therefore an assumption that growth was the same between years. What is the evidence to support this strong assumption? For example, please show the age-length data by year during 1995-2004, for each season. (ST Q17)

Response

There is no strong reason, but the sample size is insufficient....

> The age-length data during 1995-2004 were previously presented.

> Growth curve estimated from data for each year in 1995 to 2004 are;



1. Biology and Stock Assessment

Reviewer's Comments

- Q13: It appears that a sex ratio by size class was used to split the catch into sexes. How variable is the sex ratio by size class between years? (ST Q18)
- Q14: The sex ratio indicates that more females are present at larger sizes. Could this suggest that there is sex-specific natural mortality? (PTK Q9)
- Q15: Has the sex ratio of catch and stock remain the same with changing fishing pressure and other factors over time? (TY Q2)

Response

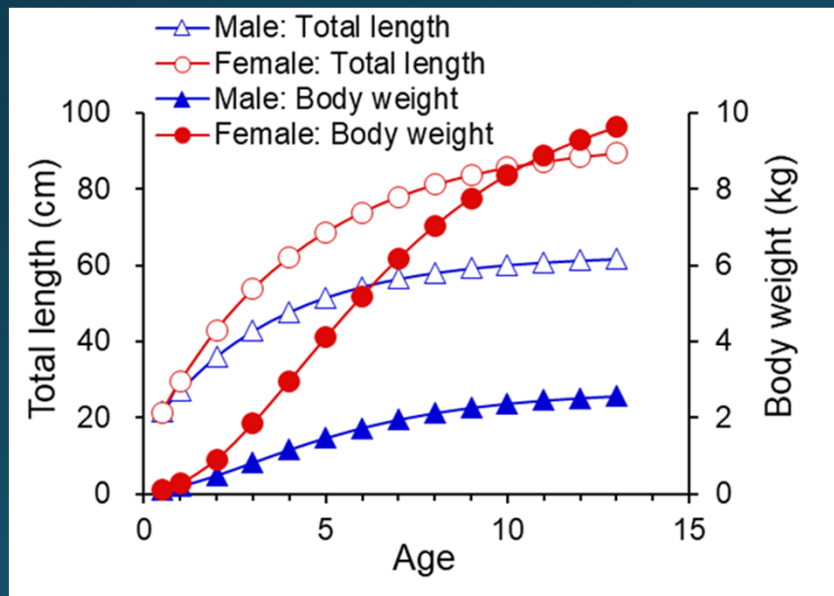
We would like to explain detailed information in following slides.

1. Biology and Stock Assessment

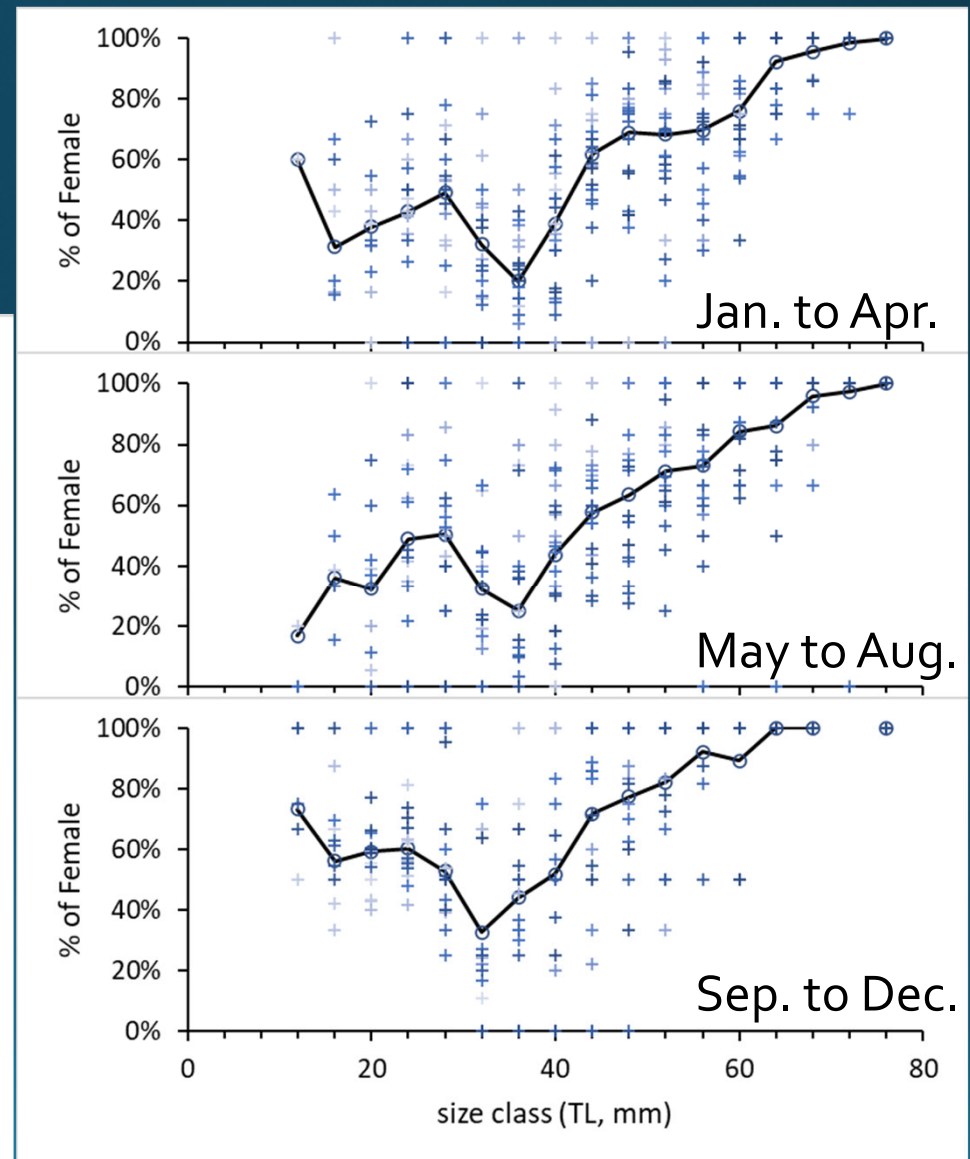
Reviewer's Comments

- Q13-15: **Response**

Larger proportion of female in the larger size class due to sexual dimorphism.
Variations of the sex ratio by size class →



+ 1998
+ 1999
+ 2000
+ 2001
+ 2002
+ 2003
+ 2004
+ 2005
+ 2006
+ 2007
+ 2008
+ 2009
+ 2010
+ 2011
+ 2012
+ 2013
+ 2014
+ 2015
+ 2016
+ 2017
+ 2018
+ 2019
+ 2020
+ 2021
+ 2022
○ all



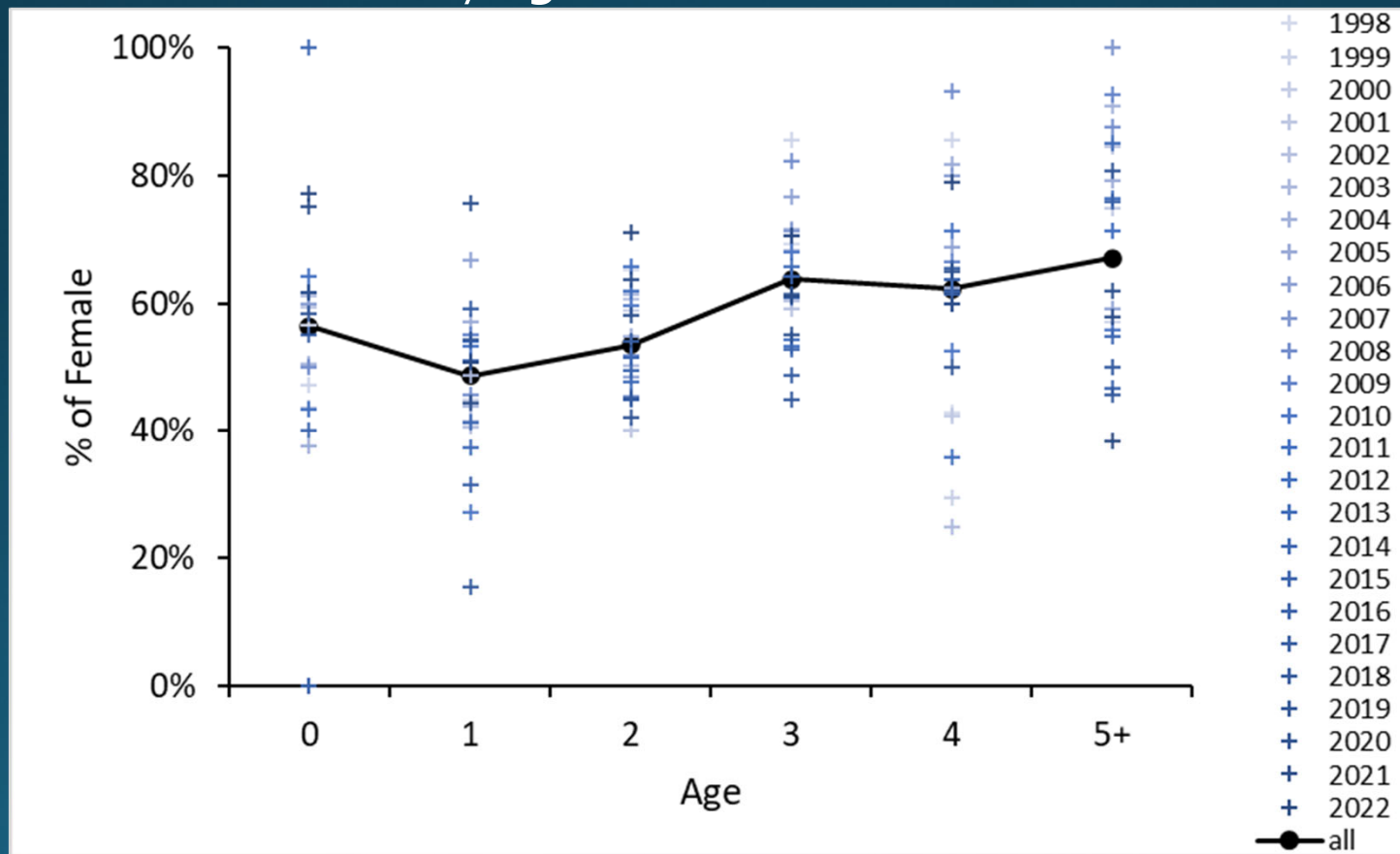
1. Biology and Stock Assessment

Reviewer's Comments

- Q13-15: **Response**

Sex-specific natural mortality is not expected in the stock assessment (however there is no strong evidence to prove so).

Variations of the sex ratio by Age



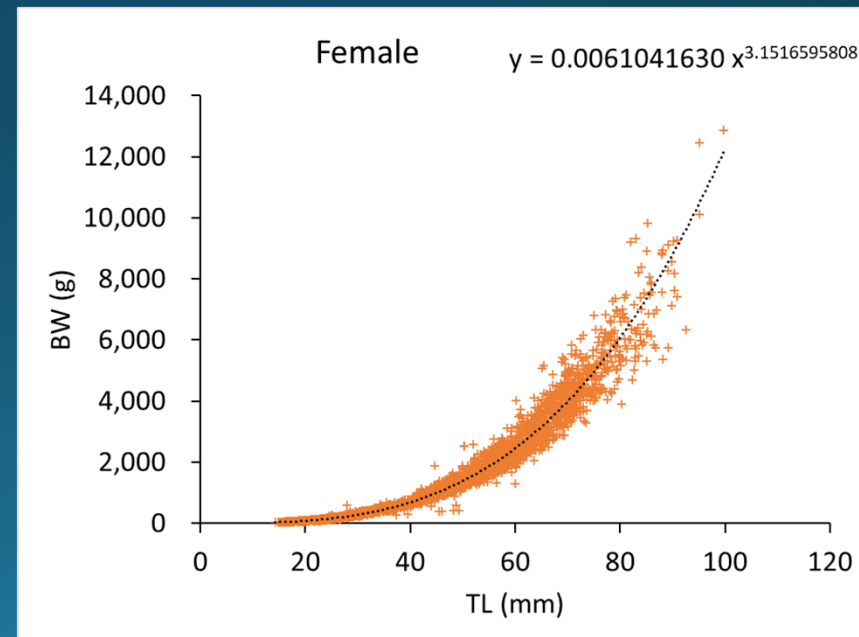
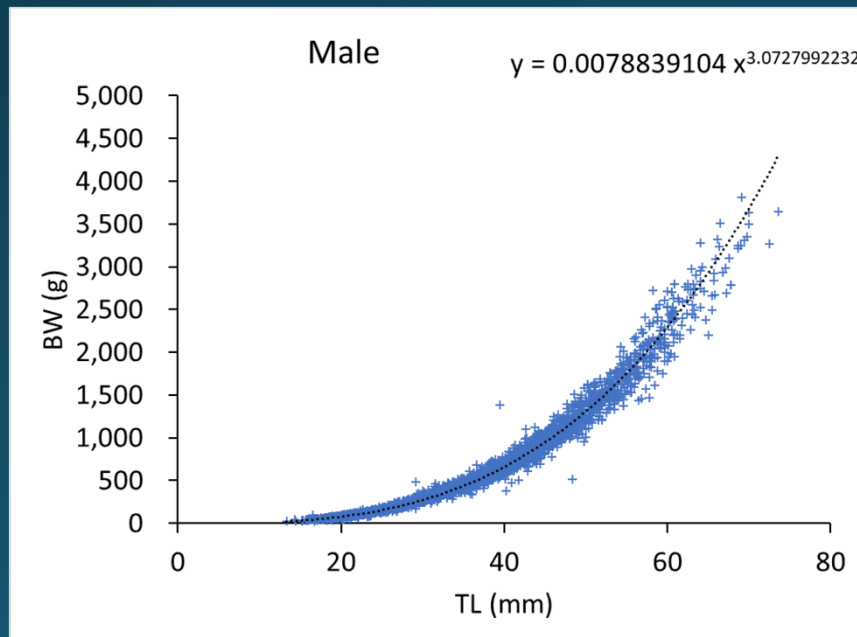
1. Biology and Stock Assessment

Reviewer's Comments

- Q16: Similarly, how variable is the mean weight by length class by sex between years? (ST Q19)

Response

TL-weight relationships for all years

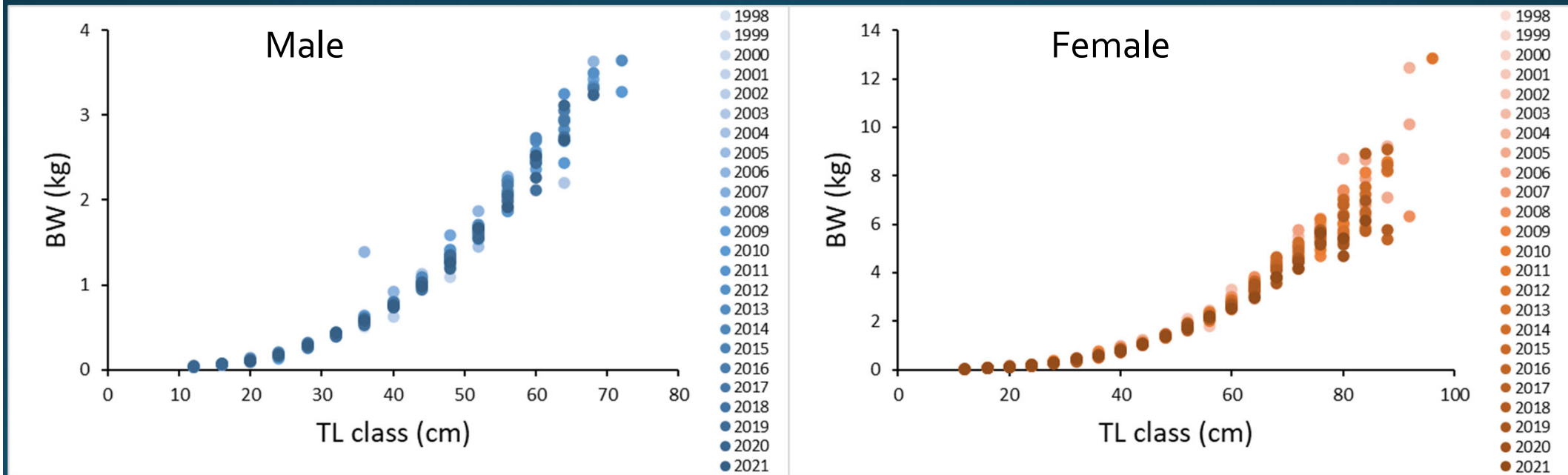


1. Biology and Stock Assessment

Reviewer's Comments

- Q16: **Response**

The mean weight by length class in each year;
> Not so variate.



1. Biology and Stock Assessment

> Estimation of Catch Number at Age

- ③-a; Estimate the length composition of annual catch for each season
- ③-b; Estimate the Age-length key for each season and sex
- ④ **Estimate the catch in number at age (CAA)**

frequency composition for TL class by season (in number)



× sex ratio by size class by season

× mean weight by length class by sex

frequency composition for TL class by season and sex (in weight)



× Catch weight

× ALK

Catch-at-age in weight by TL class, season and sex



/ mean weight by length class by sex

Catch-at-age in number by TL class, season and sex

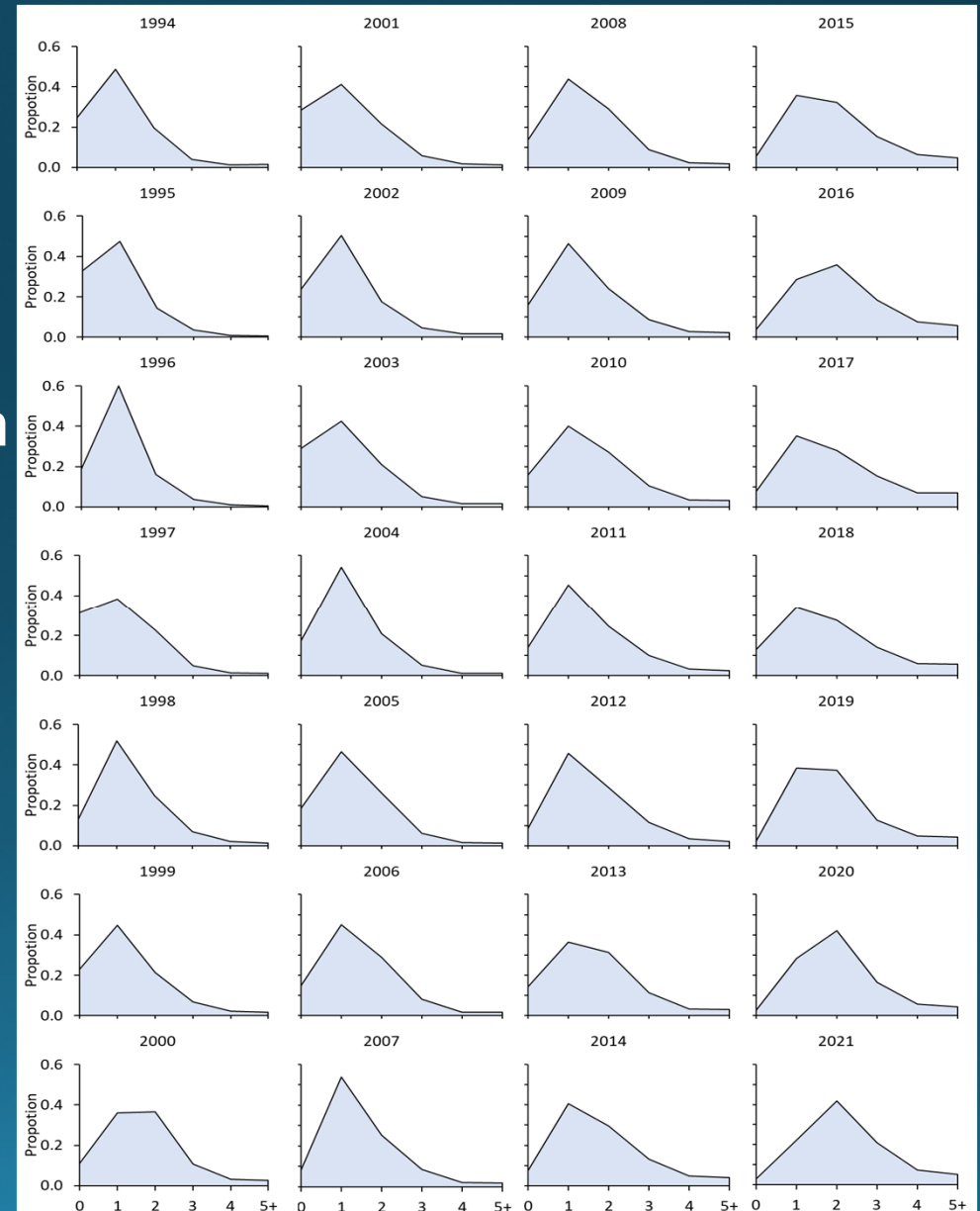


Catch-at-age for each year

1. Biology and Stock Assessment Reviewer's Comments

- Q17: Can you please plot the fishery age composition data by year as opposed to a stacked bar plot (I think these are Figure 3-2 in all the documents)? (PTK GQ2)

Response →



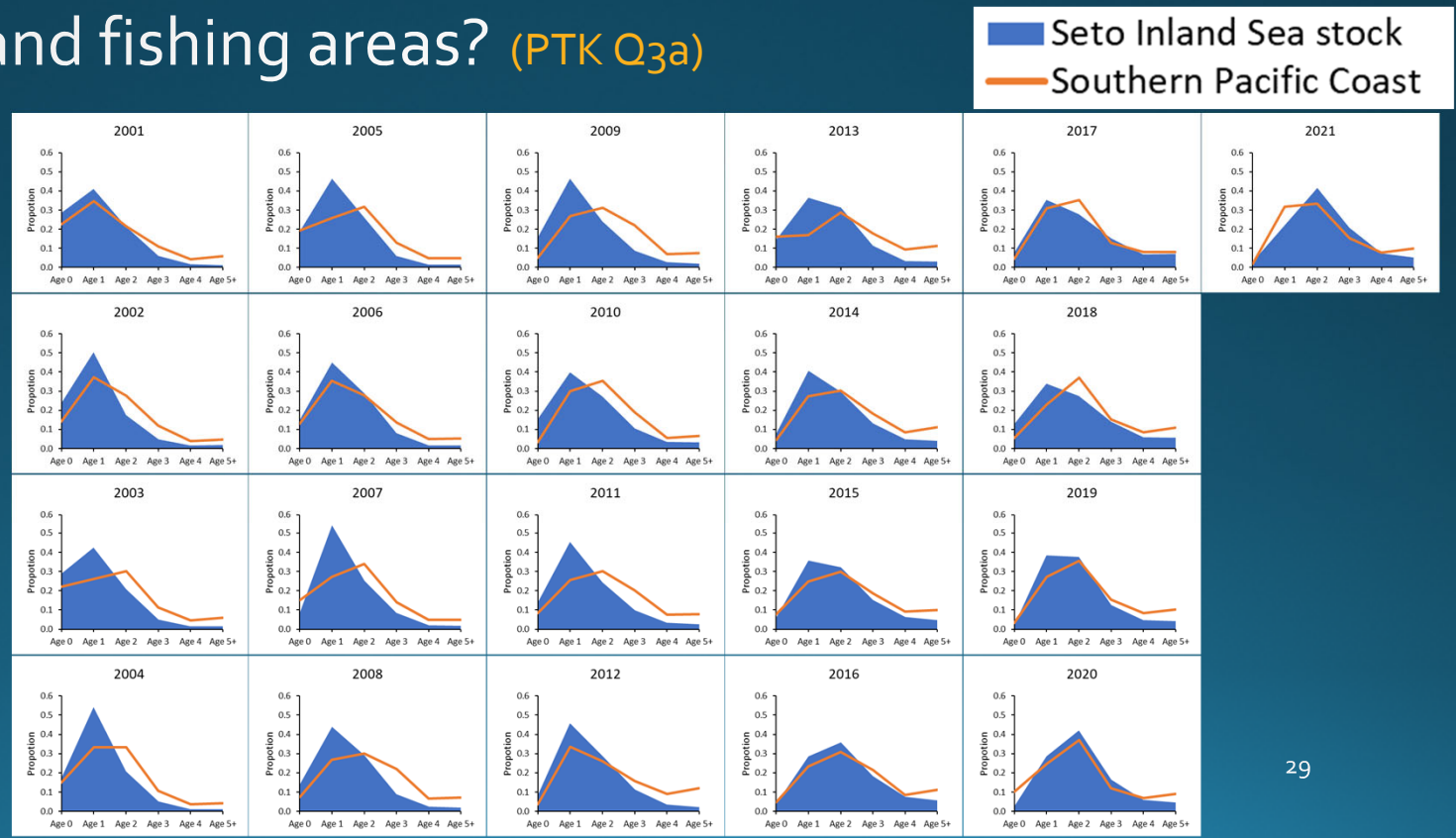
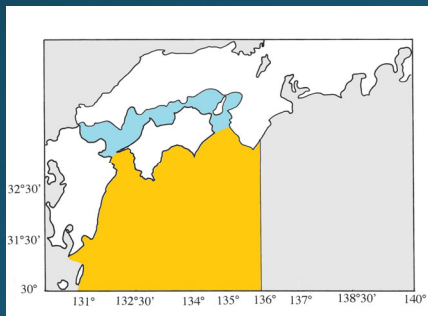
1. Biology and Stock Assessment

Reviewer's Comments

- Q18: Nearly all of the catch is made up of age 0-2 fish. Given that bastard halibut likely have a longer life history than an anchovy for example, is it possible that the older fish are moving out of the survey area and fishing areas? (PTK Q3a)

Response

Catch composition of Seto Island Sea and Southern Pacific coast



1. Biology and Stock Assessment

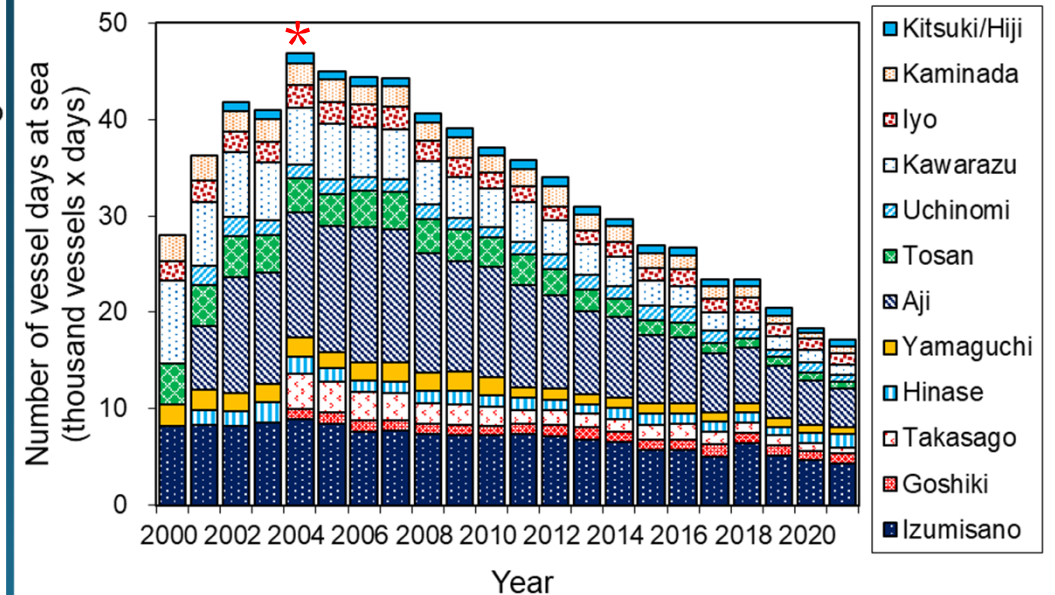
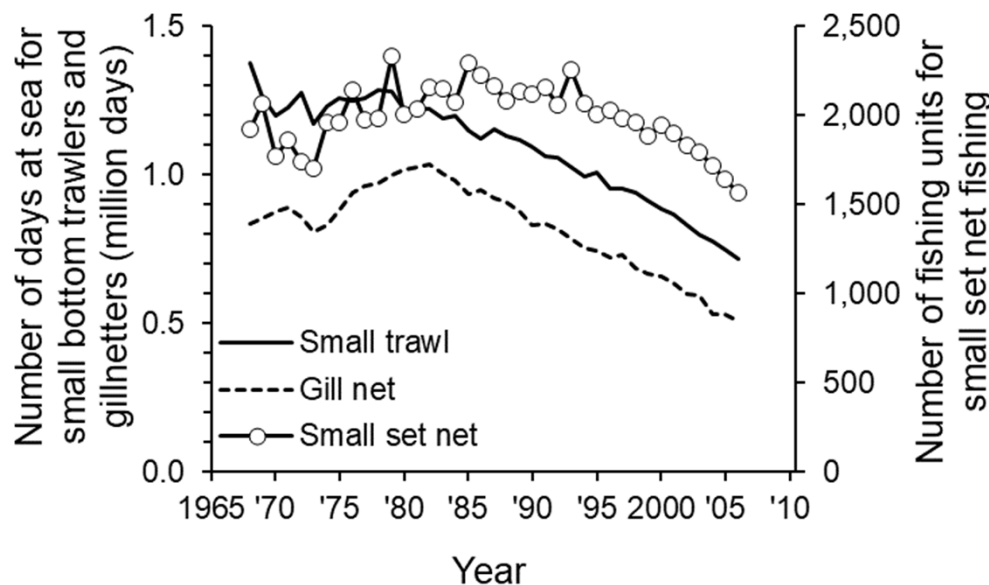
> Stock abundance indices

➤ Fishing Effort:

- Effort tends to decline over time

Fishing Efforts based on Agricultural, Forestry and Fisheries Statistics (up to 2006)

Number of vessels × days for Small trawl



*Current tracking information has been available since 2004

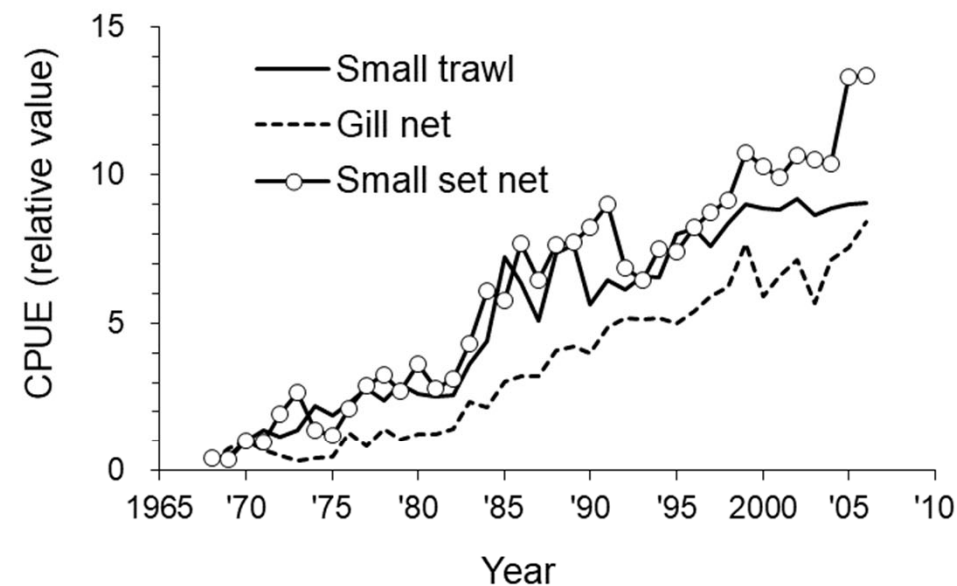
1. Biology and Stock Assessment

> Stock abundance indices

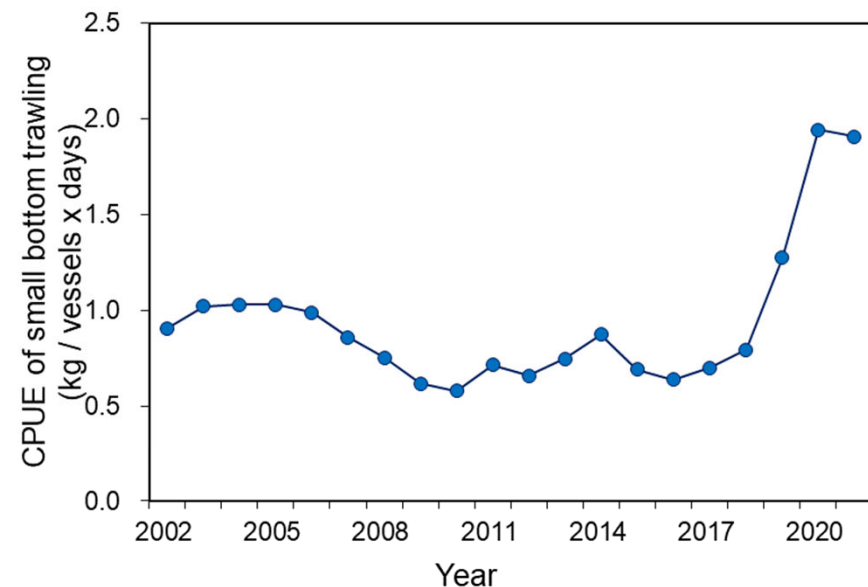
➤ Abundance indices:

- CPUE generally remained flat or increasing trend

CPUE based on Agricultural, Forestry and Fisheries Statistics (up to 2006)



Weighted average of CPUE of Small trawl



1. Biology and Stock Assessment

Reviewer's Comments

- Q19: What are the age compositions for the index? (ST Q23)

Response

Age composition is unknown.

We only receive monthly and fishing cooperative based catch and effort data.

- Q20: CPUE seemed to be increasing across all sectors up to 2005. Were there market conditions or changes in management that resulted in the numbers of vessels declining? (PTK Q6)

Response

No significant change in management. Decline may be due to aging of fishers.

- Q21: For the cohort analyses that are tuned to indices of abundance, what were the catchability Q values used? What was the rationale for selecting these values? (PTK QG1)

Response

We use the operational data of small bottom trawls. The rationale is because we do not have other effective data.

1. Biology and Stock Assessment

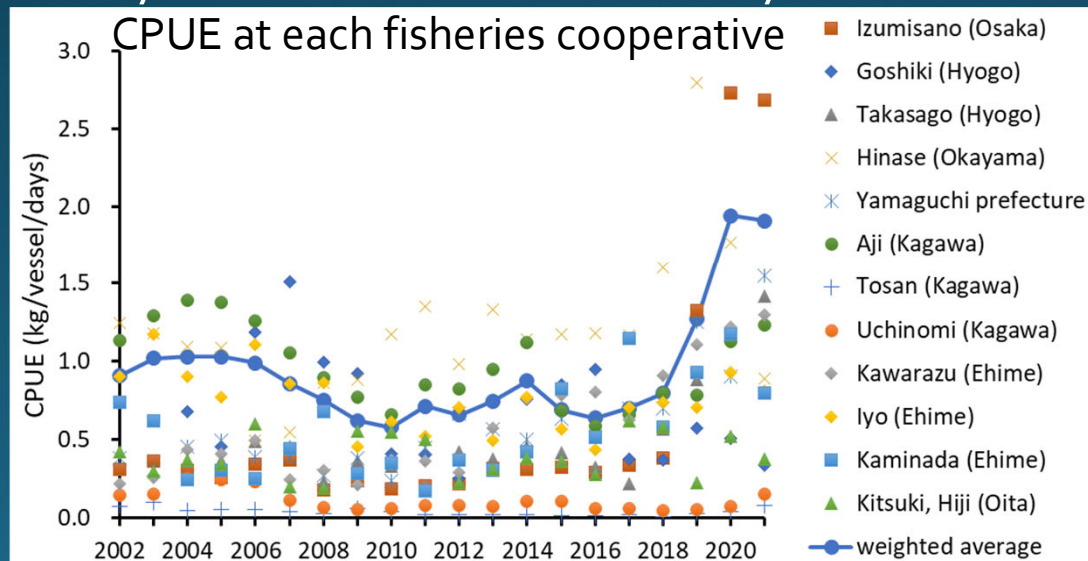
Reviewer's Comments

- Q22: What are the uncertainties around the index values? (ST Q22)
- Q23: When plotting the tuned fits to the indices of abundance, is it possible to include the uncertainties around each of the index points? (PTK QG3)
- Q24: Effort is number of vessels*days. Is there any information on how variable the number of trawls per trip is? (PTK Q3b)

Response

Uncertainties are not evaluated.

Data on the number of hauls by day and by operation were also not available, however preliminary data from another survey showed a large variation.



1. Biology and Stock Assessment

Reviewer's Comments

- Q25: The tuning index appears to be a catch-weighted CPUE of the small trawl fishery. There does not appear to be any attempt to standardize the CPUE. Is that correct? Please describe how the index was developed in more detail. (ST Q20)
- Q26: If the above is correct, why is standardizing the CPUE not necessary? (ST Q21)
- Q27: Is there a need to standardize the CPUE? (TY Q3)

Response

We recognize the importance of CPUE standardization, however the data is coarse to obtain good results.

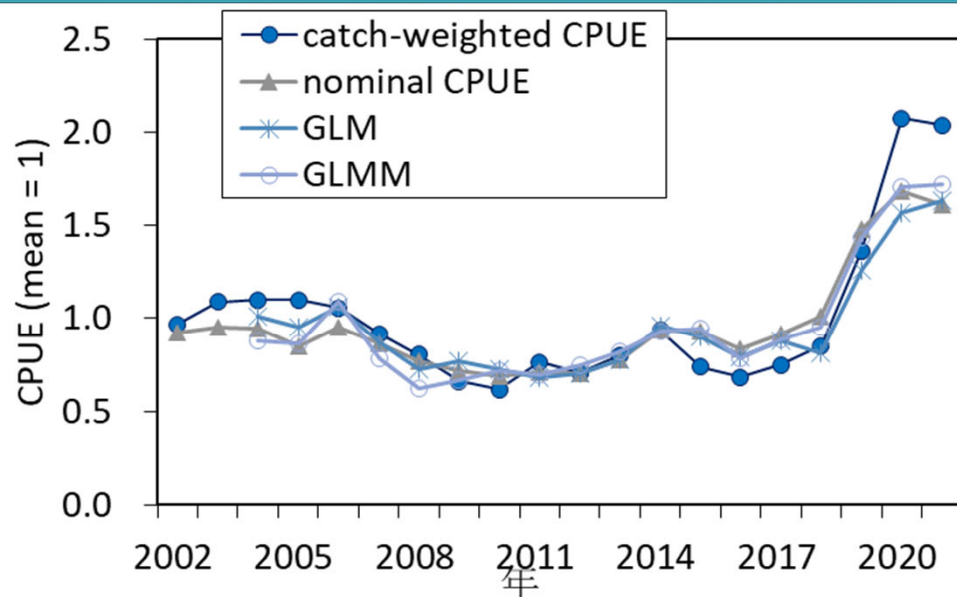
We would like to consider further including conducting a recruitment survey.

1. Biology and Stock Assessment

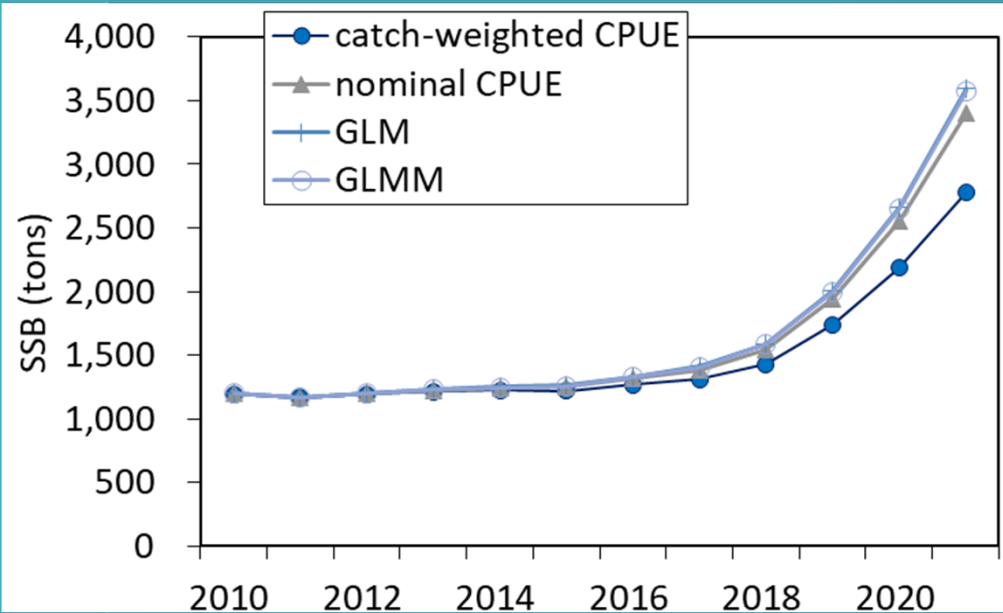
> Stock abundance indices

- About the “weighted average for Small trawl fishery CPUE”
 - Trend of CPUE from the preliminary calculation and result of VPA using the CPUE as index
 - Introduction of other indices in VPA calculation tends to overestimate the biomass, hence they are not utilized.

Preliminary indices



Estimated SSBs



1. Biology and Stock Assessment

> Stock assessment method (VPA)

➤ Cohort analysis

- ✓ Pope's method using CAA (age: 0 ~ 5+)
- ✓ M : 0.3125 / year
- ✓ Selectivity in the latest year: the average F for the previous 3 years
- ✓ Tuning index: "weighted average for Small trawl fishery CPUE"
- ✓ Parameters $F_{4,y}$ and b is estimated by minimizing the equation;

$$SS = \sum_y \left(\ln(u_y) - \ln \left(q \sum_a (s_{a,y} N_{a,y} W_a)^b \right) \right)^2$$

- ✓ u_y : tuning index at year y
- ✓ Estimated $F_{4,y} = 0.207$, $q = 0.182\text{E-}5$, $b = 1.45$

1. Biology and Stock Assessment

Reviewer's Comments

- Q28: The plus group is age 5 and the oldest observed fish was 16. Using Hamel and Cope 2022, a prior for M could range from 1.08 ($5.4/\text{age}5$) to 0.3375 ($5.4/\text{age}16$). Please provide more details to support the assumption that $M=0.31$. (PTK Q2b)
- Q29: I didn't realize that the age-0 M is 0.0781. Please provide justification for this. Typically M decreases as fish get older (Lorenzen 1996). Please also include this detail in the main text (PTK Q10)

Response

Natural mortality (M) was estimated using the method of Tauchi and Tanaka ($M = 2.5 / A_{\text{max}}$, Tanaka 1960), assuming a maximum age of 8 (Watanabe et al. 2004).

$M = 2.5/8 = 0.3125$ per year was used for all age.

For age-0, M value was $0.0781 = 0.3125 / (3 / 12)$, assuming recruitment to be October 1.

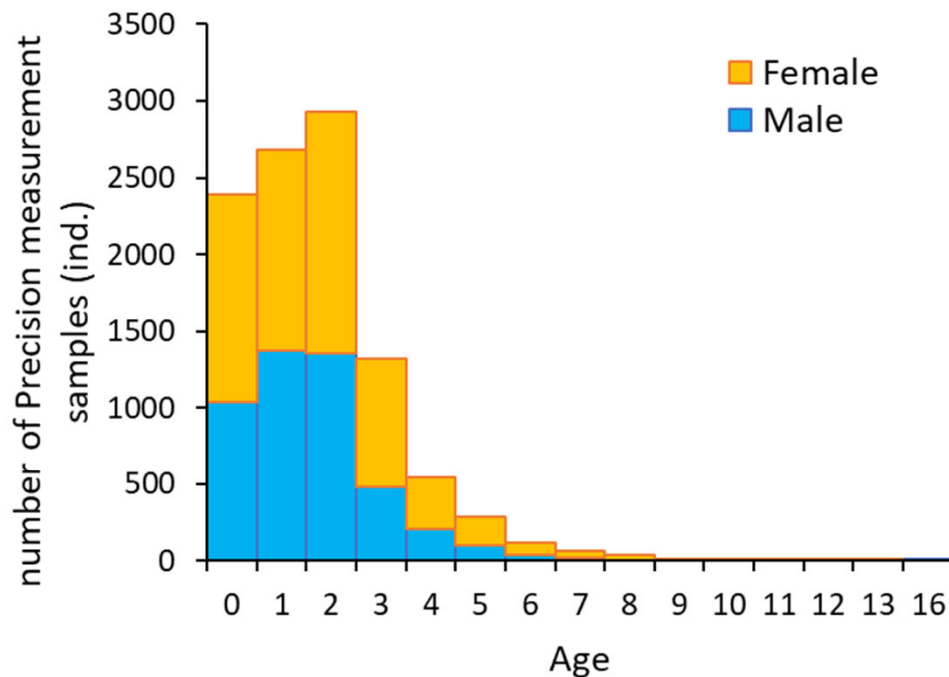
1. Biology and Stock Assessment

> Natural mortality (M)

- Maximum age was assumed to be 8 (Watanabe et al. 2004)
- M value was relatively low in the method of Tauchi & Tanaka .

Age composition of measured samples
(n=10,409)

Estimated M values ($A_{\max}=8$)



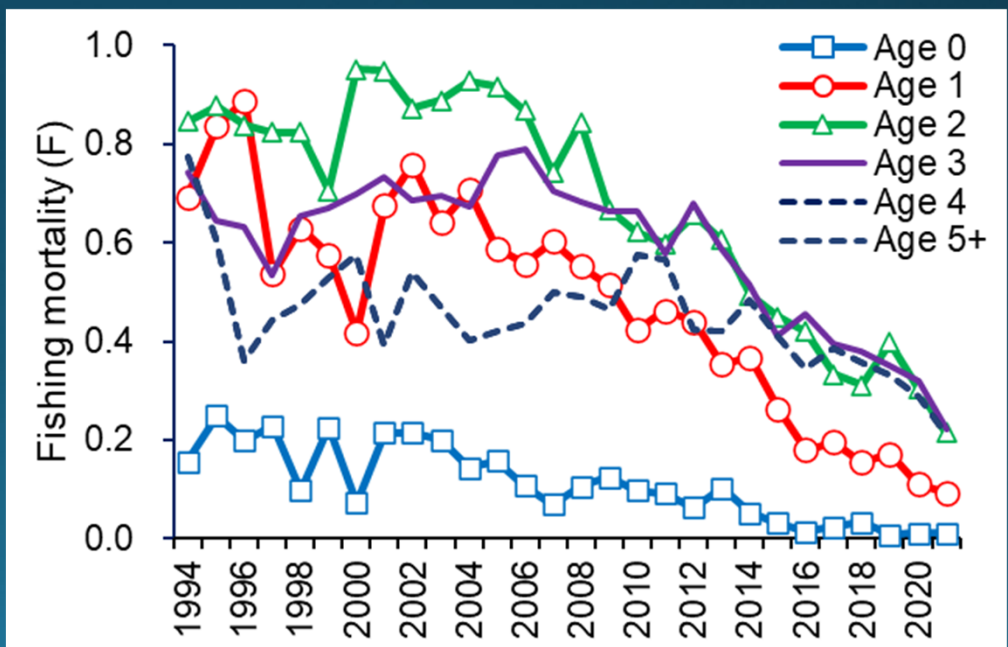
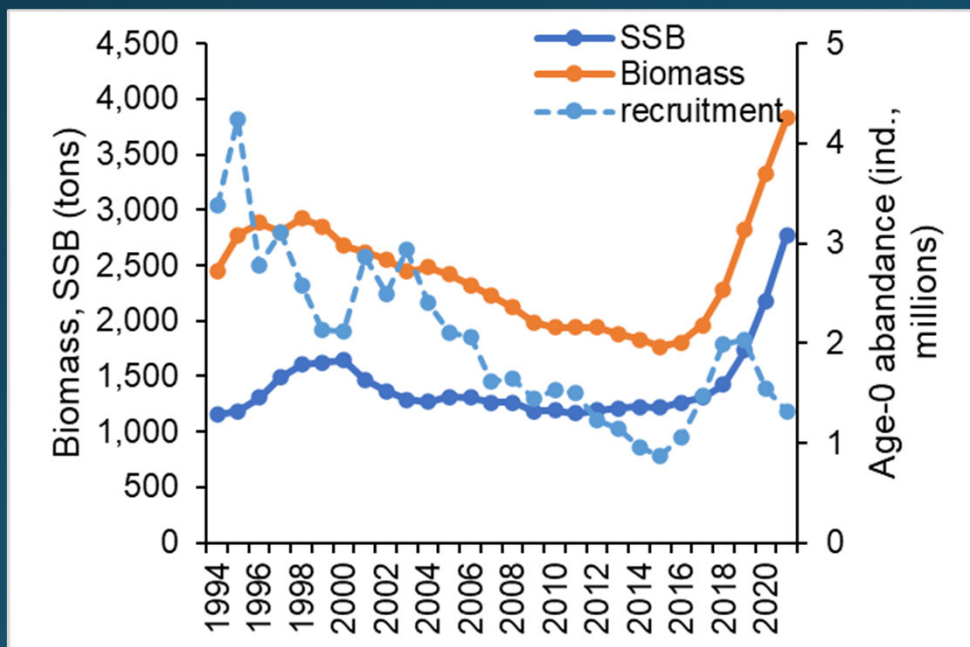
M value	
Tauchi & Tanaka (Tanaka 1960)	0.313
$M=2.5/A_{\max}$	
Hamel and Cope (2015)	0.675
$M=5.4/A_{\max}$	
Then et al. (2015)	0.729
$M = 4.899A_{\max}^{(-0.916)}$	

1. Biology and Stock Assessment

> Stock assessment (VPA)

➤ Result of analysis

- ✓ Biomass, Recruitment, SSB, F
- ✓ Biomass was on a long-term declining trend, however turned in to an increasing trend since 2016 (increase in older fishes).
- ✓ Fishing pressure has been declining especially F of age-0 and age-1.



1. Biology and Stock Assessment

Reviewer's Comments

- Q30: I think the age 4 line may be missing from the figure. (PTK Q8a)

Response

F of age-4 and age-5+ are assumed to be the same so the lines are overlapped.

- Q31: From this plot, the older halibut may be moving out of the stock area. With $M=0.31$, F for age 2 has to be high as hardly any fish are making it to ages 3, 4, and 5+ (as shown in Fig. 3-2). Is there a halibut stock assessment for nearby regions that catches predominantly age 3+ fish? (PTK Q8b)

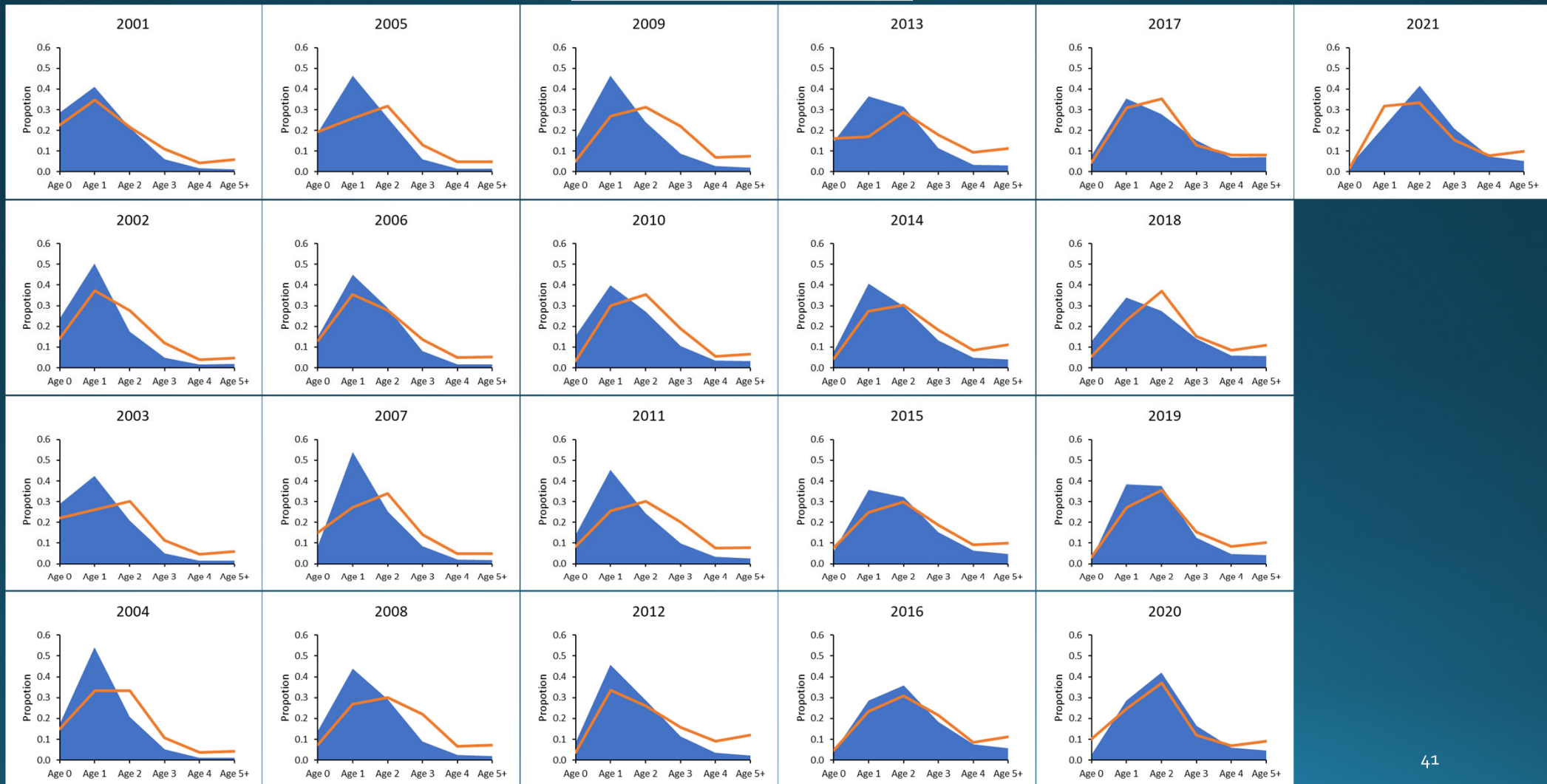
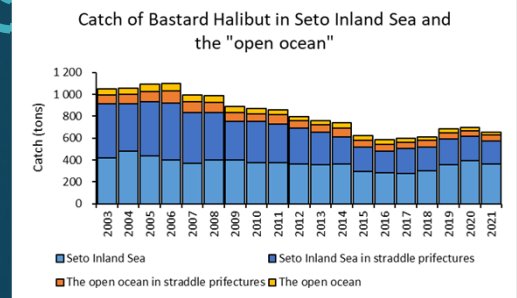
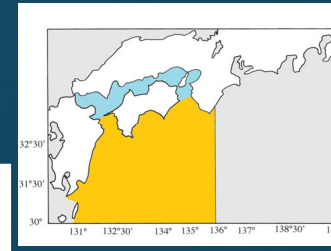
Response

Catch of age-3+ fish is not dominant in the nearby regions as well.

1. Biology and Stock Assessment

Catch composition of Seto Inland Sea and Southern Pacific coast

■ Seto Inland Sea stock
— Southern Pacific Coast



1. Biology and Stock Assessment

Reviewer's Comments

- Q32: The residuals and retrospective analysis seem to be good. Any thoughts on the model diagnostics? (ST Q26)

Response No

- Q33: Is there a table of the estimated parameters and their uncertainty? (ST Q27)

Response Uncertainties are not evaluated

- Q34: Is there any possibilities on conducting sensitivity analysis of M and using its result to conduct further sensitivity analysis of SBmsy and Fmsy? (TY Q4)

Response

The result may affect the management measures. We would like to consider this based on future requests from stakeholders and discussion at the meeting.

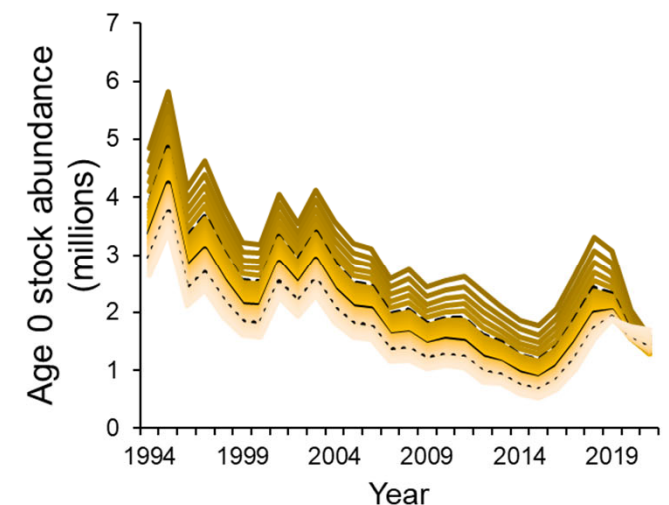
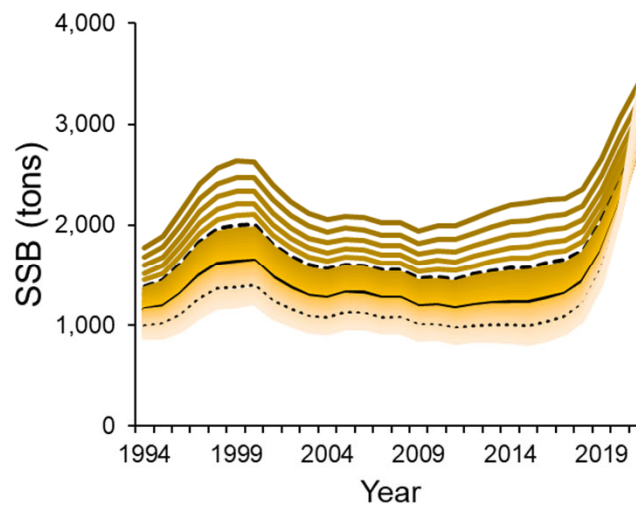
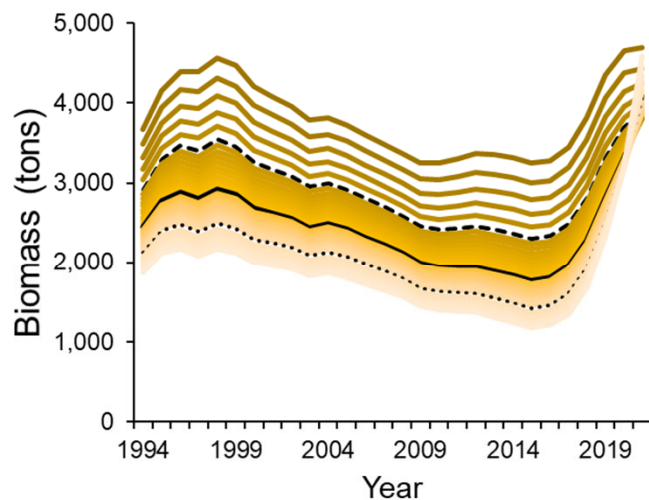
1. Biology and Stock Assessment

Reviewer's Comments

- Q₃₅: Please provide some justification for the sensitivity with ± 0.1 of the M value. (PTK Q_{4c})

Response

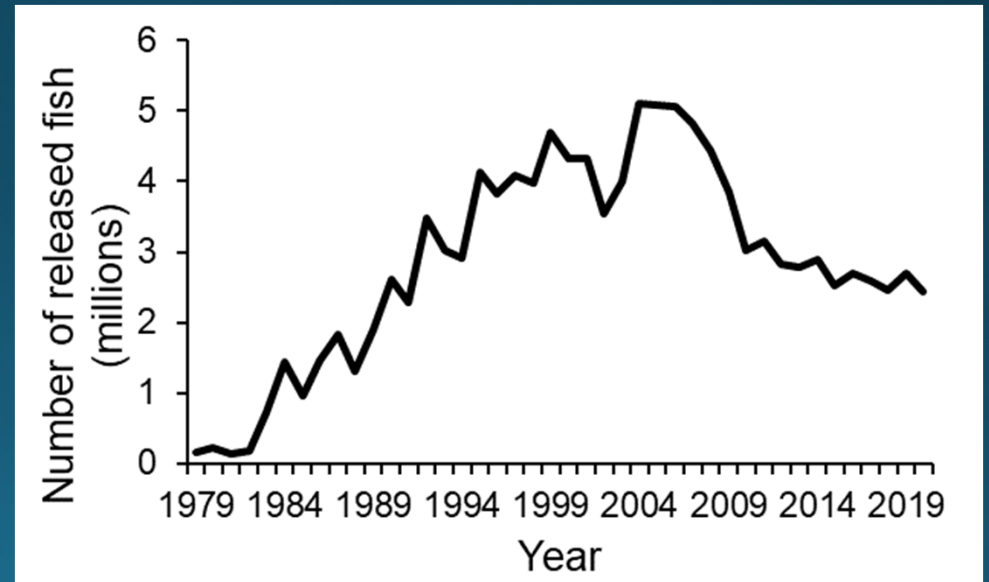
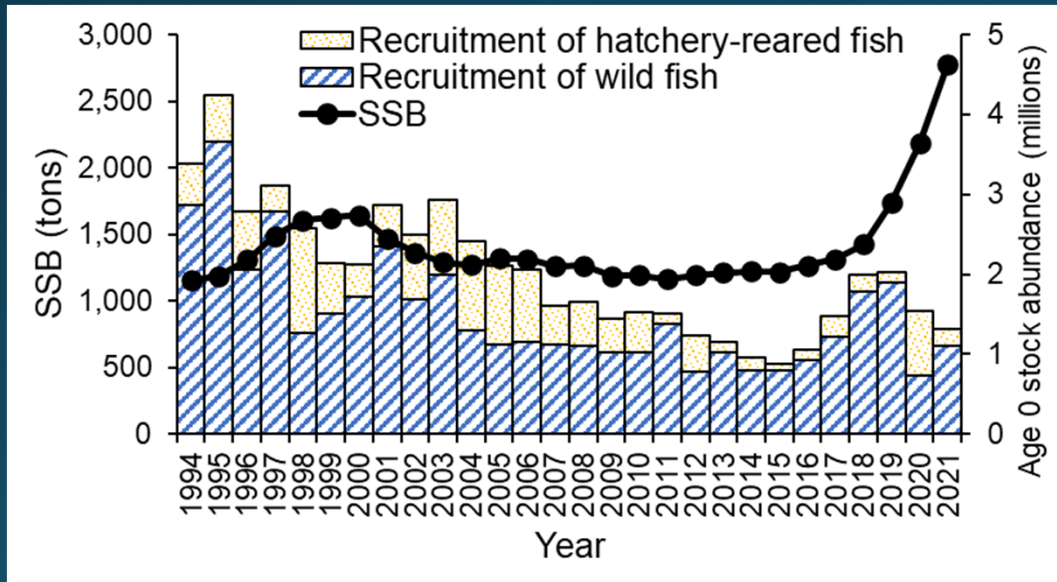
There is no certain justification on the number used.
Result of sensitivity analysis with $M \pm 0.2$ with more fine scales.



1. Biology and Stock Assessment

> Stock enhancement and recruitment

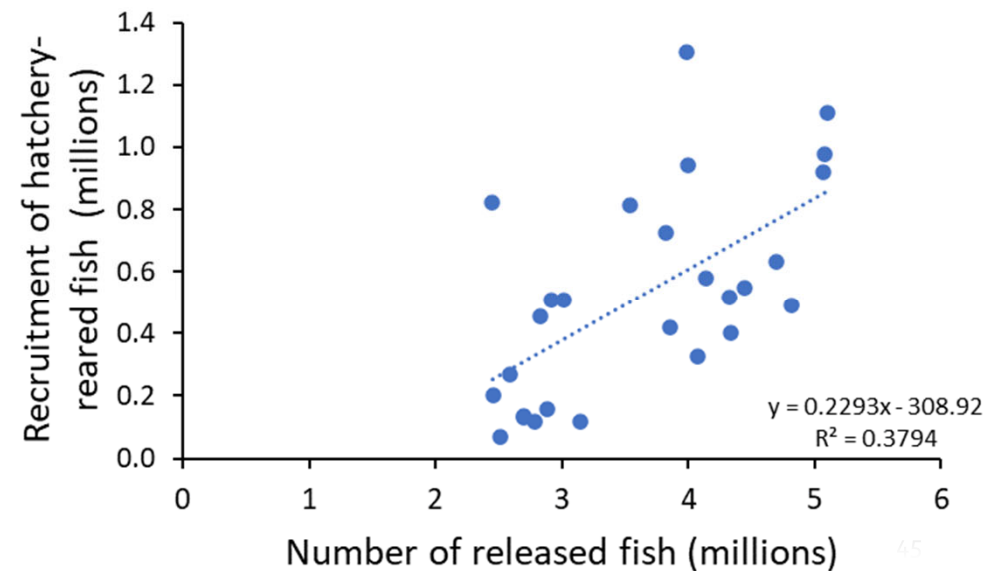
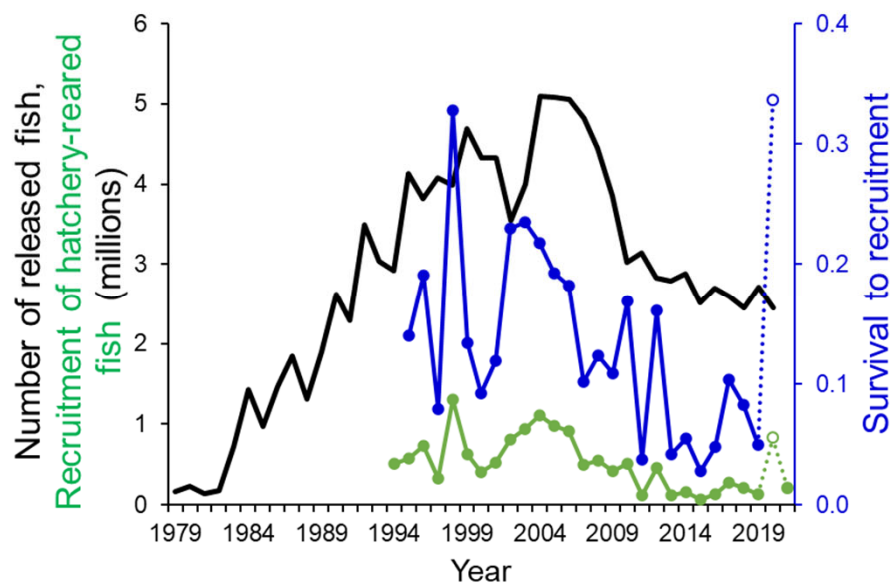
- Recruitment: age 0 stock abundance include wild and hatchery-reared fish
- Stock enhancement have been implemented since the late 1970s.



1. Biology and Stock Assessment

Reviewer's Comments

- Q36: What if the trend of hatchery-reared recruitments and the rate of survival to recruitment are overlapped on Fig 4-11? (TY Q7)
- Q37: What is a possible explanation for the proportionally high recruitment of hatchery-reared fish in years like 1998, 2003, 2004, 2005? I see in Figure 4-11 that these were years in which relatively high number of fish were released. Are there environmental conditions that might be contributing to hatchery fish recruitment success? (PTK Q7)
 - → Environmental condition such as food availability are considered as well as the size and health of seedlings



1. Biology and Stock Assessment

Reviewer's Comments

- Q38: This assessment incorporates data from both hatchery releases and wild-origin fish into the analysis. Please clarify the general aim for the assessment and management of this stock with regards to hatchery releases versus wild-origin fish. For example, is the primary aim to assess and manage the wild-origin fish? Or is it important to manage the hatchery releases as well? (ST Q1)
 - → The general aim is management of resources, including both wild and released fish.
- Q39: Is the goal of the hatchery to improve recruitment? Or provide fish to be caught in the fishery? Please provide more details. (PTK Q1d)
 - → "Creation of resources and increase in the catch"
- Q40: Were the hatchery-origin recruits considered to be equivalent to wild-origin recruits for the fishery, stock, and ecosystem? (ST Q2)
 - → Yes.
- Q41: Is the recruitment contribution for hatchery releases considered part of the stock and after maturity, part of the SSB? (ST Q3)
 - → Yes.

1. Biology and Stock Assessment

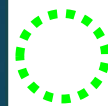
Reviewer's Comments

- Q42: Hatchery releases, if not captured, can be assumed to contribute to the SSB and future recruitment. Is the per capita contribution of hatchery-origin fish similar to wild-origin fish? How does this affect the assessment and management for this stock? (ST Q4)
 - → Contribution of hatchery-origin fish to the stock after recruitment is assumed to be the same as that of wild-origin fish.
- Q43: What is the age and size of the fish that are released? How does this compare to the age and size of recruits? (ST Q5)
 - → Release at age-0 (mainly May to June), 50-80mm TL.
Age-0 catch is limited to above 250mm TL from October.
- Q44: Are there any regulations on the hatchery releases? (ST Q6)
 - → No

1. Biology and Stock Assessment

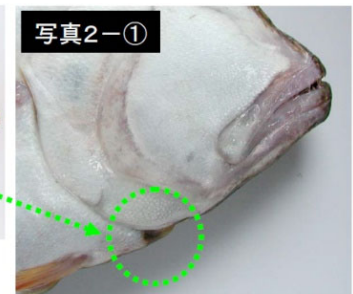
Reviewer's Comments

- Q45: How are hatchery-released fish distinguished from wild?
(PTK Q1c)
 - → Distinguished by abnormal pigmentation (hypermelano).
- Q46: Does the hypermelanism rate for hatchery fish change as the fish ages? This is similar to tag retention rate. (ST Q11)
 - → No



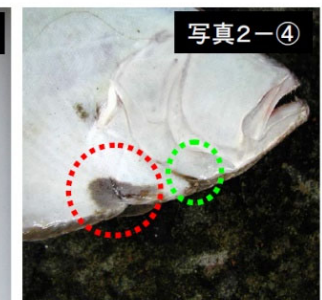
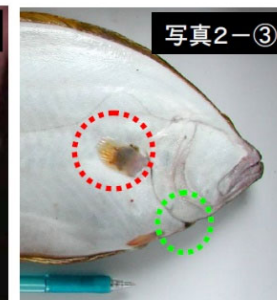
wild-origin

Minor pigmentation is **not** considered as hypermelano-hatchery-origin.



hatchery-origin

These individuals with hypermelano in pharyngeal part also exhibit hypermelano in other areas. Hypermelano in the pharynx tends to play as a key.



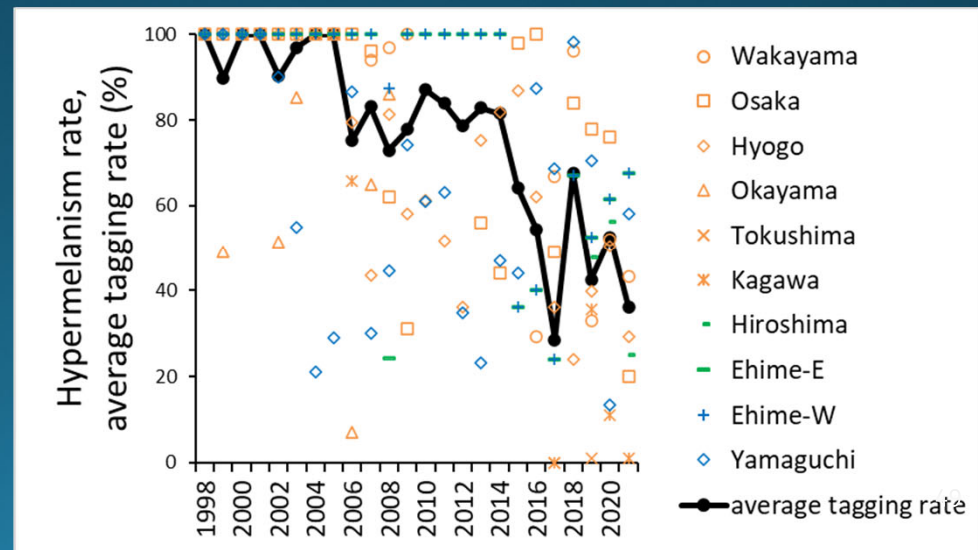
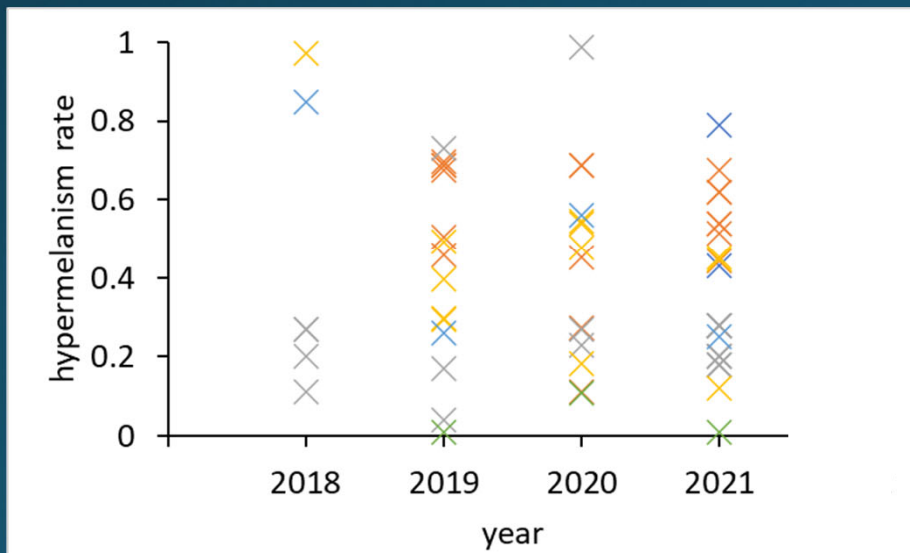
1. Biology and Stock Assessment

Reviewer's Comments

- Q47: How variable is the hypermelanism rate between hatcheries and batches of releases? (ST Q12)
- Q48: Given the lack hypermelanism data from some hatcheries, what is the uncertainty in the “average” tagging rate? (ST Q13)
 - → (A46,47) Uncertainties are expected to be high but not yet to be evaluated.

Example of hypermelanism rate
in sample batches and

in prefectures where the report was made



1. Biology and Stock Assessment

Reviewer's Comments

- Q49: Is the dispersal rate of hatchery fish high enough that they are well mixed with the wild-origin fish? This is similar to tag mixing rate. (ST Q14)
 - → We assume the mixing rate is high enough to be well mixed with the wild origins although this belongs to the further studies to be researched.
- Q50: Are the genetics of hatchery-origin fish similar to wild-origin fish? (ST Q15)
 - → We assume there is no significant difference.
- Q51: Is there evidence (maybe genetic?) that hatchery fish are spawning with wild fish? (PTK Q4d)
- Q52: Eqns 11 & 12 in Appendix 2 assumes that 1) the survival of tagged fish is the same as untagged and wild-origin fish; 2) tag loss is negligible; and 3) tags are well mixed into the general population. What is the evidence to support these assumptions? (ST Q24)
 - → (A50&51) No distinct evidence yet no evidence that the survival rate of tagged, untagged, and wild-origins are different. Therefore, there is no assumption incorporated.

1. Biology and Stock Assessment

Reviewer's Comments

- Q53: Tagging models with recaptures over multiple years are able to extract more information from the data and provide more precise estimates. Why only consider age-0 fish? (ST Q25)
 - → Survey on the contribution-rate is conducted only on the age-0. We are going to consider the further survey on older fish.
- Q54: How does the recruitment of hatchery releases interact with wild-origin fish? For example, is there any covariance of the survival or number of hatchery releases with the recruitment of wild-origin fish? (ST Q31)
 - → The possibility has been pointed out but not yet incorporated into the evaluation.
- Q55: If the hypermelanosis rate of hatchery-origin fish is decreasing and likely negligible for some hatcheries, how are hatchery-origin fish to be identified in the future? (ST Q36)
 - → Utilization of artificial marking should be considered.

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- Estimation of Catch Number at Age
- Stock abundance indices
- VPA

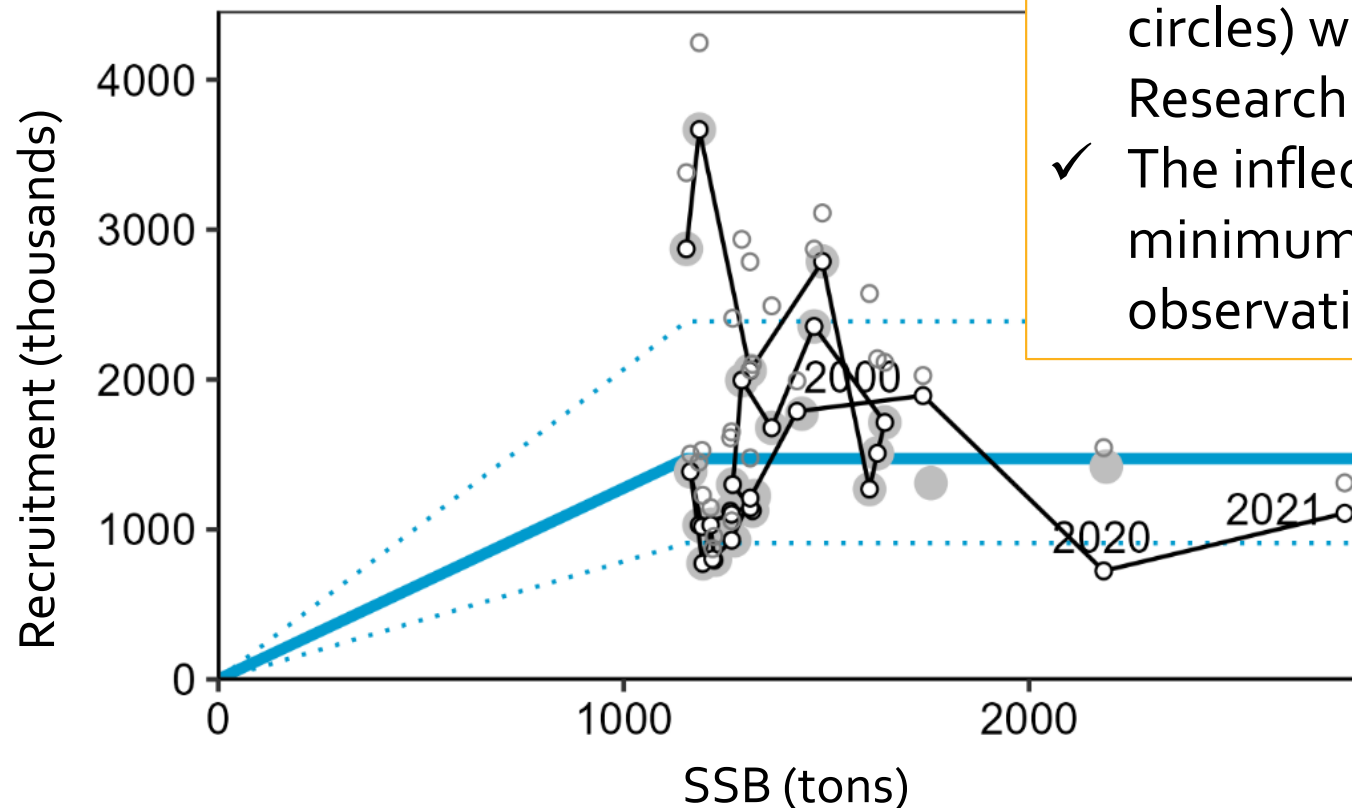
2. Stock Recruitment Relationships

3. Proposed Reference points and Kobe plot

4. Harvest Control Rule and Future projection (Appendix 4 – 6)

2. Stock Recruitment Relationship

S-R relationship model	Optimization method	Autocorrelation	a	b	S.D.	ρ
Hockey-stick	Least squares method	Yes	1.28	1,154	0.294	0.703



- ✓ The data of SA2021 (solid gray circles) with HS proposed the Research Institute Meeting in 2021
- ✓ The inflection point was set as the minimum SSB level in the observation range.

2. Stock Recruitment Relationships

Reviewer's Comments

- Q56: When estimating the SRR, only wild-origin recruits were used. Was the SSB is there a distinction between SSB of hatchery-origin versus wild-origin? (ST Q28)
 - → No
- Q57: Were alternative recruitment forms (Beverton-holt or Ricker) considered for the analysis? (PTK Q2d)
- Q58: Please explain why the hockey-stick SRR was chosen as the base case. How does the hockey-stick compare with the Beverton-Holt and Ricker? (ST Q30)
- Q59: In the renewed S-R plot, Ricker seems more appropriate. Is there a need to reconsider SRR? (TY Q5)

Response

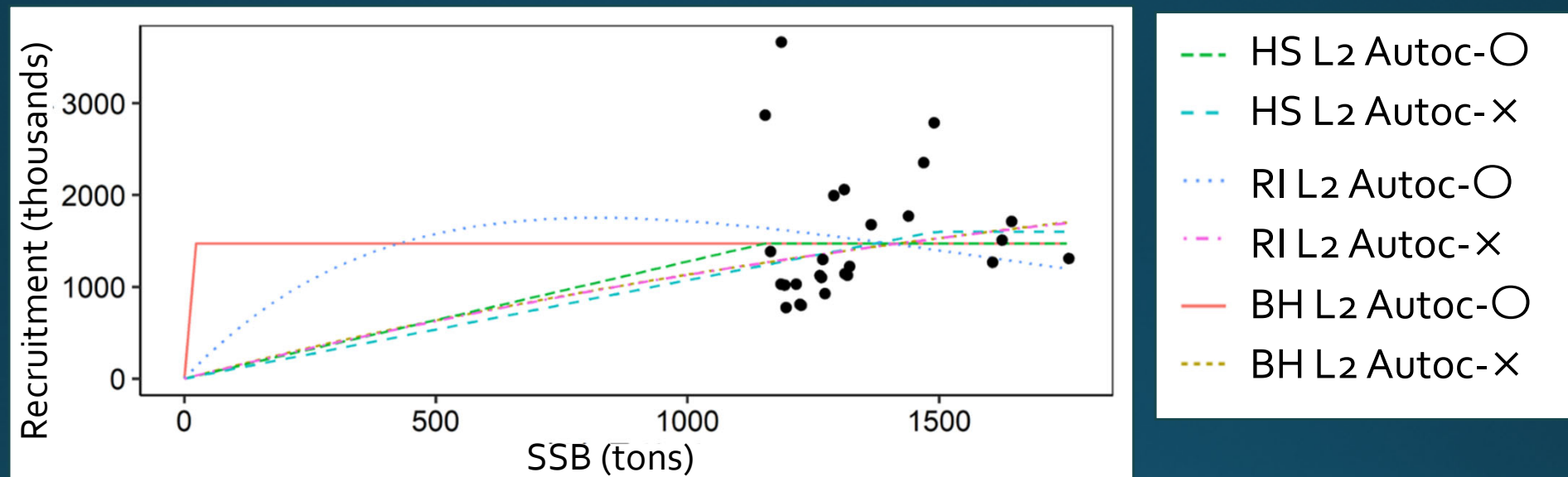
We would like to explain detailed information in next slide.

2. Stock Recruitment Relationships

- We discussed stock recruitment relationships and model selection for this stock in the Research Institute Meeting (Sept. 2021).
- Dataset for S-R relationship
 - ✓ Recruitment of wild fish and SSB values (1994 to 2019)
- Estimate parameters
 - 1) Stock Recruitment Relationship
 - ✓ Hockey stick (HS), Ricker (RI), Beverton-Holt (BH)
 - 2) Optimization methods
 - ✓ least absolute value method (L1), least square method (L2)
 - 3) Autocorrelation
 - ✓ Presence or absence

2. Stock Recruitment Relationships

Model selection in the Research Institute Meeting (Sept. 2021).

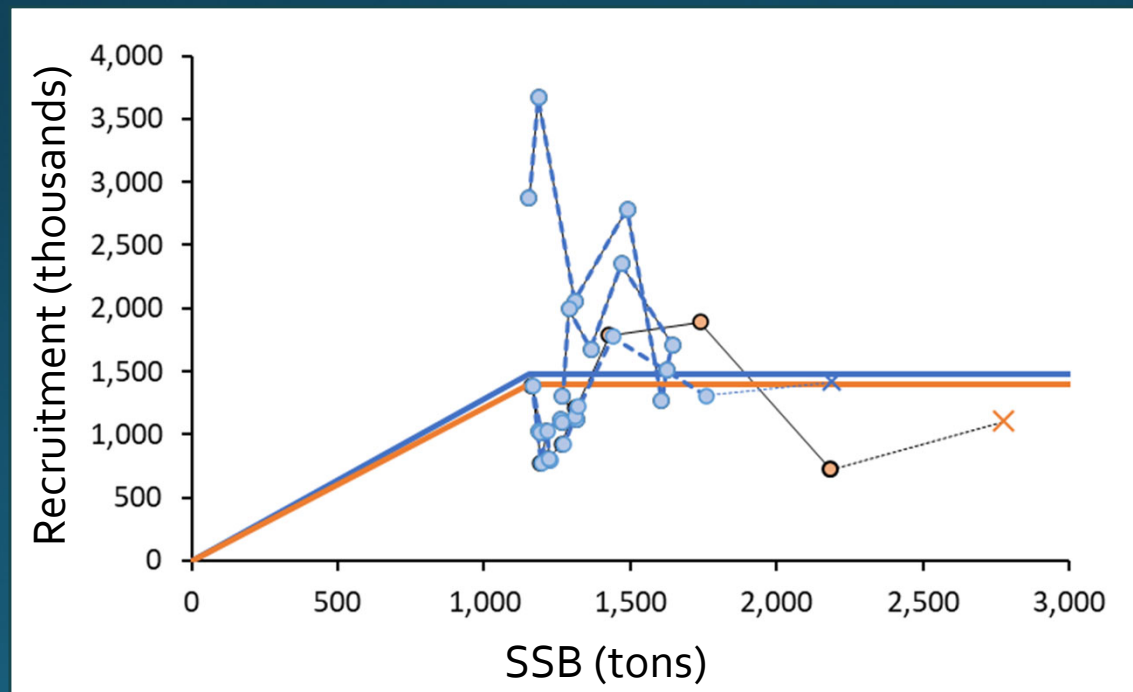


S-R relationship model	Optimization method	Autocorrelation	AICc	SBmsy (tons)
HS	L2	○	20.7	2,427
RI	L2	○	19.8	1,096
BH	L2	○	20.7	2,364
HS	L2	×	32.0	2,564
RI	L2	×	32.7	4,481
BH	L2	×	32.7	9,314

2. Stock Recruitment Relationships

Reviewer's Comment

- Q6o: Based on Fig 4-14, it appears that the SRR was based on the SSB and recruitment from 2021 (solid gray circles). Would the estimated SRR be different if the open black circles were used? (ST Q29)
 - → SRR does not change dramatically with the most recent data

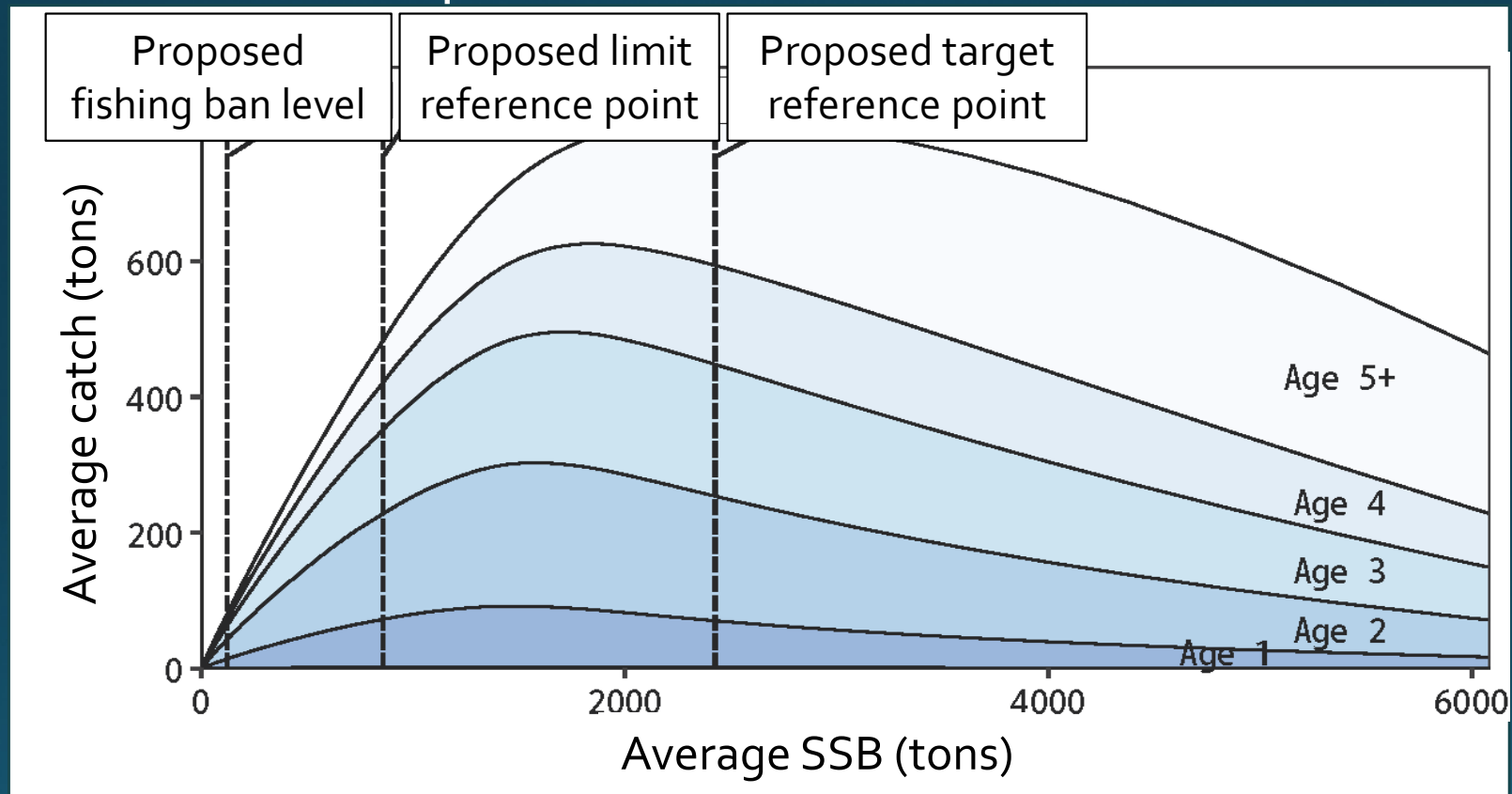


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 - VPA
2. Stock Recruitment Relationships
3. **Proposed Reference points and Kobe plot**
4. Harvest Control Rule and Future projection
(Appendix 4 – 6)

3. Proposed Reference points and Kobe plot

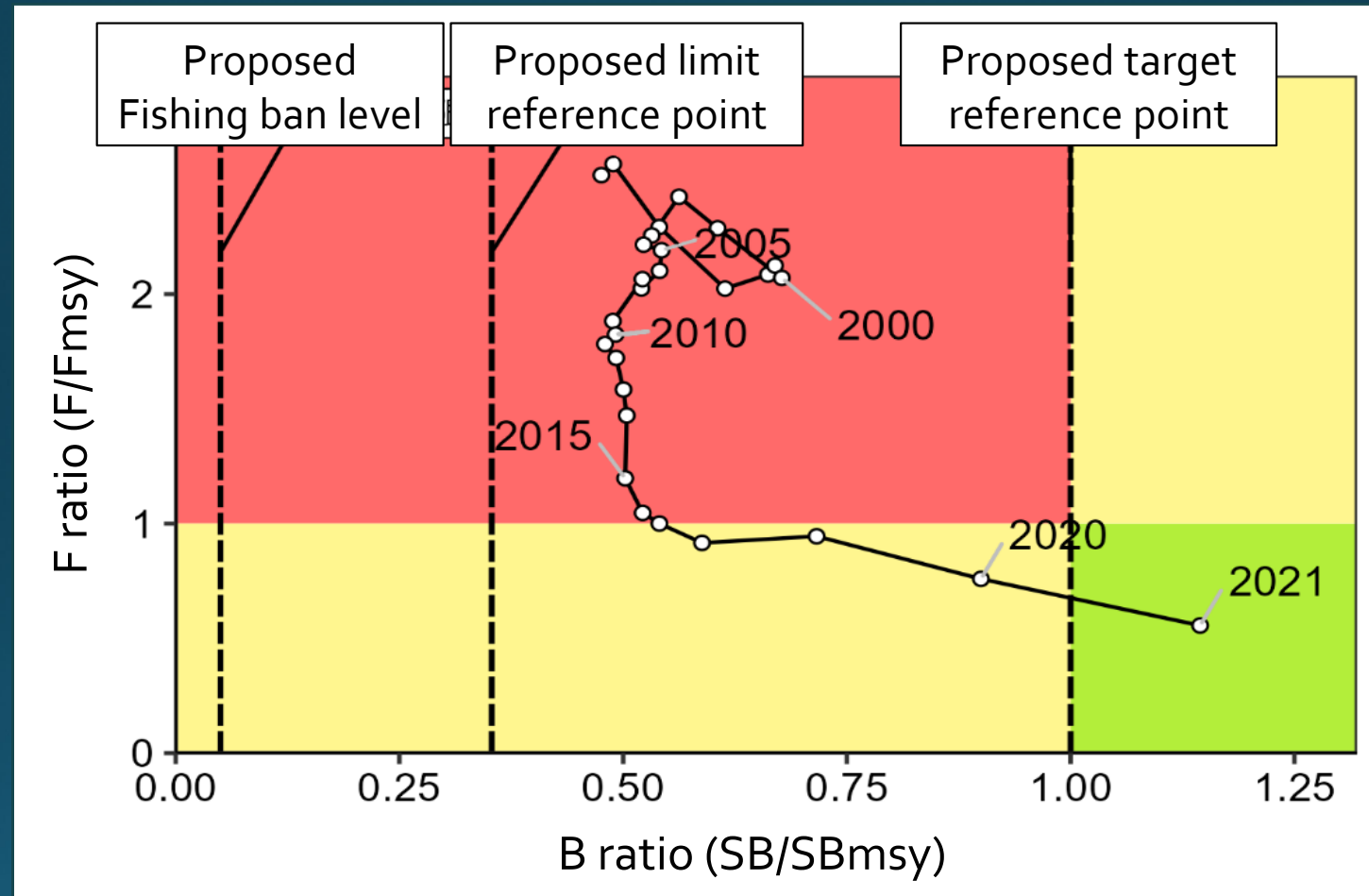
- Proposed Reference points



Proposed Reference points	SB target (SB msy)	SB limit (SB 60%msy)	SB ban (SB 10%msy)
SSB (tons)	2,427	857	121

3. Proposed Reference points and Kobe plot

- Kobe plot



- SSB in 2021 is above SB_{msy} and in increasing trend
- F/F_{msy} is below 1 after 2018

Contents

1. Biology and Stock Assessment

- Distribution and Growth
- Estimation of Catch Number at Age
- Stock abundance indices
- VPA

2. Stock Recruitment Relationships

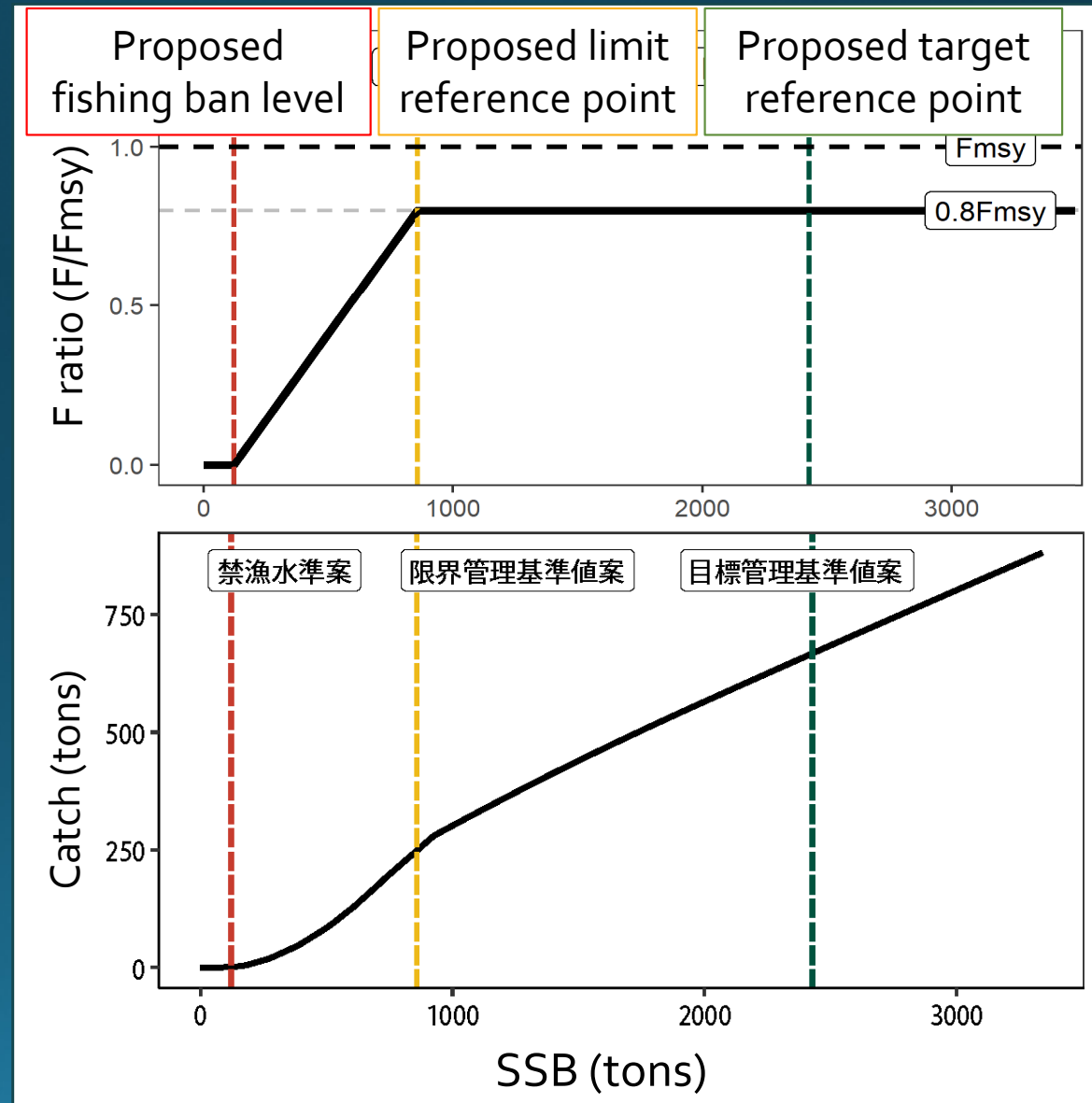
3. Proposed Reference points and Kobe plot

4. Harvest Control Rule and Future projection (Appendix 4 – 6)

4. Harvest Control Rule and Future projection (Appendix 4 – 6)

Harvest Control Rule

- ✓ F is controlled to directly reduced according to the SSB level, when the SSB falls below the limit reference point
- ✓ Multiplying the F_{msy} by the coefficient β is the upper limit of F .



4. Harvest Control Rule and Future projection (Appendix 4 – 6)

Future projection

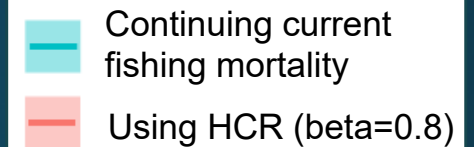
➤ Reference points and HCRs have not been established, so future prediction results based on these are **shown only in the Appendix.**

➤ Setting Future Projections

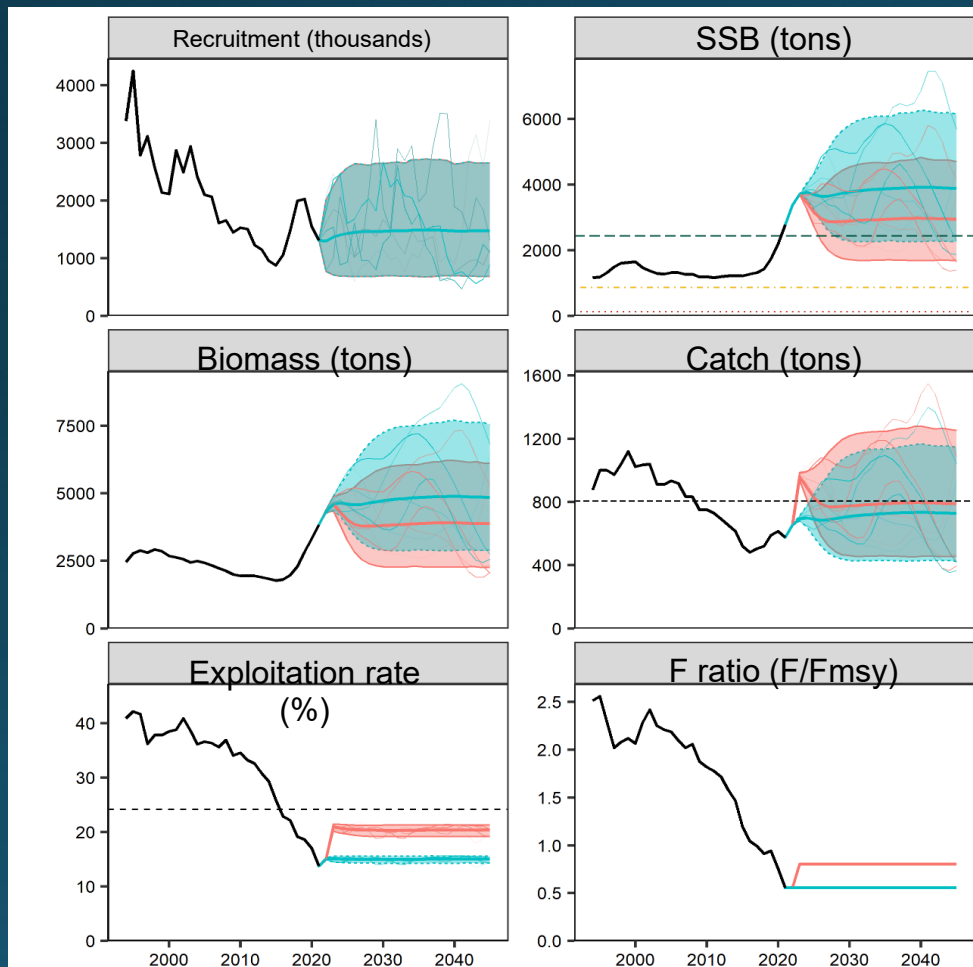
- ✓ Using a forward computation for cohort analysis
- ✓ Recruitment in future projections
 - ✓ Wild fish: According to the above HS model with errors
 - ✓ Hatchery-released fish: Average of 2017 – 2019
- ✓ F was following proposed HCRs
- ✓ Selectivity and biological parameters: Same values for MSY calculation in the Research Institute Meeting.

4. Harvest Control Rule and Future projection (Appendix 4 – 6)

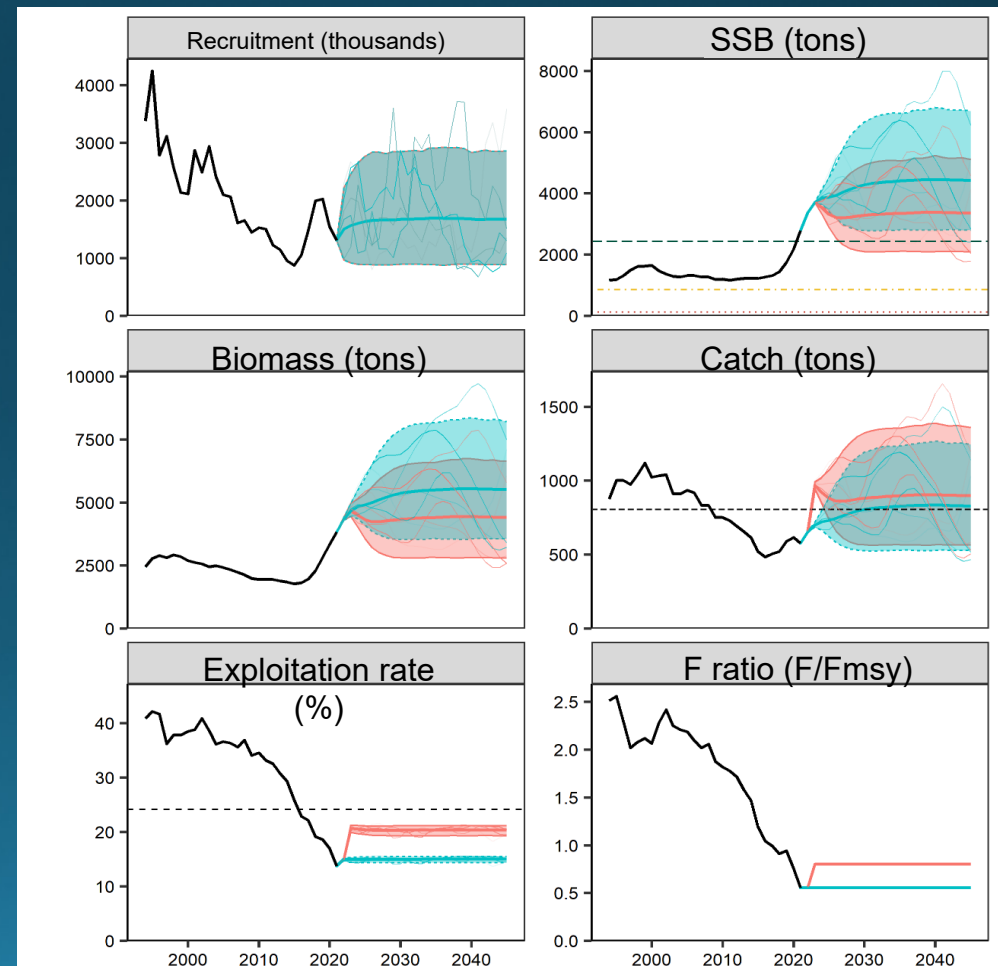
Future projection



Recruitment only from S-R relationship



With stock enhancement



Shaded areas: 5 to 95% prediction interval, thick solid lines: average value, thin solid lines: simulation results

4. Harvest Control Rule and Future projection

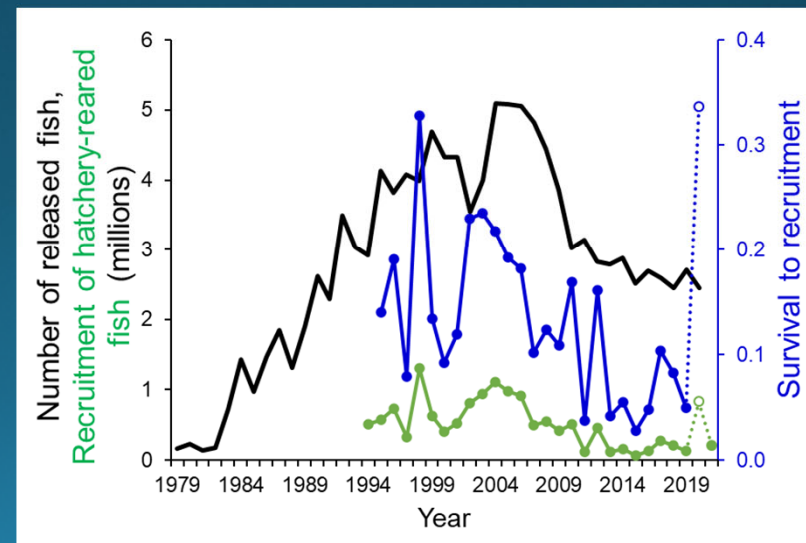
Reviewer's Comment

- Q61: What was the selectivity curve used for the per-recruit analyses? I see that this is provided in Supp Table 3-1. Please provide the basis for the selectivity values used. (PTK Q_{4c})
 - → “Current” fishing pressure (average of the recent 3 years) of the stock assessment when BRPs were estimated are used
- Q62: Based on the document “Guidelines for HCRs and ABC calculations”, these calculations are supposed to be risk-based and incorporate the uncertainties in the assessment. However, the only uncertainty included in the projections appeared to be the uncertainty in future recruitment deviates. There did not appear to be any uncertainty in the reported stock assessment results. For example, the estimated SSB, recruitment, N-at-age, F-at-age, and SRR did not appear to have any uncertainties associated with them. Were these uncertainties not estimated or not reported? (ST Q₃₂)
 - → No other uncertainties are estimated (further study)

4. Harvest Control Rule and Future projection

Reviewer's Comment

- Q63: The survival and number of hatchery releases are also highly variable. Why use only the 2017-2019 average values? (ST Q33)
 - → Recruitment to survival and number of hatchery releases is in a long-term declining trend, therefore the recent averaged values is used.
- Q64: How would incorporating more of the above uncertainties affect the assessment results and projections? (ST Q34)
 - → Uncertainties of the stock assessment shall be considered as the topic of further study.



Others

Reviewer's Comment

- Q65: How about showing the effect of reducing the catch of young fish by describing a yield isopleth diagram with F and t_c (age of recruitment to fishery)? (TY Q6)
 - → The result may affect the management measures. We would like to consider this based on future requests from stakeholders and discussion at the meeting.
- Q66: Section 6 stated that the size restrictions were highly effective in reducing F on the stock. However, the effort was also reducing over time. How would the HCRs and projections be different with and without the size restrictions? (ST Q35)
 - → Apology for the poor translation. The original meant that by limiting the catch of small and immature fishes, overexploitation can be avoided without reducing F dramatically.
- Q67: What are the potential improvements for this assessment? (ST Q37)
 - → Enrichment of data on biomass index is preferred, especially ones with fishery-independent survey.