Sardinops melanostictus

Tsushima Warm Current stock Japanese sardine

Contents

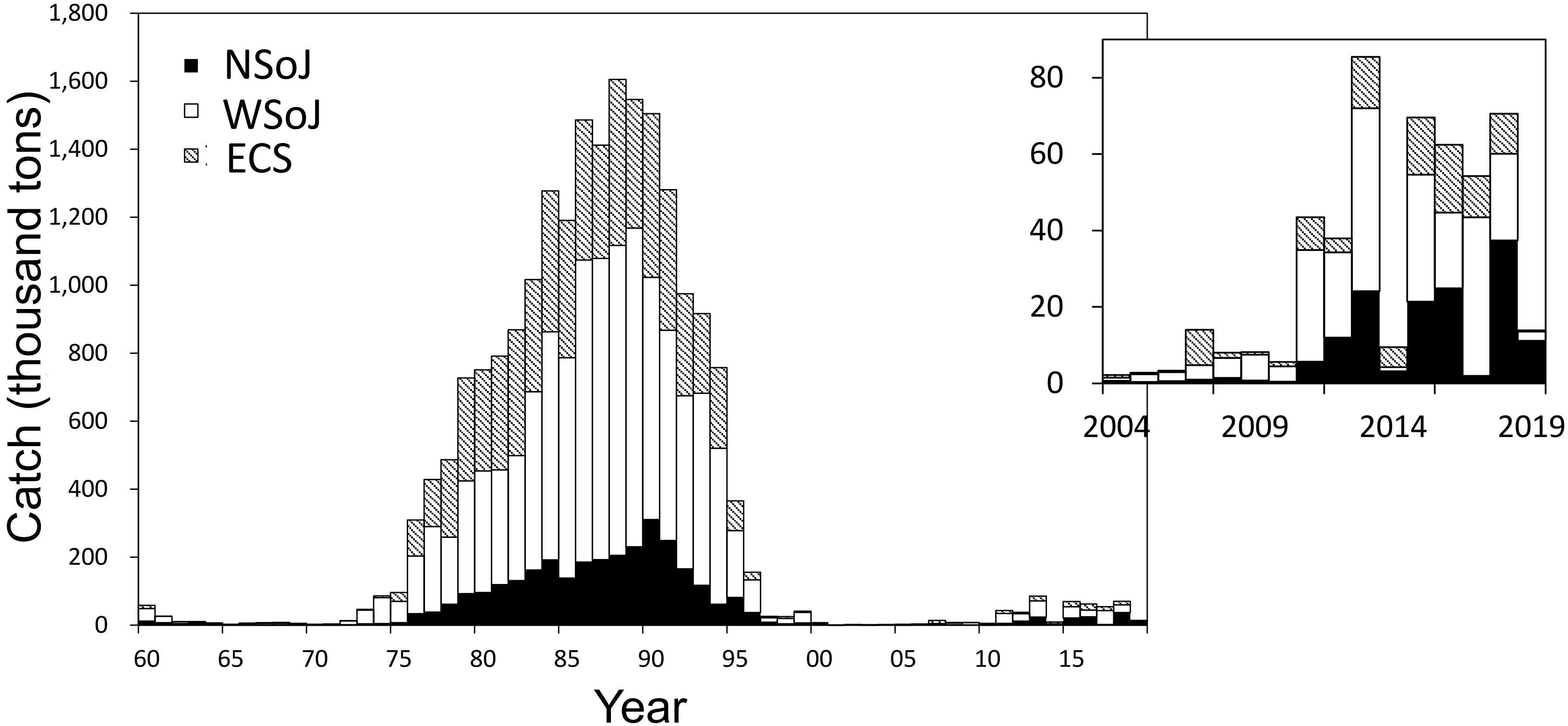
- Biology and Stock assessment
  Regime-shift, Distribution, Growth, Estimation of Catch Number at Age, Stock abundance indices, VPA

- Stock-Recruitment Relationships

- Reference points, Kobe-plot

- Harvest Control Rule, Future projection

Catch



- Catch amount of this species has large fluctuations.
- The maximum catch size of Tsushima Current stock was 1606 thousand tons in 1988, and the catch was drastically decreasing by 2001.
- The catch size has been increasing since 2010s.

Reviewers Comments

- Fisheries from Korea, Russia and China are cited as catching substantial amounts, which is not surprising considering the distribution of the fish. How about other countries (e.g., Taiwan, North Korea)?
- Please explain why non-Japanese catches were not included for the base case scenario?
- I can understand why an index is not used for a year due to catchability or distribution changes beyond the standardization model or survey design. But I do not understand the logic in discarding the catch. Please explain why the Japanese catch for 2019 was not included? If 2019 catch was not included, it would be more reasonable to consider the terminal year of the assessment to be 2018, with 2019 being the start of projections.

Response

- As Japanese sardine mainly distributes in the waters near Japan, then the catch amount of North Korea may be too little, then the catch amount in North Korea can be neglected. Furthermore, this species cannot distribute sub-tropical and tropical waters, then the catch in Taiwan is also too small.
- As the first response, the main country to catch Japanese sardine Tsushima current stock is Japan.
- The catch of this species in 2019 was rapidly dropped, however the catch in first half of 2020 was rapidly recovered. Then we judged the poor catch in 2019 could be caused by oceanographic conditions, the fish may distribute offshore area in 2019.
- In 2019 stock assessment, we calculated VPA and the terminal year was assumed to be 2018, and projected for 2019 and 2020. The age structure in 2020 was applied only first half of 2020, however, main fishing periods of this species is first half of a year, then the age structure in 2020 may be reasonable.

Regime-shift

Normal regime		High recruitment regime
Main distribution area is coastal Main spawning ground: SoJ	Distribution	Widely distributed Main spawning ground: ECS
Well growth	Growth	Less growth
Age 1	First maturation age	Age 2
Not well	Recruitment	Well

- Regime-shift is large, abrupt changes in ecosystem with climate change.
- The stock and catch size of Japanese sardine have large fluctuation, and biological characteristics and distribution of this species could be affected by the stock fluctuation due to the regime-shift.

SoJ: Sea of Japan, ECS: East China Sea

Climate change

ORIGINAL ARTICLE | Full Access

Improvement in recruitment of Japanese sardine with delays of the spring phytoplankton bloom in the Sea of Japan

Taketoshi Kodama, Taku Wagawa, Seiji Ohshimo, Haruyuki Morimoto, Naoki Iguchi, Ken-Ichi Fukudome, Tsuneo Goto, Motomitsu Takahashi, Tohya Yasuda

First published: 30 January 2018 | https://doi.org/10.1111/fog.12252 | Citations: 11

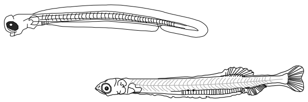
Wind Strength

Strong | Weak

Bloom timing of primary production

Late | Early

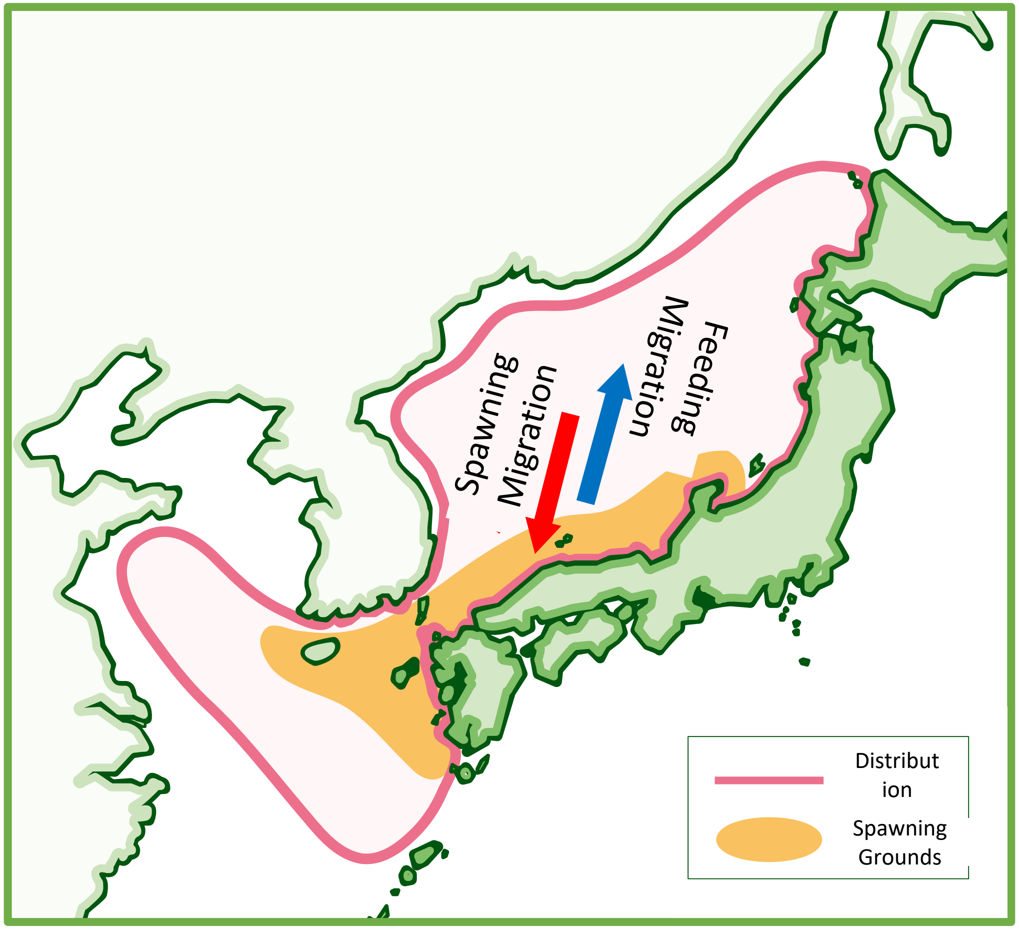
Survival rate



Well | Not Well

- Kodama et al. (2018) suggested that the match/mismatch hypothesis on survival of early life of Japanese sardine with climate change.
- We are evaluating this hypothesis.

Distribution



- Japanese sardine distributes widely in the Sea of Japan, East China Sea and Yellow Sea.
- The distribution area is wide/narrow when the stock size is large/small.

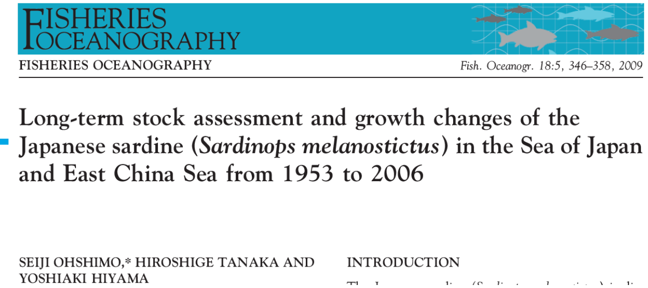
Reviewers Comments

- Are you sure that the Pacific and Tsushima stocks are not the same stock? Please provide evidence to support the assumption that the Tsushima stock is a separate stock.

Responses

- Two stocks may be partly mixed in each area.
- Population dynamics among two stocks was almost synchronized. However in the recent years, increasing rate in the Pacific stock is larger than Tsushima current stock.
- That indicates the mechanism of population dynamics among two stocks is slightly different.

Growth

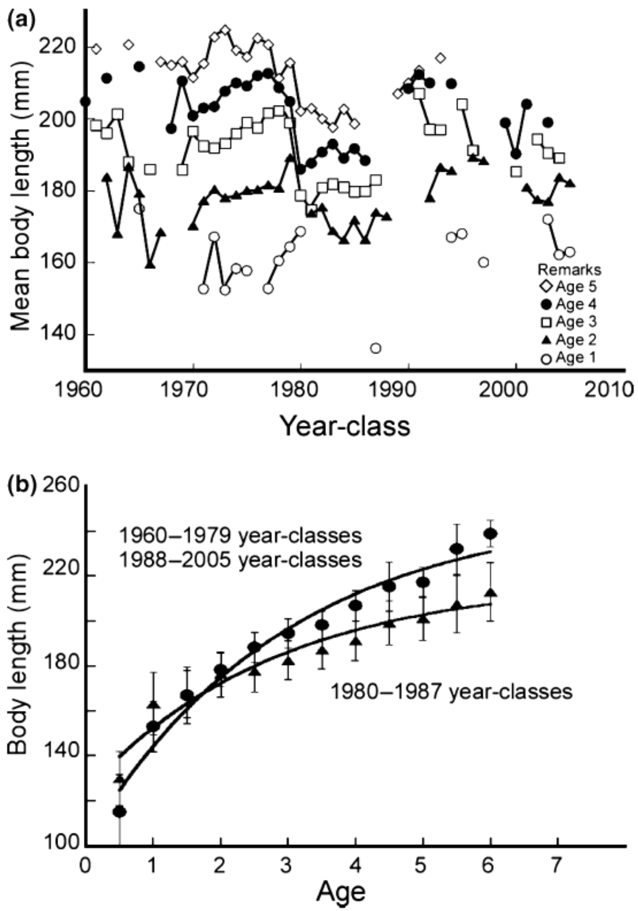

FISHERIES OCEANOGRAPHY

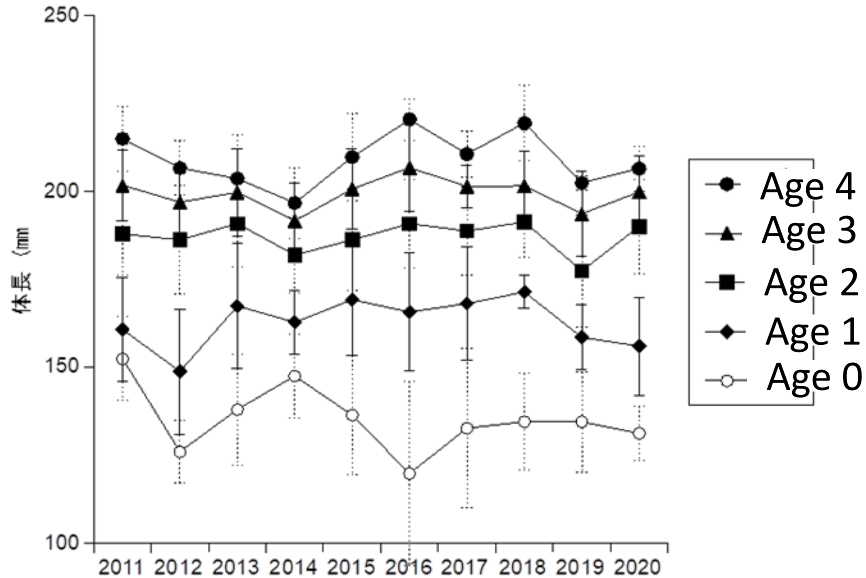
FISHERIES OCEANOGRAPHY Fish. Oceanogr. 18:5, 346–358, 2009

Long-term stock assessment and growth changes of the Japanese sardine (*Sardinops melanostictus*) in the Sea of Japan and East China Sea from 1953 to 2006

SEIJI OHSHIMO,* HIROSHIGE TANAKA AND YOSHIAKI HIYAMA

INTRODUCTION





- Age determination has been conducted using a scale (Ohshimo et al. 2009).
- Mean body length at age 2-5 in the 1980s was smaller than that in the other years.

Estimation of catch number at age

$$C_{t,i} = \frac{\dfrac{n_i \times BW_i}{\sum_{i=0}^{250}(n_i \times BW_i)} \times CW \times ALK_{t,i}}{BW_i}$$

FISHERIES OCEANOGRAPHY
FISHERIES OCEANOGRAPHY Fish. Oceanogr. 18:5, 346–358, 2009

Long-term stock assessment and growth changes of the Japanese sardine (*Sardinops melanostictus*) in the Sea of Japan and East China Sea from 1953 to 2006

SEIJI OHSHIMO,* HIROSHIGE TANAKA AND
YOS

INTRODUCTION

Age0												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	1	1	1	1	1	1	1	1	1
5	0	0	0	1	1	1	1	1	1	1	1	1
10	0	0	0	1	1	1	1	1	1	1	1	1
15	0	0	0	1	1	1	1	1	1	1	1	1
20	0	0	0	1	1	1	1	1	1	1	1	1
25	0	0	0	1	1	1	1	1	1	1	1	1
30	0	0	0	1	1	1	1	1	1	1	1	1
35	0	0	0	1	1	1	1	1	1	1	1	1
40	0	0	0	1	1	1	1	1	1	1	1	1
45	0	0	0	1	1	1	1	1	1	1	1	1
50	0	0	0	1	1	1	1	1	1	1	1	1
55	0	0	0	1	1	1	1	1	1	1	1	1
60	0	0	0	1	1	1	1	1	1	1	1	1
65	0	0	0	1	1	1	1	1	1	1	1	1
70	0	0	0	1	1	1	1	1	1	1	1	1
75	0	0	0	1	1	1	1	1	1	1	1	1
80	0	0	0	1	1	1	1	1	1	1	1	1
85	0	0	0	1	1	1	1	1	1	1	1	1
90	0	0	0	1	1	1	1	1	1	1	1	1
95	0	0	0	0	1	1	1	1	1	1	1	1
100	0	0	0	0	0	1	1	1	1	1	1	1
105	0	0	0	0	0	0	1	1	1	1	1	1
110	0	0	0	0	0	0	1	1	1	1	1	1
115	0	0	0	0	0	0	1	1	1	1	1	1
120	0	0	0	0	0	0	1	1	1	1	1	1
125	0	0	0	0	0	0	0.5	1	1	1	1	1
130	0	0	0	0	0	0	0.5	1	1	1	1	1
135	0	0	0	0	0	0	0	1	1	1	1	1
140	0	0	0	0	0	0	0	0.5	1	1	1	1
145	0	0	0	0	0	0	0	0.5	1	1	1	1
150	0	0	0	0	0	0	0	0	1	1	1	1
155	0	0	0	0	0	0	0	0	1	1	1	1
160	0	0	0	0	0	0	0	0	0.5	1	1	1
165	0	0	0	0	0	0	0	0	0	1	1	1
170	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0

Age1												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	1	1	1	0	0	0	0	0	0	0	0	0
5	1	1	1	0	0	0	0	0	0	0	0	0
10	1	1	1	0	0	0	0	0	0	0	0	0
15	1	1	1	0	0	0	0	0	0	0	0	0
20	1	1	1	0	0	0	0	0	0	0	0	0
25	1	1	1	0	0	0	0	0	0	0	0	0
30	1	1	1	0	0	0	0	0	0	0	0	0
35	1	1	1	0	0	0	0	0	0	0	0	0
40	1	1	1	0	0	0	0	0	0	0	0	0
45	1	1	1	0	0	0	0	0	0	0	0	0
50	1	1	1	0	0	0	0	0	0	0	0	0
55	1	1	1	0	0	0	0	0	0	0	0	0
60	1	1	1	0	0	0	0	0	0	0	0	0
65	1	1	1	0	0	0	0	0	0	0	0	0
70	1	1	1	0	0	0	0	0	0	0	0	0
75	1	1	1	0	0	0	0	0	0	0	0	0
80	1	1	1	0	0	0	0	0	0	0	0	0
85	1	1	1	0	0	0	0	0	0	0	0	0
90	1	1	1	0	0	0	0	0	0	0	0	0
95	1	1	1	1	0	0	0	0	0	0	0	0
100	1	1	1	1	1	0	0	0	0	0	0	0
105	1	1	1	1	1	1	0	0	0	0	0	0
110	1	1	1	1	1	1	0	0	0	0	0	0
115	1	1	1	1	1	1	0	0	0	0	0	0
120	1	1	1	1	1	1	0	0	0	0	0	0
125	1	1	1	1	1	1	0.5	0	0	0	0	0
130	1	1	1	1	1	1	0.5	0	0	0	0	0
135	1	1	1	1	1	1	1	0	0	0	0	0
140	1	1	1	1	1	1	1	0.5	0	0	0	0
145	1	1	1	1	1	1	1	0.5	0	0	0	0
150	1	1	1	1	1	1	1	1	0	0	0	0
155	1	1	1	1	1	1	1	1	0	0	0	0
160	1	1	1	1	1	1	1	1	0.5	0	0	0
165	1	1	1	1	1	1	1	1	1	0	0	0
170	1	1	1	1	1	1	1	1	1	1	1	1
175	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1
180	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5
185	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0

Age2												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0
175	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0	0	0	0
180	1	1	1	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5
185	1	1	1	1	1	1	1	1	1	1	1	1
190	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1
195	0.5	0.5	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
200	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
205	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0

Age3												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	0	0	0	0	0	0
190	0.5	0.5	0.5	0	0	0	0	0	0	0	0	0
195	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
200	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
205	1	1	1	1	1	1	1	1	1	1	1	1
210	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
215	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0

Age4												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
210	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
215	1	1	1	1	1	1	1	1	1	1	1	1
220	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
225	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
230	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0

Age5												
体長	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	0	0	0	0	0	0
220	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
225	1	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
230	1	1	1	1	1	1	1	1	1	1	1	1
235	1	1	1	1	1	1	1	1	1	1	1	1
240	1	1	1	1	1	1	1	1	1	1	1	1
245	1	1	1	1	1	1	1	1	1	1	1	1
250	1	1	1	1	1	1	1	1	1	1	1	1

- Catch number at age was calculated by ALK, monthly catch and monthly size distribution in each East China Sea and Sea of Japan.
- The ALK has been changed annually using the results of age determination.

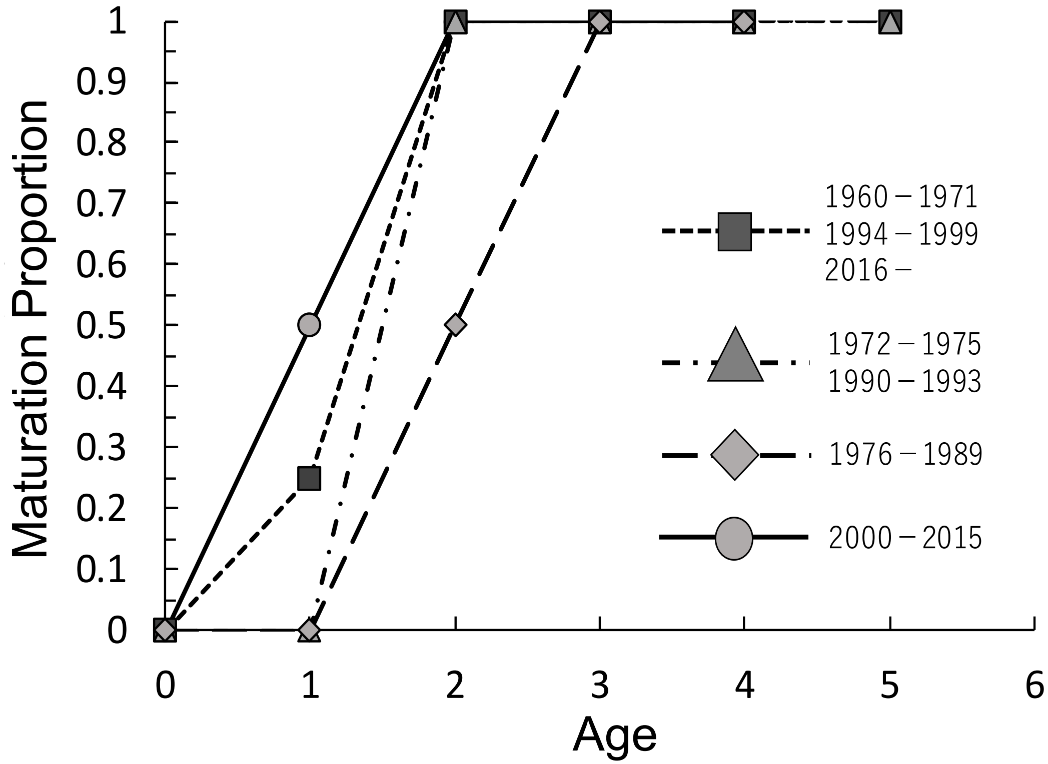
Reviewers Comments

- The Ohsimo et al. paper methods are not detailed enough to review how the catch-at-age was developed. Please provide a presentation similar to the Sardine-Pacific stock document on catch-at-age.
- Please show the ALKs and length-weight relationships used. Given that the age-length and length-weight relationships for sardine are known to be highly variable over space and time, how did the ALKs and length-weight relationships vary over space and time?
- It appears that the ages were from reading scales. Typically, age from scales tend to be biased low, especially at older ages. Why were scales used instead of otoliths? Have there been a study comparing scale to otolith ages for sardines, or some sort of age validation study?
- Is there a study on aging error?

Responses

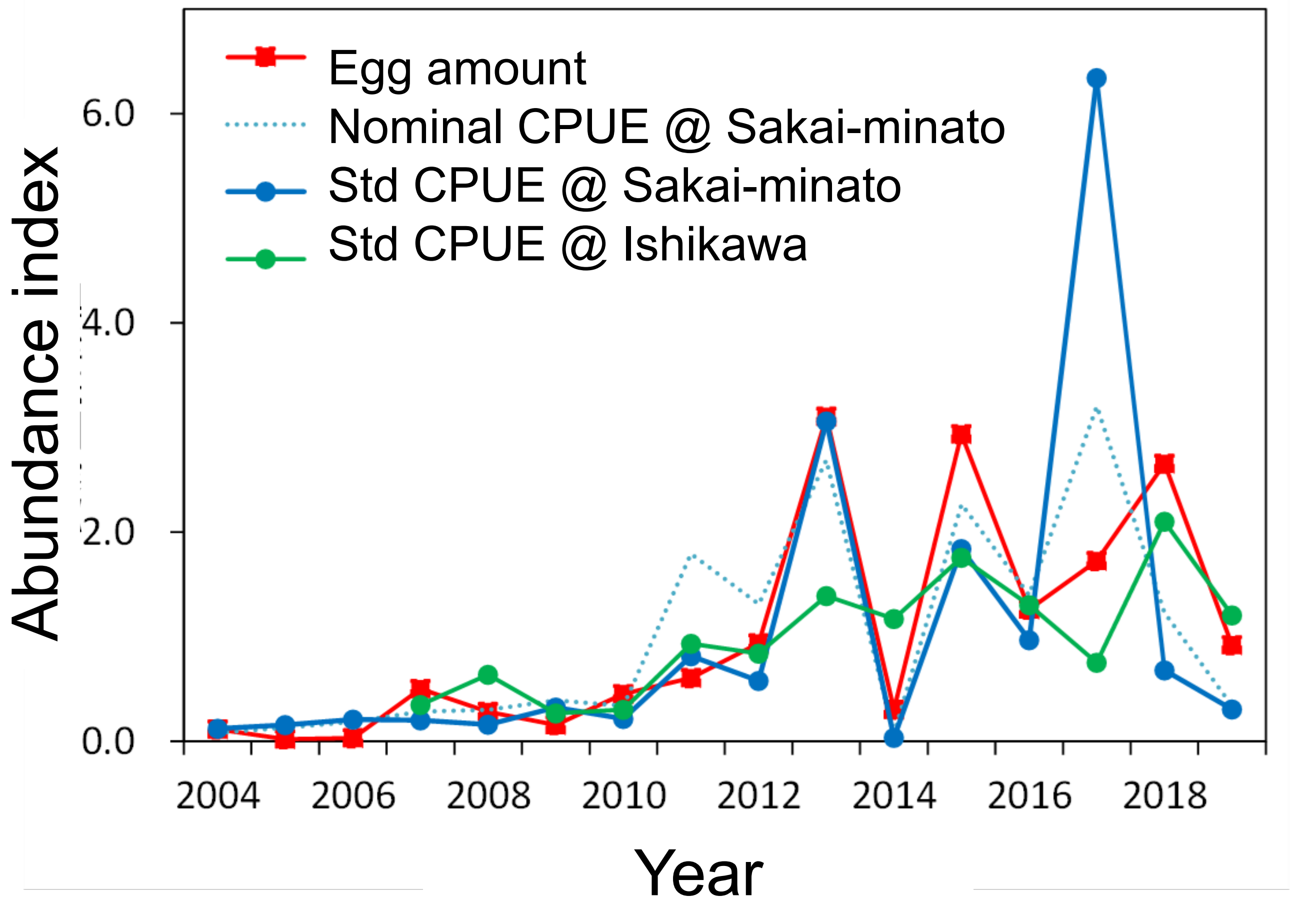
- The process of calculation of CAA of this species is same as Ohshimo et al. (2009). The ALKs are explained in this presentation.
- Age determination of Japanese sardine Tsushima current stock has been conducted every year, and the ALKs are also made every year.
- Two length-weight relationships are applied for calculating CAA, one is for East China Sea and the other is for Sea of Japan.
- Because the scales of this species have been stored since 1950s, we usually use the scale for reading the age. There are no reports on the validation age reading between scale and otolith for Tsushima current stock.
- Yes, we agree the age determination in elder individual may be biased when we used the scales. However, most of individual of caught sardine was under age 3. Then, elder individuals were pooled.

Maturation



- Histological evaluation on reproduction has been conducted every year, and the maturation proportions of this species are affected by their stock size.
- The relationships between maturation proportion and age are set into four scenarios.

Abundance indices

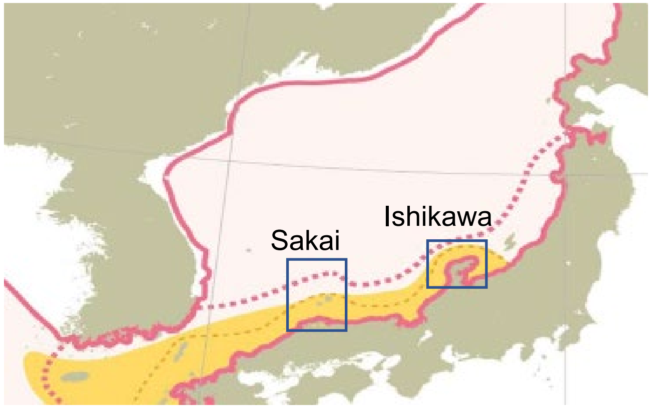


- Three indices are used for tuning VPA.

Reviewers Comments

- The Egg Production Index (EPI) is likely the most important index because it represents the SSB but there is not enough details to understand the index. Please provide more details. For example, what are the stations and areas covered by the egg and larval survey, especially compared with the distribution of the SSB? Noting that the reproductive biology of sardines vary by area, time, and environmental conditions, were the fecundity and maturity of the stock sampled during the survey or assumed based on other info? If sampled, how were they sampled? If assumed, what was assumed and based on what info?
- Please describe the the spatial and temporal coverage for the Sakai and Ishikawa indices.
- What were the age classes for the Sakai and Ishikawa indices?
- The unit of effort for the Sakai index was stated to be “number of fleets”. This does not make sense to me. Please explain.
- I am not that comforatable using a random effects for the year*month interactions in the standardization for the Sakai Index. What does the index look like if you use the standard year*month interactions?
- I do not understand the Ishikawa Index. Please explain in more detail how the index was calculated. Was this index standardized? Not sure I understand what a directed index is.
- Why was the midwater trawl survey not used as an index?

- Responses
- Rough area for the Sakai and Ishikwa are follows,

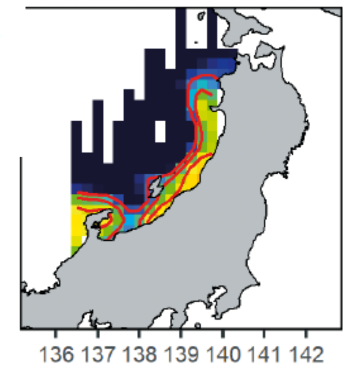


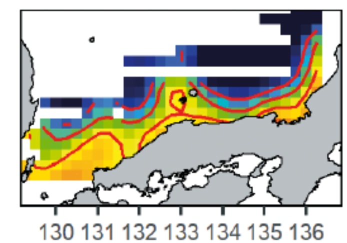
Responses

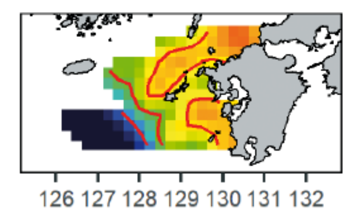
Vol. 633: 157–168, 2020
https://doi.org/10.3354/meps13169
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published January 9

Disentangling the effects of climate and density-dependent factors on spatiotemporal dynamics of Japanese sardine spawning

Sho Furuichi[1,2,*], Tohya Yasuda[1,2], Hiroyuki Kurota[1], Mari Yoda[1], Kei Suzuki[1], Motomitsu Takahashi[1], Masa-aki Fukuwaka[1,3]







- Spatio-temporal distribution of sardine egg is described (Furuichi et al. 2020 , right figures)
- Main spawning area of Japanese sardine is coastal waters off Japan, and high density areas in the recent years are near Noto peninsula and around Oki Islands.
- These migrated adult fish for Noto peninsula and Oki islands were captured by the purse seine fisheries in Ishikawa and Sakai, respectively.
- The ovaries of at the Noto peninsula and Oki islands were analyzed based on histological technique. The maturity ogive is checked every year.
- In 2019 assessment, effort in Sakai-fleet has not been recorded.
- A lot of missing combinations, Year*Month interaction could not be treated as the fixed effect.
- Ishikawa index was followed by Biseau (1998). The basic idea of directed CPUE is that the data are subsetted according to the ordered relative composition of a species in the catch for each year and then CPUE is given by the annual mean of the subsetted data.
- Midwater trawling survey in the wide range Sea of Japan has been conducted for recent three years. Then, we cannot apply for tuning VPA.

Stock assessment (tuning VPA)

Step 1: Basic part

$$N_{a,y} = N_{a+1,y+1} \times \exp(M) + C_{a,y} \times \exp\left(\frac{M}{2}\right)$$

$$N_{p-1,y} = \frac{C_{p-1,y}}{C_{p,y} + C_{p-1,y}} N_{p,y+1} \times \exp(M) + C_{p-1,y} \times \exp\left(\frac{M}{2}\right)$$

$$N_{p,y} = \frac{C_{p,y}}{C_{p-1,y}} N_{p-1,y} = \frac{C_{p,y}}{C_{p,y} + C_{p-1,y}} N_{p,y+1} \times \exp(M) + C_{p,y} \times \exp\left(\frac{M}{2}\right)$$

$$N_{a,y} = \frac{C_{a,y} \times \exp\left(\frac{M}{2}\right)}{\left(1 - \exp\left(-F_{a,y}\right)\right)}$$

$$F_{a,y} = -\ln\left\{1 - \frac{C_{a,y} \times \exp\left(\frac{M}{2}\right)}{N_{a,y}}\right\}$$

Step 2: Tuning part

$$-\ln L = \sum_f \sum_y \frac{\left[\ln I_{f,y} - \left(b_f \ln B_{f,y} + \ln q_f\right)\right]^2}{2\sigma_f{}^2} - \ln\left(\frac{1}{\sqrt{2\pi}\sigma_f}\right)$$

$$I_{f,y} = q_f B_y^{b_f}$$

- See document “FRA-SA2020-BRP01-2e-1”

Reviewers Comments

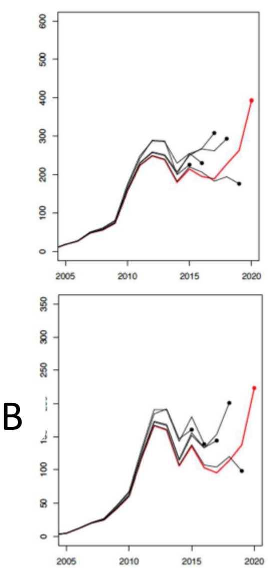
- Since there was a egg production index developed, there should be fecundity and maturity estimates from samples of adult fish during the sampling for the survey. What was the maturity ogive from the data compared to the assumptions made?
- The M (0.4) seems a little low compared to the EPO sardine posterior (0.585). Where did the 0.4 come from?
- Please show the model diagnostics for the base case. Retrospective, fits to the indices, and the various model params.

Responses

- The egg production index means sum of area averaged egg accounts during January and June in the East China Sea and Sea of Japan. Maturity ogive is changed according to the stock level, and the ogives were made from histological methods.
- Our institute just start the discussion on about the natural mortality.

Stock Size

SSB

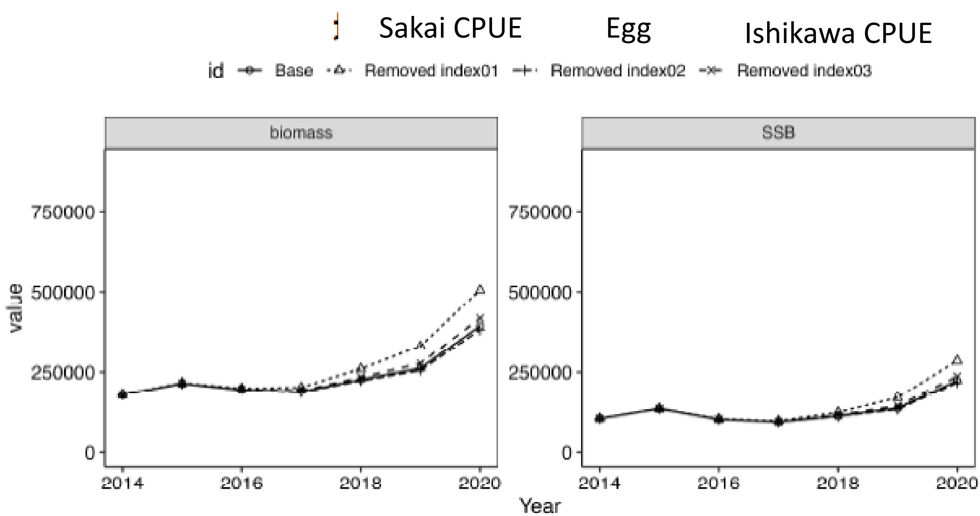


Reviewers Comments

- It is likely that the current base model would not be considered BSIA because of the missing catch from non-Japanese fisheries. I think it would be useful to explore the following models as potential BSIA models. Let's discuss and explore during the meeting.
- Model 1: Base case with no tuning indices
- Model 2: Base case with EPI only
- Model 3: Base case with no tuning indices + catch from non-Japanese fleets (make reasonable assumptions similar to the Pacific stock). You may need a few different catch scenarios to cover the range of possibilities.
- Model 4: Same as Model 3 + EPI
- Model 5: Same as Model 3 + EPI + Sakai index + Ishikawa index
- Please show the above-mentioned model diagnostics for these models.

Responses

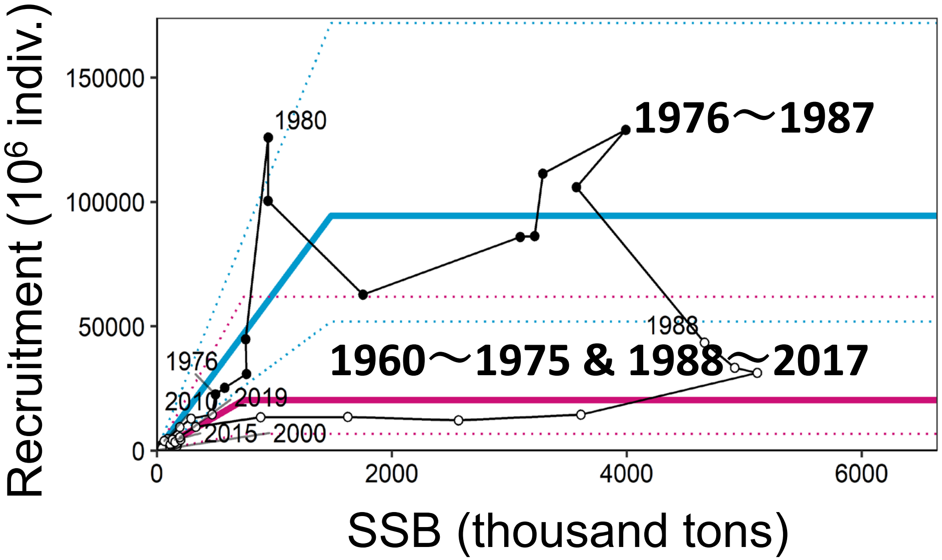
- Assessment in 2019 was not normal calculation process, then sensitivity results in 2020 was shown in right figures.
- Index 01, 02, 03 represent Sakai CPUE, EPI, Ishikawa CPUE, respectively. Base case include three indices.
- Both biomass and SSB was slightly larger than the other scenarios when Sakai CPUE was removed.

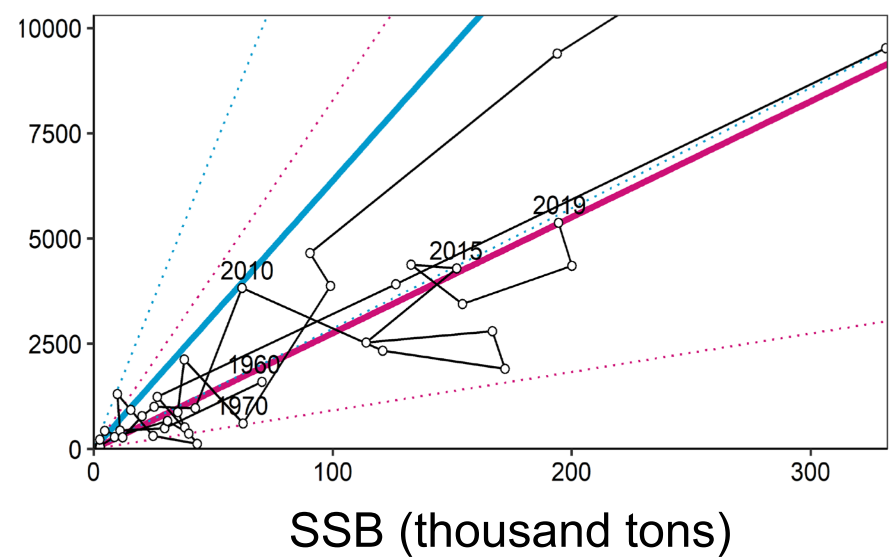


Contents

- Biology and Stock assessment
  Distribution, Growth, Estimation of Catch Number at Age, Stock abundance indices, VPA, Regime-shift
- Stock-Recruitment Relationships
- Reference points, Kobe-plot
- Harvest Control Rule, Future projection

Contents





- We evaluated the SSB-R relationships of Japanese sardine, 1) one relationship or 2) two relationships.
- Based on AIC, two relationships were selected, and one is normal regime (red lines) and the other is high-recruitment regime (blue lines).

Reviewers Comments

- Key issue is whether to use high or low period SRR to estimate stock status and projections. So probably let’s discuss during the meeting.
- Likely that stock is trending towards a high period but may not be fully in the high regime. May be reasonable to use the ‘normal’ period SRR to calculate current stock status but may not be reasonable to do so for the projections. Let’s discuss during the meeting.
- Please tell me during the meeting whether the choice of SRR is considered a management or science decision.

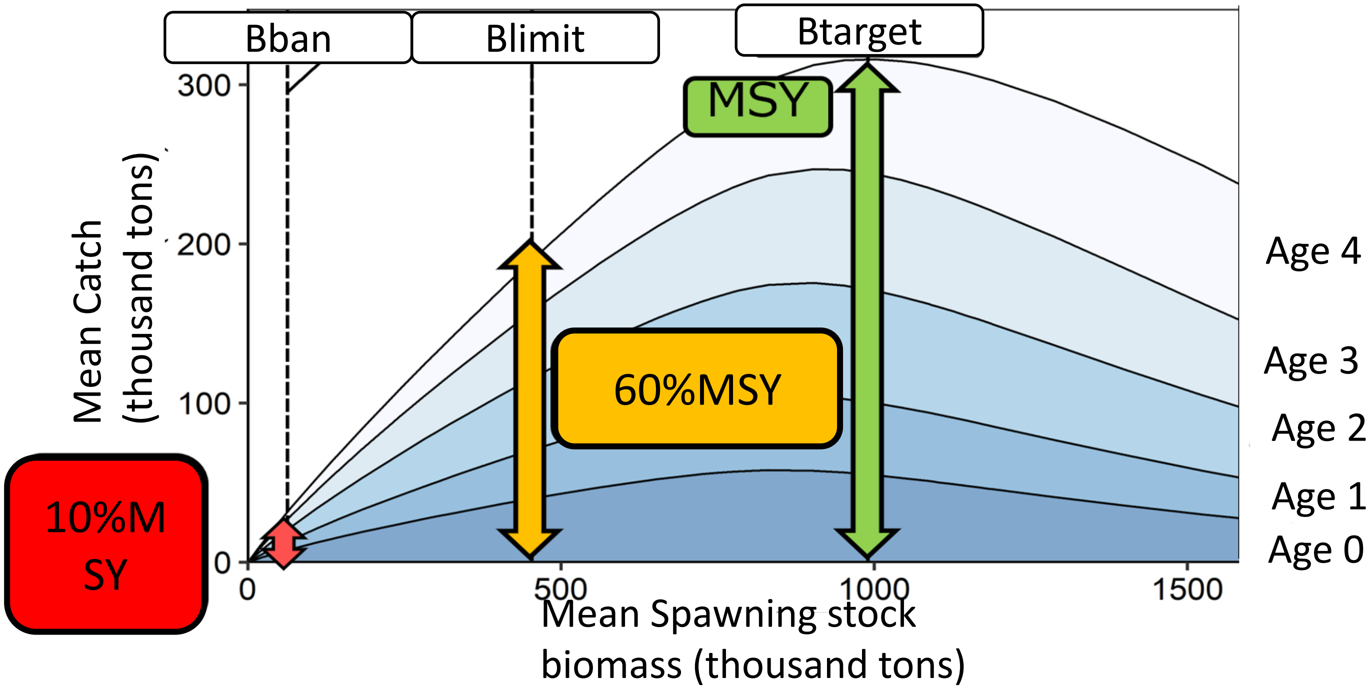
Responses

- Yes, it is problem. Full stock assessment will be conducted every five years.
- Stock management procedure will be changed if the SRR conditions will change to high SRR from normal SRR.

Contents

- Biology and Stock assessment
  Distribution, Growth, Estimation of Catch Number at Age, Stock abundance indices, VPA, Regime-shift
- Stock-Recruitment Relationships
- Reference points, Kobe-plot
- Harvest Control Rule, Future projection

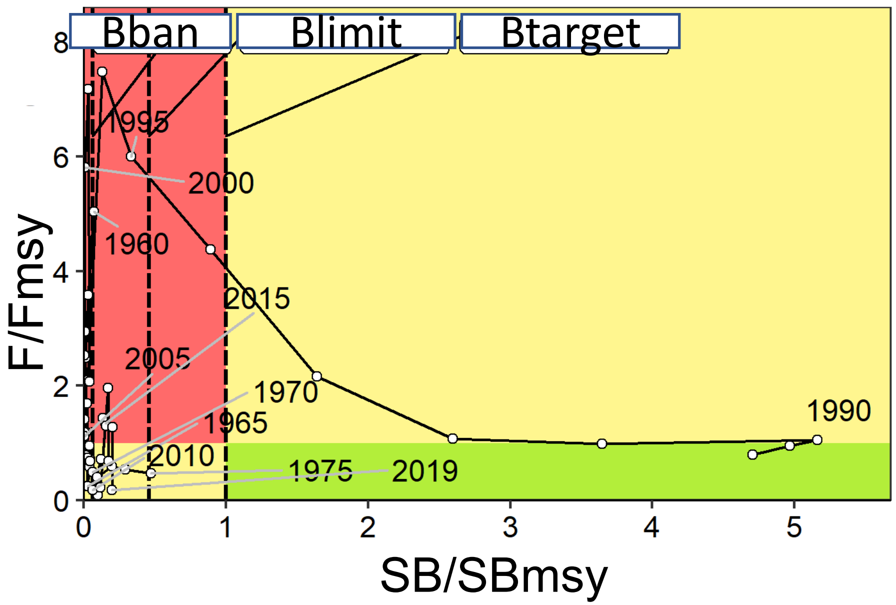
Reference point

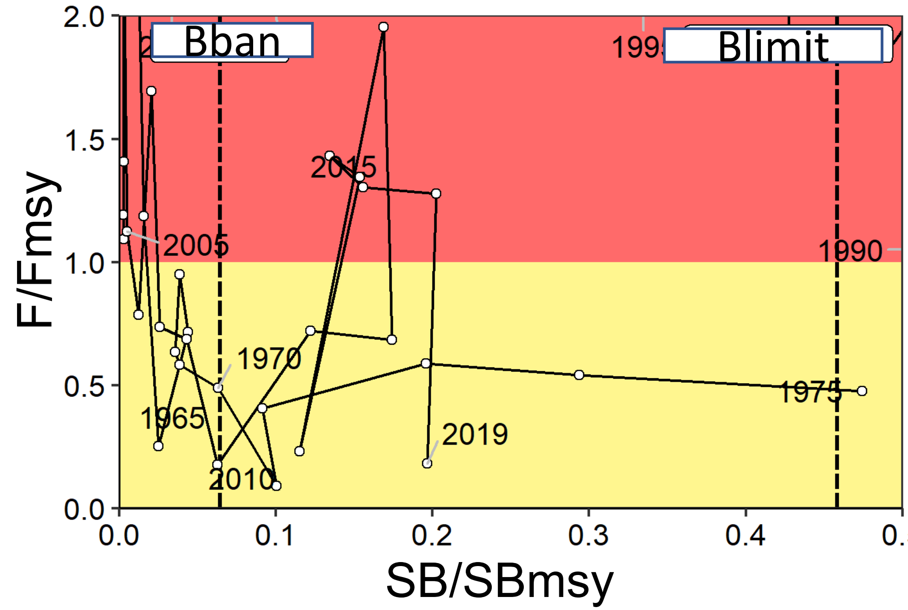


Unit: thousand tons

Btarget (Sbmsy)	Blimit	Bban	SSB2019	MSY
1093	465	66	232	338

Kobe plot





- SB2019 was smaller than Sbmsy (Btarget), and F2019 was smaller than Fmsy.

Contents

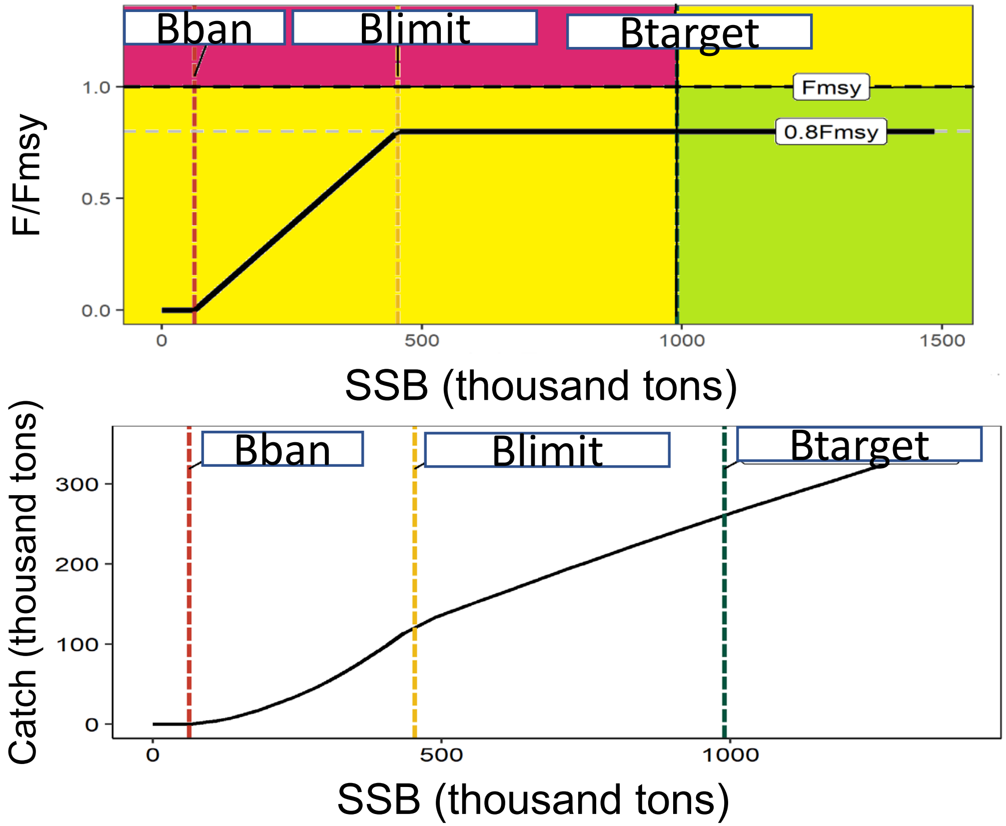
- Biology and Stock assessment
  Distribution, Growth, Estimation of Catch Number at Age, Stock abundance indices, VPA, Regime-shift

- Stock-Recruitment Relationships

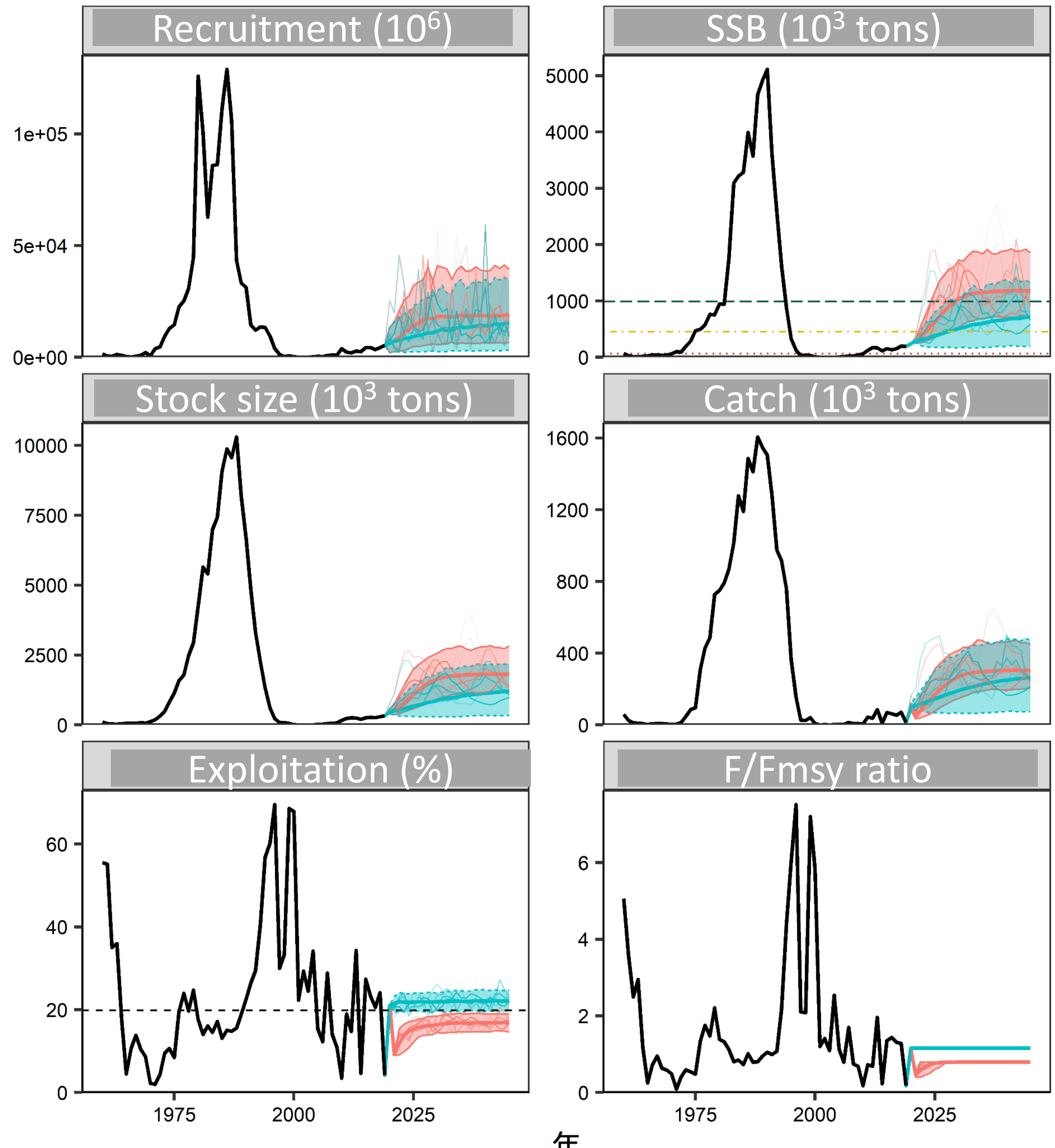
- Reference points, Kobe-plot

- Harvest Control Rule, Future projection

Harvest Control Rule



Projection



(塗り:5-95%予測区間, 太い実線: 平均値, 細い実線: シミュレーションの1例)

Reviewers Comments

- For Appendix 8, if the idea is to provide projections for the case where the stock is going into a high period, why not use SRR from the high period and resampling of the recruitment residuals of the high period (maybe with some periodicity to switch to the low period at some point in time) rather than the 2000-2014 period? How different would the results be?
- It was a little bit difficult to compare the projections from base case vs Appendix 8. Please show a quick comparison?
- Was uncertainty in the terminal year N-at-age of the VPA considered?

Responses

- Comments on Appendix 8 is for Pacific Stock, the stock level and SRR for Tsushima stock is low and normal, respectively. Then, we will follow the projections of Pacific stock when the stock and SRR for Tshushima stock is high and high, respectively.
- The calculation of terminal year N at age is deterministic, we will conduct another scenario by next full stock assessment as well as possible.

Projection; probability

Probability (%) of future SSB exceeding the target reference point

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.000	0	0	0	1	5	10	17	22	27	31	35	37	38	43	42
0.900	0	0	0	1	6	13	21	28	35	40	44	46	48	52	52
0.880	0	0	0	1	6	14	22	29	36	42	45	48	50	54	54
0.800	0	0	0	2	7	16	26	35	44	49	53	55	58	62	62
0.700	0	0	0	2	9	20	32	43	52	59	63	66	68	72	72
0.600	0	0	0	2	10	24	39	52	62	69	73	76	78	80	81
0.500	0	0	0	2	12	29	46	61	71	78	82	85	86	88	89
0.400	0	0	0	3	14	34	54	70	79	86	89	92	93	94	94
0.300	0	0	0	3	17	40	62	78	86	91	95	96	97	97	97
0.200	0	0	0	3	19	46	70	84	92	96	98	98	99	99	99
0.100	0	0	0	3	22	53	77	90	96	98	99	100	100	100	100
0.000	0	0	0	4	26	60	83	94	98	99	100	100	100	100	100
現状F	0	0	0	1	3	6	10	12	15	16	17	19	20	23	23

Probability (%) of future SSB exceeding the limit reference point

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.000	0	0	18	51	69	77	83	87	90	92	93	95	96	97	98
0.900	0	0	18	55	73	81	87	91	93	95	96	97	98	99	99
0.880	0	0	18	56	74	82	88	91	94	96	97	98	98	99	99
0.800	0	0	18	59	78	85	90	94	96	97	98	99	99	100	100
0.700	0	0	18	62	82	89	93	96	98	98	99	99	100	100	100
0.600	0	0	18	66	86	92	96	98	99	99	100	100	100	100	100
0.500	0	0	18	70	89	95	97	99	99	100	100	100	100	100	100
0.400	0	0	18	74	92	96	99	99	100	100	100	100	100	100	100
0.300	0	0	18	77	94	98	99	100	100	100	100	100	100	100	100
0.200	0	0	18	81	96	99	100	100	100	100	100	100	100	100	100
0.100	0	0	18	84	98	100	100	100	100	100	100	100	100	100	100
0.000	0	0	18	87	99	100	100	100	100	100	100	100	100	100	100
現状F	0	0	18	42	54	60	64	68	70	72	74	75	77	83	86

Projection; SSB and Catch

SSB（10^3ton）

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.000	194	240	286	335	399	458	515	560	601	631	654	669	684	722	718
0.900	194	240	286	342	416	487	555	610	659	694	719	737	752	788	783
0.880	194	240	286	344	419	493	563	620	671	707	733	751	766	801	796
0.800	194	240	286	350	434	517	599	664	721	761	790	808	824	857	851
0.700	194	240	286	357	453	551	647	724	789	834	866	885	901	930	924
0.600	194	240	286	365	473	586	699	788	863	913	948	968	984	1,010	1,004
0.500	194	240	286	373	495	625	755	859	943	999	1,037	1,058	1,075	1,100	1,093
0.400	194	240	286	382	517	667	816	936	1,031	1,094	1,135	1,158	1,176	1,202	1,195
0.300	194	240	286	390	541	711	882	1,019	1,127	1,198	1,244	1,271	1,291	1,320	1,314
0.200	194	240	286	399	566	759	954	1,110	1,233	1,313	1,367	1,398	1,422	1,459	1,453
0.100	194	240	286	408	593	811	1,031	1,210	1,350	1,443	1,506	1,545	1,574	1,624	1,619
0.000	194	240	286	417	621	866	1,115	1,319	1,480	1,589	1,666	1,715	1,752	1,824	1,820
現状F	194	240	286	314	353	386	417	441	464	482	496	506	516	559	566

Catch (10^3ton)

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.000	14	98	88	107	128	146	163	177	188	197	204	209	213	223	223
0.900	14	98	80	101	122	141	160	175	187	196	203	208	212	221	220
0.880	14	98	79	99	121	140	159	174	186	196	203	208	212	220	219
0.800	14	98	72	94	115	135	155	171	183	193	199	204	208	215	214
0.700	14	98	64	85	107	127	147	164	177	186	192	197	200	205	205
0.600	14	98	56	76	97	118	138	154	167	176	182	186	189	193	192
0.500	14	98	47	66	86	105	125	141	153	161	167	171	173	177	176
0.400	14	98	38	55	73	91	109	123	135	143	148	151	153	156	156
0.300	14	98	29	43	58	73	89	102	112	118	123	126	127	130	130
0.200	14	98	20	30	41	53	64	75	82	88	91	93	95	97	97
0.100	14	98	10	16	22	28	35	41	46	49	51	52	53	55	55
0.000	14	98	0	0	0	0	0	0	0	0	0	0	0	0	0
現状F	14	98	110	124	136	147	158	166	174	179	184	188	192	206	209