Trachurus japonicus

Tsushima Warm Current stock jack mackerel

Contents

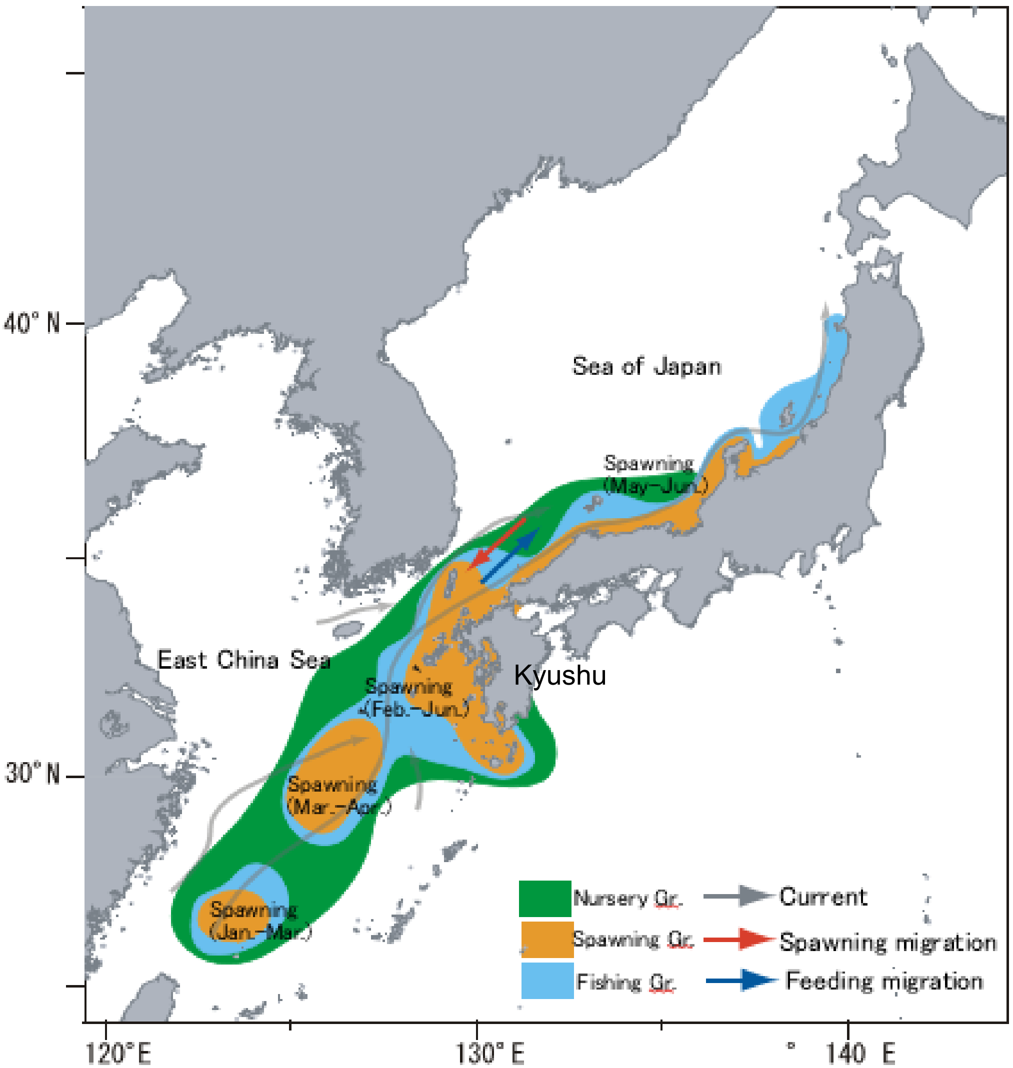
- Biology and Stock assessment
  Distribution, Growth, Estimation of Catch at Age, Stock abundance indices, VPA

- Stock-Recruitment Relationships

- Reference points, Kobe-plot

- Harvest Control Rule, Future projection

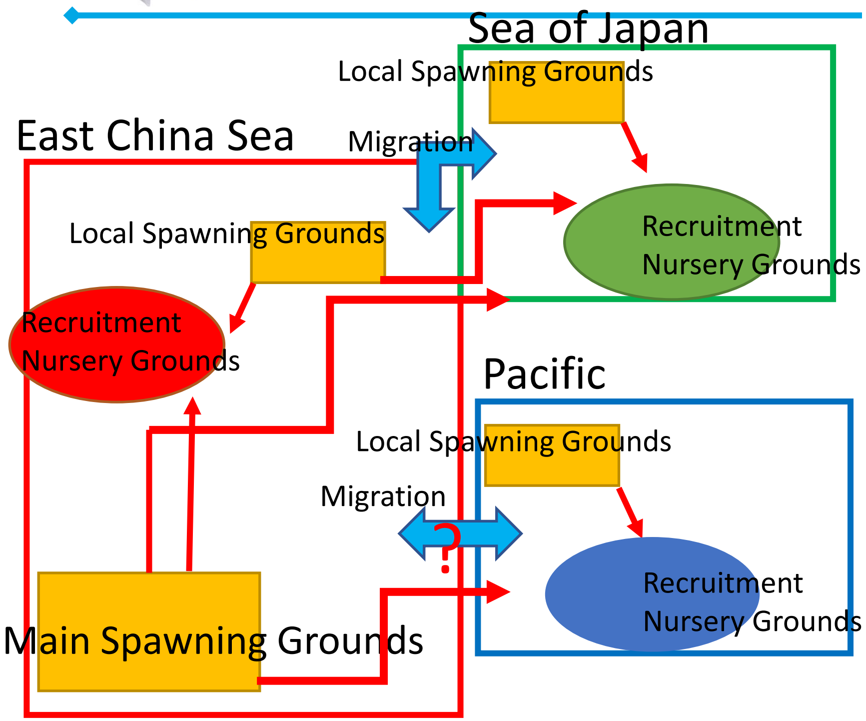
Distribution



Jack mackerel mainly distributes on the continental shelf region. The main fishing grounds are East China Sea and coastal areas off western Kyushu and Sea of Japan.

The spawning grounds are southern East China Sea area and coastal areas off Kyushu and Sea of Japan.

資源構造



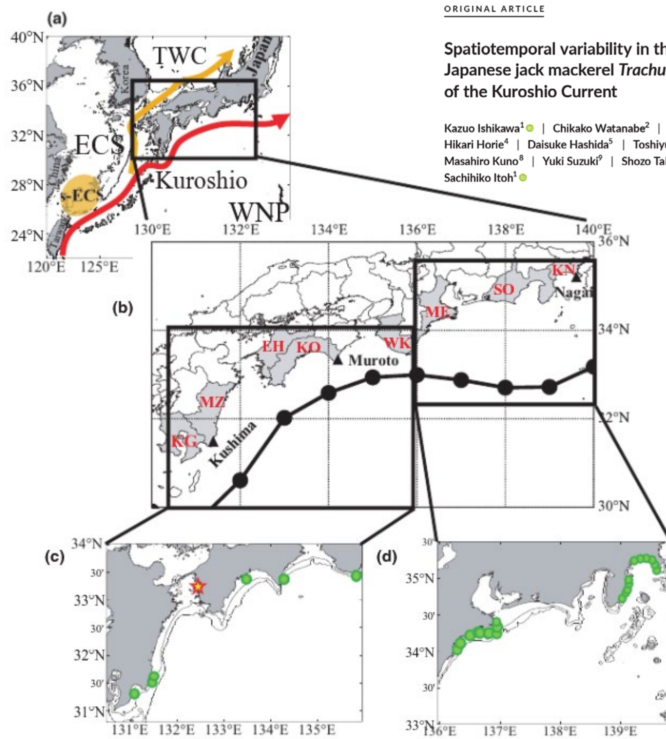
DOI: 10.1111/fog.12538

ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

Spatiotemporal variability in the occurrence of juvenile Japanese jack mackerel *Trachurus japonicus* along coastal areas of the Kuroshio Current

Kazuo Ishikawa[1] | Chikako Watanabe[2] | Takahiko Kameda[2] | Tsutomu Tokeshi[3] | Hikari Horie[4] | Daisuke Hashida[5] | Toshiyuki Ookawa[6] | Takashi Takeda[7] | Masahiro Kuno[8] | Yuki Suzuki[9] | Shozo Takamura[10] | Ryousuke Fukumoto[11] | Sachihiko Itoh[1]



- 1) Some research surveys and analyses have been conducted. Currently, Jack mackerel in the Pacific could be consisted of East China Sea (main spawning grounds) and Pacific (local spawning grounds). Also, in the Sea of Japan could be consisted of two spawning grounds.
- 1) Distribution of this species in the East China Sea and Sea of Japan is continuous and could be migrated among these areas. However, juvenile and adult fish cannot move from Pacific to East China Sea due to Kuroshio current, but its unclear.
- 2) The magnitude of recruitment from East China Sea to Pacific is unclear. Some works have been conducted.

レビューワーからの質問

- 中国、韓国の漁場がわかっているのであれば提示をしていただき、想定される影響を簡単にまとめていただきたい。漁場が日本側で取っているデータに近い場合どの年齢層の漁獲に影響があるか（定量的には無理だとしても定性的に）想定できるのではないか？

回答

- 中国の漁場は分かりません。今後、日中海洋生物専門家小委員会や科学者間の交流などで明らかにしていきたいと考えています。
- 韓国の漁場は日本とほぼ同じような海域と考えています。そのため、現状では日本と韓国の年齢組成は一緒と仮定しています。

Growth, Age-Length Key Estimation of CAA

Fish Sci (2014) 80:61–68
DOI 10.1007/s12562-013-0687-5

ORIGINAL ARTICLE

Age and maturation of jack mackerel *Trachurus japonicus* in the East China Sea

Mari Yoda · Tetsuro Shiraishi · Ryuji Yukami · Seiji Ohshimo

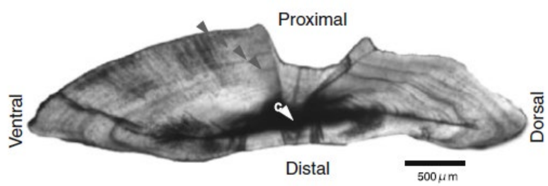


Fig. 2 Section of otolith of jack mackerel (*Trachurus japonicus*) with four ring marks. *Black arrows* Ring marks, *C* core

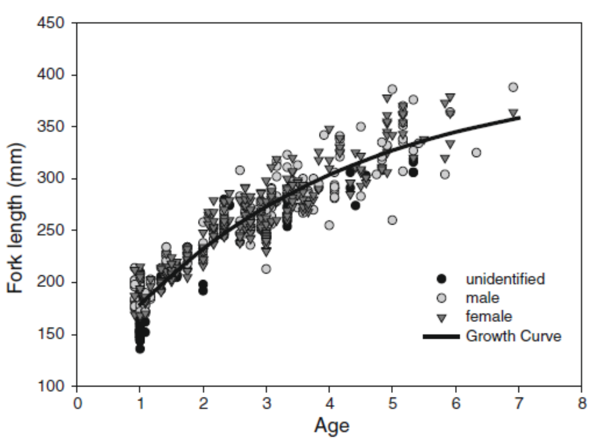


Fig. 4 von Bertalanffy growth curves fitted to observed fork length (*L*) and age (*t*) data for male (*gray circles*), female (*inverted triangles*), and unidentified (*black circles*) jack mackerel specimens

Offshore area

FL(cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0	0
2	1	1	1	1	0	0	0	0	0	0	0	0
3	1	1	1	1	0	0	0	0	0	0	0	0
4	1	1	1	1	0	0	0	0	0	0	0	0
5	1	1	1	1	0	0	0	0	0	0	0	0
6	1	1	1	1	0	0	0	0	0	0	0	0
7	1	1	1	1	0	0	0	0	0	0	0	0
8	1	1	1	1	0	0	0	0	0	0	0	0
9	1	1	1	1	0	0	0	0	0	0	0	0
10	1	1	1	1	0	0	0	0	0	0	0	0
11	1	1	1	1	1	0	0	0	0	0	0	0
12	1	1	1	1	1	0	0	0	0	0	0	0
13	1	1	1	1	1	1	0	0	0	0	0	0
14	1	1	1	1	1	1	0	0	0	0	0	0
15	1	1	1	1	1	1	1	0	0	0	0	0
16	1	1	1	1	1	1	1	1	0	0	0	0
17	1	1	1	1	1	1	1	1	1	0	0	0
18	1	1	1	1	1	1	1	1	1	1	0	0
19	2	2	2	1	1	1	1	1	1	1	1	1
20	2	2	2	2	1	1	1	1	1	1	1	1
21	2	2	2	2	2	1	1	1	1	1	1	1
22	2	2	2	2	2	2	1	1	1	1	1	1
23	2	2	2	2	2	2	2	1	1	1	1	1
24	2	2	2	2	2	2	2	2	1	1	1	1
25	2	2	2	2	2	2	2	2	2	1	1	1
26	3	3	3	2	2	2	2	2	2	2	2	2
27	3	3	3	3	3	2	2	2	2	2	2	2
28	3	3	3	3	3	3	3	2	2	2	2	2
29	3	3	3	3	3	3	3	3	2	2	2	2
30	3	3	3	3	3	3	3	3	3	2	2	2
31	3	3	3	3	3	3	3	3	3	3	3	3
32	3	3	3	3	3	3	3	3	3	3	3	3
33	3	3	3	3	3	3	3	3	3	3	3	3
34	3	3	3	3	3	3	3	3	3	3	3	3
35	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3
37	3	3	3	3	3	3	3	3	3	3	3	3
38	3	3	3	3	3	3	3	3	3	3	3	3
39	3	3	3	3	3	3	3	3	3	3	3	3

Coastal area: East China Sea and western part of Sea of Japan

FL(cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0	0
2	1	1	1	1	0	0	0	0	0	0	0	0
3	1	1	1	1	0	0	0	0	0	0	0	0
4	1	1	1	1	0	0	0	0	0	0	0	0
5	1	1	1	1	0	0	0	0	0	0	0	0
6	1	1	1	1	0	0	0	0	0	0	0	0
7	1	1	1	1	0	0	0	0	0	0	0	0
8	1	1	1	1	0	0	0	0	0	0	0	0
9	1	1	1	1	0	0	0	0	0	0	0	0
10	1	1	1	1	0	0	0	0	0	0	0	0
11	1	1	1	1	1	0	0	0	0	0	0	0
12	1	1	1	1	1	0	0	0	0	0	0	0
13	1	1	1	1	1	1	0	0	0	0	0	0
14	1	1	1	1	1	1	0	0	0	0	0	0
15	1	1	1	1	1	1	1	0	0	0	0	0
16	1	1	1	1	1	1	1	1	0	0	0	0
17	1	1	1	1	1	1	1	1	1	0	0	0
18	1	1	1	1	1	1	1	1	1	1	0	0
19	2	2	2	1	1	1	1	1	1	1	1	1
20	2	2	2	2	1	1	1	1	1	1	1	1
21	2	2	2	2	2	1	1	1	1	1	1	1
22	2	2	2	2	2	2	1	1	1	1	1	1
23	2	2	2	2	2	2	2	1	1	1	1	1
24	2	2	2	2	2	2	2	2	1	1	1	1
25	2	2	2	2	2	2	2	2	2	1	1	1
26	3	3	3	2	2	2	2	2	2	2	2	2
27	3	3	3	3	3	2	2	2	2	2	2	2
28	3	3	3	3	3	3	3	2	2	2	2	2
29	3	3	3	3	3	3	3	3	2	2	2	2
30	3	3	3	3	3	3	3	3	3	2	2	2
31	3	3	3	3	3	3	3	3	3	3	3	3
32	3	3	3	3	3	3	3	3	3	3	3	3
33	3	3	3	3	3	3	3	3	3	3	3	3
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36	3	3	3	3	3	3	3	3	3	3	3	3
37	3	3	3	3	3	3	3	3	3	3	3	3
38	3	3	3	3	3	3	3	3	3	3	3	3
39	3	3	3	3	3	3	3	3	3	3	3	3

Coastal area: Northern part of Sea of Japan

FL(cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0	0
2	1	1	1	1	0	0	0	0	0	0	0	0
3	1	1	1	1	0	0	0	0	0	0	0	0
4	1	1	1	1	0	0	0	0	0	0	0	0
5	1	1	1	1	0	0	0	0	0	0	0	0
6	1	1	1	1	0	0	0	0	0	0	0	0
7	1	1	1	1	0	0	0	0	0	0	0	0
8	1	1	1	1	1	1	0	0	0	0	0	0
9	1	1	1	1	1	1	0	0	0	0	0	0
10	1	1	1	1	1	1	0	0	0	0	0	0
11	1	1	1	1	1	1	0	0	0	0	0	0
12	1	1	1	1	1	1	0	0	0	0	0	0
13	1	1	1	1	1	1	1	0	0	0	0	0
14	1	1	1	1	1	1	1	1	0	0	0	0
15	1	1	1	1	1	1	1	1	1	0	0	0
16	2	2	2	1	1	1	1	1	1	1	1	1
17	2	2	2	2	1	1	1	1	1	1	1	1
18	2	2	2	2	2	2	1	1	1	1	1	1
19	2	2	2	2	2	2	2	1	1	1	1	1
20	2	2	2	2	2	2	2	2	1	1	1	1
21	2	2	2	2	2	2	2	2	2	2	2	2
22	3	3	2	2	2	2	2	2	2	2	2	2
23	3	3	3	2	2	2	2	2	2	2	2	2
24	3	3	3	3	2	2	2	2	2	2	2	2
25	3	3	3	3	3	3	2	2	2	2	2	2
26	3	3	3	3	3	3	3	2	2	2	2	2
27	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3
29	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3
31	3	3	3	3	3	3	3	3	3	3	3	3
32	3	3	3	3	3	3	3	3	3	3	3	3
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36	3	3	3	3	3	3	3	3	3	3	3	3
37	3	3	3	3	3	3	3	3	3	3	3	3
38	3	3	3	3	3	3	3	3	3	3	3	3
39	3	3	3	3	3	3	3	3	3	3	3	3

Please see the document “Estimating procedure of catch number at age of jack mackerel (*Trachurus japonicus*) in the Sea of Japan and East China Sea”

Response to comment no20.

Nearshore area: Kyushu-West&Central Sea of Japan

FL(cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0	0	0
4	0	0	0	0	2	52	6	19	1	0	0	0
5	0	0	0	0	20	289	40	47	15	1	1	0
6	1	7	13	2	40	190	128	114	69	9	1	0
7	1	84	108	32	73	33	367	314	247	146	15	0
8	2	102	167	74	35	7	346	378	325	294	144	11
9	8	31	169	204	117	6	854	1283	736	287	342	93
10	42	16	83	189	171	2	316	281	193	278	261	237
11	108	2	42	73	179	28	540	610	245	186	141	329
12	209	2	11	35	173	48	368	519	248	347	235	196
13	367	16	66	53	56	41	218	125	469	587	266	134
14	281	141	115	170	64	51	87	22	434	303	352	341
15	168	269	89	204	129	87	13	26	127	83	230	421
16	278	220	202	147	237	165	67	111	77	100	160	224
17	295	363	178	218	406	403	133	245	114	106	114	178
18	172	311	167	146	352	417	229	441	231	195	113	139
19	140	212	242	187	310	381	298	317	273	276	206	162
20	174	206	252	138	285	368	248	160	214	261	239	215
21	290	247	203	139	171	193	206	151	143	141	179	247
22	285	183	126	115	152	90	181	207	104	63	148	237
23	131	70	81	57	151	43	119	312	161	80	116	215
24	45	65	51	35	122	63	84	286	158	119	156	173
25	26	83	35	40	89	76	61	166	118	137	154	124
26	41	58	43	56	94	62	72	91	94	149	192	97
27	20	59	36	49	115	50	75	62	94	176	133	97
28	19	45	51	9	114	44	67	40	77	125	64	114
29	14	40	30	7	106	83	53	21	22	78	13	71
30	11	15	19	0	89	120	39	25	10	52	10	31
31	6	3	14	1	65	123	43	13	1	42	23	41
32	0	0	8	1	58	88	26	13	3	23	23	33
33	1	0	20	7	81	51	23	11	4	15	10	34
34	1	0	19	7	71	25	25	7	7	8	8	46
35	0	0	19	9	54	14	27	2	2	3	3	36
36	0	2	13	4	34	5	20	1	0	1	1	27
37	0	3	5	1	28	1	9	0	1	0	0	10
38	0	0	4	4	15	2	9	0	0	0	1	3
39	0	3	2	0	14	0	1	0	0	0	0	4

Nearshore area: North Sea of Japan

FL(cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	3	0	0	0	0
6	0	0	0	0	0	0	4	53	17	0	0	0
7	0	0	0	0	0	0	43	141	69	0	0	0
8	0	0	0	0	0	0	83	248	67	5	0	0
9	0	0	0	0	0	0	60	228	232	69	12	4
10	0	0	0	0	1	0	7	92	278	192	91	47
11	0	1	6	0	0	0	2	23	118	177	193	60
12	4	6	21	6	6	0	0	0	15	111	264	53
13	39	69	77	46	29	2	1	0	2	53	134	86
14	76	104	91	106	111	11	11	12	6	14	53	95
15	52	51	23	112	113	63	82	88	22	16	18	24
16	29	13	19	66	65	120	228	182	92	42	63	5
17	12	17	30	46	76	126	283	232	214	122	160	25
18	16	42	38	39	62	118	149	148	140	164	214	64
19	18	41	29	48	72	141	68	66	47	123	182	48
20	32	52	17	97	107	156	69	35	33	56	142	44
21	45	31	0	86	119	151	105	11	10	27	150	35
22	39	16	0	53	96	116	122	13	14	21	128	75
23	8	10	0	39	78	73	103	15	14	36	121	72
24	4	5	0	33	70	68	51	5	5	34	111	90
25	1	3	0	32	69	43	32	4	4	20	121	105
26	0	3	0	22	47	34	12	1	17	13	159	90
27	0	5	0	13	31	19	8	1	15	4	121	47
28	0	3	0	6	36	9	6	1	18	5	42	10
29	0	1	0	0	20	3	8	0	8	3	23	5
30	0	0	0	1	11	3	10	0	2	6	6	0
31	0	0	0	0	3	2	17	0	0	2	5	0
32	0	0	0	0	3	2	14	0	0	0	0	0
33	0	0	0	0	2	0	10	0	0	0	1	1
34	0	0	0	0	0	0	5	0	0	0	0	0
35	0	0	0	0	0	0	3	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	2	0	0	0	0	0
38	0	0	0	0	0	0	2	0	0	0	0	0
39	0	0	0	0	0	0	1	0	0	1	0	0

- 20) This figures overlapped ALKs and measured size frequencies in 2019. The ALK at two areas are slightly different. The side bars represents size distributions of jack mackerel in each area in 2019.

Maturation

Fish Sci (2014) 80:61–68
DOI 10.1007/s12562-013-0687-5

ORIGINAL ARTICLE

Age and maturation of jack mackerel *Trachurus japonicus* in the East China Sea

Mari Yoda · Tetsuro Shiraishi · Ryuji Yukami · Seiji Ohshimo

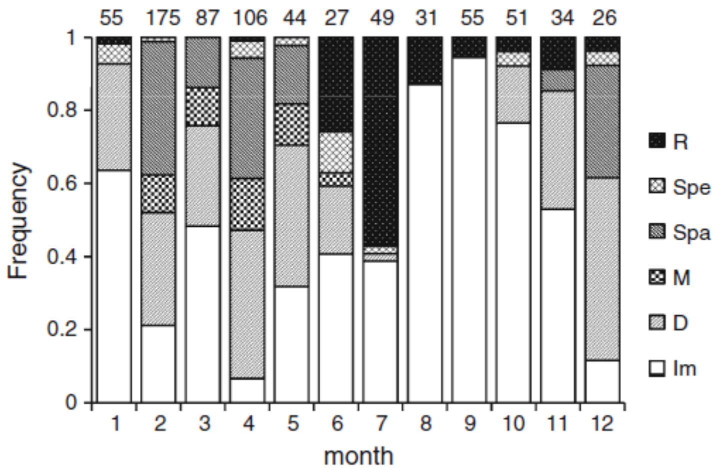
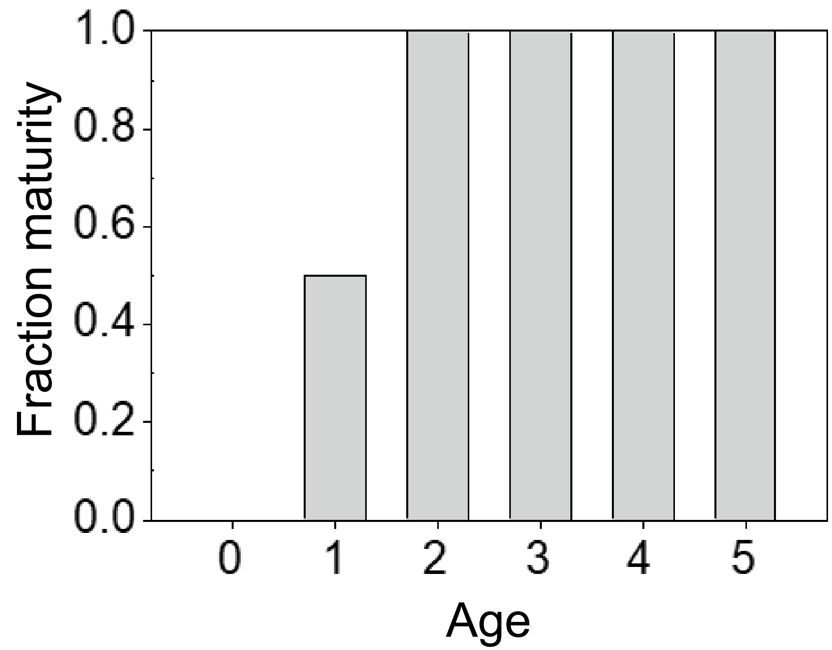


Fig. 6 Monthly changes in the frequency of occurrence of various maturity stages of ovaries of jack mackerel. *D* Developing stage, *Im* immature stage, *M* mature stage, *R* resting stage, *Spa* spawning stage, *Spe* spent stage



FRA samples small pelagic fish species every year, and analyzes maturation characteristics based on histological methods of small pelagic fish.

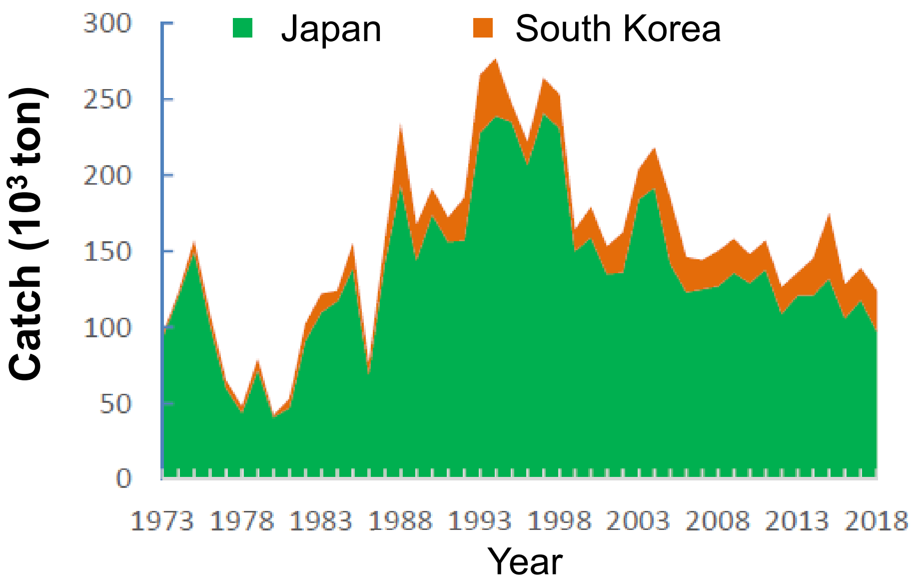
レビューワーからの質問

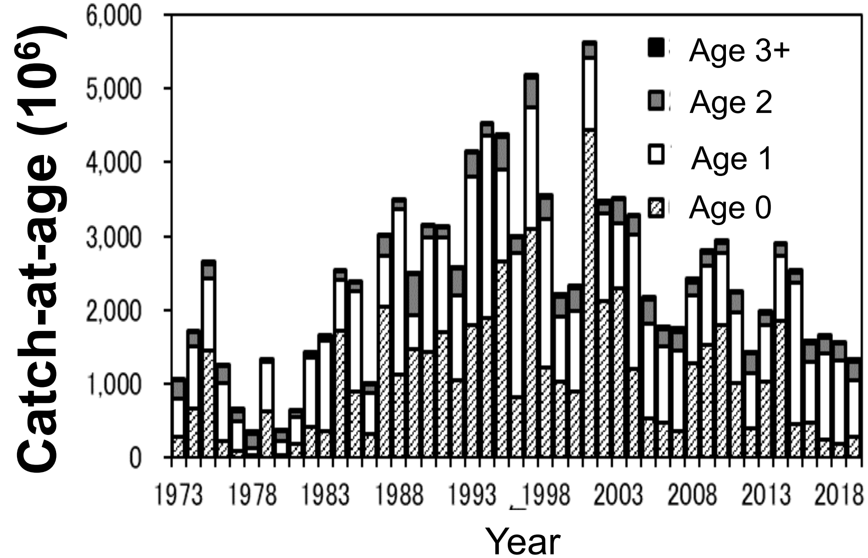
- 生物学的特性に関して現在未解明な点の整理と今後の調査予定はあるか。特に自然死亡係数に関する調査予定

回答

- 成長や成熟に海域間差があると想定されるため、特に日本海西部のサンプルを中心に解析を進めています。
- 太平洋側と協力し、マアジの資源構造に関する調査研究を推進しています。
- 自然死亡係数（M)について、マアジだけではなく他の魚種にも関係するため機構全体での協議が必要だと考えています。もし、調査でMが推定できるのであれば教えていただけたら助かります。

Catch and Catch-at-age





Jack mackerel is exploited mainly by Japanese and Korean fisheries in the East China Sea and Sea of Japan. Age 0 and 1 fish are mainly caught.

Procedures of tuned VPA

Fundamental part

$$N_{a+1,y+1} = N_{a,y} \exp(-F_{a,y} - M)$$

$$F_a^{new} = \ln\left\{1 + \frac{C_a}{N_{a+1}} \exp(-M) \frac{F_a + M}{F_a} \frac{1-\exp(-F_a)}{1-\exp(-F_a - M)}\right\}$$

$$F_{3+,y} = \alpha F_{2,y}$$

N:Stock number, a: age, y: year, F: fishing mortality

M: natural mortality 0.5/year, α : coefficient (0.3)

Tuning part

$$-\ln L = \sum_k \sum_y \left[\frac{\left[\ln I_{k,y} - \left(b_k \ln N_{k,y} + \ln q_k\right)\right]^2}{2{\sigma_k}^2} - \ln\left(\frac{1}{\sqrt{2\pi}\sigma_k}\right)\right]$$

$$I = q_k {N_{k,y}}^{b_k}$$

N:Stock number, I:abundance index

y: year

レビューワーからの質問

- 他の多様なモデルについても検討してみる可能性があるかどうか。

回答

- 外国人レビューワーからも指摘をされていますが、SCAAなど年齢構造に誤差があるようなモデルを検討したいと考えています。
- 調査船調査のCPUE標準化やチューニング過程における計算過程についても検討を進めてまいります。

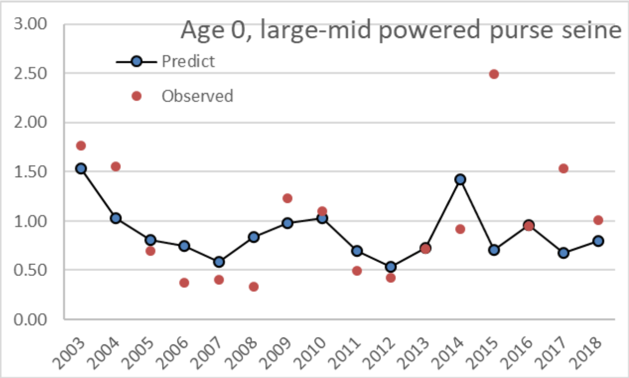
レビューワーからの質問

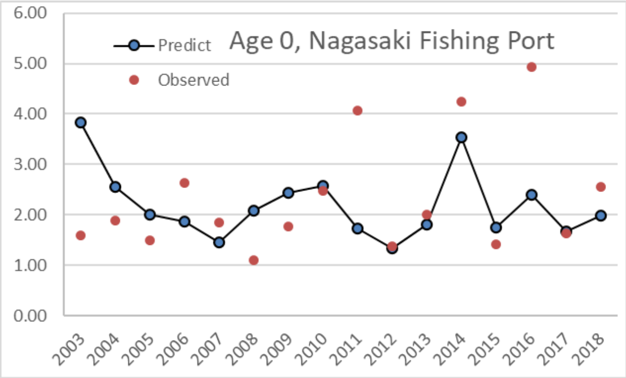
- 1歳魚資源量指標値として用いられる大中まき，島根中まき，着底トロールの指標値（図4-3）で，両まき網では比較的同調した傾向を示していますが，着底トロールの傾向が両漁法と異なっているように見えます（例えば2003-2004年，2008年2013年あたり）。この要因は何かありますでしょうか。
- また，これらをVPAのチューニング指数として用いておりますが，推定された資源変動をより強く反映している指標値はどの値でしょうか。または年代ごとに影響の強さが変化していますでしょうか。

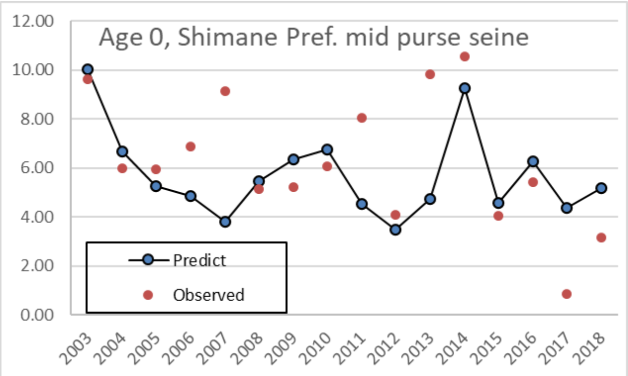
回答

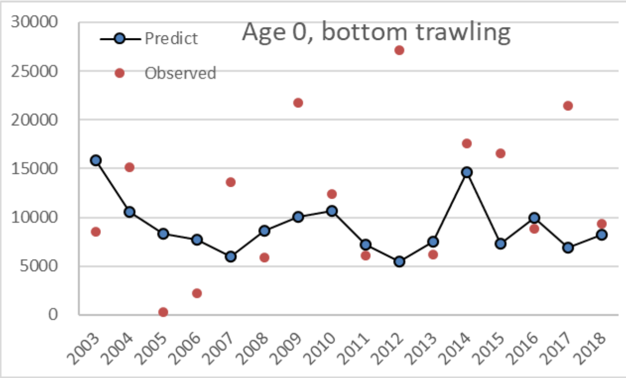
- 明確には分かりませんが、まき網が同調しているのは現状の主漁場である対馬海峡から日本海西部の資源動態を表しているのかもしれません。
- チューニング指数として用いていますが、分散の大きさで重みづけをしてフィッティングしています。分散が大きい場合には重みづけを小さくしています。

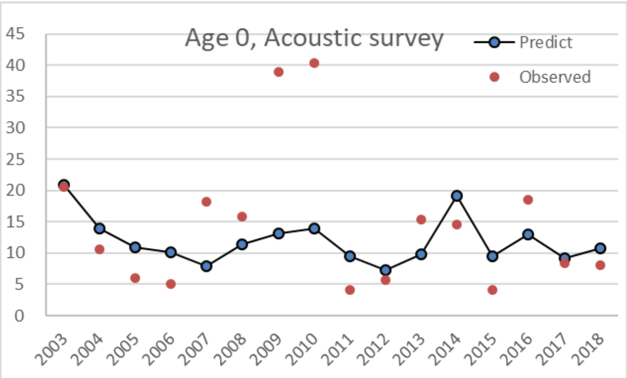
Abundance indices: Age 0

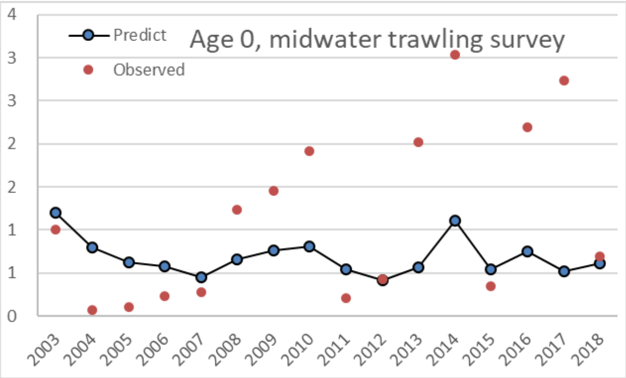




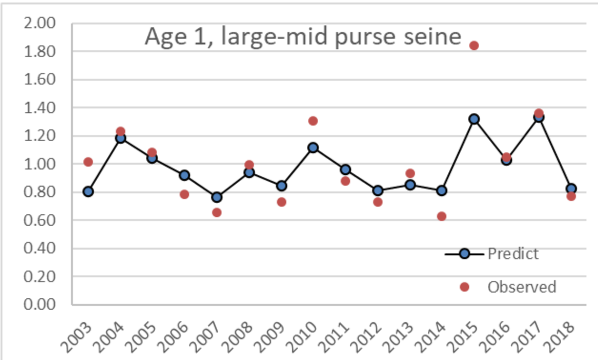


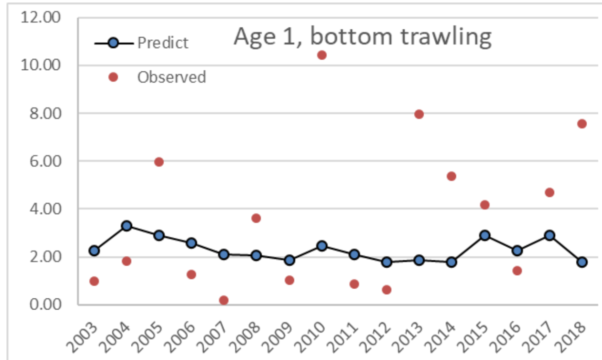


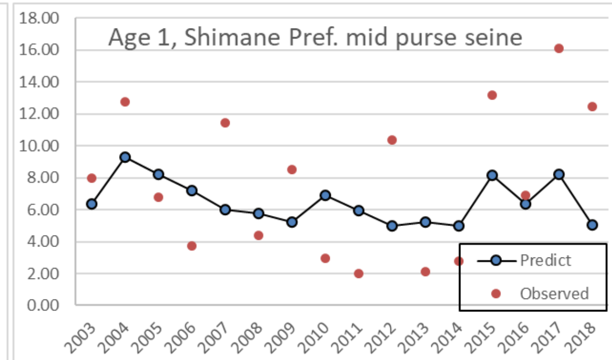


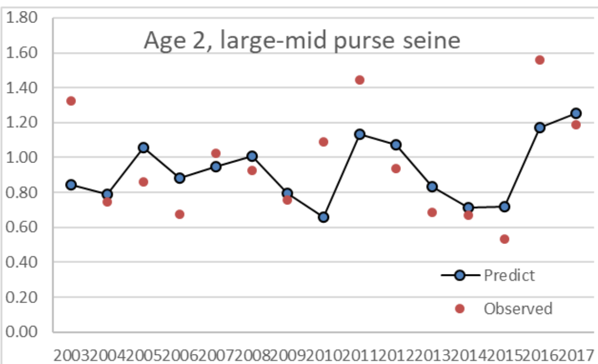


Abundance indices: Age 1,2 and 3+

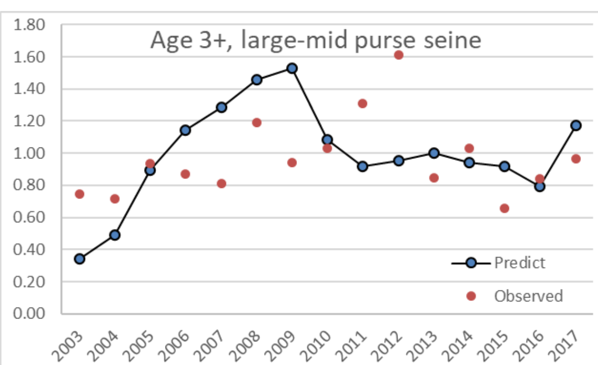




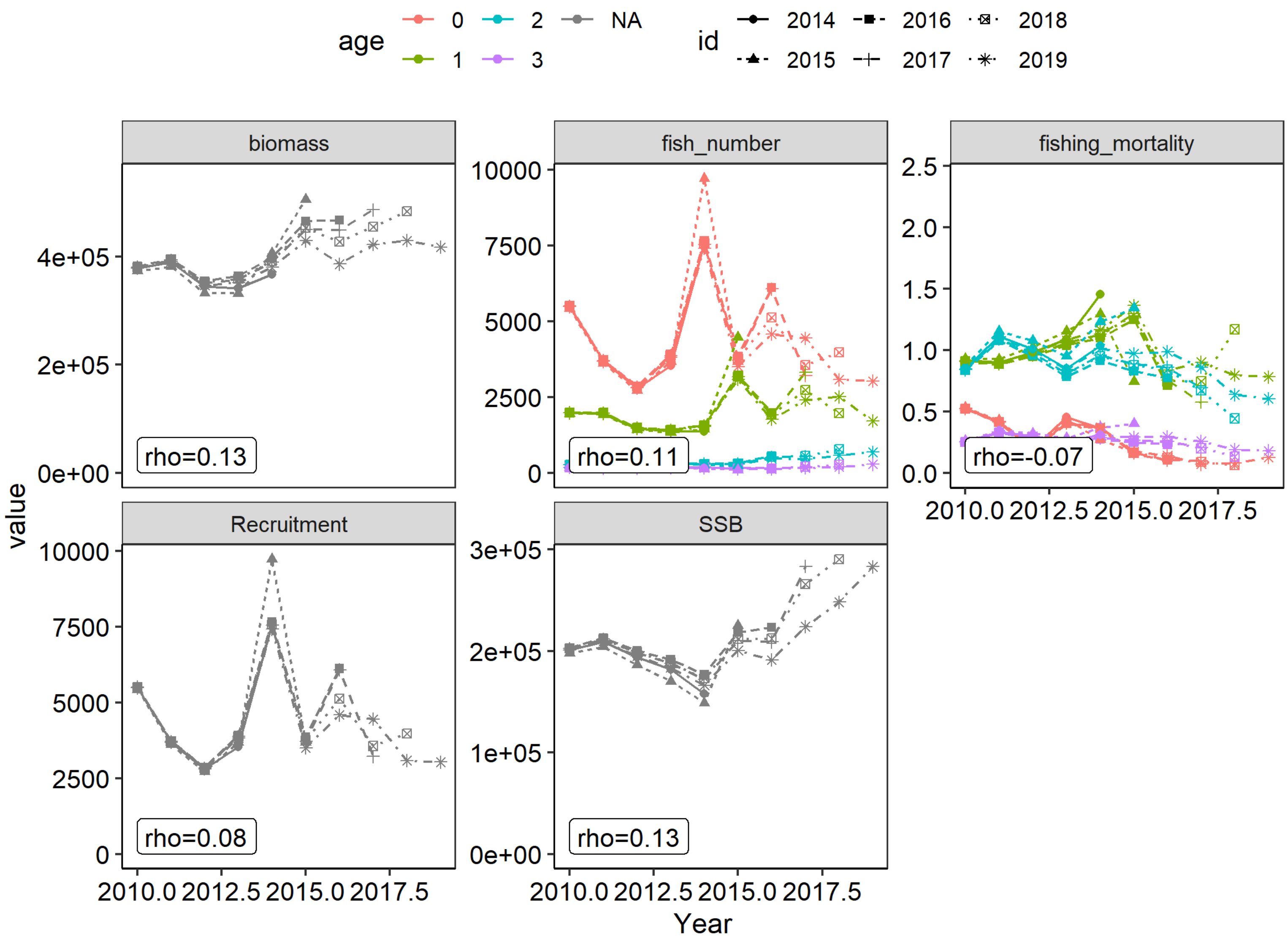




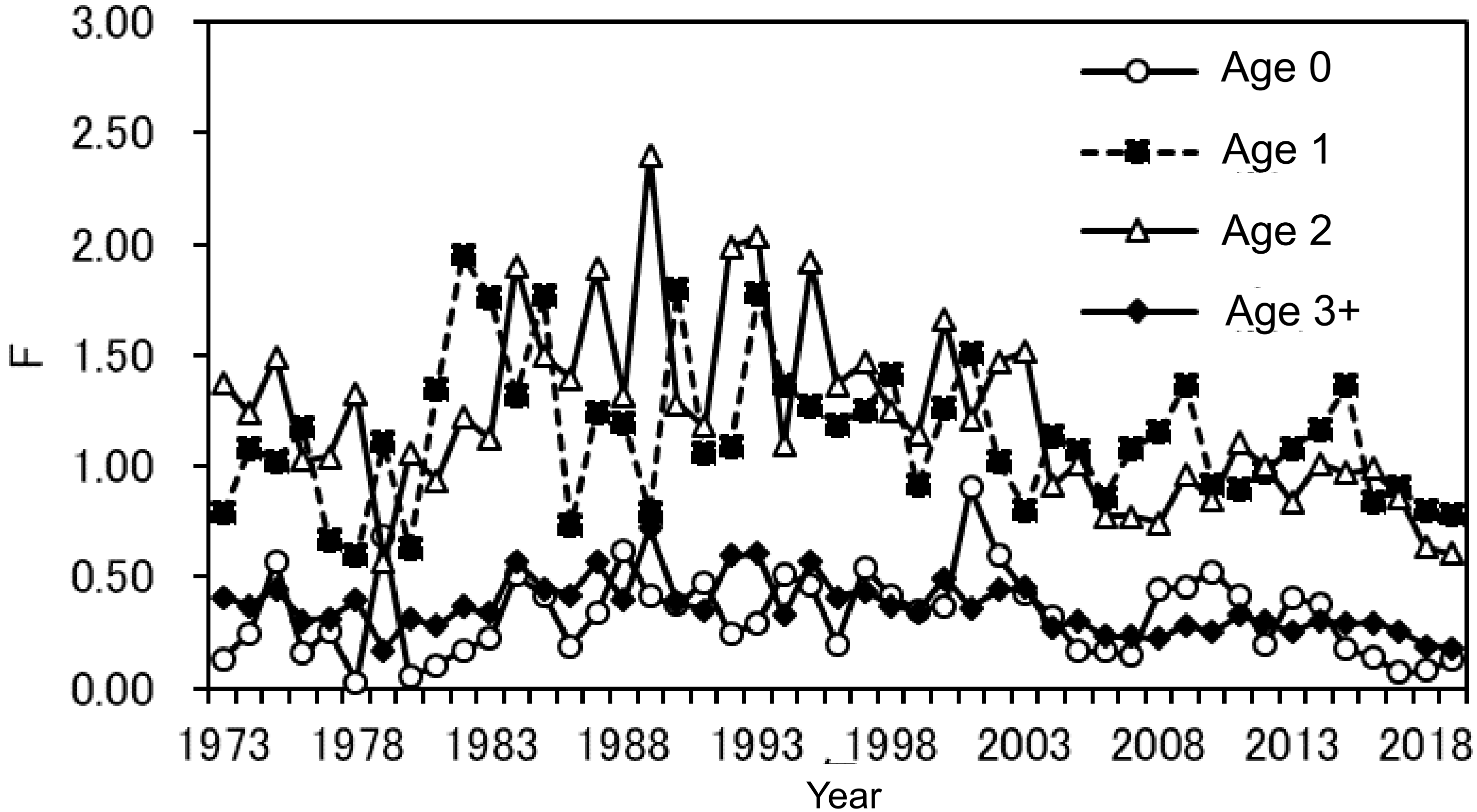
There are six abundance indices for age 0, three for age 1, and one index for age 2 and 3+.



Retrospective analysis

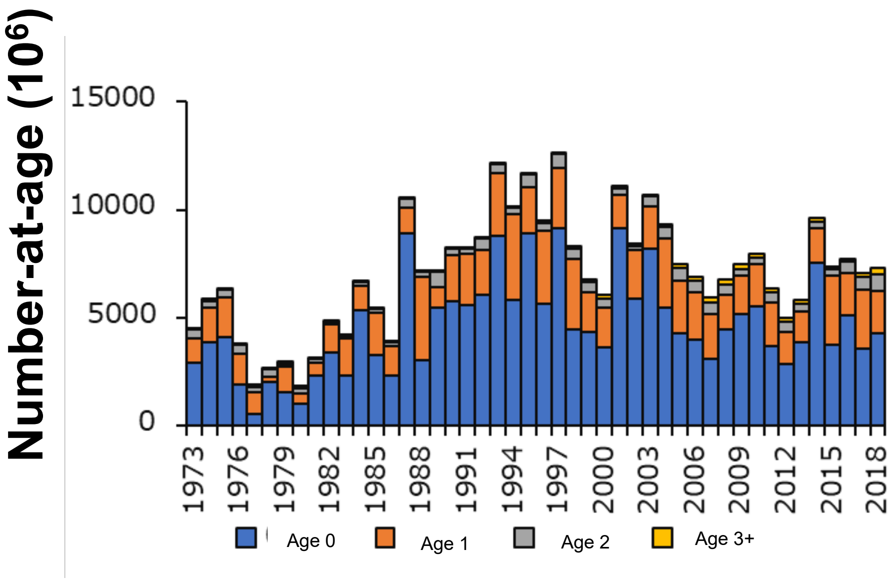


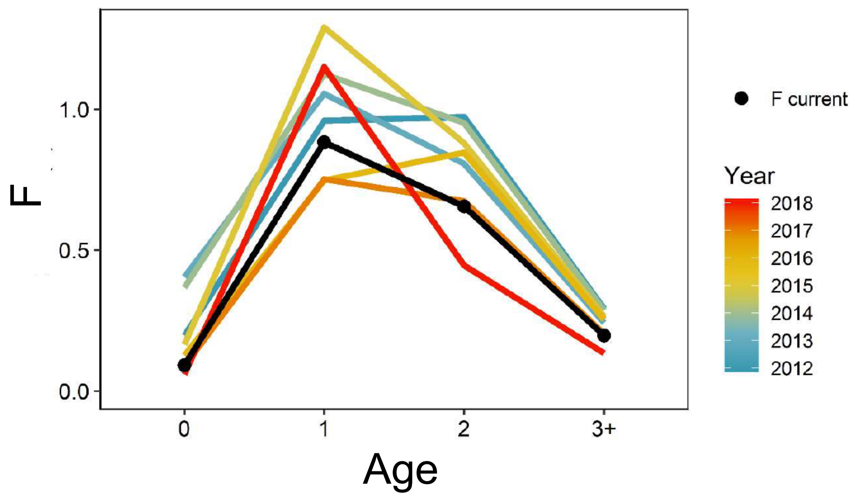
Fishing mortality at age



Fishing mortality in the 1980s was relatively higher than those of the other year periods, and the fishing mortality has gradually decreased.

Number-at-age and selectivity





Age 0 and 1 fish were dominant, the total stock number of Jack mackerel was at a low level in the late 1970s and gradually increased until the mid-1990s. After the 1990s, the total stock number was almost stable with some fluctuations. Fishing mortality at each age (selectivity) was the highest at age 1.

レビューワーからの質問

- 1歳魚の漁獲が多いように見受けられるがMSYの漁獲圧の下でよりケアをしたほうが良い年齢については検討されているか。検討されているのであれば結果をご提示いただきたい。

回答

- 現状では検討をしていません。
- 本提案では現状の選択率で漁獲をした場合という仮定をおいています。仮に漁業者のほうで年齢別の獲り分けが可能で、現状よりも積極的に資源管理を推進することになれば検討するかもしれません。

Contents

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

Stock-Recruitment Relationship ：Evaluation

- Data set

1) SSB & Recruitment values (1973 – 2017)

These values in 2018 were removed because the most recent values have large uncertainties.

- Estimate parameters

1) Stock-Recruitment Relationship

a) Hockey-stick (HS), b) Ricker (RI), c) Beverton-Holt (BH)

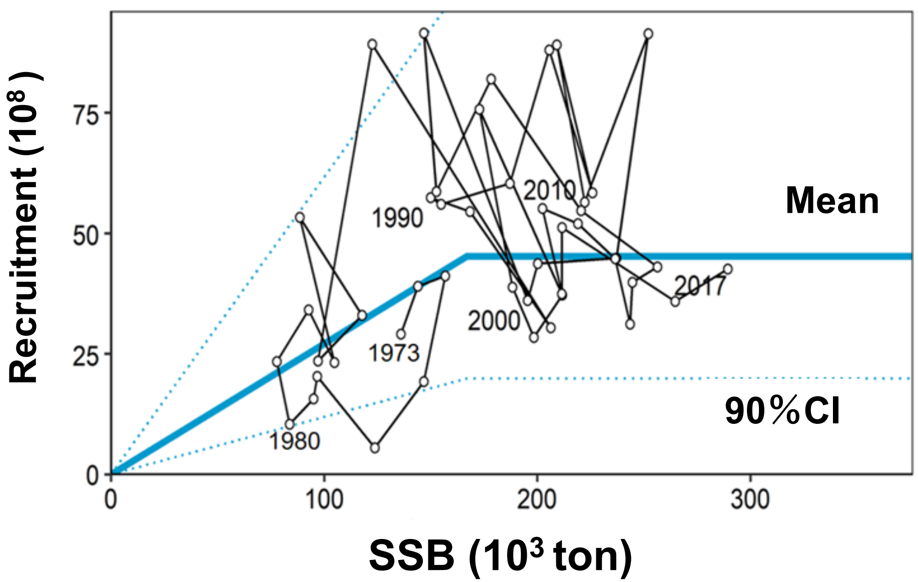
2) Optimization methods

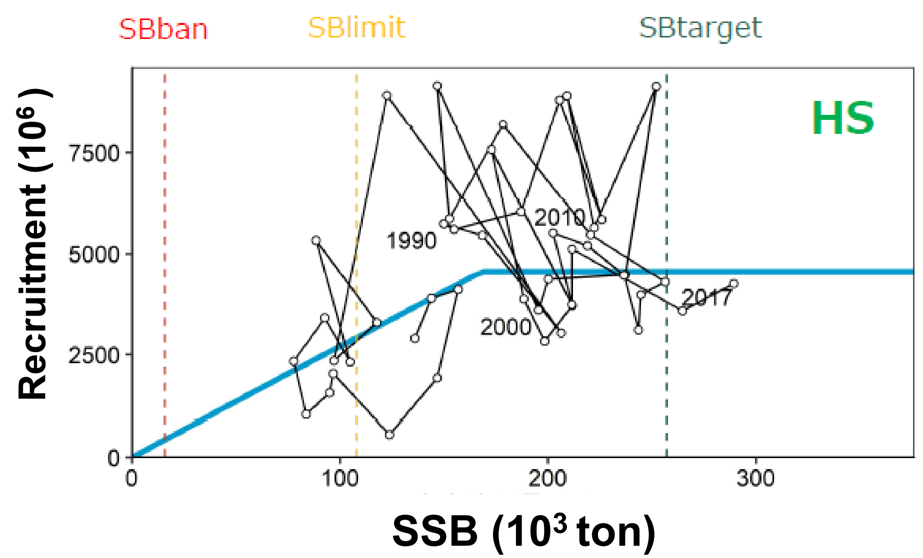
a) least absolute value method (L1), b) least square method (L2)

Stock-Recruitment Relationship ：Evaluation

S-R rel.	Optimization method	pars.a	pars.b	pars.sd	pars.rho	AICc	deltaAIC(AIC_AR - AIC_noAR).1	Autocorrelation
HS	L1	0.027093	166970.4	0.499608	0	65.32322	NA	No
HS	L1	0.027093	168005.9	0.4613	0.271831	65.32322	-1.5931	Two step
HS	L2	0.027191	177808.6	0.482606	0	68.71992	NA	No
HS	L2	0.027191	177808.6	0.462586	0.24513	68.71992	-0.89589	Two step
RI	L1	0.034523	1.77E-06	0.523826	0	69.58343	NA	No
RI	L1	0.034523	1.77E-06	0.475469	0.264324	69.58343	-1.35648	Two step
BH	L1	0.035437	2.25E-06	0.525529	0	69.87547	NA	No
BH	L1	0.035437	2.25E-06	0.477311	0.265162	69.87547	-1.37059	Two step
RI	L2	0.032705	1.66E-06	0.495151	0	71.02958	NA	No
RI	L2	0.032705	1.66E-06	0.474914	0.25716	71.02958	-1.17937	Two step
BH	L2	0.0329	2.00E-06	0.495904	0	71.16623	NA	No
BH	L2	0.0329	2.00E-06	0.476363	0.255109	71.16623	-1.12237	Two step

Stock-Recruitment Relationship ：Results





We selected HS (hockey-stick) relationships due to low AICc values. Based on this SR relationship, the SBtarget was calculated.

Contens

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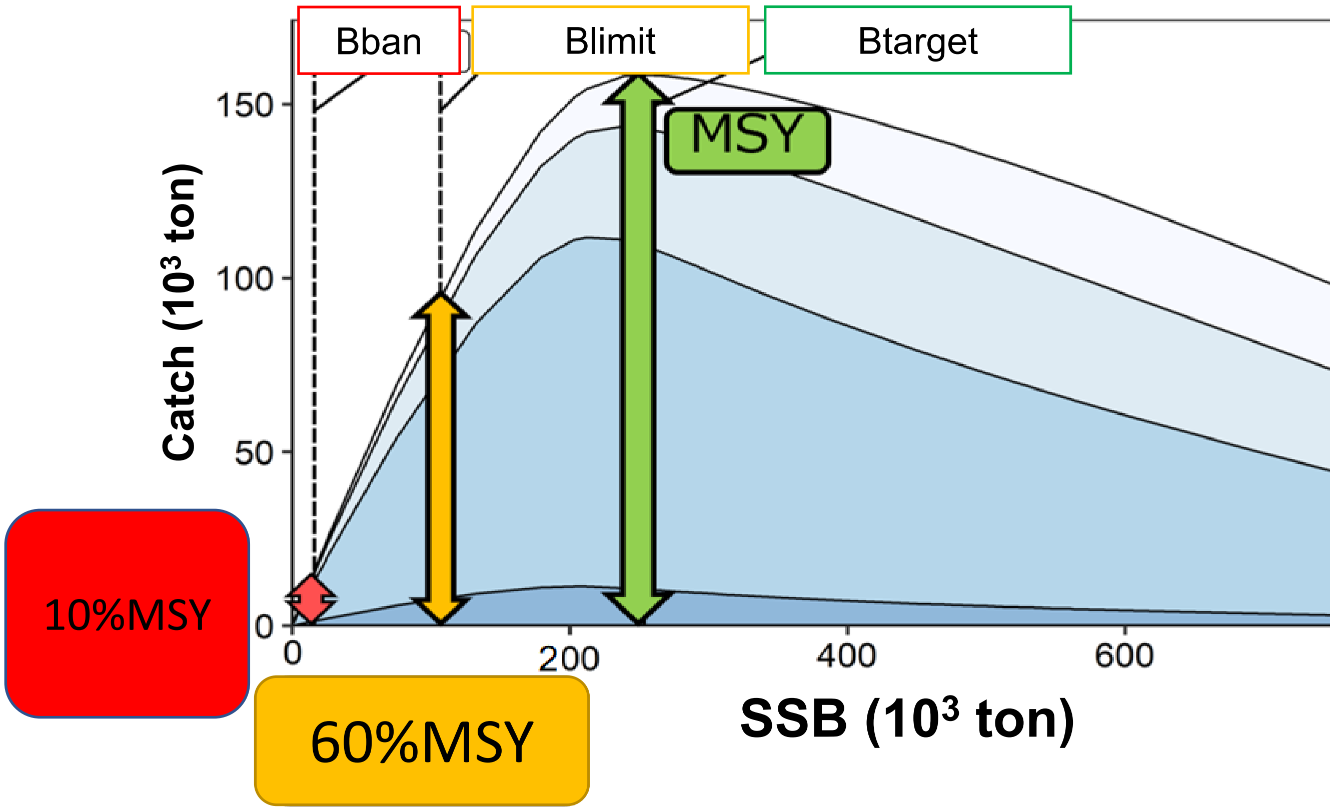
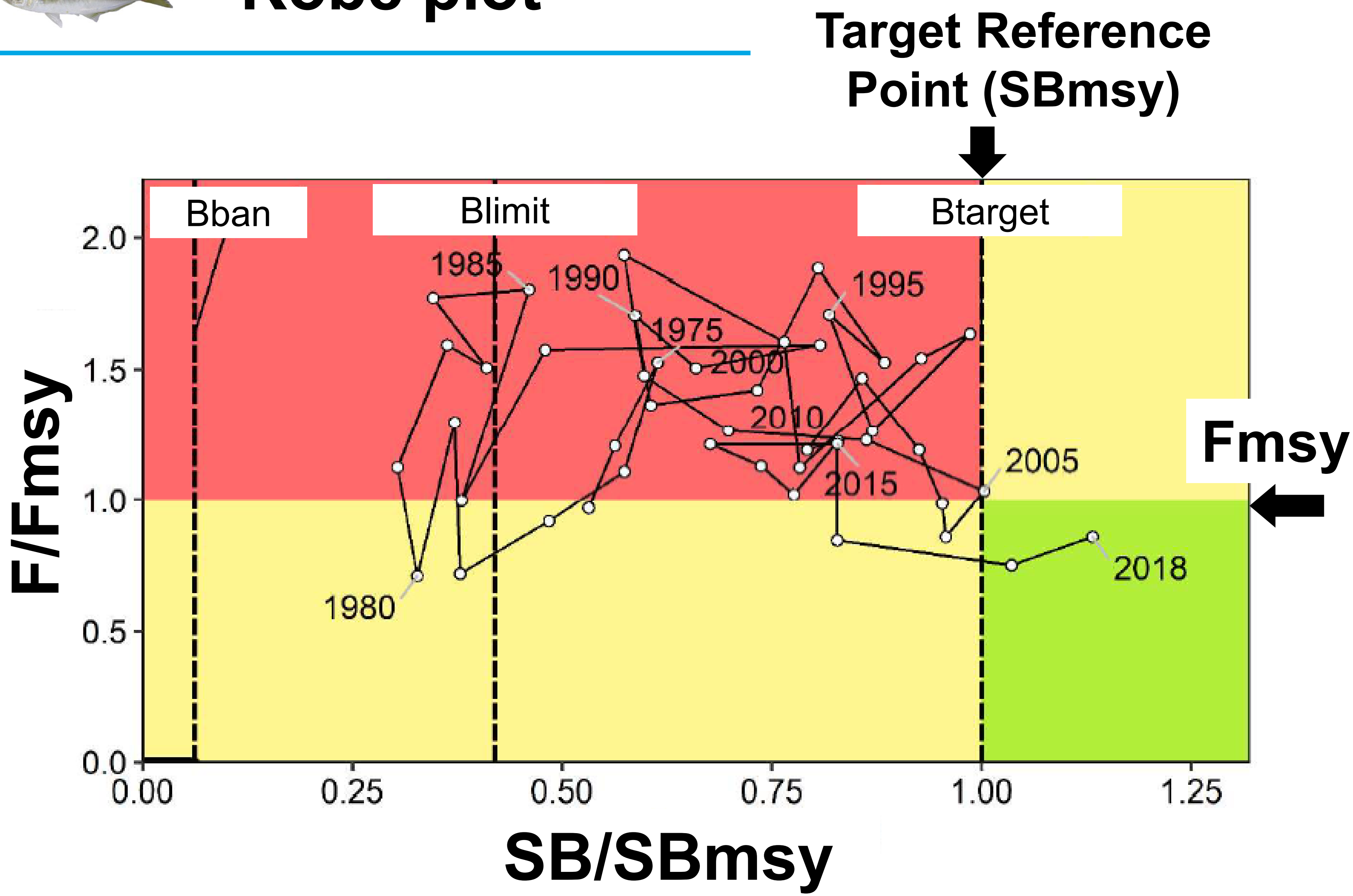
Reference Points



Reference Points	Expected Catch (10^3ton)	SSB (10^3ton)
B_{target} (SBmsy)	158	254
B_{limit}	95	107
B_{ban}	16	16

Kobe plot


Target Reference Point (SBmsy)
Bban
Blimit
Btarget
Fmsy
F/Fmsy
SB/SBmsy
2.0
1.5
1.0
0.5
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1975
1980
1985
1990
1995
2000
2005
2010
2015
2018

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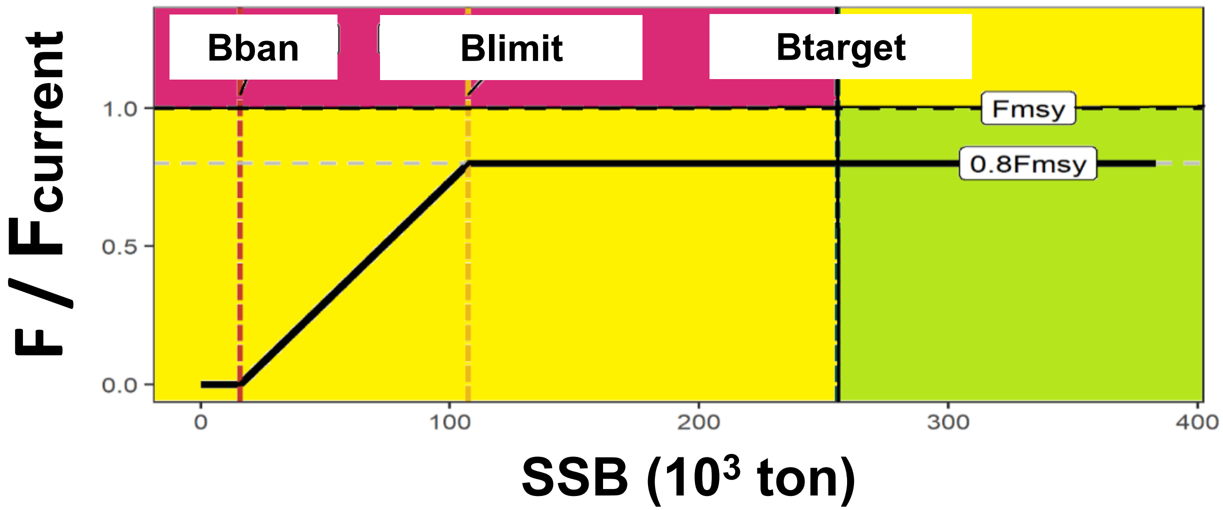
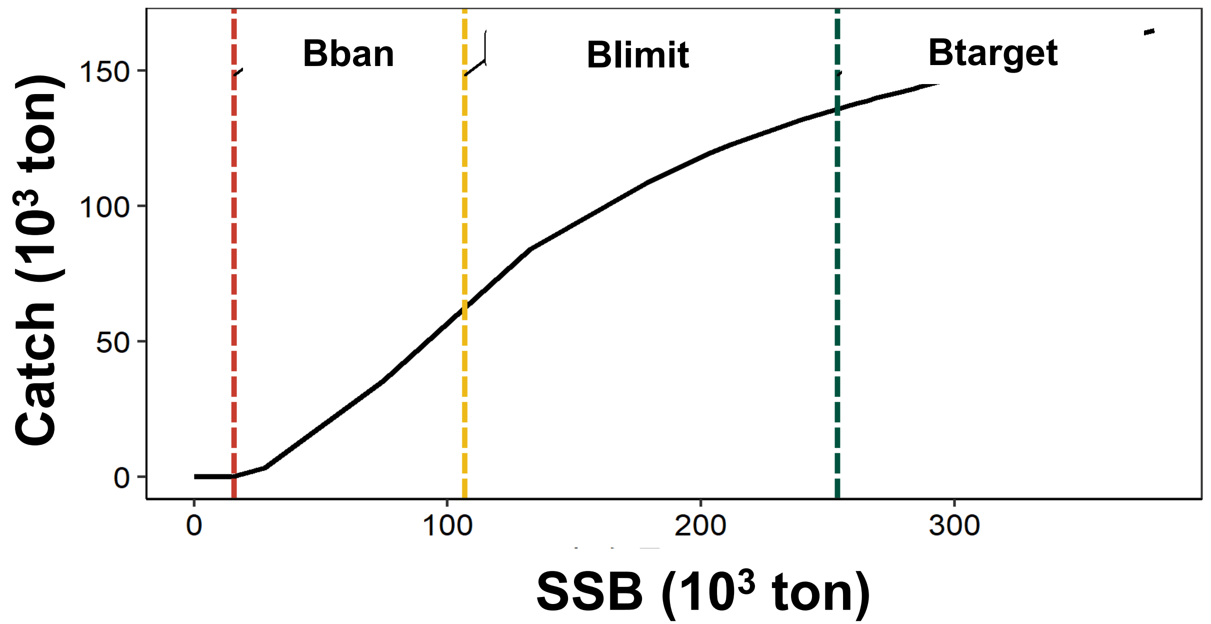
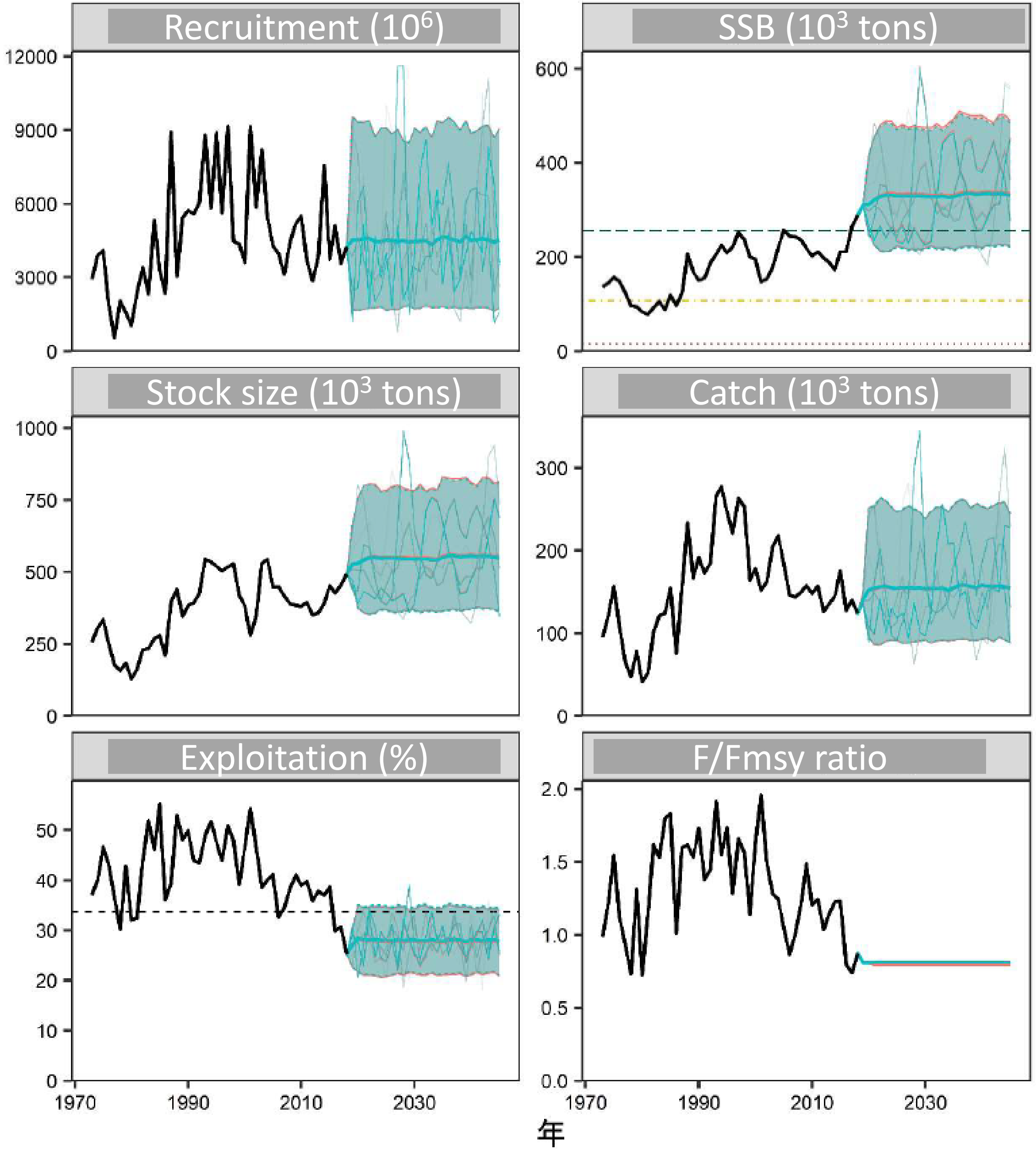
Harvest Control Rule





Future Projection: Graphs



Future 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
1.0	100	94	83	67	59	53	49	46	48	47	48	47	45	48	47
0.9	100	94	83	74	71	69	67	67	67	66	67	68	68	68	68
0.8	100	94	83	82	81	84	84	83	84	83	85	85	85	87	85
0.7	100	94	83	86	89	93	95	95	95	94	95	95	95	96	96
0.6	100	94	83	91	95	98	99	99	99	99	99	98	99	99	99
0.5	100	94	83	94	98	99	100	100	100	100	100	100	100	100	100
0.4	100	94	83	97	100	100	100	100	100	100	100	100	100	100	100
0.3	100	94	83	98	100	100	100	100	100	100	100	100	100	100	100
0.2	100	94	83	99	100	100	100	100	100	100	100	100	100	100	100
0.1	100	94	83	100	100	100	100	100	100	100	100	100	100	100	100
0.0	100	94	83	100	100	100	100	100	100	100	100	100	100	100	100

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
1.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.9	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.6	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Future Projection: SSB and Catch

SSB（10^3ton）

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.0	311	311	321	294	279	268	262	260	259	258	257	256	256	261	263
0.9	311	311	321	311	305	299	295	294	293	293	292	291	291	296	298
0.8	311	311	321	329	335	335	334	334	334	334	334	333	332	338	340
0.7	311	311	321	349	369	377	380	382	383	383	383	382	382	389	390
0.6	311	311	321	371	409	428	435	440	442	443	444	443	443	451	452
0.5	311	311	321	395	455	487	502	510	515	517	518	518	517	527	528
0.4	311	311	321	421	509	558	583	595	603	607	609	610	609	621	621
0.3	311	311	321	450	571	643	680	700	712	719	722	723	723	737	737
0.2	311	311	321	482	643	743	798	827	845	856	862	864	864	881	881
0.1	311	311	321	516	727	864	941	983	1,010	1,026	1,035	1,039	1,041	1,061	1,061
0	311	311	321	554	826	1,009	1,115	1,174	1,213	1,237	1,250	1,257	1,261	1,287	1,286

Catch (10^3ton)

β	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2041	2051
1.0	141	152	179	169	166	161	160	160	160	159	159	158	158	161	164
0.9	141	152	167	163	162	159	157	158	158	157	158	157	157	160	162
0.8	141	152	153	156	157	155	154	155	155	154	154	154	154	157	159
0.7	141	152	139	147	150	149	149	150	150	149	150	149	149	152	154
0.6	141	152	123	136	141	141	141	143	143	142	143	142	142	145	147
0.5	141	152	107	123	129	131	131	133	133	133	133	133	133	135	137
0.4	141	152	89	107	114	117	118	119	120	120	120	120	120	122	124
0.3	141	152	69	87	95	98	100	101	102	102	102	102	102	104	105
0.2	141	152	48	63	71	74	75	77	78	78	78	78	78	79	80
0.1	141	152	25	35	40	42	43	44	44	45	45	45	45	46	46
0	141	152	0	0	0	0	0	0	0	0	0	0	0	0	0