Stock assessment of Blue Mackerel East China Sea stock (2019)

Responsible Institute: National Research Institute of Fisheries Science,
Saikai National Fisheries Research Institute

Summary

The stock biomass stayed around 100,000 to 200,000 tons since 1992 and estimated as 204,000 tons in 2018. The SSB was historical high of 87,000 tons in 2018. The Hockey Stick (HS) model of reproduction curve was recommended in the ‘Research Institute meeting on Reference points for the East China Sea Stock of Blue Mackerel’ held in April, 2019. The SBmsy was estimated as 109,000 tons (Hayashi et al. 2019). Following the reference based on MSY standard, SSB2018 was below SBmsy. Recently the F tended to decrease, but it rapidly increased over Fmsy in 2018. The status of SSB was considered “increasing” referencing the past five years trend (2014-2018). The stock was also caught by South Korea and China, and it is considered that hundreds of Chinese fishing vessels operating in the area might have strong influence, but not included in the analysis.

Summary table of reference relating to MSY

Reference	Values
Regarding MSY	
SBmsy	109,000 tons
Fmsy	0yr, 1yr, 2yr, 3yr and above=0.36, 0.47, 0.66, 0.66
%SPR(Fmsy)	26.4%
MSY	76,000 tons
SSB and Fishing pressure in 2018	
SB2018	87,000 tons
F2018	0yr, 1yr, 2yr, 3yr and above=0.88, 1.05, 1.62, 1.62
%SPR(F2018)	9.3%
%SPR(F2016-F2018)	18.4%
Ratio to MSY	
SB2018/SBmsy	0.80
F2018/Fmsy	2.40

S-R relationship assumption: Hockey stick (without autocorrelation)

Summary of stock status:

Status of current SSB	Below SBmsy
Status of F	Above Fmsy
Status of SSB	increasing

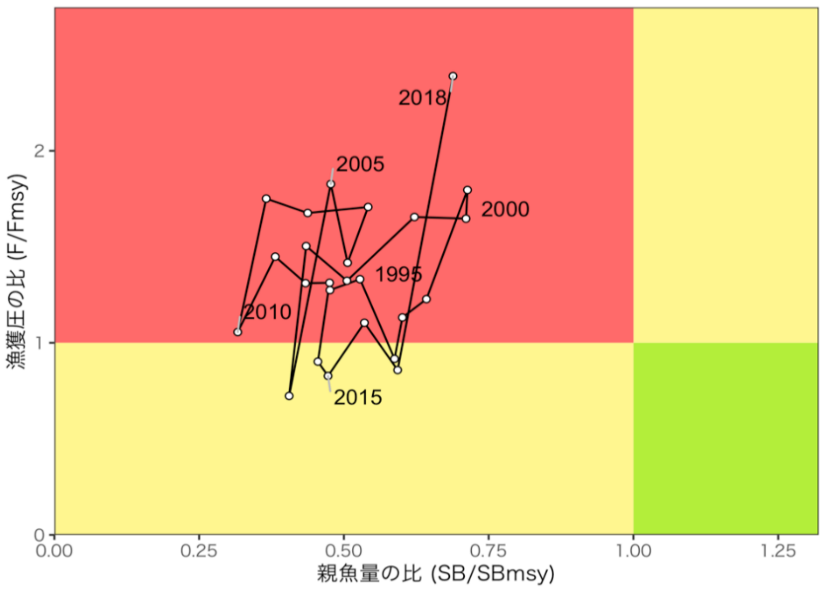

Figure. The relationship between SB/SBmsy and F/Fmsy.

The values of three years moving average were used for both SB and Fishing intensity.

1. Data set

The data set used for the stock assessment is as follows.

Data set	Data source and research
Catch number by age and year	National statistics of Ministry of agriculture, forestry and fisheries Landing at major ports (Fukuoka-Kagoshima [5] prefecture) Landing in number at Kyusyu major ports (National Fisheries institute) Logbook report of purse seine fisheries (Fishery agency) Length composition by month (NRIFS, Fukuoka-Kagoshima [5] prefectures); market measurement National Fisheries statistics of South Korea (http://www.fips.go.kr, March, 2019)
Index of the stock	Logbook report of purse seine fisheries (Fishery agency) * Landing statistics by size of purse seine at Makurazaki port (Kagoshima prefecture) * Neuston-net larval survey (Feb-Jun) Acoustic and midwater trawl biomass survey (Aug-Sep) Bottom trawl survey (East china sea) (May-Jun)
Natural mortality	Assuming M = 0.4 per year

* Tuning index for cohort analysis

Birth date was assumed at 1st of January.

2. Ecology of the species

1) Distribution and migration

Blue mackerel distribute relatively high temperature area than chub mackerel (Collette and Nauen 1983, Yamada et al. 2007, Fig. 2-1). Blue mackerel spawn at the area from Uotsuri Island to Kuchiminose during January to April, after grown up it appears in the southern waters of East china sea to western water of Kyusyu, with a portion reaches in the Japan sea. In the southern Kyusyu area spawning occurs January to May, juvenile reaches to the western water of Kyusyu to Pacific coastal waters of Japan. It migrates to the north for feeding during spring and summer, and migrates down south for wintering at fall and winter (Tsujita and Kondo 1957, Tanoue 1966).

2) Age and growth

The detail of growth is unknown. However, in the report, blue mackerels is assumed to be 28cm FL at age 1, 32cm at age 2, 36cm at age 3, 38cm at age 4, and 39cm at age 5 (Fig. 2-2). The longevity is considered as around 6 years.

3) Reproduction

Main spawning grounds are formed in the central and southern waters of East china sea in January to April, and in the central East china sea to southern water of Kyusyu in May (Yukami et al. 2009, Sassa and Tsukamoto 2010). Although the exact maturation age is unknown, it is assumed that it proportion of maturation as 60% at age 1, 85% at age 2, and 100% at age 3 above considering study results of chub mackerel (Shiraishi et al. 2008) and observation of biological measurements (Fig. 2-3).

4) Prey-predator relationships

Blue mackerel mainly feeds copepod and appendicularia at larval stage, anchovy and sardine larvae at juvenile, and planktonic crustacean and small teleost at adult stage (Tsujita and Kondo 1957, Sassa et al. 2008). Larvae may be eaten by ichthyophagous fish (Tanoue 1966).

3. Fisheries on the species

1) Outline of fisheries

Most of the catches of blue mackerel are made by purse seine fisheries. Main fishing grounds are from the East china sea to the southern water of Kyusyu.

2) Historical catch and size compositions

In the official statistics, chub and blue mackerel catches has been reported as mackerels and not separated by species. In this report, blue mackerel catches were estimated from official statistics (See Appendix 2-1-notes 1, Table 3-1). The Japanese blue mackerel catch from the East china sea and the Japan sea stayed around 50,000 tons since 1970s with fluctuations (Fig. 3-1, Table 3-1). Recently it decreased from the peak of 49,000 tons in 2011, but the catch in 2018 increased from previous year to 41,000 tons.

Korean blue mackerel catch was 11,000 tons in 2017, but it increased historical high of 74,000 tons in 2018 (See Appendix 2 for the ratio of chub and blue mackerel in

Korean catch). Chinese catch increased up to 500,000 tons since 2010, and was 440,000 tons in 2017（FAO Fishery and Aquaculture Statistics. Global capture production 1950-2017, March 2019 http://www.fao.org/fishery/statistics/software/fishstatj/en）. However, it is unknown for catches by species.

The 2018 catch mainly consists with age 0 and 1 fish as usual (Fig. 3-2, Appendix 4).

3) Annual fishing effort by fisheries

The number of nets of purse seine fishery operating in the East china sea and western waters of Japan sea is shown in Fig. 3-3. It reached at peak in 1980s, then continued to decrease after 1990. It recorded the lowest (4,710 nets) in 2018 due to the shift of fishing operations in the Pacific.

4. Stock status

（1）Stock assessment methods

We conducted cohort type analysis using the data of catch, effort, catch by age by year with biological information (Appendix 1 and 2). In the analysis, using catch by age data for Japanese and Korean during 1992-2018, F was estimated by fitting the trends between the abundance index by age of Japanese purse seine fishery and abundance index of Makurazaki landing data. Additionally, estimating methods using penalty to avoid overestimate of terminal F was used from the assessment of 2017 (ridge VPA; Okamura et al. 2017). The Chinese catch data was not used due to the mixture of chub and blue mackerels catches and lack of latest catch (2018).

The surveys were conducted using neuston net (Feb-Jun) to estimate recruitment, bottom trawl (May-Jun) for biomass, bottom trawl and acoustic survey (Aug-Sep) to estimate biomass (Appendix 3). However, all survey results were used as qualitative reference information due to the lack of reliable information of blue mackerel recruitment index. We will continue to improve methods of surveys and analysis.

（2）Changes in the biomass indices

The density index (tons/net) was estimated using statistics of purse seine fishery operating in the East china sea and western waters of Japan sea as an index of long-term trends of stock since 1973. The indices stayed at low level as average 6 tons/net during 1970s and 1980s, but it increased from late 1990s and reached 18 tons/net in 2005 (Fig. 4-1). Thereafter, it decreased to 9 tons/net in 2018. The effective efforts increased during 1995 to 2001, and decreased from 2002 to 2010, then stayed at same level after increased in 2011 (Fig. 4-1). The density index is the average value of catch per net at 30 minutes of grid where blue mackerel caught in 2018.

Stock abundance index at age calculated from the landing data by size of purse seine operating at the East china sea and the Japan sea after 2003 were used for cohort analysis (Fig. 4-2, Appendix 2-note3). When the abundance indices of 2018 are compared to the past 15 years, values were low at age 0 and 1, but maintained the same level at age 2 and 3. The abundance index calculated from the landing data at Makurazaki port was used for analysis as an index representing abundance of coastal waters of southern Kyusyu (Fig. 4-3, Appendix 2-note3). From the 2018 assessment, the new classification of data was introduced to estimate more accurate age composition which classified small size as for age 0-1 and middle and large size as age 2 above. Both abundance indices of age indicated gradual fluctuations since 2003. The abundance indices for age 0-1 and 2 above in 2018 indicated near average figures of past 16 years.

(3) Trends in biomass and fishing ratio

The stock biomass estimated by cohort model stayed ranging 100,000 to 200,000 tons since 1992 and is relatively stable (Fig. 4-4, Table 4-1). The abundance estimated for 2018 was 204,000 tons. Fishing ratio was around 40% until 2012, then it continued to be 40%, but it rapidly increased to 57% in 2018.

The recruitment (abundance of age 0) fluctuated between 200 to 400 million fish since 1992, it became 390 million in 2018 (Fig.4-5, Table 4-1). The SSB (abundance of adult) fluctuated between 30 to 80 thousand tons until 2014, then increased up to 87 thousand tons in 2018 (Fig. 4-5, Table 4-1).

As sensitivity test of natural mortality (M) used for cohort analysis, M=0.3 and 0.5 were used for analysis. The biomass, SSB and recruitment in 2018 increased according increase of M, it affected around 10% of estimated values if M changed 0.1 (Fig.4-5).

Fishery coefficient F (average of F at each age) fluctuated between 0.5 to 1.0 during 1992 to 2017 (Fig. 4-7). After 2012, F indicated gradually decreased, it became 0.47 in 2017, then rapidly increased to 1.29 in 2018.

Item	Value	Remarks
SB2018	87,000 tons	SSB in 2018
F2018	(age 0, 1, 2, 3+)=(0.88, 1.05, 1.62, 1.62)	
U2018	57%	Fishing ratio in 2018

(4) Yield per recruitment (YPR), spawning per recruitment (SPR) and current fishing pressure

In order to compare the fishing pressure considering the influence of selectivity, Figure 4-8 shows the %SPR (ratio of SPR which assumes no fishing divided by the SPR with current catch) calculated by converting the *F* value of each year. The lower the fishing pressure, the higher the %SPR. The %SPR fluctuated and tended to increase since late 2000s, but the value of 2018 was low as 9.3%.

The relation between average fishing pressure in recent five years selectivity (2014 to 2018) and %SPR are shown in Fig. 4-9. The current fishing pressure (F2016-F2018) is higher than Fmed, F30%SPR and F0.1. Figure 4-9 also indicates the relation between average fishing pressure at MSY and %SPR which was presented at the 'Research Institute meeting on Reference points for the East China Sea Stock of Blue Mackerel ' held at April, 2019. The current F (F2016-2018) and F2018 are higher than Fmsy.

Item	Value	Remarks
%SPR (F2018)	9.3%	%SPR in 2018
%SPR (F2016-2018)	18.4%	%SPR corresponding to current fishing pressure (F2016-F2018)

(5) Stock-recruitment relationship

Figure 4-10 shows the Stock-recruitment (S-R) relationship between SSB (in weight) and recruitment (in numbers). According to the 'Research Institute meeting on Reference points for the East China Sea Stock of Blue Mackerel ' mentioned above, it is suggested to use the Hockey-Stick functional response type for the S-R relationship of this stock (Hayashi *et al*. 2019). Parameters for the S-R relationship is estimated based on the SSB and recruitment which are estimated by the stock assessment conducted in 2018, and as for the optimization method, least-squares method is used. The model does not consider auto-correlation between the residuals of the recruitment. Estimated parameters for the S-R relationship are shown below.

S-R relationship	Optimization method	Auto-correlation	*a*	*b*	S.D.
Hockey-Stick (HS) type	Least square	No	0.00493	84,935	0.33

Here, parameter *a* is the steepness of the HS S-R curve (numbers / kg) from the origin to the break point, and *b* is the SSB (ton) at the break point.

（6）Level of SSB and fishing pressure that will achieve MSY under the current environmental condition.

The table below shows the SSB and *F* that will achieve MSY (SBmsy, Fmsy) under the current environmental condition since 1992, which was suggested at the 'Research Institute meeting on Reference points for the East China Sea Stock of Blue Mackerel ' (Hayashi *et al*. 2019).

Item	Suggested value	Remarks
SBmsy	109,000 tons	SSB that will obtain MSY
Fmsy	（age 0, 1, 2, 3+）=（0.36, 0.47, 0.66, 0.66）	
%SPR（Fmsy）	26%	%SPR corresponding to Fmsy
MSY	76,000 tons	MSY

（7）Stock status, stock trend and level of fishing pressure

A Kobe-plot shows the relationship between SSB and its corresponding fishing pressure in Fig. 4-11. A Kobe-plot based on fishing ratio is also shown in Appendix 8. F/Fmsy shows the yearly ratio between F and F under the current selectivity that gives Fmsy which was converted to %SPR. The fishing ratio and SSB were calculated as three years moving average. The fishing pressure in recent years has been above the level of MSY. The fishing pressure in 2018 was 2.40 times larger than Fmsy. The SSB is considered to be lower than the SBmsy since 1992. The SSB in 2018 is 0.80 times the SBmsy. The trend of SSB is classified "increasing" considering trend of recent five years (2014-2018).

Item	Value	Remarks
SB2018/ SBmsy	0.80	Ratio between the SSB that gives MSY and the SSB in 2018
F2018/ Fmsy	2.40	Ratio between the fishing pressure that gives MSY and the fishing pressure in 2018 *

* Ratio between *F* in 2018 and *F* under the current selectivity that gives Fmsy which was converted to %SPR.

Level of SSB	below SBmsy
Level of *F*	above Fmsy
Trends in SSB	Increasing

5. Stock assessment summary

Biomass of this stock stayed in ranging 100 to 200 thousand tons, and it was estimated 204 thousand tons in 2018 (Fig. 4-4, Table 4-1). The SSB (abundance of adult) fluctuated between 30 to 80 thousand tons until 2014, thereafter it increased up to historical high of 87 thousand tons (Fig. 4-5, Table 4-1). The SSB in 2018 was below SBmsy. The trends of SSB was considered “increasing” based on the trends of recent five years (2014-2018). Fishing pressure were high from Fmsy in the most years, it stayed around Fmsy during 2014 to 2017. However, F of 2018 rapidly increased to 1.29 which is below Fmsy. Recruitment (abundance of age 0 fish) fluctuated between 200 to 400 million fish, and it became 390 million fish in 2018 (Fig. 4-5, Table 4-1).

6. Other matters

It is possible that different interpretation of rapid increase of Korean catch in 2018 and different methods of assessment may provide uncertainty for the assessment results. The Korean catch largely increased in 2018, but such change did not appear in Japanese catch and abundance index (Fig. 4-2, 4-3). If we use same method of assessment used in previous year, estimate value may be largely changed by the influence of large catch by Korea (Appendix 9-14). Or if we assume Korean catch is not rapid change but gradual, the estimated abundance is 30% smaller than the assessment of this year (Appendix 15-20).

It is considered that other cause of large uncertainty of assessment is that the information of Chinese vessels is not used (Kuroda et al. 2019b). It is difficult to include both Korean and Chinese information for future projection due to the unknown situation for their fishery management. There are practical issues that TAC is managed as “mackerels” both chub and blue mackerel together in Japan. It should be noted that those uncertainty mentioned above are not included in the future projection of this study.

7. References

Collette, B.B. and C.E. Nauen (1983) FAO species catalogue. Vol. 2. Scombrids of the Worl d. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related specie s known to date. FAO Fish. Synop., **125**, 1-137.

林 晃・安田十也・黒田啓行 (2019) 平成 31(2019)年度ゴ゛マサバ゛東シナ海系群の管理基準 値等に関する研究機関会議報告書.
http://www.fra.affrc.go.jp/shigen_hyoka/SCmeeting/201 9-1/detail_gomasaba_e.pdf (last accessed 11 Nobember 2019).

黒田啓行・依田真里・林 晃・竹垣草世香・佐々千由紀・髙橋素光(2019a)平成 30(2018) 年度ゴ゛マサバ゛東シナ海の資源評価. 平成 30 年度我が゛国周辺水域の漁業資源評価 第 1 分冊, 209-247, http://abchan.fra.go.jp/.

黒田啓行・北島 聡・後藤常夫・佐々千由紀・田中秀一・平松一彦・向草世香・安田十也・ 山田明徳・山田東也・由上龍嗣・依田真里(2019b)マサバ゛対馬暖流系群の生態と資源, 水産海洋研究, 84(4), 237-251.

Okamura, H., Y. Yamashita and M. Ichinokawa (2017) Ridge virtual population analysis to reduce the instability of fishing mortalities in the terminal year. ICES J. Mar. Sci., **74**, 2 424-2436.

Sassa, C., Y. Tsukamoto and Y. Konishi (2008) Diet composition and feeding habits of *Trachurus japonicus* and *Scomber* spp. larvae in the shelf break region of the East China Sea. Bull. Mar. Sci., **82**, 137-153.

Sassa, C. and Y. Tsukamoto (2010) Distribution and growth of *Scomber japonicus* and *S. australasicus* larvae in the southern East China Sea in response to oceanographic conditions. Mar. Ecol. Prog. Ser., **419**, 185-199.

Shiraishi, T., K. Okamoto, M. Yoneda, T. Sakai, S. Ohshimo, S. Onoe, A. Yamaguchi and M. Matsuyama (2008) Age validation, growth and annual reproductive cycle of chub ma ckerel *Scomber japonicus* off the waters of northern Kyushu and in the East China Sea. Fish. Sci., 74, 947-954.

Tanoue, T. (1966) Studies on the seasonal migration and reproduction of the spotted mackerel, *Pneumatophorus tapeinocephalus* (BLEEKER). Mem. Fac. Fish., Kagoshima Univ., **15**, 91- 175.

辻田時美・近藤正人 (1957) 東支那海のサハ゛の生態と漁場の海洋学的研究(1).西水研研報, **14**, 7-47.

山田梅芳・堀川博史・中坊徹次・時村宗春(2007)コ゛マサハ゛. 東シナ海・黄海の魚類誌, 東海大学出版会, 神奈川, 979-983.

Yukami, R., S. Ohshimo, M. Yoda and Y. Hiyama (2009) Estimation of the spawning grounds of chub mackerel *Scomber japonicus* and spotted mackerel *Scomber australasicus* in the Ea st China Sea based on catch statistics and biometric data. Fish. Sci., **75**, 167-174.

Authors: Akira Hayashi, Tohya Yasuda, Hiroyuki Kuroda, Ryuji Yukami

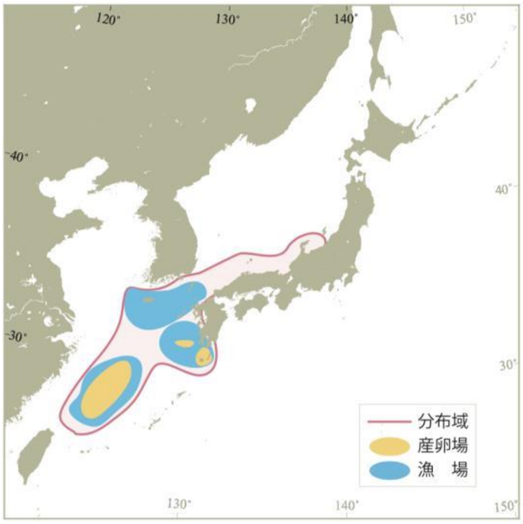

Figure 2-1. Distribution and migration of blue mackerel East china sea stock.

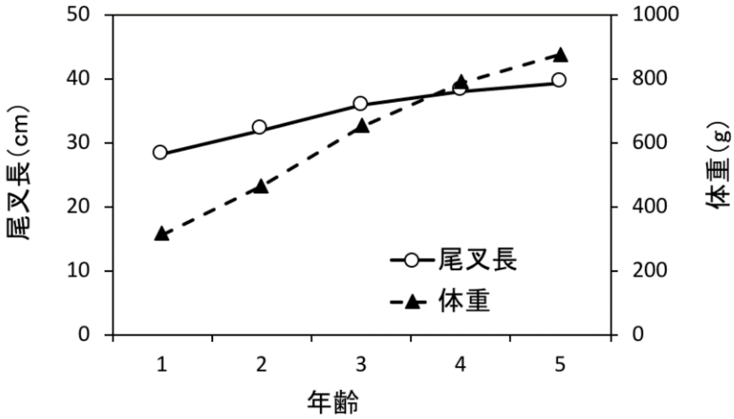

Fig. 2-2. Age and growth.

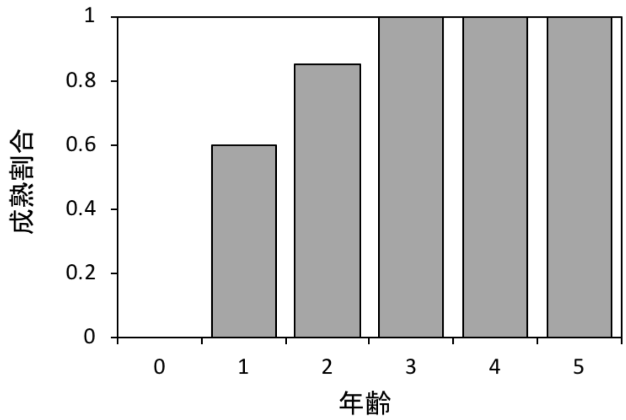

Figure 2-3. Maturity rate by age.

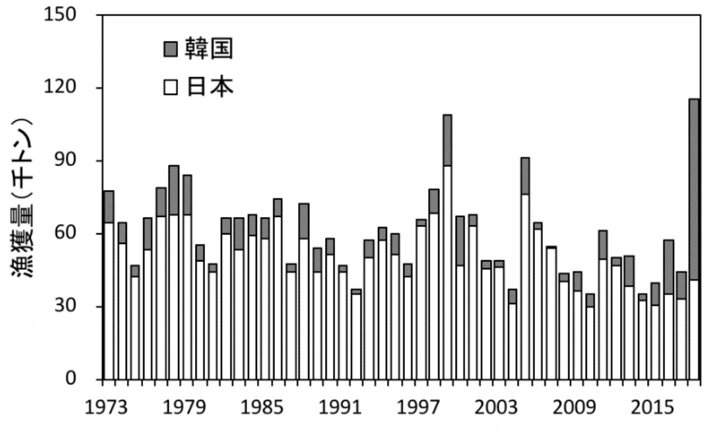

Figure 3-1. Annual catches of blue mackerel by fisheries (in thousand tons). (Grey: Korea, white: Japan).

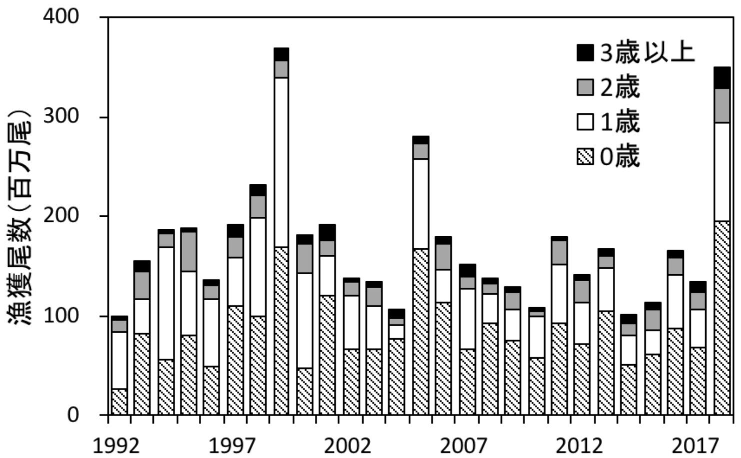

Figure 3-2. Annual age composition in catch (in million fishes). Each color represents age (0, 1, 2, 3+).

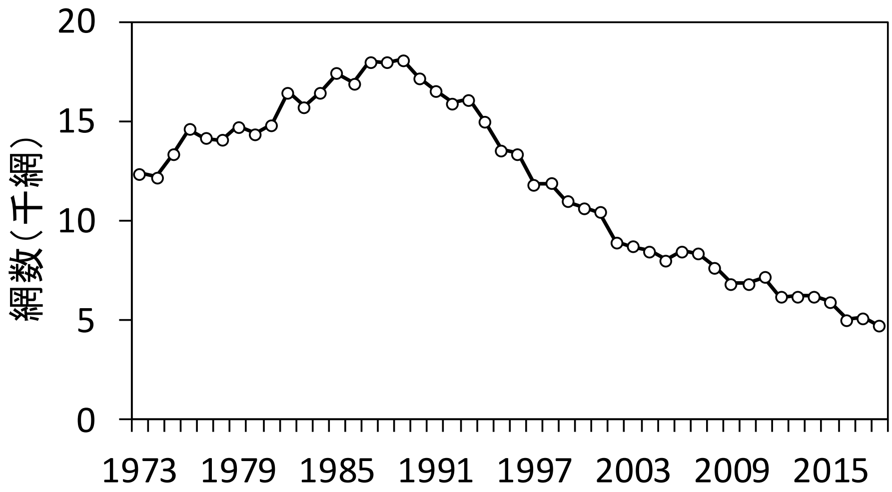

Fig. 3-3. Annual number of nets of purse seine operating in the East china sea and Japan sea (in thousand nets).

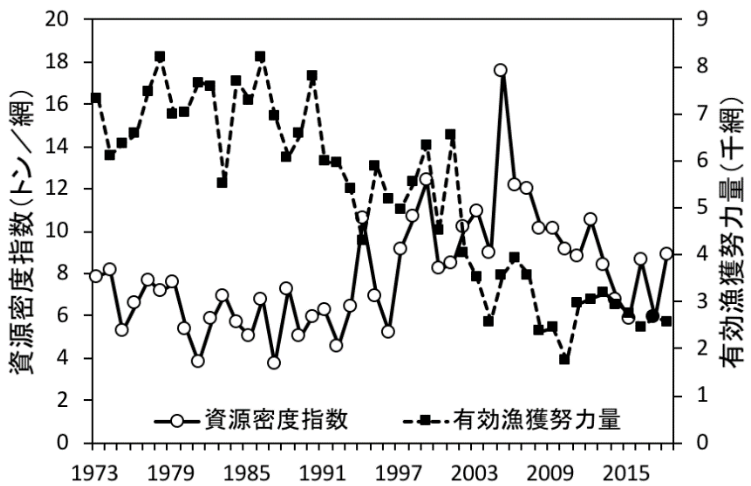

Figure 4-1. Density indices by year and annual effective effort on blue mackerel by purse seine fishery.

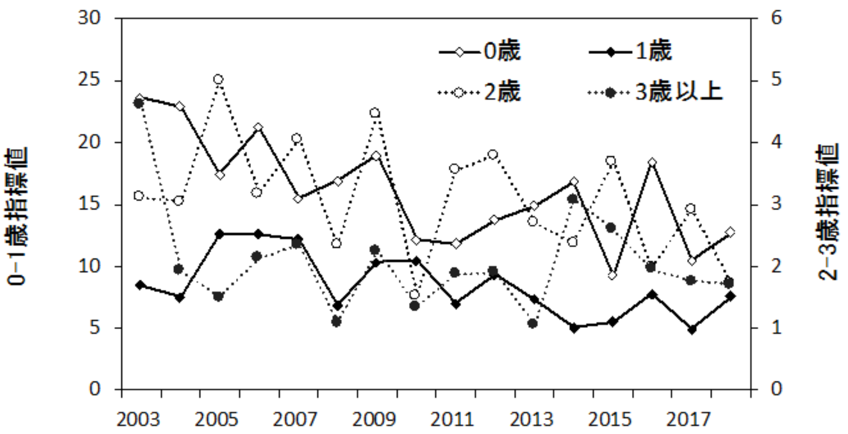

Fig. 4-2. Abundance indices by age calculated by catch by size of purse seine operating in the East china sea and Japan sea. The left axis represents index scale for 0 and 1 years old, and the right axis represents index scale for 2 and 3+ year old.

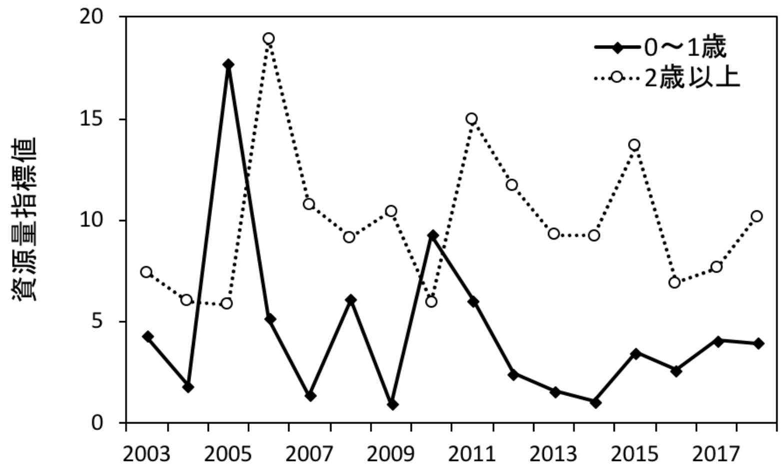

Fig. 4-3. The estimated abundances indices by age from landing data at Makurazaki port, Kagoshima prefecture.

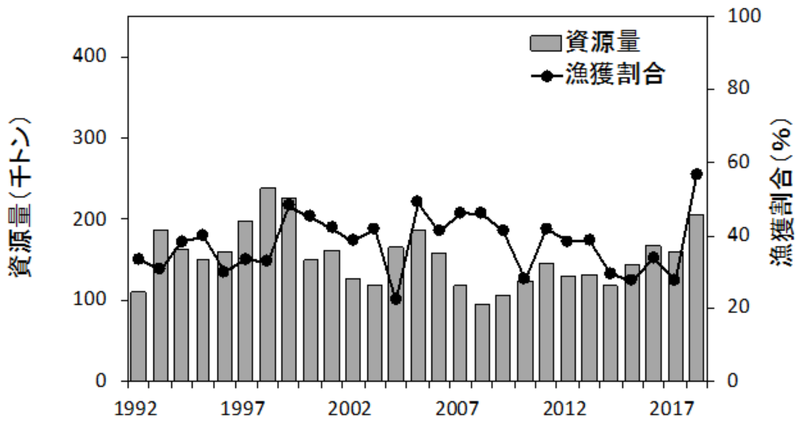

Fig. 4-4. The estimated blue mackerel abundance and fishing ratio by year. The left axis and right axis represent stock abundance (in thousand tons) and fishing ratio, respectively.

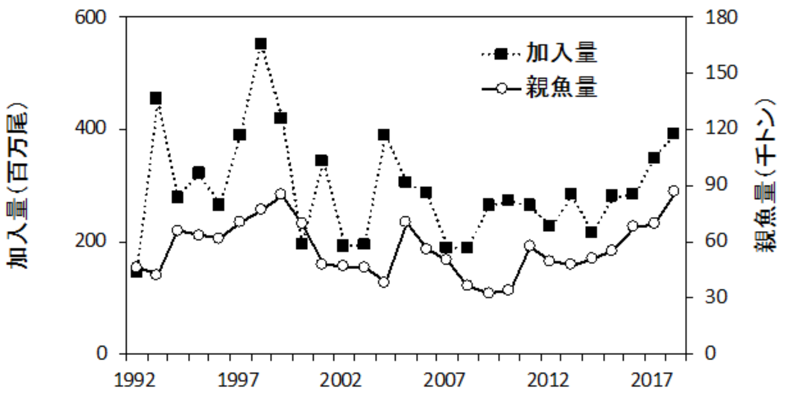

Fig. 4-5. Fluctuations of SSB and recruitment of blue mackerel East china sea stock. The black line with open circle represent SSB (left axis) and dotted line with black square represent recruitment (left axis).

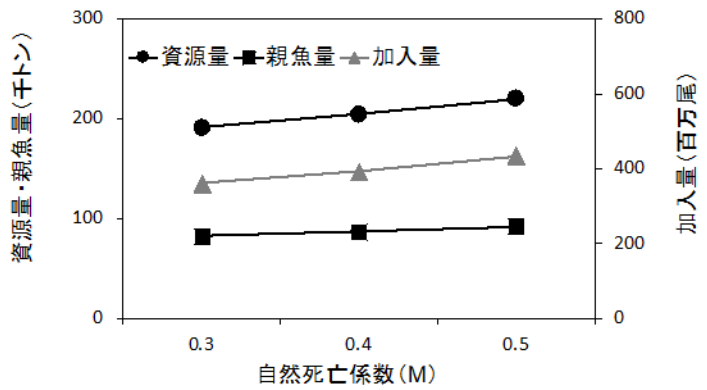

Fig 4-6. Change in stock abundance (circle), SSB (square), and recruitment (grey triangle) with various value of natural mortality coefficient M. The left axis represents stock abundance and SSB (in thousand ton) and the right axis represents recruitment (in million fish).

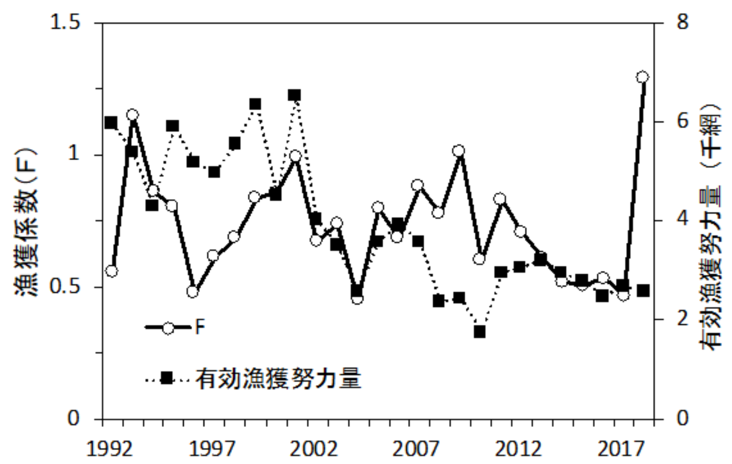

Fig. 4-7. The average of F at age (black line with open circle, left axis), and effective efforts by year (dotted line with solid square, right axis in thousand nets).

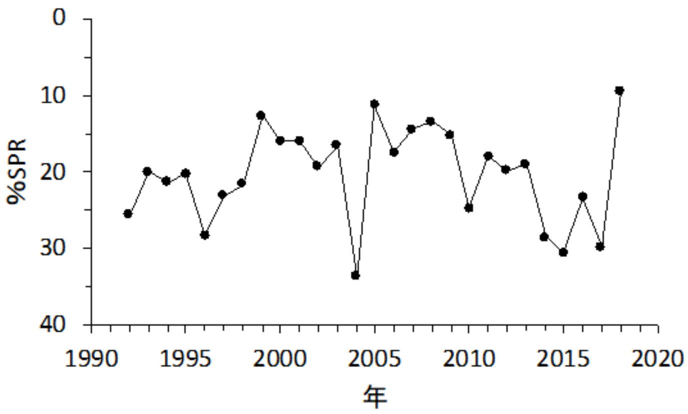

Fig. 4-8. Fluctuations in %SPR by years. %SPR shows the ratio of SSB when no fishing to the SSB when there is fishing, and %SPR becomes low with high *F* and vice versa.

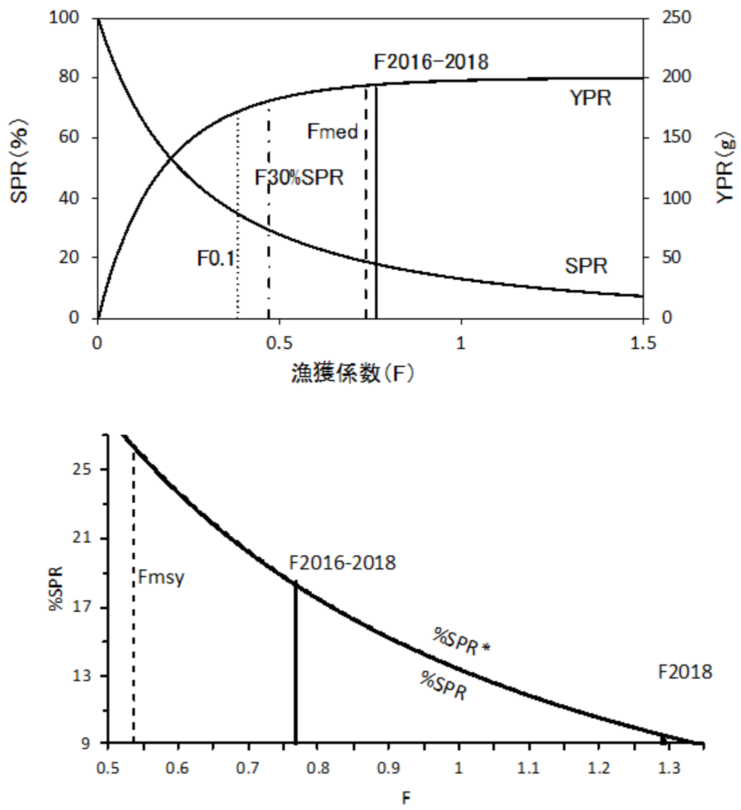

Fig. 4-9. Relationship between the fishing mortality (F2016-2018) and %SPR, YPR (above). Relationship between F and %SPR (below). %SPR* (dotted line) is the relationship between %SPR and average F under MSY.

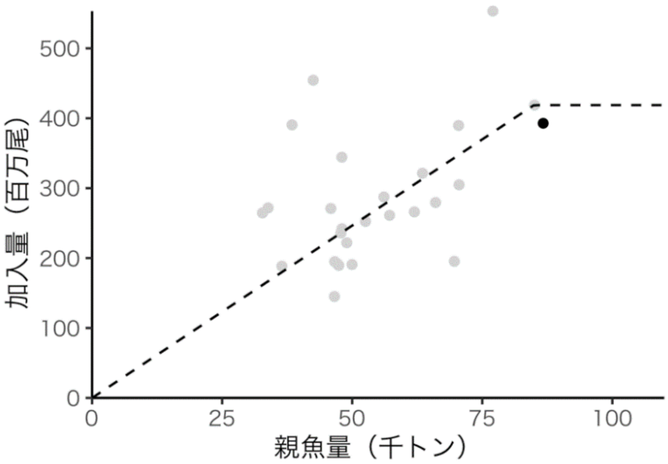

Fig. 4-10. Relationship between SSB and recruitment. The dotted line shows the S-R relationship suggested at the 'Research Institute meeting on Reference points for the East China Sea Stock of Blue Mackerel ' held in April 2019 (Hayashi et al. 2019). Black dot indicates value of 2018.

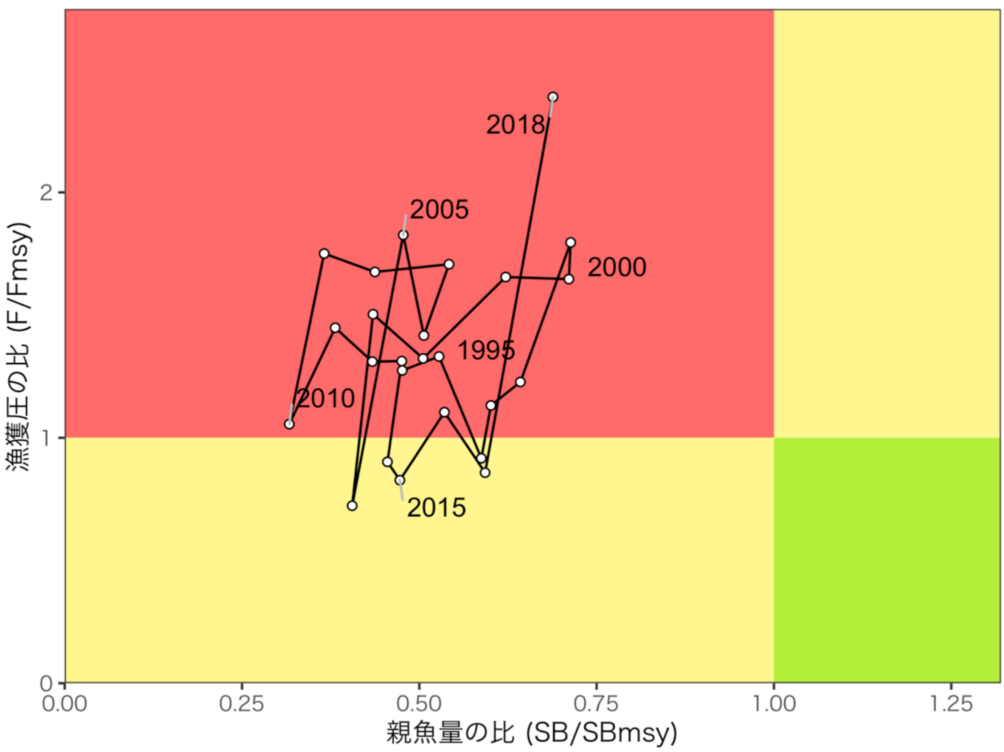

Fig. 4-11. Relationship between the SSB/SBmsy and F/Fmsy (Kobe plot). The *F* and SSB is the three-year moving average.

Table 3-1. Annual catch of blue mackerel (tons) by purse seine and by prefecture. The captions in the table below are from the left: Calendar year, catch by purse seine, Kagoshima, Kumamoto, Nagasaki, Saga, Fukuoka, Yamaguchi, Shimane and Tottori, respectively.

暦年	大中まき	鹿児島	熊本	長崎	佐賀	福岡	山口	島根	鳥取
1973	215,160	966	942	2,414	34	764	1,911	38,598	9
1974	295,856	746	575	1,716	17	676	2,821	33,423	487
1975	237,859	1,361	828	2,132	14	662	1,619	38,432	212
1976	215,601	1,789	889	2,138	24	332	772	36,709	868
1977	250,593	1,749	863	3,647	41	674	1,338	21,241	247
1978	257,417	959	1,197	9,622	51	648	587	18,498	262
1979	212,769	2,542	1,093	7,102	106	705	1,069	38,385	118
1980	255,753	2,100	623	4,595	84	617	1,378	25,388	171
1981	203,333	2,740	2,106	7,098	140	549	1,477	19,952	260
1982	233,390	2,848	2,883	6,753	182	1,016	2,094	25,179	630
1983	197,112	2,863	1,268	5,590	266	1,440	2,235	24,158	377
1984	150,995	2,952	1,308	5,063	77	789	2,150	28,426	24
1985	152,021	3,853	2,784	12,803	42	743	2,957	21,189	233
1986	144,646	2,082	551	4,902	107	1,060	1,778	30,167	893
1987	124,383	2,307	2,358	25,887	370	1,623	2,863	25,006	266
1988	158,964	1,782	1,050	10,914	316	1,409	3,738	52,260	255
1989	213,583	1,524	1,019	7,711	613	1,625	1,485	47,890	13
1990	104,467	696	254	3,490	75	798	4,035	14,554	21
1991	111,700	867	1,454	4,227	65	571	6,687	25,152	3
1992	111,697	1,208	1,242	4,849	163	883	3,639	17,885	0
1993	175,995	2,240	1,457	10,058	489	3,518	3,202	33,375	5
1994	265,917	1,143	610	8,742	452	2,453	5,394	44,236	6
1995	154,712	1,051	1,933	9,467	187	1,483	5,683	28,748	2
1996	358,199	1,742	2,106	9,232	149	1,814	5,244	26,246	0
1997	173,610	2,297	2,748	11,288	275	786	3,900	12,204	11
1998	125,813	1,137	472	7,321	152	1,194	6,260	18,756	11
1999	79,681	1,372	671	8,745	149	1,373	2,713	10,555	12
2000	65,284	1,400	286	6,046	70	519	4,649	7,797	9
2001	54,132	1,157	50	7,580	145	1,142	3,602	7,824	8
2002	62,323	345	76	7,822	25	988	3,360	9,877	5
2003	62,440	1,135	7	8,046	11	1,177	939	7,850	0
2004	58,008	959	131	14,251	37	953	319	6,648	0
2005	61,858	2,331	117	10,843	20	879	928	10,252	1
2006	55,971	2,326	125	13,799	231	962	1,579	11,929	12
2007	71,649	1,771	282	12,065	51	2,353	1,728	13,451	2
2008	82,358	2,793	313	13,478	146	743	1,606	16,412	4
2009	92,412	1,744	59	14,416	13	578	2,005	17,123	5
2010	89,528	2,476	126	11,666	83	844	1,416	9,000	7
2011	62,842	4,164	290	19,802	19	1,282	1,528	15,684	2
2012	70,195	2,515	108	14,034	69	860	818	14,772	75
2013	41,032	2,172	117	9,062	45	69	557	6,818	114
2014	46,591	1,946	192	14,736	17	201	856	15,081	1
2015	76,914	2,390	301	14,489	20	614	1,763	9,917	6
2016	47,860	2,134	278	13,326	52	193	2,580	23,633	5
2017	60,078	3,881	548	21,230	35	445	1,504	19,358	7
2018	84,054	13,229	348	32,640	92	845	2,284	27,587	3

Table 3-1 (continued). Annual catch of blue mackerel (tons) by purse seine and by prefecture. The captions in the table below are from the left: Calendar year, catch by Hyogo, Kyoto, Fukui, Ichikawa, Toyama, Niigata, Yamagata, Akita and Total, respectively.

暦年	兵庫	京都	福井	石川	富山	新潟	山形	秋田	合計
1973	340	1,235	2,252	1,254	539	2,039	10	84	268,551
1974	1,486	477	2,520	3,172	1,205	1,500	6	144	346,826
1975	279	130	1,937	1,916	519	1,881	5	147	289,932
1976	678	169	2,070	3,356	1,120	2,041	2	227	268,787
1977	1,725	80	1,481	3,646	1,689	2,494	9	233	291,750
1978	1,676	61	979	3,415	1,419	1,495	0	153	298,439
1979	377	503	1,235	1,816	465	1,225	7	352	269,867
1980	43	295	894	2,492	1,000	1,446	7	215	297,101
1981	650	153	903	2,665	1,010	405	1	101	243,544
1982	1,772	95	791	2,579	402	603	1	140	281,358
1983	942	97	2,045	2,406	330	1,054	3	79	242,265
1984	557	106	1,504	2,224	239	905	6	204	197,530
1985	393	333	2,199	2,988	223	799	11	98	203,670
1986	383	93	1,164	3,382	465	1,059	15	110	192,858
1987	722	100	1,984	4,920	207	622	5	78	193,701
1988	369	140	2,179	5,408	316	838	4	102	240,043
1989	474	692	1,340	3,678	216	638	7	73	282,580
1990	187	301	494	1,510	134	184	0	29	131,228
1991	69	146	390	1,233	172	216	0	37	152,991
1992	70	120	190	1,047	230	140	0	24	143,385
1993	76	447	835	1,916	665	249	2	26	234,555
1994	746	632	1,334	5,180	1,357	498	3	50	338,751
1995	373	388	478	2,237	1,039	250	0	48	208,078
1996	283	298	516	4,255	764	335	2	31	411,217
1997	54	409	405	1,802	509	280	5	37	210,618
1998	10	472	183	1,257	1,306	144	4	32	164,524
1999	167	294	409	564	842	337	3	34	107,839
2000	113	409	265	1,028	1,134	178	1	59	89,249
2001	2	202	147	990	319	144	1	68	77,514
2002	6	276	151	630	117	85	1	33	86,121
2003	24	363	164	765	192	102	0	4	83,219
2004	2	180	51	1,144	525	112	6	51	83,377
2005	81	88	146	3,665	390	193	7	70	91,870
2006	35	1,399	602	878	348	232	27	58	90,514
2007	10	348	258	1,714	310	338	11	43	106,384
2008	57	279	188	1,316	764	545	16	53	121,073
2009	16	306	142	984	365	344	5	44	130,559
2010	14	86	199	1,368	495	339	4	26	117,678
2011	26	275	164	3,212	1,004	382	14	109	110,798
2012	18	53	162	2,870	1,193	283	1	23	108,048
2013	7	146	137	2,826	994	246	4	28	64,373
2014	4	514	29	3,156	3,201	447	3	15	86,990
2015	57	263	268	3,529	4,018	547	5	50	115,149
2016	4	217	249	2,989	754	456	3	32	94,765
2017	5	257	193	2,762	808	305	3	25	112,668
2018	11	141	204	5,353	1,251	567	4	55	150,659

Table 3-2. Annual catch by countries and results of the cohort-analysis. The captions in the table are from the left: fishing year, catch (thousand tons) by Japan, Korea and Total, estimated abundance (thousand tons), SSB (thousand tons), recruitment (million fish), fishing ratio (%), and RPS (numbers/kg).

	漁獲量(千トン)			資源量	親魚量	加入量	漁獲割合	再生産成功率
年	日本	韓国	計	(千トン)	(千トン)	(100万尾)	(%)	(尾／kg)
1973	269	61	330	1,026	312	2,078	32	6.667
1974	347	72	419	1,029	380	1,749	41	4.608
1975	290	65	355	946	327	1,759	38	5.373
1976	269	95	364	976	316	1,911	37	6.052
1977	292	101	393	1,070	325	2,202	37	6.777
1978	298	79	378	1,044	360	1,906	36	5.286
1979	270	104	374	1,123	363	2,229	33	6.144
1980	297	57	354	921	415	1,203	38	2.900
1981	244	105	348	985	329	2,026	35	6.162
1982	281	93	374	1,116	343	2,295	34	6.684
1983	242	110	352	1,050	408	1,714	34	4.202
1984	198	93	291	902	406	1,283	32	3.163
1985	204	60	264	926	380	1,647	28	4.332
1986	193	97	290	866	388	1,252	33	3.229
1987	194	98	292	1,255	339	2,992	23	8.816
1988	240	149	389	1,219	533	1,576	32	2.957
1989	283	154	437	876	521	762	50	1.463
1990	131	91	222	636	256	1,187	35	4.631
1991	153	89	242	735	236	1,559	33	6.616
1992	143	114	258	917	265	1,963	28	7.397
1993	235	168	403	1,098	377	2,100	37	5.570
1994	339	205	544	1,118	400	2,145	49	5.366
1995	208	192	400	1,292	295	3,287	31	11.152
1996	411	410	821	1,370	468	2,456	60	5.247
1997	211	158	368	832	247	1,775	44	7.183
1998	165	163	328	715	245	1,349	46	5.507
1999	108	157	265	617	213	1,286	43	6.048
2000	89	126	215	446	190	1,046	48	5.490
2001	78	199	277	559	159	1,166	50	7.341
2002	86	139	225	467	137	972	48	7.076
2003	83	119	202	459	116	991	44	8.539
2004	83	178	262	627	125	1,497	42	11.934
2005	92	120	212	509	183	830	42	4.529
2006	91	99	189	443	165	887	43	5.387
2007	106	143	249	522	138	1,132	48	8.224
2008	121	187	308	696	131	1,779	44	13.580
2009	131	168	298	551	188	955	54	5.079
2010	118	94	212	511	112	1,237	41	11.073
2011	111	139	250	516	143	1,326	48	9.260
2012	108	125	233	487	144	1,057	48	7.336
2013	64	102	166	371	125	804	45	6.412
2014	87	127	214	555	109	1,487	39	13.686
2015	115	132	247	570	173	1,144	43	6.607
2016	95	133	228	480	157	1,023	47	6.502
2017	111	104	215	640	130	1,986	34	15.262
2018	151	142	292	654	238	1,329	45	5.580