Stock assessment of Chub Mackerel Tsushima stock (2019)

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Summary

The stock biomass was estimated by cohort model considering abundance index. The biomass stayed around one million tons during 1973 to 1996 except a few years, but it decreased around 500,000 tons after 2000. However, after 2004, it increased around 600,000 tons supported by strong recruitments, and it became 650,000 tons in 2018. The SSB in 2018 was estimated 240,000 tons.

For this stock, we propose the Hockey Stick (HS) model of reproduction curve, and SBmsy was estimated as 310,000 tons. Following the reference, SSB in 2018 is below MSY. Recently fishing pressure on the stock stay at similar level and is above Fmsy. The trend of SSB is considered “increasing” by the transition of past five years (2014-2018). The stock is caught by South Korea and China, and it is considered that Chinese fishing operations by more than hundreds of boats may have strong effect on the stock, especially. However, it is not including in the analysis.

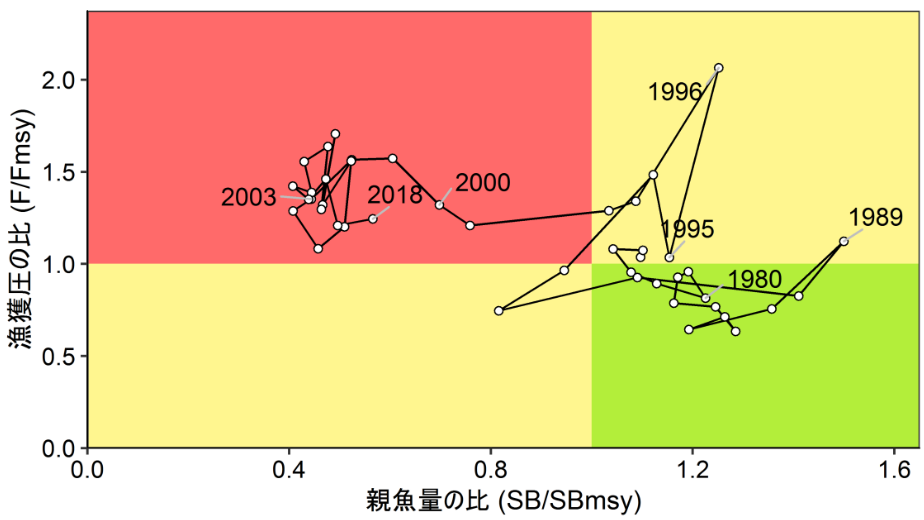
Summary table of reference relating to MSY

Reference	Values
Regarding MSY	
SBmsy	310,000 tons
Fmsy	0.33, 1.07, 0.69, 0.69=0yr, 1yr, 2yr, 3yr and above
%SPR(Fmsy)	20%
SSB and Fishing pressure at 2018	
SB2018	238,000 tons
F2018	0.30, 1.34, 1.01, 1.01=0yr, 1yr, 2yr, 3yr and above
%SPR(F2018)	16.7%
%SPR(F2016-F2018)	15.6%
Ratio to MSY	
SB2018/SBmsy	0.77
F2018/Fmsy	1.24

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



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 (Hokkaido-Miyazaki [17] prefectures, JAFIC, Northern Purse Seine Fisheries Association) Landing in number at Kyusyu major ports (National Fisheries institute) Logbook report of purse seine fisheries (Fishery agency) Length composition by month (NRIFS, Hokkaido-Miyazaki [17] prefectures, JAFIC); 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 Sakai port (Tottori prefecture) Neuston-net larval survey (Feb-Jun) Acoustic biomass survey (Aug-Sep) Bottom trawl survey (East china sea) (May-Jun) NORPAC net larval survey (all the year round)
Natural mortality	Assuming M = 0.4 per year (Limbong et al., 1988)

Birth day was assumed at 1st of January.

2. Ecology of the species

1) Distribution and migration

Chub mackerel Tsushima stock distributes from the southern part of East china sea, northern part of the Japan sea to the Yellow sea Bo Hai (Yamada et al. 2007, Fig. 2-1). It migrates to north for feeding during spring and summer, and down south for spawning and wintering at fall to winter. There are some schools stay at the northern part of Japan sea for wintering (Limbong et al. 1991, Yasuda et al. 2014).

2) Age and growth

Although growth differ by area and year, it grows to 25-28cm in fork length one year after hatch, 29-32cm at two years, 33-35cm at three years, 36cm at four years, and 37cm at five years (Shiraishi et al. 2008, Fig. 2-2). The longevity is around six years.

3) Reproduction

Main spawning grounds are found in the waters of Chinese coast in the East china sea, coastal waters of Korean peninsula, coastal waters of Kyusyu and Sanin districts of Japan (Yamada et al. 2007, Sassa and Tsukamoto 2010). The spawning season is early in the southern region (Jan-Apr) and late in the northern region (May-Jun) (Ouchi and Hamazaki 1979, Yukami et al. 2009). The age of maturity range one to two year old, and rates of maturity are 60% for one year old, 85% for two, and 100% for three and above (Shiraichi unpublished data, Fig. 2-3).

4) Prey-predator relationships

It is considered that the adults feed mainly planktonic crustaceans including krill, opossum shrimps and copepods, and small teleost like anchovy (Yamada et al. 2007 and Moriwaki and Miyabe 2012). Larvae may be eaten by ichthyophagous fish.

3. Fisheries on the species

1) Outline of fisheries

Chub mackerel of Tsushima stock are mainly caught by various size of purse seine fisheries. Main fishing grounds are the East china sea, coastal water of South Korea, northwest coast of Kyusyu, and western water of the Japan sea, but after 2016 catches from northwestern Kyusyu and western waters of the Japan sea fishing grounds increased. After 2016, fishing effort for the stock decreased at the lowest level due to the shift of fishing operations to the Pacific fishing grounds.

2) Historical catch and size compositions

In the official statistics, chub mackerel catch has been reported with blue mackerel as mackerels. In this report, chub mackerel catches were estimated from official statistics (See Appendix 2-1-notes 1, Table 3-1). The chub mackerel catch of Tsushima stock stayed around 300,000 tons at the late 1970s, and it decreased around 150,000 tons in the early 1990s (Fig. 3-1, Table 3-2). Thereafter it increased up to 410,000 tons in 1996, and stayed at the low level of around 80,000-120,000 tons after 2000. The catch of 2013 was 60,000, the lowest after 1973, then it increased to 150,000 tons in 2018. Korean catch in 2018 was 140,000 tons, and it increased from 100,000 tons of previous year (See Appendix 2-1 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 chub and blue mackerel.

The Japanese catch are mainly consisted with 0- and 1-year old fish (Fig. 3-2, Appendix 4). The ratio of zero-year fish increased and two and above decreased after 1990s. It of one-year fish was high in 2018. The age composition of Korean and Chinese catches are unknown.

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 at the lowest (4,710 nets) in 2018 due to the shift of fishing operations in the Pacific. The effective efforts also revealed decreasing trend since 1998 (Fig.4-1).

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, 2-1). In the analysis, using catch by age for Japanese and Korean catch data, F was estimated for fitting the trends between the abundance index by age of Japanese purse seine fishery and estimated abundance by age. The Chinese catch data was not used due to the mixture of chub and blue mackerels catches.

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). The larval survey was conducted all over the year. However, all research results were used as qualitative information, because the accuracy of estimates was not enough. 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 decreased from the early 1970s to the late 1980s, but were high at middle of 1990s and around 2009 (Fig. 4-1). Recently, it decreased from 2011 to 2013, then it stayed high level after 2015. The effective efforts stayed at the same level until 1994, it gradually decreased thereafter (Fig. 4-1).

The density index is the average value of catch per net at 30 minutes of grid where chub mackerel caught in 2018. The effective effort was calculated by the catch in each grid in 2018 divided by density index.

The abundance index by age (0 - 3+) calculated by 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 2-1-note3). The abundance indices of 2018 are high at age 1 and low at age 2 comparing with past 14 years. The indices of age 0 and 3 are average level in 2018. From 2018, new abundance for age 0 and 1 calculated with size data of landing statistics at Sakai port were used for analysis (Kuroda et al. 2019, Fig. 4-2, Appendix 2-1-note3). The abundance indices in 2018 were slightly low at age 0 and very high at age 1 comparing with past 14 years. It is considered that each index well indicates the status of stock at age from fitting of indices and model projection in cohort model.

(3) Trends in biomass and fishing pressure

The stock biomass estimated by cohort model were around 1,000,000 tons during 1973 to 1989 and relatively stable (Fig. 4-3, Table 3-2). It rapidly decreased to 640,000 tons in 1990, then increased again, and it became 1,370,000 tons in 1996. Thereafter, it again rapidly down to 500,000 tons after 2000. Recently it became the lowest of 370,000 tons in 2013, then after 2014 it increased around 600,000 tons and 650,000 tons in 2018. Fishing ratio rapidly increased in 1996, then stayed in high level of 40 to 50%, and decreased at 2014 and 2017. The ratio of 2018 was 45% (Fig. 4-3, Table 3-2).

The recruitment (abundance of age 0) indicated high number of 3,300 million individuals in 1995, then decreased around 1,000 to 1,500 million after 2000s (Fig.4-4, Table 3-2). Recently it decreased 800 million in 2013, then became high level of 1,500 million in 2014 and 2,000 million in 2017. The number of 2018 was 1,300 million.

The SSB (abundance of adult) increased up to 470,000 tons during 1993 to 1996, it rapidly decreased in 1997, it down to 120,000 tons in 2003 (Fig. 4-4, Table 3-2). Thereafter it fluctuated ranging 110,000 to 190,000 tons until 2014, it increased from 110,000 at 2014 to 170,000 tons in 2015 by high recruitment of 2014. Then it decreased, but it increased again up to 240,000 tons in 2018.

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 increased according increase of M, it affect around 10% od estimated values if M changed 0.1 (Fig.4-5).

Fishery coefficient F (average of F at each age) decreased during 1973 to 1984, then gradually increased until 1995, then rapidly increased in 1996 (Fig. 4-6). After 2009, F indicated gradually decreased, it stayed around same level past five years. F of age 0 tended to increase after 1990, but it decreased after 2009 (Fig. 4-6). Although the effective effort of purse seine decreased, but F did not decrease. It may be due to the Korean catch.

Item	Value	Remarks
SB2018	238,000 tons	SSB in 2018
F2018	（age 0, 1, 2, 3+）=（0.30, 1.34, 1.01, 1.01）	
U2018	45%	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 4-7 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 was the lowest in 1996, then it tended to increase.

The relation between average fishing pressure in recent five years selectivity (2014 to 2018) and %SPR are shown in Fig. 4-8. The current fishing pressure (F2016-F2018) is higher than Fmed, F30%SPR and F0.1 as biological reference point. Figure 4-8 also indicates the relation between average fishing pressure at MSY and %SPR. The current F (F2016-2018) and F2018 are higher than Fmsy.

Item	Value	Remarks
%SPR（F2018）	16.7%	%SPR in 2018
%SPR（F2016-2018）	15.6%	%SPR corresponding to current fishing pressure (F2016-F2018)

（5）Stock-recruitment relationship

Figure 4-9 shows the Stock-recruitment (S-R) relationship between SSB (in biomass) and recruitment (in numbers). According to the ‘Research Institute meeting on Reference points for the Pacific Stock of Chub Mackerel’ mentioned above, it is suggested to use the Hockey-Stick functional response type for the S-R relationship of this stock (Yasuda *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（Kuroda et al. 2019）, 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 in the Table below.

S-R relationship	Optimization method	Auto-correlation	*a*	*b*	S.D.
Hockey-Stick (HS) type	Least square	No	0.00755	237,192	0.31

Here, parameter *a* is the steepness (numbers / g) of the HS S-R curve 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 1973, which was suggested at the 'Research Institute meeting on Reference points for the Pacific Stock of Chub Mackerel' suggested above (Yasuda *et al.* 2019).

Item	Suggested value	Remarks
SBmsy	310,000 tons	SSB that will obtain MSY
Fmsy	（age 0, 1,2,3+）=（0.33, 1.07, 0.69, 0.69）	
%SPR（Fmsy）	20%	%SPR corresponding to Fmsy
MSY	323 thousand tons	MSY

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

Figure 4-10 shows a Kobe-plot which shows the relationship between SSB and its corresponding fishing pressure. F/Fmsy shows the yearly ratio between F and F under the current selectivity that gives Fmsy which was converted to %SPR. The fishing pressure of this stock in recent years has been above the level of MSY. The fishing pressure in 2018 was 1.24 times larger than Fmsy. Moreover, the SSB is considered to be lower than the SBmsy since 1997 (Table 3-2), and the SSB in 2018 is 0.77 times the SBmsy. The values used in Fig. 4-10 are calculated by three years moving average.

Item	Value	Remarks
SB2018/ SBmsy	0.77	Ratio between the SSB that gives MSY and the SSB in 2018
F2018/ Fmsy	1.24	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 were around 1 million tons during 1973 to 1996, and it decreased around 500,000 tons since 2000. After 2014, it increased around 600,000 tons due to the high recruitment, and it became 650,000 tons in 2018. The SSB (abundance of adult) increased 470,000 tons during 1993 to 1996, it rapidly decreased in 1997, and it down to 120,000 tons in 2003. Thereafter the SSB fluctuated between 110,000 and 190,000 tons until 2014. It increased to 240,000 tons in 2018.

The SSB in 2018 is considered as “warning” level due to the lower level of SBmsy, but its trend is considered “increasing” because of the trends of past five years (2014-2018). Fishing pressure in recent years stays in same level, and it is above Fmsy level.

6. Other matters

So far, management of the stock was conducted by effort control including limitation of licensed vessels for purse seine. It is also conducted the management based on TAC of “mackerels” including blue mackerel since 1997. In addition, the stock rebuilding plan for Jack mackerel (including chub mackerel and pacific sardine) in western Japan sea and western water of Kyusyu was conducted during 2009 to 2011. The plan aimed to protect small juvenile, it required shift of fishing ground for large purse seine and reducing fishing and landing days for small purse seine when they have the concentration of small fish catch. Those trials are continued under new guideline of fishery stock management after 2012.

It is considered that the cause of large uncertainty of assessment is the lack of the information of Chinese vessels. Other cause of uncertainty for future projections are less accuracy of Chinese and Korean predicted catches, and the difficulty of Japanese catch projection caused by the TAC including both chub and blue mackerels. Those causes may afect on stock-recruitment relationship, biological reference points and probability of achievement management goals. For more effective stock management, it needs study for mechanism of recruitment fluctuation and migrating pattern, and conducting international cooperation of monitoring fisheries (Kuroda et al. 2019).

7. References

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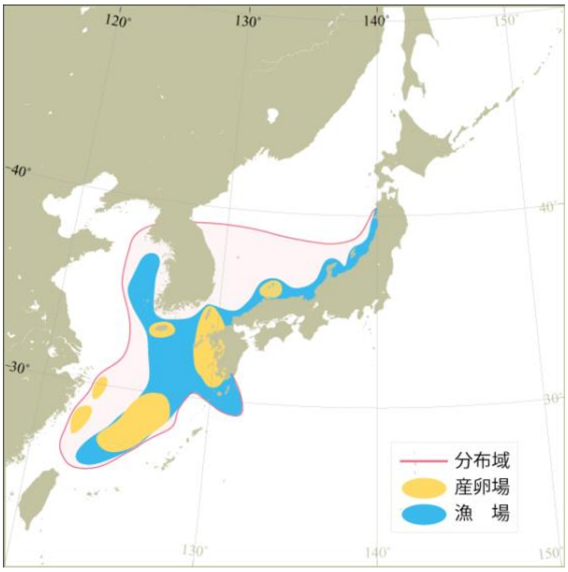

Figure 2-1. Distribution and migration of chub mackerel Tsushima stock. Yellow indicate spawning grounds, blue indicates fishing grounds.

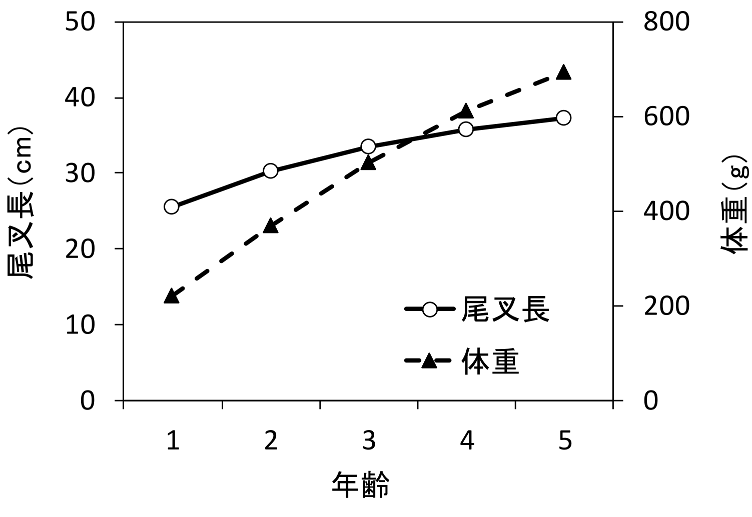

Fig. 2-2. Age and growth. Bold line indicates length (FL) by age, dotted line indicates weight by age.

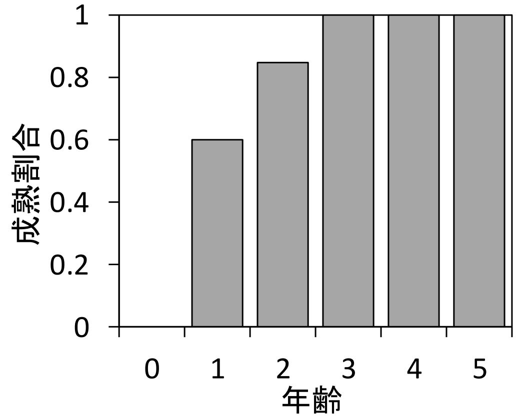

Figure 2-3. Maturity rate by age.

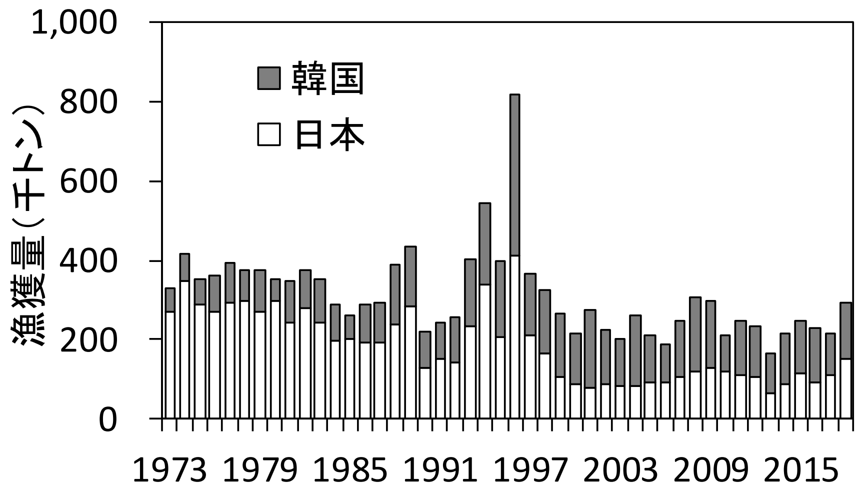

Figure 3-1. Annual catches of chub mackerel by fisheries. (Grey: Korea, white: Japan).

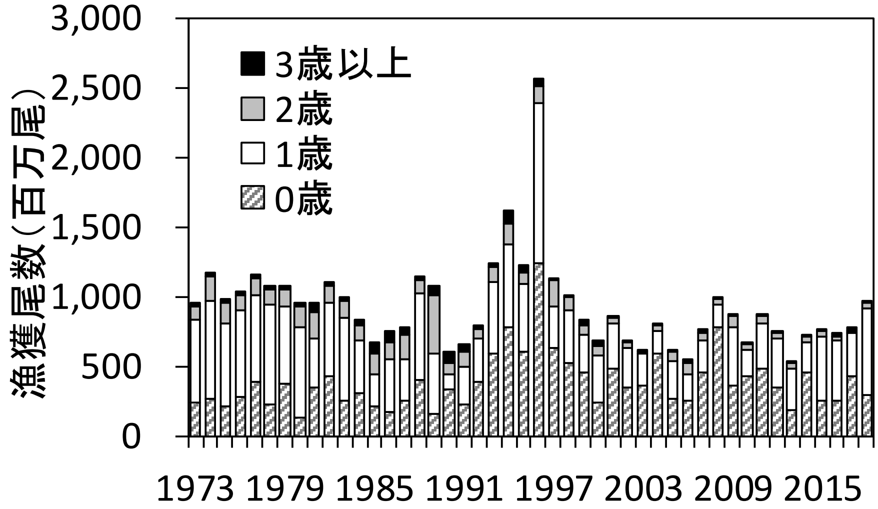

Figure 3-2. Annual age composition in catch.

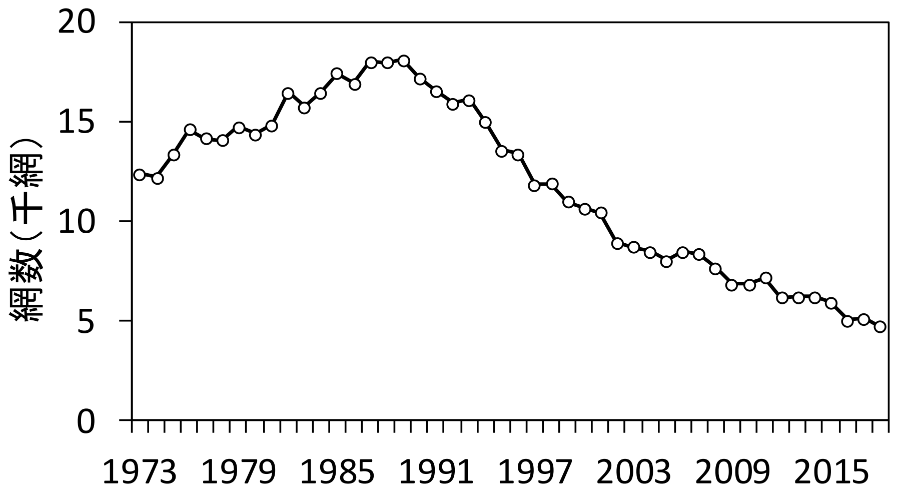

Fig. 3-3. Annual number of purse seine nets (thousands) operating in the East china sea and Japan sea.

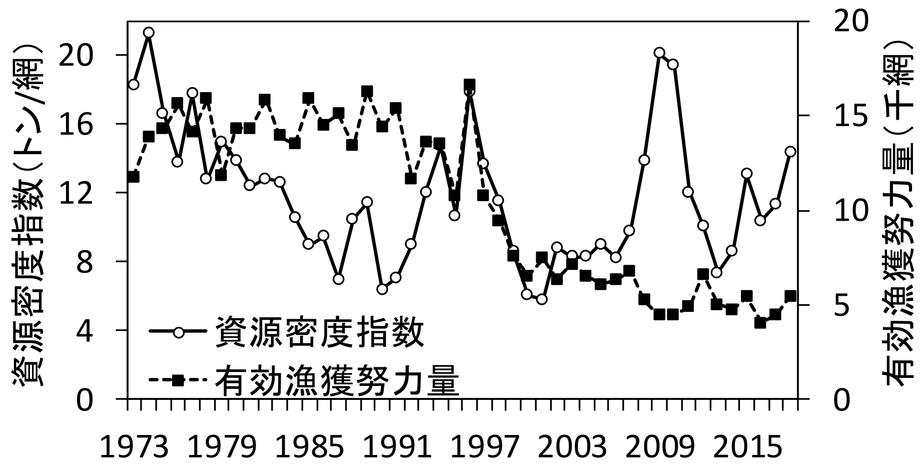

Figure 4-1. Density indices by year (bold line) and annual effective effort (dotted line) on chub mackerel by purse seine fishery. The left axis is density (ton/net), and the right axis is effective efforts (thousand nets).

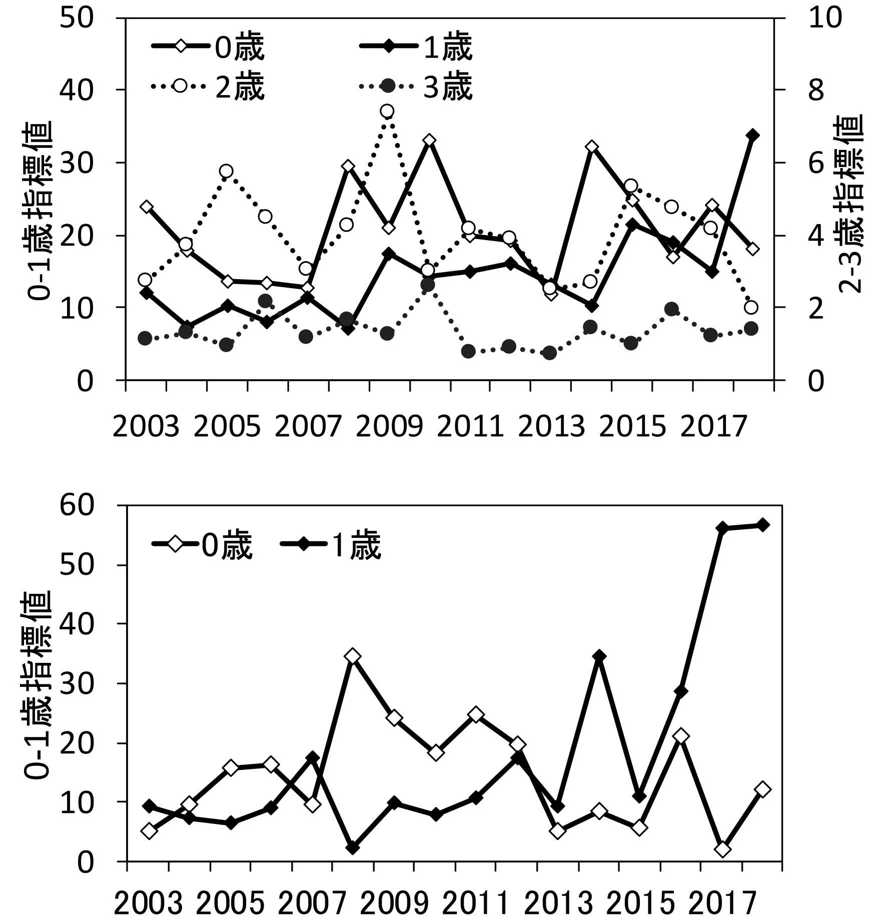

Fig. 4-2. Abundance indices by age calculated by catch by size of purse seine operating in the East china sea and Japan sea (above) and abundance indices for age 0 and 1 fish calculated by catch by size of purse seine landed at Sakai port (below).

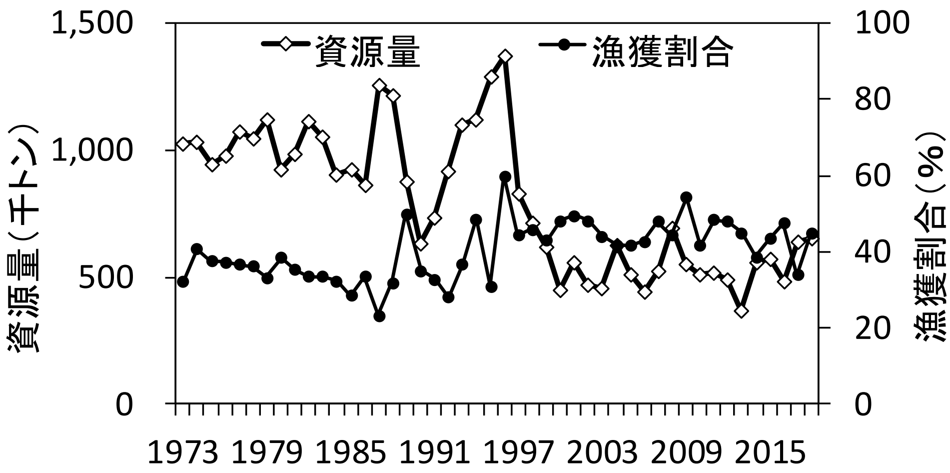

Fig. 4-3. The estimated abundances (white square) and fishing ratios (black dots) by year. The left axis is abundance (thousand tons), the right axis is fishing ratio (%).

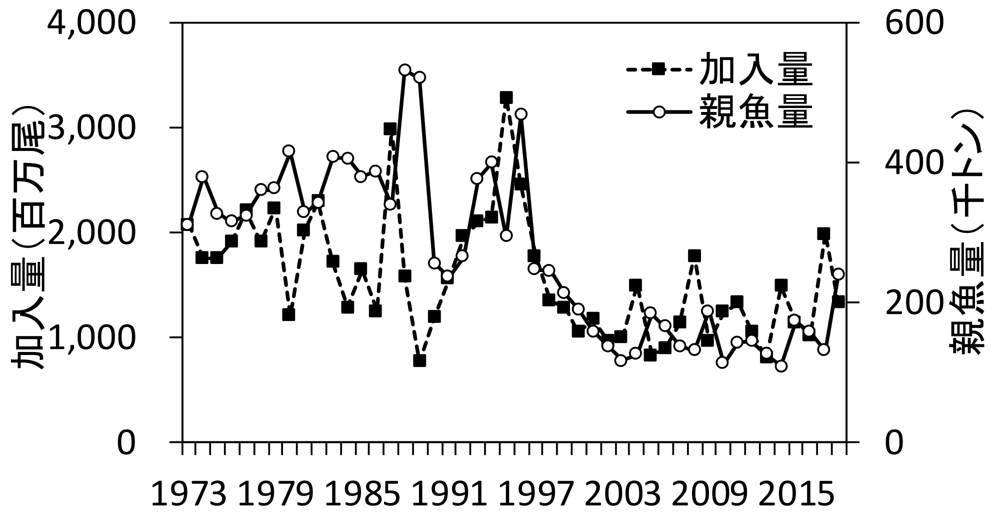

Fig. 4-4. Estimated SSB (bold line) and recruitments (dotted line) by year. The left axis is recruitment (million fish), and the right axis is SSB (thousand tons).

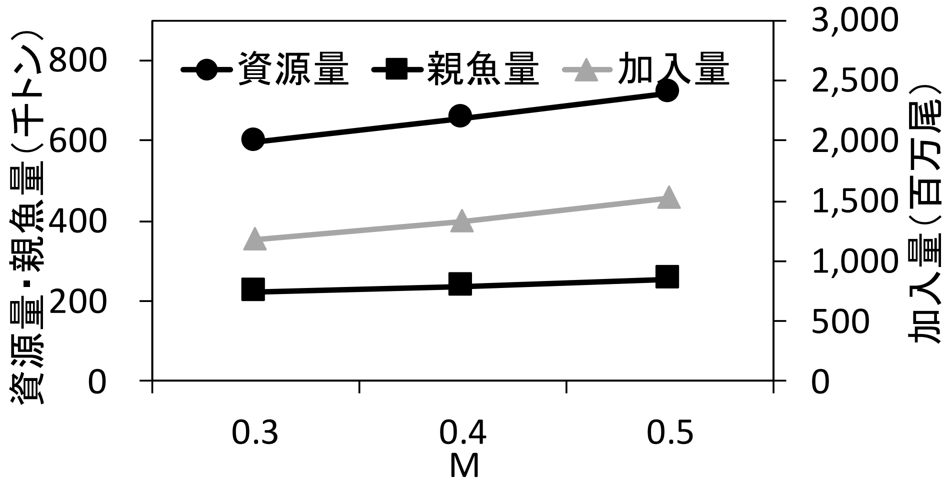

Fig. 4-5. Fluctuations of stock abundance (circle), SSB (square) and recruitment (triangle) according to changes of natural mortality M.

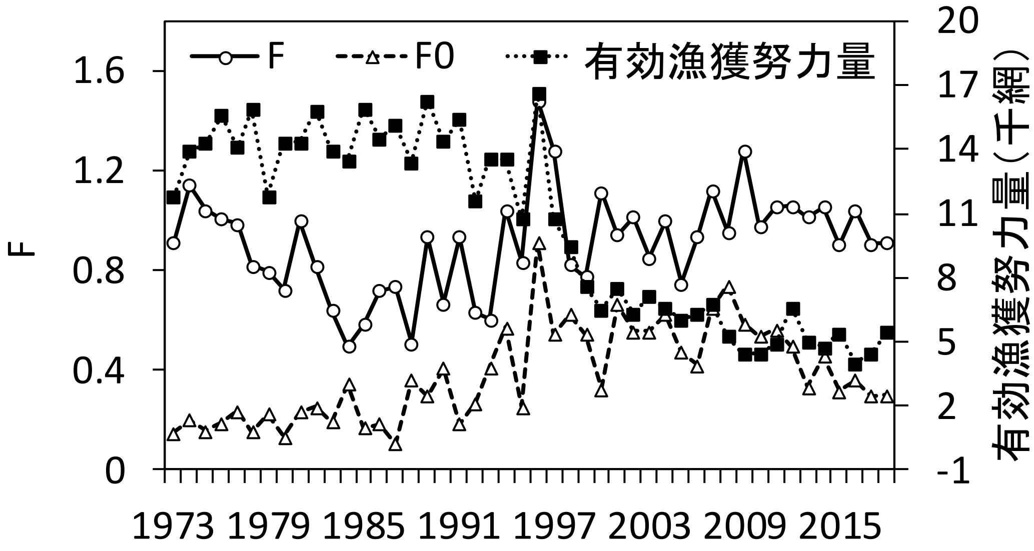

Fig. 4-6. The average of F at age (white circle), F of age 0 (triangle), and effective efforts (square) by year. The left axis indicates F, and the right indicates effective effort (thousand nets).

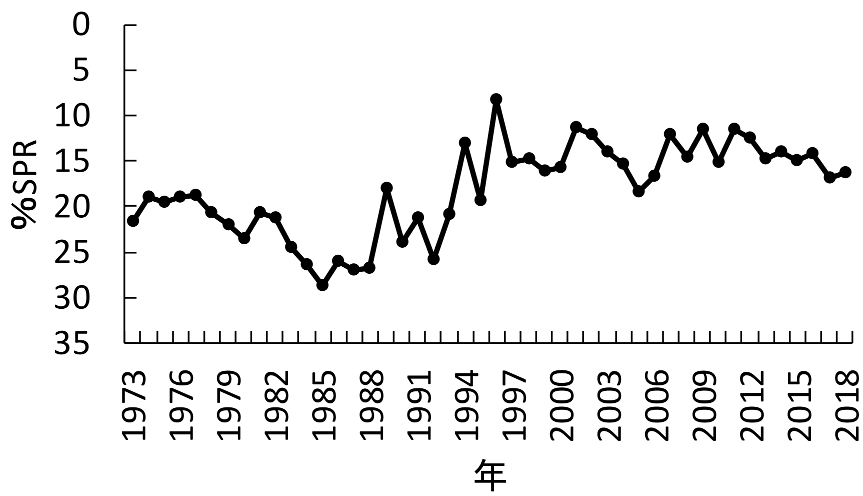

Fig. 4-7. Fluctuations in %SPR by years. %SPR shows the ratio of SSB when no fishing to the SSB when there is fishing, and %SPR becomes low with high *F* and vice versa.

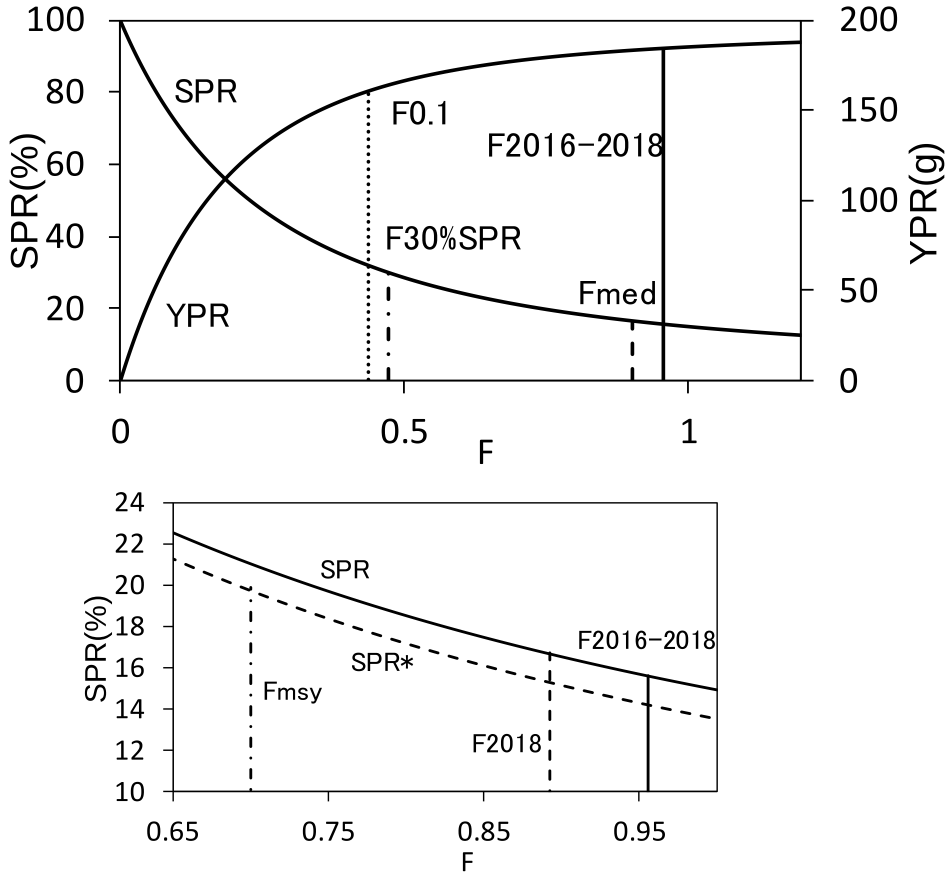

Fig. 4-8. Relationship between the fishing mortality (F, simple average) and %SPR, YPR (above). Relationship between F and %SPR (below).

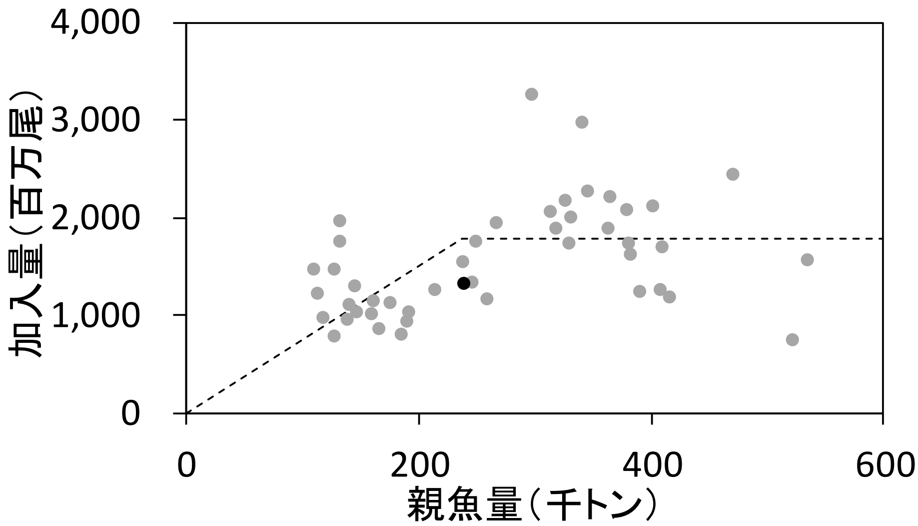

Fig. 4-9. Relationship between SSB (thousand tons) and recruitment (million fish). The dotted line shows the S-R relationship suggested at the 'Research Institute meeting on Reference points' held in April 2019 (Yasuda et al. 2019). Black dot indicates value of 2018.

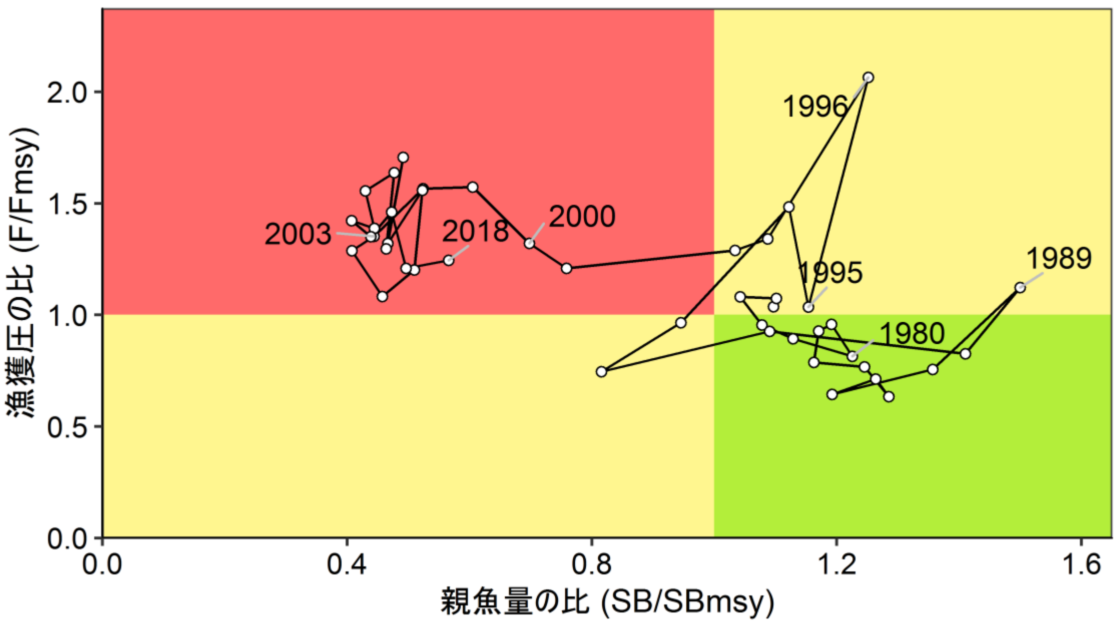

Fig. 4-10. Relationship between the SSB/SBmsy and F/Fmsy (Kobe plot). The *F* and SSB is the three-year moving average.

Table 3-1. Annual chub mackerel catch (tons) by purse seine and by prefecture. The captions in the table below are from the left: Fishing 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 chub mackerel catch (tons) by purse seine and by prefecture. The captions in the table below are from the left: Fishing 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