North Pacific Fisheries Commission

NPFC-2022-TWG CMSA05-WP04

Update stock assessment based on ASAP (age-structured assessment program) for Chub mackerel in the North Pacific Ocean 2022

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Introduction

To support the development of operating model for Chub mackerel *Scomber Japonicus*, this research established an Age-Structured Assessment Program (ASAP), which is the one of five stock assessment model candidates (ASAP, SAM, VPA, BSSPM and KAFKA) for Chub mackerel in the NPFC. This document provided the progress of ASAP for Chub mackerel, updating based on the previous version in NPFC-2021-TWG CMSA04-WP01. The updated ASAP, considered all scenarios and model settings, which were adopted in the last meeting of the technical working group for Chub mackerel stock assessment (TWG CMSA04).

Materials and methods

The dataset used in this study, was still the data that China, Japan and Russia submitted in September, 2020, and complied by Dr. Shota Nishijima. This dataset includes catch-at-age, maturity-at-age, weight-at-age and abundance index. To be consistent with Japanese indices and to simplify the stock assessment model fitting process, the indices from China and Russia were all scaled by their mean values (Figure 1). The natural mortality *M* were derived from NPFC-2019-TWG CMSA02-WP01 (Rev.2), which were the median estimate 0.41 and age-specified *M* from Gislason 1 method. According to the report of TWG CMSA04, for age-0 M in Gislason1, an extrapolated value was calculated (0.57; using a second order polynomial from the values of age-1 – 0.47; age-2 – 0.38; age-3 – 0.32; age-4 – 0.28; age-5 – 0.26; age-6+ – 0.24).

Based on the above dataset, 6 scenarios were set for operating model, considering the different *M* estimates, different trend of maturity and weight at age among three members (Table 1). There were two base case models and four reference cases as sensitivity analysis.

ASAP is a fisheries toolbox model developed by NOAA, which has been used as an assessment tool for many fisheries, such as Pacific sardine and Pacific mackerel by SWFSC, Greenland halibut by ICES, etc. ASAP is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance.

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Results and discussions

Estimated catch was fitted well through all 12 scenarios, while the abundance indices fittings were various among different indices (Figures 2 a-f). For the base case models (S1 and S2), the CPUE indices from Japanese and Russian fisheries fitted reasonably well, while the indices derived from Japanese recruitment and egg survey, Chinese fishery did not fit well in recent years. The model fitting for the reference cases were relative worse than the base cases. Results of objective function indicated that the constant *M* among ages could improve the model fitting (Table 2). The reference cases with lowest weight and maturity performed similar with base cases, while the S3 and S4 with highest weight and maturity fitted a little bit worse.

The overall trends of total stock number, spawning stock biomass (SSB), and fishing mortality (*F*) were much similar among these 6 scenarios. The biomass of Chub mackerel has kept at high level before 1980, then declined to low value, recovered since 2010, with a similar trend of abundance and spawning stock biomass (Figures 3-4). During 1985~2005, the fishing mortality for Chub mackerel was high, and stock abundance was much low (Figures 4).

There are no significant difference of abundance and fishing mortality estimates among all scenarios. The reference cases with highest maturity and weight matrix (S3 and S4), would provide much higher estimate for SSB, while SSB estimates from reference cases with lowest maturity and weight matrix (S5 and S6), were much lower after 2015, when the different maturity and weight matrix among members were available (Figure 3).

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The maximum sustainable yield (MSY) for Chub mackerel was estimated to be 1.75×10^5 and 1.65×10^5 metric tons from S1_41_avgerage and S2_Mage_average, respectively (Table 2). The fishing mortality and SSB of base cases in the MSY level were about 1.31~1.32 and $6.19\sim6.36\times10^4$ metric tons, respectively.

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Tables

Table 1 Operating model setting for Chub mackerel in the North Pacific Ocean

	Scenarios	M	Weight-at-age	Maturity-at-age	Catch-at-age	Abundance Index	Fleet
Base cases	S1_41_average	0.41	Average	Average	Average	All six	Single
	S2_Mage_average	Gislason at age	Average	Average	Average	All six	Single
Reference cases	S3_41_high	0.41	Highest	Highest	Average	All six	Single
	S4_Mage_high	Gislason at age	Highest	Highest	Average	All six	Single
	S5_41_low	0.41	Lowest	Lowest	Average	All six	Single
	S6_Mage_low	Gislason at age	Lowest	Lowest	Average	All six	Single

Table 2 Model fitting and estimations for Chub mackerel by all ASAP scenarios

Scenarios	Objective function	$F_{0.1}$	F_{max}	$F_{30\%SPR}$	$F_{40\%FPR}$	F_{MSY}	F_{2019}	SSB_{MSY} (t)	MSY (t)
S1_41_average	2310	0.47	1.68	0.45	0.31	1.32	0.18	61901.5	174966
S2_Mage_average	2322	0.32	2.39	0.32	0.21	1.31	0.21	63612.3	165303
S3_41_high	2314	0.42	0.80	0.62	0.44	0.78	0.14	311659	234604
S4_Mage_high	2327	0.34	0.73	0.51	0.34	0.71	0.16	340810	228861
S5_41_low	2311	0.42	1.34	0.31	0.22	0.89	0.21	34673.2	145635
S6_Mage_low	2322	0.28	1.46	0.23	0.17	0.77	0.24	50434	138361

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Figures

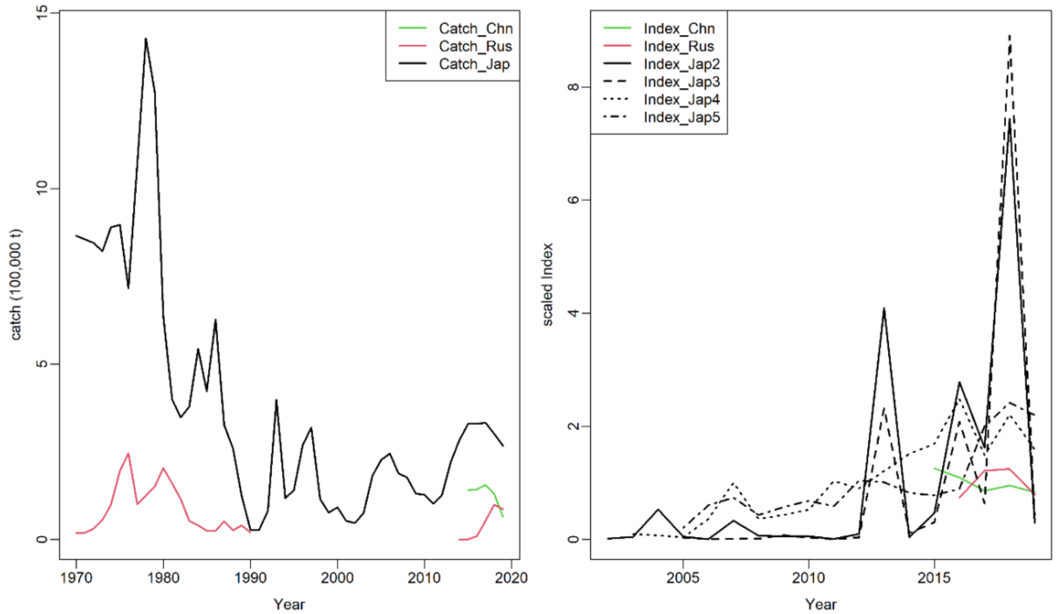

Figure 1. Catch and abundance index of Chub mackerel fisheries of China, Japan and Russia in the north Pacific Ocean from 1970 to 2019

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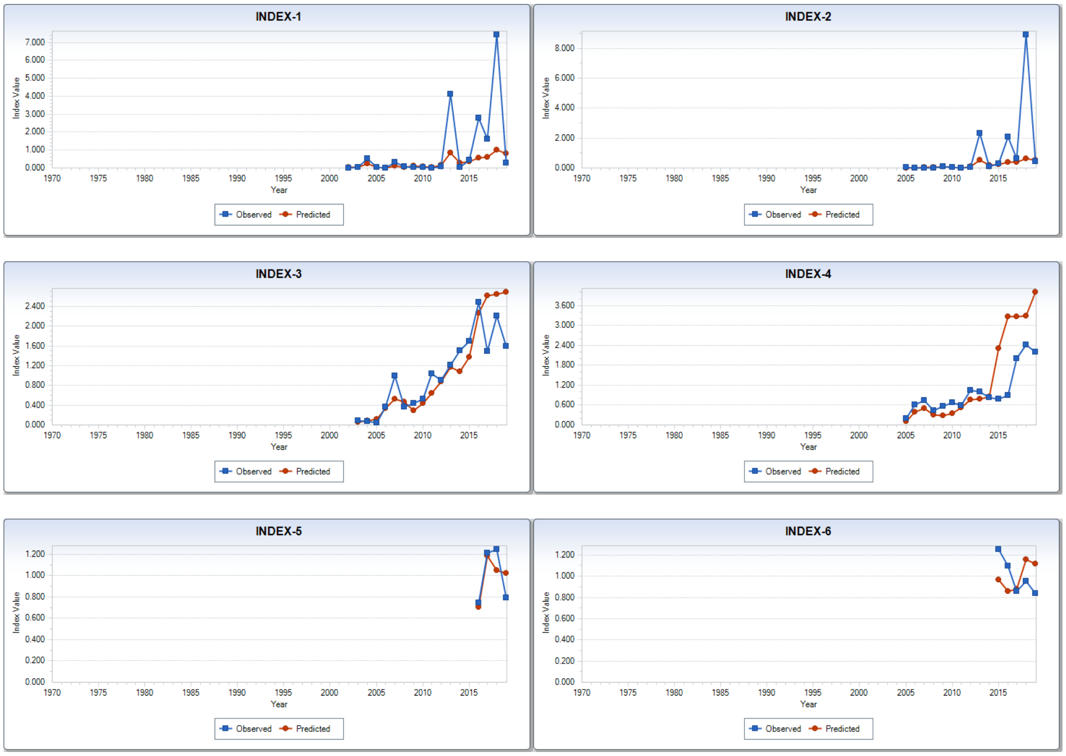

Figure 2(a). Index fitting in the ASAP S1-41-avg for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
INDEX-3 represents the Index_Jap4, form the Japanese die-net fishery.
INDEX-4 represents the Index_Jap5, form the Japanese egg survey.
INDEX-5 represents the CPUE from Russian fishery.
INDEX-6 represents the CPUE from Chinese fishery.

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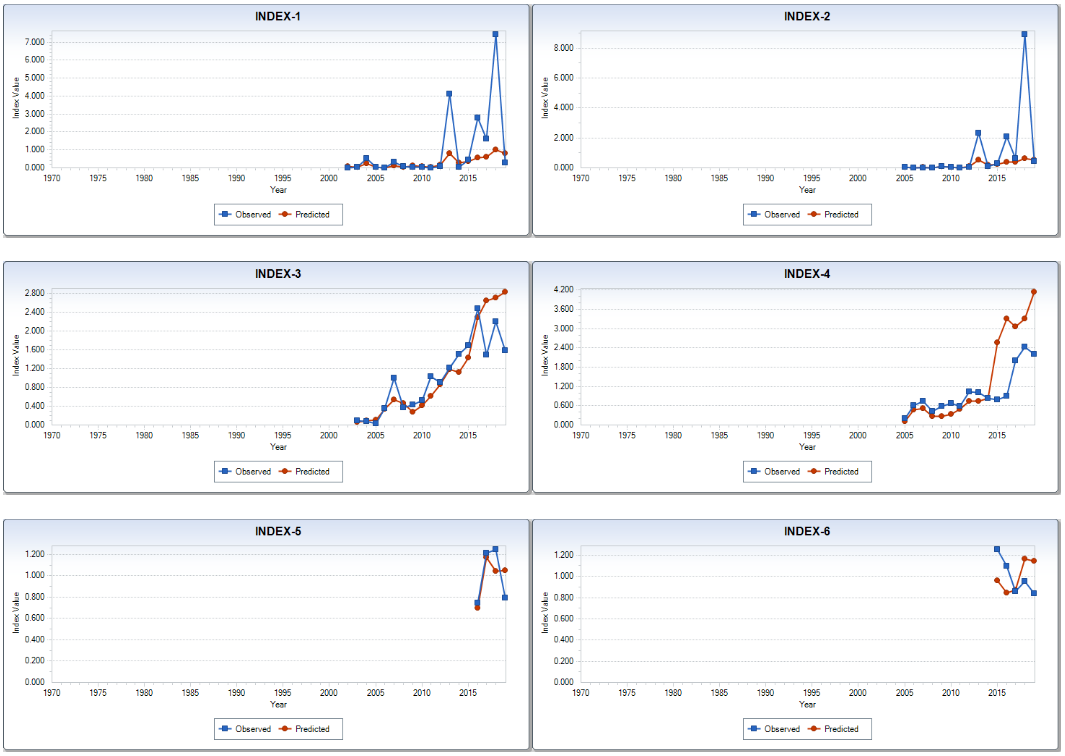

Figure 2(b). Index fitting in the ASAP S2-Mage-avg for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
INDEX-3 represents the Index_Jap4, form the Japanese die-net fishery.
INDEX-4 represents the Index_Jap5, form the Japanese egg survey.
INDEX-5 represents the CPUE from Russian fishery.
INDEX-6 represents the CPUE from Chinese fishery.

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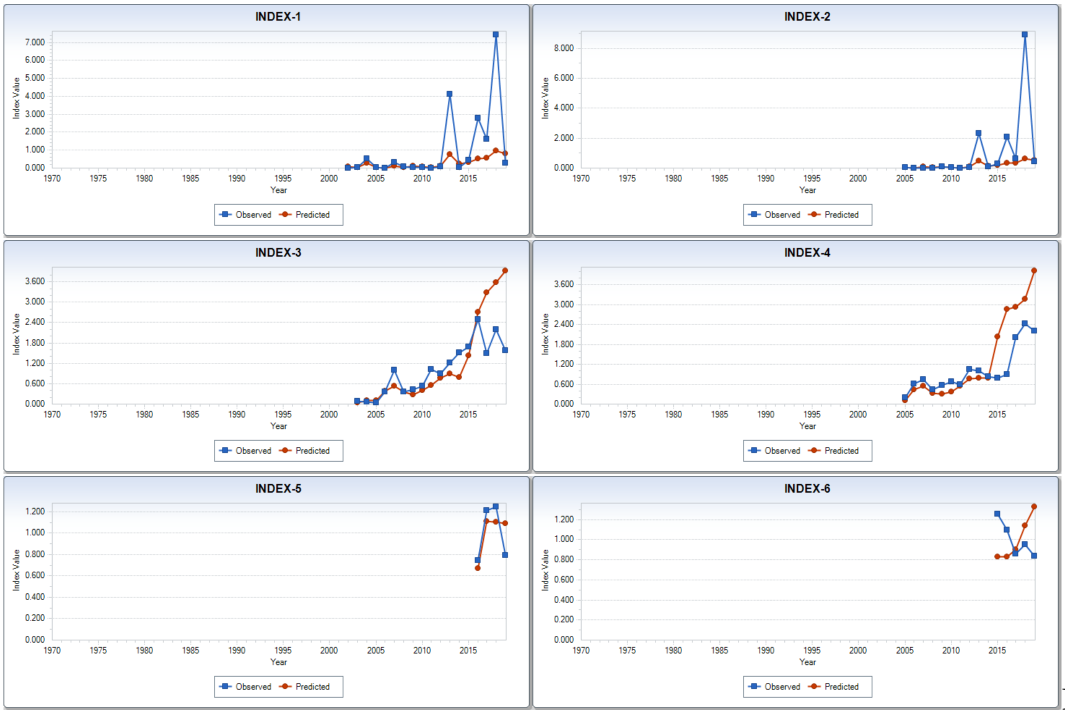

Figure 2(c). Index fitting in the ASAP S3-41-high for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
INDEX-3 represents the Index_Jap4, form the Japanese die-net fishery.
INDEX-4 represents the Index_Jap5, form the Japanese egg survey.
INDEX-5 represents the CPUE from Russian fishery.
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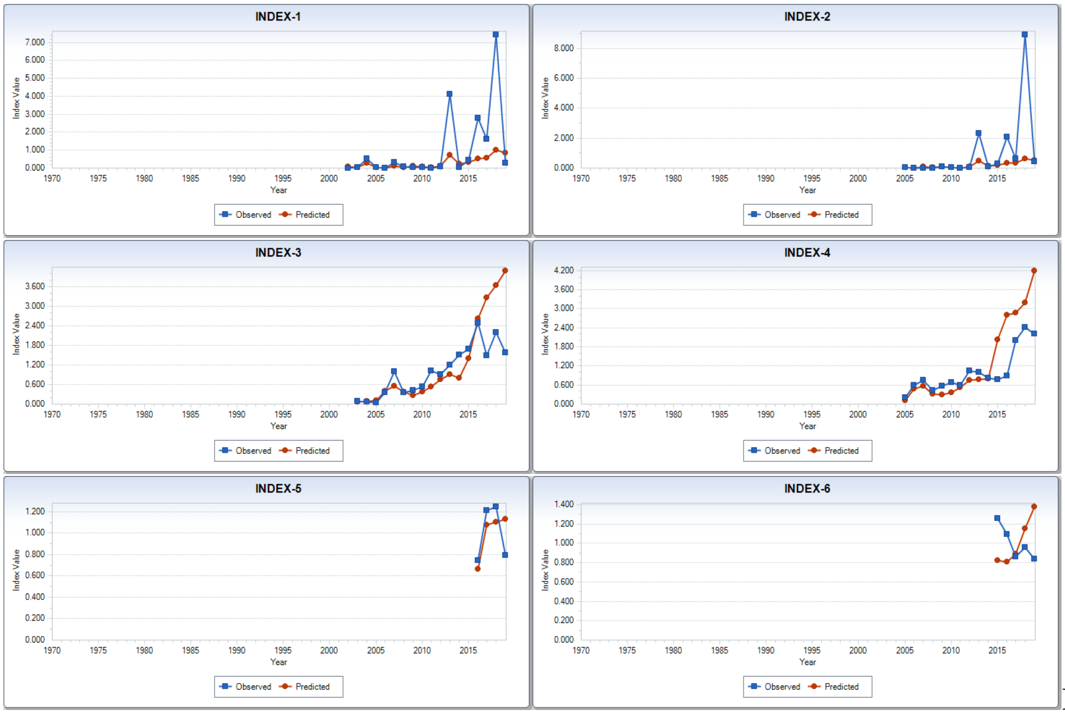

Figure 2(d). Index fitting in the ASAP S4-Mavg-high for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
INDEX-3 represents the Index_Jap4, form the Japanese die-net fishery.
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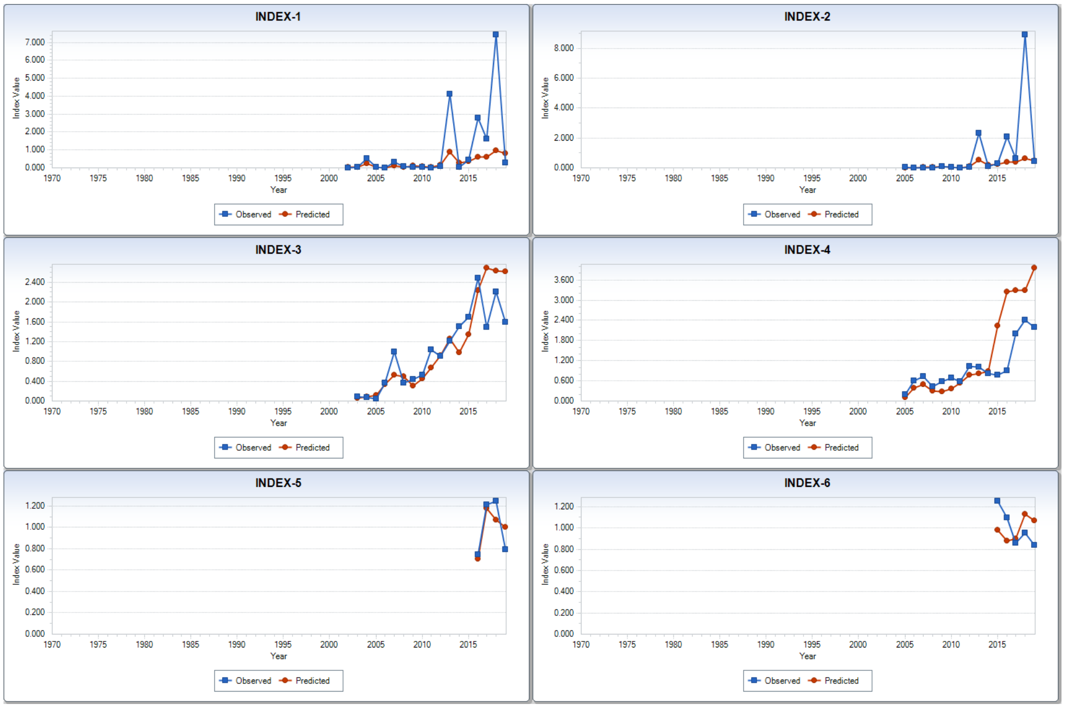

Figure 2(e). Index fitting in the ASAP S4-Mavg-high for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
INDEX-3 represents the Index_Jap4, form the Japanese die-net fishery.
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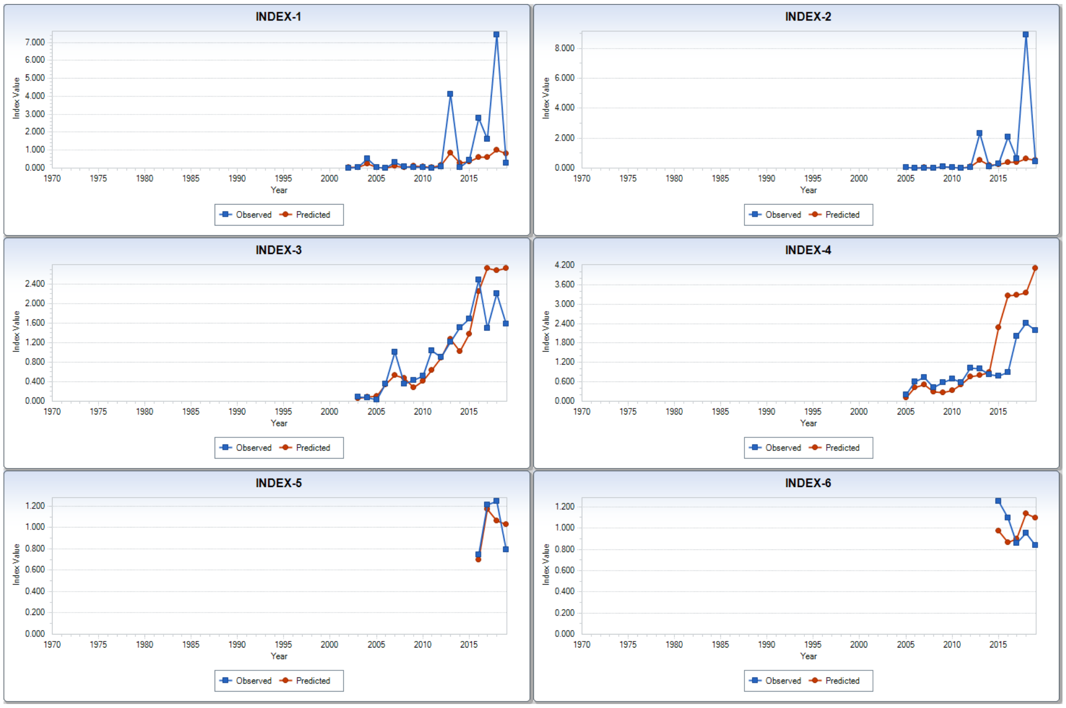

Figure 2(f). Index fitting in the ASAP S4-Mavg-high for Chub mackerel.

INDEX-1 represents the Index_Jap2, form the Japanese Recruitment survey in summer.
INDEX-2 represents the Index_Jap3, form the Japanese Recruitment survey in autumn.
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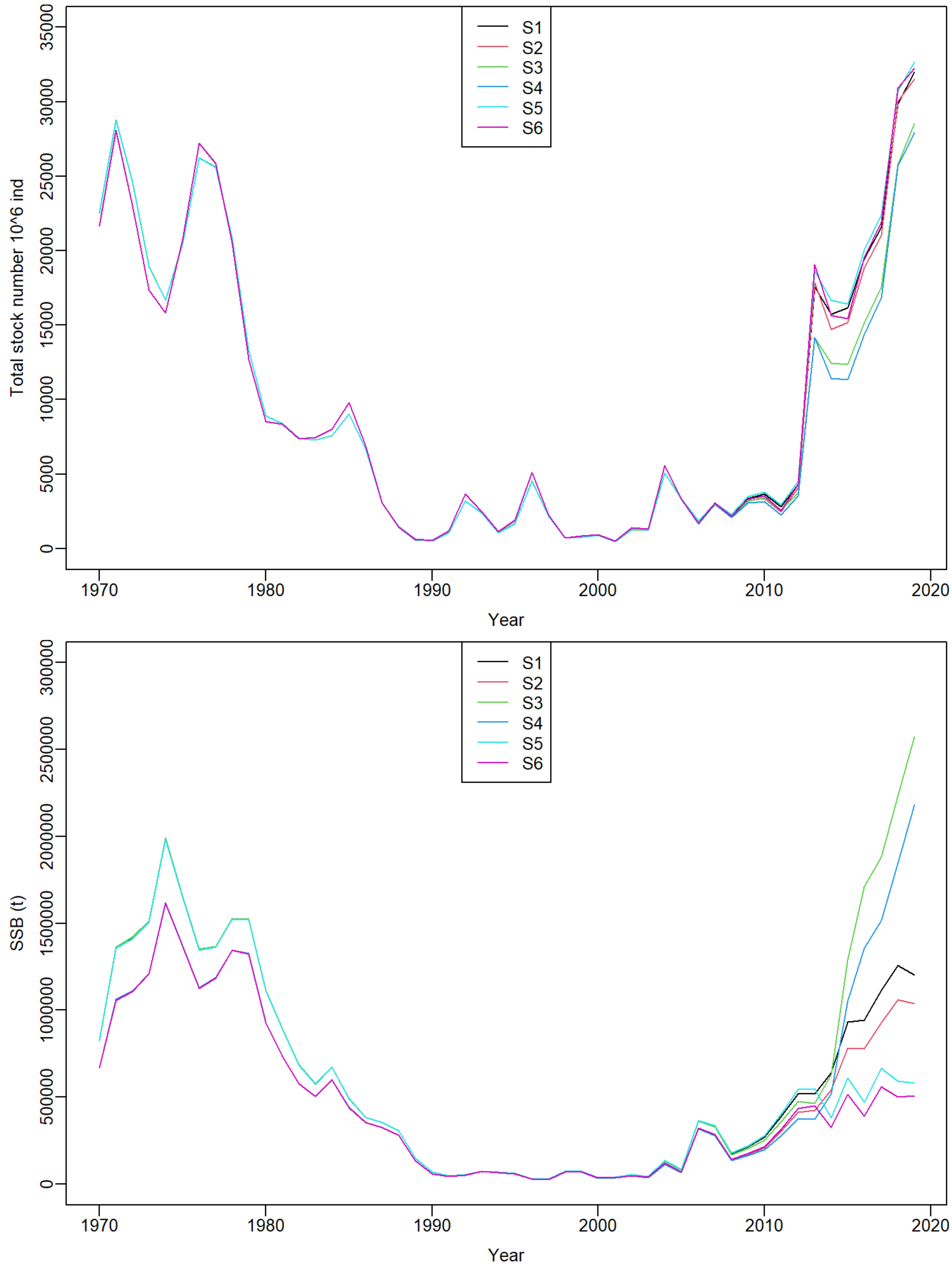

Figure 3. The abundance and SSB estimates from ASAP for Chub mackerel

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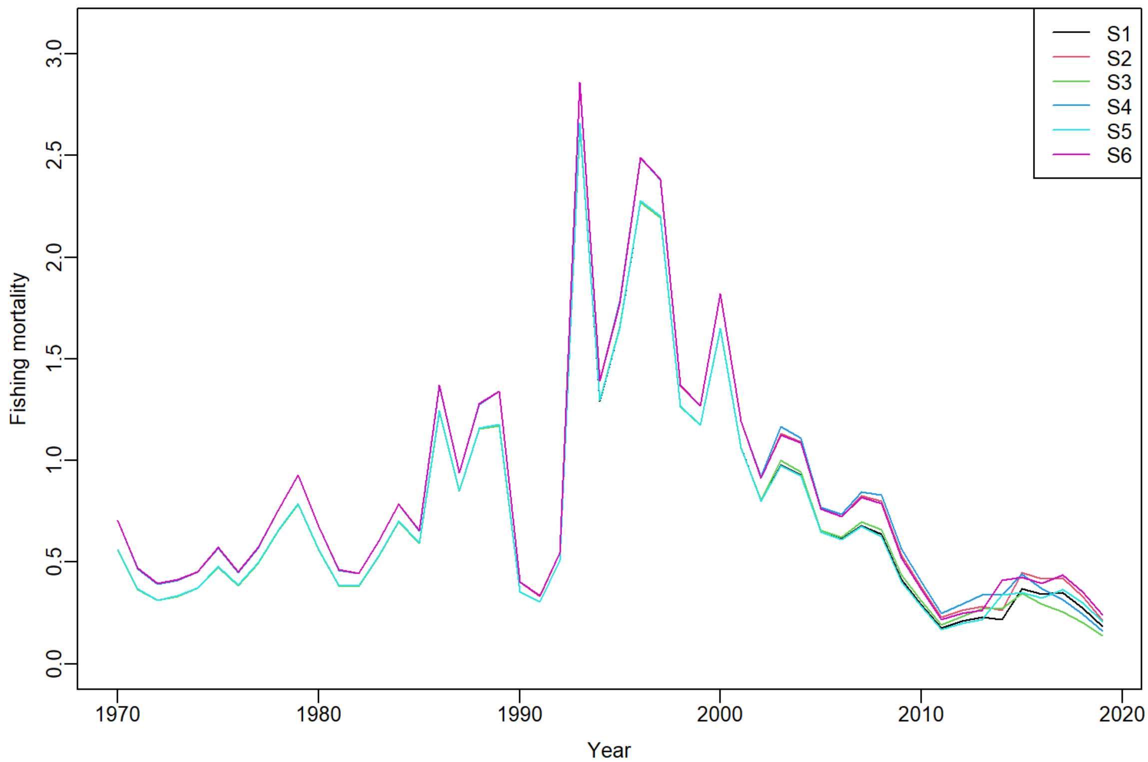

Figure 4. The fishing mortality estimates from ASAP for Chub mackerel

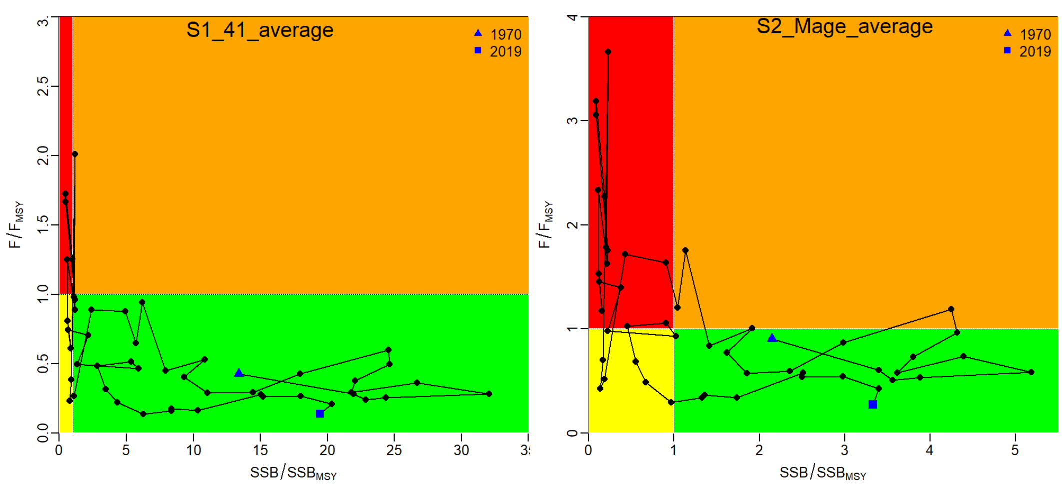

Figure 5. The Kobe plot among 1970-2019 from ASAP Base Case 1&2 for Chub mackerel.

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