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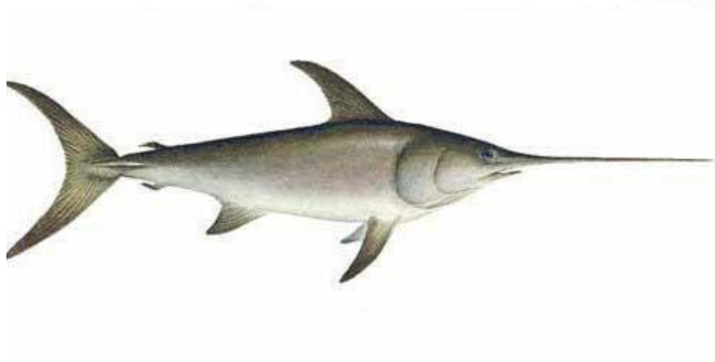
A Sensitivity Analysis of Alternative Natural Mortality Schedule and Steepness in the Pacific Blue Marlin Stock Assessment [1]

Mikihiko Kai and Kotaro Yokawa
National Research Institute of Far Seas Fisheries
Shimizu, Shizuoka, Japan



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A sensitivity analysis of alternative natural mortality schedule and steepness in the Pacific blue marlin stock assessment

Mikihiko Kai[a] and Kotaro Yokawa[a]

[a]National Research Institute of Far Seas Fisheries
Orido5-7-1, Shimizu, Shizuoka, Shizuoka, 424-0902, Japan.

Abstract

This paper describes an alternative proposal of key input parameters of natural mortality rate (*M*) and steepness (*h*) in stock synthesis 3 using sensitivity analyses based on the results of a preliminary base run (Model 1) provided by Lee et al. (2013). Higher *M* and lower *h* tended to increase the SSB and lower *M* and higher *h* tended to decrease the SSB. In particular, it was cleared that high adult M (2+) can increase the SSB in early periods and decrease the SSB in late periods. The changes in *M* also impact on the SSB ratio (SSB1971/S0), while there were no clear patterns of the SSB ratio for *h*. In conclusion, the results of several trials suggest that the re-examinations of the natural mortality schedule could have some positive effect.

This paper describes an alternative proposal of key input parameters of natural mortality rate (*M*) and steepness (*h*) in stock synthesis 3 (Method 2012) using sensitivity analyses based on the results of a preliminary base run (i.e. Model 1 in Lee et al. (2013), it's referred to as "Base" in this paper). An issue is the interpretation of low level for the stock spawning biomass (SSB) ratio. The relative value of SSB to unfished SSB (S0) in 1971 (initial year of stock assessment period) was 27% (Table1, Fig.1). Since the level of mean catch (12,748 tons) before 1971 was lower than that (17,742 tons) after 1970 (Fig.2), the lower catch in 1950s and 1960s may not account for the sharp decline of SSB from S0. In addition, the annual catch less than 10,000 tons of billfishes from 1922 to 1951 (Fig.3) supports the low catch of blue marlin in early periods. Though the species of billfish can not be identified from the record, catch of blue marlin should not be the largest ones among billfish as swordfish and striped marlin are more abundant in the area around Japan. Thus the catch level of blue marlin in this period should be rather low than that in the 1950s. The lower SSB level in the initial year estimated by SS3 also seems not supported by the alternative stock assessment results (Kanaiwa et al.2013, Chang et al, 2013) by Bayesian Surplus Production Model (BSPM, McAllister and

Babcock 2006). that suggested the catch in the 1950s and 1960s had minor influences on the biomass level.

To investigate the possible solution for the problems described above, an alternative test run was conducted using the data for 1952-2011. The effect of lower catch in the early periods on the estimates of S0 was examined. The specification of the model setting was the same as the “Base” except for the catch data. Annual catch of fleet 1(Japanese distant water and offshore longline early) was separated into four seasonal catches using the ratio of mean seasonal catch for 1971-1975. Mean annual catch of 1,719 tons from 1946 to 1951 was given as an initial equilibrium catch for fleet1 based on the assumption that the catch of blue marlin may accounts for about 1/3 of billfish (See at Fig.3). The time series of SSB indicated similar low level of SSB ratio over the whole stock assessment periods (Fig.4). This result means that the ratio is implausible because the catch level of blue marlin before 1952 is believed to be considerably low (Fig.3).

Natural mortality rate (*M*) and steepness (*h*) parameters can be major sources of model misspecification in the stock assessment. In order to examine the impacts of *M* and *h* on the estimation of SSB, S0, and the ratio, sensitivity analyses were conducted based on the results of a “Base” (Lee et al. 2013). The impacts of the changes in *M* and *h* were shown in Table1. The annual changes in SSB were shown in Figs.5 and 6. These results showed that *M* and *h* may have large impacts on the magnitude of SSB over the whole stock assessment period. Higher *M* and lower *h* tended to increase the SSB and lower *M* and higher *h* tended to decrease the SSB (Figs.5 and 6). In particular, it was cleared that high adult M (2+) can increase the SSB in early periods and decrease the SSB in late periods. The changes in *M* also impact on the SSB ratio in 1971, while there were no clear patterns of the SSB ratio for steepness (Table1).

Two sex-specific M schedules for two scenarios “Base” and “High_Female_Age2+” in table1 were shown in Fig.7. The historical time series of SSB (tons) for the scenarios were shown in Fig.8. When the value of *M* for adult female was increased from 0.22 to 0.32, the SSB ratio in 1971 was raised from 27% to 49 %. Therefore, higher value of adult female M is more suitable than lower adult M from the perspective of the consistency with historical catch of Pacific blue marlin.

Further scenario for “High_Female_Age2+” was conducted using the catch data for 1952-2011(right panel in Fig.9). The result indicated that the SSB in 1952 was almost similar to the unfished stock level (Table 2) and the SSB sharply decreased thereafter until 1970s (Fig.9). This was because of the increase of adult female *M* and small initial equilibrium catch of fleet1 resulted in low estimates of fishing mortality rate (*F*) of fleet1 (Table2). This is an extreme result but it should be taken notice that the cpue and size data for 1952-1970 were not included in the scenario. The problem might be mitigated if those data are added.

The preliminary stock assessment done by Lee et al. 2013 seems to attain good fitting of the estimates to the inputs data. Thus the SSB trajectory in the period of 1971-2011 would be well estimated and it seems that there is no conflicting with the ones by BSPM. In this document, we seek the possibilities to adjust the observed large differences of biomass levels in 1971 relative to S0 or K estimated by SS3 and BSPM. The results of several trials suggest that the re-examinations of the natural mortality schedule could have some positive effect, because investigation of other possibilities other than M would also be necessary to prepare the more plausible results. This should also give good benefit for the improvement of the inputs used in the blue marlin stock assessment for the future works.

References

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Table 1. Summaries of sensitivity analyses to natural mortality rate (*M*) and steepness (*h*) based on catch data from 1971 to 2011.

Scenarios	M (Female)			M (Male)			Steepness	Initial-F of JP_DWLL	S0 (ton)	SSB1971 (ton)	Ratio (SSB1971/S0)
	Age0	Age1	Age2+	Age0	Age1	Age2+					
Base	0.42	0.37	0.22	0.42	0.37	0.37	0.87	1.10	121,393	32,805	0.27
High	0.52	0.47	0.32	0.52	0.47	0.47	0.87	0.23	84,289	59,188	0.70
Low	0.32	0.27	0.12	0.32	0.27	0.27	0.87	2.76	382,415	14,541	0.04
High_Female_Age2+	0.42	0.37	0.32	0.42	0.37	0.37	0.87	0.61	78,676	38,657	0.49
Low_Female_Age2+	0.42	0.37	0.22	0.42	0.37	0.22	0.87	1.53	113,868	20,367	0.18
High_Age0	0.52	0.37	0.22	0.52	0.37	0.37	0.87	1.10	121,366	32,836	0.27
High_Age01	0.52	0.47	0.22	0.52	0.47	0.37	0.87	0.92	116,845	37,972	0.32
High_Age2+	0.42	0.37	0.32	0.42	0.37	0.47	0.87	0.37	84,335	51,563	0.61
Low_Age0	0.32	0.37	0.22	0.32	0.37	0.37	0.87	1.10	121,421	32,774	0.27
Low_Age01	0.32	0.27	0.22	0.32	0.27	0.37	0.87	1.30	127,043	28,092	0.22
Low_Age2+	0.42	0.37	0.12	0.42	0.37	0.27	0.87	2.29	331,820	18,276	0.06
Estimate of M	2	0.50	0.35	0.00	1.46	2	0.87	0.00	114,874	111,404	0.97
h05	0.42	0.37	0.22	0.42	0.37	0.37	0.5	0.86	258,468	70,513	0.27
h07	0.42	0.37	0.22	0.42	0.37	0.37	0.7	0.57	167,939	31,745	0.19
h099	0.42	0.37	0.22	0.42	0.37	0.37	0.99	0.38	106,359	35,232	0.33
Estimate of *h*	0.42	0.37	0.22	0.42	0.37	0.37	1	0.38	105,425	35,371	0.34

Table 2. Summaries of sensitivity analysis based on catch data from 1952 to 2011.

Scenarios	M (Female)			M (Male)			Steepness	Initial-F of JP_DWLL	S0 (ton)	SSB1952 (ton)	Ratio (SSB1952/S0)
	Age0	Age1	Age2+	Age0	Age1	Age2+					
Base	0.42	0.37	0.22	0.42	0.37	0.37	0.87	2.59	121,643	13,539	0.11
High_Female_Age2+	0.42	0.37	0.32	0.42	0.37	0.37	0.87	0.00	78,549	77,534	0.99

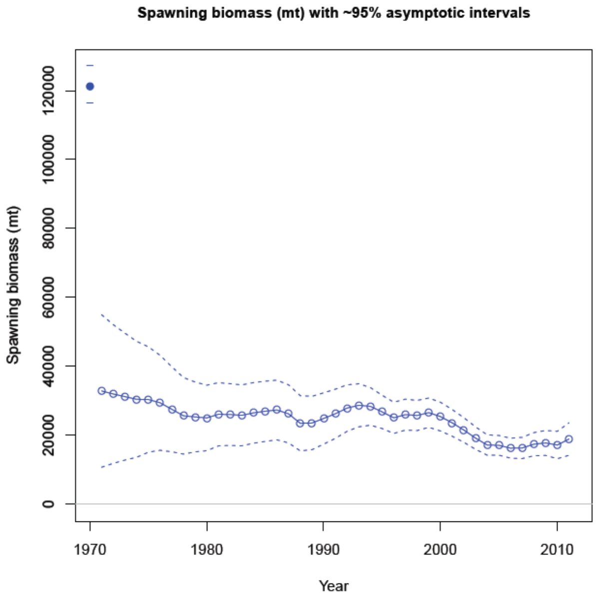

Fig.1 Historical time series of spawning stock biomass (SSB, tons) for "Base" with 95% confidence intervals (dotted lines).

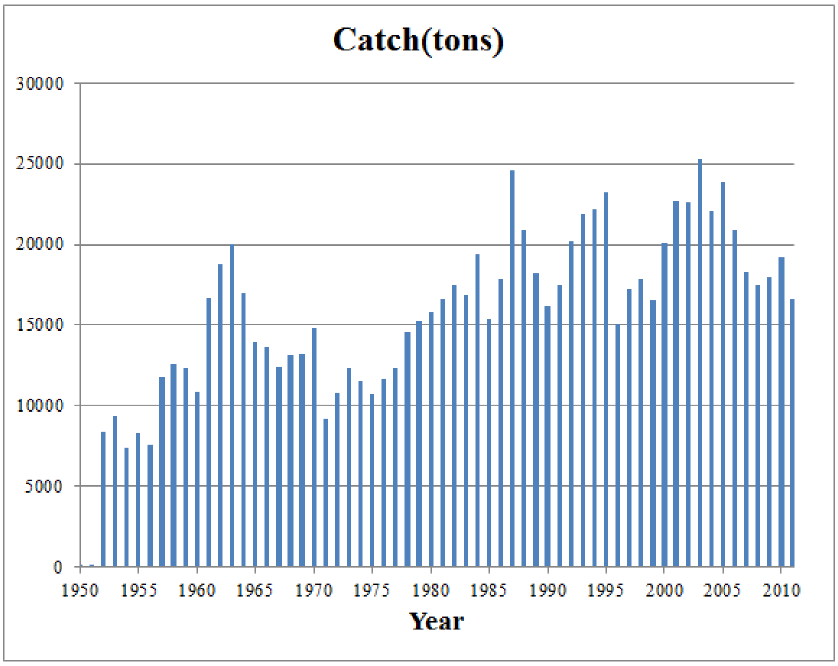

Fig.2 Annual catch (tons) of Pacific blue marlin for 1952-2011.

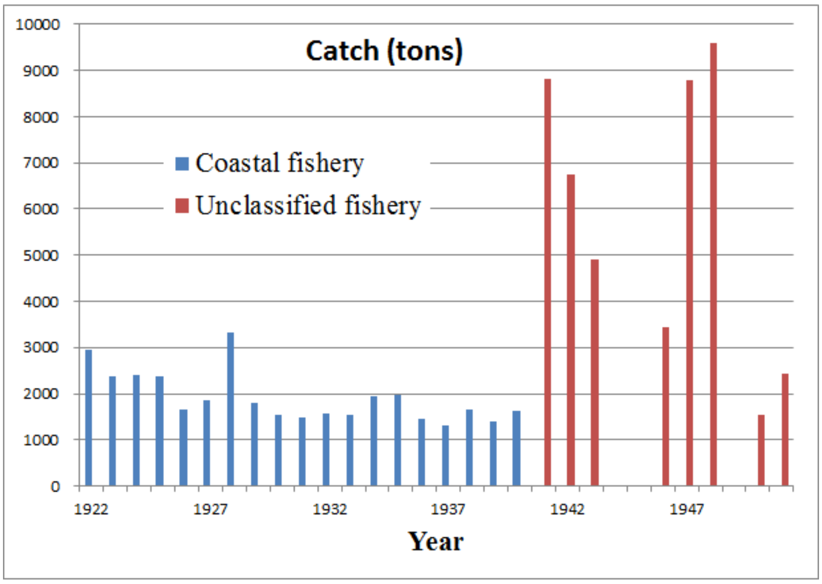

Fig.3 Annual catch of billfishes from 1922 to 1951. This was modified based on Okamoto (2004).

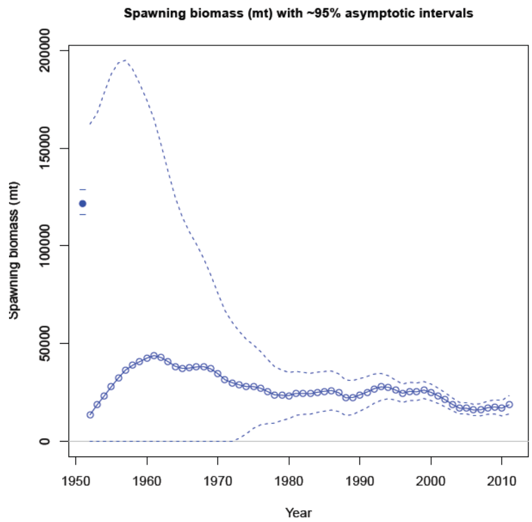

Fig.4 Historical time series of SSB (tons) with 95% confidence intervals (dotted lines). These SSB are estimated using catch data from 1952 to 2011.

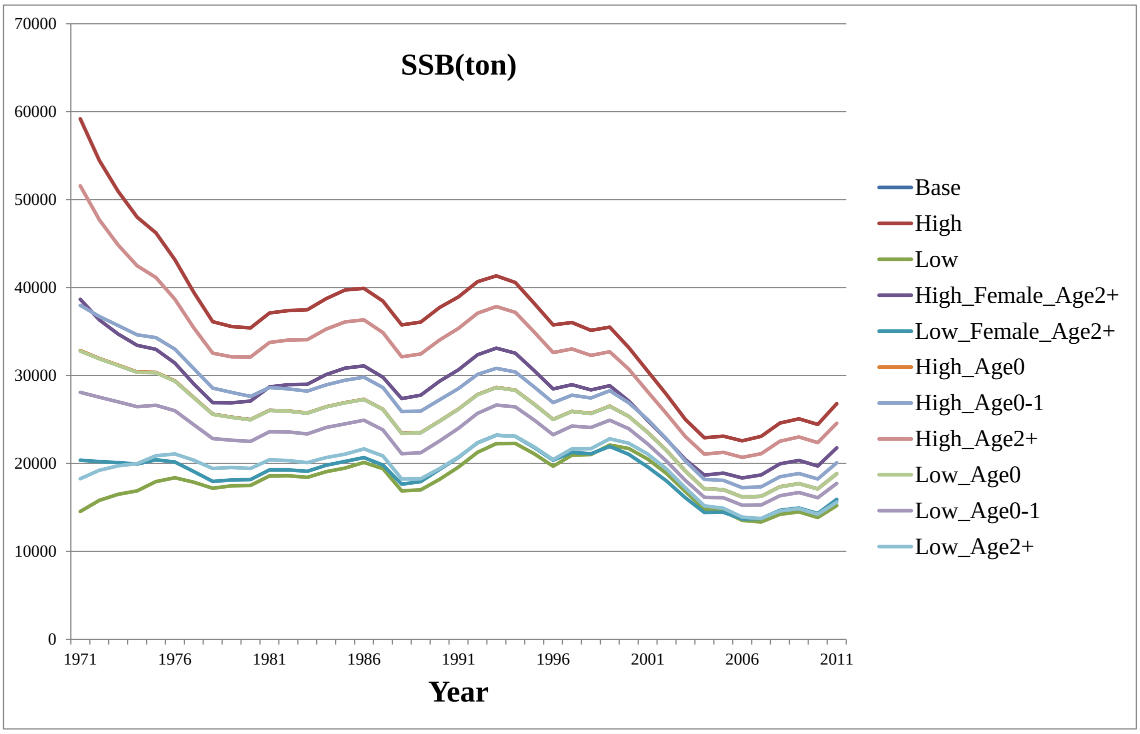

Fig.5 Historical time series of SSB (tons) derived for different *M* scenarios.

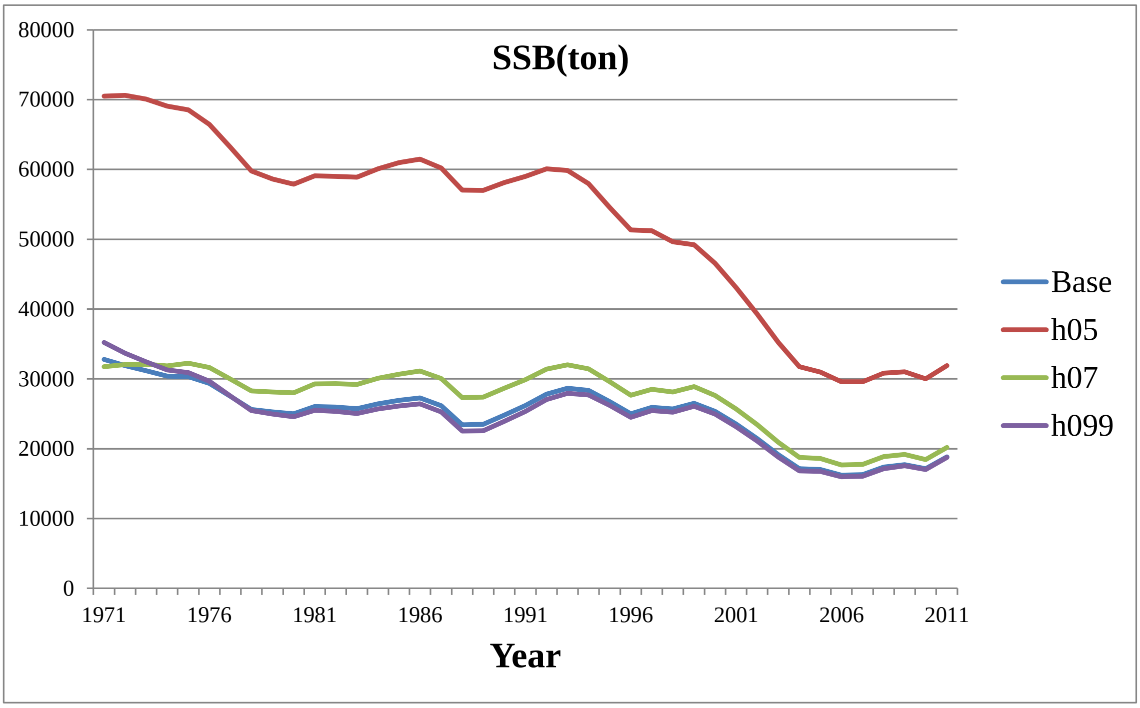

Fig.6 Historical time series of SSB (tons) derived for different values of *h*.

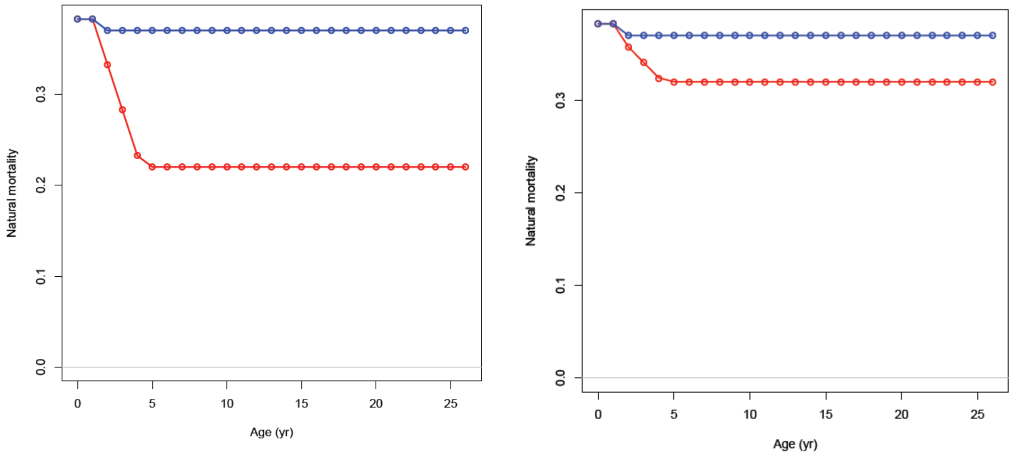

Fig.7 Sex specific *M* at ages used for two scenarios “Base” (left panel) and “High_Female_Age2+” (right panel). Blue and red lines indicate male and female, respectively.

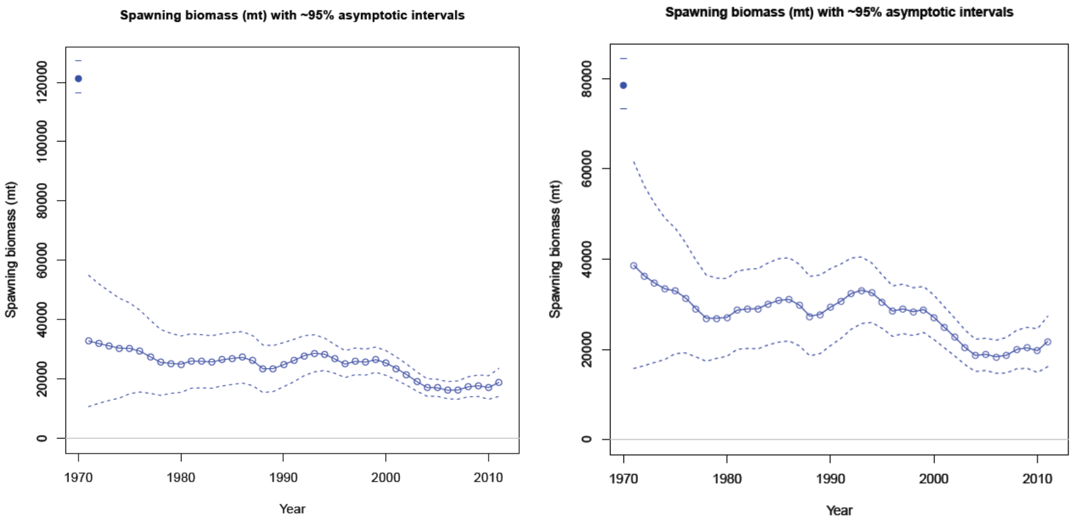

Fig.8 Historical time series of SSB (tons) for two scenarios “Base” (left panel) and “High_Female_Age2+” (right panel) with 95% confidence intervals (dotted lines).

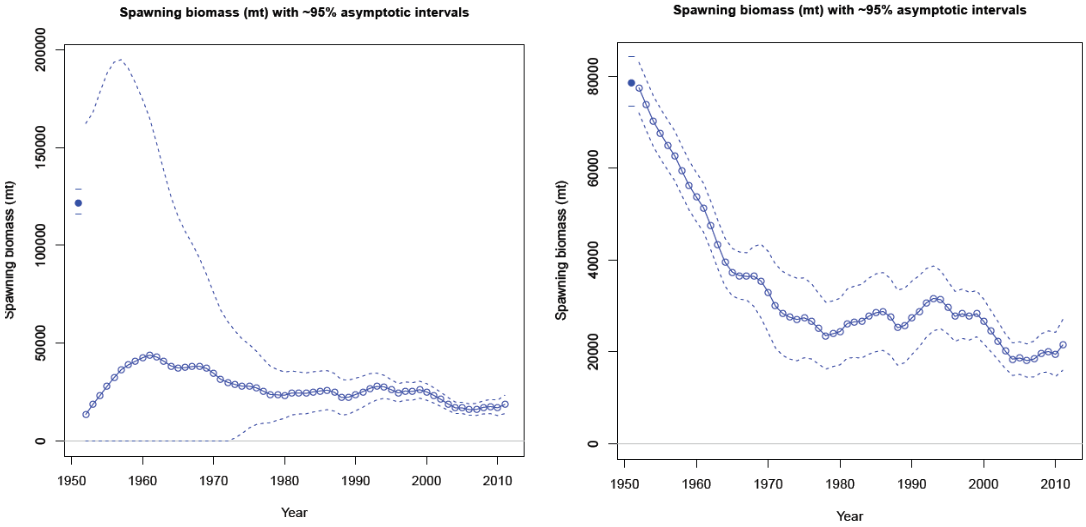

Fig.9 Historical time series of SSB (tons) for two scenarios "Base" (left panel) and "High_Female_Age2+" (right panel) with 95% confidence intervals (dotted lines). These SSB are estimated using catch data from 1952 to 2011.