Received 21 September 2013

Preliminary stock assessments of blue marlin (*Makaira mazara*) and striped marlin (*Kajikia audax*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC)

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ABSTRACT

A Stock-Production Model Incorporating Covariates (ASPIC) was used to perform the stock assessment of blue and striped marlins in the Indian Ocean based on total catch data and standardized CPUE series of Taiwanese and Japanese longline fleets. Both of Schaefer and Fox models were adopted for assessment of blue marlin due to problematic estimation of shape parameter of production function. Negligible outcomes can be observed from Schaefer and Fox models, while the assessment result of Schaefer model would be relatively conservative. The result of Schaefer model indicated that the current (2011) biomass is close to that at the MSY level, while current fishing mortality is below the MSY level. However, it should be noted that the model fits to the CPUE series are debatable since standardized both of CPUE series revealed substantial decline around late 1980s. The stock assessment of striped marlin was carried out based on a generalized model (Pella-Tomlinson model). The result indicated that the MSY reference points have been exceed, current (2011) biomass is below the MSY level and current fishing mortality is slightly higher than the MSY level.

1. INTRODUCTION

In this study, a non-equilibrium production model (A Stock-Production Model Incorporating Covariates, ASPIC) (Prager, 2005) is adopted to perform the stock assessments of blue and striped marlins in the Indian Ocean since historical catch and standardized CPUE series could be allowed to conduct assessment analyses for these two species at current time.

2. MATERIALS AND METHODS

The total catch data of Taiwanese, Japanese and Other fleets in the Indian Ocean and standardized CPUE series of Taiwanese and Japanese longline fleets are used to be fitted to the ASPIC. The time series of catch data used for stock assessment of blue marlin is from 1950 to 2011, while the time series for striped marlin is from 1970 to 2011 the uninformative data series before 1970s. The standardized CPUE series of Taiwanese longline fleet from 1980 to 2011 and Japanese longline fleet from 1971 to 2011 are considered as relative abundance indices for both of blue and striped marlins in the Indian Ocean (Nishida and Wang, 2013; Wang and Nishida, 2013a; Wang and Nishida, 2013b). The CPUE series of Taiwanese longline fleet from 1995 to 2011 also used to be fitted to the model for exploring the assessment results with short Taiwanese CPUE series standardized with effects of number of hooks between float and environmental factors.

We conducted four scenarios for exploring the assessment results by fitting the model to different combination of CPUE series:

- TW & JP: Fitting the model to Taiwanese CPUE series of 1980-2011 and Japanese CPUE series of 1971-2011 separately.
- TW95 & JP: Fitting the model to Taiwanese CPUE series of 1995-2011 and Japanese CPUE series of 1971-2011 separately.
- TW: Fitting the model to only Taiwanese CPUE series of 1980-2011.
- JP: Fitting the model to only Japanese CPUE series of 1971-2011.

Based on the preliminary runs of ASPIC, problematic estimation of the shape parameter has been found when performing the generalized production function (Pella-Tomlinson model) for blue marlin and thus both of Schaefer and Fox models are adopted to perform the stock assessment for blue marlin, while Pella-Tomlinson model is adopted for striped marlin.

3. ASSESSMENT RESULTS

3.1. Blue marlin

The model fits to the CPUE series and the residuals of fits are shown in Fig. 1. The results ndicated the model fits to the CPUE series are debatable since standardized both of CPUE series revealed substantial decline around late 1980s, especially for the fits to Japanese CPUE series.

When fitting the model to only CPUE series of Japanese longline fleet, unreasonable estimates were obtained from both of Schaefer and Fox models. The estimates of key quantities obtained from Schaefer and Fox models are listed in Table 1. Negligible differences in model estimates can be observed between Schaefer and Fox models, while the assessment result of Schaefer model would be relatively conservative. The results of Schaefer model indicated that the current (2011) biomass is close to that at the MSY level, while current fishing mortality is below the MSY level. However, it should be noted that the model fits to the CPUE series are debatable since standardized both of CPUE series revealed substantial decline around late 1980s.

The trajectories of estimated relative biomass and fishing mortality to the MSY level are shown in Fig. 2. More optimistic results were obtained when fitting the model to only Taiwanese CPUE series. Kobe plot with 90% bootstrap confidence surfaces around 2011 estimate for blue marlin is shown Fig. 3. The results of point estimate and bootstrap confidence interval indicate that there is high probability that current stock status of blue marlin in the Indian Ocean might be under a health condition.

3.2. Striped marlin

The model fits to the CPUE series and the results of fits are shown in Fig. 4. The model generally fits to Taiwanese CPUE series well, while the model cannot catch the pattern of Japanese CPUE series in early years.

The estimates of key quantities obtained from Pella-Tomlinson model are listed in Table 2. The results indicated that the current (2011) biomass is below the MSY level, while current fishing mortality is higher than the MSY level.

The trajectories of estimated relative biomass and fishing mortality to the MSY level are shown in Fig. 5. More optimistic results were obtained when fitting the model to only Japanese CPUE series. Kobe plot with 90% bootstrap confidence surfaces around 2011 estimate for blue marlin is shown Fig. 6. The results of point estimate and bootstrap confidence interval indicate that there is high probability that current stock status of striped marlin in the Indian Ocean might be under overfished and overfishing condition.

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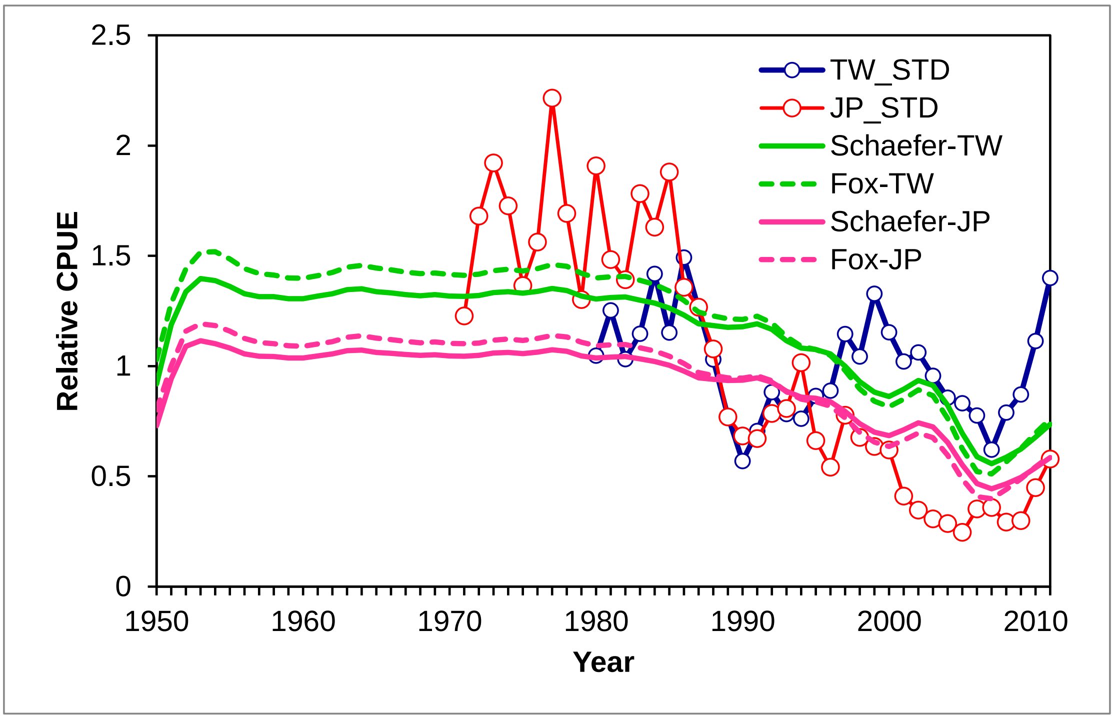


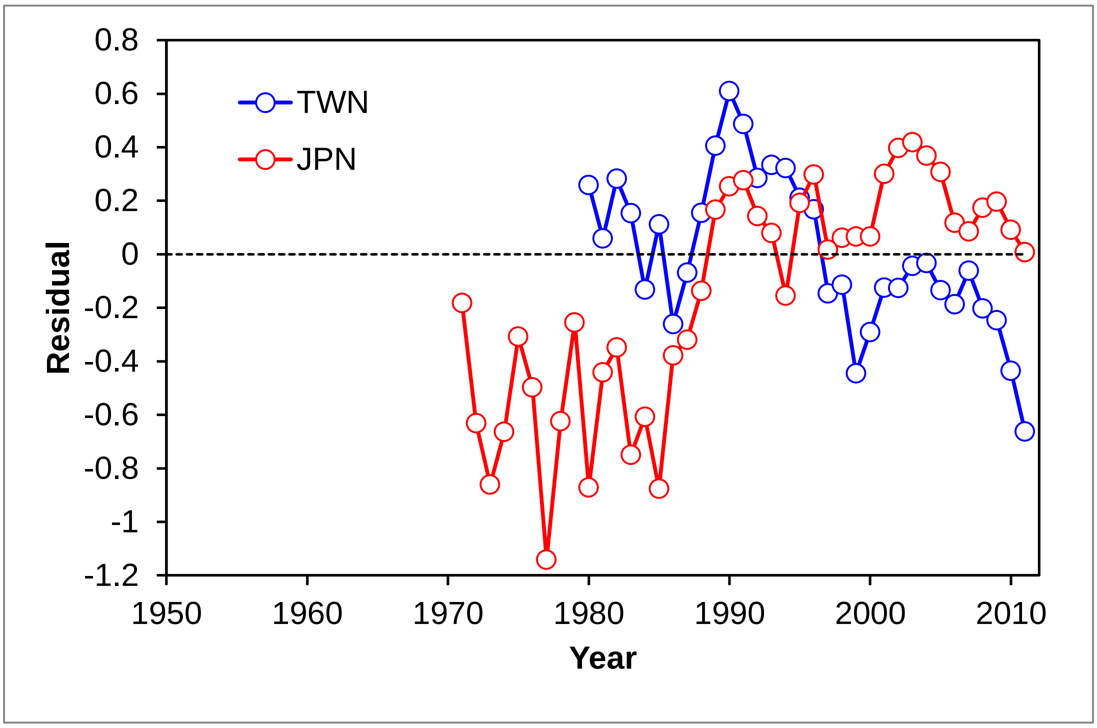
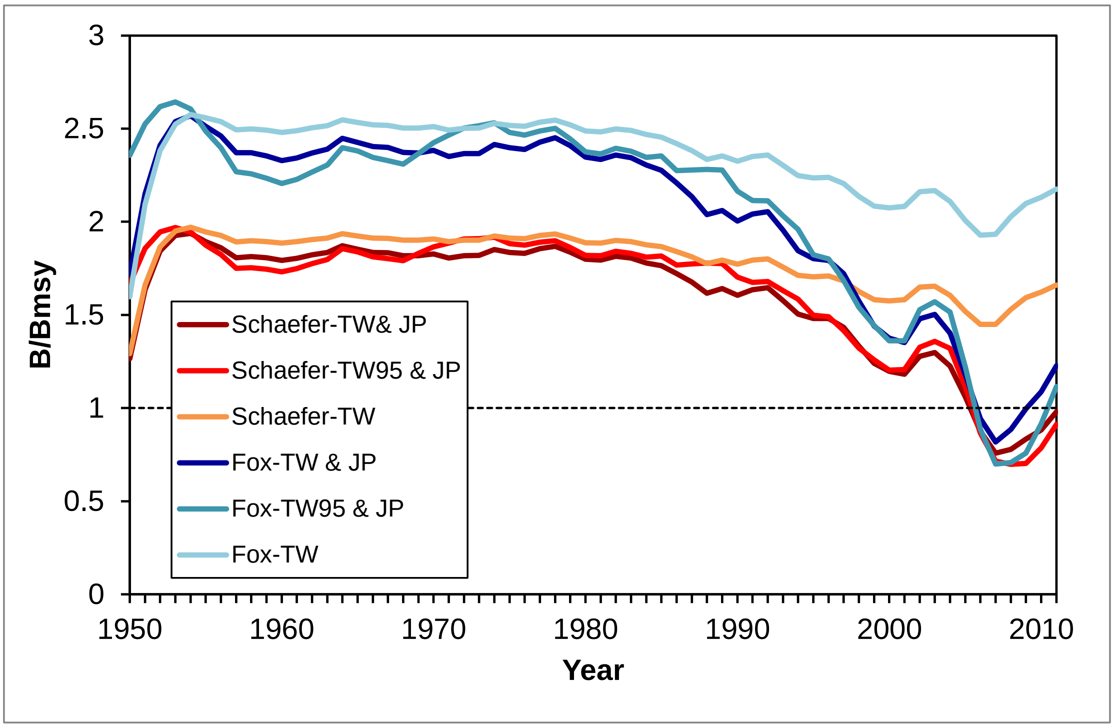


Fig. 1. The model fits to the CPUE series and the residuals of fits for blue marlin in the Indian Ocean.



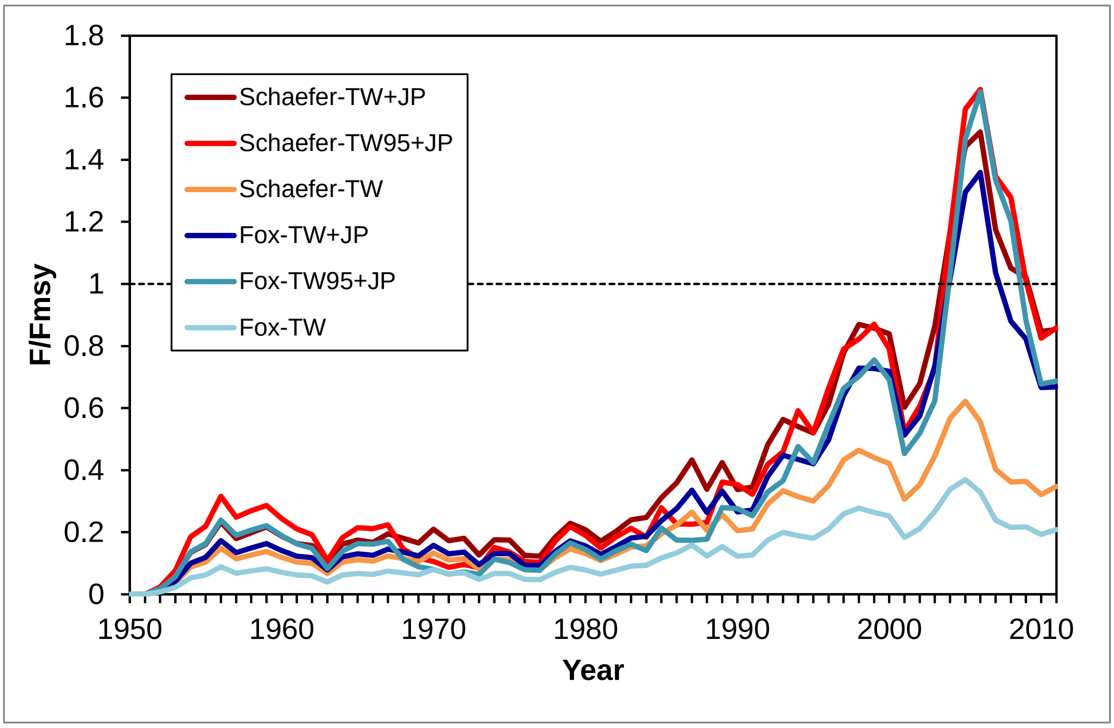


Fig. 2. The trajectories of estimated relative biomass and fishing mortality to the MSY level for blue marlin in the Indian Ocean.

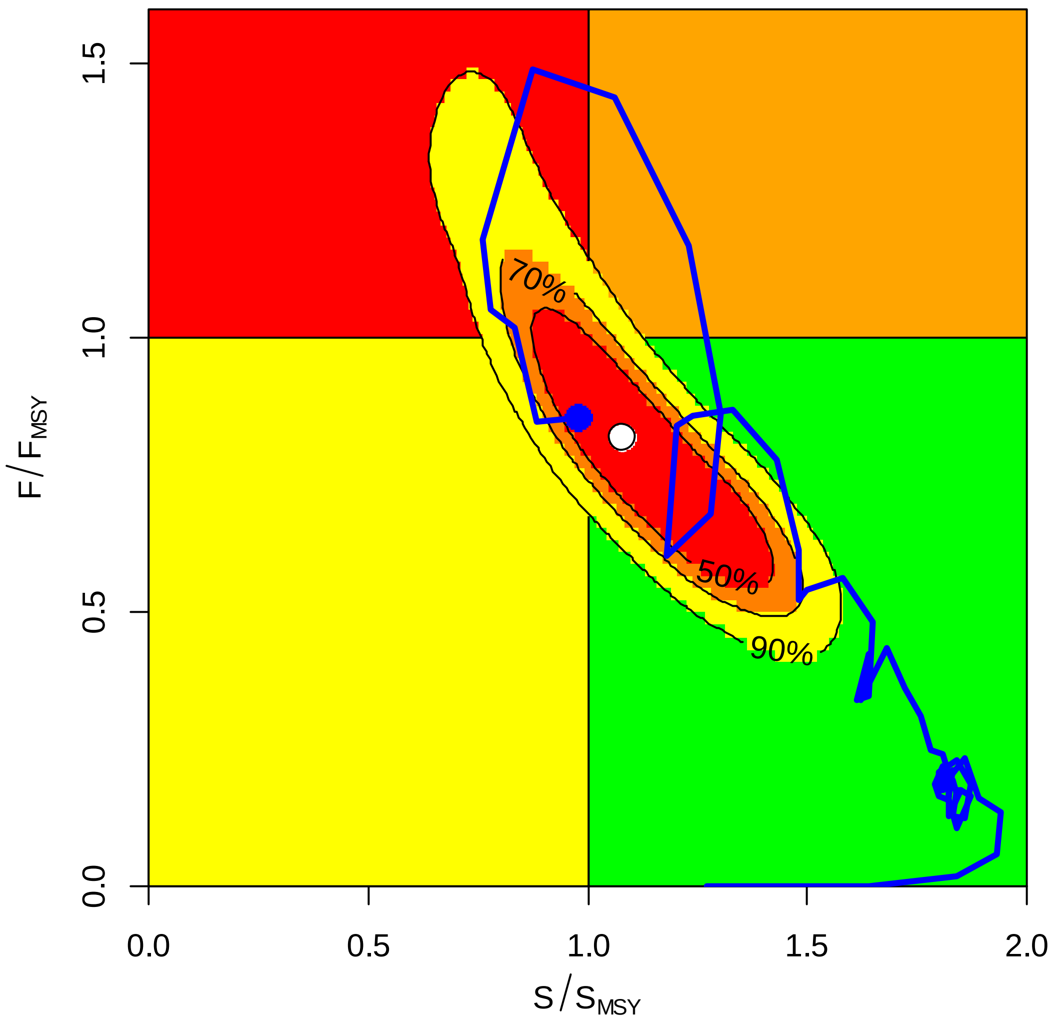
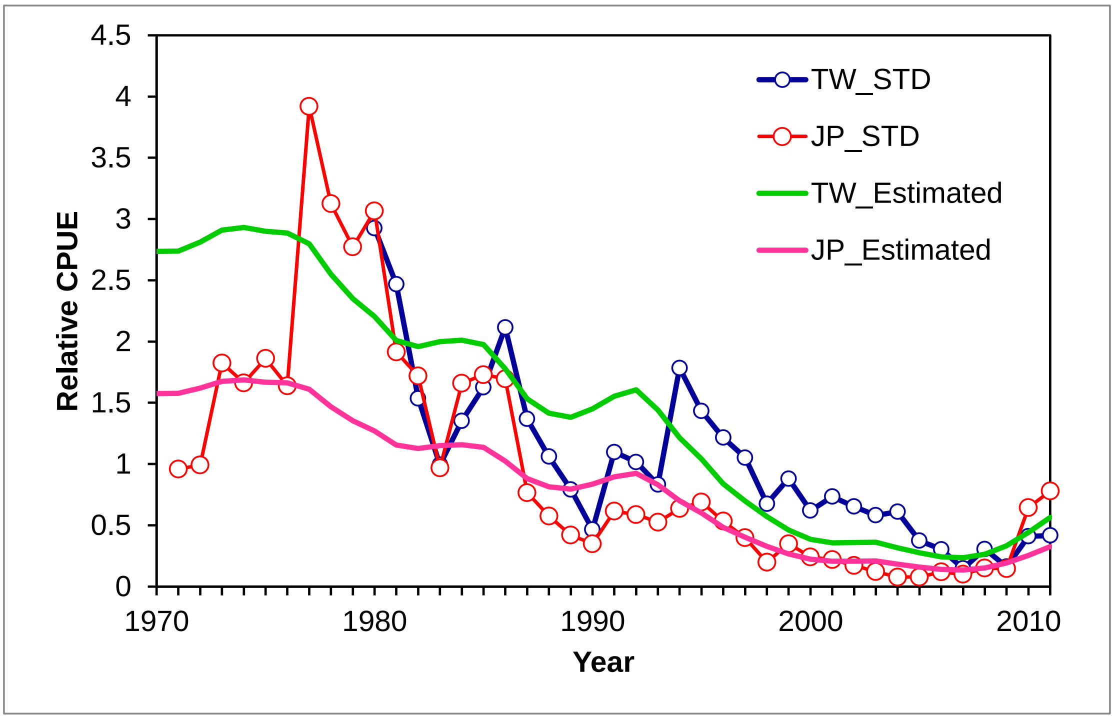


Fig. 3. Kobe plot with 90% bootstrap confidence surfaces around 2011 estimate for blue marlin in the Indian Ocean.



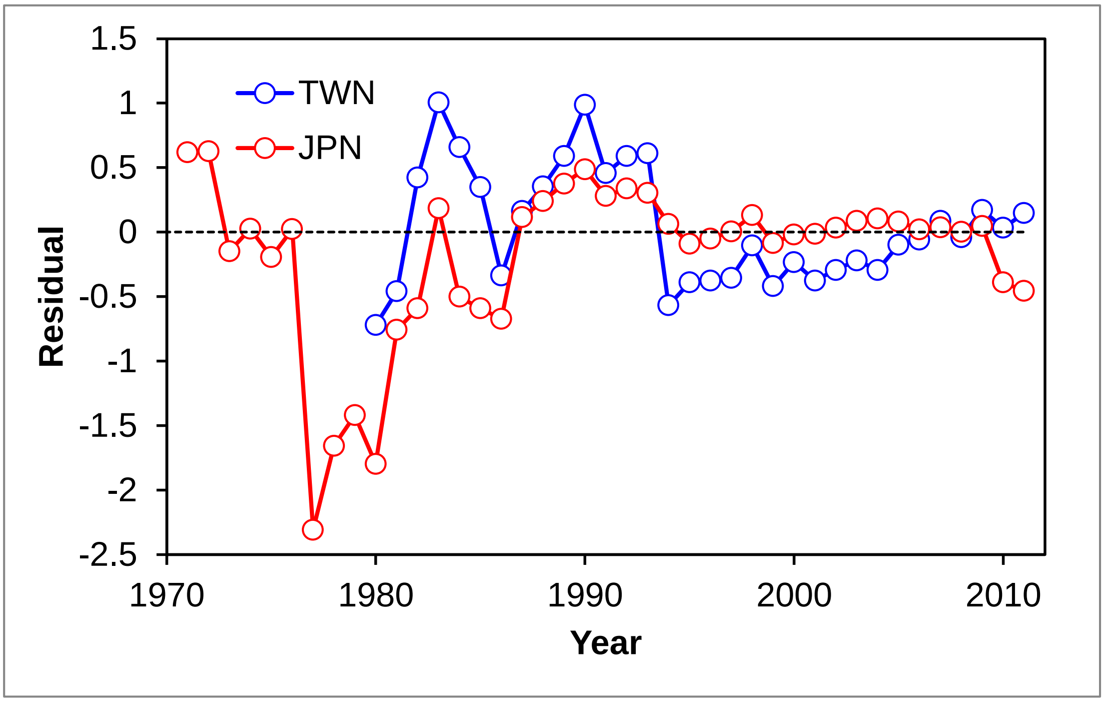
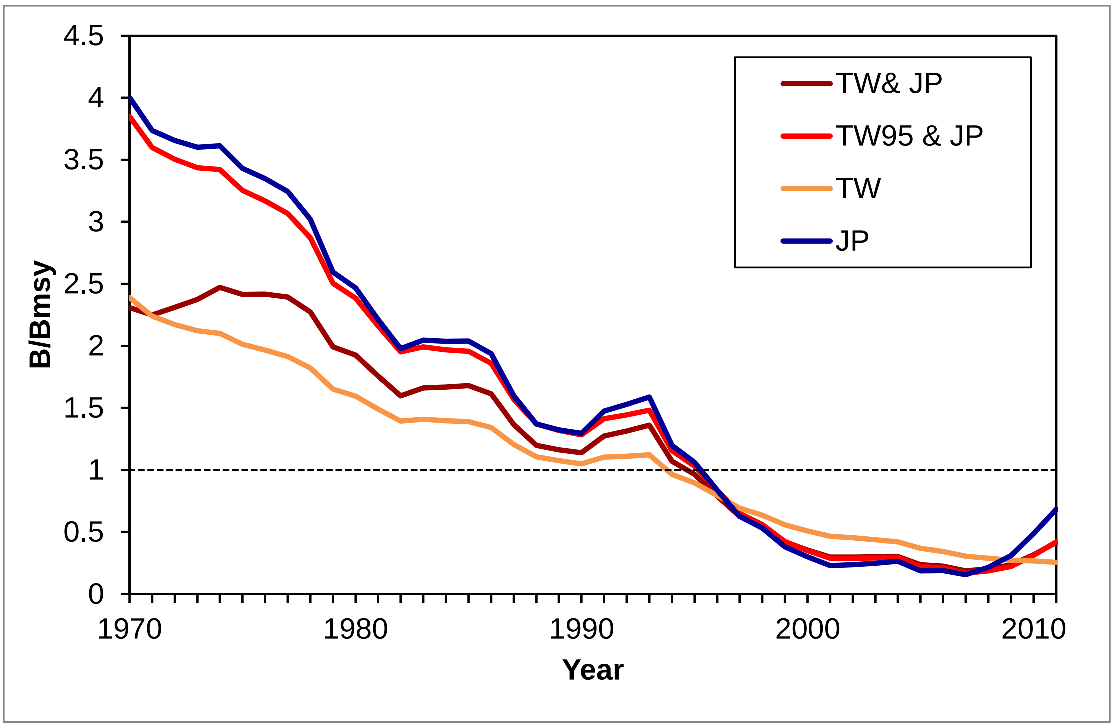


Fig. 4. The model fits to the CPUE series and the residuals of fits for striped marlin in the Indian Ocean.



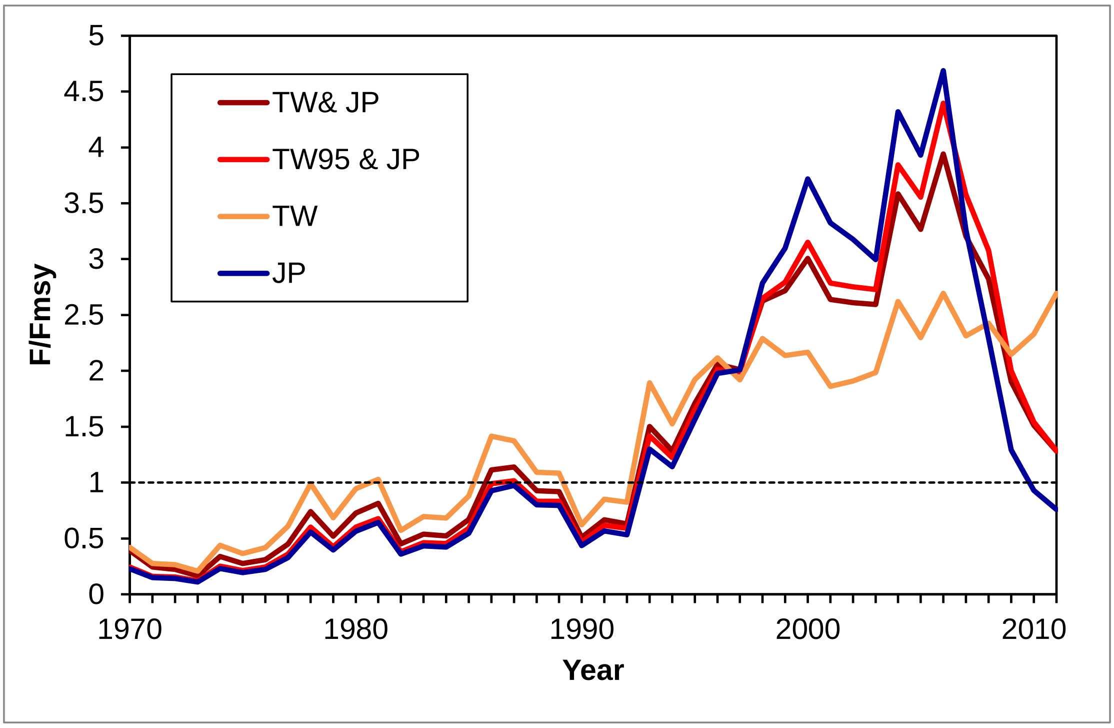


Fig. 5. The trajectories of estimated relative biomass and fishing mortality to the MSY level for striped marlin in the Indian Ocean.

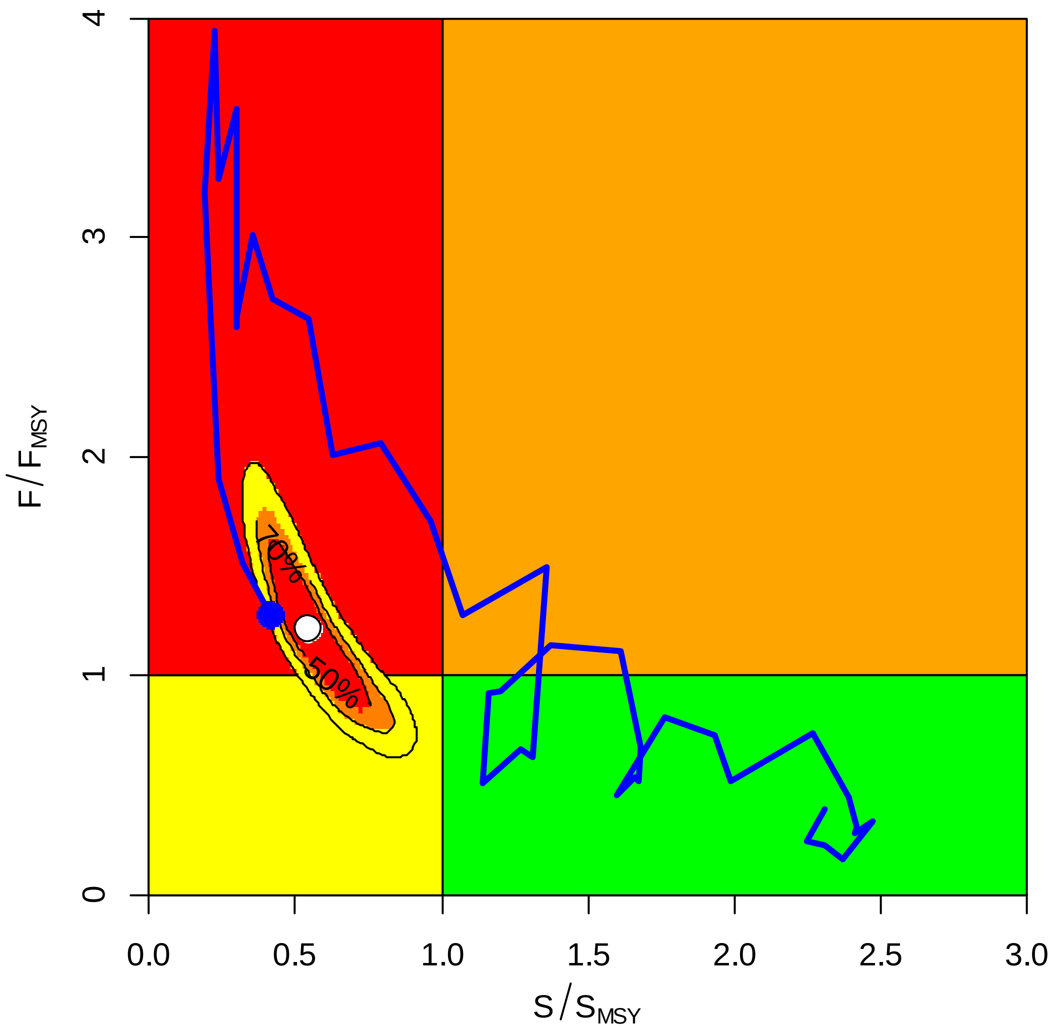


Fig. 6. Kobe plot with 90% bootstrap confidence surfaces around 2011 estimate for striped marlin in the Indian Ocean.

Table 1. The estimates of key quantities for blue marlin in the Indian Ocean obtained from Schaefer and Fox models.

Schaefer model

Parameter	TW & JP	TW95 & JP	TW	JP
MSY	11,690	8,436	17,470	
K	47,400	36,450	71,930	
Bmsy	23,700	18,230	35,970	Unreasonable
Fmsy	0.493	0.463	0.486	estimates
B2011/Bmsy	0.980	0.912	1.660	
F2011/Fmsy	0.853	0.859	0.348	
B2011/B1	0.775	0.549	1.296	

Fox model

Parameter	TW & JP	TW95 & JP	TW	JP
MSY	11,880	8,542	22,190	
K	48,990	35,420	84,350	
Bmsy	18,020	13,030	31,030	Unreasonable
Fmsy	0.659	0.656	0.715	estimates
B2011/Bmsy	1.227	1.115	2.175	
F2011/Fmsy	0.669	0.688	0.209	
B2011/B1	0.712	0.473	1.343	

Table 2. The estimates of key quantities for striped marlin in the Indian Ocean obtained from Pella-Tomlinson models.

Parameter	TW & JP	TW95 & JP	TW	JP
MSY	4,408	4,312	4,044	4,471
K	48,300	49,180	58,580	44,140
Bmsy	12,430	11,440	24,860	9,266
Fmsy	0.355	0.377	0.163	0.483
B2011/Bmsy	0.416	0.421	0.256	0.683
F2011/Fmsy	1.282	1.285	2.694	0.758
B2011/B1	0.180	0.109	0.107	0.170