Draft

Stock assessments of blue marlin (*makaira nigricans*) in the Indian Ocean using A Stock-Production Model Incorporating Covariates (ASPIC) (1950-2015)

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ABSTRACT

ASPIC was used to conduct the stock assessment of blue marlin in the Indian Ocean using total nominal catch (1950-2015) and standardized CPUE of Japanese longline fleets (1971-2015). We conducted ASPIC assuming that B0/K=1 with two model scenarios (Schaefer and Fox model). Results suggest the Fox model fits to the data better based on R2 and RMS (Root Mean Square). Estimated r (intrinsic growth rate) is 0.273 is higher than 0.11 (FAO FISHBASE) and 0.19 (0.06-0.6) (IOTC, 2014), but it is considered to be the plausible value. ASPIC results suggests that the blue marlin stock is the overfished status with F/Fmsy=1.99 and TB/TBmsy=0.67 (red zone in the Kobe plot). Risk assessments suggested………… (to be provide later)

Contents

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1. Introduction

In this study, a non-equilibrium production model (A Stock-Production Model Incorporating Covariates, ASPIC) (Prager, 2005) is applied to conduct the stock assessment of blue marlin in the Indian Ocean using historical catch and standardized CPUE

2. Stock structure

Little is known on the biology of the blue marlin in the Indian Ocean. Blue marlin is a highly migratory, large oceanic apex predator that inhabits tropical and subtropical waters of the Indian and Pacific oceans.

It is capable for long-distance migrations: in the Pacific Ocean a tagged blue marlin is reported to have travelled 3000 nm in 90 days. In the Indian Ocean a blue marlin tagged in South Africa was recaptured after 90 days at liberty off the southern tip of Madagascar crossing Mozambique Channel and travelling 1,398 km with average speed 15.5 km/day.

Other tagging off western Australia revealed potential intermixing of Indian Ocean and Pacific stocks: one individual was caught in the Pacific Indonesian waters. Blue marlin is a solitary species and prefers the warm offshore surface waters (>24°C); it is scarce in waters less than 100 m in depth or close to land.

The blue marlin's prey includes octopuses, squid and pelagic fishes such as tuna and frigate mackerel. Feeding takes place during the daytime, and the fish rarely gather in schools, preferring to hunt alone.

No information on stock structure is currently available in the Indian Ocean; thus for the purposes of assessment, one pan-ocean stock is assumed. However, spatial heterogeneity in stock indicators (catch–per–unit–effort trends) for other billfish species indicates that there is potential for localised depletion.

3. Data

To run ASPIC, we need total catch and standardized CPUE by fleet, which are explained as below.

3.1 Catch by fleet

Total nominal catch by fleet is obtained from the IOTC data sets prepared for WPB14 (Fig.1). According to Fig. 1, blue marlin is caught mainly by longlines and gillnets. The remaining catches by others (lines, purse seine and others) are nil.

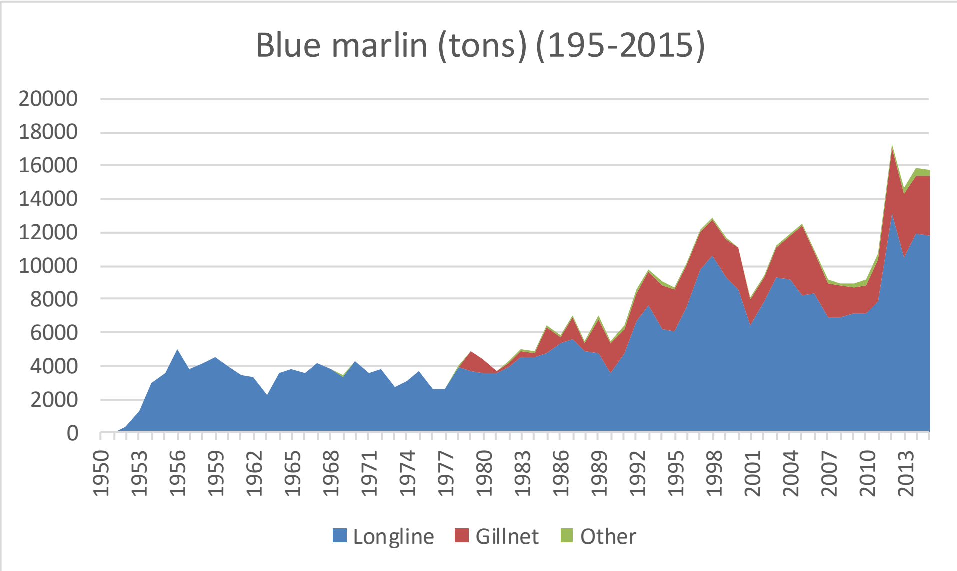


Fig. 1 Trend of nominal catch of blue marlin by fleet (IOTC, 2016)

Blue marlin is generally considered to be a bycatch except the sport fishing and tuna longlines in some early period. Catch trends for blue marlin before were more or less constant with (max) 4,000 tons, but after 1980, catch have been increasing with some ups and downs and the recent catch level is about 14,000 tons.

Fig.2 shows LL catch by fleet. Before 1985, Japan, Taiwan and Korea are the major fleets, while after 1985, Taiwan and Indonesia.

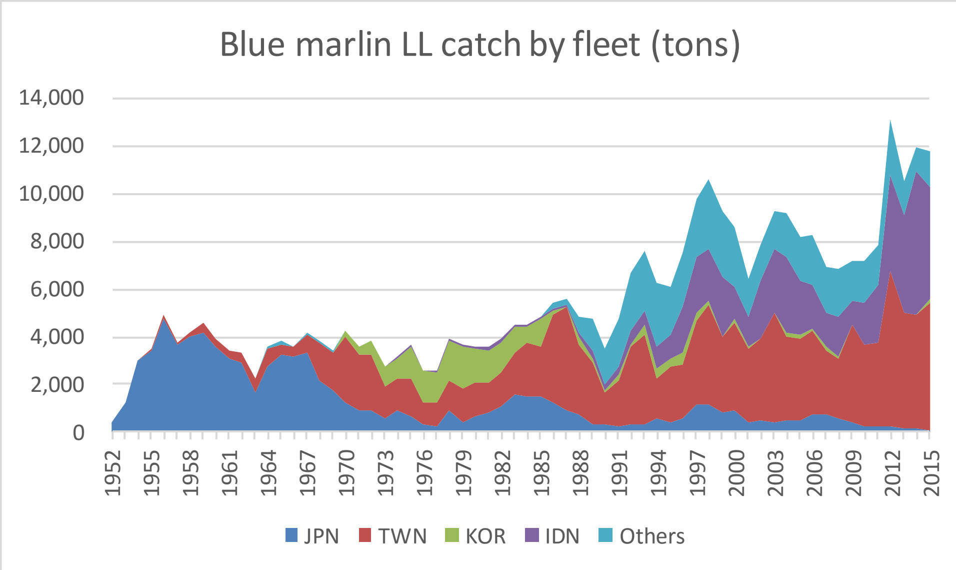


Fig.2 Blue marlin tuna longline catch by fleet

3.2 Standardized CPUE

Two standardized CPUE (Japan and Taiwan) are available in the IOTC data set for WPB14 (IOTC-2016-WPB14-20: Japan and WPB14-22: Taiwan). Fig. 3 shows two CPUE series. Two CPUE trends are similar to 1998, while large discrepancies after 1998.

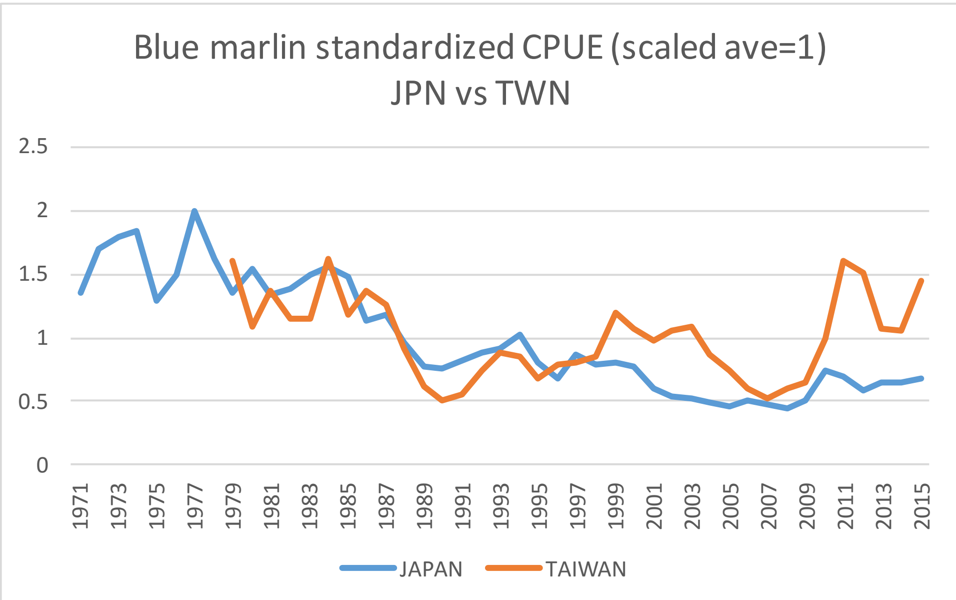


Fig. 3 Trends of blue marlin standardized CPUE (Tuna longline) (JPN and TWN)

Fig. 4 shows comparison of standardized CPUE between Japan (Yokoi, 2016) and Japan (Uozumi, 1998). Standardized CPUE by Uozumi (1998) was based on log normal GLM thus it was suggested that trends may be biased because the nominal CPUE has too many 0 (zeros) and the goodness of fitness was not well. Nonetheless, both trends in the common period are very similar. This implies that the trend of standardized CPUE by Japan LL is likely plausible.

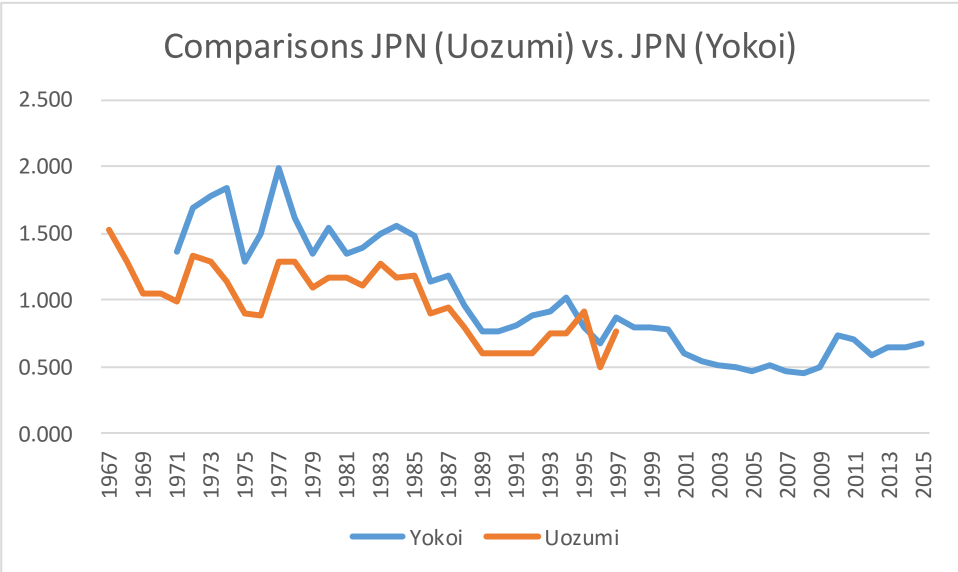


Fig 4 Comparison of standardized CPUE of Japan LL between Uozumi (1998) and Yokoi, 2016)

3.3 Relation between catch vs standardized CPUE

Fig.5 shows relation between catch and standardized CPUE(Japan) and Fig 6 for the one (Taiwan). Clearly Japan STD_CPUE fits to catch much better (strong negative correlations) than the one by Taiwan. Thus we use standardized CPUE by Japan for ASPIC.

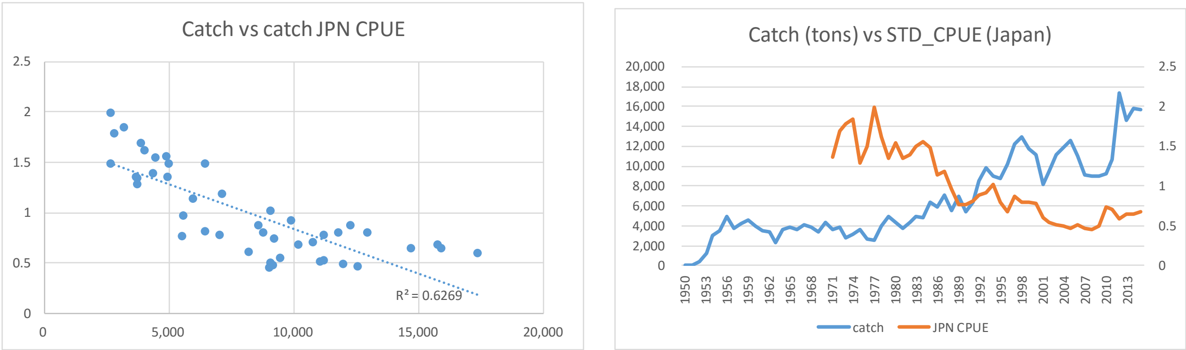


Fig. 5 relation between catch and standardized CPUE(Japan).

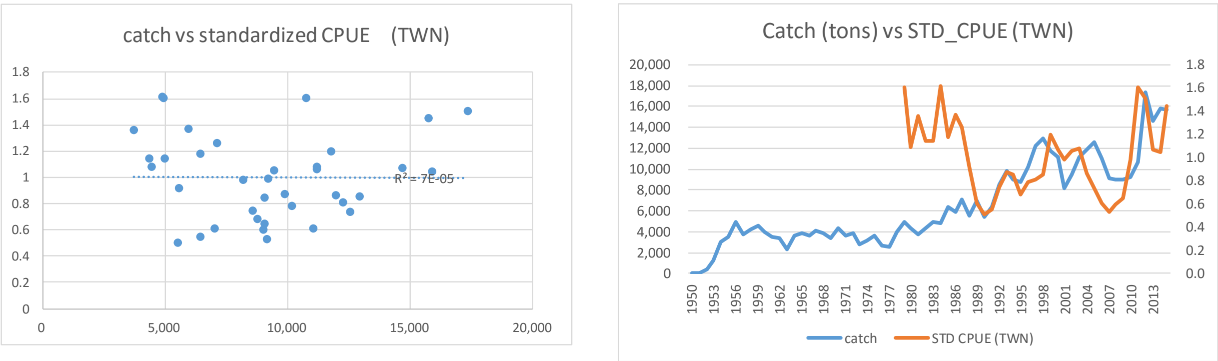


Fig. 6 Relation between catch vs standardized CPUE (Taiwan)

4. ASPIC

Using the Japan LL standardized CPUE, we conducted ASPIC assuming that B0/K=1 with two model scenarios (Schaefer and Fox model). Table 1 shows results which suggest the Fox model fits to the data better based on R2 and RMS (Root Mean Square). Table 2 and Box 1 show the results based on the FOX model. Regarding r (intrinsic growth rate) estimated as 0.273 is higher than 0.11 (FAO FISHBASE) and 0.19 (0.06-0.6) (IOTC, 2014), but it is considered to be the plausible value.

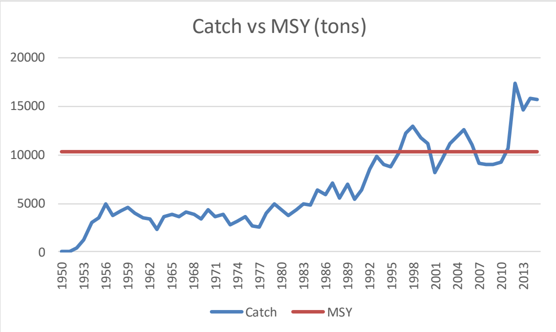
Table 1 Results of ASPIC runs for 2 scenarios

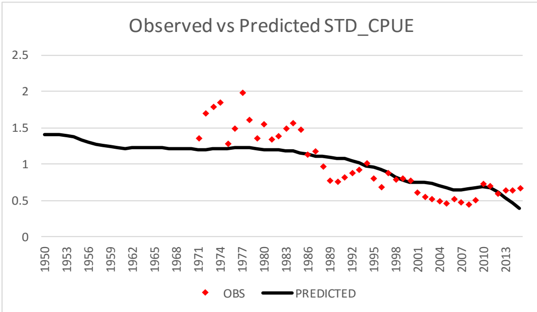
Model	B0/K	R2	q	RMS	r	K (1,000t)	MSY (1,000t)	Bmsy	Fmsy	B/Bmsy	F/Fmsy	TB (1,000t)
FOX	1	0.623	0.00001378	0.267	0.273	102.3	10.27	37630	0.273	0.6963	1.994	31.94
Schaefer	1	0.558	0.00001085	0.287	0.31	120.8	9.371	60390	0.155	0.5669	2.673	41.88

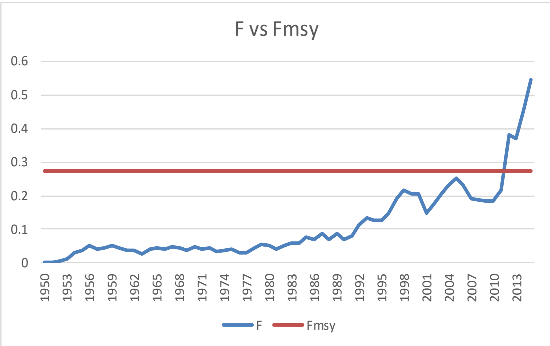
Table 2 Blue marlin: Key management quantities from the ASPIC assessment based on the Fox model, for the Indian Ocean.

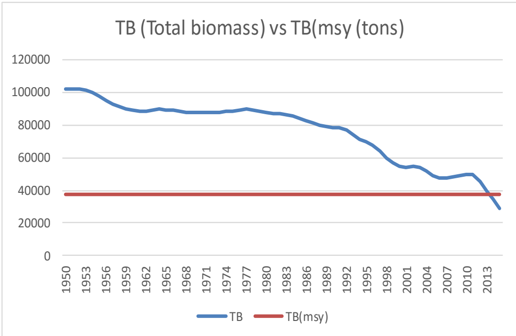
Management Quantity	Aggregate Indian Ocean
2015 catch (t)	15,706
Mean catch from 2011–2015 (t)	14,847
MSY (1000 t) (80% CI)	9,371 (8,562-11,280)
Data period (catch)	1950–2015
F_{MSY} (80% CI)	0.27 (0.14-0.50)
B_{MSY} (80% CI)	37,600 (22,320-65,400)
F_{2015}/F_{MSY} (80% CI)	1.99 (1.30-2.55)
B_{2015}/B_{MSY} (80% CI)	0.70 (0.51-0.98)
SB_{2015}/SB_{MSY} (80% CI)	(na)
B_{2015}/B_{1950} (80% CI)	0.28 n.a.
SB_{2015}/SB_{1950} (80% CI)	n.a.
$B_{2015}/B_{1950,\ F=0}$ (80% CI)	n.a.
$SB_{2015}/SB_{1950,\ F=0}$ (80% CI)	n.a.

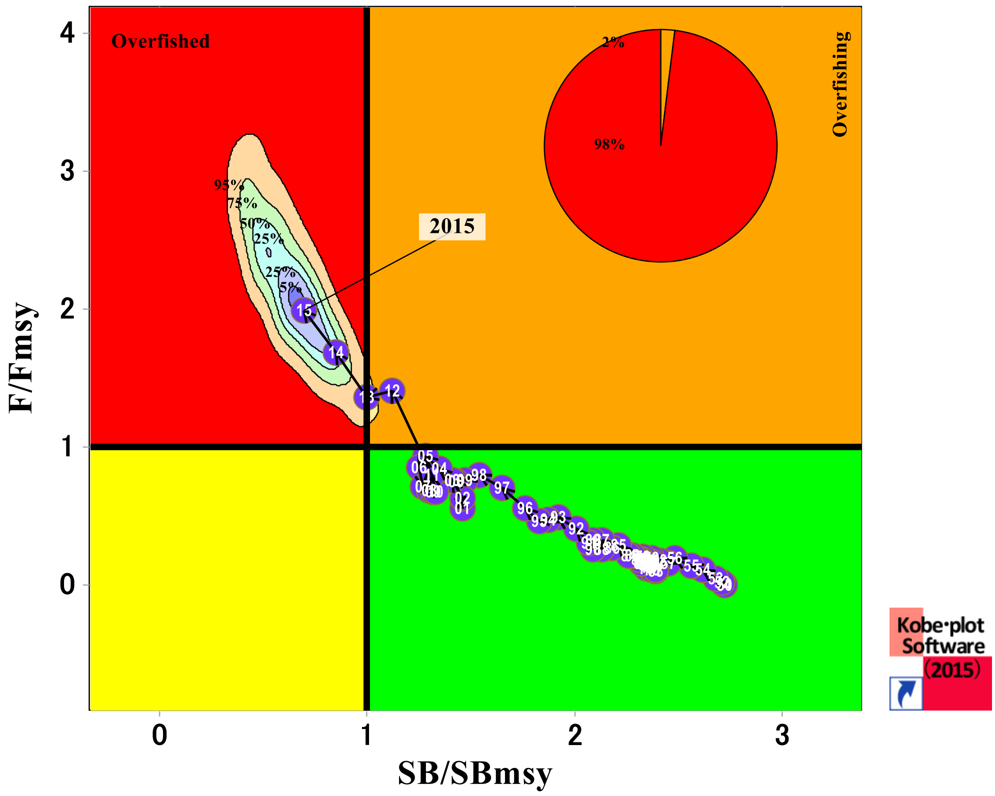
Box 1 Results of ASPIC run











Kobe plot

4.3 Discussion

The stock status of blue marlin has been significantly worsening since the last assessment using the data to 2011 (Fig. 7) comparing to the one to 2015 for this time (Box 1). The major reason is likely the stop of the piracy activities in 2011 because longliner and gillnet fisheries resume their operations of Somalia where there is the blue marlin core fishing grounds (Fig. 8).

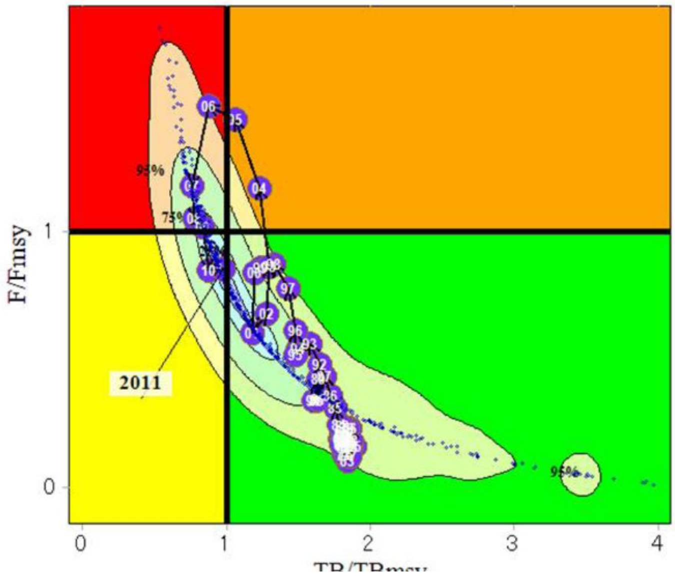


Fig. 7 Stock status of blue marlin in the last assessment using the data to 2011 (yellow zone)

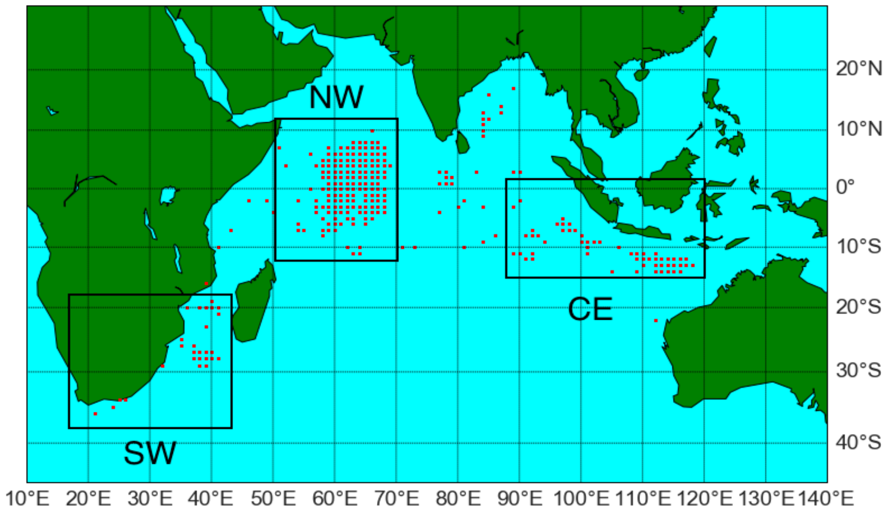


Fig. 8 Core area of blue marlin

5. Risk assessments (Kobe II)

To be completed

Table 3. Blue marlin: ASPIC aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for nine constant catch projections (average catch level from 2013–15 (xxxxx t), ± 10%, ± 20%, ± 30% and ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level from 2013–15) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)**								
Catch level	**60%**	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**	**140%**
Projected catch (tons)									
$B_{2018} < B_{MSY}$									
$F_{2018} > F_{MSY}$									
$B_{2025} < B_{MSY}$									
$F_{2025} > F_{MSY}$									

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