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Stock assessments of striped marlin (*Tetrapturus audax*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC)

(draft)

Tom Nishida

National Research Institute of Far Seas Fisheries,
Fisheries Research Agency, Shimizu, Shizuoka, Japan

ABSTRACT

To be completed

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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 assessment of striped marlins in the Indian Ocean since historical catch and standardized CPUE series could be allowed to conduct assessment analyses.

2. Stock structure

Striped marlin is the large oceanic apex predator that inhabits tropical and sub-tropical waters of the Indian and Pacific oceans. Some rare individuals have been reported in the Atlantic Ocean but there is no information to indicate the presence of a breeding stock in this area.

Its distribution is different from other marlins in that it prefers more temperate or cooler waters however in the Indian Ocean it is common in tropical zone: off the east African coast (0-10ºS), the south and western Arabian Sea, the Bay of Bengal, and north-western Australian waters. Several transoceanic migrations were reported in the Indian Ocean (the longest is from Kenya to Australia).

Therefore we assume that striped marlin in the Indian Ocean is a single stock, which apparently is most appropriate for stock assessment and management

3. Data

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

2.1 Catch by fleet

Total nominal catch by fleet is obtained from IOTC data set prepared for WPB13 (Fig.1). According to Fig. 1, striped marlin is caught mainly using drifting longlines (72% of the total catch). The remaining catches are recorded under gillnets and troll lines.

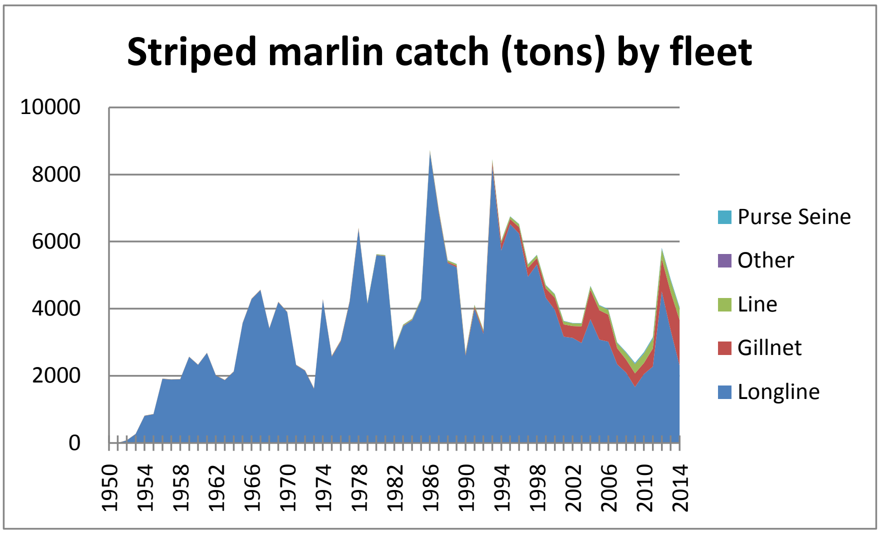


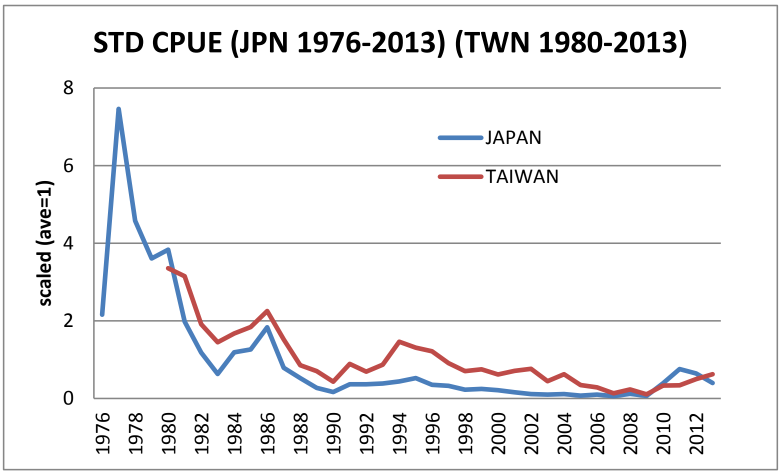
Fig. 1 Trend of nominal catch of striped marlin by fleet (IOTC, 2015)

Striped marlin is generally consi dered to be a bycatch of industrial fisheries. Catch trends for striped marlin are variable, ranging from 2000 t to 8000 t per year; however, this may reflect the level of reporting.

Similarly, catches reported using drifting longlines are highly variable, with lower catch levels between 2009 and 2011 largely due to declining catches reported by Taiwan,China, deep-freezing and fresh-tuna longliners. The catches of striped marlin increased in 2012 and 2013, as longline vessels resumed their activities in the Western tropical Indian Ocean.

2.2 Standardized CPUE

Two standardized CPUE (Japan and Taiwan) are available in the IOTC data set for WPB13. Fig. 2 shows two CPUE series. Fig 2a is the original one. The standardized CPUE in 1996 (1st year) is too low (3 times lower than in 1977), which is considered as the outlier. Hence we decided to not use for ASPIC. Fig. 2b shows the standardized CPUE (Japan and Taiwan) without 19978, which suggest the smooth and realistic trends. Both standardized CPUEs show similar trends in general.



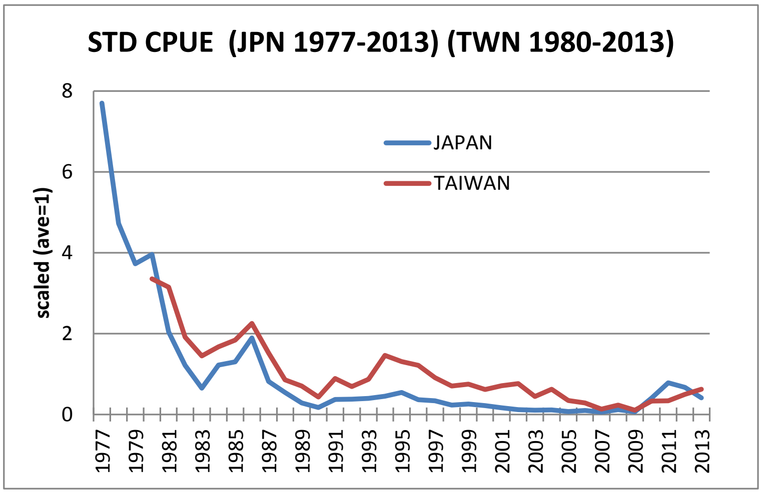


Fig. 2a (above) and Fig. 2b (below)

Trends of standardized CPUE with and without 1977

4. ASPIC

4.1 Consideration of fleets

Fig. 1 shows tuna longliners are major fleet to exploit striped marlin. Fig. 2 shows the gear composition within the longline catch, which indicate Japan and Taiwan are major countries exploiting striped marlin.

Under such situation, we define three fleets model to run ASPIC, i.e., (a) LL (Japan) fleet, (b) LL (Taiwan) fleet and (c) Surface fisheries fleet. Table 1 shows the compositions of three fleets considering their similarities and Fig. 4 shows trend of the nominal catch by 3 fleets defined in Table 1.

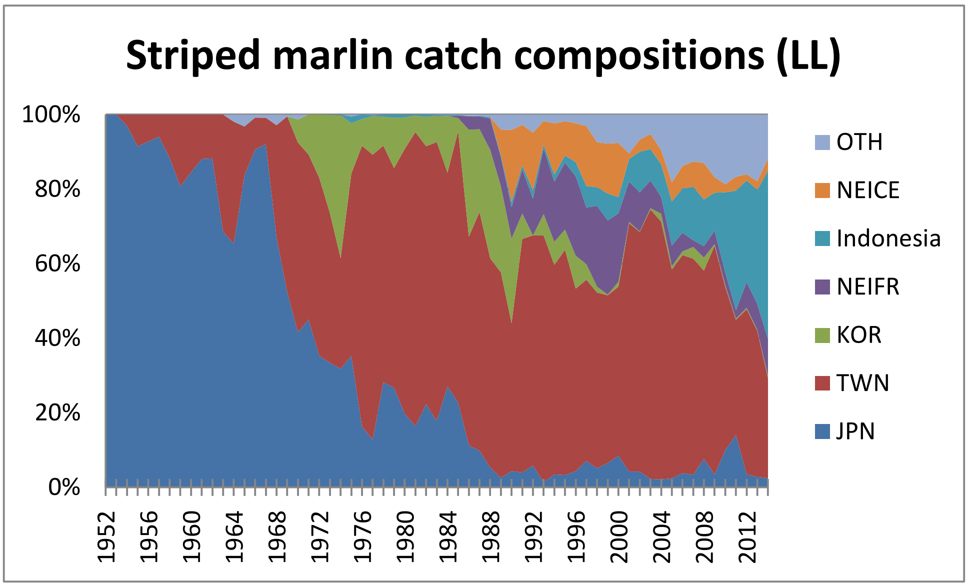


Fig. 3 Gear compositions of longline fleet

Table 1 Definition of three fleets for ASPIC runs (based on Figs 1 and 2)

Fleet	Feauture	Fisheries
LL (Japan) type	Deep freezer type LL	LL(Japan), LL(Korea) and NEIFR (other deep freezer LL)
LL (Taiwan) type	Mixed type LL (deep freezer, fresh tuna	LL(Taiwan), LL (Indonesia), LL (Others), NEICE (other fresh tuna LL) and Line
Surface type	Surface to sub-suface fisheries	Purse seine, Gilnet and Others

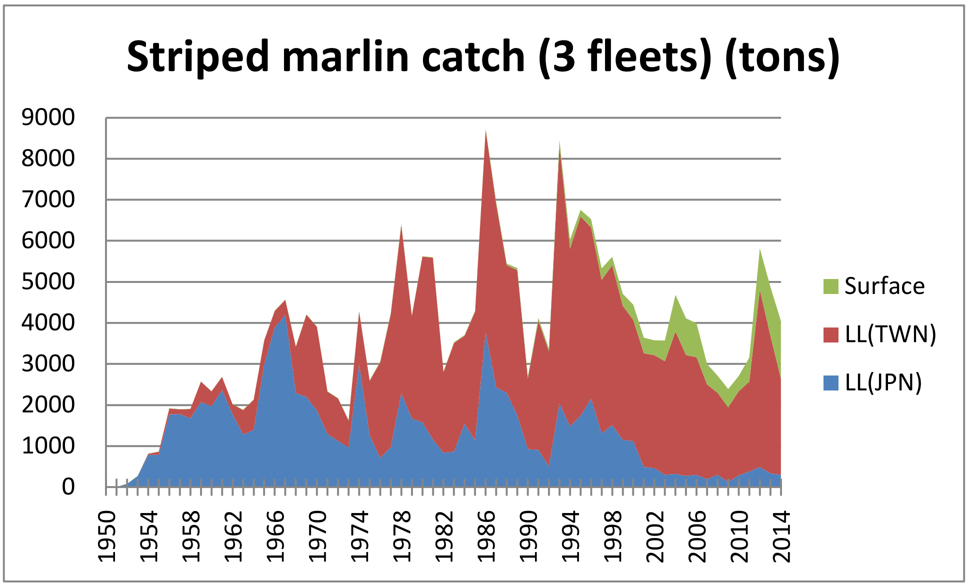


Fig. 4 Trends of nominal catch by 3 fleets defined in Table 1.

4.2 ASPIC runs and results

Using 3 fleet model with 2 standardized CPUE (Japan and Taiwan), we set up eights scenarios for ASPIC runs and results are shown in Table 2.

According to Table 2, Fox model fits better than Schaeffer model in general. When B0/K is estimated extremely too low values for both Fox and Schaefer were estimated, thus these results were not accepted Within Fox model, Scenario 6 (B0/K=1), produced the best goodness of fitness in RMSE and R2 for standardized CPUE for both Japan and Taiwan. Hence, we select scenario 6 as the representative result of ASPIC runs.

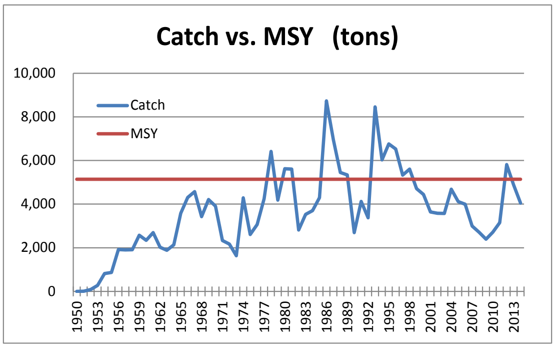
Box 1 and Table 3 summarize relevant results of scenario 6. Fig. 5 shows the Kobe plot, which confidential surface (uncertainties) are based on 500 times of the bootstrap.

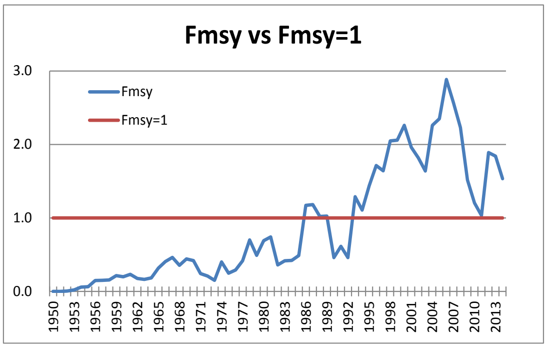
Table 2 Eight scenarios for ASPIC runs and results

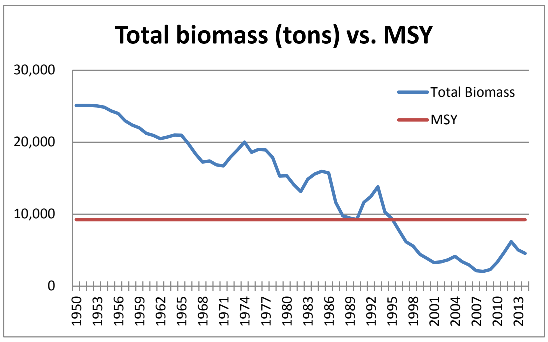
Scenario number	Production Model	B0/K		Conversion?	Results						
					estimated B0/K	RMSE (*)	R2 JPN	R2 TWN	MSY 1,000 tons	Fratio	TBratio
1	Schaeffer	Estimated		yes	0.085 Unrealistic						
2		Fixed	1			0.733	0.064	0.430	5.51	1.18	0.66
3			0.9			0.736	0.057	0.435	5.46	1.25	0.62
4			0.8			0.741	0.060	0.431	5.34	0.51	1.48
5	Fox	Estimated			0.077 Unrealistic						
6		Fixed	1			0.661	0.146	0.536	5.14	1.54	0.53
7			0.9			0.702	0.050	0.410	5.41	1.06	0.77
8			0.8			0.668	0.126	0.487	5.24	1.20	0.69

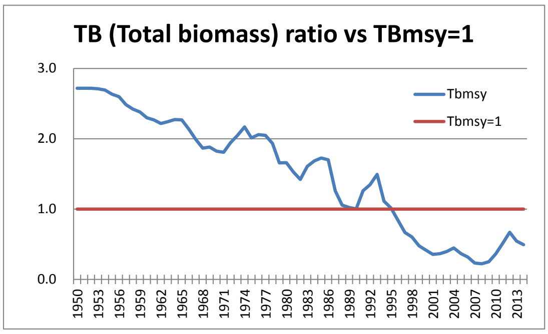
(*) Root Mean Square Errors

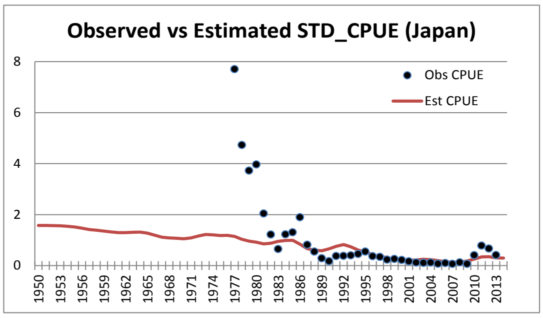
Box 1 Results of ASPIC run (scenario 6)

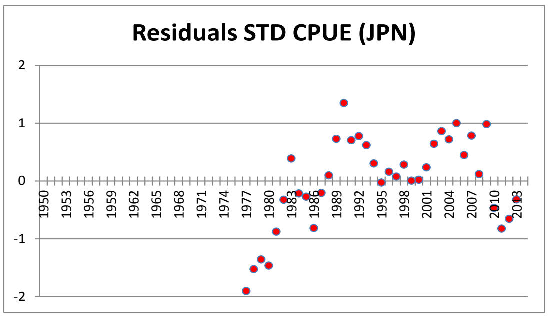


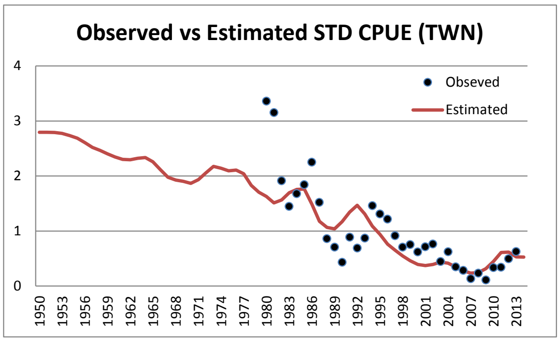


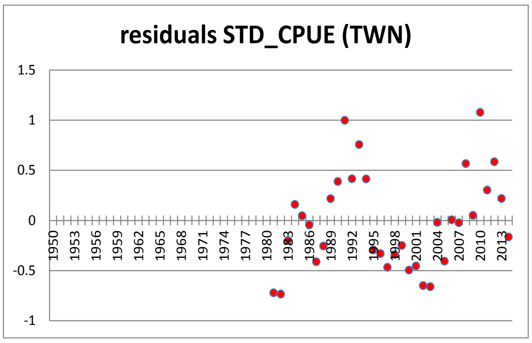


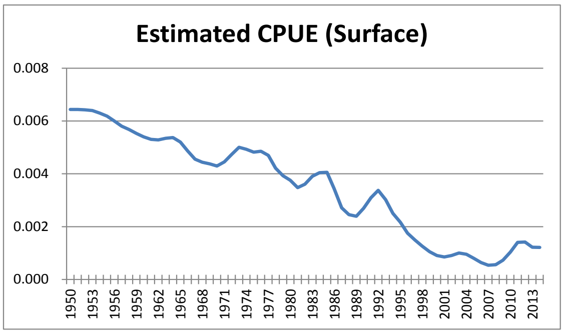












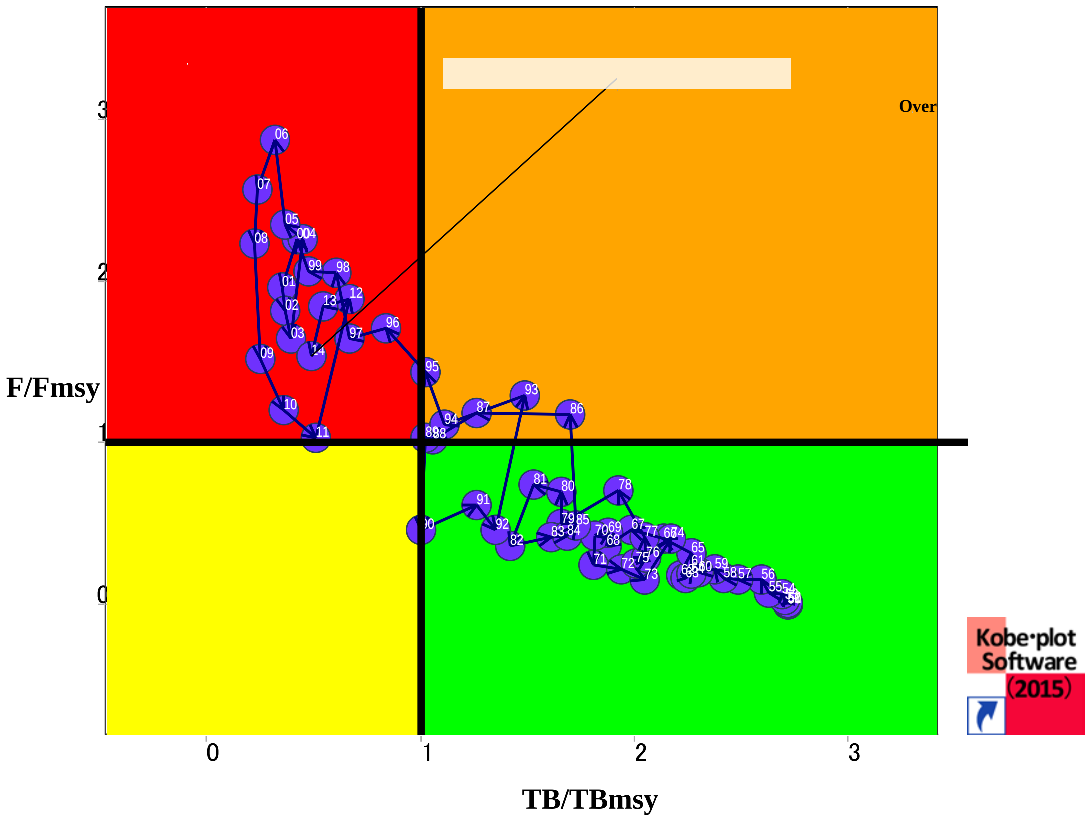


Fig. 5 Kobe plot for scenario 6 with the confidential surface (uncertainties) based on 500 times of the bootstrap.

Table 3 Summary of striped marlin stock assessment in the Indian Ocean based on ASPIC

Management Quantity	Whole Indian Ocean
Most recent catch estimate (2014)	4,049
Mean catch over last 5 years (2010-2014)	4,122
MSY (1,000 t)	5,142 (xxxx-xxxx)
Current Data Period (catch)	1950-2014
CPUE	Japan (whole Indian Ocean) (1977-2013) Taiwan (whole Indian Ocean) (1980-2013)
Fmsy (80%CI)	0.56 (xxx-xxx)
TBmsy (80%CI)	9,237 (xxx-xxx)
F(2014)/F(MSY) (80% CI)	1.54 (xxxx-xxx)
TB(2014)/TB(MSY) (80% CI)	0.53(xxx-xxx)
TB(2014)/TB(1950) (80%CI)	0.18 (n.a.)
K (tons)	25,110
r	0.82

4.3 Discussion

The result of the ASPIC stock assessments for this time suggests that the current stock status in 2014 is the overfished phase with F2014/Fmsy=1.54 (54% higher than MSY level) and TB2014/TBmsy=0.53 (53% of the MSY level).

This result is similar to conducted in 2013 also by ASPIC, which suggested that stock status in 2011 is the overfished phase with F2011/Fmsy=1.28 and TB2011/TBmsy=0.42 (Fig. 6)

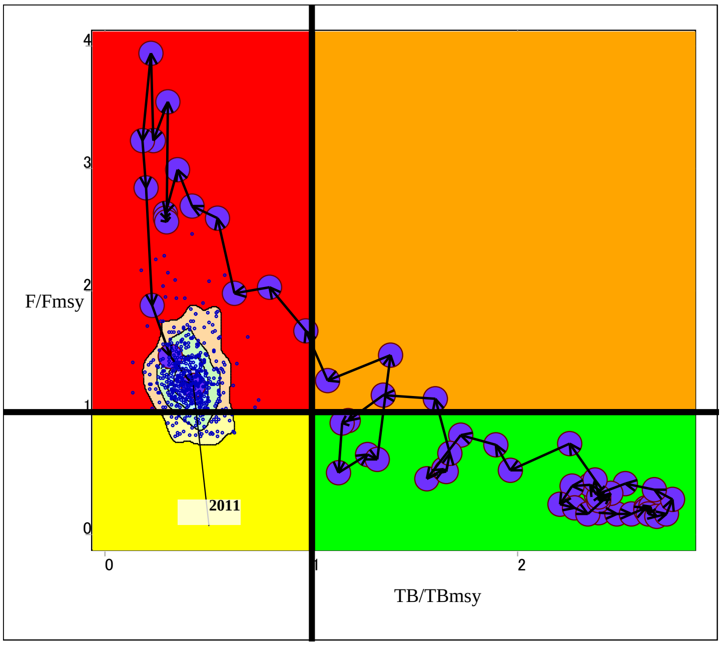


Fig. 6 Kobe plot (1950-2011) based on ASPIC conducted in WPB 11 (2013)

This indicates that the F has been increased by 26% from 2011 to 2014, while TB (total biomass) has been improved by 11%.

F has been increased because the piracy activities have been weakened since 2012 and then more longliners have come back to the western Indian Ocean which produced high F (Fig. 7). On the other hand, TB has been improved because of less fishing activities when piracy was active before 2012, which made increase of TB (Fig. 7).

Under such situation, it is expected that F will increase further and then TB will be decreased further.

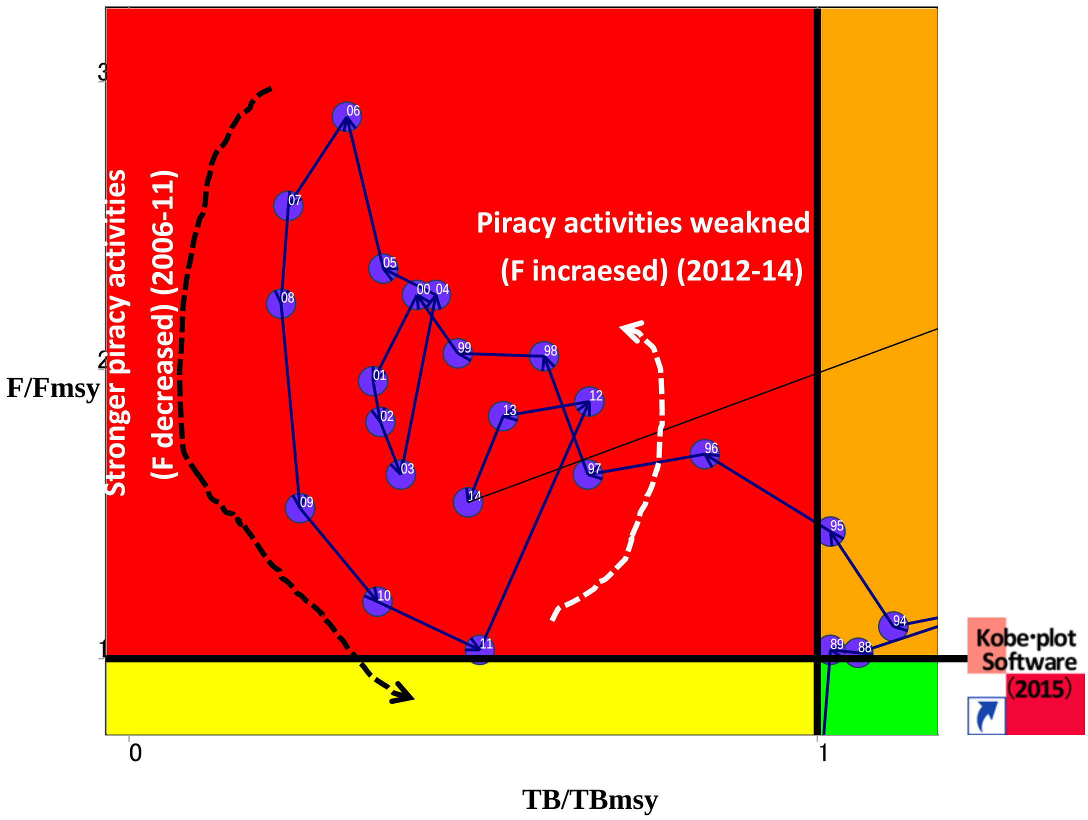


Fig. 7 Effects of piracy activities to F and TB based on the Kobe plot to 2014.
Stronger period (2006-2011) vs. weakened period (2012-14)

5. Risk assessments (Kobe II)

To be completed later

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