Preliminary stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean using Statistical-Catch-At-Age (SCAA)

Tom Nishida and Hiroki Yokoi
National Research Institute of Far Seas Fisheries (NRIFSF)
Shimizu, Shizuoka, Japan

September, 2017

Abstract

Stock assessment of swordfish in the Indian Ocean was attempted using SCAA. We examined two different biological information, i.e., information (a) previous growth curve by Wang et al (2010) and maturity-at-age by Poisson and Fauvel (2009), and new information (b) new growth curve and maturity-at-age by Farley et al (2016) by otolith. It was suggested that information (a) produced plausible results (orange zone in Kobe plot), while new information (b) did not produce any convergences nor plausible results. Its conceivable reason is that CAA are estimated by the previous growth curve by Wang et al (2010) which might not suitable for SCAA based on new biological information as the current CAA is not estimated by the new growth curve and maturity-at-age.

Indonesian fresh LL catch in 2014-2015 is likely overestimated, thus the proposed catch by Fu *et al* (2017) was used as a sensitivity run. It was resulted that the proposed catch may be too low as the stock status is too optimistic and not plausible (green zone far from MSY levels), while the original one may be too high based on the reason described by the Fu *et al* (2017). Thus, it is likely that the real catch may be in between these two catch levels. Accordingly, the stock status is likely in between these two (orange and green zone in the Kobe plot). <u>The real catch needs to be investigated in the future to identify the real stock status.</u>

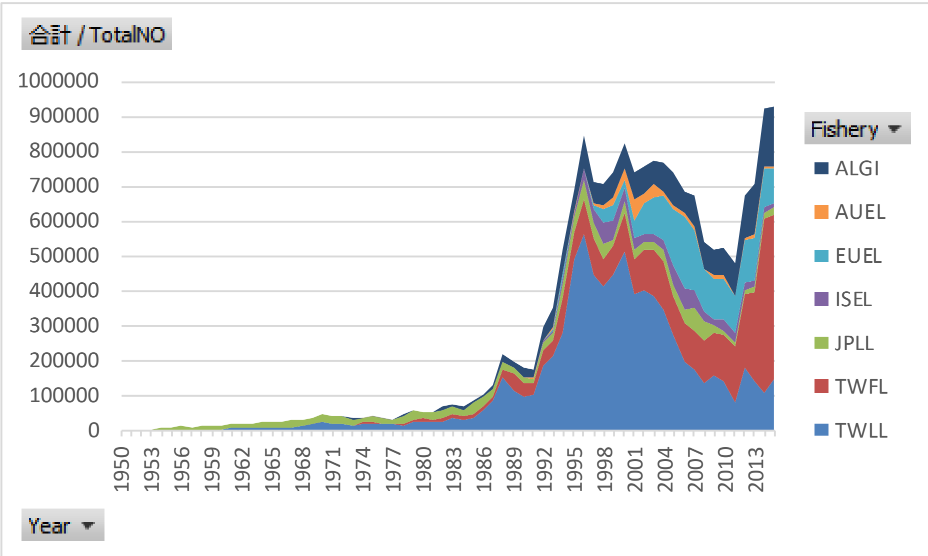
We could find plausible result in only one grid (out of 756 grids) with the original Indonesian fresh LL catch. The reason and cause of this strange situation need to be investigated in the future. Because of these 2 uncertainties (Indonesia fresh LL SWO catch and solution with only one grid), <u>we cannot suggest any plausible results, but it is likely that the current stock status may be in between two extreme points in the Kobe plot (orange and green).</u>

Contents

1. Introduction

Stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean was attempted using Statistical-Catch-At-Age (SCAA). One stock hypothesis is assumed.

2. Catch by fleet (Figs. 1 and 2)



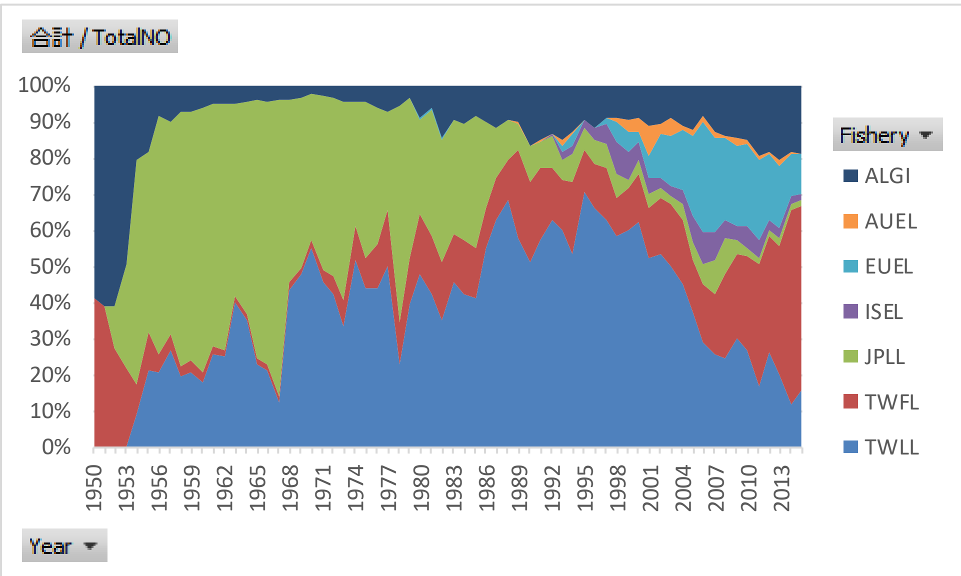
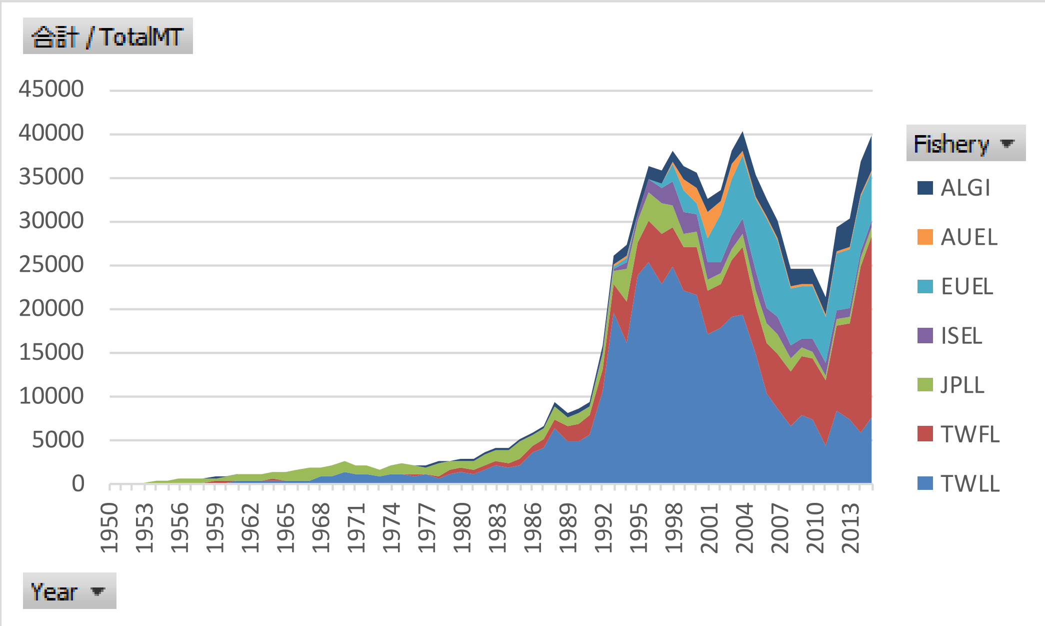


Fig. 1 Catch (number) by fleet (above) and its compositions (below)



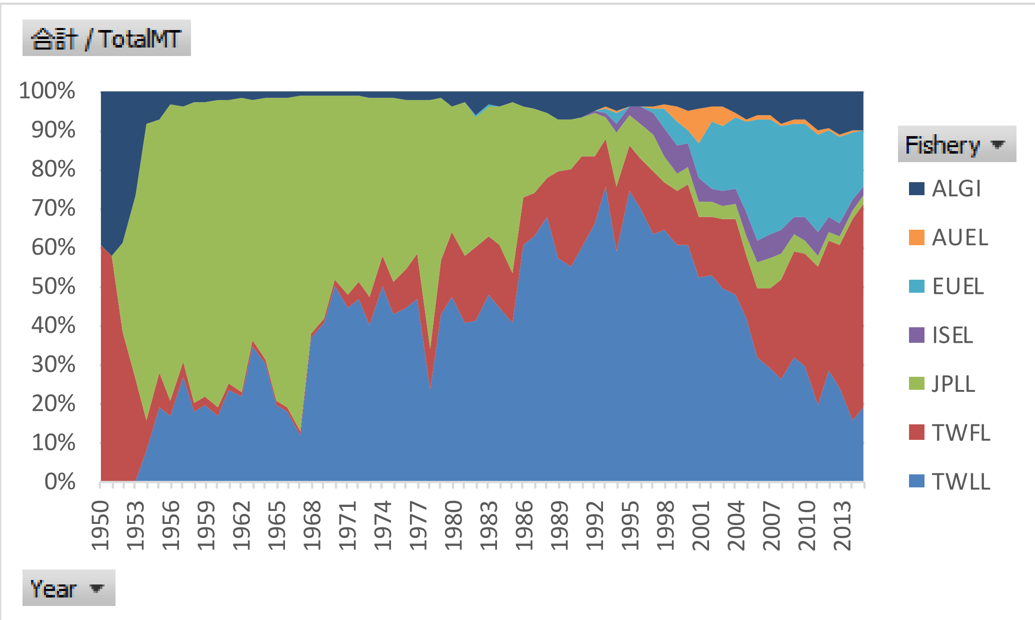


Fig. 2 Catch (weight) by fleet (above) and its compositions (below)

3. Standardized CPUE

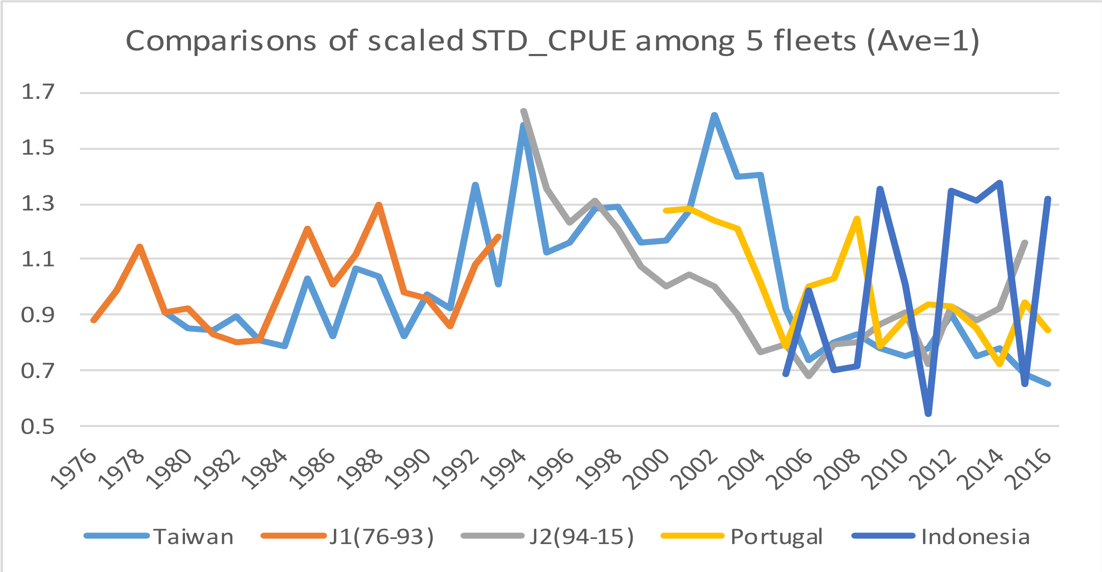


Fig. 3 Standardized CPUE by fleet

Iran: nominal CPUE are available and standardized CPUE are not available, thus not used.

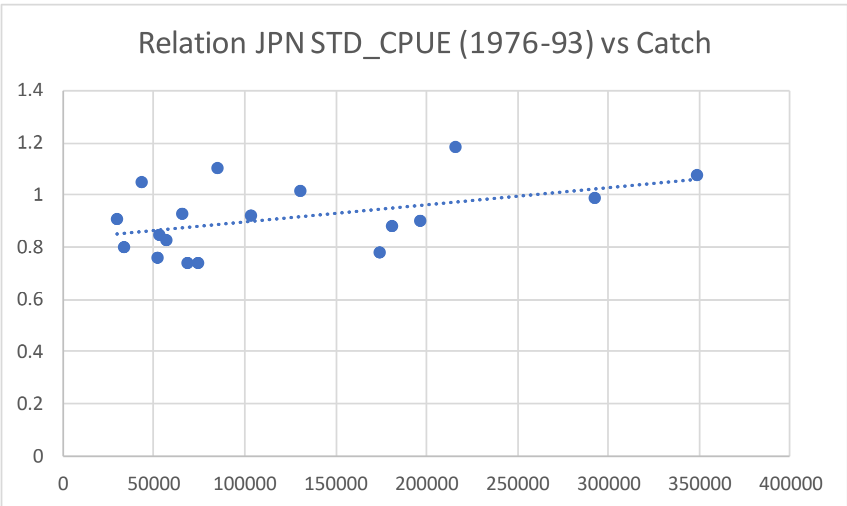


Fig. 4 Relation between catch vs. STD_CPUE (Japan 1) (1976-1993)

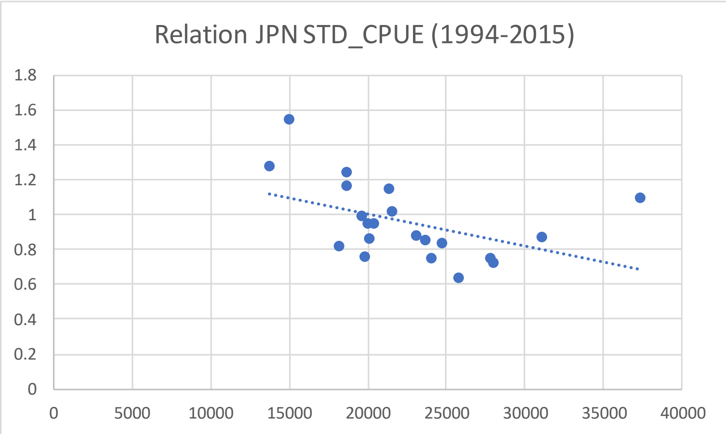


Fig. 5 Relation between catch vs. STD_CPUE (Japan 2) (1994-2015)

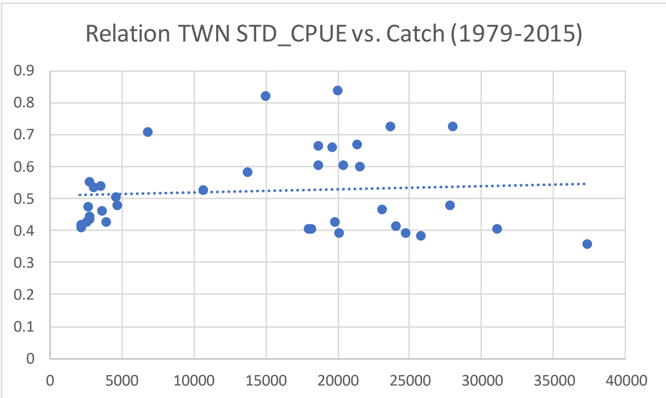


Fig. 6 Relation between catch vs. STD_CPUE (Taiwan) (1979-2015)

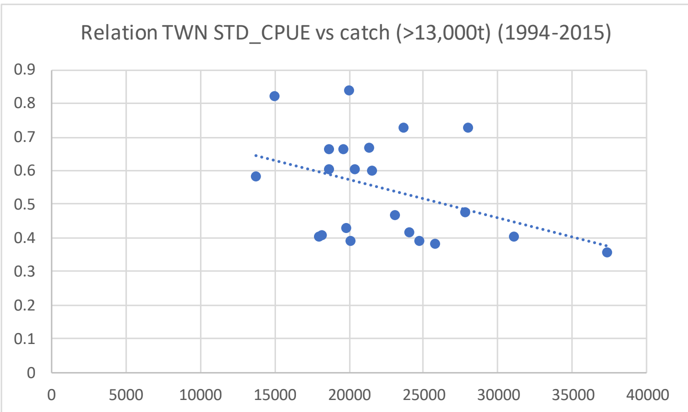


Fig. 7 Relation between catch vs. STD_CPUE (Taiwan 2) (1994-2015)

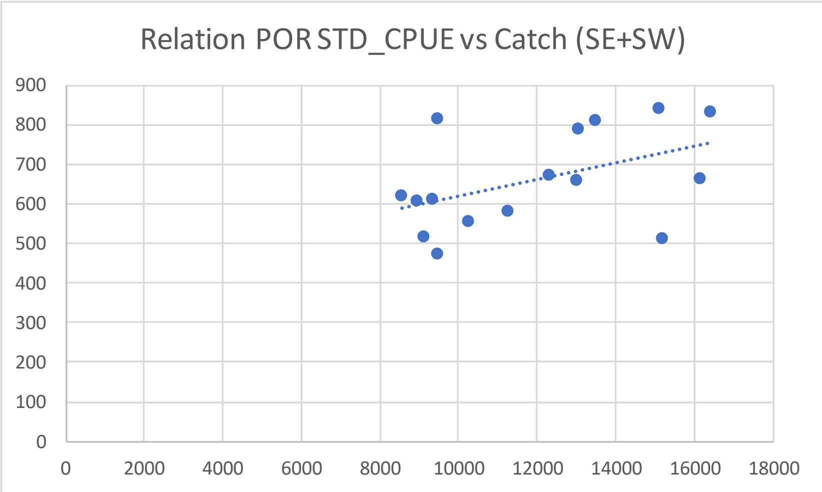


Fig. 8 Relation between catch vs. STD_CPUE (Portugal) (2000-2015)

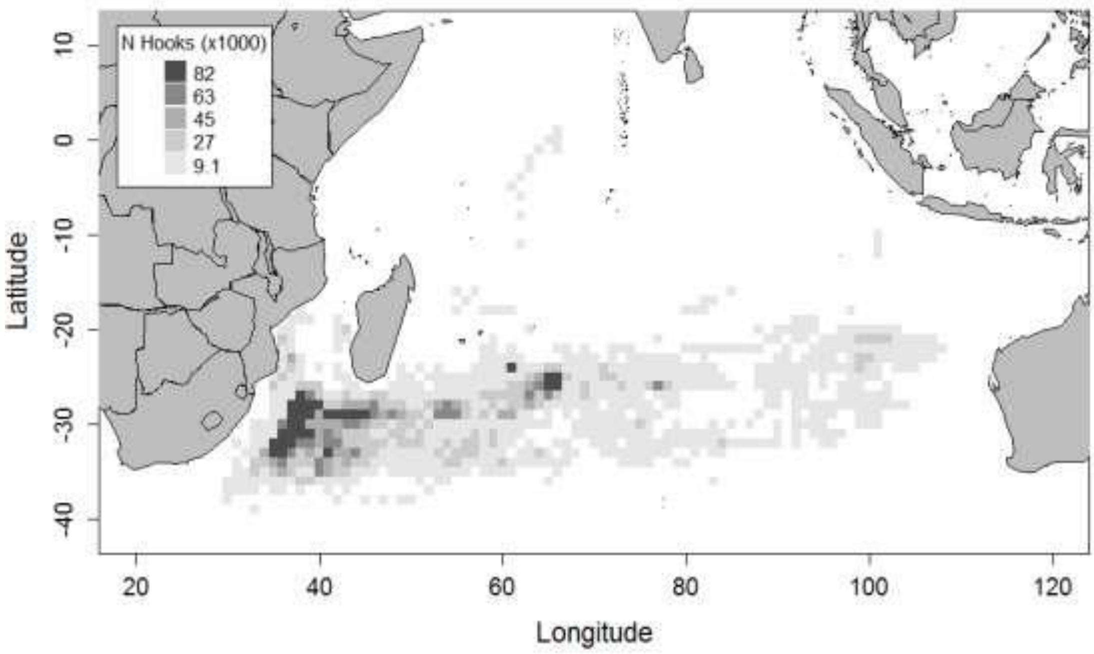


Fig. 9 Fishing ground of Portugal SWO LL

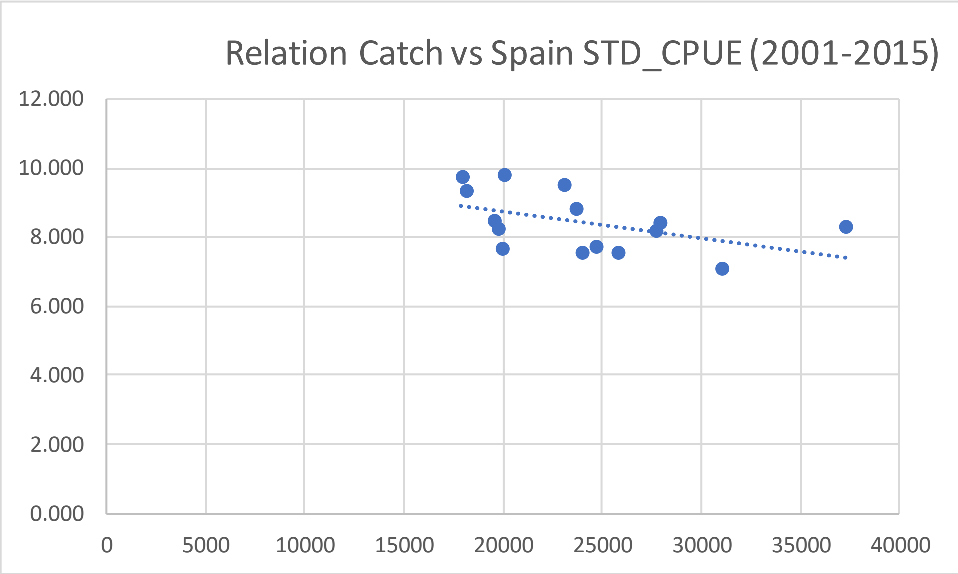


Fig. 10 Relation between catch vs. STD_CPUE (Spain) (2001-2015)

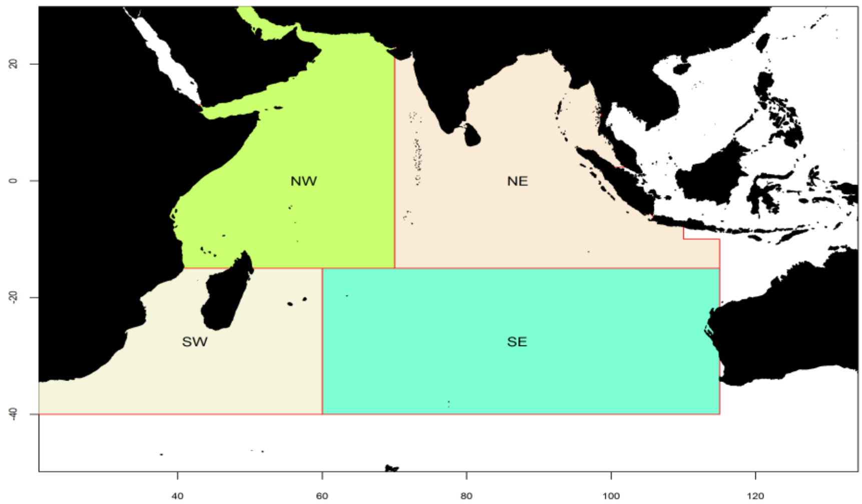


Fig 11. Distribution of the nominal fishing effort (thousands of hooks) carried out by the Spanish surface longline fleet in the Indian Ocean during the year 2015.

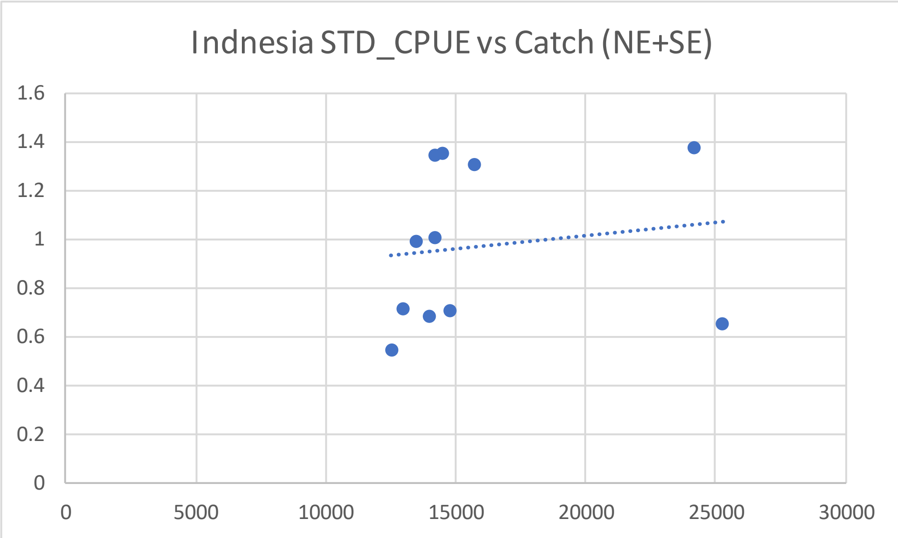


Fig. 12 Relation between catch vs. STD_CPUE (Indonesia) (2005-2015)

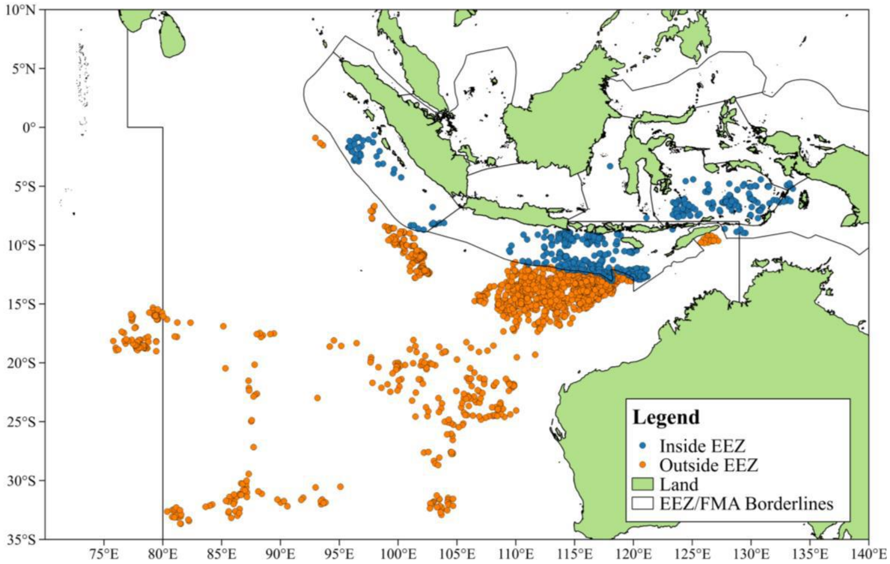


Fig. 13 Fishing ground of Indonesian LL

We selected standardized CPUE for Japan2 (1994-2015), Taiwan 2 (1994-2015) and Spain (2001-2015) because they cover the whole Indian Ocean suitable SCAA (area aggregated stock assessment model) and they are plausible, i.e., negative relation between Catch vs. standardized CPUE.

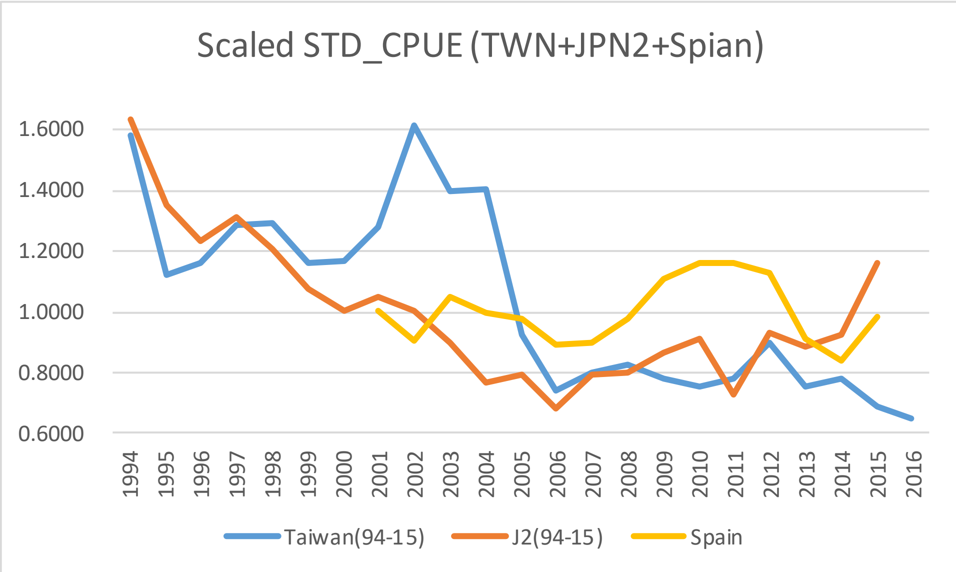


Fig. 14 Selected standardized CPUE

4. Fleet

We use 5 fleets structures for SCAA, i.e., TWLL, TWFL, JPLL, ALGL(GILL) and EL(AUEL＋EUEL＋ISEL) (SWO LL).

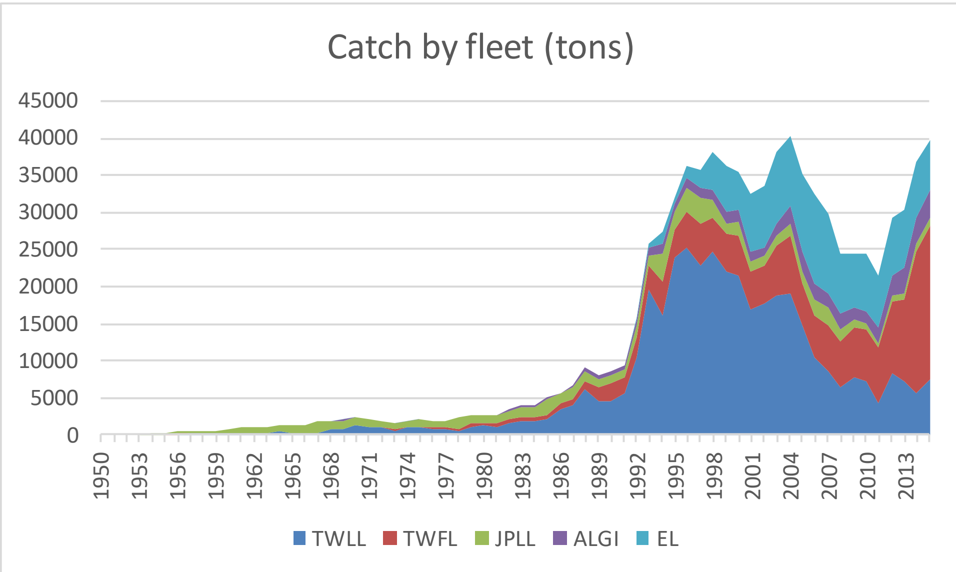


Fig. 15 Catch (tons) by 5 fleets used for SCAA

5. Stock assessment

5.1 Set up

CAA estimated by the Secretariat was used, which is based on the probability method using the growth curve and the LW (Lower Jaw to Fork length vs whole weight) relation by Wang *et al* (2010). As for the fleet, we use 5 fleets structures for SCAA, i.e., TWLL, TWFL, JPLL, ALGL(GILL) and EL(AUEL＋EUEL＋ISEL) (SWO LL). For standardized CPUE, we used Japan2 (1994-2015), Taiwan 2 (1994-2015) and Spain (2001-2015). LW by Wang (2010) was used. Minus and plus groups are defined as in Table 1 and the seeding values for selectivity by fleet are defined in Table 2.

Table 1 Minus and plus group determined based on compositions of CAA by age.

No	Code	Fleet	Minus group	Plus group	Period of available CAA data
(1)	TLL	Taiwan (like) longline (deep-freezing)	(no)	Age 14+	1954-2015
(2)	TLF	Taiwan (like) Tuna LL (fresh)	(no)	Age 14+	1954-2015
(3)	JLL	Japan (like) longline (deep-freezing)	(no)	Age 15+	1954-2015
(4)	GILL	Gillnet	(no)	Age 13+	1954-2015
(5)	ELL	European (like) Shallow LL targeting SWO	(no)	Age 13+	1993-2015

Table 2 Seeding values of selectivity by fleet

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
0.2	03	0.4	0.8		1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
0.2	0.4	0.5	0.8		1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
0.5	0.6	07	0.9		1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
0.8		1	1	1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9		
0.2	0.4	0.7	0.9		1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9		

Note: (1) is the highest selectivity (=1) specified as blanks in SCAA program file

Then we set up various parameter as below:

Our main interest is if the new growth curve and maturity-at-age (MAA) are feasible, hence we examine them in SCAA runs.

Period (2 options)	1950-2015 and 1980-2015
Standardized CPUE (7)	Japan 2 (1994-2015), Taiwan 2 (1994-2015) and Spain (2001-2015)
Growth & MAA (2)	Previous: Wang et al (2010) for growth
	Poisson and Fauvel (2009) for MAA
	New: Farley et al (2016) for growth and MAA (Otolith)
Other parameters	Sigma (SR)=0.4, 0.5 and 0.6 (3 options)
	CV of CAA: 0.2 (Fixed) (1)
	Steepness 0.7, 0.8 and 0.9 (3)
	Weighting for CAA: 0.5,1.0 and 1.5 (3)

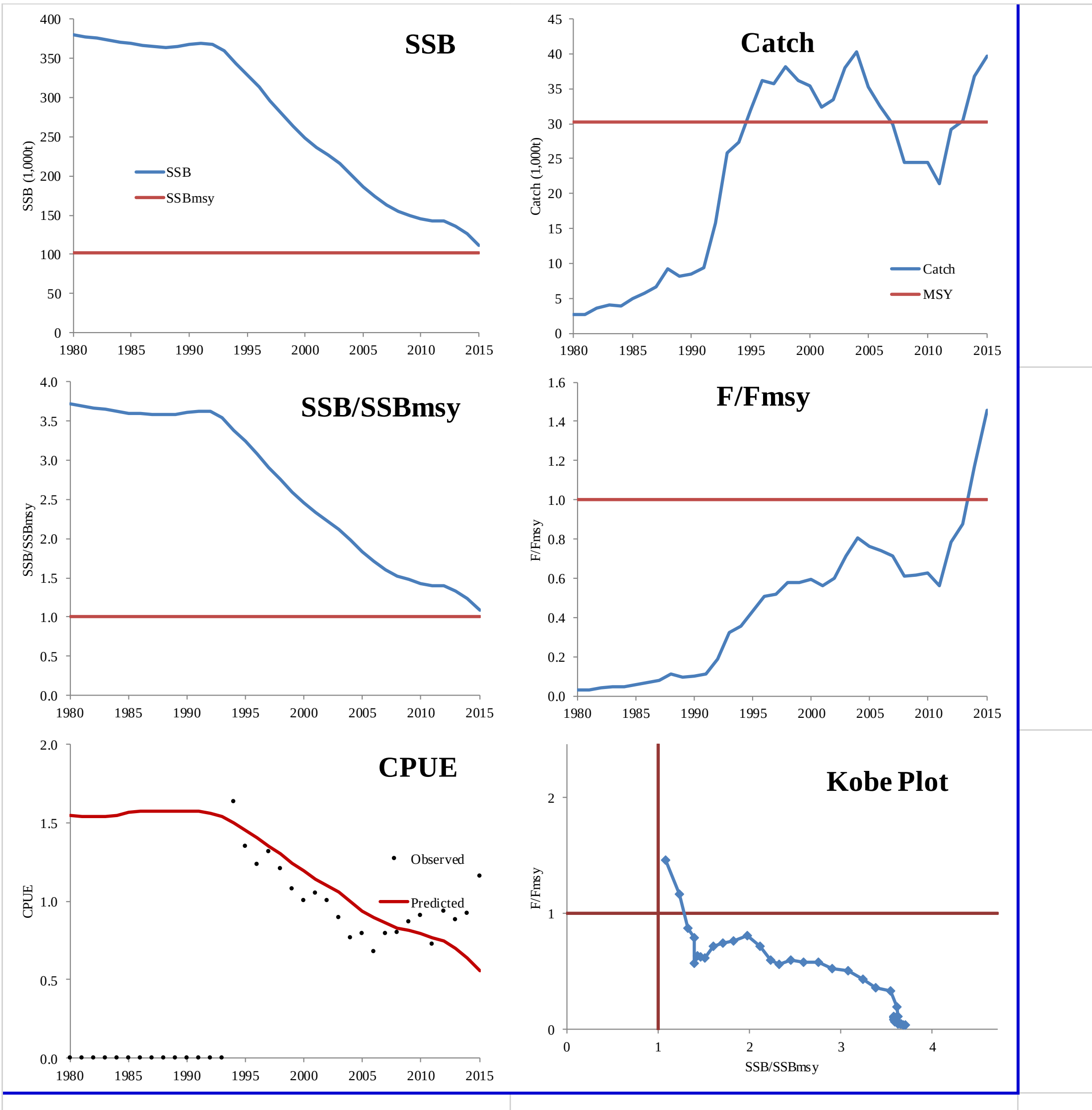
With this set-up, we have 756 scenarios for combinations of various options stated above and made grid search using the application developed for SCAA.

5.2 Results

Plausible parameters are obtained by the scenario below:

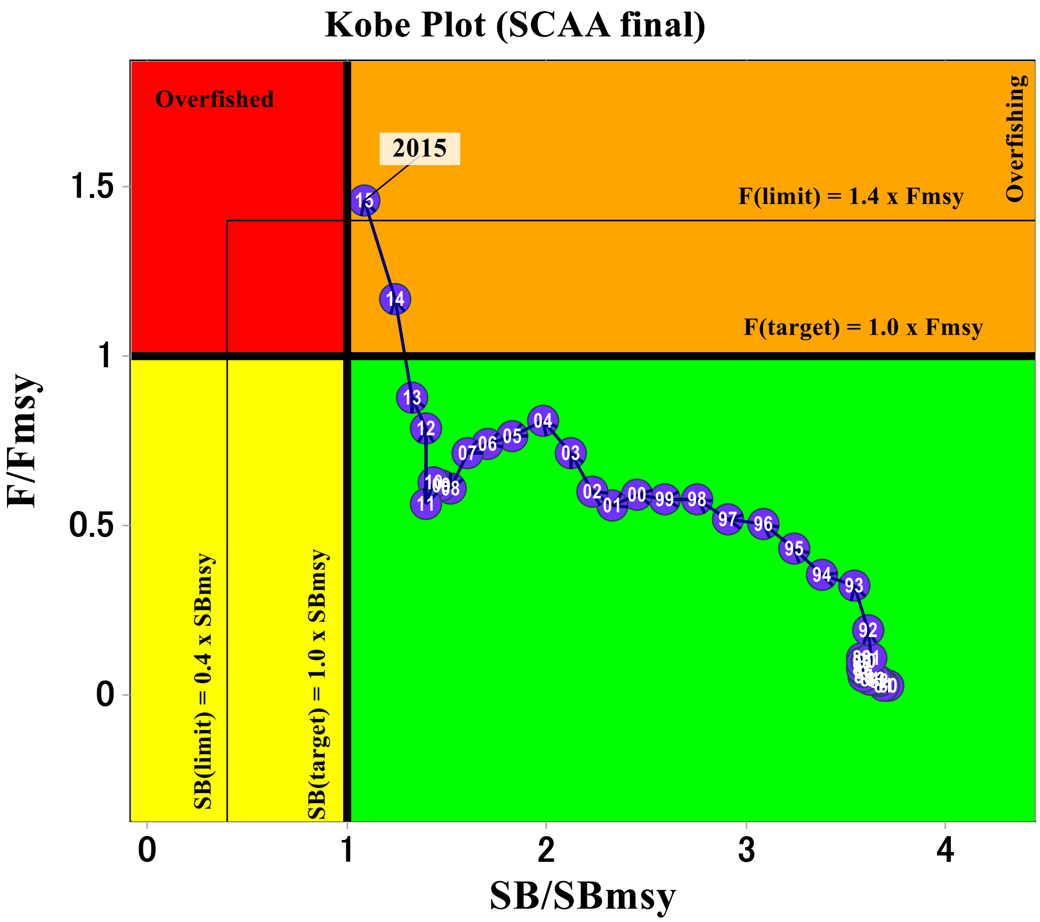
Period	1980-2015
Standardized CPUE	Japan 2 (1994-2015)
Steepness	0.7
CV for CPUE	0.2 (fixed)
Weighting for CAA	1.0
Growth & MAA	Previous: Wang et al (2010) for growth
	Poisson and Fauvel (2009) for maturity-at-age

Results are show in Figs. 16-18.



MSY=30,237 ton, SSB/SSBmsy=1.08 and F/Fmsy=1.46.

Fig. 16 Results of SCAA



MSY=30,237 ton, SSB/SSBmsy=1.08 and F/Fmsy=1.46.

Fig. 17 Kobe plot (final run)

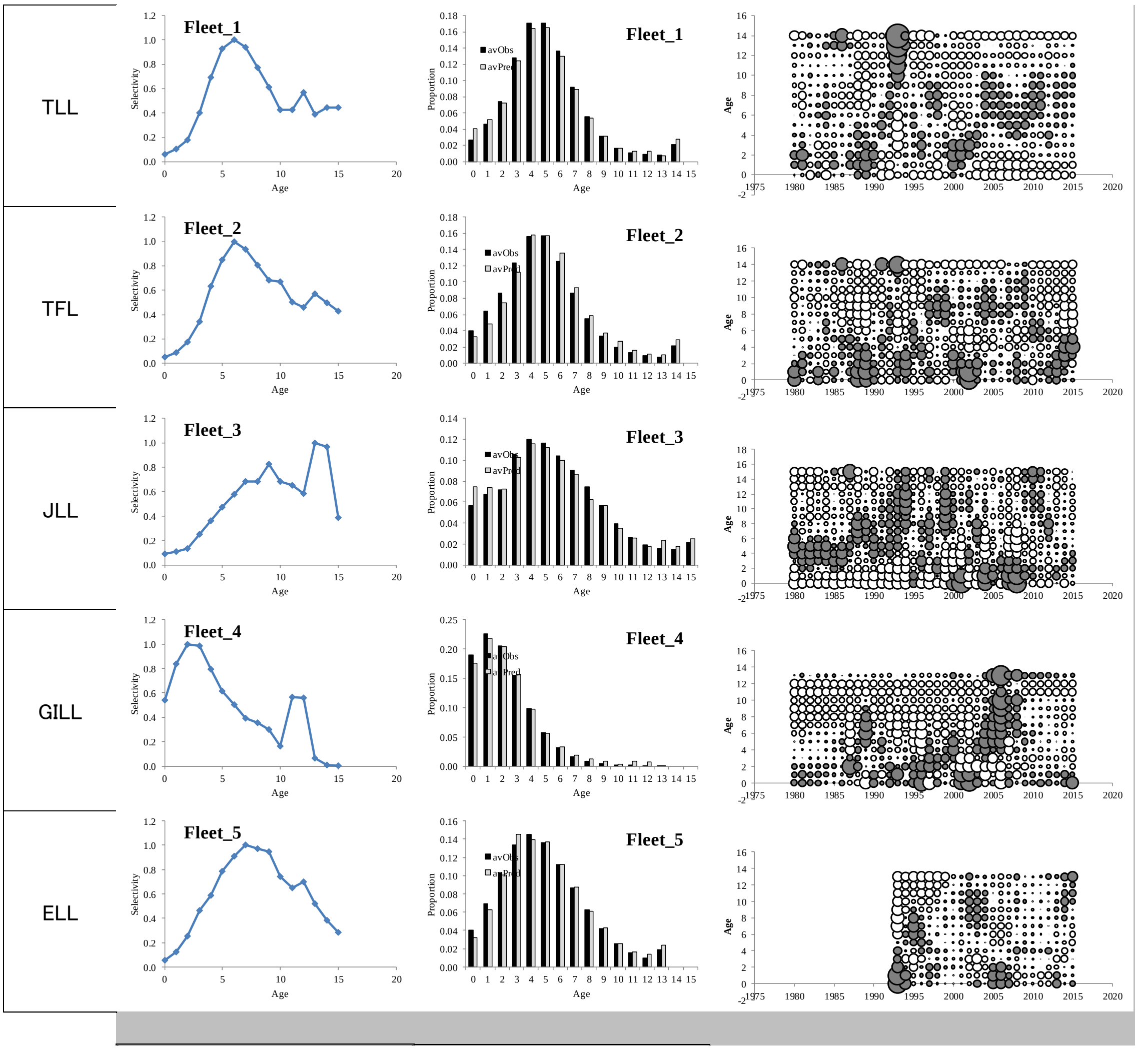


Fig. 18 Estimated selectivity by fleet (model free)

5.3 Sensitivity run

(1) Indonesian Fresh LL SWO catch (2014-2015)

Fu et al (2017) conducted SS3 in WPB15 and describes the problem of Indonesian SWO catch as follow:

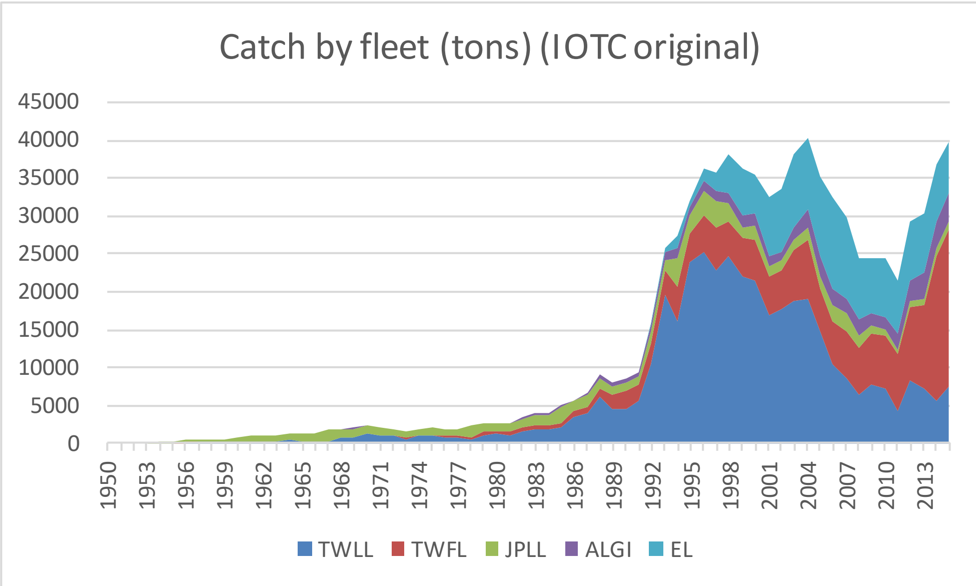
“The nominal catches are not always reported by species and/or gear by the responsible institutions in each country. The catches reported under species and/or gear aggregates are decomposed by the IOTC secretariat using alternate sources of information (if available), or a pre-defined criterion so that all catches are separated into individual gears and species.

The swordfish catch from the Indonesian Fresh Tuna Longliners was estimated using the Taiwanese fresh longline as a proxy for gear/species disaggregation. As the TWN fresh longline catch had a (more than) twofold increase from 2013 to 2014, the Indonesian catch increased significantly.

Thus, the estimated swordfish catch for the LL_NE fishery increased from 10210 t in 2013 to 17 484t in 2014, and 18 998 t in 2015. This appears very unlikely. Therefore, in the assessment we used the average catch between 2011 and 2013 as an estimate for the Indonesian Fresh Tuna Longline catch for the last two years. Accordingly, the catch estimates for the LL_NE fishery were reduced to 10 156 t and 11 460 t for 2014 and 2015. The disaggregation estimates were used in a sensitivity run instead."

We also share the same concerns. Hence, we did the extra sensitivity run using the alternate Indonesian catch proposal by Fu et al (2017) also by adjusting CAA.

Fig. 19 shows differences of the catch trends between the original and the alternate ones, which indicates large differences in 2014-2015 and will certainly change the results of stock assessments.



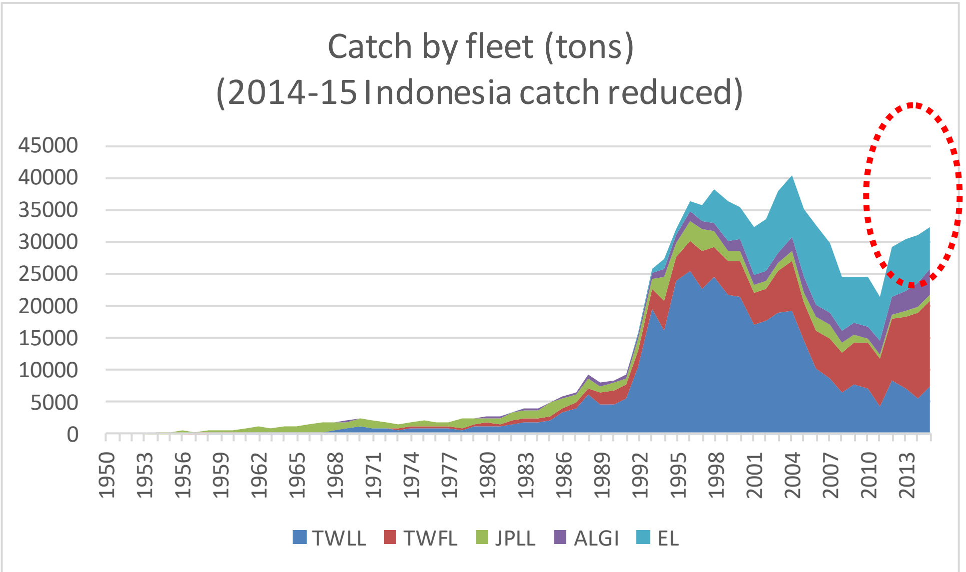
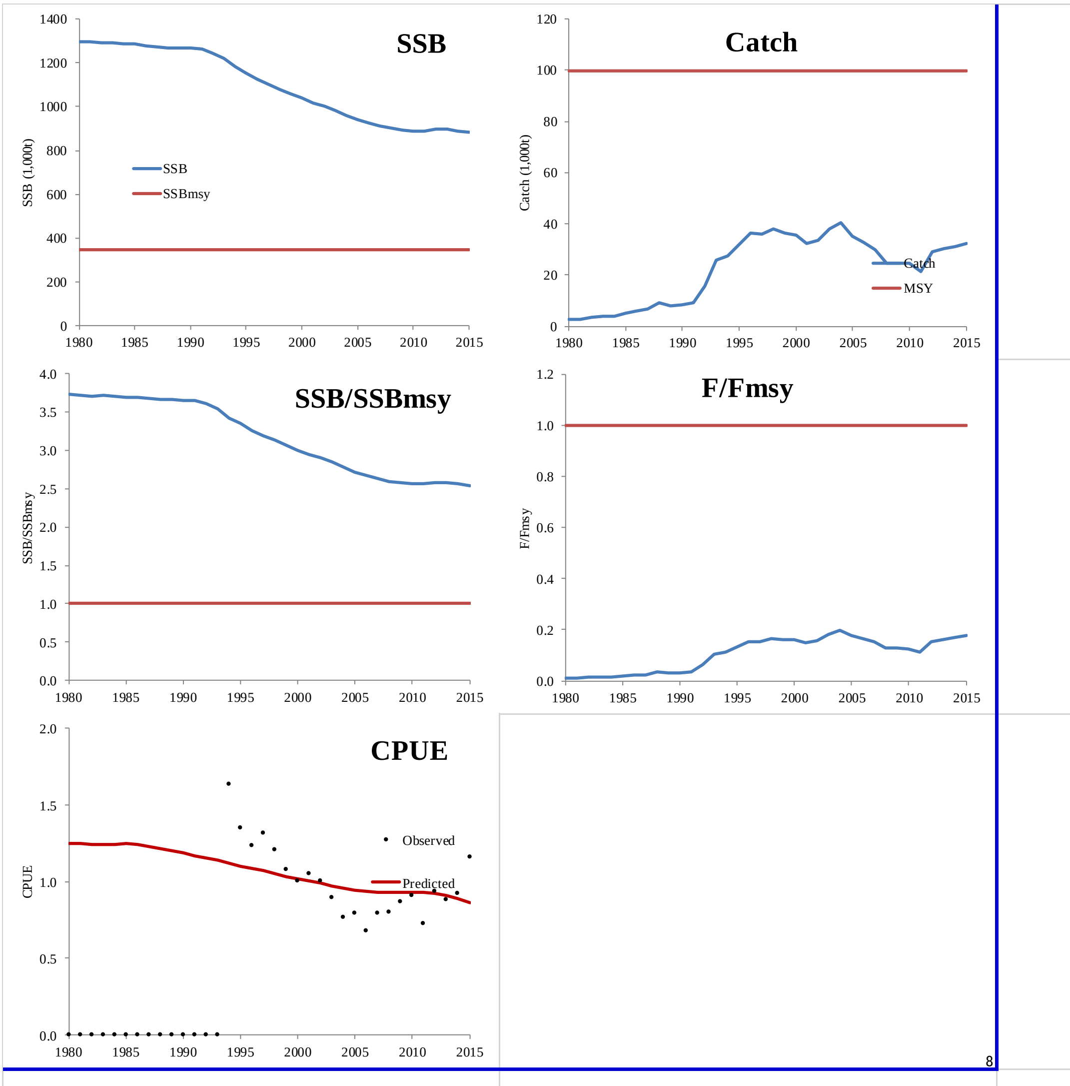


Fig. 19 Differences of the catch trends between the original one by Secretariat (18,967 tons in 2015 and 20,735 tons in 2015) (above) and the alternate one proposed by Fu *et al* (2017) (13,197 tons in 2014 and 13,411 tons in 2015) (below). This difference might be caused by the potential biased estimation by Secretariat of SWO catch by Indonesian fresh LL.

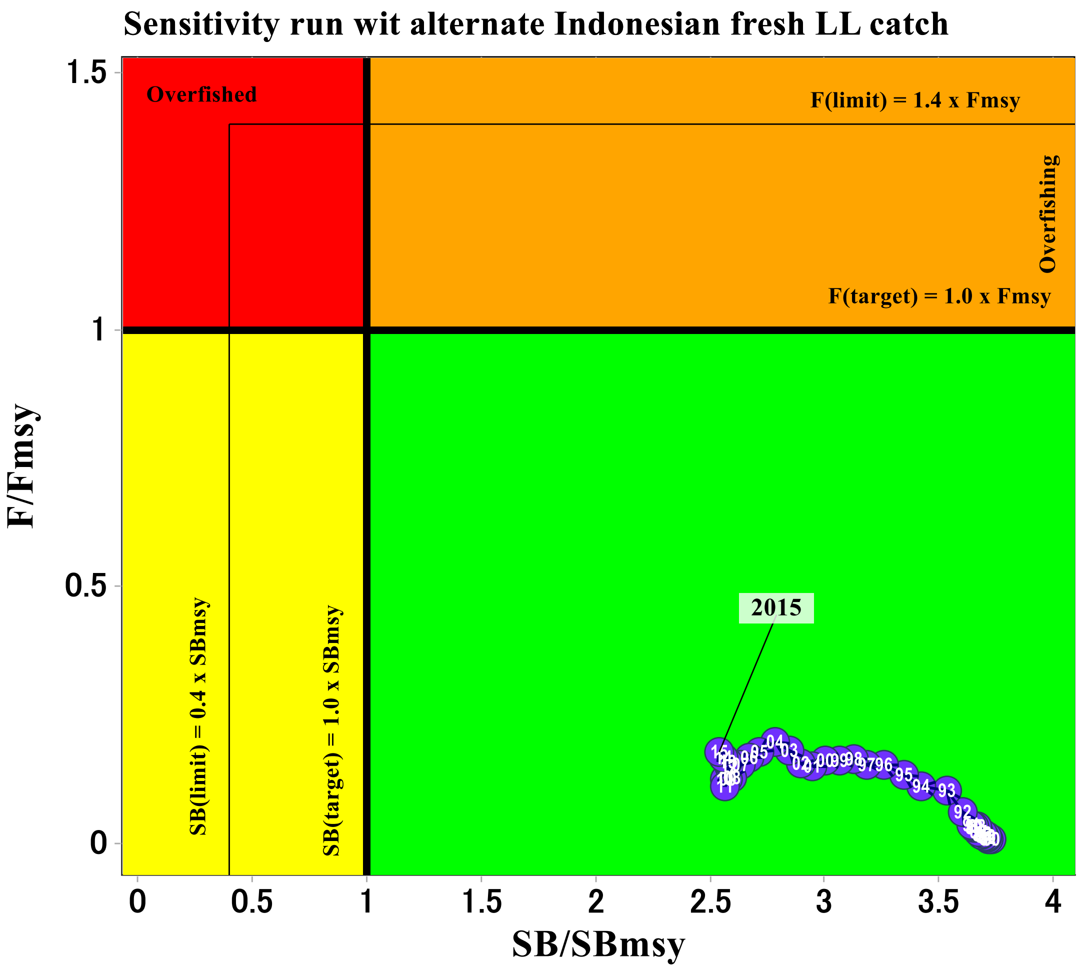
(2) Results of the extra sensitivity run

Fig. 20-22 show the results of the sensitive run. As expected, the stock status changes to much more optimistic due to usage of the substantial lower catch in 2014-15. Results are not realistic as estimated parameters (MSY and F) are not plausible considering the current situation.



MSY=99,732 ton, SSB/SSBmsy=2.54 and F/Fmsy=0.18

Fig. 20 Results of SCAA for the extra sensitivity run
using the lower catch values of Indonesian fresh LL catch in 2014-2015



MSY=99,732 ton, SSB/SSBmsy=2.54 and F/Fmsy=0.18

Fig. 21 Kobe plot for the extra sensitivity run
using the lower catch values of Indonesian fresh LL catch in 2014-2015

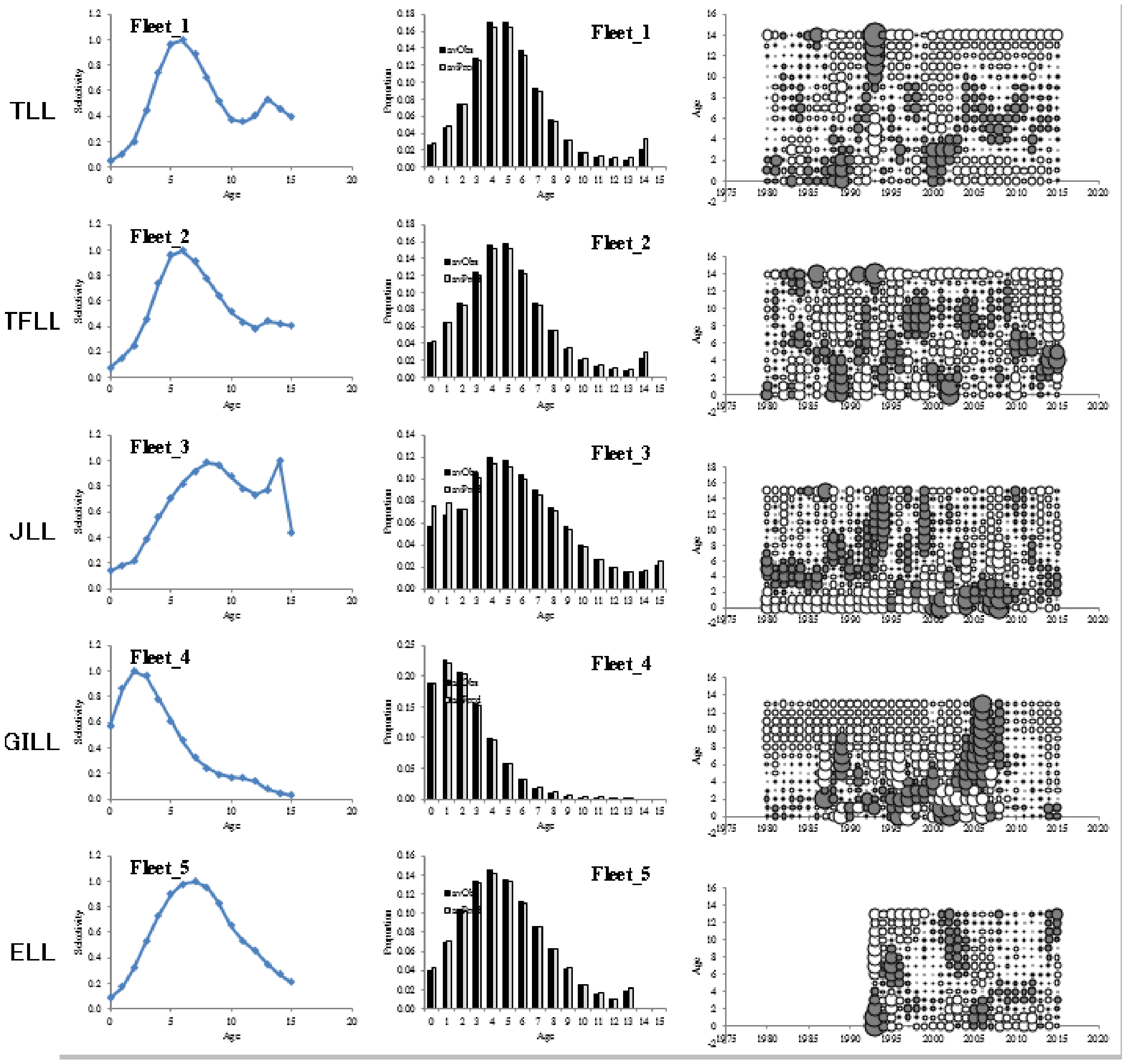


Fig. 22 Estimated selectivity by fleet (model free) for the extra sensitivity run using the lower catch values of Indonesian fresh LL catch in 2014-2015

6. Discussion and conclusion

Stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean was attempted using Statistical-Catch-At-Age (SCAA) with one stock hypothesis. We examined two different biological information, i.e., information (a) previous growth curve by Wang et al (2010) and maturity-at-age by Poisson and Fauvel (2009), and information (b) new growth curve and maturity-at-age by Farley et al (2016) by otolith.

It was suggested that information (a) produced plausible results, while information (b) did not produce any convergences nor plausible results. Its conceivable reason is that CAA is estimated by the previous growth curve by Wang et al (2010) which might not suitable for SCAA based on new biological information as the current CAA is not estimated by the new growth curve and maturity-at-age.

Regarding the Indonesian fresh LL catch in 2014-2015, the proposed catch (2014-2015) may be too low as the stock status is too optimistic, while the one original may be too high based on the reason described by the Fu et al (2017). Thus, it is likely that the real catch may be in between these catch levels. Accordingly, the stock status may be in between these two in Fig. 23. The real catch needs to be investigated in the future to identify the more realistic stock status.

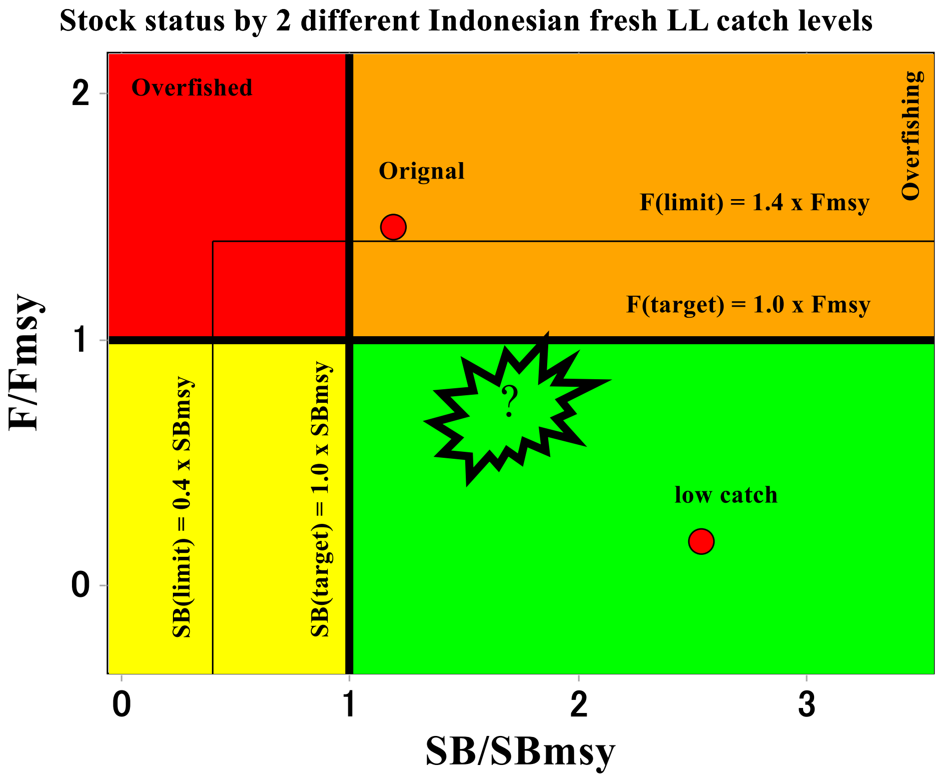


Fig. 23 Kobe plot comparing 2 Indonesian fresh LL catch I 2014-2015
Original one (Secretariat) vs. Reduced one proposed by Fu et al (2017)

In addition, we could find plausible result in only one grid (out of 756 grids) with the original Indonesian fresh LL catch. The reason and cause of this strange situation need to be investigated in the future.

Because of these 2 uncertainties (Indonesia fresh LL catch and solution with only one grid), we cannot suggest any plausible results, but it is likely that the current stock status may be in between two points shown in the Kobe plot in Fig. 23.

Recommendation

It is strongly recommended to investigate the real SWO catch by the Indonesian Fresh LL in 2014-2015.

Acknowledgments

We thank Fabio Fiorellato (IOTC Data Coordinator) providing us the SWO nominal catch and CAA data.

References

Farley, J., Clear, Naomi., Kolody, D., Krusic-Golub, K,. Eveson, Paige., Young, Jock. 2016. Determination of swordfish growth and maturity relevant to the southwest Pacific stock. R 2014/0821.

Fu, Dan (IOTC Secretariat) 2017. An age-, sex- and spatially-structured stock assessment of the Indian Ocean Swordfish fishery 1950-2015, using stock synthesis IOTC–2017–WPB15–20_Rev1

Wang, S.P., Chi-Hong, L., Chiang, W.C. 2010. Age and growth analysis of swordfish (Xiphias gladius) in the Indian Ocean based on the specimens collected by Taiwanese observer program. Working paper IOTC-2010-WPB-08 (revision 1).