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Preliminary stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean by the Age Structured Production Model (ASPM) (1952-2007)

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Abstract

We attempted the stock assessment of swordfish (SWO) in Indian Ocean by the ASPM. AI (abundance index) of TWN (1995-2007 without 2002) using the set by set data with the correction factor of targeting (NHBF), produced similar and realistic ASPM results to those of JPN, but less fitness than as for Japan (R^2=60% for JAPAN and 35% for TWN). ASPM could not get convergence if we used AI of JPN and TWN together. Based on the best scenario using only JPN's AI, F is 30% above MSY while SSB is just above the MSY level, which suggests that we should not increase the current F. 3 types of CPUE trends (JPN, TWN and La Reunion) in the SW IO (Indian Ocean) consistently show the rapid decreasing trends. Thus F especially in SW IO should be decreased.

We may have 3 hypothetical stocks based on ocean currents driven monsoons, 2 spawning areas and patterns of STD CPUE trends (NW, SW and E) as STD CPUE of Japan and Taiwan consistently shows heterogeneous patterns among these 3 areas. If this hypothesis were realistic, we need to concern the stock status mainly in the SW area as the STD CPUE shows the rapid decreasing trends, while we may not need to worry so much about the stock status in other 2 areas (NW and E) as their STD CPUE show the flat or gradual decreasing trends This may be the possible reply to the questions raised in the last annual IOTC meeting held in Bali, Indonesia.

1. Introduction

We attempted the stock assessment of swordfish (SWO) in Indian Ocean by the ASPM.

2. Input data

2.1 Fisheries data

We categorized SWO fisheries into 4 types (Box 1) and Fig. 1 shows the catch trends for these 4 gears.

Box 1 Four types of gears exploiting SWO in the Indian Ocean	
(a) LL(JPN)	*: Japanese tuna longline type by-catching SWO.*
(b) LL(TWN)	*: Taiwanese tuna longline type targeting SWO occasionally (seasonally) or by-catching*
(c) LL(TAR)	*: Shallow setting SWO tuna longline type targeting SWO (Spain, La Reunion and others)*
(d) GILL	*: Gillnet and other gears type by-catching SWO*

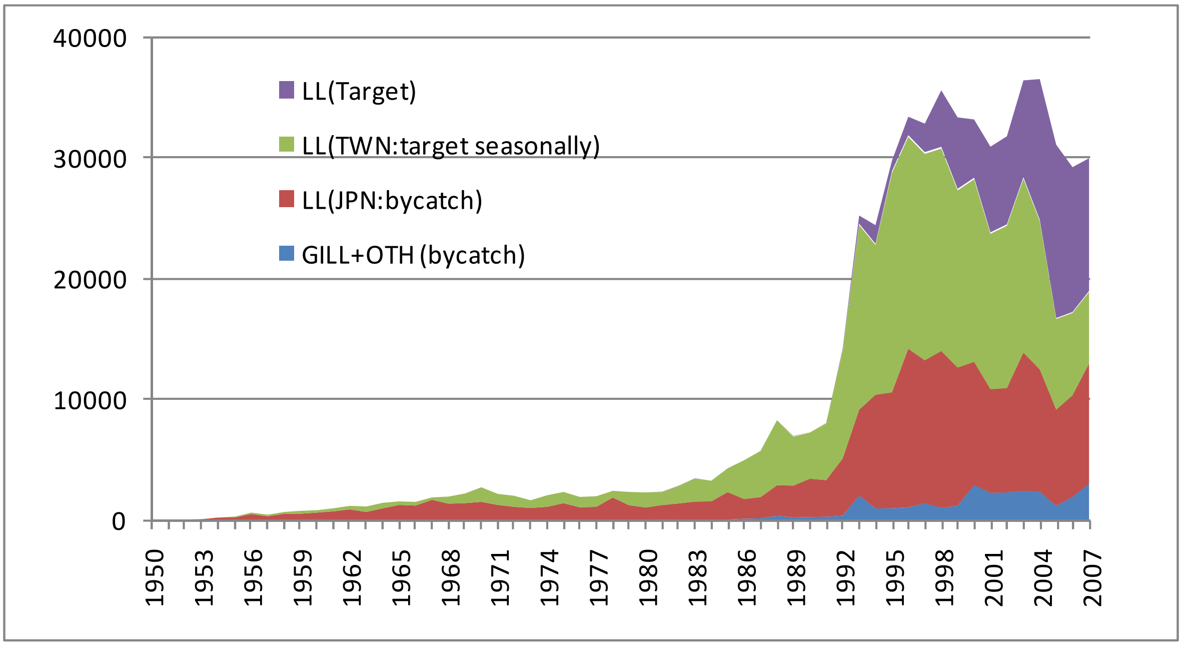


Fig. 1 Trends of SWO catch by 4 types of gears in the Indian Ocean (1952-2007) (tons)

2.2 Selectivity

IOTC Secretariat estimated CAA (catch-at-age) based on the biological information provided by Wang (2009). Using the separable VPA by Clay (1988) and modified by Miyabe (1989), selectivity for 4 years are estimated (Fig. 2).

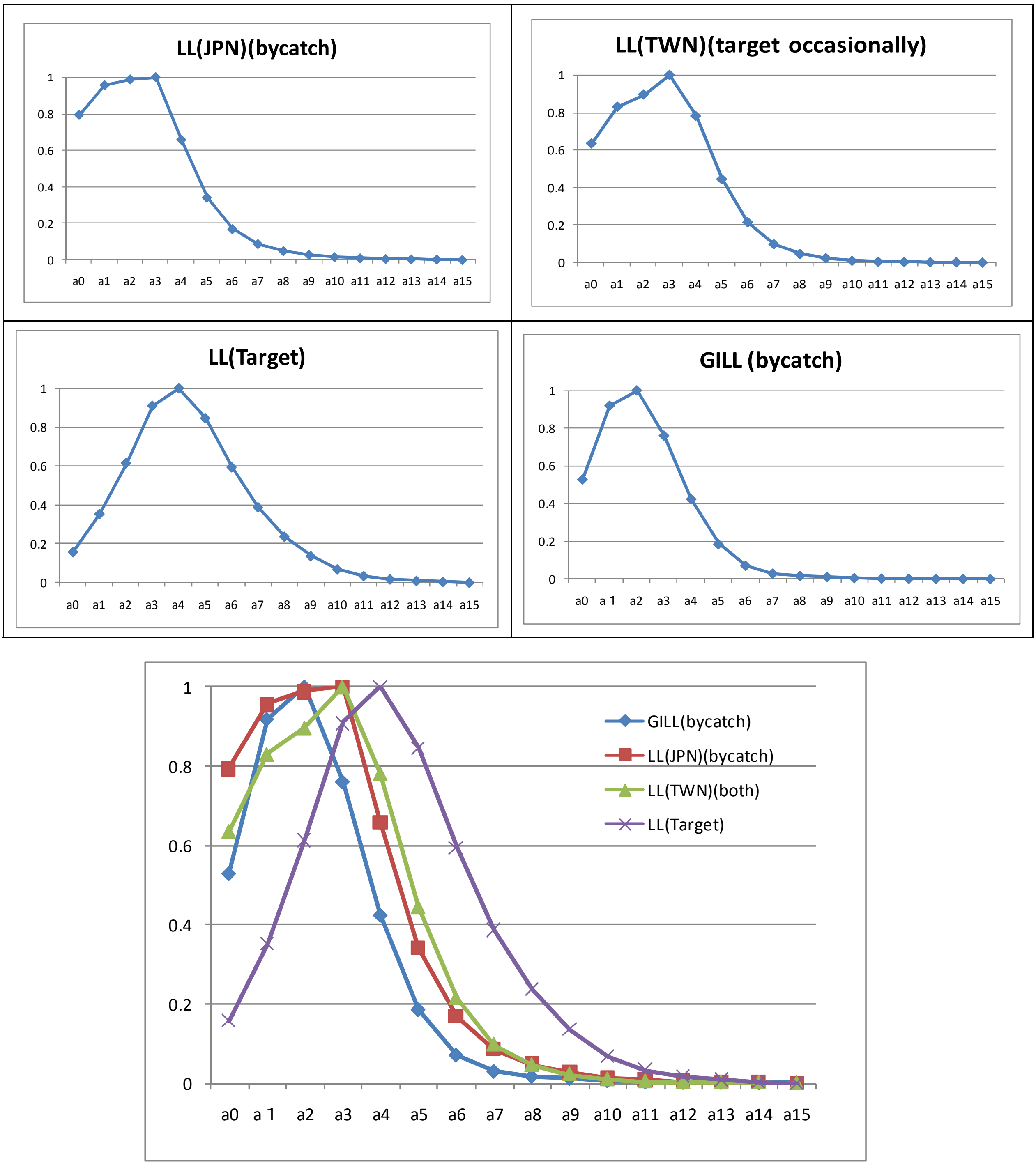
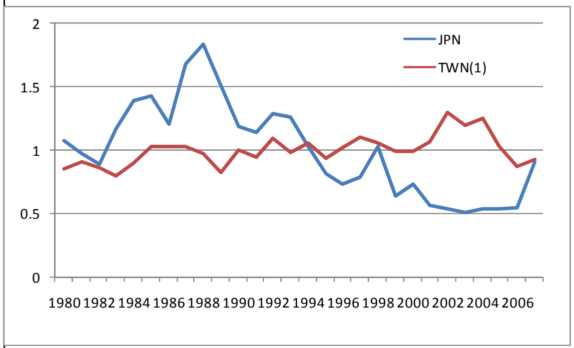


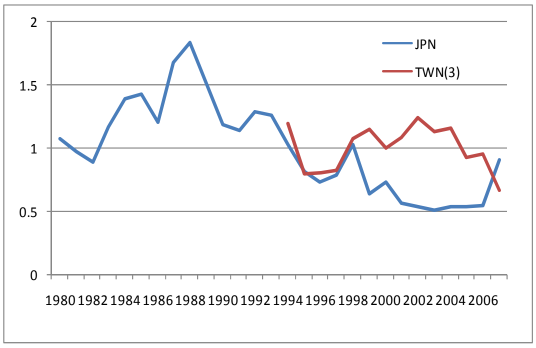
Fig 2 Upper 4 Figures: Estimated selectivity by gear type; Lower one figure: Overlaid selectivity of 4 gears.

2.3 Abundance index (AI)

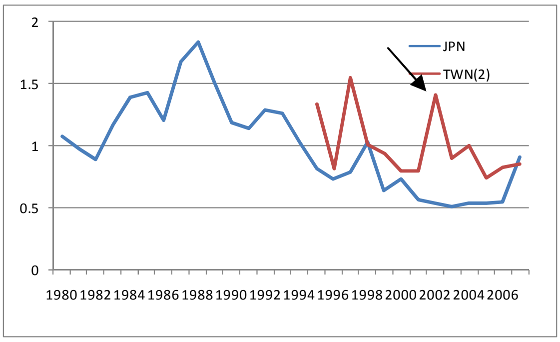
We used Japanese and Taiwanese abundance indices estimated by Nishida & Wang (2009) and Wang & Nishida (2009) respectively. Fig. 3 shows the trends of the scaled and overlaid AI of JPN and TWN (4 cases). From 4 figures, we selected TWN case 2 and 4 to be used for the ASPM (Fig. 4) because there are no similarities between 2 indices in case 1 and 2. For TWN (case 2 and case 4), the 2002 data points are excluded as they are likely un-realistic.



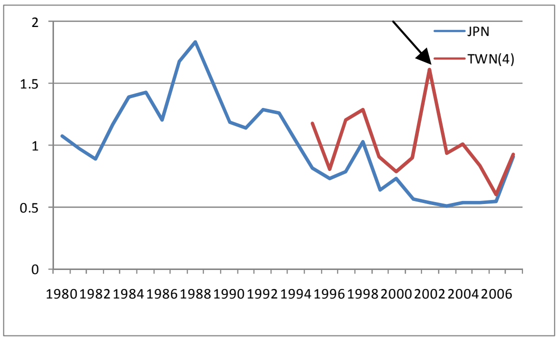
AI : JPN vs. TWN (case 1)



AI : JPN vs. TWN (case 3)

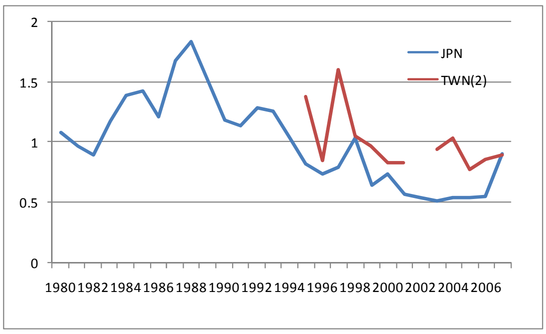


AI : JPN vs. TWN (case 2)

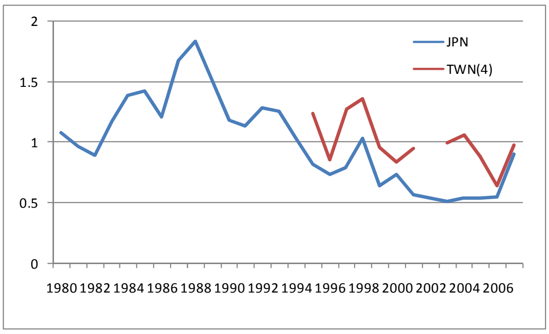


AI : JPN vs. TWN (case 4)

Fig. 3 Trends of the scaled and overlaid AI of JPN and TWN (4 cases).



AI : JPN vs. TWN (case 2) (2002 not used)



AI : JPN vs. TWN (case 4) (2002 not used)

Fig. 4 AI used for the ASPM (JPN with TWN case 2 & 4 without the unrealistic 2002 data)

2.4 Biological data

Wang (2009) estimated the age specific weight, natural mortality and maturity using available information in the Indian Ocean. Box 1 shows the biological inputs used in the ASPM runs.

Box 1 Biological inputs

```
# BIOLOGICAL inputs file
# Weight-at-age
# Beginning of the year weights by age (in tons)
#  0        1        2        3        4        5        6        7        8        9        10+
   0.00516  0.01063  0.01834  0.02820  0.03997  0.05335  0.06803  0.08367  0.09997  0.11665  0.13347
# Middle of the year weights by age   (in tons)
#  0        1        2        3        4        5        6        7        8        9        10+
   0.00755  0.01412  0.02290  0.03372  0.04632  0.06038  0.07556  0.09157  0.10809  0.12486  0.14166
# Natural mortality by age
#  0     1     2     3     4     5     6     7     8     9     10+
  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25  0.25
# Enter   fecundity by age
#  0     1        2       3        4        5        6        7        8        9        10+
   0.00  0.00001  0.0001  0.00068  0.00374  0.01485  0.03847  0.06690  0.09178  0.11277  0.13158
```

3. ASPM runs

5 scenarios by different combination of AI are attempted for ASPM runs (Table 1). Steepness is fixed as 0.9 because if we estimated the steepness we got the unrealistic value (0.999). As a result of 5 ASPM runs, scenario 1 using Japanese AI produced the best estimates. Fig. 5 shows the results and Fig 6 shows the Kobe plots for 2 scenarios.

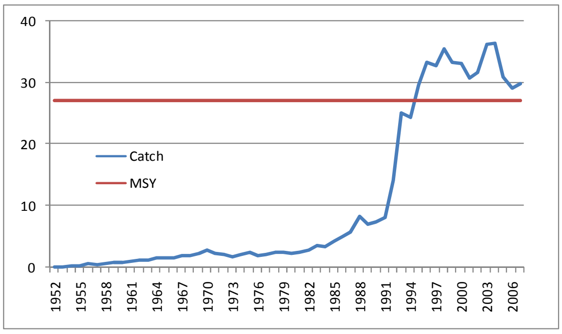
Table 2 5 scenarios of the ASPM runs and Results

Scenario no	1	2*	3*	4*	5*
AI (abundance index)	JPN	TWN (case2)	JPN+TWN (case2)	TWN (case 4)	JPN+TWN (case 4)
Steepness	0.90				
M	0.25				
-LLH	-29.7	-15.4			
R2	60%	35%		22%	
MSY (‘000 t)	27.0	27.5		28.0	
F(2007)	0.416	0.378		0.341	
F(MSY)	0.339	0.339		0.339	
F(2007) /F(MSY)	1.23	1.12	Not converged	1.01	Not converged
SSB(2007) (‘000 t)	61.1	67.2		75.0	
SSB(MSY) (‘000 t)	54.1	55.2		56.6	
SSB(2007) /SSB(MSY)	1.13	1.23		1,33	
	1 st Best	2nd best			

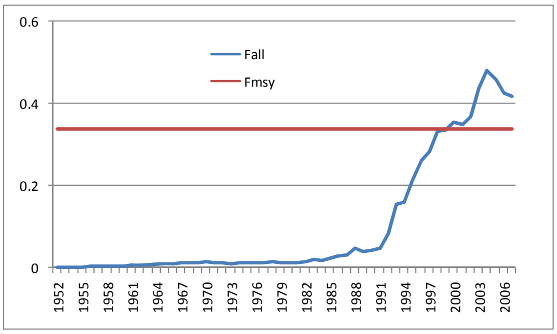
Note (*) 2002 data are not used as they (sudden jump) are realistic

Fig. 5 Results of the ASPM run (scenarios 1)

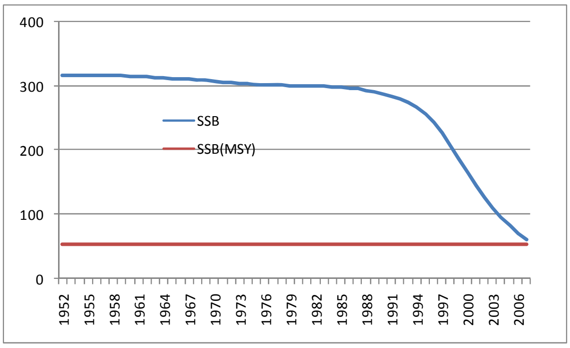
Scenario 1



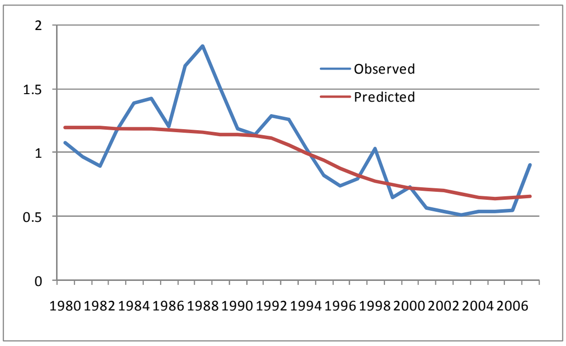
Catch vs. MSY (‘000 tons)



F vs. F(msy)



SSB vs. SSB(msy) (‘000 tons)



Predicted vs. observed abundance index

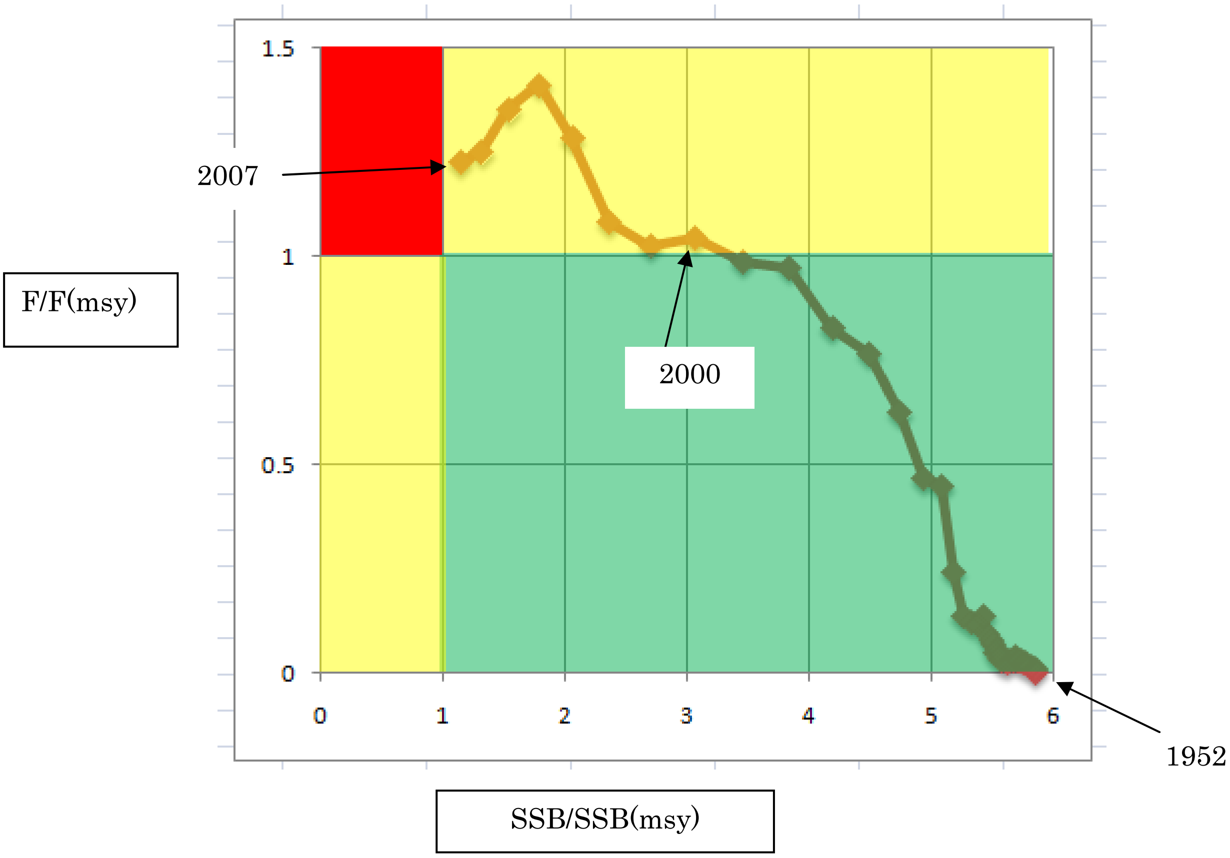


Fig. 6 Kobe plot (trends of reference points)

4. Discussion and conclusion

- AI of TWN (1995-2007 without 2002) using the set by set data with the correction factor of targeting (NHBF), produced similar trends to those of JPN which also produced reasonable ASPM results but less fitness compared to those of JPN. .

- ASPM could not get convergence if we use AI of JPN and TWN together.

- Based on the best scenario (1), F is 30% above MSY while SSB is just above the MSY level, which suggests that we should not increase the current F.

- 3 types of CPUE trends (JPN, TWN and La Reunion) in the SW IO (Indian Ocean) consistently show the rapid decreasing trend (Fig. 7). F especially in SW IO should be decreased.

- We may have 3 hypothetical stocks based on the STD CPUE trends (NW, SW and E and these stock are intermingled in the border areas due to ocean currents) as STD CPUE of Japan and Taiwan consistently shows heterogeneous patterns among these 3 areas (Fig 7 and 8) and considering ocean current driven by the monsoons and spawning areas)(Fig. 9)

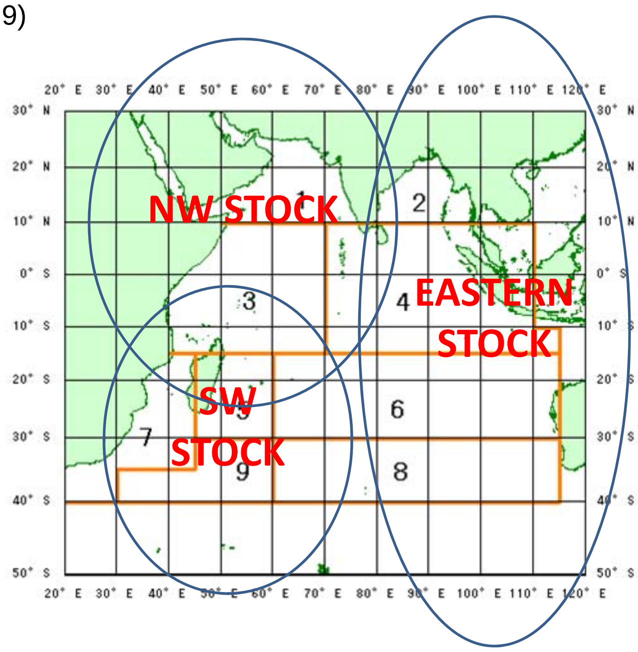


Fig 7 3 hypothetical SWO stocks in the IO based on the STD CPUE trends of Japan and Taiwan, i.e., STD CPUE trends in North, SW and SE have heterogeneous patterns (see Fig 8).

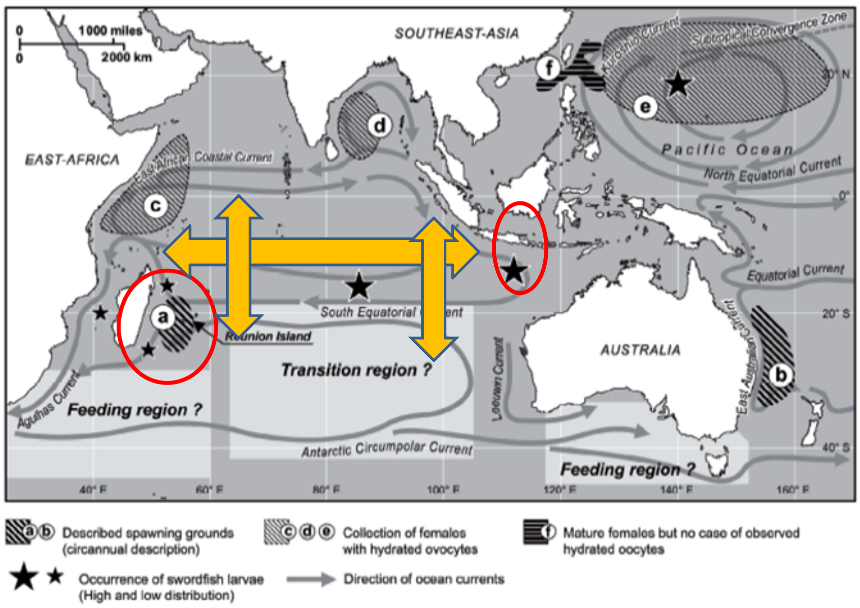


Fig. 9. Map showing all available information on the reproductive biology of swordfish in Indian Ocean and in the western Pacific Ocean.

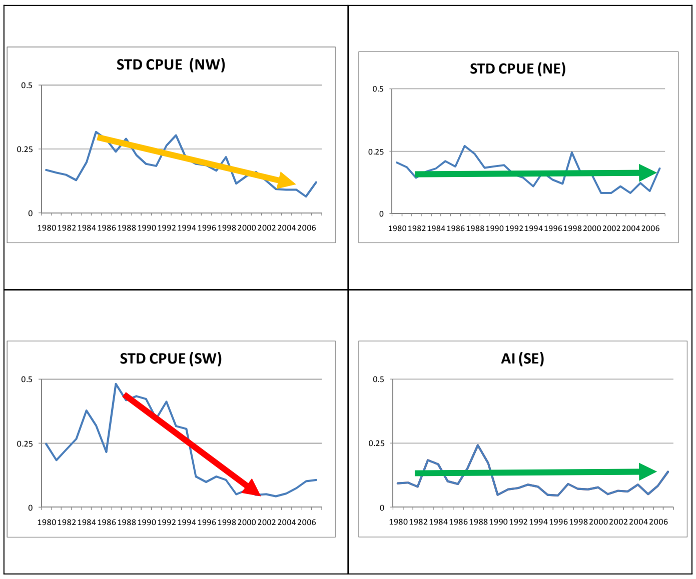
Fig 8. 2 Schematic diagram of SWO 2 spawning areas, feedings zones and ocean currents (after Poisson, 2009)

- If this hypothesis were realistic, we need to concern the stock status mainly in the SW area as the STD CPUE shows the rapid decreasing trends, while we may not need to worry so much about the stock status in other 2 areas (NW and E) as their STD CPUE show the flat or gradual decreasing trends (This may be the reply to the questions raised in the last annual IOTC meeting held in Bali, Indonesia).

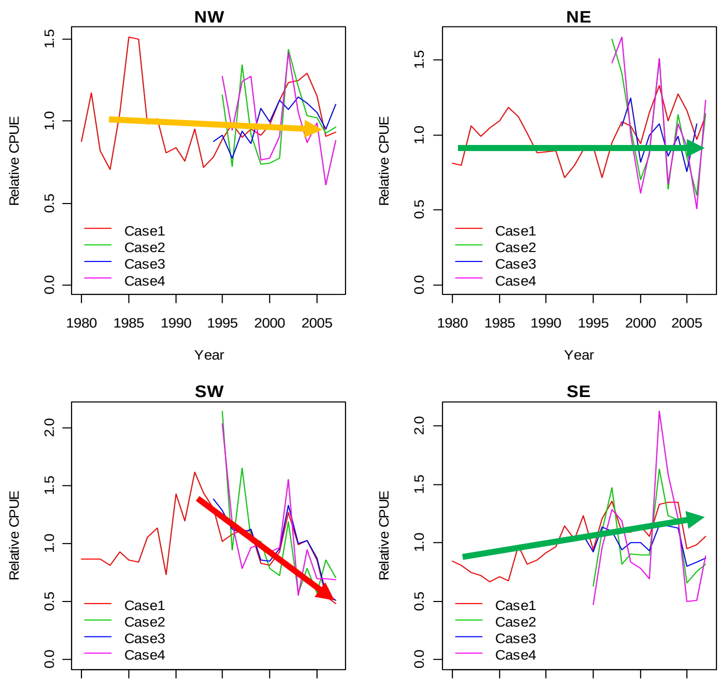
Acknowledgments

We thank Miguel Herrera (IOTC) providing us the SWO CAA data and also Dale Kolody (CSIRO, Australia) for technical suggestions.

Trend of JPN STD CPUE by area



Trend of TWN STD CPUE by area



Trend of Le Reunion CPUE (SW Indian Oean)

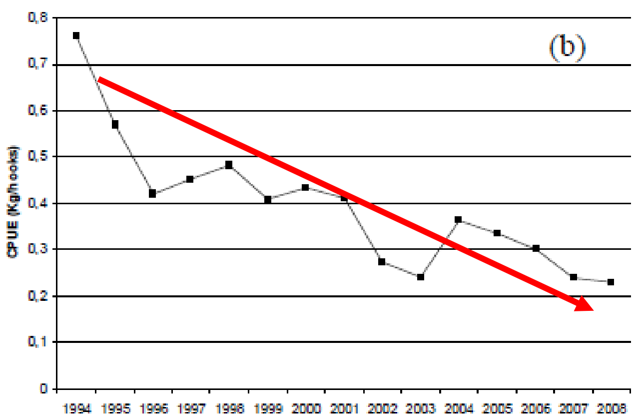


Fig 9 Trends of STD CPUE (JPN, TWN and La Reunion) by area