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Stock assessment of swordfish (*Xiphias gladius*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC)

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Abstract

We conducted the stock assessment of swordfish (*Xiphias glades*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC) for the data for 30 years from 1975-2004. We discussed the problem of discrepancies of standardized CPUE between Japan and Taiwan which largely affected the results of ASPIC runs.

Contents

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1. Introduction

In this paper, we attempted to conduct stock assessment of swordfish (*Xiphias gladius*) (SWO) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC) using the data for 30 years from 1975-2004.

2. Data

In the ASPIC analyses we use SWO catch and standardized (STD) CPUE and global nominal catch data (1975-2004) in MT are obtained form the IOTC database as of March, 2006. For the standardize CPUE we used the Japanese one (1975-2004) estimated by Nishida and Wang (IOTC-WPB-2005-07) and the Taiwanese ones (1979-2003) by Wang (IOTC-WPB-__). In the Taiwanese STD CPUE, there are two cases. We used the STD CPUE for case 2 as it used number of hook per basket which is corresponding to the Japanese STD CPUE and trends are slightly close to the Japanese STD CPUE especially in area 7.

3. ASPIC analyses

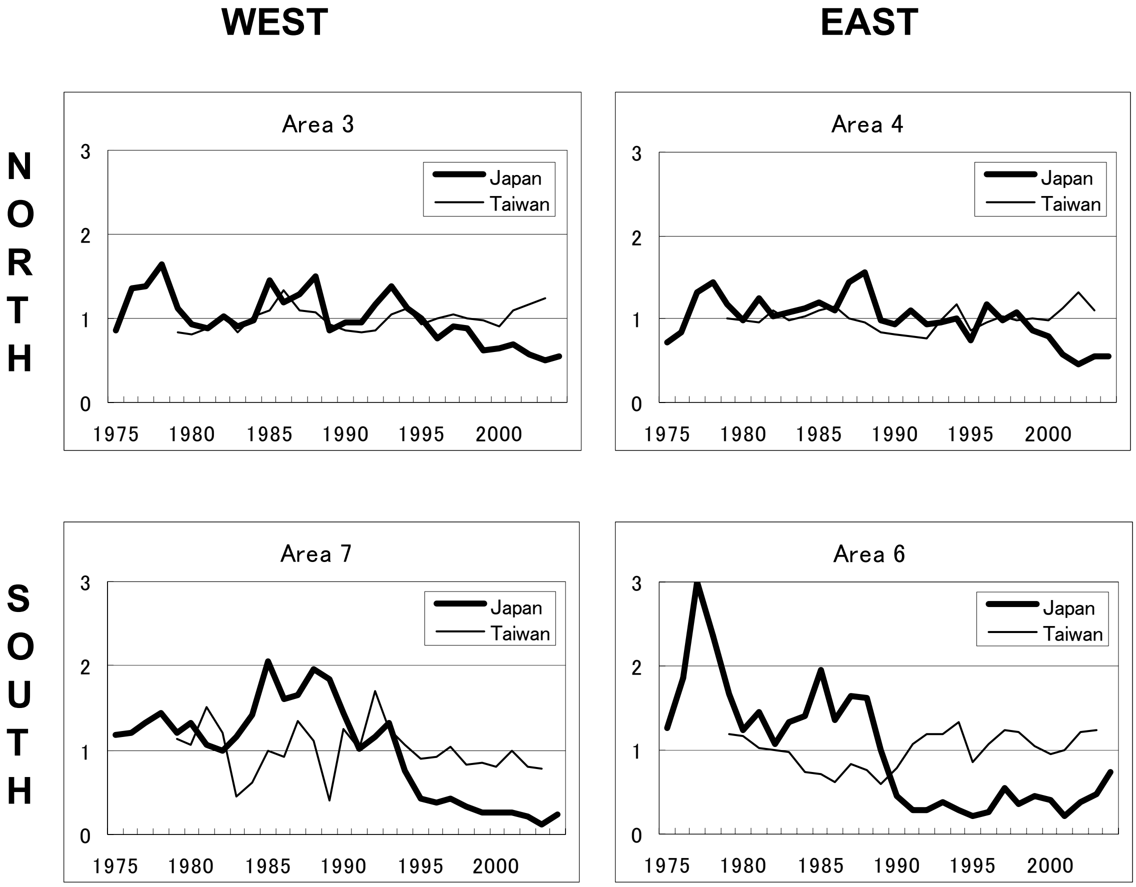
3.1 Methods

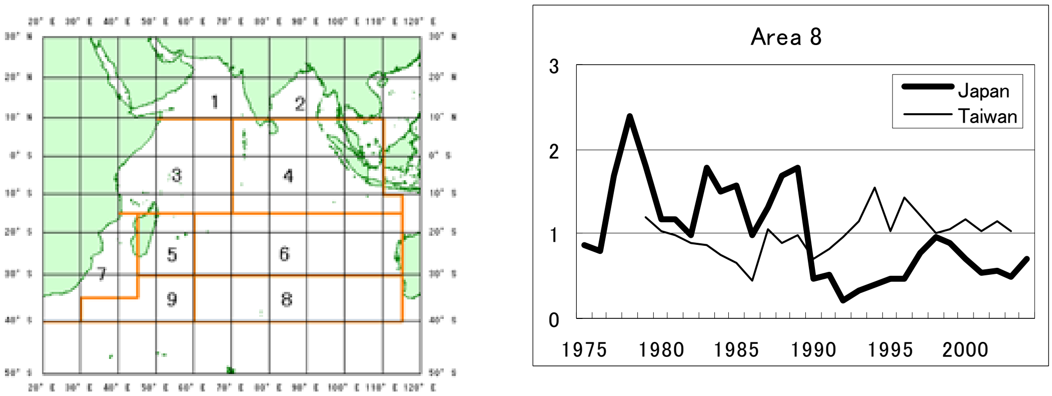
We used the ASPIC software (ver 5.05) developed by Prager (2004). STD CPUE trends are very important factor representing the abundances, which thus affect results of the ASPIC runs. Hence we initially investigated the trends of STD CPUE among sub areas (Fig. 1). Then we realized that the trends within North (area 3 and 4) and South (6, 7 and 8) are similar for both Japan and Taiwan. Considering this, we attempted ASPIC runs using STD CPUE in 3 areas as below:

[1] area weighted STD CPUE in all area combined (area 3+4+6+7+8)
[2] area weighted STD CPUE in North (area 3+4)
[3] area weighted STD CPUE in South (area 6+7+8)

In each category, we attempted to run ASPIC using STD CPUE of Japan, Taiwan, Japan & Taiwan together and mean of Japan & Taiwan. Thus we have 12 scenarios for the ASPIC runs as shown in Table 1. We assume that these CPUE represent the abundance in the whole area.

Two types of catch are used in the ASPIC runs as shown in Table 1, i.e., the global catch and two types of catches. The global catch is the total annual catch as shown in Table 2 which is corresponding to the ASPIC runs when a single STD CPUE (Japan, Taiwan or their mean) used as in scenarios 1,2 4-6, 8-10 and 12. On the other hand the two catches are corresponding to the ASPIC runs when TWO STD CPUE (Japan and Taiwan) are used as in scenarios 3,7, and 11. In such case, we separate the global catch into two groups, i.e., one group is the catch for the Japanese gear type and another is the catch for the Taiwanese gear type. The Japanese gear type is the mid-water gear not targeting SWO but exploited as by-catch, while the Taiwanese type for surface to mid-water targeting SWO.





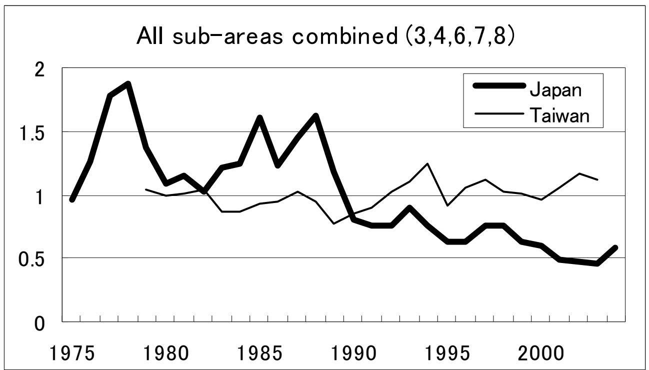


Fig.1

Annual trends of Japanese and Taiwanese (case 2) STD CPUE by sub-area used for the GLM analyses. The bottom graph shows those for all sub-areas combined.

Table 1 12 Scenarios for the ASPIC runs

Scenario	Area	Standardized CPUE	Catch
1	[1] All (area 3,4,6,7,8)	Japan	Global
2		Taiwan	
3		Japan and Taiwan	Two gear
4		Mean of Japan and Taiwan	Global
5	[2] Area N (3+4)	Japan	
6		Taiwan	
7		Japan and Taiwan	Two gear
8		Mean of Japan and Taiwan	Global
9	[3] Area S (6+7+8)	Japan	
10		Taiwan	
11		Japan and Taiwan	Two gear
12		Mean of Japan and Taiwan	Global

Table 2 Global catch used for scenarios 1,2, 4-6, 8-10 and 12 and catches by two gear types used for scenarios 3, 7 and 11 (tons)

year	global catch	[A] catch for Taiwan STD CPUE	[B] catch for Japanese STD CPUE
1975	2294	981	1313
1976	1879	888	991
1977	1925	907	1018
1978	2377	620	1757
1979	2282	1154	1128
1980	2252	1317	935
1981	2305	1162	1143
1982	2797	1534	1263
1983	3425	1973	1452
1984	3216	1769	1447
1985	4249	2048	2201
1986	4925	3543	1382
1987	5689	4247	1442
1988	8260	6701	1559
1989	6908	5827	1081
1990	7242	6145	1097
1991	8021	7086	935
1992	14114	12312	1802
1993	25103	23608	1495
1994	23222	20596	2626
1995	28952	27114	1838
1996	32292	29864	2428
1997	32192	28852	3340
1998	34807	32281	2526
1999	32728	30764	1964
2000	32920	30893	2027
2001	28064	26525	1539
2002	31179	29499	1680
2003	33932	32016	1916
2004	31288	28209	3079

[A] global catch excluding [B]
[B] catch by LL (Japan, China and Korea), HAND and LLD(deep LL)

3.2 Results

As shown in Table 1, we could get the conversion of the ASPIC runs in 4 scenarios 4, 5, 8 and12. Fig. 2 shows STD CPUE used in 12 ASPIC runs and Fig. 3 shows for the catch. Table 3 shows the summary of the converged results then the scenario 12 was accepted as it provided the most reasonable and realistic results.

Table 1 16 Scenarios for the ASPIC runs and results

Scenario	**Area**	**Standardized CPUE**	**Catch**	**Result**	**MSY (tons)**	Current Catch 2004	**K Million (tons)**	**B ratio**	**F ratio**
1	[1]All (area 3,4,6, 7,8)	Japan	Global	NA					
2		Taiwan							
3		Japan & Taiwan	2 gears	NA and NC					
4		Mean (JPN & TWN)	Global	OK	40,420	33,932 tons	0.32	1.48	0.52
5	[2] Area N (3+4)	Japan	Global	OK	8,800		0.59	0.67	5.00
6		Taiwan	Global						
7		Japan & Taiwan	2 gears	NA and NC					
8		Mean (JPN & TWN)	Global	OK	40,120	33,932	0.31	1.54	0.51
9	[3] Area S (6+7 +8)	Japan	Global	NA					
10		Taiwan	Global						
11		Japan & Taiwan	2 gears	NA and NC					
12		Mean (JPN & TWN)	Global	OK	28,610	33,932	0.45	1.30	0.84

NA : realistic estimates were not obtained. NC: Negative correlation problem

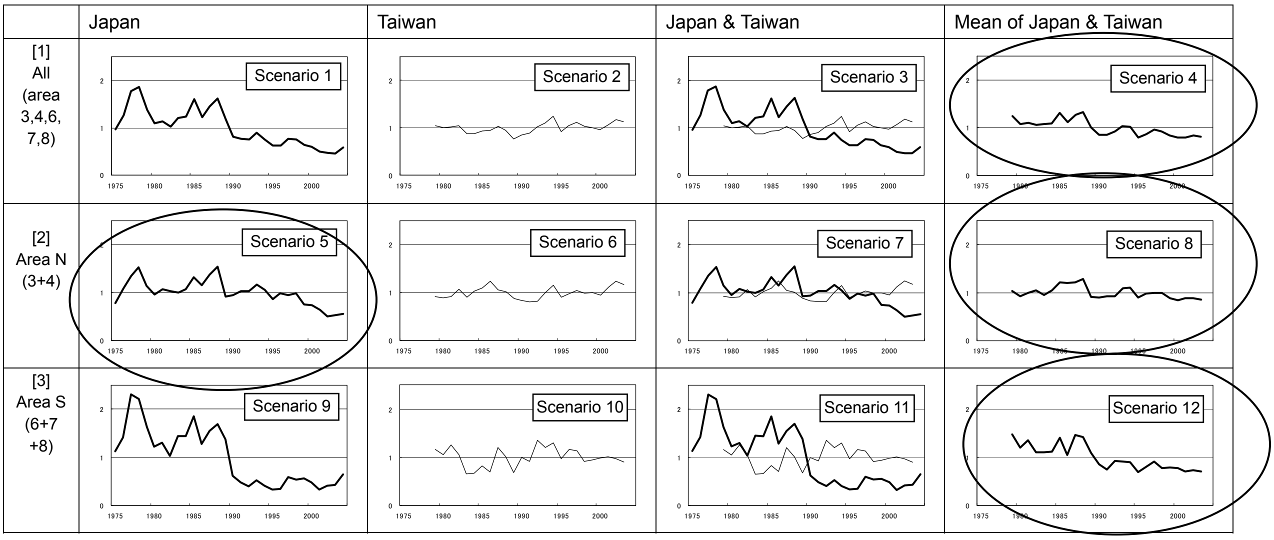


Fig.2 STD CPUE used in 12 ASPIC runs. Converged cases are circled.

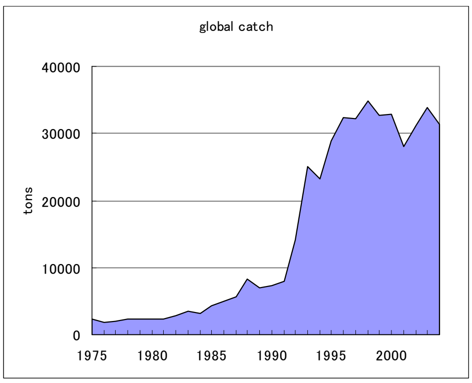
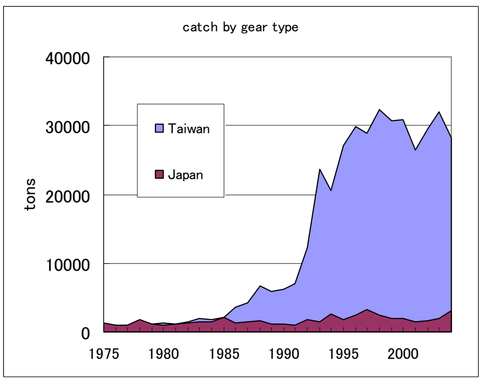
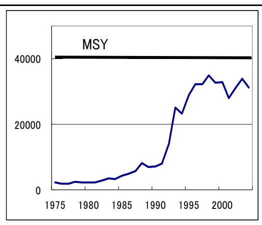
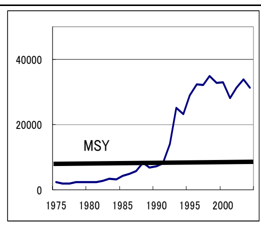
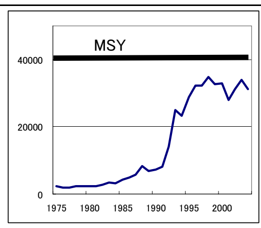
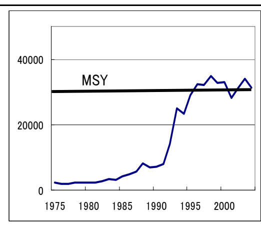
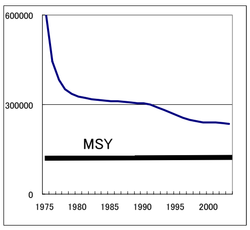
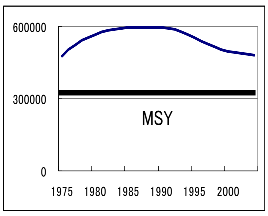
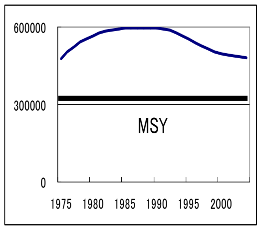
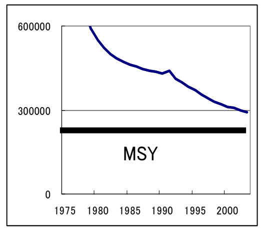
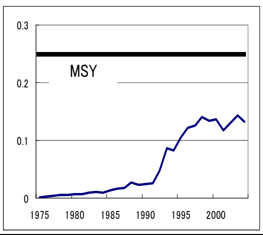
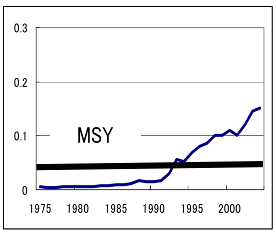
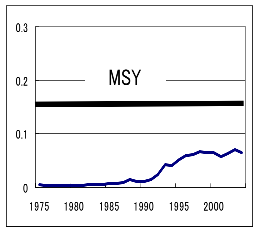
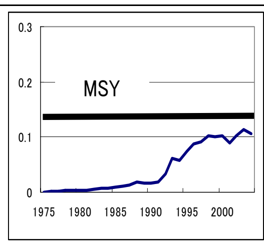
	Global catch (Scenarios 1,2,4-6, 8-10 and 12)	**Catch by two gears (see Table 2 for details) (scenarios 3, 7 and 11)**
Fig. 3 Catch used in the ASPIC runs		

Table 3 Summary of the converged results and the conclusion.

Scenario	4	5	8	12
R^2	0.54	0.61	0.35	0.62
MSE	0.012	0.024	0.011	0.023
MSY (tons)	40,420	8,800	40,120	28,610
Current Catch(tons) (2004)	33,932			
F_{MSY}	0.25	0.03	0.13	0.13
F_{2004}	0.13	0.15	0.07	0.11
F_{ratio}	0.52	5.00	0.54	0.84
B_{2004} (million tons)	0.24	0.21	0.48	0.29
B_{MSY} (million tons)	0.16	0.30	0.31	0.22
B_{ratio}	1.50	0.67	1.55	1.30
K (million tons)	0.32	0.59	0.31	0.45
Catch vs MSY				
Biomass vs. B_{MSY}				
F_{2005} vs. F_{MSY}				
Comments	Too high F_{MSY} and too low B_{MSY}	Too low MSY, B_{MSY}, too high F ratio and too low F_{MSY}	Too high F_{MSY} and too low B_{MSY}	All reference points & parameters are reasonable and realistic.
Decision	Not accepted			Accepted

4. Discussion

It was learned that ASPIC was very sensitive for the CPUE trends. This means that different CPUE trends provided quite different results (including no solutions) as observed in 12 ASPIC runs. Thus here we will primarily discuss on the problem of discrepancies of STD CPUE between Japan and Taiwan which affected the results largely. If we could find the reason for this discrepancy we may be able to detect real STD CPUE trends hence the real situation of the status of the SWO stock.

(1) Discrepancies of STD CPUE between Japan and Taiwan

The trends of STD CPUE between Japan and Taiwan are inconsistent in all sub-areas, i.e., Japan always shows the decreasing trends, while Taiwan for the constant trends. Hence we had the negative correlation problems in the ASPIC runs when we used both CPUE (scenarios 3,7 and 11). We initially discuss by country then summarize the discussion:

Japan

Japanese LL have been exploiting SWO as the incidental catch, while Taiwan targeted SWO in particular season and area. Even we adjusted this targeting factor in the STD CPUE using the hook per basket between floats (HPB) information, HPB data might not always work effectively. This is because HPB information is supposed to represent the swimming depth of tuna or billfish by assuming that the LL gear forms catenary form, but in real situation this assumption is not always satisfied (Yokawa et al, Mizuno et al and many others).

Japanese LL in earlier years before 1990 they used the normal or deep the longline (Fig. 4). Thus once this catenary shape was disturbed by the underwater currents then LL were upraised and moved up to the shallower waters where SWO swims. Thus in such situation more SWO were likely exploited than expected which made nominal CPUE overestimated (Fig. 5).

On the other hand after 1990 the Japanese LL started to use the ultra deep LL (Fig. 4). In such case, even if the catenary shapes were disturbed, less number of hooks were upraised to the shallower water unlike the situation happened in the normal LL or the deep LL cases in earlier years before 1990. Thus the problem of overestimated CPUE was likely decreased after 1990 (Fig. 5).

The problem of overestimated CPUE before 1990 can be clearly observed in Fig. 1. In the southern part of the Indian Ocean (sub areas 6, 7 and 8) they use more ultra deep LL to target bigeye tuna (BET) and southern bluefin tuna (SBT), while before 1990 they used the normal LL or the deep LL. Thus the overestimated CPUE before 1990 were more significantly resulted which were likely reflected in the CPUE STD trends in Fig. 1.

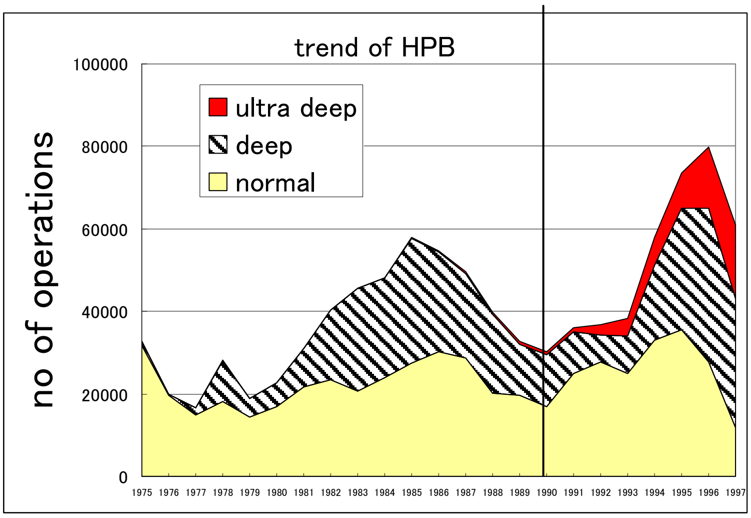


Fig. 4 Annual trends of normal (9 < NHB), deep (10-14) and ultra deep (15-) LL.

On the other hand the overestimated trend was not strongly observed in the northern water (areas 3-4) as they have been using less ultra deep LL and more the normal or the deep LL to target yellowfin tuna (YFT) swimming in shallower waters than in BET and SBT.

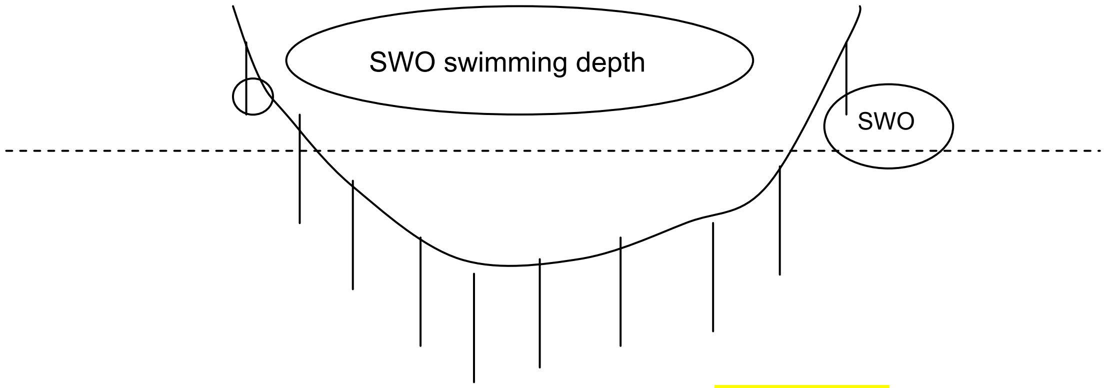
Thus the real trends of the Japanese STD CPUE are likely those in the northern waters (sub area 3-4) with less lower leveled trends before 1990 which is likely to be the trend speared in scenario 12.

Taiwan

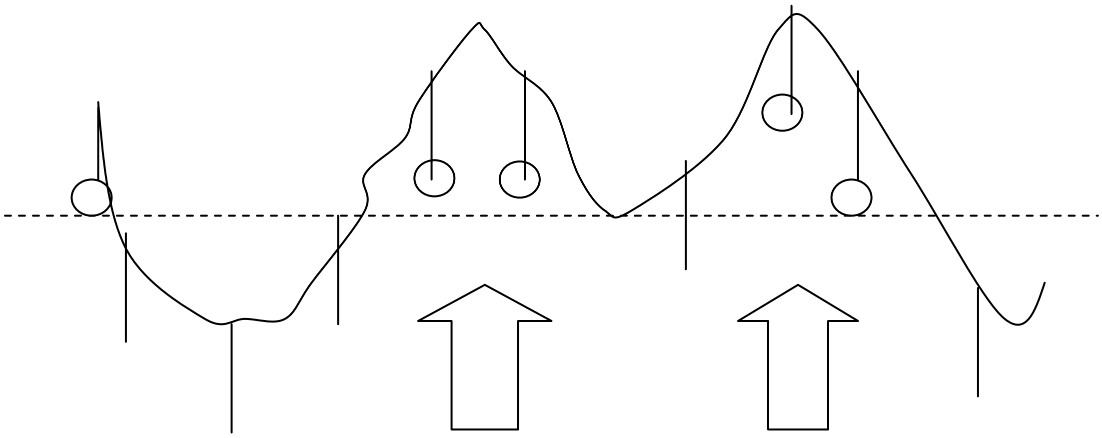
Taiwanese LL fishing effort and catch in the southern waters (sub-areas 6,7 and 8) before 1990 were very low (Fig. 6), while those for Japan, more data are available (Fig. 7). Thus the STD CPUE were unlikely stable which likely made large fluctuation (noises) (Fig. 1). Hence the trends of the STD CPUE in the southern waters before 1990 unlikely reflect the real situation of the SWO abundance.

The nominal CPUE after 1990 in all area show the similar trends (constant), but they might be overestimated except area 7 by the same reason explained for the Japanese case. Hence, it is assumed that more ultra deep LL were used in the area 7 hence the trends are likely realistic. This situation is similar to the Japanese case in the northern water.

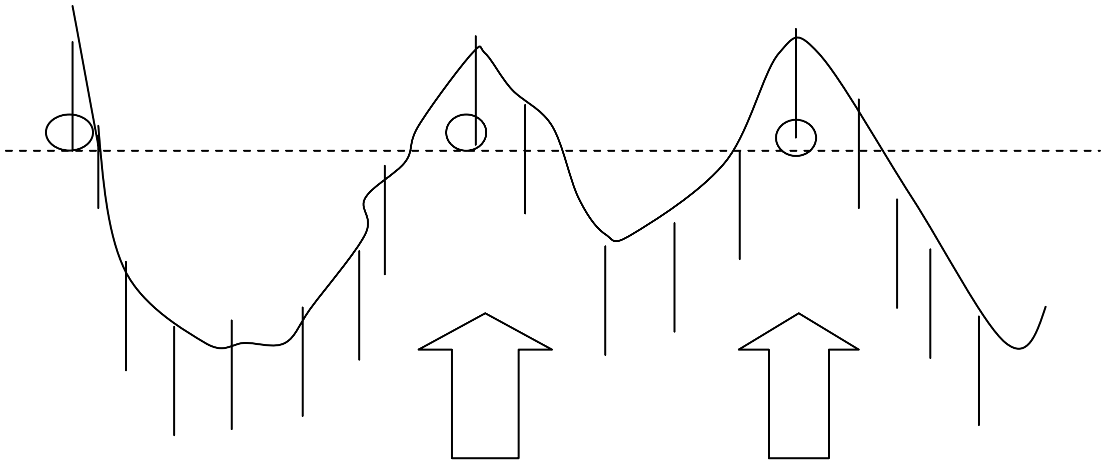
As a conclusion, the real Taiwanese STD CPUE is likely those in area 3-4 before 1990 (constant trend) and those after 1990 in area 7 (slight decreasing trends), which is likely to be similar to the STD CPUE in scenario 12.



At the normal catenary conditions of the normal or deep LL : nominal CPUE=2/10=0.2



When the catenary LL shape is disturbed by the under water current which upraised LL gear up to the shallower waters where SWO inhabits. In this case nominal CPUE becomes CPUE=5/10=0.5 which overestimate 2.5 times higher CPUE than the situation when the catenary shape is kept (above case).



In case of the ultra deep LL: nominal CPUE 3/18=0.17 (less unbiased)

Fig. 4 The schematic diagram showing why the nominal CPUE is overestimated before 1990 when the normal or the deep LL were used. After the ultra deep LL introduced (after 1990), this problem was decreased as not too many LL hooks in the ultra deep LL were upraised as their hooks were deployed much deeper waters than before 1990.

Top : Theoretical situation of the normal or the deep LL
Middle : Situation affected by the underwater current for the normal or the deep LL
Bottom :Situation affected by the underwater current for the ultra deep LL

Summary and conclusion

Fig. 8 shows the summary and the conclusion. By setting a few assumptions and hypotheses (see below) we concluded that the real STD CPUE trend for both Japan and Taiwan are likely close to the one in scenario 12. But we need to conduct following research and investigation if these hypotheses and assumptions are statistically justifiable:

- *Nominal SWO CPUE in the normal LL and the deep LL are overestimated and the one for the ultra deep LL are less affected.*
- *For the Taiwanese LL, more ultra deep LL is used in the area 7 than other waters.*
- *Time-area specific situation of shallow, normal, deep and ultra deep LL.*
- *For Taiwan, time-area specific situation of shallow LL targeting SWO.*

(2) Sensitivity of the ASPIC runs

to be presented orally.

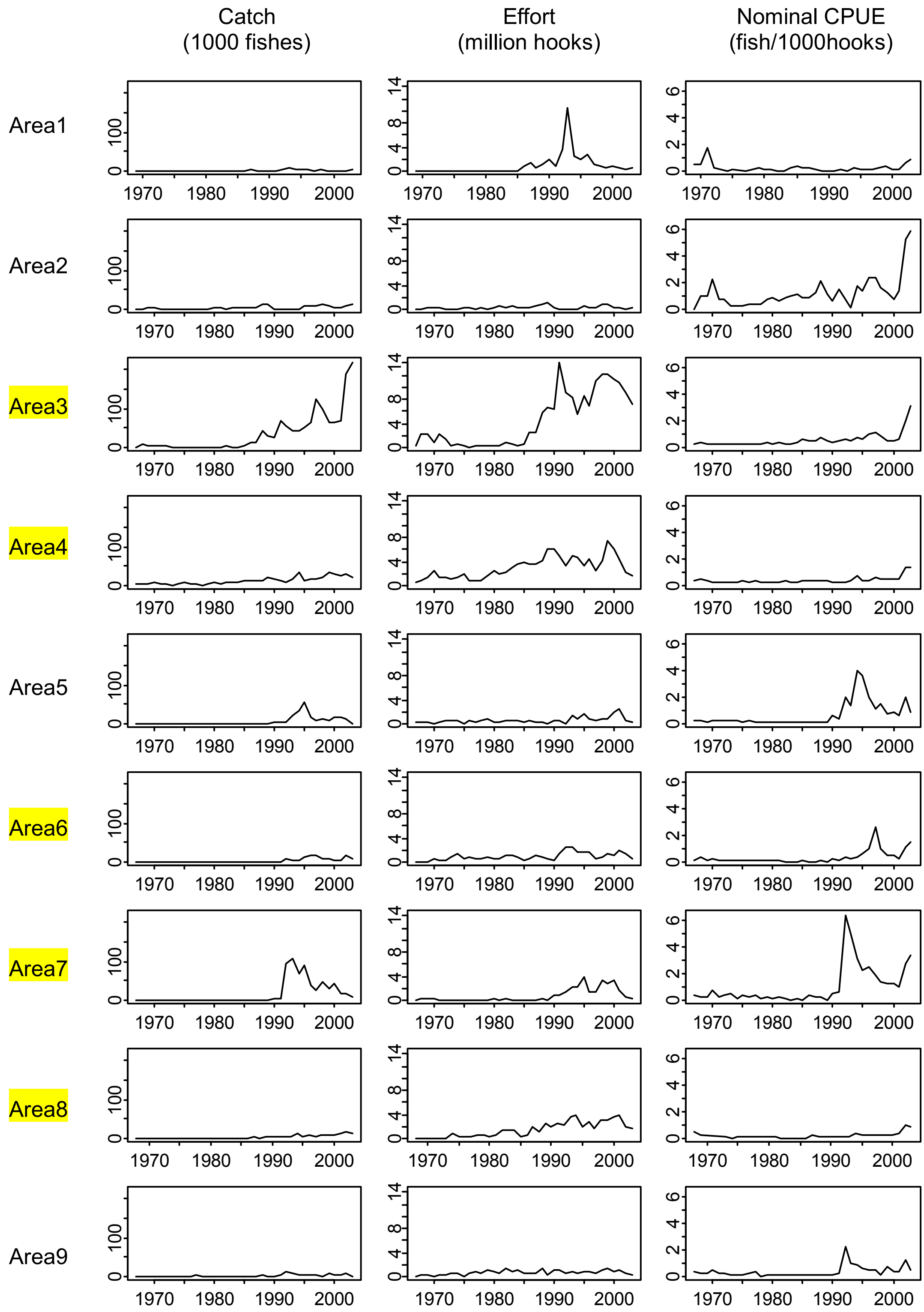


Fig. 6 Trends of catch, effort and nominal CPUE by sub-area (Taiwan LL) (1968-2003)

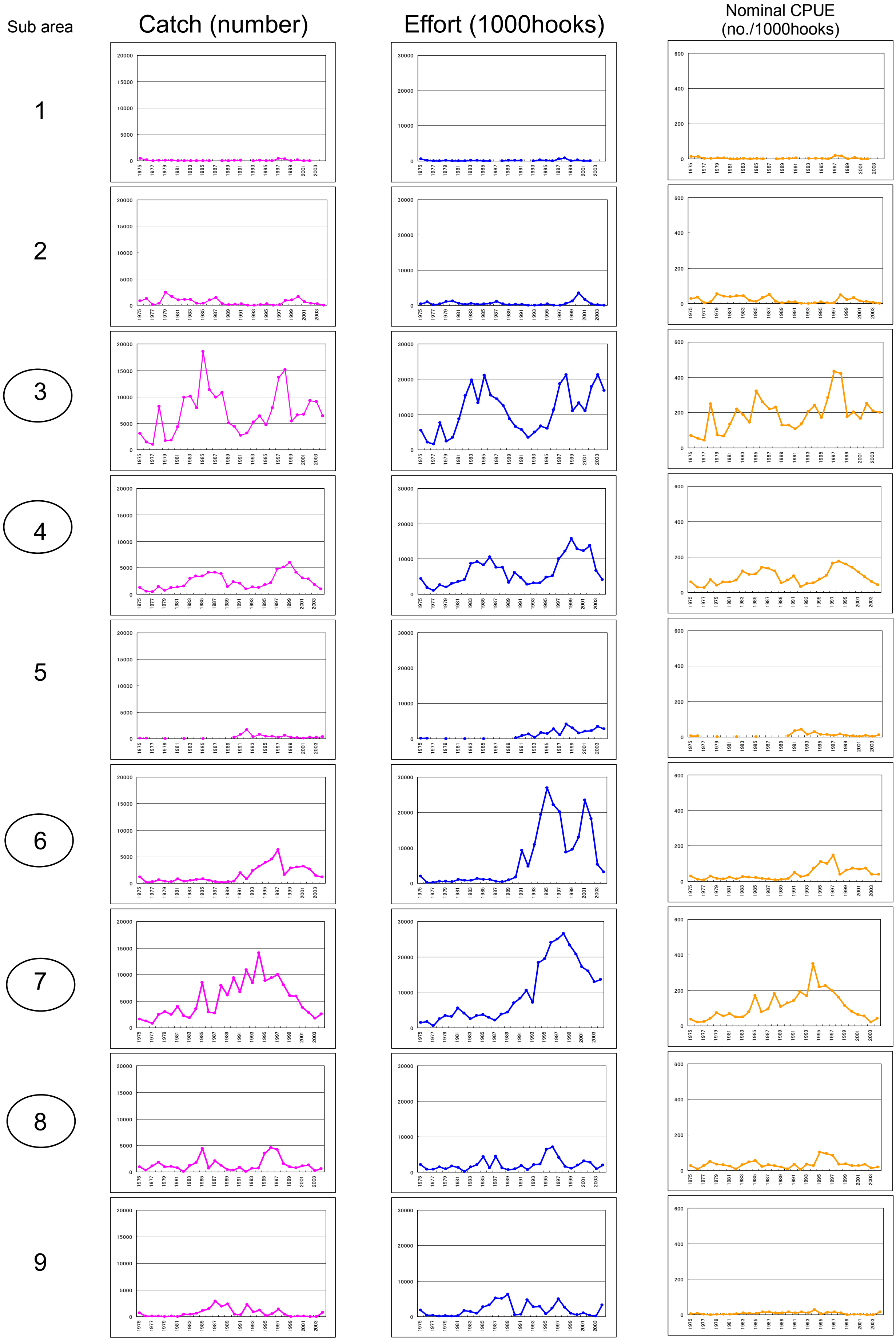


Fig. 7 Trends of catch, effort and nominal CPUE by sub-area (Japan LL) (1975-2004)

Summary and conclusion (Fig. 8)

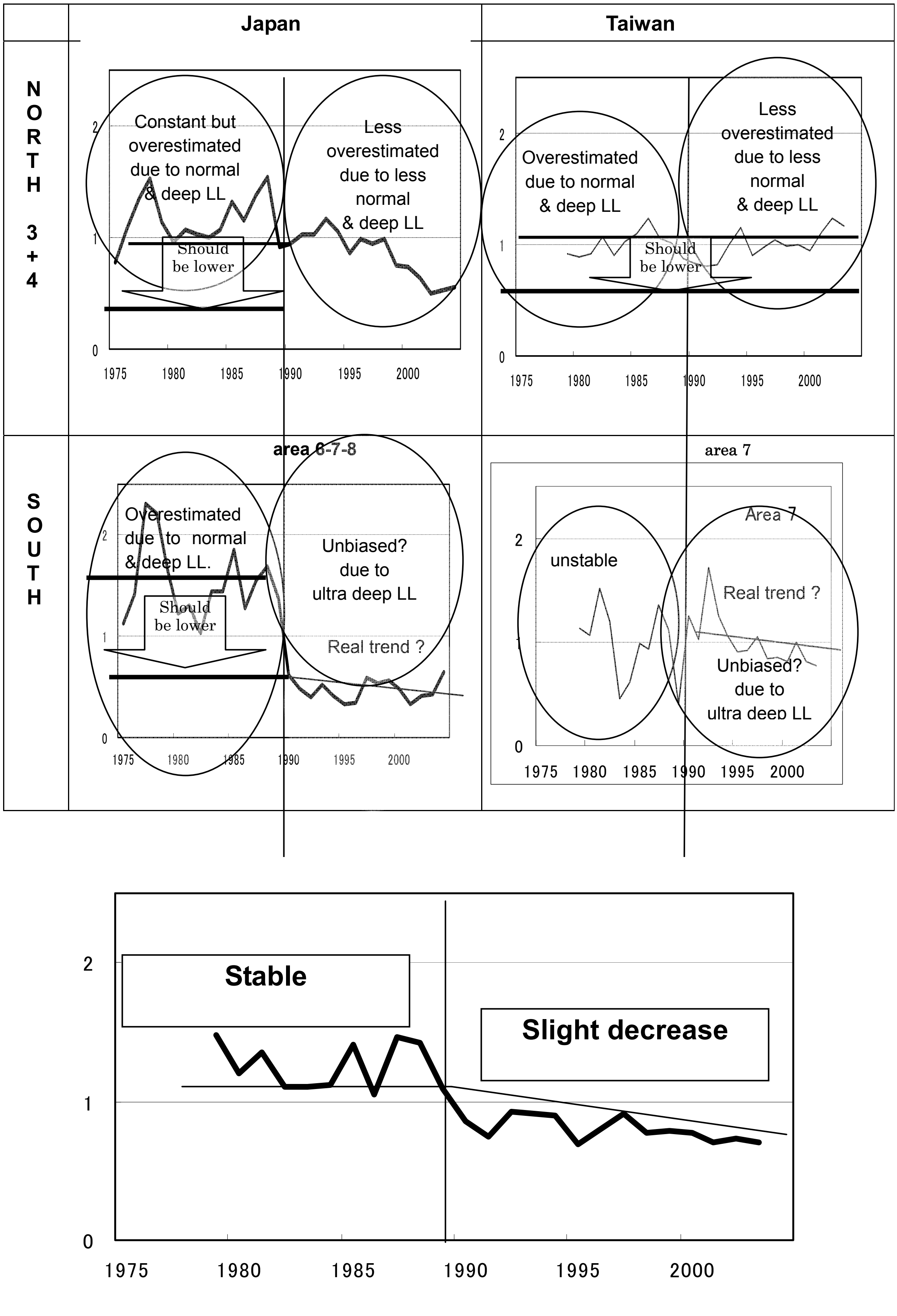


Fig. 8. Summary of the discussion (upper panel: situation of the STD CPUE trends analyzed) and conclusion (bottom panel: hypothesized situation of the real STD CPUE trend)

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User's Manual for ASPIC: A Stock-Production Model
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