SELECTION OF THE DECISION RULES OF MANAGEMENT PROCEDURES FOR SOUTHERN BLUEFIN TUNA

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Abstract

A best decision rules should be accepted by CCSBT with the tuning parameter together in order to identify the impact to the industry as a whole and provide the exact TAC path for the industry to follow. Before comparing various decision rules of the management procedures for southern bluefin tuna, we found that it is not meaningful to tune the biomass levels if the media of the biomass ratio B2022/B2002 is set unreasonably too low at 0.7 or too high at 1.5. For example, the industry may not be economically sustainable under the situation if the biomass ratio is set at 1.5 and the TAC will be lowered to 1,068 MT. Because there is no proper guidelines on how should the targets be set, I propose to evaluate the biomass ratio if we can maintain the current TAC for all years and then use it as a starting point to set up the minimum criteria. In addition, two decision rules are also specified and tested.

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Introduction

Following the workshop of management strategy of CCSBT in 2000, the management procedure (MP) workshop I in 2002 and II in 2003, the goal of MP workshop III is to consider results for final candidate MPs so as to evaluate results, formulate conclusions and provide advice to set up the management procedure for southern bluefin tuna (SBT).

In the attachment D of the fourth meeting of the Stock Assessment Group (SAG) report, the final reference set was to "integrate out" six scenarios that corresponded to different inputs for the stock recruitment steepness (h) and the value of omega (ω), by weighing different scenarios with relative probabilities.

Before comparing the management procedures, it was agreed to tune MPs to three different levels of the biomass ratio B2022/B2002 at 0.7, 1.1 and 1.5, under the assumption that each rule can be "tuned" to fall almost anywhere on the catch-biomass trade-off curve. During the simulation exercises, I found the carryover percentage of CPUE can not achieve all biomass tuning levels by changing the carryover percentage only, if the biomass ratio B2022/B2002 was set unreasonably too low at 0.7 or too high at 1.5.

After consulting the industry and mangers in Taiwan, I propose that a simple empirical CPUE-based rule is preferable to an MSY-based rule because it is easy to understand and much more robust in parameter setting. In this paper, I propose three decision rules. One of the decision rules is set to provide the minimum criteria for tuning level of the media biomass ratio B2022/B2002. In addition, this paper also provides the full range of the other two rules' turning results for CCSBT.

Testing the Performance of the Operating Model under Various Decision Rules

A proposal for a naming convention is to have a unique three-letter prefix (user's choice but unique to CCSBT MP workshop), a 2-digit serial number (user's choice, such as TAI), and a tuning level (either 1, 2, or3) suffixed with a or b:
TAI_01_1b, 2a, 2b, 2c, 3b
TAI_02_1b, 2a, 2b, 2c, 3b

where the tuning level for the media of B2022 to B2002 biomass ratio under criteria 1, 2, or 3 is defined as follows:

B2022/B2002=0.7, 1.1 and 1.5

In order to compare the performance of the OM model, I consulted with researchers in CSIRO to have a better understanding of how the TAC would adjust eventually under three turning targets on the biomass ratio.

By following the results demonstrated by CSIRO research team, the three biomass ratio scheme of 0.7, 1.1 and 1.5 could be reached if the constant catch was tuned to three different TAC levels such as 16,759 MT, 10,576 MT, and 1,068 MT, as shown in Figures 1: (a) CON_01_1b, (b) CON_01_3b, (c) CON_01_2a, (d) CON_01_2b, and (e), CON_01_2c.

Figure 1a Tuning B2022/B2002=0.7 with TAC=16,759

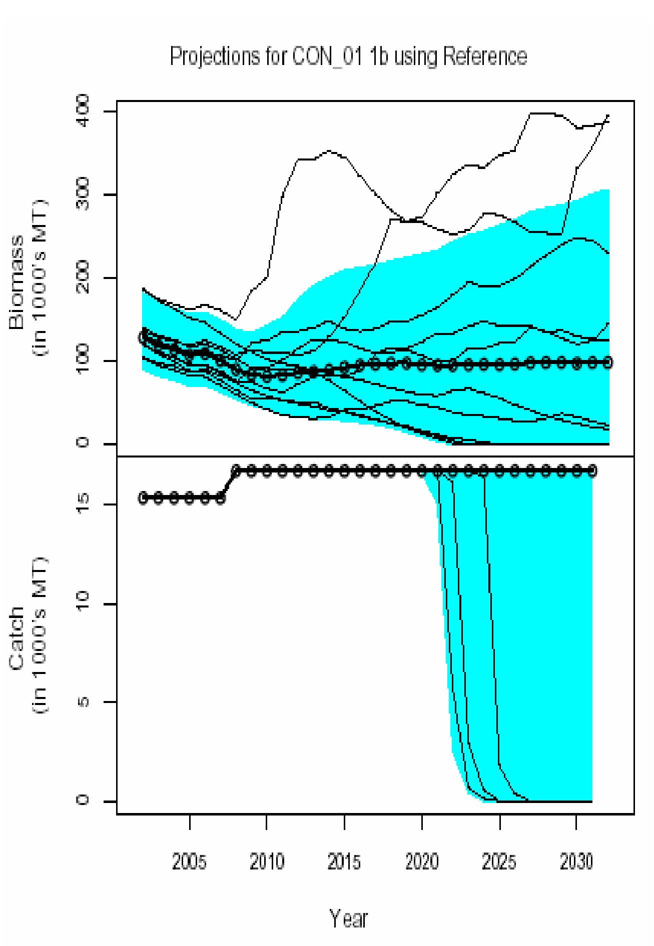
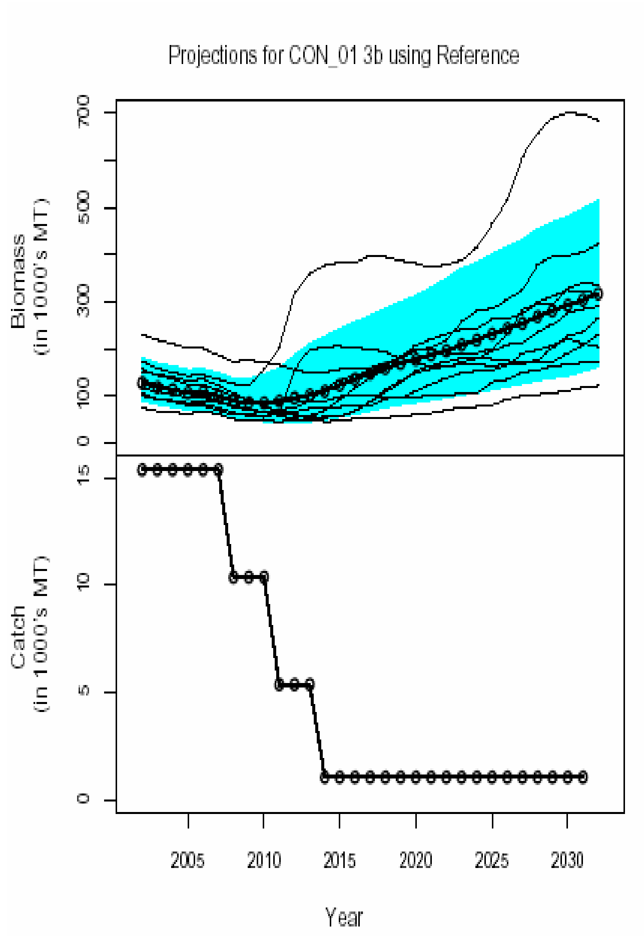


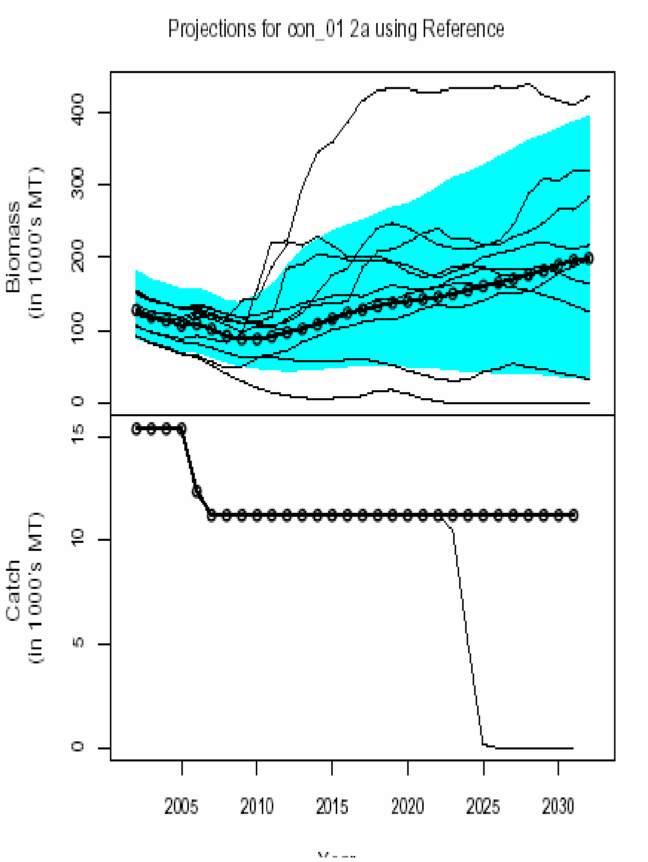
Figure 1b Tuning B2022/B2002=1.5 with TAC=1,068



By assuming that "operating models" are true and then the target of the biomass ratio is set to 1.5, the TAC will need to be lower to 1,068 MT that is only one-fifteenth of the current TAC and it would result a total collapse of the fishing industry. Even if the biomass ratio is set to 1.1, such as the case in CON_01_2b, the TAC will then be lower to 10,576 MT that indicates a 30% reduction of the TAC immediately in 2008.

Figure 1c~1e Tuning B2022/B2002=0.7

with TAC=11,226 under a (Fig 1b)
with TAC=10,576 under b (Fig 1c)
with TAC=10,582 under c (Fig 1d)

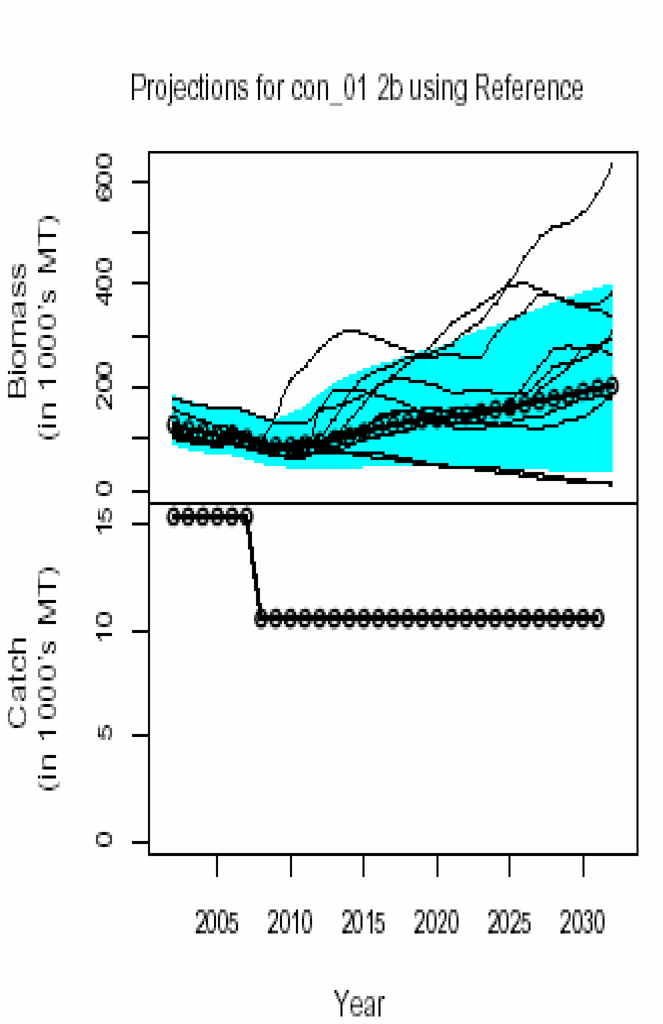


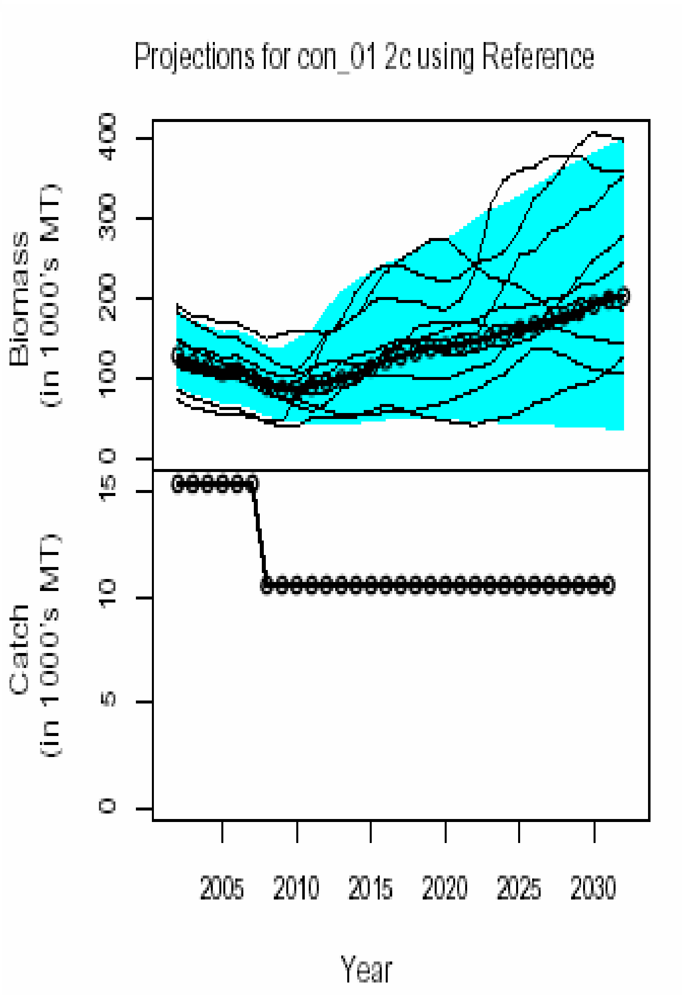
Suffixed with a, b, or c which is defined as follows:

2a: one-year blocks with fixed catch levels will be specified prior to the maximum change =3000

2b: three-year blocks with fixed catch levels will be specified prior to the maximum change =5000

2c: five-year blocks with fixed catch levels will be specified prior to the maximum change =8000





Will the industry economically sustainable with the immediate drop of catch situation and will it be economic viable to invest after 20 years when the stock recovery to 1.1 times of the current biomass? There is no proper standard on how will the target should be set.

We propose that the selection of the decision rules should be accepted by CCSBT with the tuning parameter together in order to identify its impact on fishing industry as a whole and provide the exact path for the industry to follow. Hence, we propose to find out the biomass ratio if we maintain the current TAC for all years and use it as a starting point to set up the minimum criteria. In addition, two CPUE based decision rules are also specified and tested, as follows:

1. *CON_99: constant catch in all years at current TAC*

Constant catch simply sets the TAC to a constant value *C* in all years, where *C* is a tuning parameter of the rule. Constant catch can be served as a reference point for evaluating the performance of the Operating Model; the current TAC catch case (*C* = 15,385.7) is particularly useful in this regard.

For year t, TAC_t = 15,385.7 MT

Since all participants consulted (CCSBT-ESC/0309/7) agreed that a period of stable harvest for the next 5 years would be highly desirable, it is interesting to know how the media of the biomass ratio ($\frac{B2022}{B2002}$) under 2000 integrated replications would be turn out if we maintain the TAC_{2001} at 15,385.7 MT.

The wormplot projections for both biomass and catch are shown in Figure 2 and we found the biomass ratio would reach 0.78056, which means the B2022 would only account for 78.056% of the B2002 and it is clear that the weighted average operating models for the high recruitment (no AC) tends to give us a pessimistic case. We propose to use the result of CON_99 decision rule to set up the minimum biomass ratio criteria, i.e., the B2022 should be higher than 78.056% of the B2002.

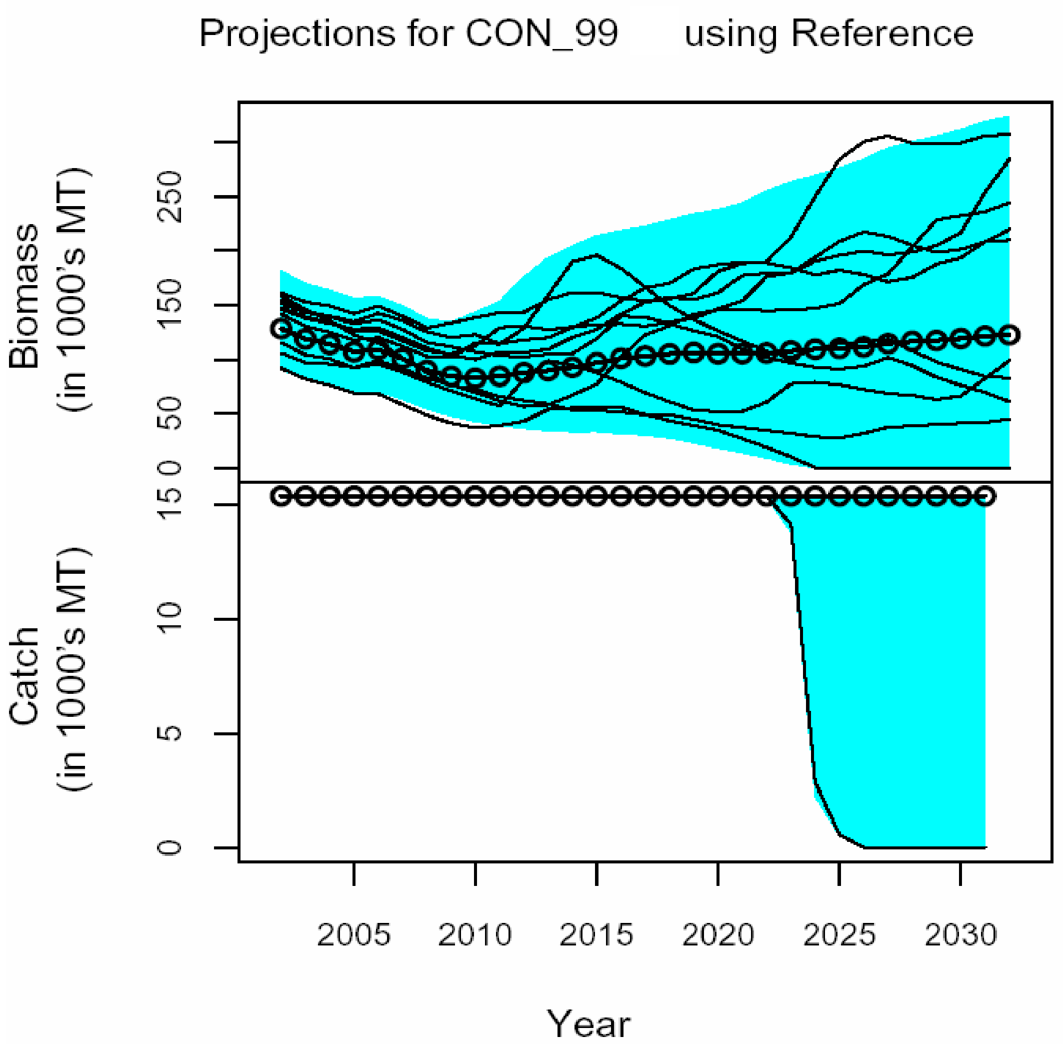


Figure 2 Wormplot projection of biomass and catch of maintaining the TAC $_{2001}$ at 15,385.7 MT (CON_99)

2. TAI_01: CPUE (nominal LL1 CPUE)

A simple CUPE based rule are proposed for it is easier for the member countries to follow. The trend in the log(nominal CPUE) over the last 5 years is used to adjust the TAC as follows:

$$\mathbf{TAC_t = w \cdot TAC_{t-1} + (1-w) \cdot TAC_{t-1} \cdot (1 + k_1 \cdot \lambda_5)}$$

where, w is the carryover percentage that is serving as a tuning parameter values,

k_1 is the weighting factor given to the log(CPUE) slope, and k_1 is set to 10

λ_5 is the slope of the regression of log(CPUE) *vs*. time over the last 5 years.

The carryover percentage means the grandfather right for the industry to maintain their long-term planning in investment. To be meaningful in the economic sense, the carryover percentage should be greater than 0 and less than 1.

By comparing the biomass ratio of TAI_01 CPUE decision rule under various tuning level of the carryover percentage parameter in Reference Scenario, I found the biomass ratio will follow a downward sloping trend when I increase the carryover percentage, as shown in Figure 3.

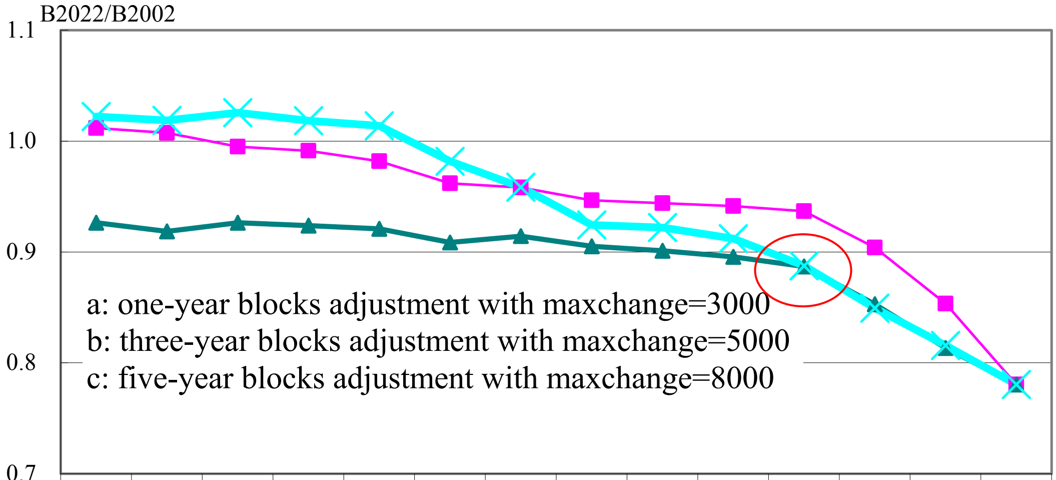
When the carryover percentage is one, the biomass ratio reaches 0.7806 and is equivalent to the case of constant rule with the TAC set at the level in 2001 for all years. For the result shown in Figure 3, it is interesting to note that if I lower the carryover ratio to 0.85, the biomass ratio will reach 0.8869 under three-year blocks adjustment with maximum change equal to 5000, which is 10% more than the CON_99 base case.

It is also interesting to note that it is not possible to turn the carryover percentage to fulfill the biomass criteria either to 1.1 or 1.5. In addition, it is not meaningful to tune the biomass ratio to 0.7, since the situation is even worse than maintaining the TAC at the 2001 level.

Moreover, if we end up modifying the original CPUE rule so that it would have an additional multiplier out front that would allow the rule to be tuned, but it is clearly to expect that the TAC would be lowered to the 1,000 MT level.

Based on the new version of the SBT MP projection code (version 1.09), there is a new switch to do a reduced recruitment robustness trail. The intent is that users will run a robustness trial where this switch is "turned on" for the Reference case set of MCMC parameter values. Under the Low Recruitment (low_R) Scenario, the biomass ratio of TAI_01 CPUE decision rule under various tuning level of the carryover percentage parameter is shown in Figure 4.

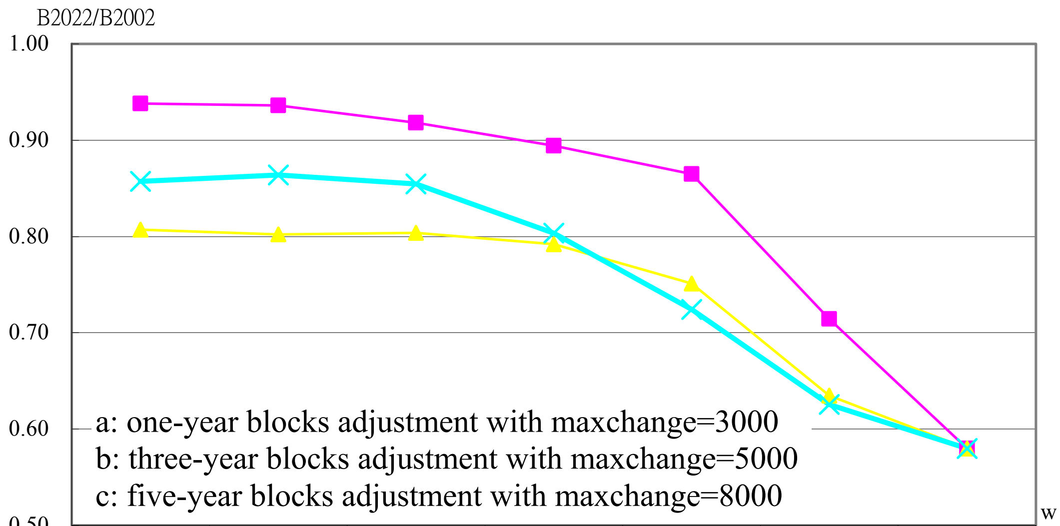
By comparing to the downward sloping trend of the biomass ratio in Figure 3, a similar result was found in Figure 4 when we increase the carryover percentage. The biomass ratio under the low_R Scenario is almost 10% to 17% less than the biomass ratio under the Reference Scenario. For example, the biomass ratio will be 0.7511 when the carryover ratio was set to 0.85.



	-2	-0.5	0	0.25	0.5	0.7	0.75	0.8	0.81	0.82	0.85	0.9	0.95	1
a	1.0117	1.0075	0.9950	0.9913	0.9817	0.9618	0.9582	0.9466	0.9440	0.9415	0.9368	0.9039	0.8534	0.7806
b	0.9265	0.9186	0.9263	0.9238	0.9209	0.9086	0.9144	0.9050	0.9010	0.8956	0.8869	0.8529	0.8132	0.7806
c	1.0223	1.0186	1.0255	1.0184	1.0138	0.9816	0.9583	0.9244	0.9221	0.9118	0.8876	0.8495	0.8158	0.7806

w: Carryover Percentage

Figure 3 Comparision of the Biomass Ratio of TAI_01 CPUE Decision Rule under Various Tuning Level of the Carryover Percentage Parameter in Reference Scenario



	0	0.25	0.5	0.75	0.85	0.95	1
a	0.9381	0.9361	0.9181	0.8941	0.8649	0.7145	0.5798
b	0.8072	0.8022	0.8038	0.7918	0.7511	0.6350	0.5798
c	0.8571	0.8638	0.8544	0.8036	0.7245	0.6255	0.5798

Figure 4 Comparision of the Biomass Ratio of TAI_01 CPUE Decision Rule under Various Tuning Level of the Carryover Percentage Parameter in Low Recruitment (low_R) Scenario

With respect to three adjustment schemes, I found that when the carryover percentage is ≥0.85 under the adjustment scheme b, which specified three-year blocks adjustment with a maximum change of 5000, produces a similar result under as adjustment scheme c, which specified five-year blocks adjustment with a maximum change of 8000 (Figure 3). By considering the flexibility to adjust to the real situation, it's better to hold the TAC in a 3-year block than a 5-years block.

I, therefore, propose to follow the TAI_01_b rule with carryover rate set to 0.85 as a suitable choice for both the SBT resource and also the industry to follow. A complete robustness test was also conducted and provided as an appendix to this paper. Figure 5 is the wormplot by combining all output files of *.s3 and *.all so as to compare plots of both biomass and catch, based on the most updated graphics package.

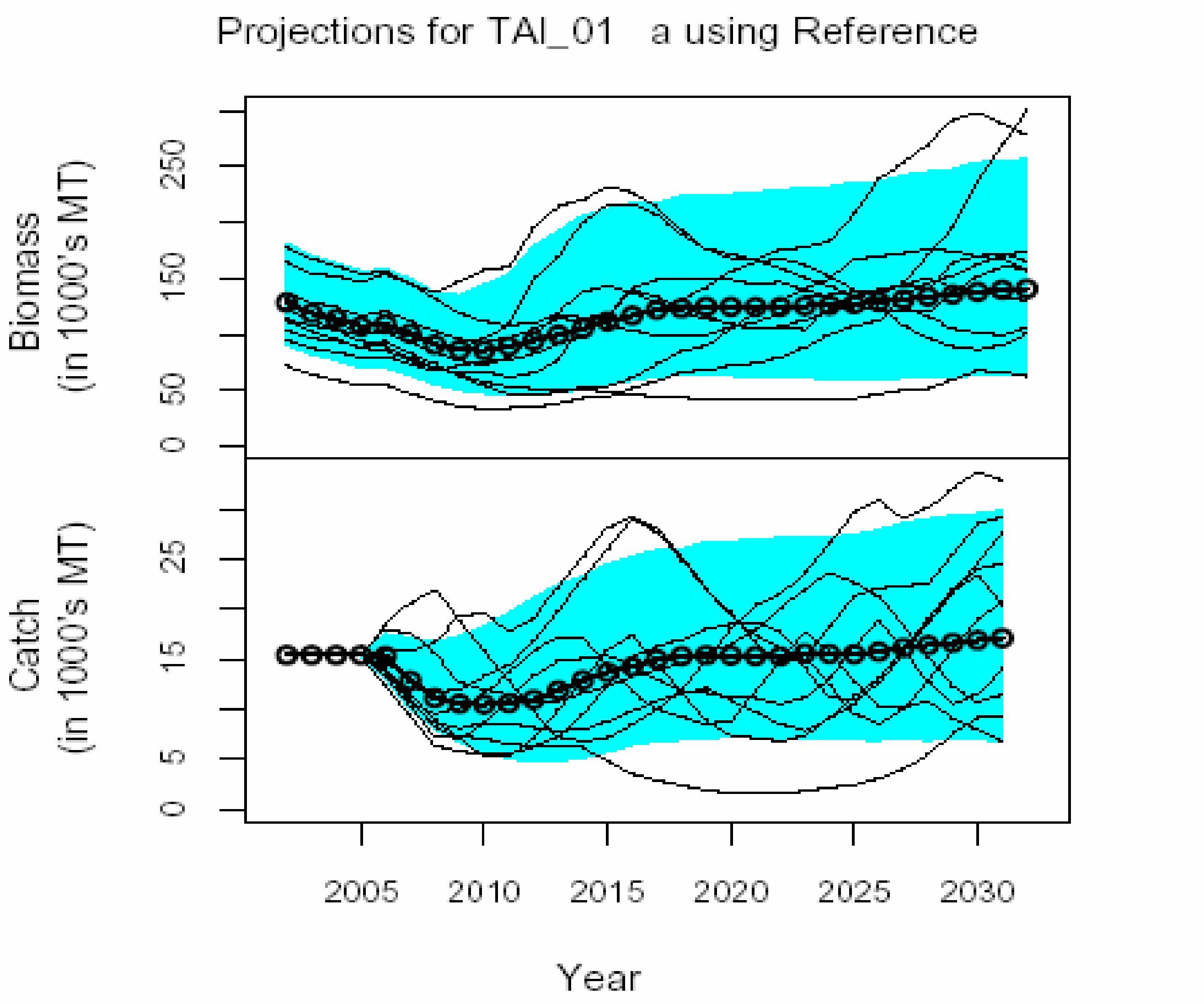
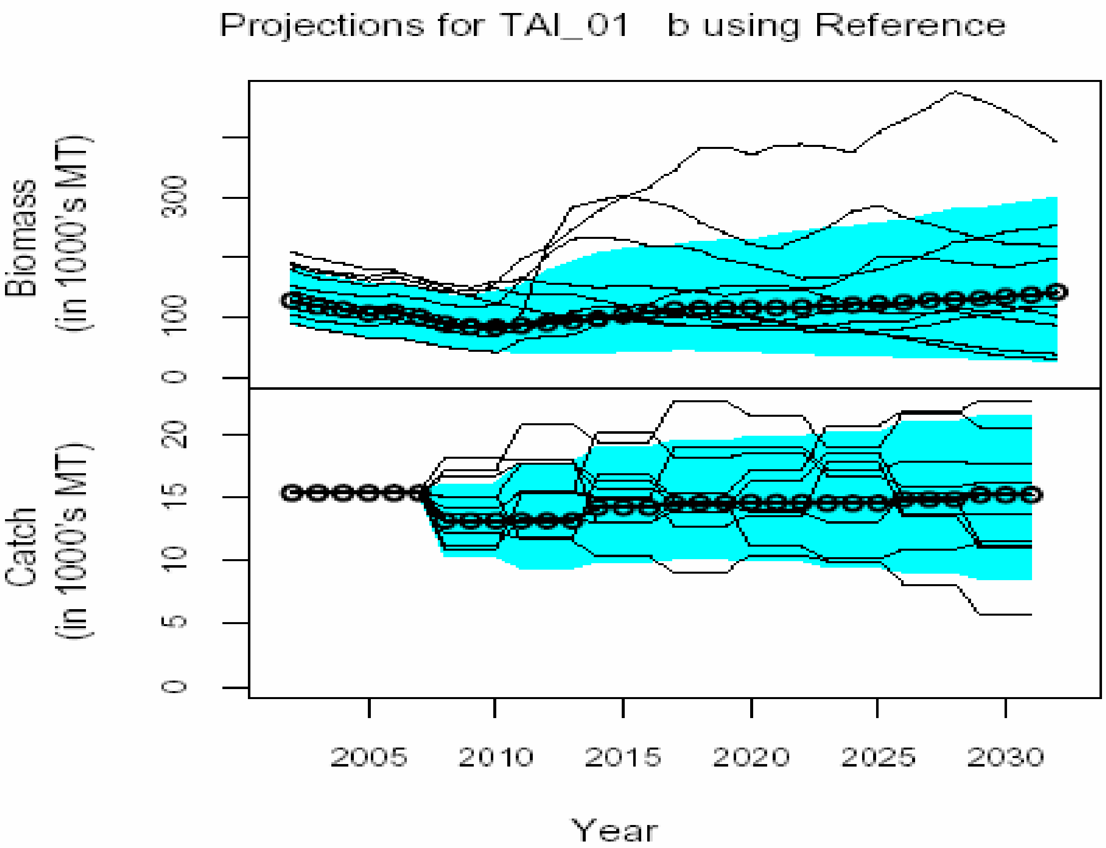


Figure 5a Womplots of biomass and catch in one-year blocks with 3000MT maxchange



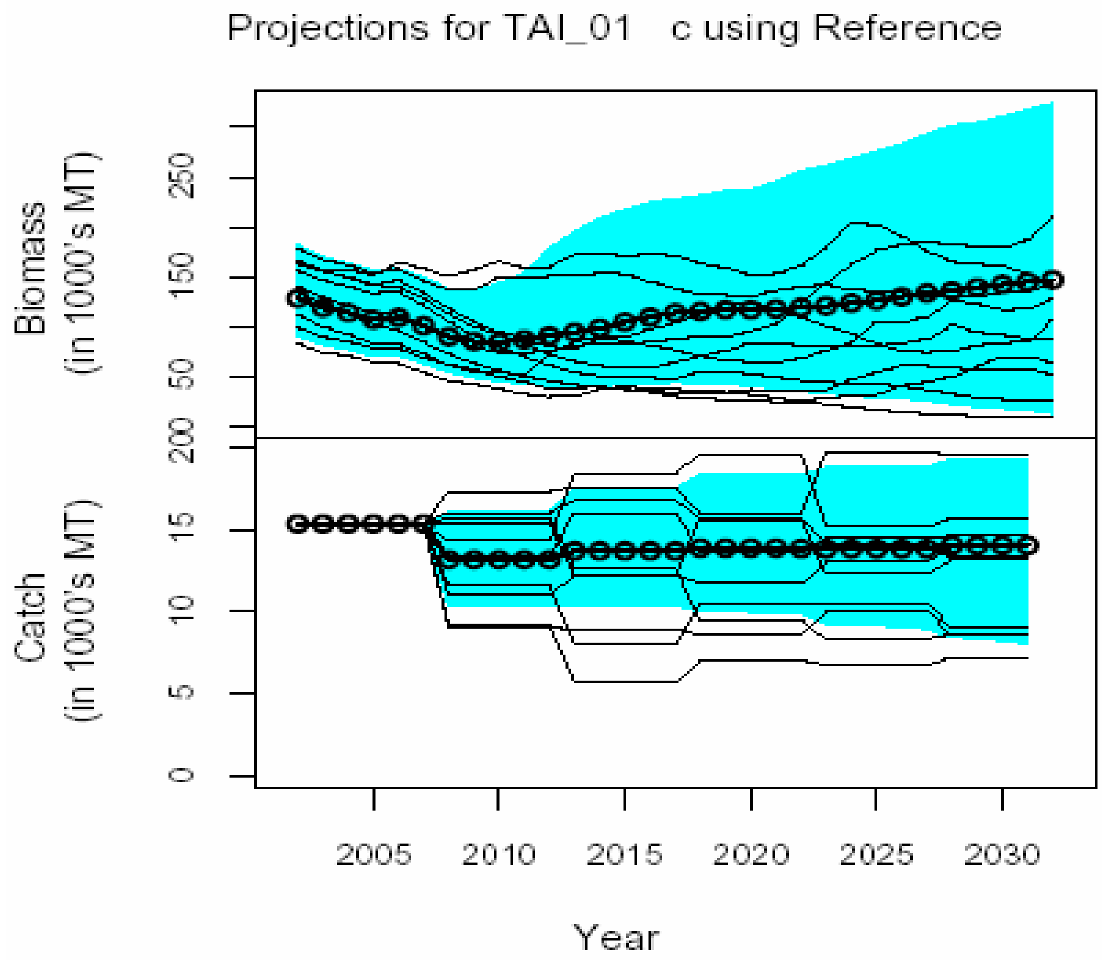
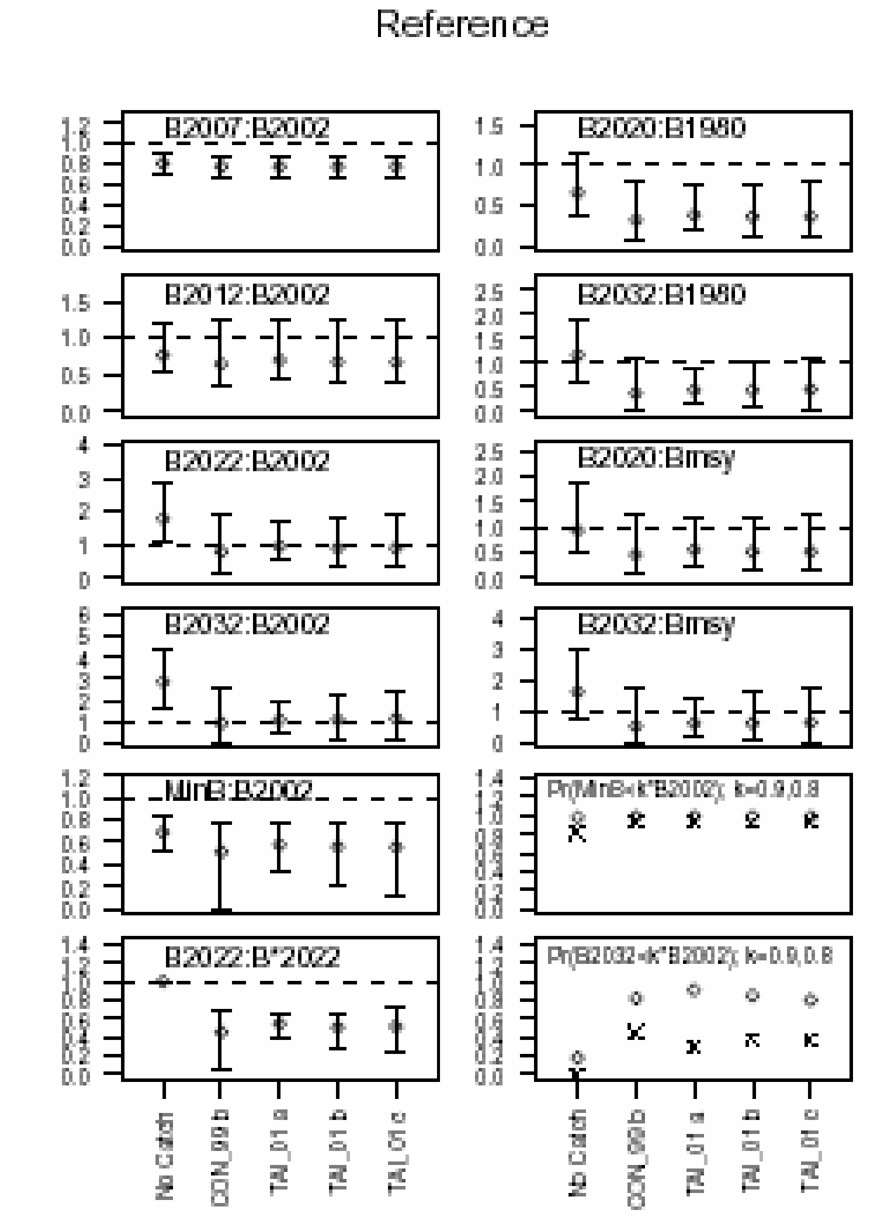
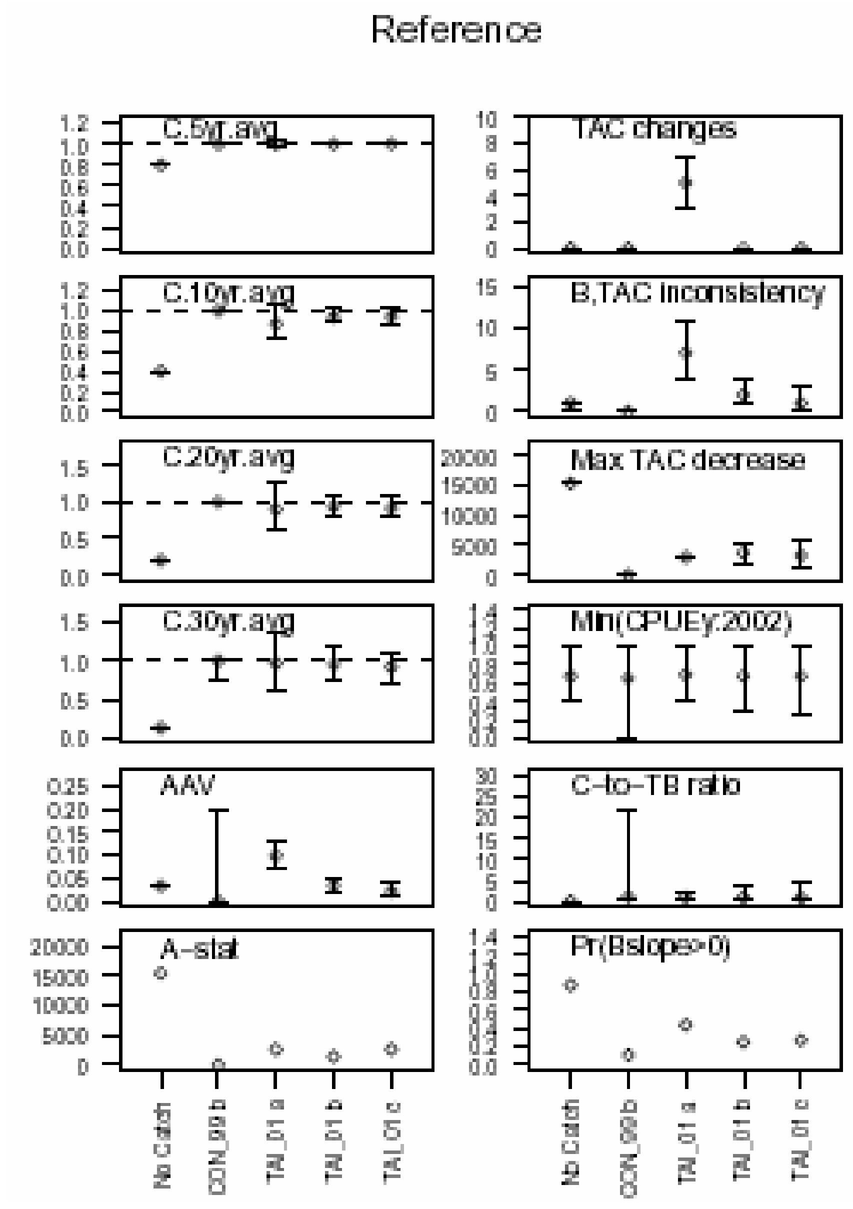


Figure 5b and 5c Womplots of biomass and catch in b: three-year and with 5000 maxchange, and c: five-year blocks with 8000 MT maxchange


Reference
B2007:B2002
B2020:B1980
B2012:B2002
B2032:B1980
B2022:B2002
B2020:Bmsy
B2032:B2002
B2032:Bmsy
MinB:B2002
Pr(MinB<k*B2002); k=0.9,0.8
B2022:B*2022
Pr(B2032<k*B2002); k=0.9,0.8
No Catch
CON_99 b
TAI_01 a
TAI_01 b
TAI_01 c


Reference
C.5yr.avg
TAC changes
C.10yr.avg
B,TAC inconsistency
C.20yr.avg
Max TAC decrease
C.30yr.avg
Min(CPUEy:2002)
AAV
C-to-TB ratio
A-stat
Pr(Bslope>0)
No Catch
CON_99 b
TAI_01 a
TAI_01 b
TAI_01 c

3. TAI_02: Considering both the Changes of CPUE and Price:

It is agreed that the industries of all member countries are sensitive to price and had expressed their concerns that increases in global TAC could result in lower prices, as stated in the paragraph 14 in Agenda item 6 of the Report of the 4th Meeting of the Stock Assessment Group. Hence, the market constraint should be imposed to reflect the adverse effect caused by a change in CPUE. If the TAC is increased under the optimistic case, the price of SBT would be reduced under the market constraint, or vice versa.

Figure 6 show the total imports and average import price of Frozen SBT in Japan since 1993 to 2003. The import price fluctuates almost on a monthly basis. Since 1999, after the total imports increase, a downward sloping trend on the import price could be easily observed.

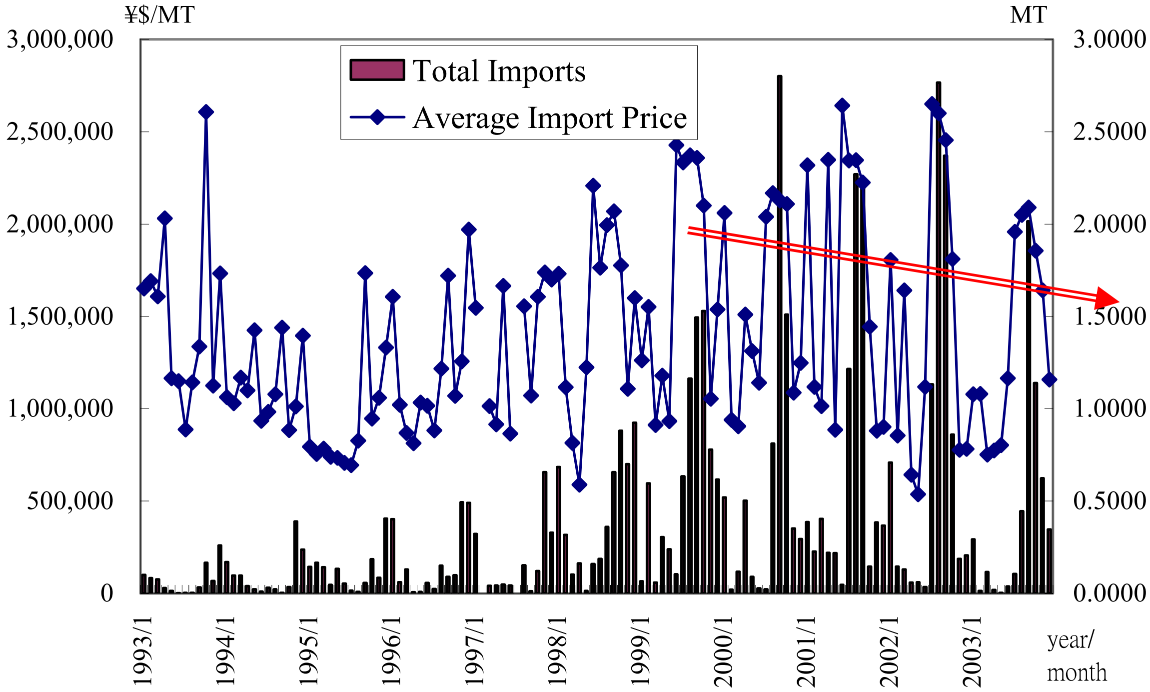


Figure 6 Total Imports and Average Import Price of Frozen SBT in Japan (1993 - 2003)

Because the price of SBT is highly depending upon the quality of the fish and the import price trend is considered by combining various qualities, it is better to examine the auction price in order to detect the market price trend. According to

Helga Josupeit and Camillo Catarci (FAO Globefish, March 15-18, 2004), they provide the world tuna industry - an analysis of imports, prices, and of their combined impact on tuna catches and fishing capacity. The following Figure 7 and 8 are cited for our reference. The Auction price in the Tsukiji Market, Japan for fresh and frozen SBT originated from Australia is shown in Figure 7.

Figure 7 Annual Prices of Southern Bluefin Tuna, G&G, Fresh and Frozen, Auction Tsukiji Market, Japan (Origin: Australia) 1995-2003

High prices of Southern bluefin tuna peaked in 1996-1997 at average year quotations of ¥11,100/kg and ¥11,292/kg, respectively. In the following years, they declined to a low of ¥7,508/kg in 2000 and fluctuated around similar values over the 2000-2003 period. In 2003, high prices of Southern bluefin tuna reached ¥7,651/kg. In turn, low prices of Southern bluefin tuna declined slightly from ¥887/kg in 1995 to ¥635/kg in 2003.

The peak prices of Southern bluefin tuna reported in Japan in 1996 and 1997 were due to reduced supplies from imports amid strong demand. In subsequent years, the decline in Japanese prices was a reflection of the market penetration of cheaper *sashimi* preparations from farmed bluefin tuna.

Since the SBT is highly substitute with the Atlantic and Pacific Bluefin tuna, it is also interesting to know the price trend of Atlantic and Pacific Bluefin tuna, as shown in Figure 8.

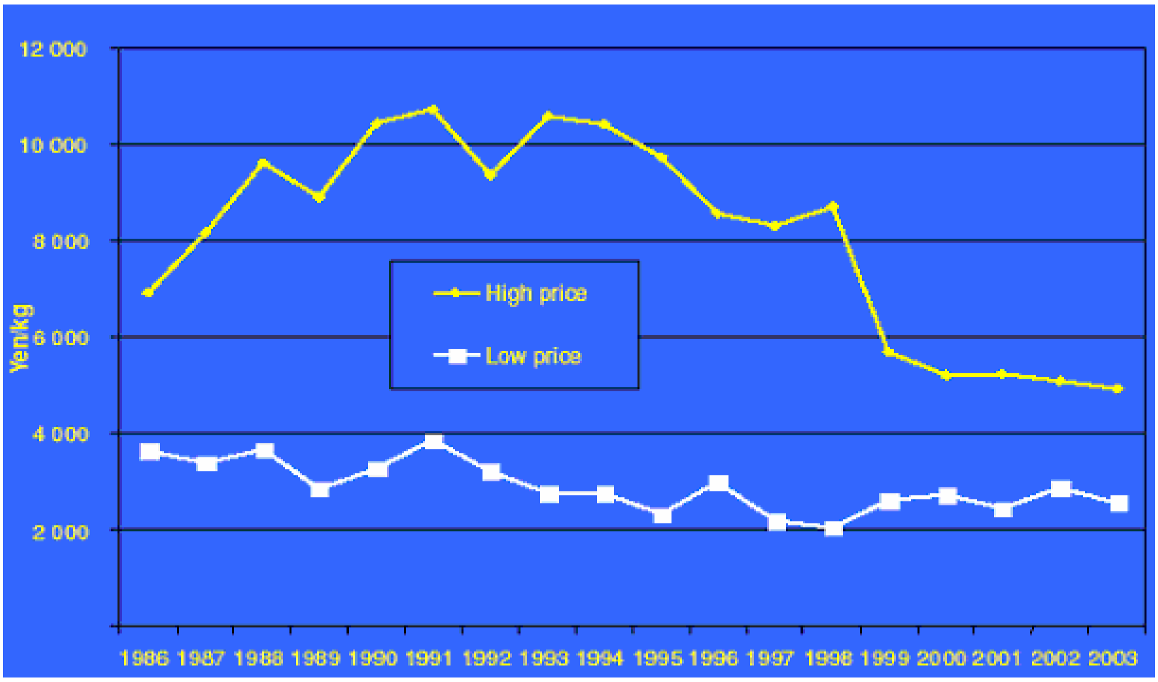


Figure 8 Annual Prices of Atlantic/Pacific Bluefin Tuna, Fresh and Frozen, Auction Tsukiji Market, Japan 1986-2003

High prices of Atlantic and Pacific bluefin tuna increased from ¥6,917/kg in 1986 to ¥10,717/kg in 1991. They declined to a low of ¥4,906/kg in 2003, while low prices of Atlantic and Pacific bluefin tuna increased from ¥3,642/kg in 1986 to ¥3,881/kg in 1991 and declined in the years which followed until they reached ¥2 555/kg in 2003. In 1999, ITN started to report quotations of farmed Atlantic and Pacific bluefins.

Prices of farmed Atlantic and Pacific bluefin tuna decreased from ¥4,000 (low price) to ¥5,000 (high price), origin Spain to ¥1,800 to 3,000 in December 2003. For the past two years, these quotations have been responsible for lowering the average bluefin quotations on the Tsukiji market.

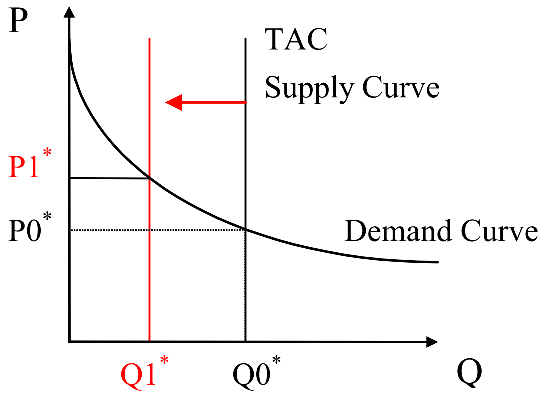
Under the market constraint, an increment of the TAC will reduce the price of SBT and the negative effect should be incorporated into the rule as a moderate adjustment measure.

Hence, a lesser increment in the next period's TAC would have to be considered under this argument. On the contrary, a lesser decrement in the next period's TAC would have to be considered when the price following an increasing trend.

The decision rule is named TAI_02 and defined as follows:

Assume the percentage change of the price of SBT is negatively correlated with the percentage change of quantity, then the Inverse Demand Elasticity is negative:

$$k_2 = \frac{\%\Delta P}{\%\Delta TAC} < 0$$



and the percentage change of price is equal to -k_2 times $\%\Delta TAC$, which should be considered as one of the factor influences the TAC in next period.

$$TAC_t = w \cdot TAC_{t-1} + (1-w) \cdot TAC_{t-1} \cdot (1 + k_1 \lambda_n) \cdot (1 - k_2 \%\Delta TAC)$$

where w is the tuning parameter values from 0 to 1

k_1 is the weight given to the log(CPUE) slope,

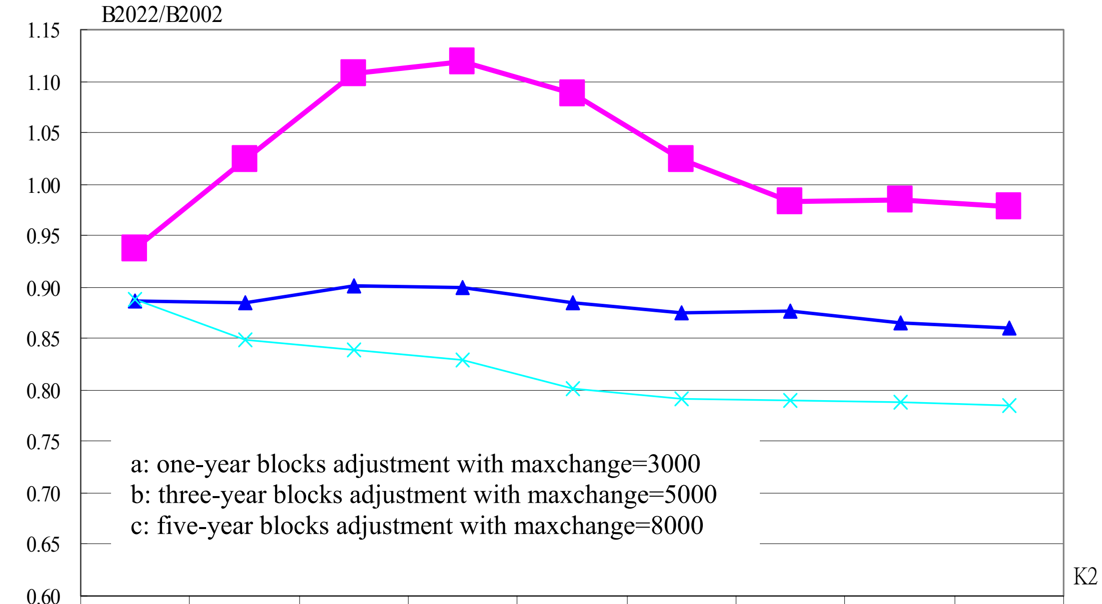
k_2 is the weight given to $\%\Delta TAC$,

λ_n is the slope of the regression of log(CPUE) vs. time over the last 5 years,

$\%\Delta TAC$ is the percentage change of TAC in one-year, three-year or five-year blocks .

Based upon the decision on the carryover percentage is set to 0.85 and k_1=10 in TAI_01, the result of the Biomass Ratio of TAI_02 Decision Rule by tuning k_2 from 0 to 1000 is shown in Figure 9. Three wormplots of TAI_02 under k_2=7 with three adjustment scheme a, b, and c are shown in Figure 10 as follows.

It is interesting to know the characteristics of TAI_02 decision rule shown the ability of self-adjusting, especially under scheme b and c. For example, if there is a huge drop of the TAC in this period, which is caused by the downward CPUE trend, and then there is a tendency to increase the price, and then the self-adjustment process come in to have a higher TAC in the next period to compensate the loss. Hence, the wormplot of TAI_01 tends to exhibit a zip-zap path for TAC.



K2	0	3	7	10	20	100	300	500	1000
a	0.9368	1.0240	1.1078	1.1195	1.0875	1.0238	0.9833	0.9847	0.9777
b	0.8869	0.8856	0.9010	0.8997	0.8849	0.8743	0.8762	0.8652	0.8611
c	0.8876	0.8486	0.8390	0.8285	0.8010	0.7910	0.7891	0.7881	0.7851

Figure 9 Comparision of the Biomass Ratio of TAI_02 CPUE Decision Rule under Various Tuning Level of the Carryover Percentage Parameter in High Recruitment (no AC) Scenario

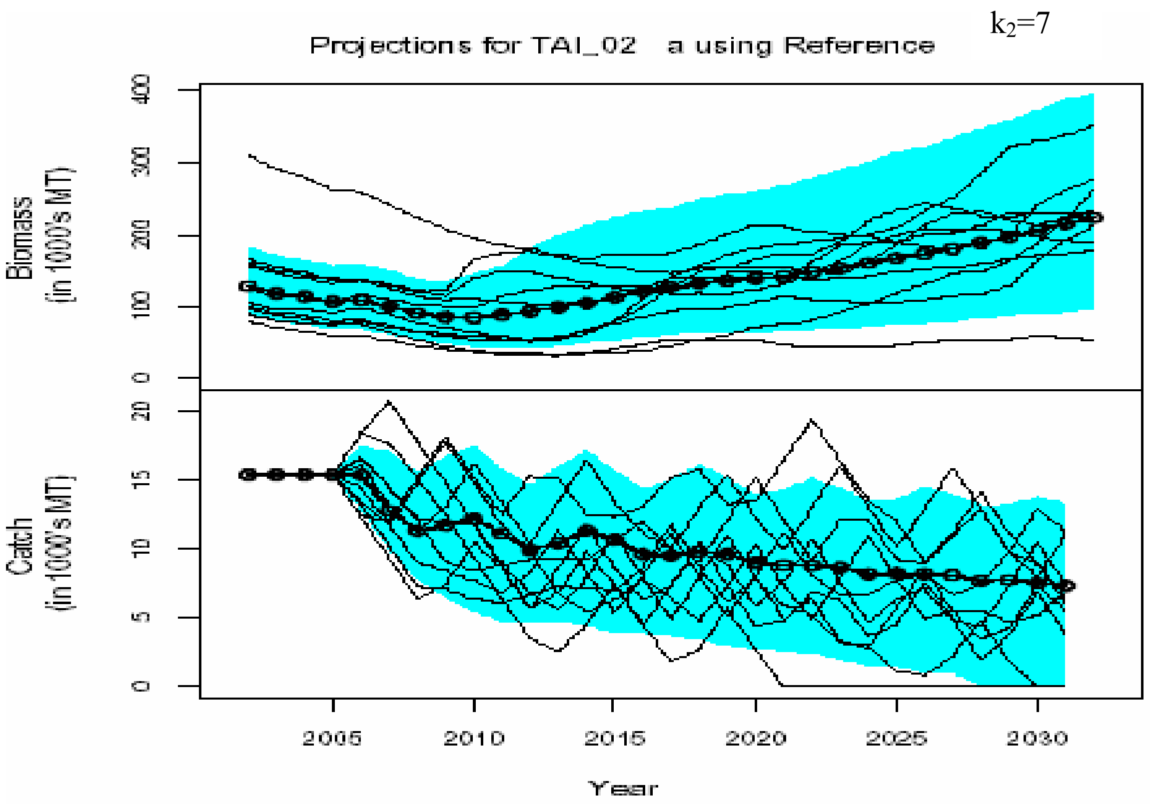
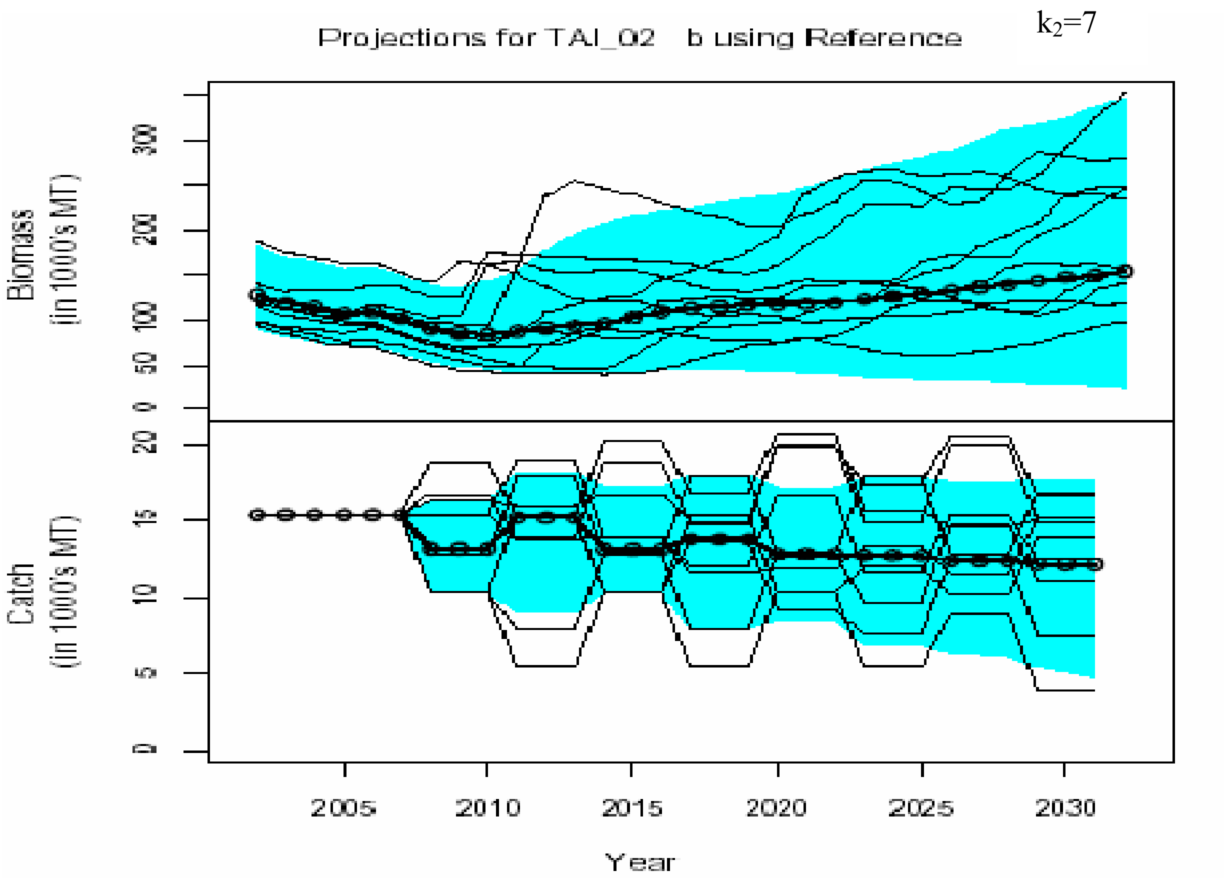


Figure 10 Projections of TAI-02 under adjustment scheme a: one-year blocks with 3000 maxchange



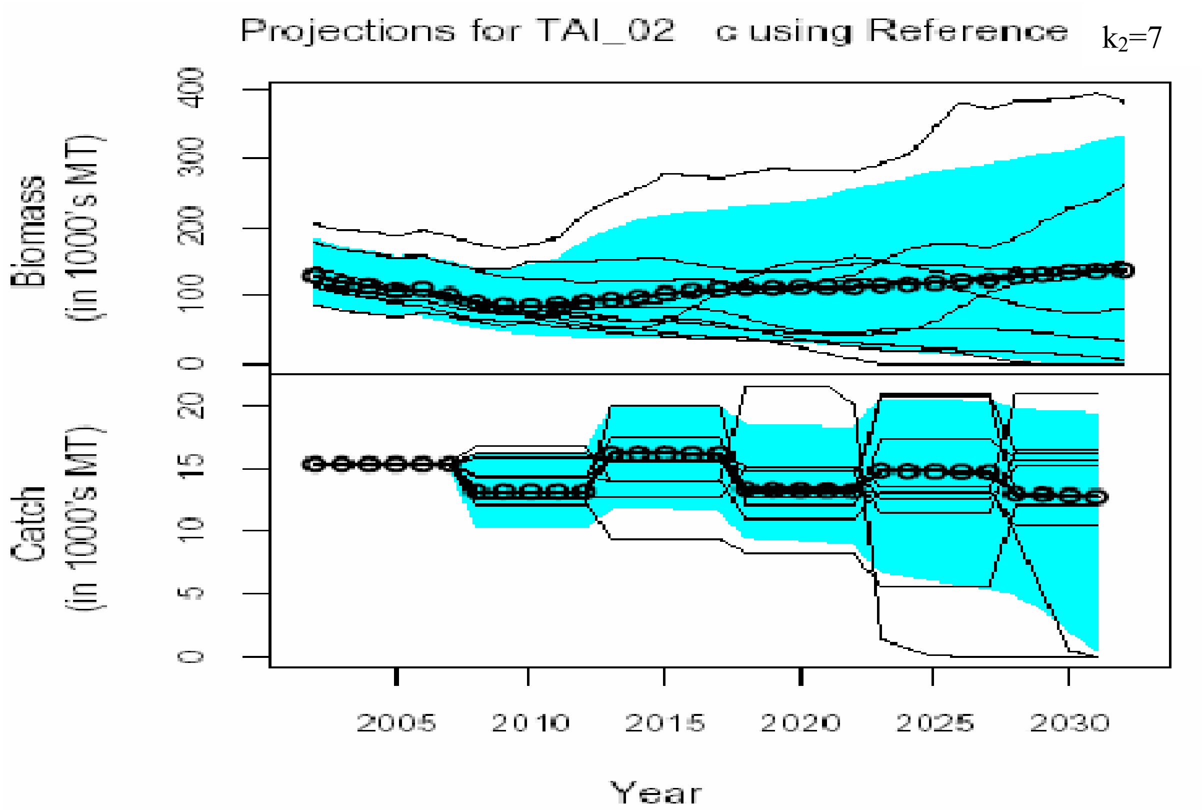


Figure 10 Projections of TAI-02 under adjustment scheme b: three-year and with 5000 maxchange and c: five-year blocks with 8000 MT maxchange

Conclusion and Discussion

By comparing various candidate management procedures, it is not meaningful to tune the biomass levels if media of the biomass ratio B2022/B2002 have been set unreasonably too low at 0.7 or too high at 1.5. For example, under the constant catch rule, if the biomass ratio is set to 1.5 then the TAC will be ended up to 1,068 MT, which is only one-fifteenth of the current TAC and resulted in a total collapse of the industry. If the biomass ratio is set to 1.1, then the TAC would be lower to 10,582 MT under 5-year blocks with the maximum change of 8,000 MT or to 11,226 MT under 1-year blocks with the maximum change of 3,000 MT, which means 30% reduction of the TAC in the first reduction period.

Assuming the "operating models" are true and the mother nature of the SBT could be respond accordingly, I found the media of the biomass ratio would reach 0.78056, if we maintain the TAC to 15,385.7 MT, as specified in the "sbtdata.dat" in 2001. Based upon my simulation, it would be a more practical rule to pursue, if the decision rules could be tuned to get the B2022 higher than 78% of the B2002. Hence, it is not meaningful to tune the biomass ratio to 0.7, since the situation is even worse than maintaining the TAC at the 2001 level.

I would then suggest choosing a moderate target that is 10% higher than the biomass ratio of 78%. As suggested from my calculated decision rule on TAI_01_b having fewer than 85% of carryover percentage, the biomass ratio would reach 88.69% from 3-year blocks and adjustment with maximum change of 5000.

Regarding to the historical data used in conditioning fits, the "*sbtdata.dat*" contain the total landing from six major fisheries statistics as shown in Figure 11. Since all the CPUE based rules and indicators are calculated based upon the LL1 fishery only, it would be very important if the LL1 data can truly reflect the current biomass status. We therefore recommend a thoughtful investigation on the definition of LL1 and a careful monitoring its reliability in the future.

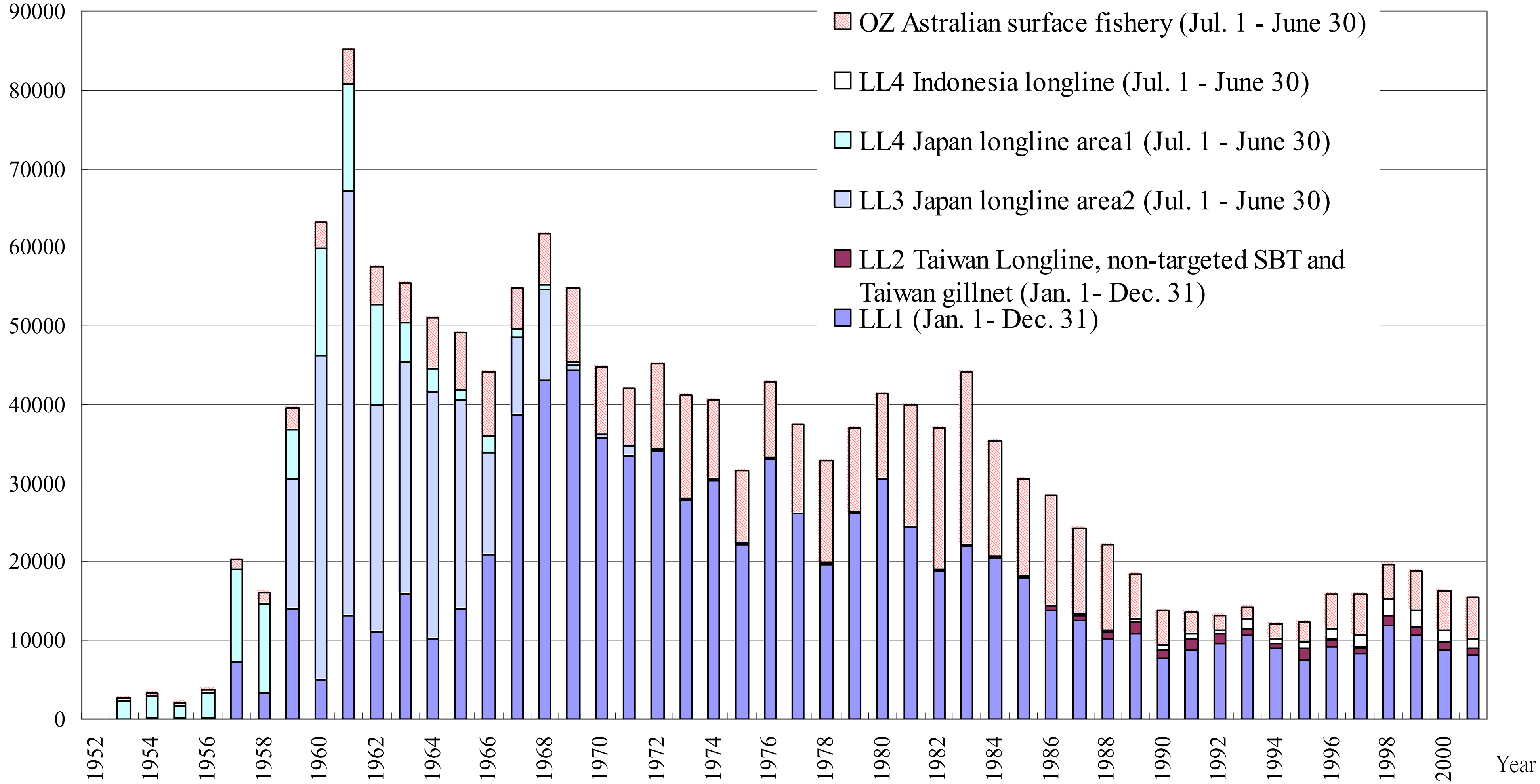


Figure 11 Historal data from "sbtdata.dat"