

Final draft (Nov., 3 2005)

**Report on the requests to the Scientific Committee raised
by the 9th Commissioner meeting (2005) regarding Resolution 05/01
(*Conservation and management measure for bigeye tuna*)**

Scientific Committee working group (*)

November, 2005

Terms of references

5. Research Recommendations and priorities

81. At the 9th Session of the IOTC, the Commission requested (via IOTC Resolution 05/01 On conservation and management measure for bigeye tuna) that the Scientific Committee be tasked to provide advice on;

- the effects of different levels of catch on the SSB (in relation to MSY or other appropriate reference point);
- the impact of misreported and illegal catch of bigeye tuna on the stock assessment and required levels of catch reduction; and
- evaluation of the impact of different levels of catch reduction by main gear types.

82. The WPTT agreed that that ASPM model, as used by Japan in 2004 would be re-run using updated fisheries data and the biological and fisheries parameters used in 2004. The results of this assessment will be made available to WPTT prior to the Scientific Committee meeting in November 2005. And new technical advice on bigeye would be prepared for the Commission by the Scientific Committee based on the results of the up-dated assessment. The WPTT requested that the Secretariat coordinate the delivery of the assessment in conjunction with Japanese scientists.

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References

Submitted to the IOTC Seventh Scientific Committee (Nov. 7-11, 2005), Victoria, Seychelles.

() Nishida, Shono and Okamoto (Japan), Chang and Wang (invited scientists), Anganuzzi, O'Brien and Herrera (IOTC), Fonteneau (EU) and Kirkwood (SC chair)*

1. Introduction

We conducted the tasks requests to the Scientific Committee raised by the 9th Commissioner meeting in 2005 regarding Resolution 05/01 (*Conservation and management measure for bigeye tuna*), i.e.,

- To conduct updated assessment by ASPM (1960-2003)
- To investigate effect of different levels of catch on the SSB (in relation to MSY or other reference point) [Evaluation of the impact of different levels of catch reduction by main gear]
- The impact of unreported and misreported catch of bigeye tuna on the stock assessment and required levels of catch reduction

This is the report of these tasks.

2. Unreported and misreported catch

Unreported catch including the IUU (illegal) catch was estimated by the IOTC. The misreported catch refers to the laundered catch by Taiwan's longliners from the Atlantic Ocean estimated by the invited scientists, i.e. about 4,000 ton in 2003. Based on available information, the invited scientists also suggested a possible 4,000 ton in 2003 that were laundered by IUU vessels from the Atlantic. In this regard, the total misreported catch from the Atlantic was estimated to be 8,000 tons. Table 1 and Fig. 1 show the situations of these catches.

3. Updated assessment by ASPM (1960-2003)

Using same inputs as in the 2004 assessment (1960-2002) (Nishida and Shono, 2004) (except for catch and CPUE which use the data up to 2003) and also using the same method, we had re-run the ASPM. For the CPUE standardization we used the same method as in 2004 by Okamoto *et al* (2004a) for Japan and also Okamoto *et al* (2004b). Table 1 shows the results for six different scenarios. As a result, we selected Run 2 as the best estimates.

We noticed that there is an auto-correlation problem in the estimated recruitment. Thus we explored ASPM Run2 by changing rho values that reduce this problem. Table 3 shows the result which suggested that ASPM Run2e when rho=0.17 produced the best estimates as the auto-correlation problem was significantly reduced. Thus we selected the results of ASPM Run2e as the 2005 assessment. Fig. 2 shows the trend of various estimated values for Run2e. For reference, Fig. 3 represents the same for those estimated in 2004. Table 4 is the comparative table of results between 2004 and 2005 assessment.

Table 1 Bigeye catch by gear and reported (R)/unreported (UR) type (in 1,000 tons)

	LL(R)	LL(UR)	PS(R)	PS(UR)	OTH	Total	Total (UR)	% of UR catch
1960	16.1	0	0	0	0	16.1	0	0
1961	14.9	0	0	0	0	15.0	0	0
1962	18.5	0	0	0	0	18.5	0	0
1963	13.3	0	0	0	0	13.3	0	0
1964	18.0	0	0	0	0	18.0	0	0
1965	19.5	0	0	0	0	19.5	0	0
1966	24.1	0	0	0	0	24.1	0	0
1967	24.8	0	0	0	0	24.8	0	0
1968	39.5	0	0	0	0	39.5	0	0
1969	30.4	0	0	0	0	30.4	0	0
1970	27.8	0	0	0	0.1	27.8	0	0
1971	23.0	0	0	0	0.1	23.0	0	0
1972	20.0	0	0	0	0.1	20.1	0	0
1973	17.4	0	0	0	0.1	17.6	0	0
1974	28.3	0	0	0	0.1	28.5	0	0
1975	37.7	0	0	0	0.1	37.8	0	0
1976	28.5	0	0	0	0.1	28.7	0	0
1977	35.9	0	0	0	0.2	36.1	0	0
1978	50.5	0	0.0	0	0.1	50.7	0	0
1979	33.5	0	0.0	0	0.1	33.6	0	0
1980	34.9	0	0.0	0	0.1	35.0	0	0
1981	34.8	0	0.0	0	0.2	35.1	0	0
1982	43.4	0	0.1	0	0.1	43.6	0	0
1983	49.5	0	0.6	0.0	0.2	50.3	0.0	0.1
1984	39.7	0	3.5	0.5	0.4	44.1	0.5	1.1
1985	44.8	0.1	6.6	0.6	0.3	52.4	0.7	1.3
1986	45.5	1.2	9.6	1.0	0.5	57.8	2.2	3.8
1987	50.3	0.9	12.6	0.8	0.4	65.1	1.7	2.6
1988	52.2	4.9	14.2	0.8	2.2	74.4	5.7	7.7
1989	44.4	12.3	11.5	0.5	0.8	69.5	12.8	18.4
1990	44.2	16.3	11.6	1.0	0.5	73.7	17.3	23.5
1991	43.6	17.2	14.1	1.5	0.7	77.1	18.8	24.3
1992	42.3	17.8	10.0	1.3	0.5	71.9	19.1	26.6
1993	62.6	22.8	13.0	3.0	0.6	102.0	25.8	25.3
1994	66.0	24.7	16.1	2.8	0.7	110.2	27.4	24.9
1995	69.8	20.0	23.7	4.7	1.3	119.4	24.7	20.6
1996	81.5	20.0	20.0	4.5	0.9	126.9	24.5	19.3
1997	93.4	19.0	26.6	7.4	0.9	147.3	26.4	17.9
1998	90.6	21.5	21.2	7.1	1.0	141.4	28.6	20.2
1999	88.3	20.3	29.2	11.4	1.2	150.5	31.8	21.1
2000	79.9	18.3	21.0	8.8	0.7	128.7	27.1	21.0
2001	78.6	9.9	17.7	6.0	1.0	113.3	16.0	14.1
2002	91.7	11.4	22.7	6.3	1.3	133.5	17.7	13.3
2003 (excl. misreported LL catch)	82.4	10.1	18.0	4.8	1.4	116.7	14.9	12.8

Note: refer to the text (page 2) about the misreported LL catch.

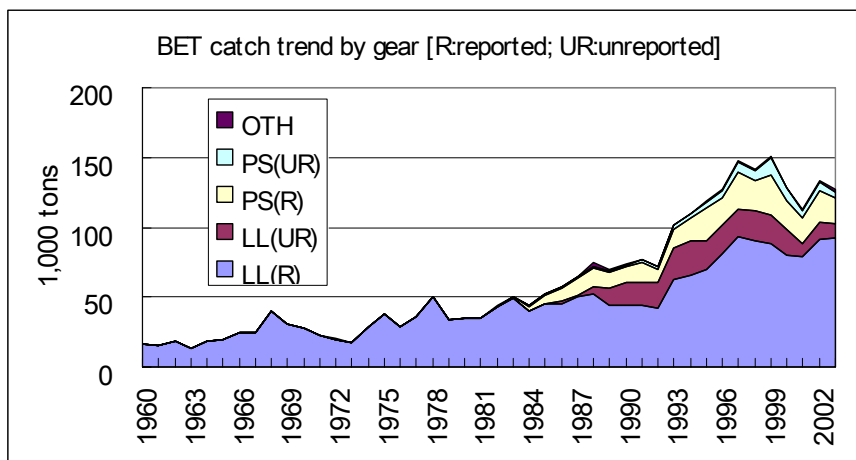


Fig. 1 Trend of bigeye catch by gear and reported (R)/unreported (UR) type (misreported catch of 8,000ton in 2003 excluded).

Table 2 Result of the initial ASPM runs (rho=0.00) : INPUTS & RESULTS

Run no.	1	2	3	4	5	6
INPUT DATA (Whole Indian Ocean)						
LW	Based on the information of the IOTC sampling programs					
Growth	Stewart (2003)					
Selectivity	LL (3 periods) and PS (2 periods)					
M (ICCAT type)	0.8 (age 0-1) and 0.4 (age 2-8)					
S-R	Beaverton-Holt model					
Period	1960-2003 (44 years)			1968-2003 (36 years)		
Catch (LL & PS) (in 1000 tons) Note : Misreported LL catch 8,000 t in 2003 is not included. (refer to the text regarding the misreported catch)						
Scaled abundance Indices based on the standardized CPUE (average=1) Japan Okamoto et al(2004a) Taiwan Okamoto et al(2004b)	Japan (1960-2003) Taiwan (1968-2003)	Japan (1960-2003)	Taiwan (1968-2003)	Japan (1968-2003) Taiwan (1968-2003)	Japan (1968-2003)	Taiwan (1968-2003)
RESULTS						
ASPM Rho=0.15 (convergence)	<i>Unrealistic MSY is too large F(2003) too small</i>	OK	<i>Unrealistic MSY is too large F(2003) too small</i>	<i>Unrealistic MSY is too large F(2003) too small</i>	OK	<i>Unrealistic MSY is too large F(2003) too small</i>
ln(likelihood)	-135	-112	-68	-117	-90	-86
R-squared	0.56	0.93	0.80	0.59	0.94	0.79
Steepness	0.99	0.99	0.99	0.99	0.99	0.99
CV(2003)	439	559	107	410	419	186
(SSB)						
SSB 2004 (million tons)	0.91	0.26	0.65	0.82	0.24	1.77
SSB(MSY) (million tons)	0.31	0.17	0.21	0.29	0.16	0.47
B ratio	2.94	1.53	3.10	2.83	1.50	3.77
(F)						
F(2003)	0.14	0.46	0.18	0.15	0.50	0.07
F(MSY)	0.49	0.60	0.45	0.49	0.61	0.40
F ratio	0.29	0.77	0.40	0.31	0.82	0.18
MSY (million tons)	0.179	0.109	0.115	0.169	0.107	0.221
		Accepted as base case				

Note (NC) not properly converged, i.e., Results of the ASPM run may not be OK.

Table 3 Sensitivities of rho for base case (RUN2) (2005 analyses)

NC: no convergence

Run no.	2a (base case)	2b	2c	2d	2e	2f
Rho ->	0	0.05	0.10	0.15	0.17	0.18
ln(likelihood)	-112	-112	-112	-112	-112	NC
R-squared	0.93	0.93	0.93	0.93	0.93	
Steepness	0.99	0.99	0.99	0.99	0.99	
CV(2003)	559	159	56	29	24	
SSB 2004 (million tons)	0.26	0.24	0.23	0.21	0.21	
SSB(MSY) (million tons)	0.17	0.16	0.16	0.15	0.15	
B ratio	1.53	1.50	1.44	1.40	1.40	
F(2003)	0.46	0.48	0.51	0.55	0.56	
F(MSY)	0.60	0.61	0.61	0.62	0.63	
F ratio	0.77	0.79	0.84	0.89	0.89	
MSY (million tons)	0.109	0.107	0.104	0.099	0.099	
					best	

Fig. 2 trends of various parameters obtained from ASPM Run 2e (2005 analyses)

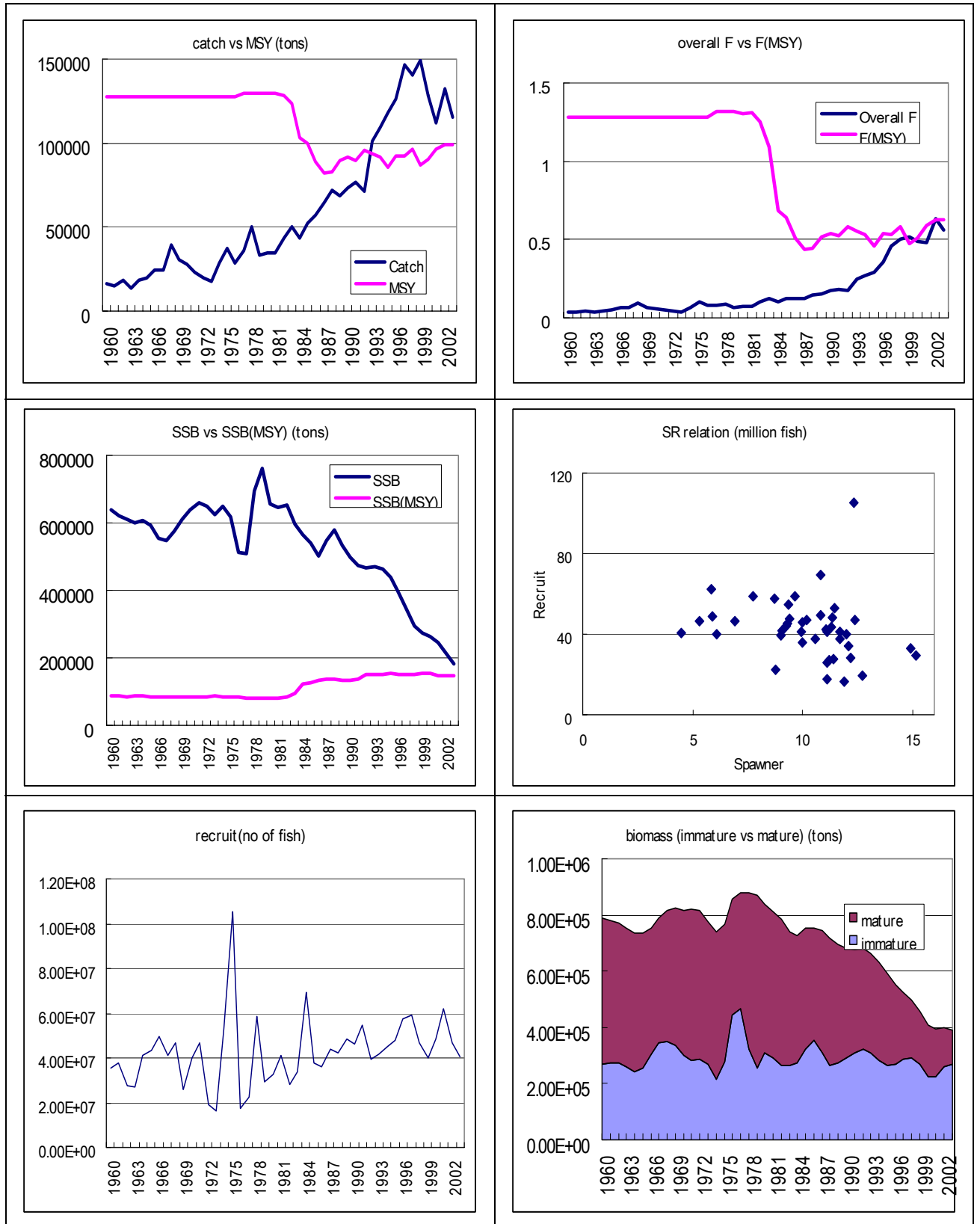


Fig. 3 trends of various parameters obtained from ASPM Run2 (2004 analyses)

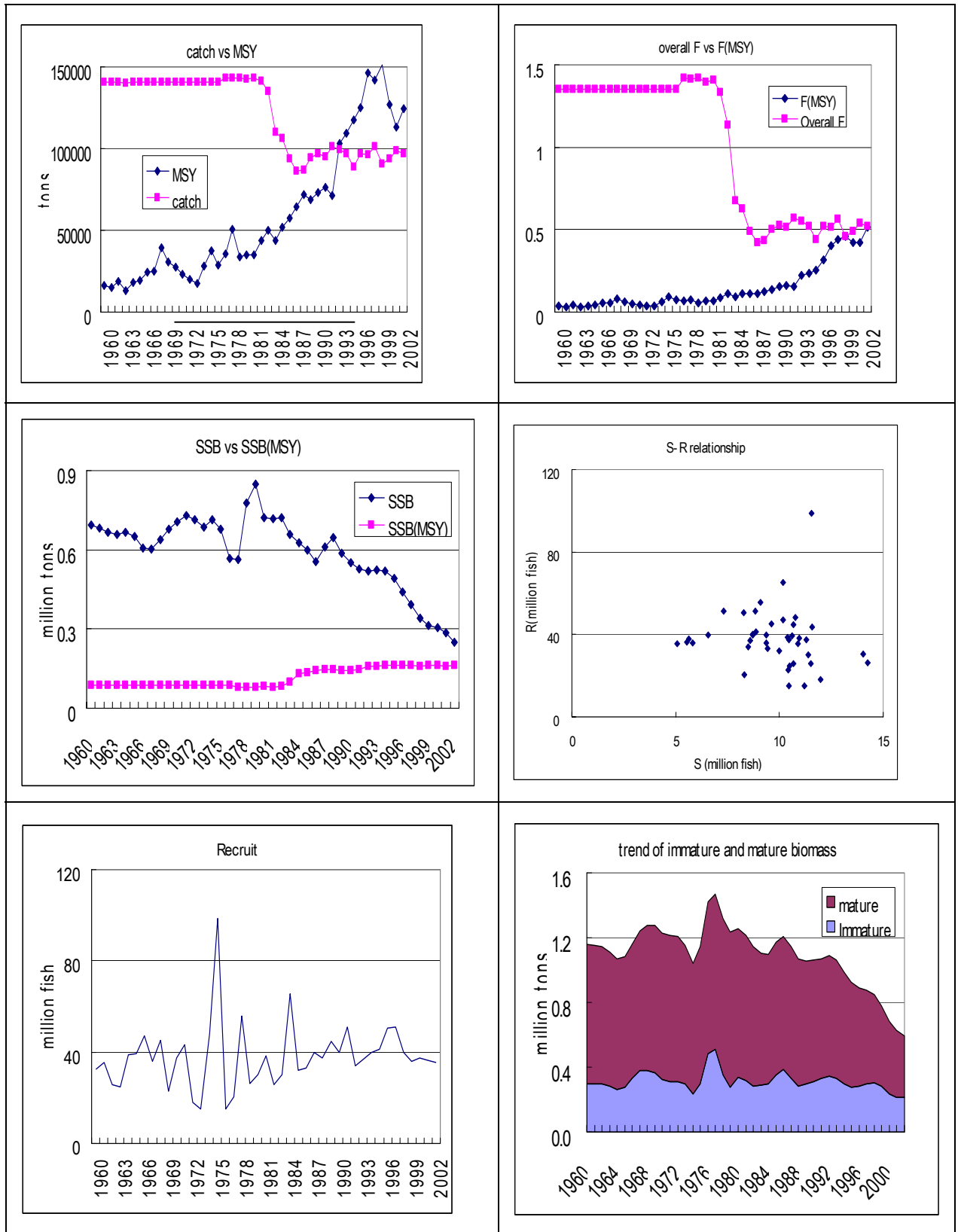


Table 4 Comparison of results between 2004 and 2005 assessment

		Last assessment (2004)	New assessment (2005)
Method (software)		ASPMS (software created by Restrepo,1997)	
Period analyzed		1960-2002 (43 years)	1960-2003 (44 years)
CPUE (abundance index) used in the ASPM		Japan (1977-2002)	Japan (1977-2003)
MSY (tons)	MSY(Point)	96,857	99,212
	(current catch) (tons)	(125,640) (2002)	(116,759) (*) (2003)
Total biomass	Virgin (million tons)(1960)	0.776	0.789
	Current (million tons)	0.385	0.392
	B1 ratio(virgin) =B(current)/B(virgin)	0.496	0.497
Spawning stock biomass (SSB)	Virgin (million tons)(1960)	0.695	0.638
	Current (million tons)	0.213	0.206
	SSB(MSY) (million tons)	0.161	0.147
	B ratio (virgin) =B(current)/B(1960)	0.306	0.323
	B ratio(MSY) =B(current)/B(MSY)	1.323	1.401
F	F(MSY)	0.520	0.626
	F (current)	0.513	0.563
	F ratio(MSY) =F(current)/F(MSY)	0.987	0.899

Note (*): Misreported catch (8,000 tons) excluded.

Very important note on confidence intervals (CI)

In the assessment in 2004(last time) and 2005(this time), it has been recognized that there were some problems to compute CI for MSY, B1ratio, Bratio and Fratio by the bootstraps (200 times) using fluctuated CPUE given by random noises, i.e., we had large CI for MSY and negative CI for other parameters. We recently found that this is due to the ASPM program structure which keeps last CPUE values and does not pick up the new CPUE values created by the bootstrap. Thus we can not conduct 200 times of batch jobs as ASPM keep the very last CPUE values used in ASPM and will not change to the new CPUE values from the batch jobs.

To solve this problem, we need to re-run (reset) ASPM each time each for 200 times MAUALLY. As 200 times of manual operations are not wise to do, we consulted Dr Restrepo who created this ASPM program if he can modify the program to solve this problem. Then he suggested using the bootstrap already built-in the ASPM. Thus we will attempt this function in the next assessments and plan to compute the proper CI. In this connection, we need to withdraw CI values for MSY appeared in the BET Executive Summary as they were computed under such problematic bootstraps (batch jobs).

Results

The stock status in 2005 was resulted to be slightly improved from the one in 2004. This is probably due to the jump of Japan CUEP in 2003 and drops of catch level recent years.

4. Effect of different levels of catch on the SSB (in relation to MSY or other reference point) [Evaluation of the impact of different levels of catch reduction by main gear]

To achieve this task, we carried out the future projection for 11 years (2004-2014) based on the updated ASPM results by changing current catch and F levels in 2003 as shown in Tables 5 and 6 respectively. We used the average catch (in tons) of recent two years as the representative of the catch. The misreported catch (8,000 tons) in 2003 is excluded. Fig. 4 shows the trends of projected SSB (spawning stock biomass) including point estimates and their 90% confidence intervals by 100 times of the bootstraps. The basic procedure of the projection is described in Shono *et al* (2004).

Table 4 6 catch control scenarios by decreasing the current catch level in 2003.

Scenario (level of catch reduction by gear)	LL (longline) Current catch level in 2003 (92,544 ton)	PS (purse seine) Current catch level in 2003 (22,834 ton)
Catch-1 (LL-0%, PS-0%)	current level	current level
Catch-2 (LL-10%, PS-0%)	10% Reduction	current level
Catch-3 (LL-0%, PS-10%)	current level	10% Reduction
Catch-4 (LL-10%, PS-10%)	10% Reduction	10% Reduction
Catch-A (LL-10,000 t, PS-0 t)	Reduction of 10,000 ton	current level
Catch-B (LL-0 t, PS-10,000 t)	current level	Reduction of 10,000 ton
Catch-C(LL-10,000 t,PS-10,000 t)	Reduction of 10,000 ton	Reduction of 10,000 ton

Table 3 4 F control scenarios by increasing current F level in 2003

Scenario (increase level of F by gear)	LL (longline) Current F level in 2003 (F=0.508)	PS (purse seine) Current F level in 2003 (F=0.196)
F-1 (LL-0%, PS-0%)	current level	current level
F-2 (LL-6%, PS-0%)	Increase F (6% per year)	current level
F-3 (LL-0%, PS-6%)	current level	Increase F (6% per year)
F-4 (LL-6%, PS-6%)	Increase F (6% per year)	Increase F (6% per year)

Results

- If 10% of current (2003) catch level of PS and LL were reduced annually, SSB (point estimate) will be maintained above the MSY level for 11 years until 2004.
- If PS catch or both LL & PS catch were reduced by 10,000 t annually, BET stock will be very healthy, i.e., SSB (point estimate) will be maintained in 50,000-100,000 above its MSY level for 11 years until 2004.
- If current (2003) F level of PS and LL were maintained, SSB (point estimate) will be maintained above the MSY level for 11 years until 2004.

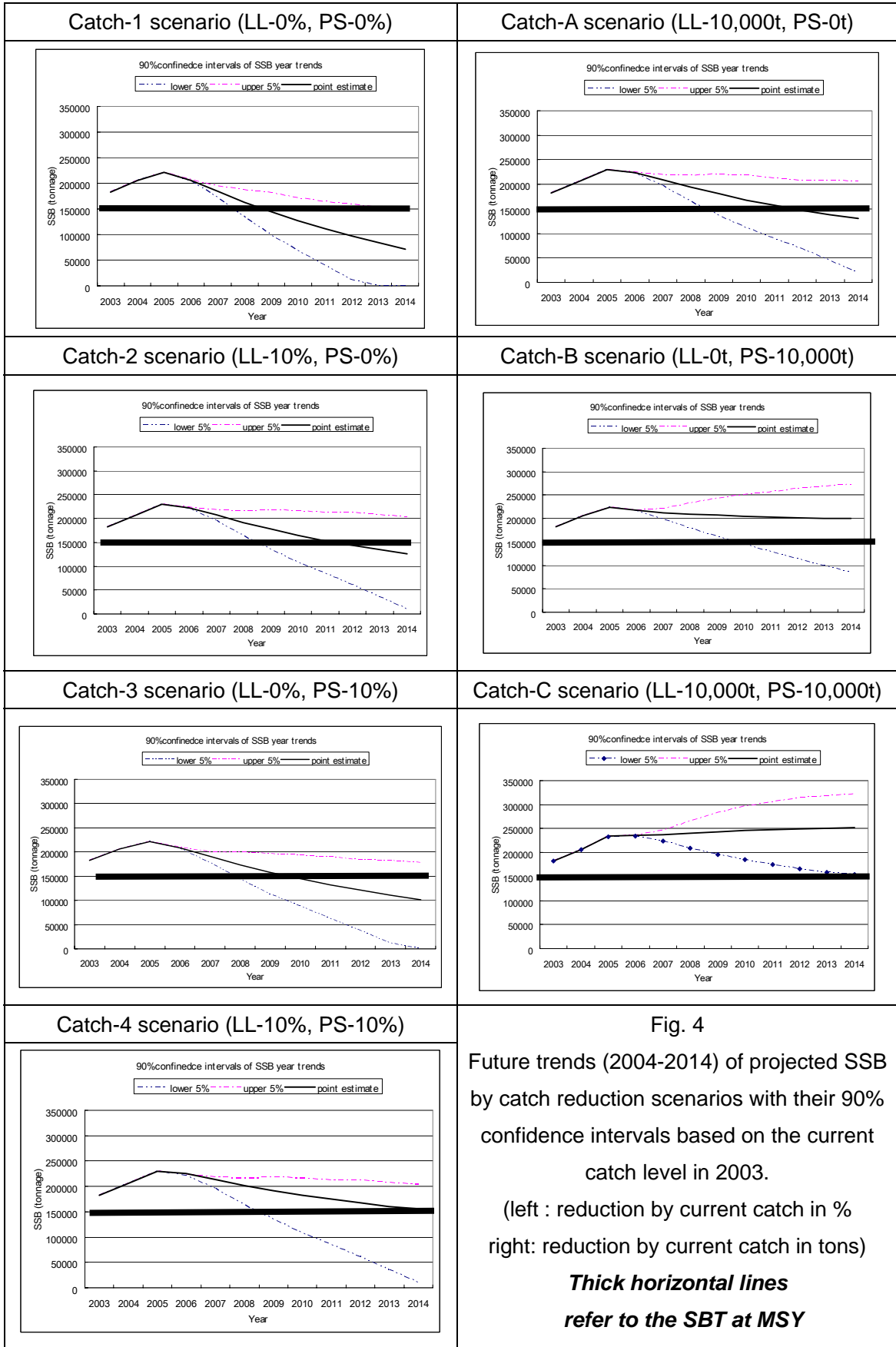
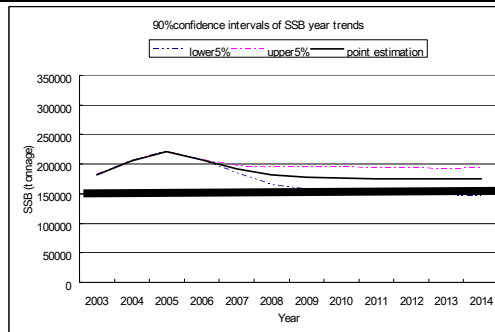


Fig. 5

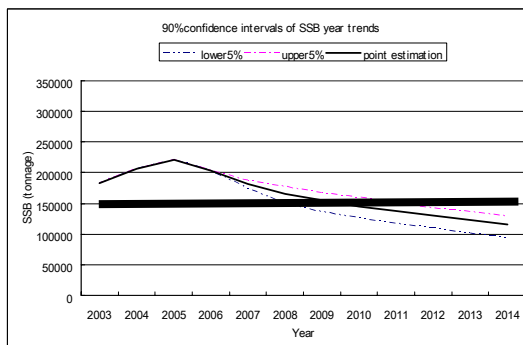
Future trends (2004-2024) of projected SSB by F increase scenarios with their 90% confidence intervals based on the current F level in 2003.

Thick horizontal lines refer to the SBT at MSY

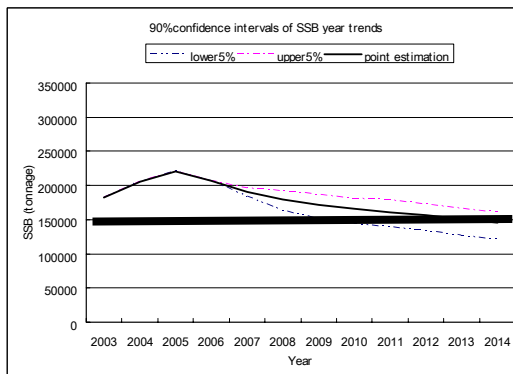
F-1 scenario (LL-0%, PS-0%)



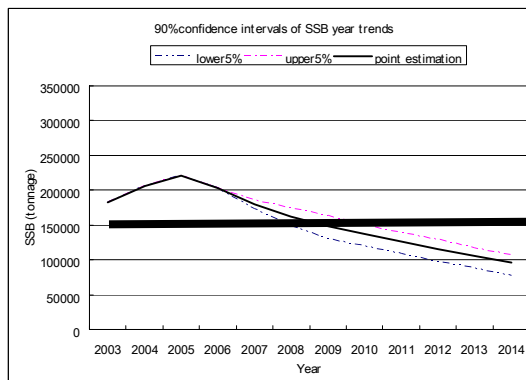
F-2 scenario (LL-6%, PS-0%)



F-3 scenario (LL-0%, PS-6%)



F-4 scenario (LL-6%, PS-6%)



5. The impact of misreported and unreported catch of bigeye tuna on the stock assessment and required levels of catch reduction

5.1 Impact of the unreported catch

To achieve this task, we carried out the future projection for 11 years (2004-2014) based on the updated ASPM results by EXCLUDING unreported (refer to Table 1 & Fig. 1) and controlling current catch and F levels in 2003 as shown in Table 5. The misreported catch (8,000 tons) in 2003 is excluded. We used the average legal catch (in tons) of recent two years (2002-2003) for LL & PS as their representative (starting) values. Through these projections, we can see the future trend of SSB when unreported catch were not reduced.

Fig. 6 (left column) shows the trends of projected SSB WITHOUT unreported catch, while Fig. 6 (right) for those WITH ALL catches which is taken from Figs. 4 and 5. All graphs include point estimates and their 90% confidence intervals by 100 times of the bootstraps. The basic procedure of the projection is described in Shono *et al* (2004).

Table 5 Catch & F control scenarios for the future SSB projection EXCLUDING unreported catch.

Scenario	LL (longline)	PS (purse seine)
Catch control		
(level of catch reduction by gear)	Current (legal) catch level in 2003 (82,586 ton)	Current legal catch level in 2003 (18,800 ton)
Catch-op1 (LL-0%, PS-0%)	Current level	Current level
Catch-op4 (LL-10%, PS-10%)	10% Reduction	10% Reduction
F control		
(level of F increase by gear)	Current F level in 2003 (F=0.442)	Current F level in 2003 (F=0.163)
F-op1 (LL-0%, PS-0%)	Current level	Current level
F-op4 (LL-6%, PS-6%)	F Increase (6% per year)	F Increase (6% per year)

Results

If there were NO unreported (illegal) catch and current level of the legal catch were continued, SSB of the BET stock will be above its MSY level for next 11 years until 2014. This implies that the unreported (illegal) PS & LL catch affect the BET stock seriously. Hence, the current unreported (illegal) catch of PS (48,000 tons) and LL(101,000 tons) need to be reduced as much as possible.

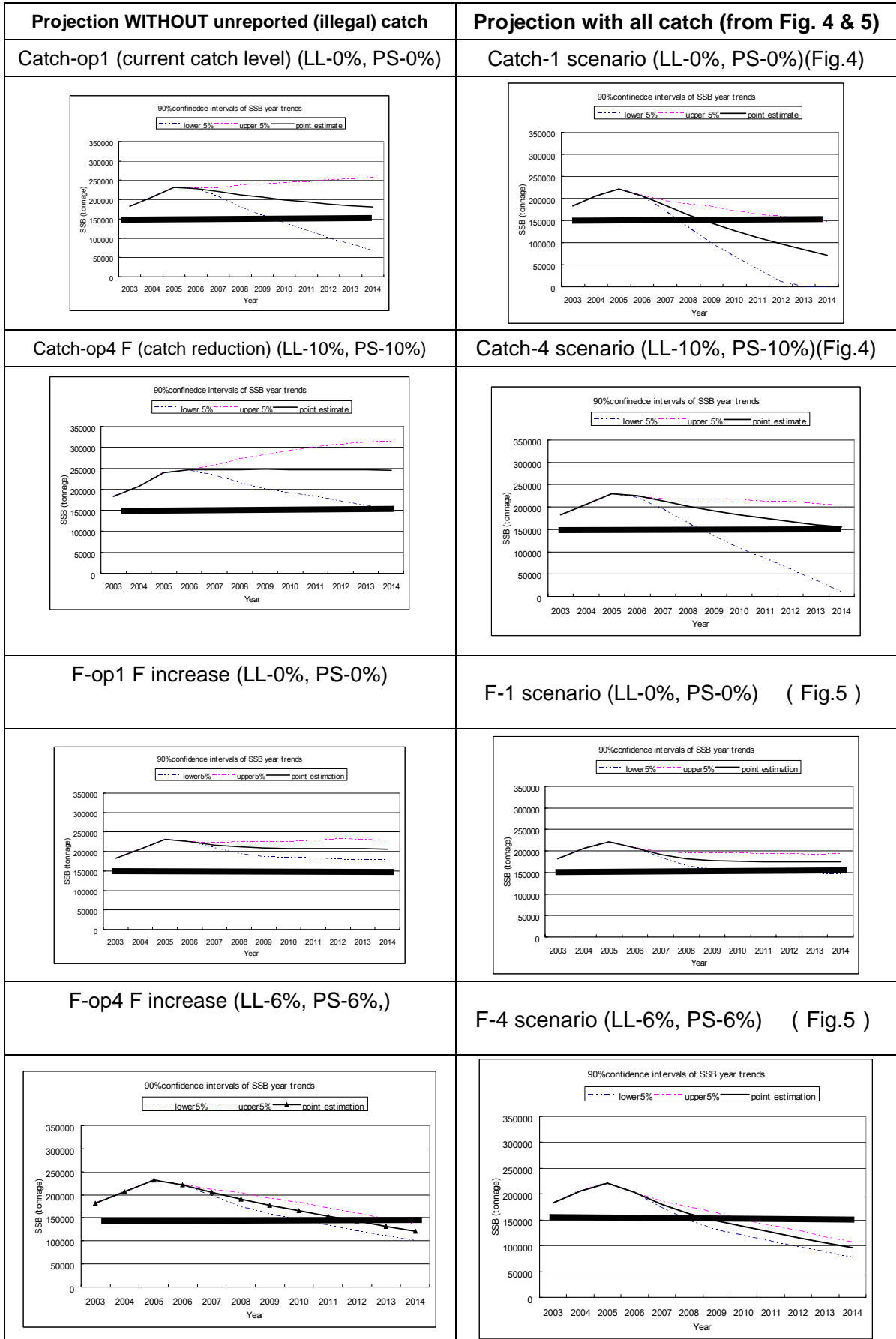


Fig. 6 Projected SSB with (right) & without (left) unreported (illegal) catch

Thick horizontal lines refer to the SBT at MSY

5.2 Impact of the misreported catch

To investigate the impact of the misreported catch in 2003, we did ASPM RUN2e' by adding 8,000 ton to the 2003 LL catch to see how this catch affect, then compared to the results without 8,000 ton (RUN2e).

Table 6 Comparison of the ASPM results with and without the misreported catch

Run no.	2e	2e'
Misreported catch 8,000 ton in 2003	Excluded	Included
Rho ->	0.17	0.17
ln(likelihood)	-112	-97
R-squared	0.93	0.93
Steepness	0.99	0.99
CV(2003)	24	36
SSB 2004 (million tons)	0.21	0.20
SSB(MSY) (million tons)	0.15	0.15
B ratio	1.40	1.33
F(2003)	0.56	0.61
F(MSY)	0.63	0.65
F ratio	0.89	0.93
MSY (million tons)	0.099	0.102

Result

The misreported catch 8,000 tons in 2003 did not significantly affect the stock such as MSY, SSB and other population parameters.

6. Results and Conclusion

6.1. Summary of the results

(1) Stock status

The stock status in 2005 was resulted to be slightly improved from the one in 2004. This is probably due to the jump of Japan CUEP in 2003 and drops of catch level recent years.

(2) Projection by all the catch including the unreported & misreported catch

- If 10% of current (2003) catch level of PS and LL were reduced annually, SSB (point estimate) will be maintained above the MSY level for 11 years until 2004.
- If PS catch or both LL & PS catch were reduced by 10,000 t annually, BET stock will be very healthy, i.e., SSB (point estimate) will be maintained in 50,000-100,000 above its MSY level for 11 years until 2004.
- If current (2003) F level of PS and LL were maintained, SSB (point estimate) will be maintained above the MSY level for 11 years until 2004.

(3) Projection without unreported catch (Impact of the unreported catch)

If there were NO unreported (illegal) catch and current level of the legal catch were continued, SSB of the BET stock will be above its MSY level for next 11 years until 2014. This implies that the unreported (illegal) PS & LL catch affect the BET stock seriously. Hence, the current unreported (illegal) catch of PS (48,000 tons) and LL(101,000 tons) need to be reduced as much as possible.

(4) Impact of the misreported catch

The misreported catch 8,000 tons in 2003 did not significantly affect the stock such as MSY, SSB and other population parameters.

6.2 Conclusion

Based on our analyses, it is concluded that the best option is to eliminate all the unreported (IUU) catch, then the current legal catch level in 2003 for PS (18,800 tons) and LL (82,600 tons) can sustain the SSB at MSY level at least for next 11 years. As it is difficult to implement, another effective option is to keep current F levels of PS ($F=0.163$) and LL ($F=0.442$) including the unreported (illegal) catch, then SSB will be maintained above its MSY level at least for next 11 years.

7. References

Okamoto, Miyabe and Shono(2004a) Standardized Japanese longline CPUE for bigeye tuna in the Indian Ocean up to 2002 with consideration on gear categorization (IOTC-WPTT-2004-18).

Okamoto, Yeh and Hsu (2004b) Standardized Taiwanese longline CPUE for bigeye tuna in the Indian Ocean up to 2002 applying targeting index in the model (IOTC-WPPT-2004-20).

Nishida and Shono (2004) Updated stock assessment of bigeye tuna (*Thunnus obesus*) resource in the Indian Ocean by the age structured production model (ASPM) analyses to 2002 (IOTC-WPTT-04-09).

SHONO, NISHIDA and OKAMOTO(2004) Future projections for bigeye tuna in the Indian Ocean (IOTC-WPPT-2004-19).