UPDATED BIGEYE TUNA (*THUNNUS OBESUS*) RESOURCE ANALYSES IN THE INDIAN OCEAN - CPUE, ASPM (MSY) AND PROJECTIONS -

Tom Nishida, Hiroshi Shono, Hiroaki Okamoto and Ziro Suzuki

National Research Institute of Far Seas Fisheries (NRIFSF)

Fisheries Research Agency

5-7-1, Orido, Shimizu-City, Shizuoka, Japan 424-8633

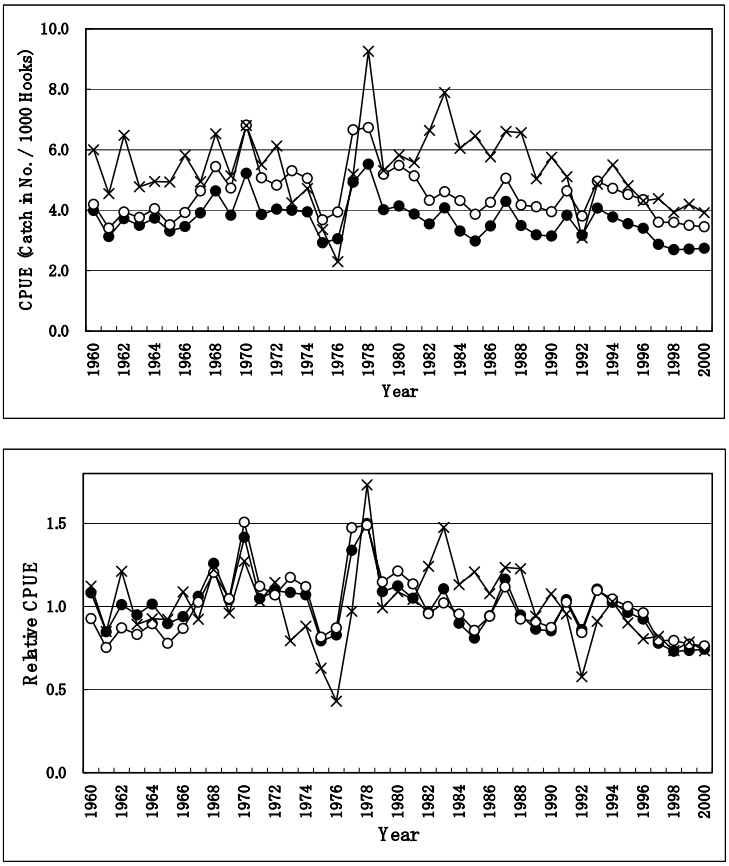
ABSTRACT

We updated the standardized Japanese longline CPUE and the ASPM analyses based on the ASPM runs adopted in the 2001 WPTT for bigeye tuna (BET) (Thunnus obesus) resources in the Indian Ocean. Using the updated ASPM results, we estimate the confidence intervals of the MSY and the future projections by applying the bootstrap experiments.

INTRODUCTION

In this paper, we updated the standardized Japanese longline CPUE and the ASPM analyses based on the ASPM runs adopted in the 2001 WPTT for bigeye tuna (BET) (*Thunnus obesus*) resources in the Indian Ocean. Using the updated ASPM results, we estimate the confidence intervals of the MSY and the future projections by applying the bootstrap experiments.

UPDATED CPUE TRENDS



Figs. 1 shows the results of the updated standardized CPUE (1960-2000).

Fig. 1 Standardized (open and solid circles) and nominal (cross) CPUEs of bigeye caught by Japanese longline fisheries in the Indian Ocean, up to 2000, in real scale (upper figure) and relative scale (lower figure), which presented grand average as 1.0. Used areas were all area, that is, area 1 – area 7 in Okamoto *et al*. (2001).

In both types of standardizations, the same GLM model was used. MODEL: YR + MN + AREA + NHFCL + SST + SOI + YR*AREA + MN*AREA + AREA*NHFCL + AREA*SST + AREA*SOI. In the original standardization (solid circle), NHFCL (class of the number of hooks between floats) was categorized to three, 1: 5-9 hooks, 2: 10-15 hooks, and 3: 16-21) through the years analyzed, while in the modified standardization (open circle), NHFCL was categorized to two, 1: 5-9 and 2: 10-21 until 1993 and 1: 5-12 and 2: 13-21, thereafter. Furthermore, data in the time-area strata (by month, by 5-degree latitude and by 5-degree longitude) in which the effort was less than 10,000 hooks were not used in the latter standardization.

UPDATED ASPM RUNS

At the 2001 WPTT, two ASPM Runs by different scenarios were adopted (Anonymous, 2001). These two results (in terms of MSY and estimated parameters) were very close. In this paper, we use the results of Run 1, which is slightly more conservative than in those of Run 2.

With the updated 1999 BET data provided by the IOTC, we re-run the ASPM using two ρ (serial correlation coefficient in the error terms of the S-R model) values (0 and 0.25). In the last ASPM runs during the 2001 WPTT, we used the optimal (default) ρ value (0.25). However, when we use $0<\rho$, we will need to include the very complex correction terms for the CV and σ (variance) to be used in the bootstrap experiments for the projections because the default value ($\rho=0.25$) produce biases on these two parameters (CV and σ).

If ASPM results by two Runs are not significantly different, we can use the results with $\rho=0$ for the future projections without including the complex correction terms. In addition, we took the log normal for the CPUE and used the normal error model for the objective function of the ASPM runs. This is because we can obtain the better fitness in the ASPM Runs.

In summary, we update the ASPM runs in three points:

(A). To use the updated 1999 data.

(B). To use ρ (serial correlation coefficient in the error terms of the S-R model) = 0.

(C). To use the nomal error model for the objective function of the ASPM with the log normal CPUE.

Table 1 shows the results with those from the 2001 WPTT.

Based on Table 1, we decided to use the results with $\rho= 0$ for the projections as the fitness between two results by two ρ values are almost identical and furthermore, we can greatly reduce number of parameters (corrections terms) for the projection if we use the ASPM results with $\rho= 0$.

Table 1 Summary of the ASPM Runs in the 2000 WPTT and those with the updated information.

1999 data	CPUE	Objective Function	ρ	R^2	-log Likelihood (fitness)	MSY (t)	SSB at MSY (million tons)	Total Biomass at MSY (million tons)	Parameters of B-H	
									α	β
(2001 WPTT) Total 143, 422 t LL 104,512 t Surface 38,901 t	Anti-log CPUE values	Log Normal Error	0.25	0.827	-92.6	89,786	0.18	0.33	3,227,400	2,019
(Updated, 2002) Total 147,410 t LL 108,301 t Surface 39,109 t	Natural Log values	Normal Error	0.25	0.878	-108.4	80,273	0.16		2,871,200	1,797
			0.00	0.869	-107.8	101,522	0.20	0.38	3,735,700	2,337

CONFIDENCE INTERVALS OF THE MSY BY THE BOOTSTRAP

Based on the updated ASPM results, we estimate the confidence interval of the MSY by the 200 times of the bootstrap experiment by adding the random noises into CPUE and the Spawner-Recruit relation.

METHODS

- Add the normal random numbers into the annual CPUE (1960-2000).
- Do 200 times of the ASPM Runs using the 200 CPUE created in (a).
- Estimate the new S-R relation (B-H model) by the new S-R data set which is made by re-sampling from the original S-R data set from the ASPM result.
- Repeat (c) 200 time and get 200 S-R relations (B-H models).
- Using the new S-R relation with the age specific selectivity (from the ASPM result), estimate MSY by optimizing age specific F.

- Repeat (e) 200 times and get 200 MSY values.
- Estimate the confidence intervals based on 200 MSY values.

RESULTS

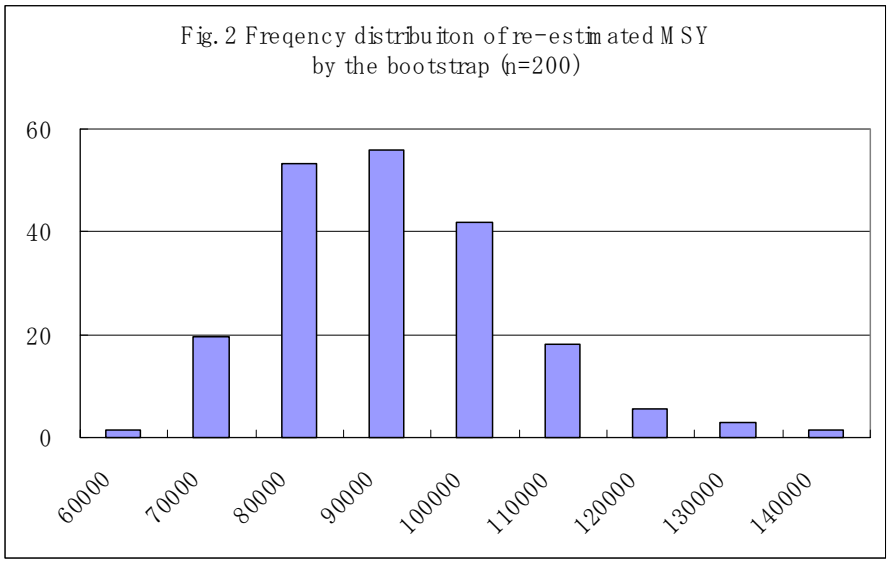


Fig. 2 and Table 2 show the results.

Table 2 Summary of the results

Parameters	Estimated values	unit
Estimated MSY	96,377	tons
SE	14,011	tons
CV	14.5	%
Point estimate by the ASPM	101,522	tons
95% confidence intervals	72,927– 129,254	tons

DISCUSSION

Although in the bootstrap experiment, we obtained the lower MSY value by about 4,000 tons than the one in the ASPM, we could estimate rather certain level of the MSY confidence interval (CV=14.5%) even we used the uncertain quality of the data. Hence, the newly estimated MSY (101,522 tons) is likely accurate and robust.

Even if the real MSY were in the higher end of the 95% confidence interval (i.e., about 129,254 tons), the current catch (147,410 tons) is considerably higher the MSY level. Therefore, as a conclusion, we strongly recommend to reduce the current BET catch level to make the sustainable yield possible for the long future as the BET resources are the shared stock by many fishing nations (more than 20 countries) in the Indian Ocean.

FUTURE PROJECTIONS

Catch control by the bootstrap

METHODS

Two catch scenarios are attempted by varying the 1999 catch level, which are described in Table 2.

Table 2 Two scenarios by varying the 1999 catch level

Scenario	PS	LL
1	1999 catch level	1999 catch level
2.	Reduction of the 20% of the 1999 catch level	Reduction of the 20% of the 1999 catch level

Based on results of the updated ASPM Run, stochastic projections are attempted using the bootstrap method. Following steps are taken:

- In each scenario, we use the results of the 200 ASPM runs conducted in the previous Section.
- We start the projection from the year of 2000.
- Compute the recruitment (age 0) for 2000 by the SSB value and the estimated B-H model.

- Add normal random numbers into that recruitment by incorporating the variances (ó) obtained from the ASPM.
- Estimate the age specific population by subtracting the age specific catch and number of fish died according to the natural mortality vector (M).
- When subtracting the age-specific catch, we compute those corresponding to the age specific selectivity by optimizing F for LL and PS.
- Then, we use optimized age specific catch for subtraction.
- We make the projection until year 2020.
- When we obtain the NEGATIVE population in some cohort, we stop the projection.

(2) Results (Figs. 3-6)

RESULTS AND DISCUSSION

Figs 3-6 show the results. For both scenarios, in 100% of the probability, we expect that the SSB and the TB(Total Biomass) will become lower levels producing the MSY by 2006. In 50% of the probability, we expect that the SSB of the BET stock will become zero by 2012 if 80% of the current catch level (about 118,000 tons) were continued. Although we don't expect the current catch level can be sustained due to the over-fishing stock status, we strongly recommend to reduce the currebt catch level by more than 20% to make the sustainable yield possible for the long future.

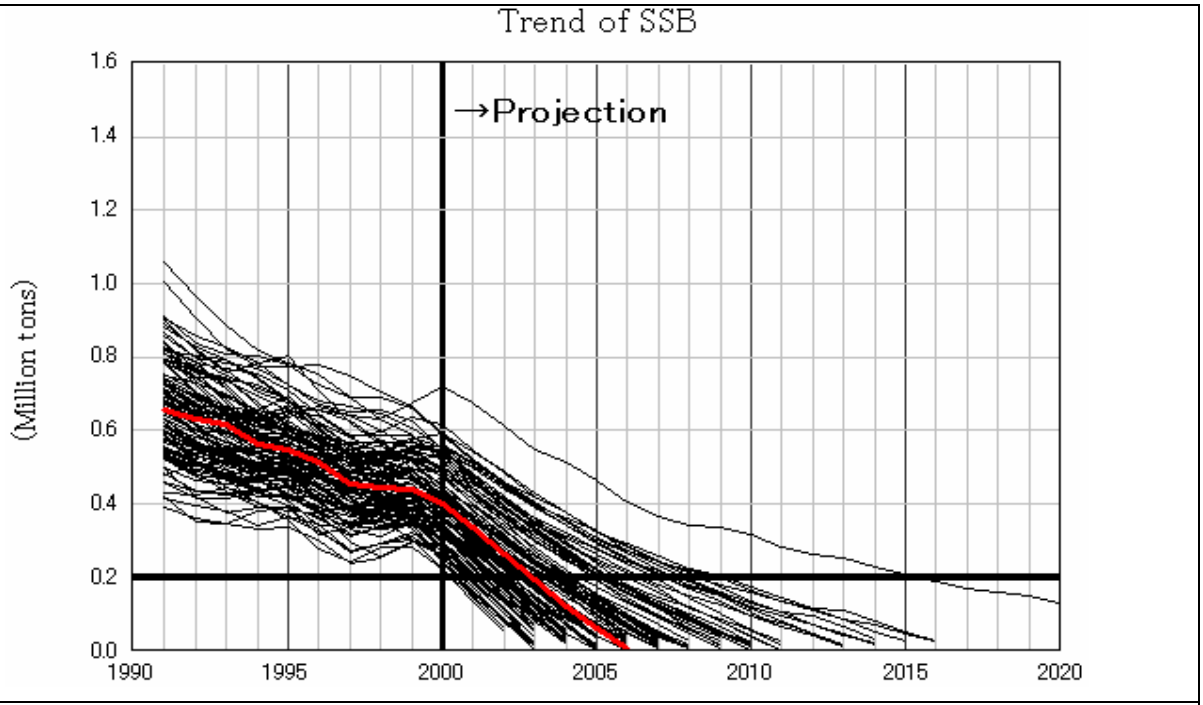


Fig. 3 Result of the projection for the SSB in case the 1999 catch level were continued (n=200).

(Note) Red line indicates the point estimate. The thick horizontal line (SSB=0.2) represents the SSB at MSY of the point estimate.

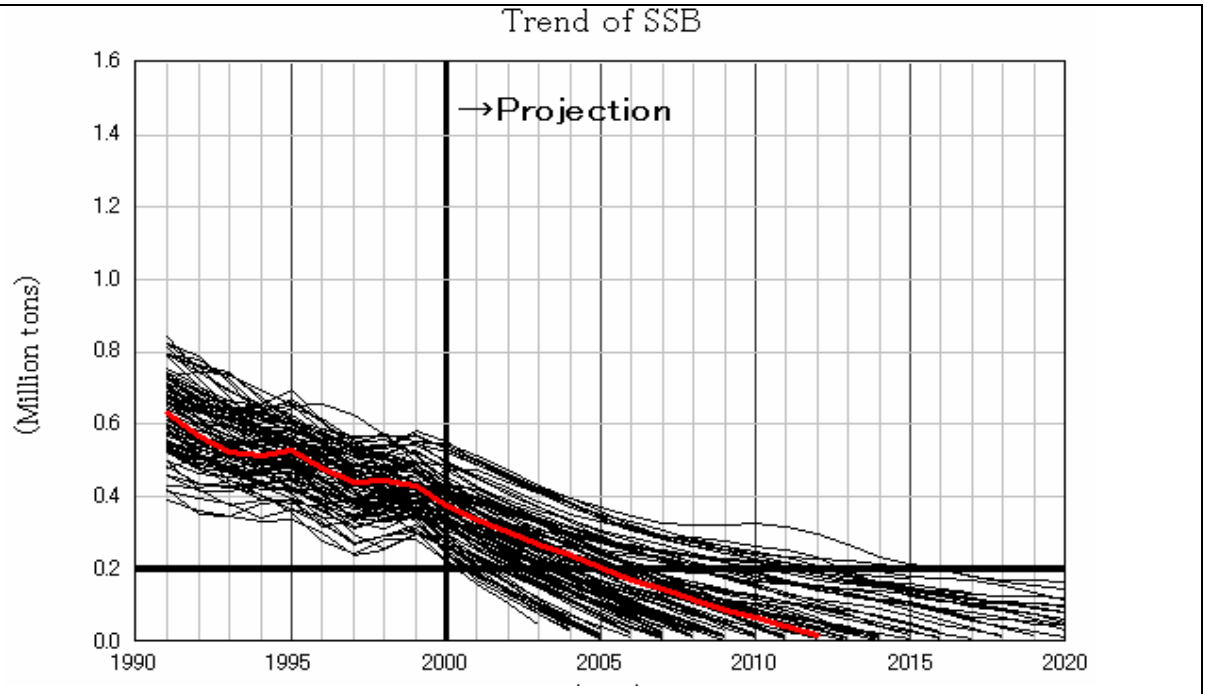


Fig. 4 Results of the projection for the SSB in case 20% of the 1999 catch level were reduced and continued.

(Note) Red line indicates the point estimate. The thick horizontal line (SSB=0.2) represents the SSB at MSY of the point estimate

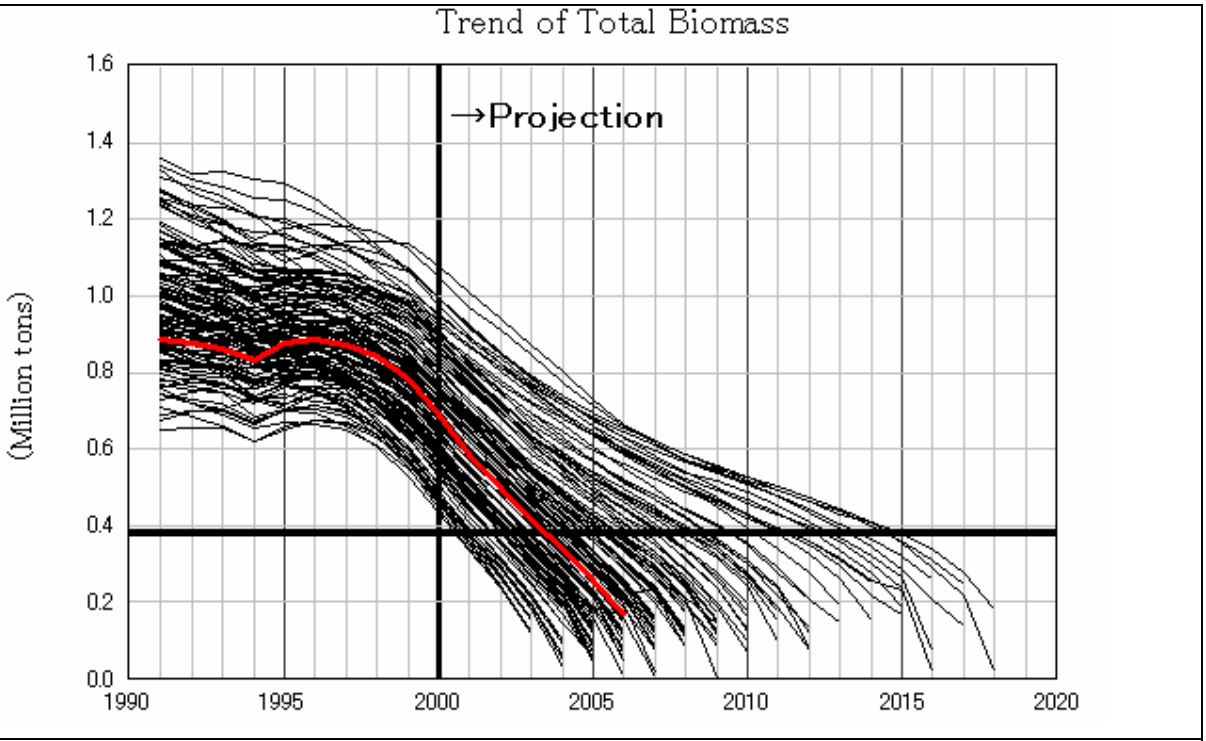


Fig. 5 Result of the projection for the total biomass (TB) in case the 1999 catch level were continued (n=200).

(Note) Red line indicates the point estimate. The thick horizontal line (TB=0.38) represents the TB at MSY of the point estimate.

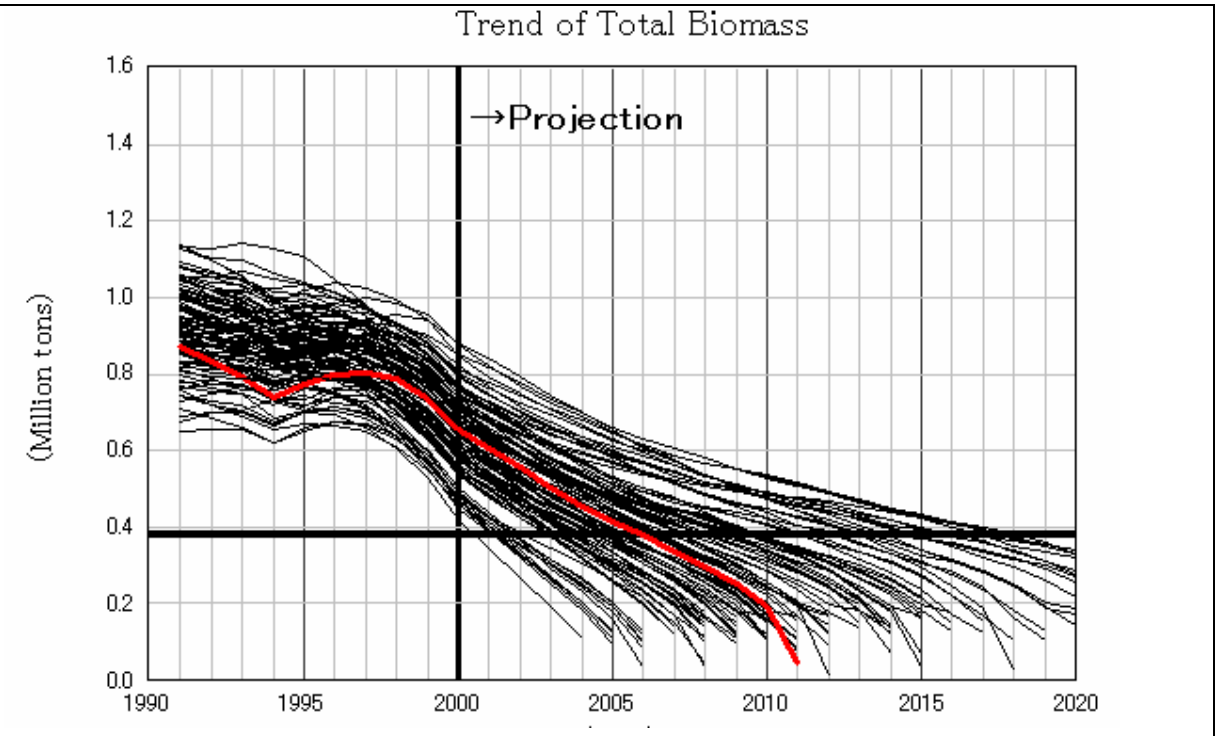


Fig. 6 Result of the projection for the total biomass (TB) in case 20% of the 1999 catch level were reduced and continued (n=200).

(Note) Red line indicates the point estimate. The thick horizontal line (TB=0.38) represents the TB at MSY of the point estimate.

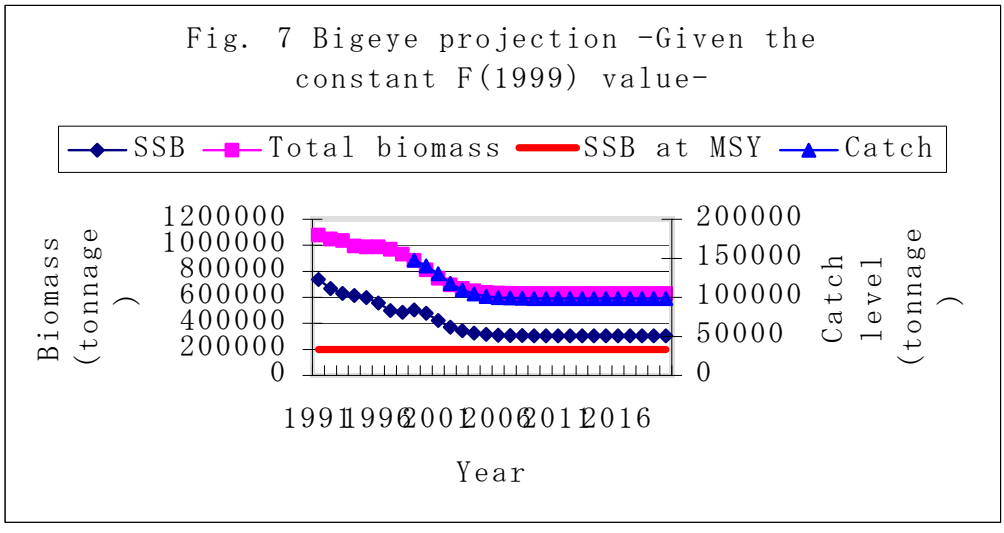
F control (point estimate)

METHODS

In this Section, we attempt the deterministic future projection using the constant F at the 1999 level without adding the normal random number in the CPUE series and the S-R relations as was in the previous case (catch control option). Using the updated ASPM result, we compute the projection from 2000-2020.

RESULTS AND DISCUSSION

Fig 7 shows the result. If the current F level were continued, both SSB and total biomass (TB) will be constantly reduced in 5 years. Then, the SSB will reach at about 0.3 million ton level and for the TB (total biomass), the 0.6 million ton level, which are about 2/3 of the 1999 levels. Afterwards, SSB and TB will be stabilized. The current catch (0.14 million tons) will also decrease in first 5 years and will be stabilized at the 0.10 million ton level, which is also 2/3 of the current level.



The convergent level of the SSB is about 0.3 million tons, which is higher than the SSB at MSY level (0.2 millions). This is caused by the SSB at MSY in 1999 being used in the projection as the FIXED value. However, the constant F level is actually lower than the F at MSY and the catch is also a few thousand tons lower than the MSY level. Hence, if this situation were continued, MSY will increase every year. Accordingly, SSB at MSY will increase every year. Therefore the difference between SSB at MSY (0.3 million tons) and the SSB (0.2 million tons) will become much smaller if we incorporate such correction factor. Thus, we expect that SSB will become much closer to the SSB at MSY level (than in Fig. 7) in the projection period.

DISCUSSION

Based on the updated analyses on CPUE, ASPM (MSY) and projections, we strongly recommend to reduce the BET catch from the current level at least by 20% as the projection clearly show that if 20% of the current catch were reduced and continued (i.e., about 118,000 tons of the catch), with the 100 % of the probability, we expect that the SSB and TB (total biomass) of the BET will become lower levels producing the MSY by 2006.

Considering the serious over-fishing status of the BET, the MSY level of the YFT stock (IOTC/WPTT/02/ , Nishida and Shono, 2002) and the multi-species nature of tuna fisheries in the Indian Ocean, only possible way to keep the sustainable yield for the future is the immediate initiation of the management measure to reduce catch and/or effort. Then, the commercially important shared BET and YFT can be utilized and shared for the long future by more than 20 tuna fishing nation in the Indian Ocean.

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