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**STOCK ASSESSMENT OF BET IN THE WESTERN AND CENTRAL PACIFIC OCEAN
USING AN AGE-STRUCTURED PRODUCTION**

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Stock assessment of bigeye tuna in the western and central Pacific Ocean using an age-structured production model* (Preliminary)

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Introduction

In this study, we attempt to analyze the status of bigeye tuna in the western and central Pacific Ocean (WCPO) using a stochastic age-structured production model (ASPM; see Restrepo and Legault, 1998 for details).

Materials and Method

The total catches of bigeye tuna in WCPO by flags (check this??), gears and fleets from 1950 to 2004 were obtained from on the WCPFC database (2004 version). The CPUE data of Taiwan (1964-2004) and Japan (1967-2003) were standardized using GLM and used as abundance index in modeling. Size data including length and weight compositions were available for the Japanese longline fishery from 1965 to 2005. However, the size data in 2004 and 2005 were still preliminary and therefore not used in this study.

The weight at age was calculated from the von Bertalanffy growth equation and the length-weight relationship (Sun et al., 2001). The maximum age was assumed to be 10 years and fishes older than 10 years were included in age 10 group in this study. Thus age 10 essentially was treated as plus group. The age specific natural mortality was estimated using the method of Chen and Watanabe (1989), which was estimated based on the von Bertalanffy growth parameters. The fecundity was assumed to be proportional to the body weight. According to the studies of reproductive biology of bigeye tuna in the western Pacific Ocean (Sun et al., 2006), all fishes with length greater than 100 cm (2.3 years) are mature and the minimum size at maturity is 90 cm

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(1.8 years). Accordingly we assumed that the maturity probability was 0 for age 1, 50% for age 2 and 100% for fishes older than 3 years. The fecundity was then calculated from the body weight multiple by maturity probability.

Size data of the Japanese longline fishery were transferred to age compositions using the age-length key derived from the biological parameters of Sun et al. (2001). The selectivity was estimated using separable VPA (Pope and Shepherd, 1982; Lassen and Medley, 2001) based on the age composition data and the age specific natural mortality. For selectivity model, we adopted a logistic curve for longline gear instead of separable selectivity parameters. The estimated selectivity is shown in Fig. 1.

In this study, we attempted 8 ASPM runs defined in Table 1. For the first run, we tried to incorporate the catches of all flags and gears, and assumed a lower stochastic recruitment and a lower autocorrelation for recruitment deviation. Selectivities for all fisheries were assumed to be the same as that of Japanese longline fishery because selectivity was only available for the Japanese longline fishery. However, this assumption is rather arbitrary and unrealistic. Therefore, only the catches of longline fisheries were used for runs 2-8. Various assumptions regarding the stochasticity and autocorrelation of recruitment were examined for model runs 2-8. A Beverton-Holt type of stock recruitment relationship was assumed for all runs.

Results and discussion

The convergences of estimation and the outputs were shown in Table 2. The estimations were not converged for runs 7 and 8 with higher levels of stochasticity and autocorrelation of recruitment. This might result from the absence of abundance index of the whole period for describing the temporal variations in population abundance in modeling. Although several management biological reference points such as MSY were estimated by ASPM and listed in Table 2, we would not focus on these absolute estimates because of remaining uncertainties in the estimation. For model run 1, all catches of bigeye in WCPO were used in ASPM but only the longline selectivity was available for the analysis. This assumption was not realistic for a species exploited by multiple gears. For runs 2-8, all catches except for those of the longline fishery were excluded, and the MSY was likely to be underestimated as a result of the use of partial catches in the assessment.

Figs. 2-5 show the key population parameters with respect to the values of management biological reference points, which show the status of the stock. More pessimistic results were obtained by runs 5 and 6 which assumed the higher autocorrelation of recruitment. The results of all runs reveal that the spawning stock

biomass declined to about 30-40% of the initial stock biomass (in 1950) during 1960-1980, became steady thereafter, and followed with an increase since 2000 (Fig. 2). The temporal trends of the ratio of the spawning stock biomass to stock biomass at MSY were similar to those of depletions and indicated that the ratios were close to 1 during 1980-2000 for runs 5 and 6 (Fig. 3). The fishing mortality increased since 1970 and slightly exceeded the fishing mortality at MSY level during the mid-1990's to 2000 for runs 5 and 6 (Fig. 4). The estimated catches revealed an upward trend for all runs and were occasionally higher than MSY since mid-1970's except for run 1 (Fig. 5) .

The results of this study should be viewed with caution because only the selectivity of the Japanese longline fishery was used in the ASPM analyses. In addition, only the CPUEs of the Taiwanese and Japanese longline fisheries were used as the stock's abundance indices. Restrepo and Legault (1998) suggested that the abundance indices should be developed for both young ages and spawners. Therefore, more investigations of abundance index and selectivity are necessary for further analyses.

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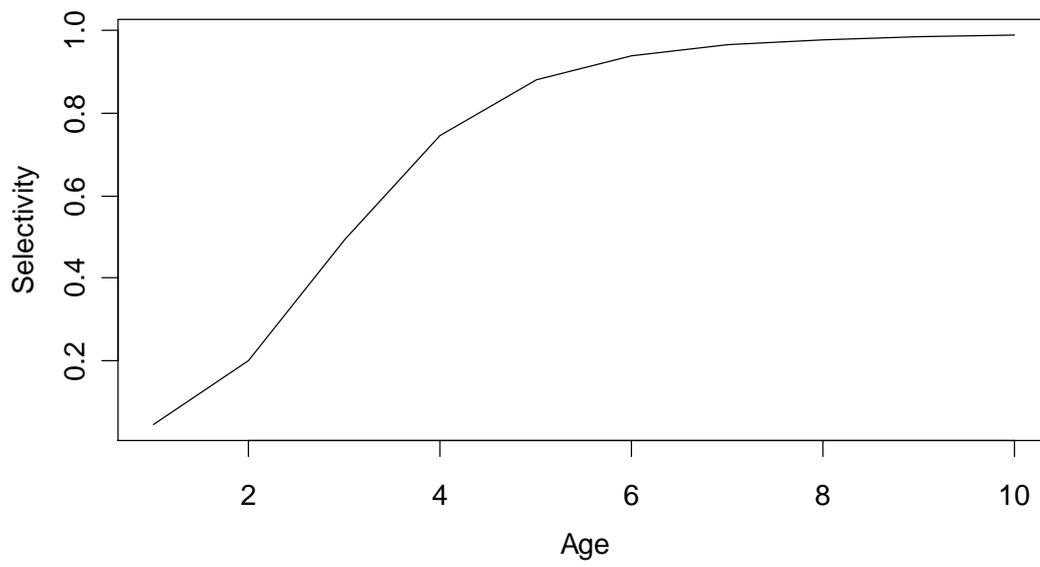


Fig. 1. Estimated selectivity for the Japanese longline fishery.

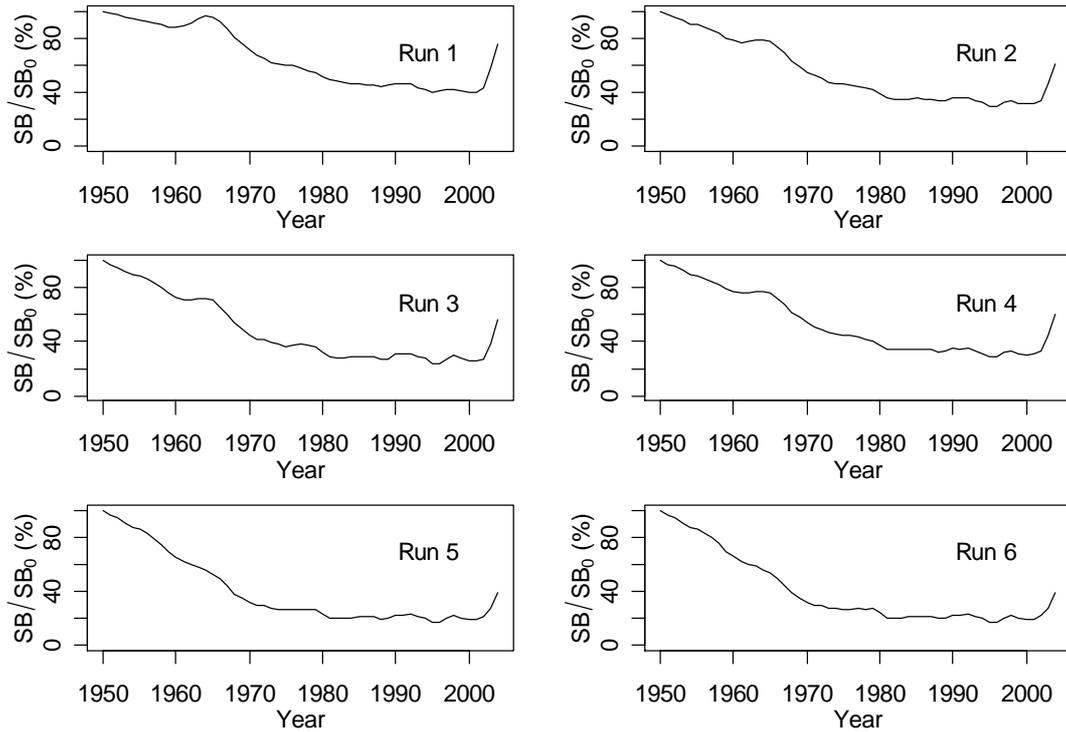


Fig. 2. Temporal trajectory of the ratio of spawning stock biomass to the initial stock biomass (in 1950) (SB/SB_0).

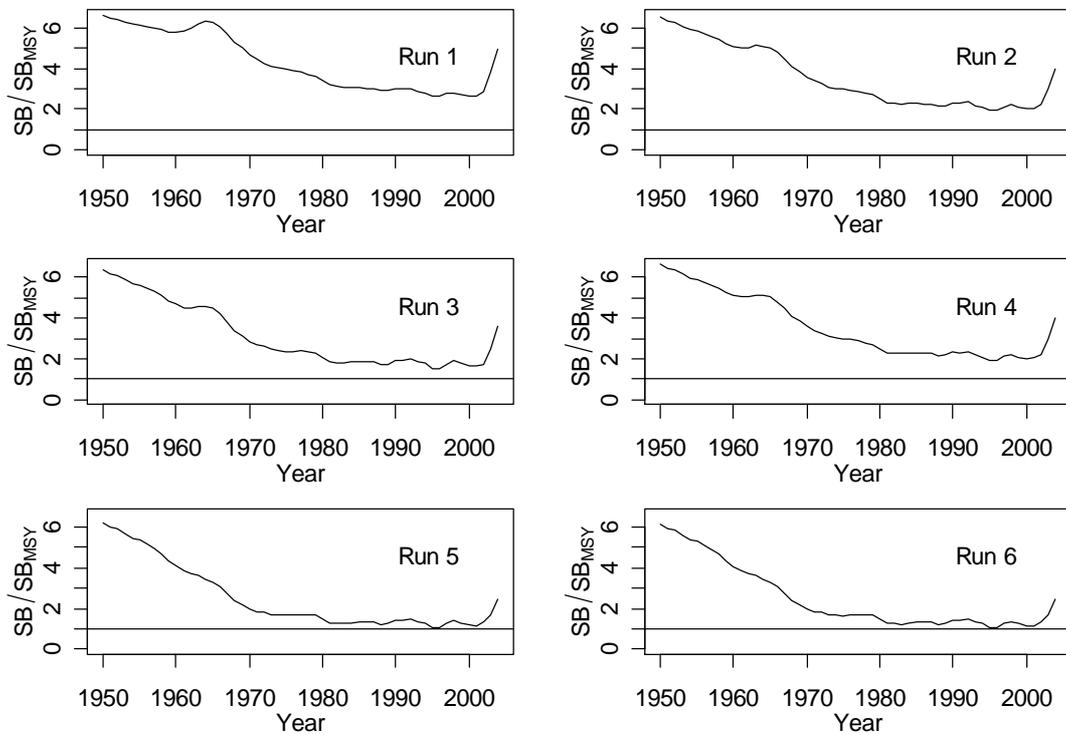


Fig. 3. Temporal trajectory of the ratio of spawning biomass to that at which MSY is achieved (SB/SB_{MSY}).

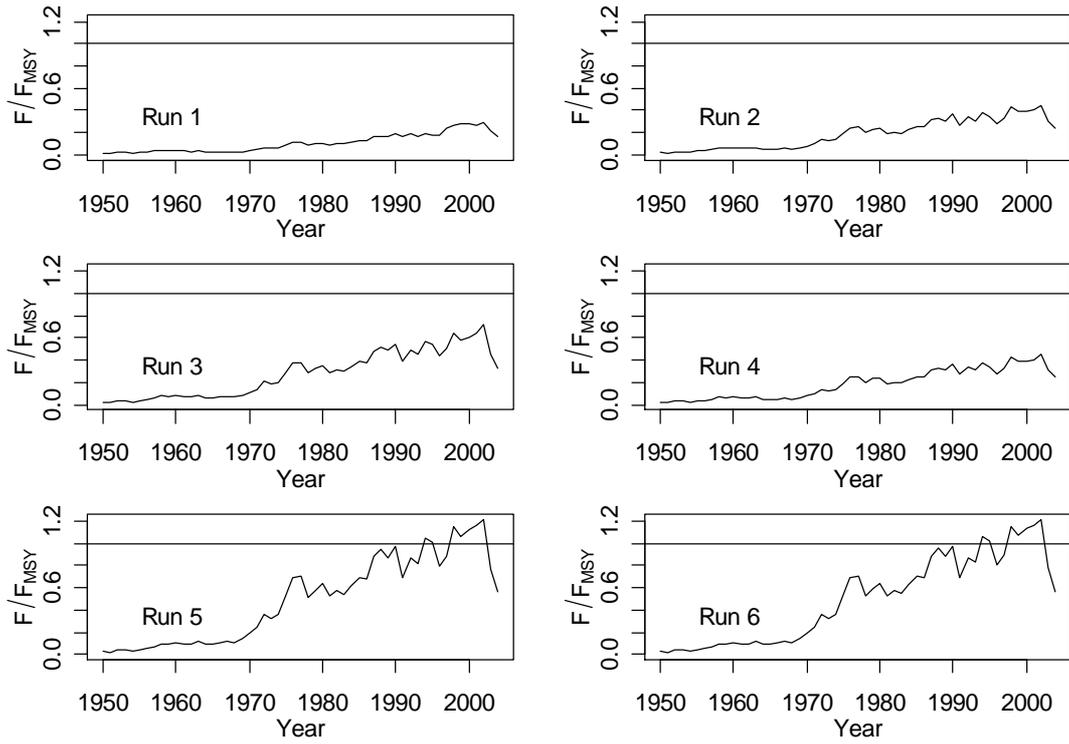


Fig. 4. Temporal trajectory of the ratio of overall fishing mortality to fishing mortality at MSY (F/F_{MSY}).

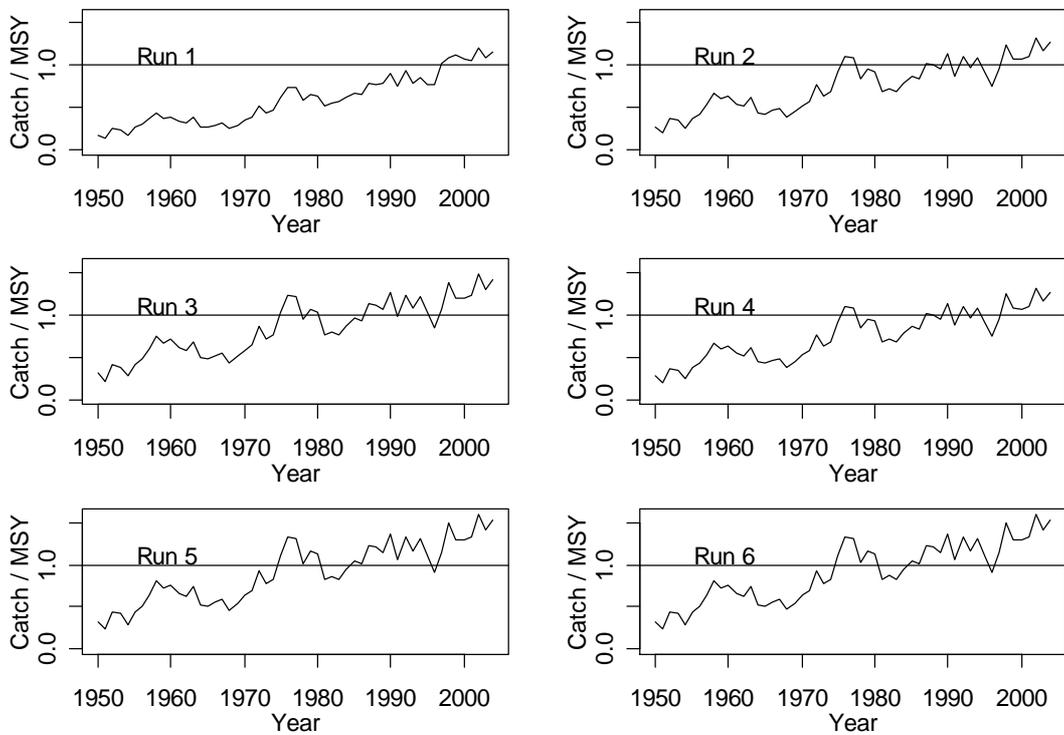


Fig. 5. Temporal trajectory of the ratio of the total catches to MSY.

Table 1. Summary statistics for the 8 ASPM runs.

Run	Catch data	ρ	σ_{η}^2	$\nu_{t=0}$
1	All fisheries	0	0.2	0.1
2	Longline fishseries	0	0.2	0.1
3	Longline fishseries	0	0.5	0.1
4	Longline fishseries	0	0.2	0.3
5	Longline fishseries	0.5	0.2	0.1
6	Longline fishseries	0.5	0.2	0.3
7	Longline fishseries	0.5	0.5	0.1
8	Longline fishseries	0.5	0.5	0.3

Table 2. Summary of results for ASPM runs.

Run	Covergence	$-\ln(\text{likelihood})$	R^2	Steepness	MSY	SB_{2004}	SB_{MSY}	B	F_{2004}	F_{MSY}	SB_{2004}/SB_{MSY}	F_{2004}/F_{MSY}
1	Yes	-115.67	0.580	0.99	111825	825005	166813	495676	0.261	1.554	4.946	0.168
2	Yes	-118.08	0.596	0.99	66578	395433	99317	222005	0.381	1.554	3.982	0.245
3	Yes	-100.42	0.637	0.99	59531	316627	88805	164827	0.513	1.554	3.565	0.330
4	Yes	-117.54	0.596	0.99	66610	396084	99365	222459	0.380	1.554	3.986	0.245
5	Yes	-126.37	0.640	0.99	55219	200782	82371	97452	0.868	1.554	2.438	0.559
6	Yes	-125.82	0.640	0.99	55184	199860	82320	96894	0.873	1.554	2.428	0.562
7	No	-	-	-	-	-	-	-	-	-	-	-
8	No	-	-	-	-	-	-	-	-	-	-	-

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