NORTHERN COMMITTEE
SIXTH REGULAR SESSION
7-10 September 2010
Fukuoka, Japan

ISSUES OF CURRENT PACIFIC BLUEFIN TUNA STOCK ASSESSMENT IN RELATION TO THE SUSTAINABILITY OF THE STOCK

WCPFC-NC6/IP-04
03 September 2010

Hideki Nakano[1] and Yukio Takeuchi[1]

[1] National Reserarch Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu-ku, Shizuoka, Japan

Issues of current Pacific bluefin tuna stock assessment in relation to the sustainability of the stock

Introduction

Stock assessment of Pacific bluefin tuna (*Thunnus Orientalis*, PBF) has been conducted by the Pacific bluefin tuna working group (PBFWG) of ISC (The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean). Since the stock assessment in 2008, Stock Synthesis (Methot 2005), integrated stock assessment software has been used for the stock assessment. Stock Synthesis has been updated in 2009 and 2010. Although the results of the stock assessments have been accepted by the ISC plenary meetings, they involve several issues which may limit the utility of the stock assessment results for the stock management. This working paper summarizes the issues to be resolved in the current stock assessment of Pacific bluefin tuna with emphasis on the possible effects on the management of the stock.

Fishery trend of Pacific bluefin tuna

Historical catch of Pacific bluefin tuna (PBF) has been fluctuating from about 9,000 to 40,000tons with large variation. In recent years, about 35,000 tons of PBF was caught in 1981, and then the catch declined to the historical lowest level of 9,000tons. From early 1990s, PBF catch has increased in accordance with the increase of biomass. In recent years, catch has been around 22,000tons, while in 2009, although it is preliminary, catch declined to 19,000ton (Fig. 1). Since the majority of the PBF catch is juvenile, variations of catch of each fishery is likely affected by the yearly variation of recruitment.

Reliability of the current Pacific bluefin tuna stock assessment by ISC

Stock assessments of Pacific bluefin tuna have been conducted by using Stock Synthesis (II in 2008 and III in 2009 and thereafter) since the 2008 stock assessment. Although the stock assessment in 2008 was accepted by ISC 8 plenary, ISC 8 plenary requested that the ISC PBF WG investigate the causes of model results, some of which were implausible (e.g. large B0, low SPR and depletion level. See ISC8 Plenary report). In 2009, the stock assessment results were reanalyzed using the same data through 2005 with the different natural mortality vector and Stock Synthesis III. ISC PBF WG concluded that the results of the 2009 reanalysis were more plausible and those results were presented to ISC9. In 2010, ISC PBF WG conducted an update of the 2009 analysis along with a complete set of sensitivity analyses and stock projections using data through 2007. Data used in the 2010 update were analyzed using the same methods and parameters in the stock assessment model as in 2009. ISC PBF WG reviewed the results of the update with the objectives of characterizing the recent relative change in fishing mortality rate and spawning biomass. One of the main results was that the assumption of adult M is particularly influential to the estimate of absolute spawning biomass and fishing mortality. Although absolute estimates from the stock assessment model were sensitive to different assumptions of M, relative measures were less sensitive. Biological reference points based on Maximum Sustainable Yield (MSY) and unfished biomass level are also highly sensitive to the assumption of adult M (Kai 2010, Ichinokawa et al 2010). Unless the above mentioned problems of the current PBF stock assessment are resolved, it is difficult to manage the PBF stock in terms of optimizing yield, i.e., MSY or its related management benchmarks. As an interim measure, therefore, it is advisable to manage the PBF stock in terms of keeping the stock sustainable to obtain the reasonable level of yield as suggested by Maunder et al (2010) who concluded based on the impact analyses (Wang et al 2009)

Resilience of the Pacific bluefin tuna stock when SSB declined historically lowest level

Historically, there is a slight but statistically non-significant indication of decline of the average level of recruitment when the spawning stock experienced the lowest level during mid-1970s and 1980s

(Kai et al 2010a, Fig.2). Although this potential decline of average recruitment level when the SSB is close to the historical lowest level is to be further investigated in the future by ISC PBF WG, intuitively, it is notable that, even during the period of the SSB level close to the historical lowest level in 1980s, a relatively stronger (natural logarithm of deviation of recruitment from mean recruitment was 0.77 > σ_R=0.57) recruitment was observed in 1989 while its corresponding spawner's level was only about 22% higher than the historical lowest level. Subsequently, 1989 year class contributed to the increase of the spawners in 1990s. This fact suggests that PBF can be expected to remain productive even very close to the historical observed SSB level.

Effects of keeping the level of fishing mortality in 2002-2004

ISC 10 plenary reported that if future fishing mortality is kept at the level of 2002-2004, the median spawning stock biomass is likely decline subsequent years, but recover to levels close to the median of historically observed levels(Anon. 2010). In addition, it was also reported that F levels in 2002-2004 have no chance (0%) of declining to the lowest observed spawning biomass (Fig 3 top). On the other hand, the predicted decline of the spawning biomass around the 25th percentile of historical SSB levels with approximately 5% chance of declining to or below the historically lowest SSB with the F levels in 2004-2006(Fig 3 bottom).

Equilibrium based per recruit analyses among the wide range of sensitivity runs of the 2010 update (Ichinokawa *et al* 2010, see table 1 for definition of the base case and sensitivity runs) were also conducted[2]. The results indicated that the average increase of %SPR when the level of F was reduced from that in 2004-2006 to that in 2002-2004 are 65% (55-77%, in inter-quartile, 23% in minimum). The Average increase of Yield per Recruit is 4% (2.6-6.4%, in inter-quartile, 6.6% decrease in minimum) (see table 2). These substantial expected increases of %SPR may contribute to keep the stock at a sustainable level without losing future yield.

Reference

Anon. 2010 Report of the tenth meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, July 20-27, Victoria, BC, Canada, 50p

Ichinokawa, M., Kai, M., Takeuchi, Y. 2010. Stock assessment of Pacific bluefin tuna with updated fishery data until 2007. ISC/10-1/PBFWG/01.

Kai, M., Ichinokawa, M. and Takeuchi, Y. 2010. Applicability of F_{loss} for Pacific Bluefin Tuna as a limit reference point (LRP). ISC/10-1/PBFWG/02

Kai, M., Ichinokawa, M., Takeuchi, Y. 2010. Updated biological reference points (BRPs) for Pacific Bluefin tuna and the effect of uncertainties on the BRPs. ISC/10-1/PBFWG/02.

Maunder, M, Aires-da-Silva, A. and Deriso, R. 2010. A fishery-impact-based management reference level for Pacific bluefin tuna in the Eastern Pacific ocean. Paper presented at the 1st meeting of Scientific Adivisory Committee of Inter-American Tropical Tuna Commission, 31 August- 3 September 2010, SAC-01-16

Methot, R. D. 2005. Technical description of the Stock Synthesis II assessment program. NOAA Fisheries. http://www.sefsc.noaa.gov/sedar/download/S16_AW_04.pdf?id=DOCUMENT

Wang, S-.P., Maunder, M.N., Aires-da-Silva, A. And Bayliff, W.H. 2009. Evaluating fishery impacts:

[2] Calculations of YPR and SPR on the set of sensitivity analyses of Ichinokawa et al were conducted for this working paper after the ISC PBF workshop held in July 6-9. Therefore the results of expected increase of YPR and %SPR were not discussed by ISC PBF WG.

application to bigeye tuna (Thunnus obesus) in the eastern Pacific Ocean. Fisheries Research 99: 106-111.

Table and Figures

Table 1 Setting of the base case run of 2010 update and sensitivity analyses conducted in ISC PBF WS in July 2010 (table 2 of Ichinokawa et. al 2010)

Categories	Base case	Sensitivity	Run name	Convergence
Biological parameters (growth)				
* CV at age-0 (L1)	fixed, 0.25	0.15	03_CV_0.15	
* CV at age-3 (L2)	fixed, 0.08			
* L at Lmin	fixed, 21.5			
* L_inf & K	fixed, Shimose et al. (2008)	Lower K (Fig. 1)	53_Lmax110K0.166	
		Hiher K (Fig. 1)	54_Lmax130K0.22	
		Shimose et al. 2009 (Linf=249.6, K=0.173, t0=-	55_2009growth	
Biological parameters (other)				
* Maturity at age	fixed, 0.2 for age 3, 0.5 for age 4	0.2 for age 4, 0.5 for age 5 and 1 for >6 ages	05_maturity	
* Steepness in	fixed, 1	fixed, 0.8	06_h=0.8	No possitive definite
Biological parameter (M)				
* Natural mortality	Fixed, 1.6 for 0-age, 0.386 for 1-age, 0.25 for >1 ages	Ms >3 years old is 0.27	42_higher_adultM (Table 1)	
		Ms >3 years old is 0.20	43_lower_adultM	
		Ms >1 years old is 0.27	62_higher_adultM27	
		Ms >1 years old is 0.29	57_higher_adultM29	
		Ms >1 years old is 0.31	58_higher_adultM31	
		Ms >1 years old is 0.23	59_lower_adultM23	
		Ms >1 years old is 0.21	60_lower_adultM21	
		Ms >1 years old is 0.19	61_lower_adultM19	
		Ms of 0-1 year old is 1.80 and 0.46	44_high_youngM	
		Ms of 0-1 year old is 1.30 and 0.30	45_low_youngM	
		Ms used in 2006 with VPA	46_M2006	
		Michael's M	47_MichaelsM	
		Ray's M	48_ray_lowM	Not converged
		Ms used in 2008 stock assessment	50_previous_adultM	
Assumption of recruitment				
* S-R function form	1, Beverton-Holt	4, CAGEAN-like unconstrainted recruitment	07_cagean	
* Sigma R	Fixed, 0.6	Fixed, 1	08_sigmaR=1	
* Term for estimating recruitment deviations	1946-2006	Estimated from 1951 to 2006	09_Rdev51-04	
		Estimated from 1941 to 2006	26_Rdev41-04	
CPUE				
* Weighing factors	5 for JLL CPUE, and 1 for others	1 for all CPUEs	13_all_lambda1	
* Survey data of CPUE series	Seen in Table 1	Add additional CPUE of 25	10_add_25	
		Add additional CPUE of 26	11_add_26	
		Add additional CPUE of 27	12_add_27	
		Replace CPUEs of 14 and 15 with 12 and 13	14_replace14.15_with12.13	
		Replace CPUEs of 14 and 15 with 16 and 17	15_replace14.15_with16.17	
		Replace CPUEs of 14 and 15 with 18 and 19	16_replace14.15_with18.19	
		Replace CPUEs of 17 with 21	17_replace_20_with21	
		Replace CPUEs of 17 with 22	18_replace20_with22	
		Remove CPUE of JLL	35_removeJp-CLL	
		Remove CPUEs	36_removeJp-DLL52-74	
		Remove CPUEs	37_removeJp-DLL75-92	
		Remove CPUEs	38_removeJp-DLL52-92	
		Remove CPUEs	39_removeJp-Troll	
		Remove CPUEs	40_removeTw-LL	
		Remove CPUEs	41_removeUS-PS	
Equilibrium catch				
* Assumption of equilibrium catch	Fixed referring Muto et al. 2008. The fishereis with equilibrium catch are FL1, FL3 and FL4.	Twice of all equibrium catch	19_All_Eqc_double	
		Half of all equibirium catch	20_All_Eqc_half	
		Twice of purse seine fisheries	21_PS_Eqc_double	
		Half of purse seine fisheries	22_PS_Eqc_half	
		Twice of troll fisheries	23_TR_Eqc_double	
Length data				
* Weithing lambda	Same weitining factor used in 2009 (Anon. 2009a)	All length lambda is 1	24_length_lambda=1	
		Length lambda is re-weighting one time	56_1timerw	
* Length data	Detailes are shown in Table 1	Remove length data	27_removeJp-LL	
		Remove length data	28_removeJp-smallPS	
		Remove length data	29_removeJp-tunaPS	
		Remove length data	30_removeJp-troll	
		Remove length data	31_removeJp-PL	
		Remove length data	32_removeJp-SetNet	
		Remove length data	33_removeTw-LL	
		Remove length data	34_removeEPO-PS	

Table 2 Ratios of %SPR (2nd columns) and YPR (3rd column) and between associated with the F levels in 2002-2004 and 2004-2006 by the base case and the sensitivity runs in 2010 update listed in table 1.

	%SPR0204/%SPR04	YPR0204/YPR0406			%SPR0204/%SPR04	YPR0204/YPR0406
00_basecase	1.63	1.05		31_removeJp-PL	1.66	1.05
03_CV_0.15	1.47	1.02		32_removeJp-SetNet	1.29	0.97
05_maturity	1.65	1.05		33_removeTw-LL	1.64	1.05
06_h=0.8	1.39	0.99		34_removeEPO-PS	1.86	1.07
07_cagean	1.63	1.05		35_removeJp-CLL	1.31	0.97
08_sigmaR=1	1.61	1.04		36_removeJp-DLL52-74	1.62	1.05
09_Rdev51-04	1.71	1.06		37_removeJp-DLL75-92	1.77	1.07
10_add_25	1.77	1.07		38_removeJp-DLL52-92	1.92	1.09
11_add_26	1.77	1.07		39_removeJp-Troll	1.52	1.03
12_add_27	1.63	1.04		40_removeTw-LL	1.33	0.99
13_all_lambda1	1.24	0.95		41_removeUS-PS	1.71	1.06
14_replace14.15_with12.13	1.81	1.07		42_higher_adultM	1.42	0.99
15_replace14.15_with16.17	1.61	1.04		43_lower_adultM	1.91	1.10
16_replace14.15_with18.19	1.76	1.07		44_high_youngM	1.68	1.05
17_replace_20_with21	1.48	1.02		45_low_youngM	1.61	1.05
18_replace20_with22	1.58	1.04		46_M2006	1.78	1.03
19_All_Eqc_double	1.61	1.04		47_MichaelsM	1.90	1.04
20_All_Eqc_half	1.65	1.05		50_previous_adultM	2.16	1.14
21_PS_Eqc_double	1.61	1.04		53_Lmax110K0.166	1.83	1.05
22_PS_Eqc_half	1.64	1.05		54_Lmax130K0.22	1.78	1.09
23_TR_Eqc_double	1.72	1.06		55_2009growth	1.81	1.06
24_length_lambda=1	1.72	1.05		56_1timerw	1.47	1.02
26_Rdev41-04	1.63	1.05		57_higher_adultM29	1.39	0.97
27_removeJp-LL	1.41	0.98		58_higher_adultM31	1.36	0.94
28_removeJp-smallPS	2.21	1.26		59_lower_adultM23	1.77	1.08
29_removeJp-tunaPS	1.67	0.96		60_lower_adultM21	1.88	1.10
30_removeJp-troll	1.64	1.05		61_lower_adultM19	1.97	1.12
				62_higher_adultM27	1.42	0.99

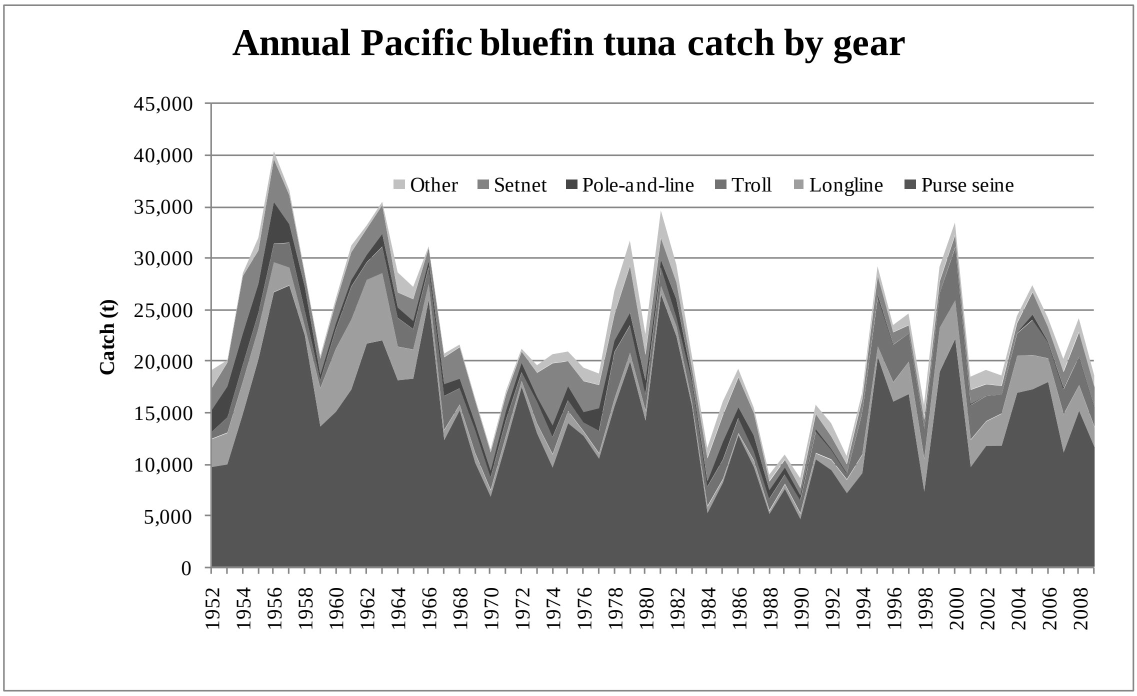

Figure 1 Annual Pacific bluefin tuna catch in the entire Pacific ocean by gear categories. The data was taken from ISC10 plenary report (Anon. 2010)

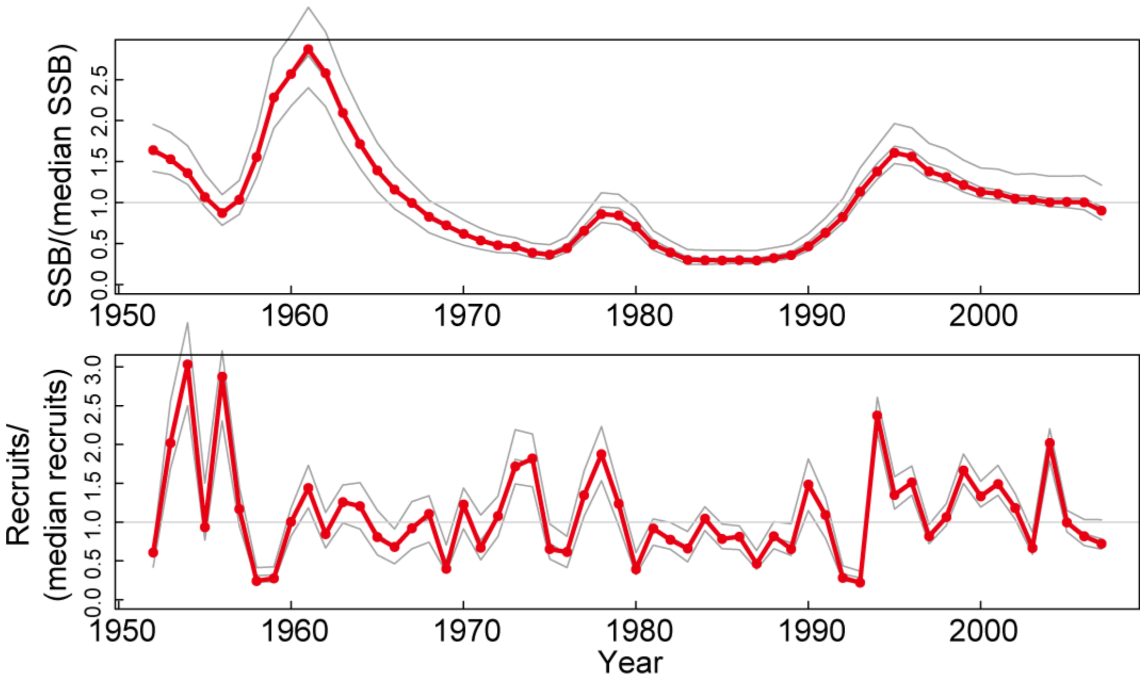

Figure 2 Estimated relative trend of the spawning stock biomass and recruitment of Pacific bluefin tuna with 80% confidence . Scaling was done by dividing the median of stock assessment period (1952-2007).

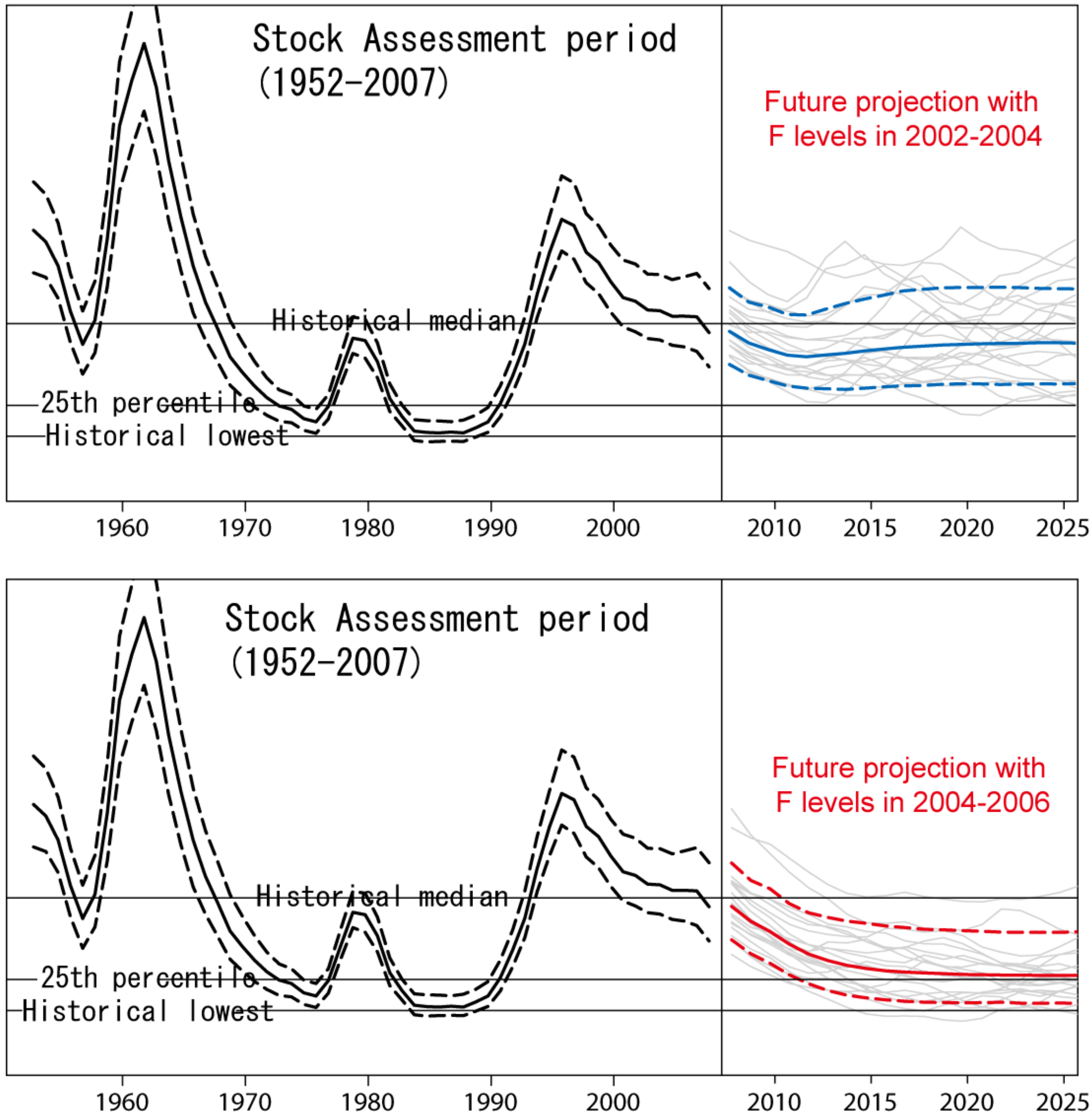

Figure 3 Spawning biomass trend of base case run of 2010 update with results of future projection with future F levels of 2002-2004 F levels (top) and 2004-2006 F levels (bottom).