DRAFT

INTER-AMERICAN TROPICAL TUNA COMMISSION

EXTERNAL REVIEW OF IATTC BIGEYE TUNA ASSESSMENT

La Jolla, California (USA)
3-7 May 2010

DOCUMENT BET-01-04 (DRAFT)

INVESTIGATION OF CATCH-PER-UNIT-OF-EFFORT DATA USED IN THE EASTERN PACIFIC OCEAN BIGEYE ASSESSMENT MODEL

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Catch per unit of effort (CPUE) are the only data available to create indices of abundance for bigeye tuna in the EPO. There are no surveys conducted on tuna in the EPO. CPUE data are available from both the longline and purse-seine fisheries. The longline CPUE data provides information on large bigeye while the purse seine CPUE data provides information on small bigeye. Therefore, it is informative to have CPUE data from both types of fisheries. The CPUE from the purse-seine fisheries are considered to provide less reliable indices of abundance due to the targeting of tuna aggregations. The weighting of the CPUE data is determined by estimating an additive constant on the standard deviation of the likelihood for each fishery. Some purse-seine fisheries CPUE are not used in the model (early floating object, inshore floating object, and early and late dolphin/unassociated fisheries), mainly because the effort is low or because the CPUE is too variable.

Purse-seine CPUE is calculated as catch divided by the number of days fished. Days fished are assumed to be a better measure of effort than the number of sets because it relates to search time. However, floating objects have locator technology and success is more related to the number of fish under a FAD that is checked than the ability to find FADs. Because vessels can make different types of sets (floating object, dolphin associated, unassociated school) in a trip, the amount of time spent fishing using a particular fishing type is unknown. The number of days fished by set type is calculated by regressing total days fished versus number of sets for the three set types. The estimated coefficients are the number of days fished corresponding to a single set of each set type. These can then be multiplied by the number of sets by set type to estimate the number of days fished by set type.

The longline CPUE data are standardized, using a delta-lognormal general linear model in which the explanatory variables are latitude, longitude, and hooks per basket. Only Japanese longline data are used in these analyses because the detailed data from the Japanese fleet covers a greater number of years. The fishing depth of the longline gear has changed over time as the fishery has targeted bigeye tuna. The fishing depth of the gear is related to the number of hooks per basket. The more hooks the deeper the gear fishes. This change in depth has made bigeye more vulnerable to the longline fishery and therefore hooks per basket has been used in the general linear model standardization. Several other methods have also been used to standardize the longline CPUE including regression trees (Watters and Deriso 2000), neural networks (Maunder and Hinton 2006) and the statistical habitat-based standardization model (Maunder et al. 2006; Langley et al. 2005). These models link the depth fished with the environmental data at that depth and the environmental preference of bigeye tuna. In general, the different methods used to standardize the CPUE do not have a large influence on the estimated abundance index. Analyses in the western central Pacific Ocean (WCPO) have shown that inclusion of latitude and longitude eliminate the need for a habitat effect in the satHBS, indicating that latitude and longitude could be a proxy for habitat and that the habitat is reasonably constant over time.

A sensitivity analysis was made in which the only CPUE data used in the stock assessment model was from the southern longline fishery. The results differ moderately from the base case (Table 1). In particular, the current spawning biomass is estimated to be above the level that supports MSY.

A sensitivity analysis, using iterative reweighting, was conducted to investigate the weighting of the data sets. Specifically, the appropriate standard deviations and sample sizes for the likelihood functions were determined iteratively, based on the fit to the data. We only used two iterations and scaled the sample sizes by fitting a Beverton-Holt model to the effective and input data (Figure 1). When iterative reweighting was applied, more weight was given to the length-frequency data (Table 2), and the fit to the southern longline CPUE data was poor (Figure 2). The population was estimated to be much more depleted than the base case (Figure 3).

The bigeye tuna assessment assumes that catchability is constant over time. Any trends in catchability are somewhat absorbed in the estimate of the standard deviation of the likelihood function. Previous analyses have looked at trends in catchability of the purse-seine fisheries while assuming that longline catchability has remained constant. Recent analyses by scientists at the Secretariat of the Pacific Community (SPC) (Hoyle 2009) indicate that the longline catchability has been increasing (the fishing vessels are getting more efficient) over time (about 0.4-1.0% per year). The increase in catchability was determined by looking at the increase in vessel effects of new vessels entering the fishery. We ran a sensitivity analysis where catchability increased by 1% per year. If CPUE is assumed proportional to catchability (q) and abundance (N), and catchability changes 1% a year and the model has a time step (t) in quarters

$$CPUE_t = q\left(1 + \frac{0.01}{4}t\right)N_t$$

Then the CPUE can be modified to reflect the change in catchability

$$CPUE_t^{new} = \frac{CPUE_t}{\left(1 + \frac{0.01}{4}t\right)} = qN_t$$

The new CPUE can then be used in the stock assessment model to represent the change in catchability (qtrend). The fit to the data was worse than the base case (Table 3). The results are similar to the base case except that the current biomass is more depleted (Table 1).

TABLE 1. Estimates of management quantities from the three sensitivity analyses compared to the base case.

	BC	**LLCPUE**	**qtrend**	**RW1**	**RW2**
MSY	83605	91170	86334	69052	68755
B_{MSY}	289409	315679	297742	239854	239033
S_{MSY}	60612	66127	62245	50511	50354
B_{MSY}/B_{zero}	0.25	0.25	0.25	0.24	0.25
S_{MSY}/S_{zero}	0.19	0.19	0.19	0.19	0.19
$C_{recent}/_{MSY}$	1.19	1.09	1.15	1.44	1.45
B_{recent}/B_{MSY}	0.99	1.56	0.92	0.72	0.72
S_{recent}/S_{MSY}	0.89	1.13	0.81	0.49	0.49
$F_{multiplier}$	0.80	0.81	0.80	0.81	0.81

TABLE 2. Length frequency input and estimated effective sample size for the base case and the two iterations of the reweighting.

Flt	N quar-ters	BC			RW1			RW2		
		Mean input	**Mean effective**	**eff/input**	**Mean input**	**Mean effective**	**eff/input**	**Mean input**	**Mean effective**	**eff/input**
1	62	4	21	5.47	16	21	1.35	16	21	1.33
2	60	17	75	4.44	64	86	1.34	71	86	1.21
3	63	15	66	4.41	56	66	1.19	55	65	1.19
4	37	2	8	3.97	5	8	1.61	5	8	1.57
5	53	11	59	5.36	48	65	1.37	52	66	1.26
6	40	6	27	4.21	19	28	1.48	19	28	1.46
7	53	3	14	5.10	8	15	1.73	9	15	1.73
8	88	4	63	14.85	41	67	1.65	43	67	1.56
9	132	14	171	12.22	148	209	1.41	182	210	1.16

TABLE 3. Negative log-likelihood values from the sensitivity analysis that assumes an increase in longline catchability compared to the base case.

Component	BC	qtrend
TOTAL	1656.33	1661.44
Catch	0.00	0.00
Survey	-269.00	-269.16
Length_comp	1648.17	1655.61
Age_comp	307.62	307.95
Recruitment	-30.46	-32.97

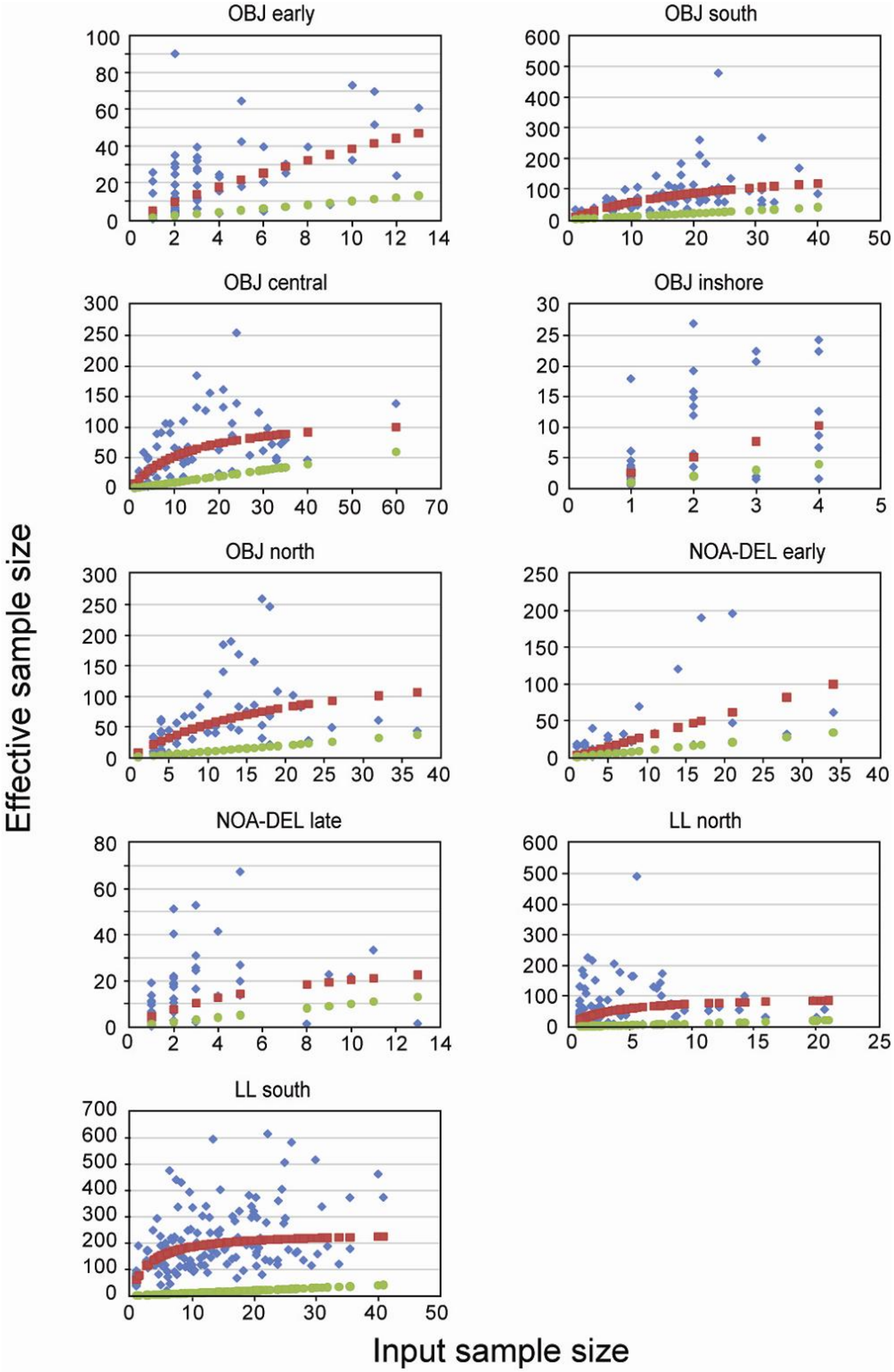
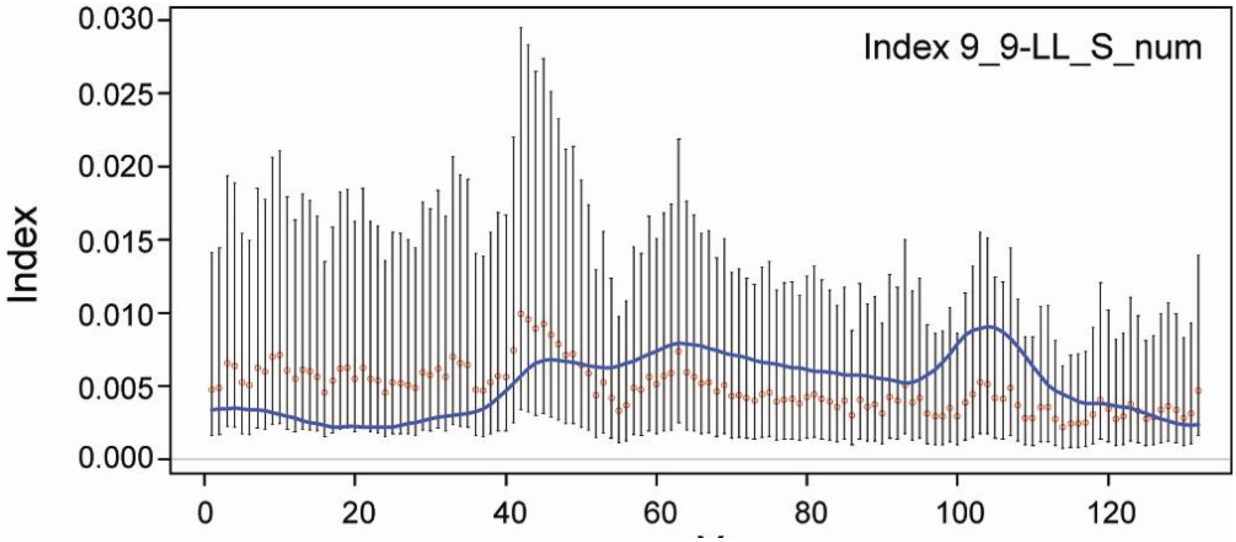


FIGURE 1. Estimated effective sample size from the second iteration of the reweighting versus input sample size in the base case model. The green points is the one to one line. The red squares are a Beverton-Holt model fit to the data that was used to generate new samples sizes for the sensitivity analysis.



F**IGURE 2.** Fit to the southern longline CPUE from the reweighting sensitivity.

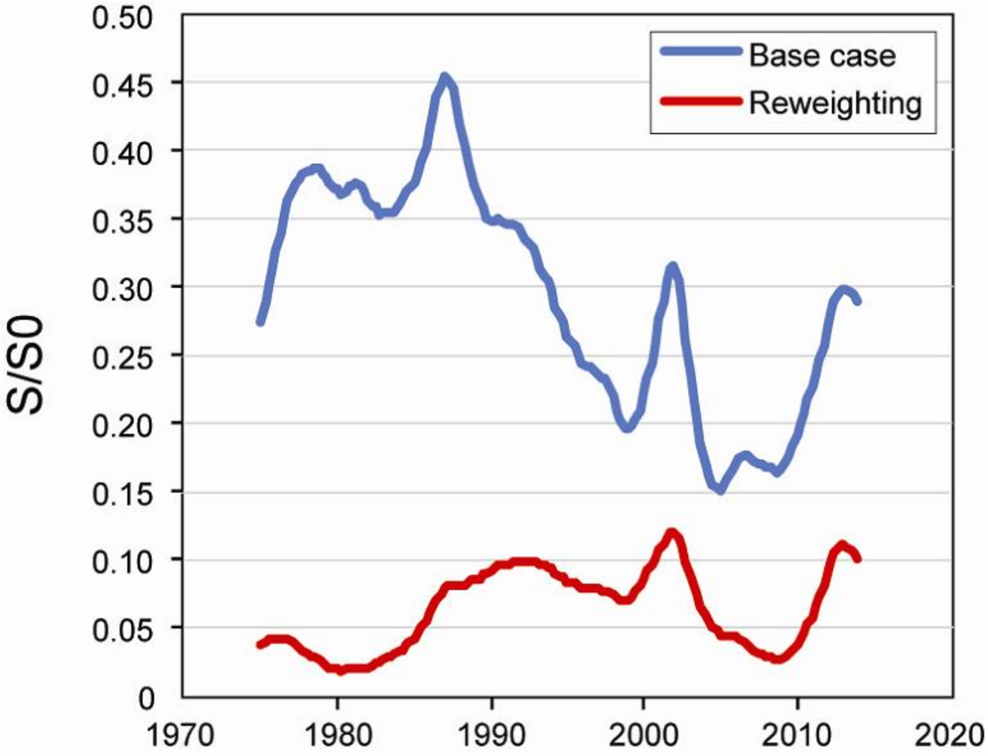


FIGURE 3. Comparison of the SBR from the reweighting sensitivity to the base case.