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LIMIT AND TARGET REFERENCE POINTS FOR SKIPJACK TUNA IN THE EASTERN PACIFIC OCEAN

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SUMMARY

Analyses based on assumptions about the steepness of the Beverton-Holt stock-recruitment relationship (h = 0.75) for skipjack Tuna in the EPO support the conservative BMSY/B0 = 0.3 proxy target biomass reference point previously proposed based on values estimated for bigeye and yellowfin tuna in the EPO.

INTRODUCTION

During 2022 an interim stock assessment was conducted for skipjack tuna in the EPO (SAC-13-07). This is the first stock assessment that has been considered by the IATTC staff to be reliable enough to be used for management advice (IATTC-100-04). The assessment still has some remaining issues, but sensitivity analyses showed that the management implications were generally robust to these issues (SAC-13-07).

Yield-per-recruit analyses for skipjack in the EPO have indicated that maximum yield occurs at very high or infinite exploitation rates due to the combination of natural mortality and growth used in the assessment and the estimated selectivities (SAC-13-07). These results in combination with the assumption that recruitment is independent from spawning stock biomass (steepness =1), make defining MSY (Maximum Sustainable Yield) based reference points for skipjack tuna in the EPO problematic. For this reason, SAC-13-07 defined a conservative proxy target biomass reference point of 30% of the unexploited spawning biomass (0.3S0) based on the range estimated under different assumptions for yellowfin (SAC-11-07 REV) and bigeye (SAC-11-06 REV) tuna in the EPO.

Here we re-evaluate the target reference points for skipjack tuna in the EPO and define the limit reference points. We also describe the IATTC harvest control rule (HCR) defined in IATTC Resolution C-16-02. We then evaluate the status of the stock estimated by the 2022 skipjack assessment relative to these reference points and discuss the results with respect to the HCR.

LIMIT REFERENCE POINT

Limit reference points are related to stock levels or fishing mortality levels that should be avoided because further stock depletion or higher fishing mortalities could endanger the biological sustainability of the stock. The IATTC adopted an interim biomass limit reference point in 2014 for tropical tunas (IATTC Resolution C-16-02). This reference point is defined as the spawning biomass that produces 50% of the virgin recruitment (R0) if the spawner-recruitment relationship follows the Beverton-Holt function with a conservative steepness (h) of 0.75 (SAC-05-14). The spawning biomass at the limit reference point is equal to 0.077 of the equilibrium unfished spawning biomass (S_0 or B_0). The fishing mortality (F) limit reference point is the value of F that, under equilibrium conditions, maintains the spawning biomass at the biomass limit reference point.

TARGET REFERENCE POINT

Target reference points are related to the management objectives. Article VII 1(c) of the IATTC's Antigua Convention states that "[The Commission shall perform the following functions…] to maintain or restore the populations of harvested species at levels of abundance which can produce the maximum sustainable yield". In conjunction with IATTC Resolution C-16-02, we interpret this by defining target reference points that correspond to MSY.

SAC-13-07 defined a conservative proxy target biomass reference point of $S_{MSY}/S_0 = 0.3$ based on the range estimated for yellowfin and bigeye tuna in the EPO under different assumptions (Table 1). The definition of this reference point was based on the same productivity-susceptibility argument that has been used previously to manage skipjack tuna based on the assessments of yellowfin and bigeye tuna (i.e. skipjack is more productive than the other two species and has similar susceptibility). It is therefore considered a conservative reference point. Other more arbitrary proxy reference points such as the value advocated by the Marine Stewardship Council (MSC) for stocks that do not have explicitly calculated reference points, SPR = 0.4, could also be used. SPR is equivalent to S/S_0 when steepness = 1.

Here we explicitly develop an alternative conservative target reference point for skipjack tuna in the EPO by taking the biology assumed and the selectivities estimated in the stock assessment and use these to calculate a target reference point based on a conservative value for the steepness of the stock-recruitment relationship (i.e. we run Stock Synthesis starting from the par file estimated from the stock assessment, with the steepness value replaced with the desired value, and turn estimation off by making the maximum phase zero). We use steepness of h=0.75 to be consistent with the assumption used in calculating the limit reference point. For the reference model this results in $S_{MSY}/S_0 = 0.15$. The S_{MSY}/S_0 values for most of the other alternative models are the same with a few higher up to 0.23 (Table 2). These values are all at a more depleted level than the original proxy ($0.3S_0$) based on the yellowfin and bigeye assessments.

HARVEST CONTROL RULE

The IATTC HCR for tropical tunas as defined in IATTC Resolution C-16-02 requires action be taken if the probability of the spawning biomass being below the limit reference point is greater than 10% [i.e. $P(S_{cur} < 0.077) > 0.1$]. The HCR also requires action to be taken if the probability of the current fishing mortality is above the limit reference point is greater than 10% [i.e. $P(F_{cur} > F_{S/S0=0.077}) > 0.1$]. The scientific recommendations for management action, as defined by the HCR, are based on the stock of the three tropical tunas (yellowfin, bigeye, and skipjack) that requires the strictest management.

EVALUATION OF STATUS RELATIVE TO REFERENCE POINTS

Current status

The probability of exceeding a reference point is computed by assuming that the probability distribution for the ratio S/S_0 is normally distributed. Some approximations had to be applied because S/S_0 was calculated using S_0 based on average recruitment rather than the parameter R0, but the standard deviation estimated in Stock Synthesis is for S/S_0. We therefore first calculated the CV of S/S_0 and then applied it to the recruitment adjusted value to get the corresponding standard deviation. The estimated standard deviation was not available for one of the scenarios so we simply used the average CV across all the other scenarios. The standard deviations were not available for the dynamic depletion, and due to the correlation between dS0 and S, the standard deviation is likely to be different, but the general conclusions from the probabilities should be similar.

The average CV of S_{cur}/S_0 is 16% for all the models with a range between 12%-19% (Table 3). The CV for S_{MSY}/S_0 was assumed to be small as only the selectivities were estimated (Growth, M, and steepness were fixed in the stock assessment model) and could not be calculated given how the proxy was defined. Therefore, the large differences in the probabilities are mostly influenced by the estimate of S_{cur}/S_0 rather than by the uncertainty in S_{MSY}/S_0.

The estimated probability of being below the limit reference point is zero for all models (Table 3). All except 3 models have a 95% or higher chance of being above the S/S_0 = 0.30 target reference point. The eastern stock model (Model l) has a 91% chance, and the models that avoid dome shape selectivity for at least one unassociated fishery (Model j and o) have little or no chance (Table 3). There is more of a range of probabilities of being above the S/S_0 = 0.40 target reference point (Table 3).

Projections

The model is projected into the future for 10 years using the current fishing mortality (the average age-specific fishing mortality over 2019-2021) by basically treating the future as part of the estimation period. This allows the uncertainty in future recruitments, which are treated as estimated parameters penalized by a distributional assumption, to be incorporated in addition to parameter estimation uncertainty. The penalty, which is based on a distributional assumption for recruitment variation, represents the uncertainty about the recruitment in the future. Since there is no data on future recruitment, the log-normal bias correction is not applied for future years. The probabilities being above the biomass reference points are calculated.

The projections have currently only been run for the reference model because the hessian needs to be run to calculate the standard deviations and this take a substantial amount of computer time. The projected (uncorrected S/S_0) is plotted in Figure 1 and the probability of being above the S/S_0 = 0.3 and S/S_0 = 0.4 target reference points in 2032 is 0.98 and 0.90, respectively. The projection shows that there is substantial variation in S/S_0 in the future due to recruitment and this could influence the probability of exceeding the reference points, particularly for models with lower estimated S_{cur}/S_0.

DISCUSSION

The analyses show that the original S_{MSY}/S_0 = 0.3 target reference point, which was based on those estimated for yellowfin and bigeye tuna, is a reasonable conservative proxy target reference point for skipjack tuna in the EPO. The analyses also show that there is no risk of the limit reference point having been exceeded during the assessment period. Low probability of being above the S_{MSY}/S_0 = 0.3 target reference point only occurs if one of the NOA fisheries is assumed to not have dome shape selectivity.

Projections show that there is more uncertainty about the future S/S_0 due to the effect of uncertainty about recruitment, but, at least in the reference model, there is still a very high probability of the skipjack biomass being above the target reference point and no probability of being below the limit biomass reference point.

TABLE 1. Ranges of S_{MSY}/S_0 estimated in the bigeye (SAC-11-06, Table 7) and yellowfin (SAC-11-07, table 8) stock assessments.

Steepness (h)	Bigeye	Yellowfin
1.0	0.20 – 0.24	0.23 – 0.32
0.9	0.25 – 0.27	0.28 – 0.35
0.8	0.28 – 0.30	0.32 – 0.37
0.7	0.31 – 0.32	0.35 – 0.40

TABLE 2. Estimates of S_{MSY}/S_0 for the different models when steepness is fixed at 0.75.

	Model	SMSY/S0
	Reference	0.15
a	Linf = 73	0.15
b	Linf = 83	0.15
c	Lcv = 0.05	0.15
d	Lcv = 0.07	0.15
e	Adjusted Catch	0.15
f	No Echo	0.15
g	No LL	0.15
h	OBJ	0.15
i	NOA	0.15
j	NOA asym	0.22
k	OBJ asym	0.18
l	Eastern	0.19
m	Higher Adult M	0.23
n	High F	0.15
o	Rapid reduction in growth	0.16

TABLE 3. Probability of the biomass being above the biomass reference points.

Model	S/S_0	SE	CV	Recruitment adjusted S/S_0	SE	Limit 0.077	Target 0.3	Target 0.4
Reference	0.52	0.08	0.16	0.53	0.08	1.00	1.00	0.94
a	0.53	0.09	0.16	0.54	0.09	1.00	1.00	0.95
b	0.50	0.08	0.17	0.51	0.09	1.00	0.99	0.90
c	0.52	0.08	0.16	0.53	0.08	1.00	1.00	0.94
d	0.52	0.09	0.16	0.52	0.09	1.00	0.99	0.92
e	0.53	0.08	0.16	0.53	0.08	1.00	1.00	0.94
f	1.09	0.20	0.19	1.05	0.20	1.00	1.00	1.00
g	0.40	0.07	0.16	0.41	0.07	1.00	0.95	0.56
h	0.52	0.07	0.14	0.54	0.07	1.00	1.00	0.97
i	0.53	0.07	0.14	0.54	0.08	1.00	1.00	0.97
j	0.17	0.03	0.17	0.17	0.03	1.00	0.00	0.00
k	0.41		0.16	0.42	0.07	1.00	0.96	0.62
l	0.36	0.04	0.12	0.36	0.04	1.00	0.91	0.18
m	0.72	0.13	0.19	0.72	0.13	1.00	1.00	0.99
n	0.52	0.08	0.16	0.53	0.09	1.00	1.00	0.94
o	0.22	0.04	0.18	0.22	0.04	1.00	0.02	0.00

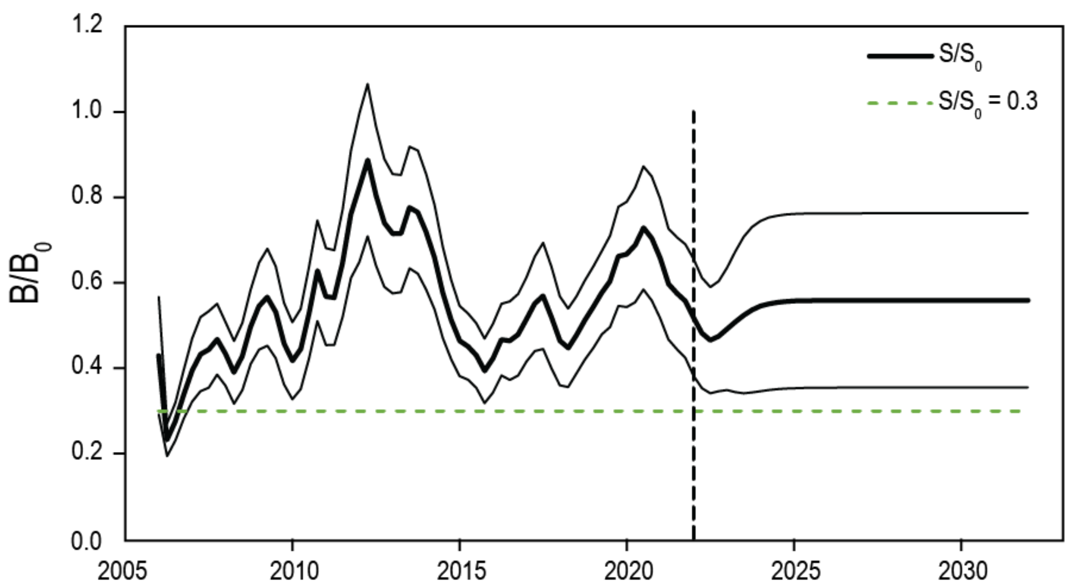

FIGURE 1. Estimated and projected S/S_0 (unadjusted) for the reference Model with 90% confidence intervals compared to the proxy target biomass reference point ($S/S_0 = 0.3$). The vertical dashed line is the start of 2022.