Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

Estimation of management quantities and associated uncertainty

1st External review of modelling aspects in stock assessments of tropical tuna in the eastern Pacific Ocean
6 - 10 Nov 2023 - Videoconference

Key messages and issues

- Biomass limit reference point is based on equilibrium B0
- Biomass target reference point is based on dynamic B0
- Fishing mortality reference points are evaluated using the average estimated F for the last 3 years
- Uncertainty is approximated by a normal distribution around the estimates
- Variability taken from the estimated variability in each model, or proxy

IATTC reference points for tropical tunas

INTER-AMERICAN TROPICAL TUNA COMMISSION

90^{TH} MEETING

La Jolla, California (USA)
27 June-1 July 2016

RESOLUTION C-16-02

HARVEST CONTROL RULES FOR TROPICAL TUNAS (YELLOWFIN, BIGEYE, AND SKIPJACK)

Resolution C-16-02 defines target and limit reference points, expressed in terms of spawning biomass (S) and fishing mortality (F), for the tropical tuna species: bigeye, yellowfin, and skipjack.

The reference points are used in a harvest control rule (HCR)

Limit reference points

- The spawning biomass limit reference point (**SLIMIT)** is the threshold value of S that should be avoided because further depletion could endanger the sustainability of the stock. The interim SLIMIT adopted by the IATTC in 2014 is the spawning biomass that produces 50% of the virgin recruitment (R0) if the stock-recruitment relationship follows the Beverton-Holt function with a steepness (h) of 0.75. This spawning biomass is equal to 0.077 of the equilibrium virgin spawning biomass (S0) (Maunder and Deriso 2014 – SAC-05-14).

- The HCR requires action be taken if the probability (P) of the spawning biomass at the beginning of 2020 (Scurrent) being below SLIMIT is greater than 10%. Thus, to provide management advice, Scurrent/SLIMIT, and the probability of Scurrent < SLIMIT (or P(Scurrent/SLIMIT <1), which is computed by assuming the probability distribution function for the ratio is normal), are reported.

- The fishing mortality limit reference point (**FLIMIT**) is the threshold value of F that should be avoided because fishing more intensively could endanger the sustainability of the stock. The interim FLIMIT adopted by the IATTC in 2014 is the fishing mortality rate that, under equilibrium conditions, maintains the spawning population at SLIMIT. The HCR requires action to be taken if the probability of the average fishing mortality during 2017-2019 (**Fcurrent**) being above **FLIMIT is greater than 10%.** Thus, to provide management advice, Fcurrent/FLIMIT, and the probability of this ratio being > 1 (by assuming the probability distribution function for the ratio is normal) are reported

Target reference points

- The spawning biomass target reference point (**STARGET**)is the level of spawning biomass that should be achieved and maintained. The IATTC adopted SMSY (the spawning biomass that produces the MSY) in 2014 as the target reference point.

- The HCR requires that actions taken to achieve SMSY have at least **a 50% probability** of restoring the spawning biomass to the dynamic MSY level (SMSY_d) within five years or two generations. Here, SMSY_d is equal to SMSY_d1, which is derived by projecting the population into the future, assuming historical recruitment and a fishing mortality rate that produces MSY, F = FMSY.

- The value of SMSY_d1 used to compute reference points for yellowfin is the mean S for the last four quarters of the projection. To provide management advice, Scurrent/SMSY_d1, and the probability that this ratio is < 1 (by assuming CV is equal to that of Fcurrent/FMSY), are included

- The dynamic MSY (MSY_d) is the sum of the total catches for the last four quarters of the projection.

- The fishing mortality target reference point (**FTARGET**) of is the level of fishing mortality that should be achieved and maintained. The IATTC adopted FMSY (the fishing mortality rate that produces the MSY) in 2014 as the target reference point. Thus, to provide management advice, Fcurrent/FMSY, and the probability that this ratio is > 1 (by assuming the probability distribution function for the ratio is normal), are reported, as is the inverse of Fcurrent/FMSY (the F multiplier).

Management table (point estimates and probabilities)

	1	2
	BASE	GRO
***h* = 1.0**		
MSY	461,752	488,404
MSY_d	257,732	263,175
$C_{current}$/MSY_d	0.97	0.95
S_{MSY}/S_0	0.32	0.24
$S_{current}/S_0$	0.15	0.16
$S_{current}/S_{LIMIT}$	2.00	2.09
$p(S_{current}<S_{LIMIT})$	0.00	0.00
$F_{current}/F_{LIMIT}$	0.40	0.40
$p(F_{current}> F_{LIMIT})$	0.00	0.00
$S_{current}/S_{MSY\_d}$	0.90	1.26
$p(S_{current}<S_{MSY\_d})$	0.84	0.07
$F_{current}/F_{MSY}$	1.08	0.80
$p(F_{recent}> F_{MSY})$	0.74	0.03
***h* = 0.9**		
MSY	468,040	481,752
MSY_d	260,403	252,946
$C_{current}$/MSY_d	0.96	0.98
S_{MSY}/S_0	0.35	0.29
$S_{current}/S_0$	0.14	0.15
$S_{current}/S_{LIMIT}$	1.86	1.95
$p(S_{current}<S_{LIMIT})$	0.00	0.00
$F_{current}/F_{LIMIT}$	0.47	0.46
$p(F_{current}> F_{LIMIT})$	0.00	0.00
$S_{current}/S_{MSY\_d}$	0.75	1.01
$P(S_{current}<S_{MSY\_d})$	1.00	0.47

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Yellowfin tuna

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- Management table for yellowfin tuna in the EPO, 2020.
- Respectively, Scurrent and SMSY_d are the spawning biomass at the beginning of 2020 and at dynamic MSY level
- Fcurrent and FMSY are the fishing mortality during 2017-2019 and at MSY
- SLIMIT and FLIMIT are the limit reference points for spawning biomass and fishing mortality.
- Current is the total catch of yellowfin in 2019, in metric tons, and MSY_d is the dynamic MSY, for each reference model and steepness value of the stock-recruitment function (h).

Kobe plot

In 2020:
In the Kobe plot, the time series of SMSY_d is computed based on two approximations:

SMSY_d1, derived by projecting the population into the future, assuming historical recruitment and a fishing mortality rate that produces MSY, F = FMSY)

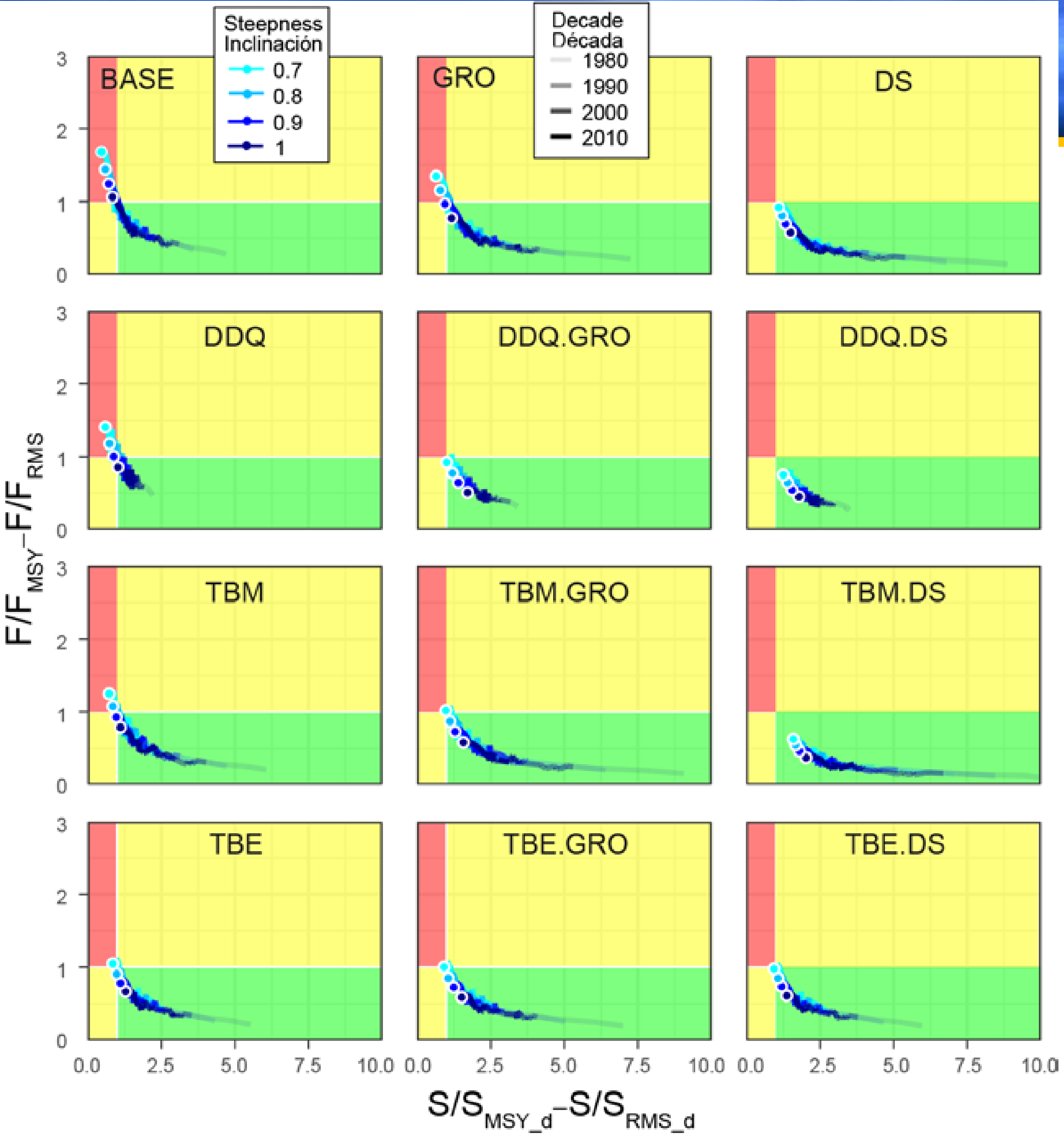
SMSY_d2= S0_d (SMSY/S0), where S0_d is the dynamic spawning biomass in the absence of fishing and SMSY/S0 is the depletion level that, under equilibrium, produces the maximum sustainable yield.

The two approximations are weighted as follows to obtain the trajectory of SMSY_d in the Kobe plot:

$$SMSY\_d(t) = (1 - p(t))\, SMSY\_d1(t) + p(t)\, SMSY\_d2(t)$$

where p increases linearly as a function of year (t) from 0 in the start year to 1 in the end year.

Kobe plot

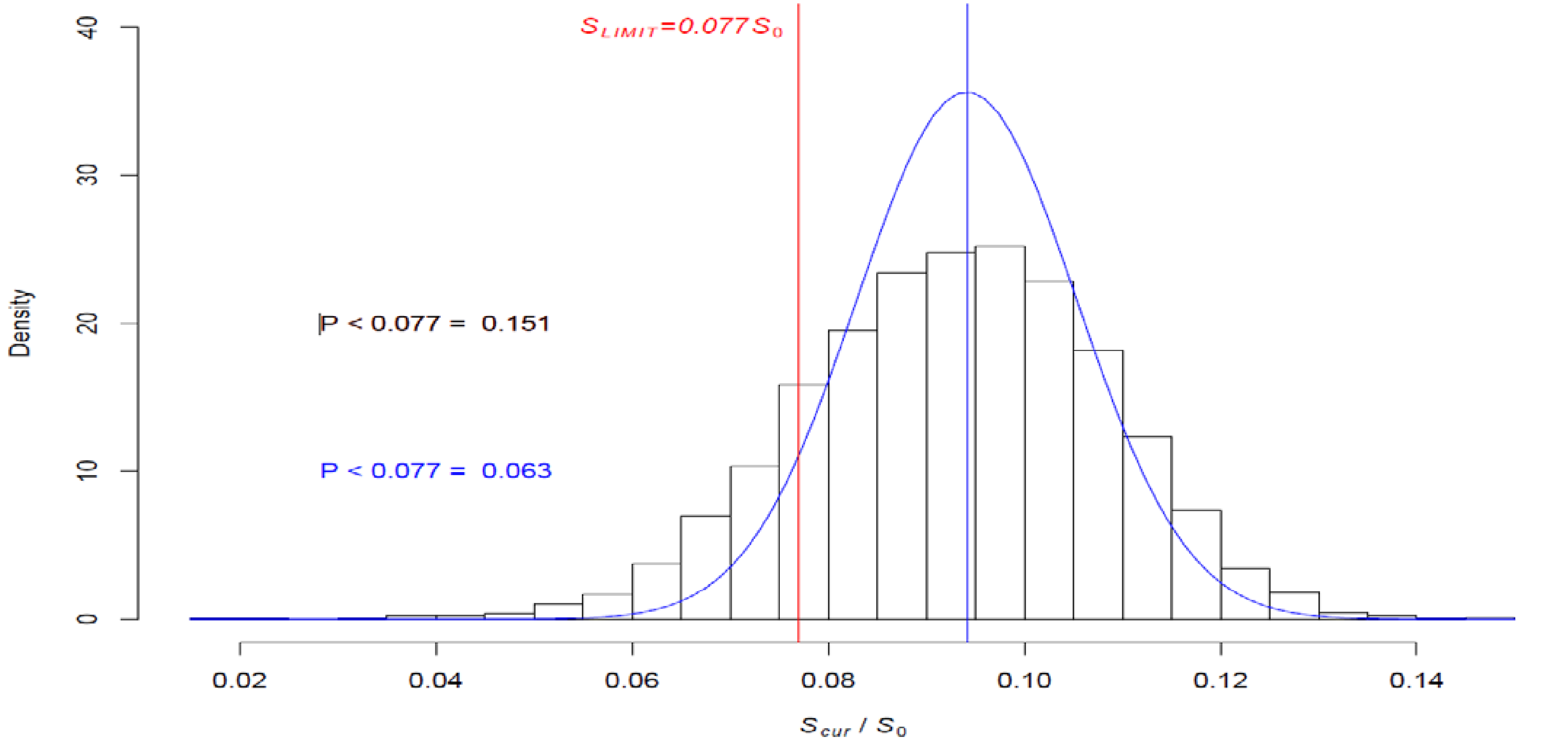


Steepness
Inclinación
0.7
0.8
0.9
1
Decade
Década
1980
1990
2000
2010
BASE
GRO
DS
DDQ
DDQ.GRO
DDQ.DS
TBM
TBM.GRO
TBM.DS
TBE
TBE.GRO
TBE.DS
0
1
2
3
0.0
2.5
5.0
7.5
10.0
F/F_{MSY}–F/F_{RMS}
S/S_{MSY_d}–S/S_{RMS_d}

Calculating probability distributions for quantities of interest for a model

- Normal approximations based on the estimate and standard error
- Some standard errors are approximated
- Works well when the data is very informative
- The resulting distribution is rescaled to obtain P(Quantity|Model=m).
- Probability distribution may be asymmetrical
- Posteriors derived from limited MCMC analyses used to evaluate appropriateness of the approximation

Probability distributions: MCMC comparison



Bayesian posterior distribution (bars) for the ratio of current biomass over equilibrium virgin biomass (S_{cur}/S_0) for the bigeye *Short-term, Fixed* model MCMC. Red line is biomass limit reference point (S_{LIMIT} =0.077S_0), blue vertical line is the mean S_{cur}/S_0 from the MLE, blue curve is the normal distribution from MLE estimates of mean and variance, “P < 0.077” are the probabilities of being below S_{LIMIT} derived from both the MCMC posterior (**black text**) and the MLE normal distribution (**blue text**).

Preguntas -Questions