

Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission



Reference Points

2nd IATTC Tropical Tuna MSE Workshop, *by videoconference*, May 03-04, 2021



Outline

- Reference Points (RP)
 - Biomass, Mortality, Empirical
 - Target, Threshold, Limit, Rebuilding target
- Limit Reference Points, considerations
- RP for tuna and billfish stocks
- Summary
- Discussion on alternative reference points to consider

Reference Points

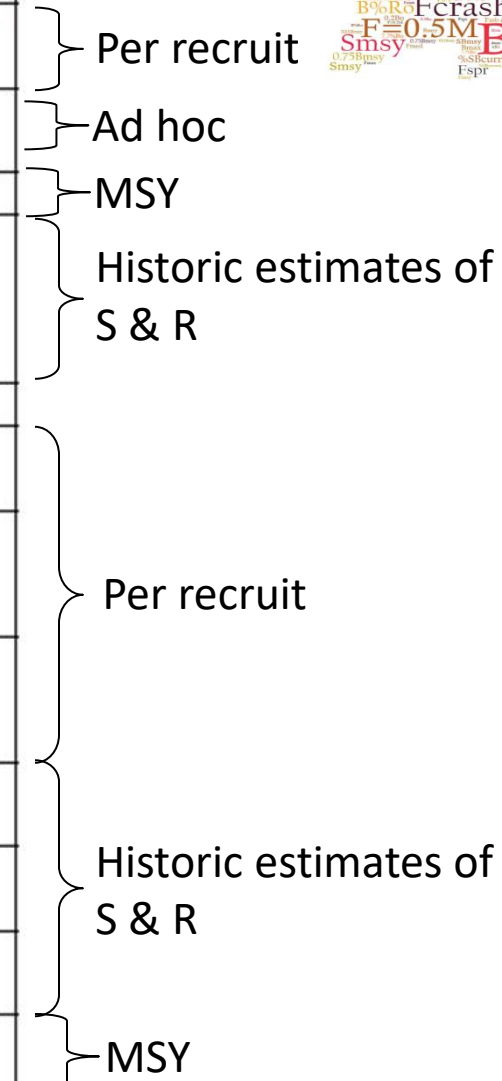
- Guidelines for management
 - Benchmarks against which the abundance of the stock, the fishing mortality rate or economic and social indicators can be measured to determine its status.

Reference Points

- May be based on model estimates (exploitation rates, biomass)
- May be based on empirical data (CPUE, effort, fish size)
- F_{MSY} and B_{MSY} dependent on **stock-recruit relationships**
- B_{MEY} based on **economics**
- F_{max} , $F_{0.1}$, $F_{35\%}$, $F_{40\%}$ based on **per-recruit** (assumes recruits independent of stock size)

Some example Reference Points, alphabet soup?

Reference point	Description
%SPR	spawner per recruit as a percentage of the unfished spawner per recruit - usually set in terms of the harvest rate that implies this
B/B ₀	biomass relative to unexploited biomass (or often defined in terms of spawning biomass).
B _{msy}	the biomass which corresponds with maximum sustainable yield
MBAL	(Minimum Biological Acceptable Level) a spawning biomass level below which, observed spawning biomasses over a period of years, are considered unsatisfactory and the associated recruitments are smaller than the mean or median recruitment.
F _{max}	Fishing mortality rate which corresponds to the maximum yield per recruit (as a function of fishing mortality)
F _{0.1}	fishing mortality rate at which the slope of the yield per recruit curve (as a function of fishing mortality) is 10% of its value near the origin. (Similarly defined F _{0.2} has been used in some cases; see Caddy, 1998)
F _{spr.x%}	fishing mortality rate which corresponds to spawner per recruit being x% of unfished spawner per recruit (values of 30%, 35%, 40% have been used; see e.g. Mace and Sissenwine, 1993)
F _{low}	fishing mortality rate on an equilibrium population with a SSB/R equal to the inverse of the 10 th percentile of the observed R/SSB
F _{med} (F _{rep})	fishing mortality rate on an equilibrium population with a SSB/R equal to the inverse of the median (50 th percentile) of the observed R/SSB
F _{high}	fishing mortality rate on an equilibrium population with a SSB/R equal to the inverse of the 90 th percentile of the observed R/SSB
F _{msy}	fishing mortality rate which corresponds to the maximum sustainable yield as estimated by a production model (or age-based model with stock-recruit curve)

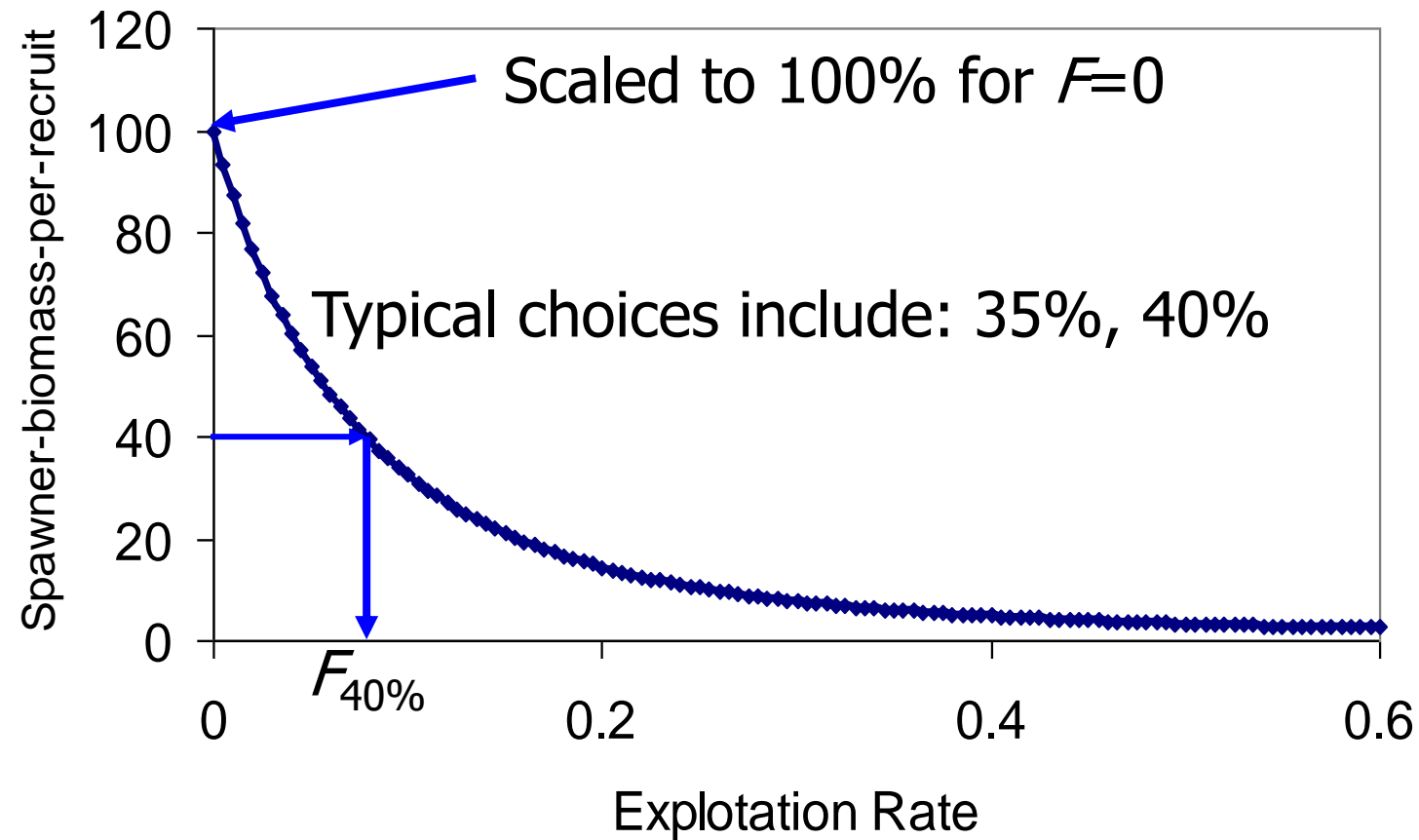


Spawner Biomass-per-Recruit Reference Points

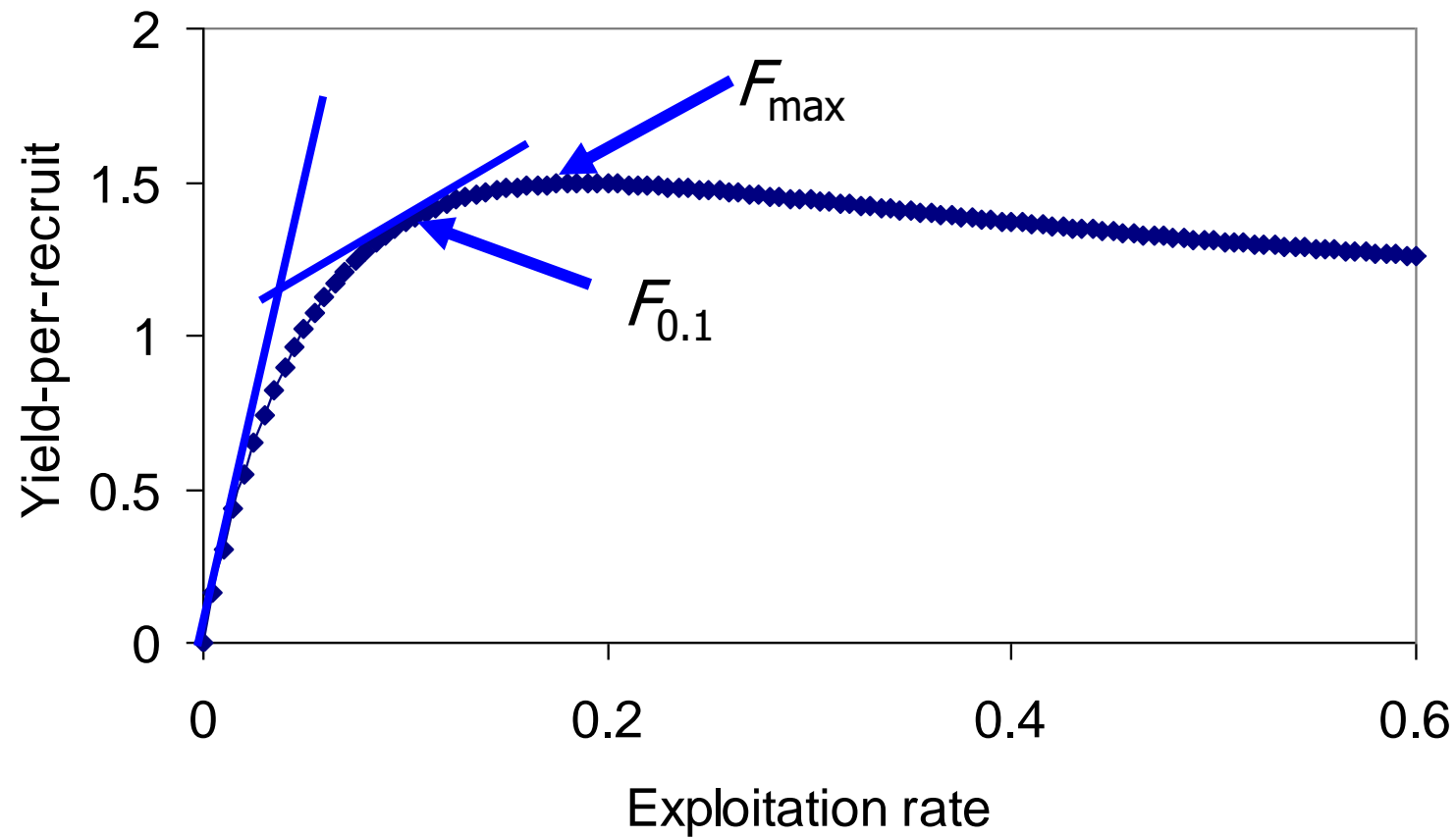
- **SPR** rates refer to the fishing mortality rate that corresponds to levels that would reduce the *unfished* **S**pawner biomass **P**er **R**ecruit to a %
 - e.g, if you have 100 recruits, how many survive to spawn, how much they weigh or how many eggs they produce?
 - Depends on: gear selectivity, growth, fecundity at age, natural mortality rate

Spawner Biomass-per-Recruit
Reference Points

Spawner Biomass-per-Recruit Reference Points

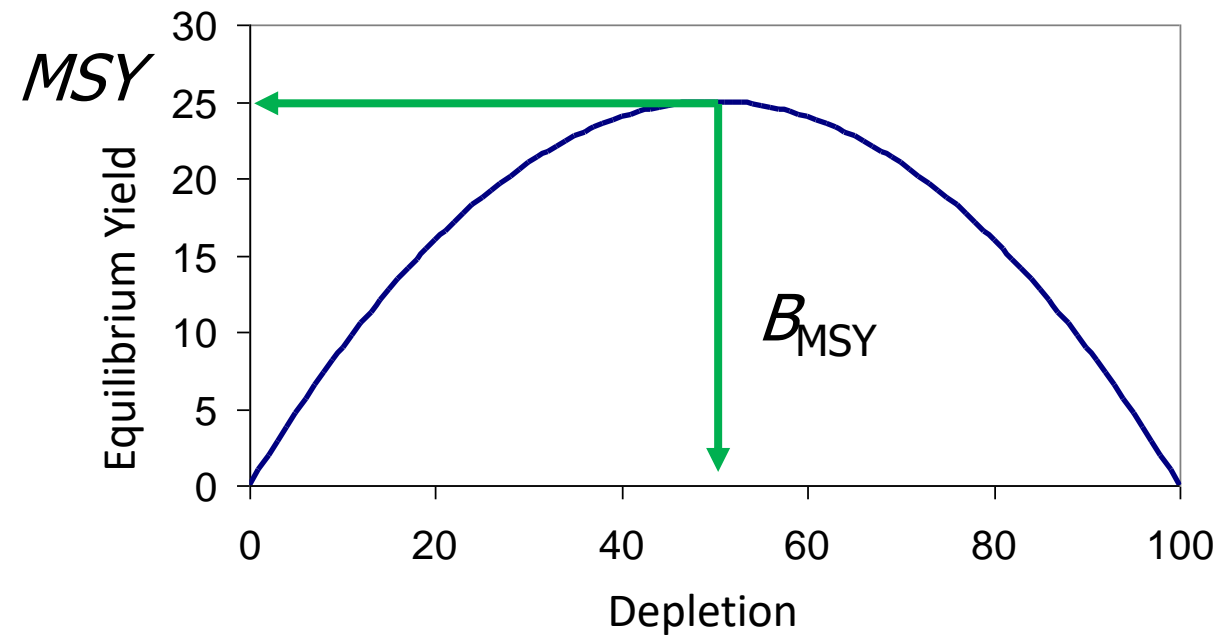


Yield-Per-Recruit Reference Points



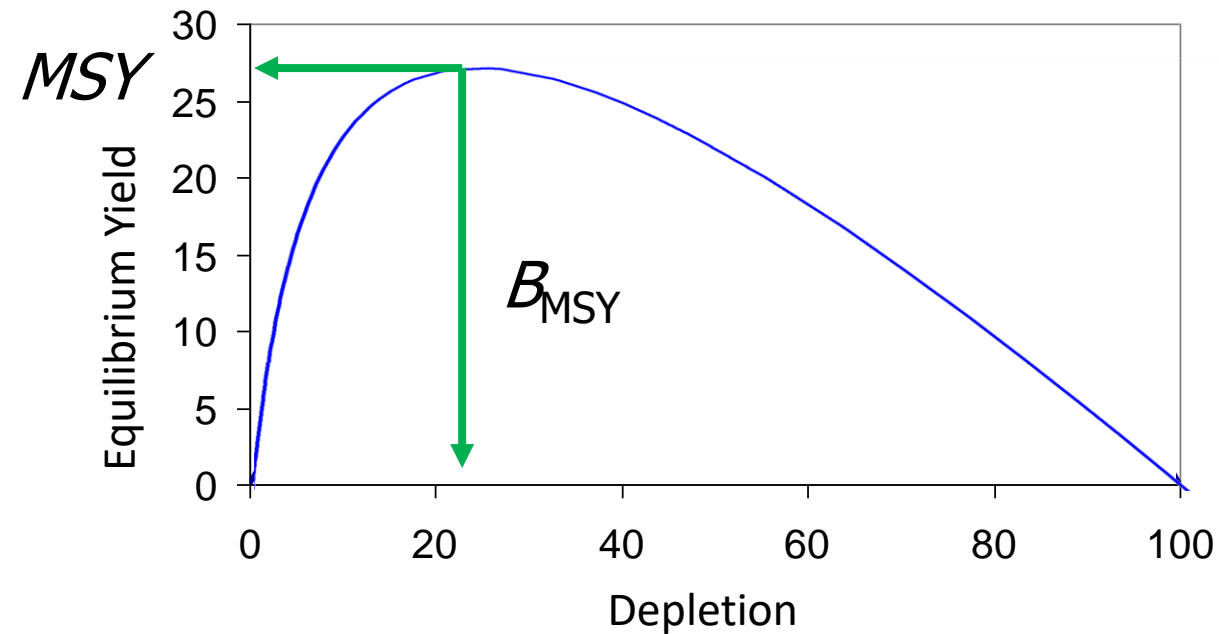
MSY Reference Points

- B_{MSY} : biomass at which Maximum Sustainable Yield MSY is achieved.
- Shape depends on model: e.g. Schaefer



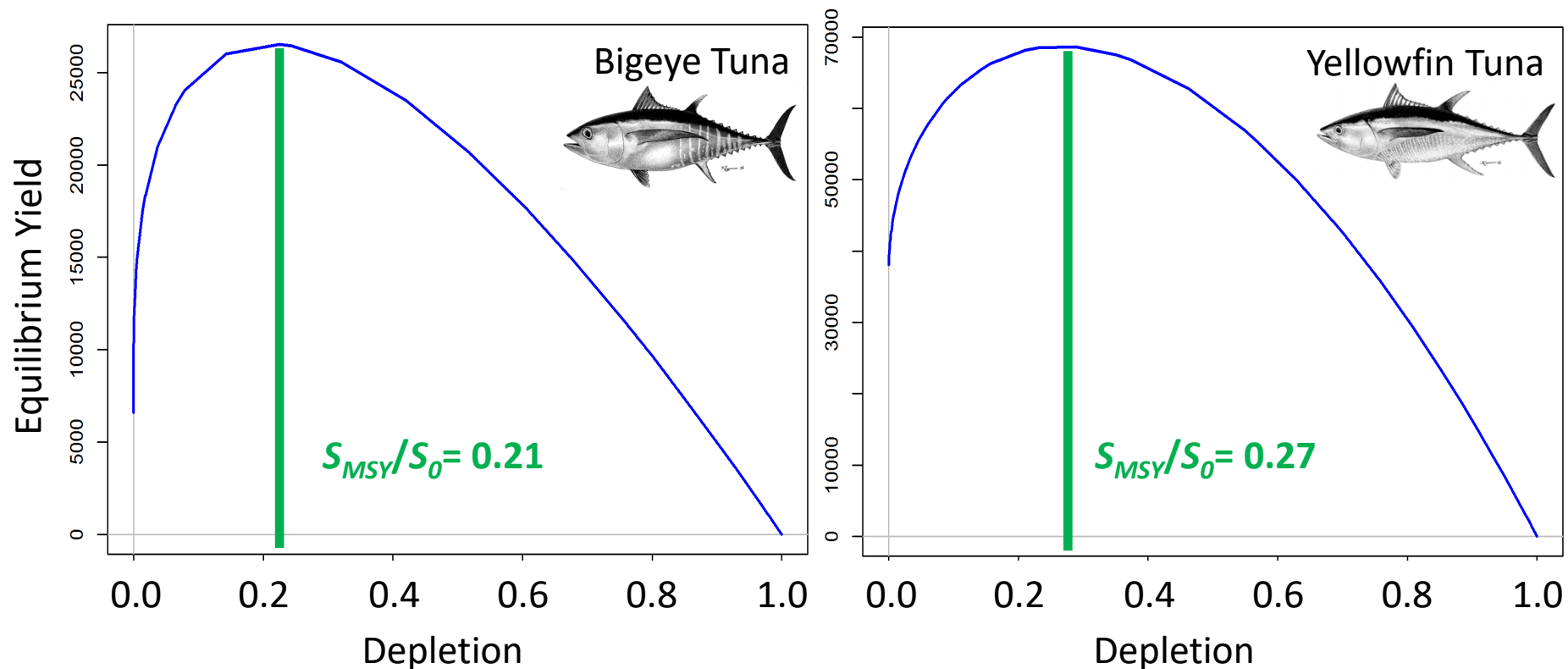
MSY Reference Points

- B_{MSY} : biomass at which Maximum Sustainable Yield *MSY* is achieved.
- Shape depends on model: e.g. (Integrated age-structured model, SS)



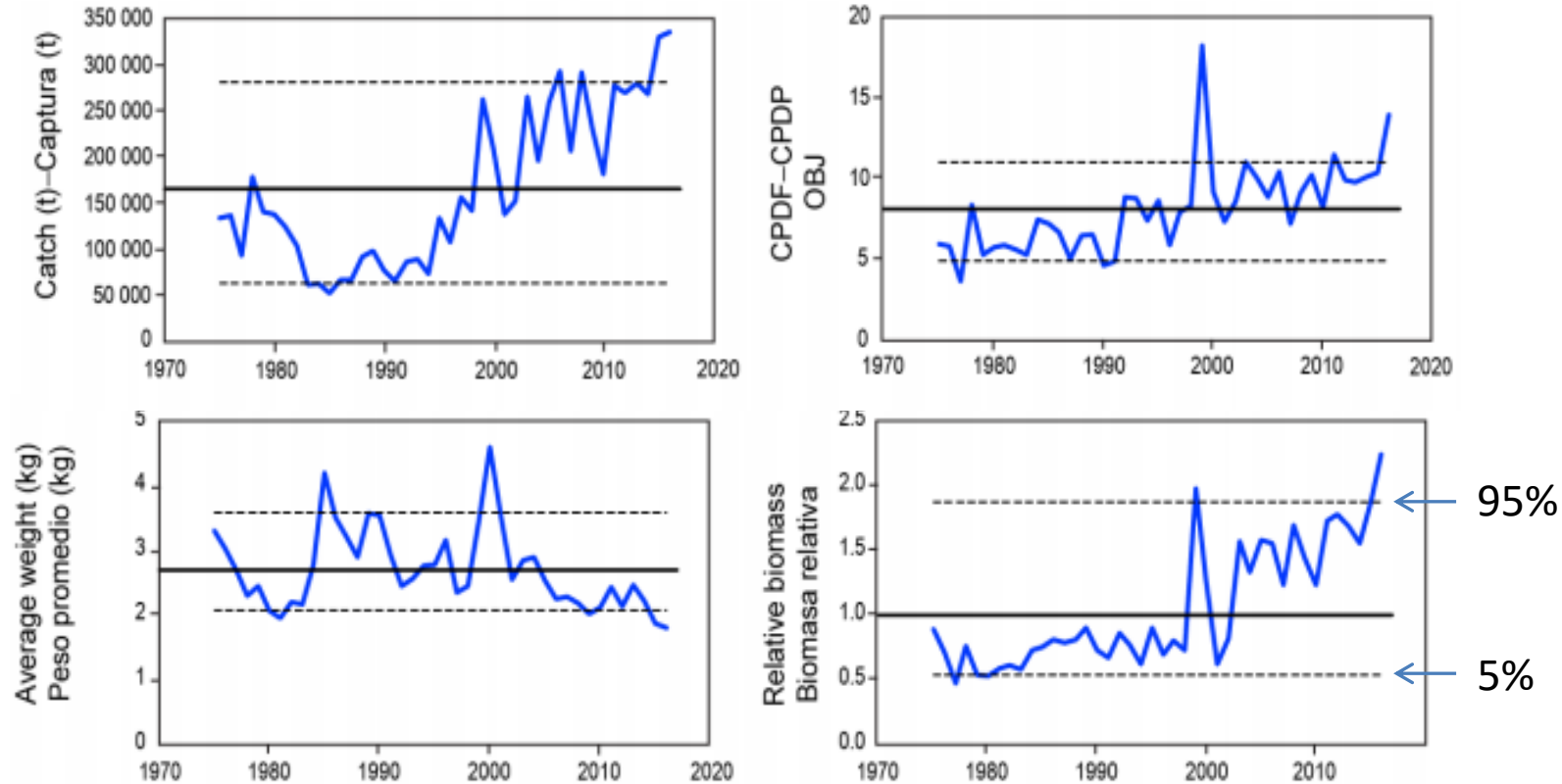
MSY Reference Points

- B_{MSY} : biomass at which Maximum Sustainable Yield MSY is achieved.
- Shape depends on model and biology (M, h, growth) and selectivity



Empirical Reference Points

Skipjack tuna (Maunder 2017)



- PROS: Easier to compute, understand and communicate.
- CONS: Not commonly used, potential confounding of fishery and population processes, not clear if they are robust. Need evaluation

IATTC Target and Limit Reference Points

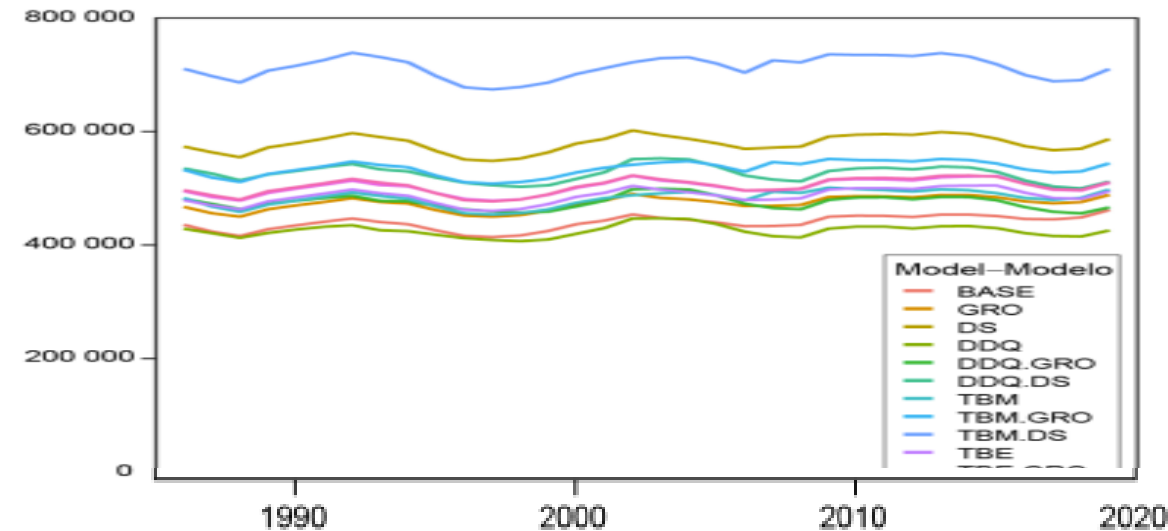
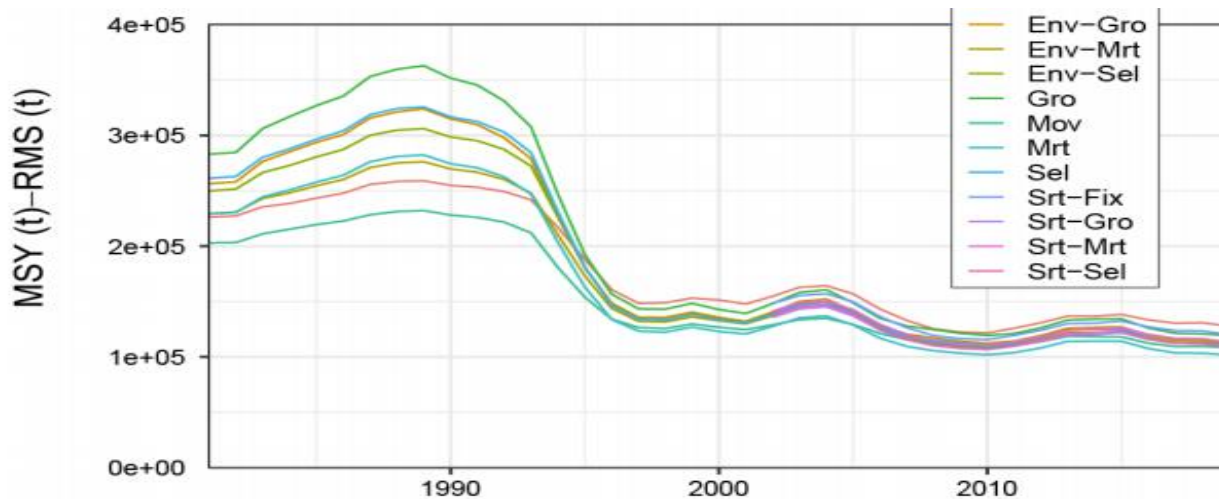
- IATTC adopted interim target and limit reference points in 2014.
- **Target (TRP):**
 - Biomass (B) and Fishing mortality rate (F) corresponding to maximum sustainable yield (B_{MSY} and F_{MSY})
- **Limit (LRP):**
 - B and F associated with a 50% reduction in unfished recruitment ($50\%R_0$) using a conservative stock-recruitment relationship (steepness, or $h = 0.75$).



IATTC Target Reference Point

- **Target:**

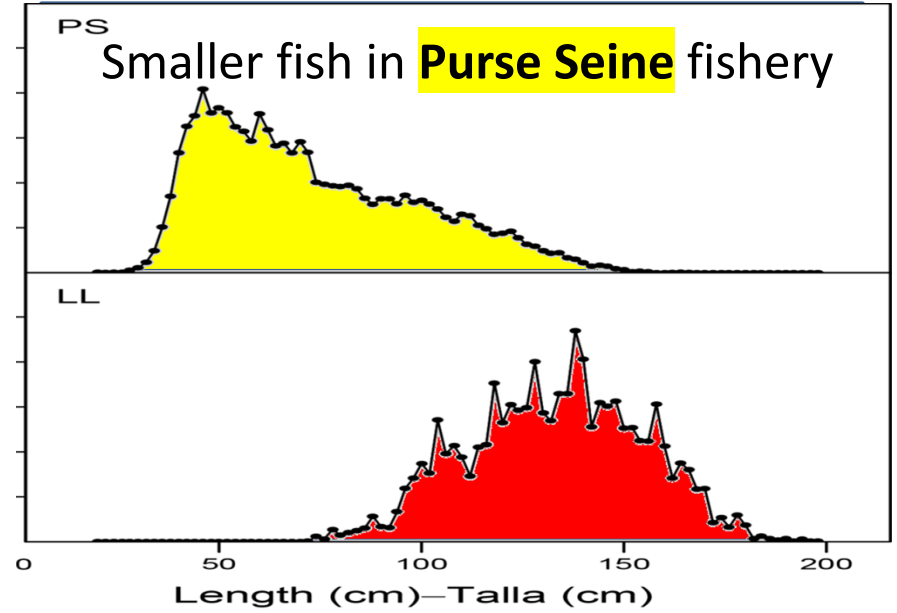
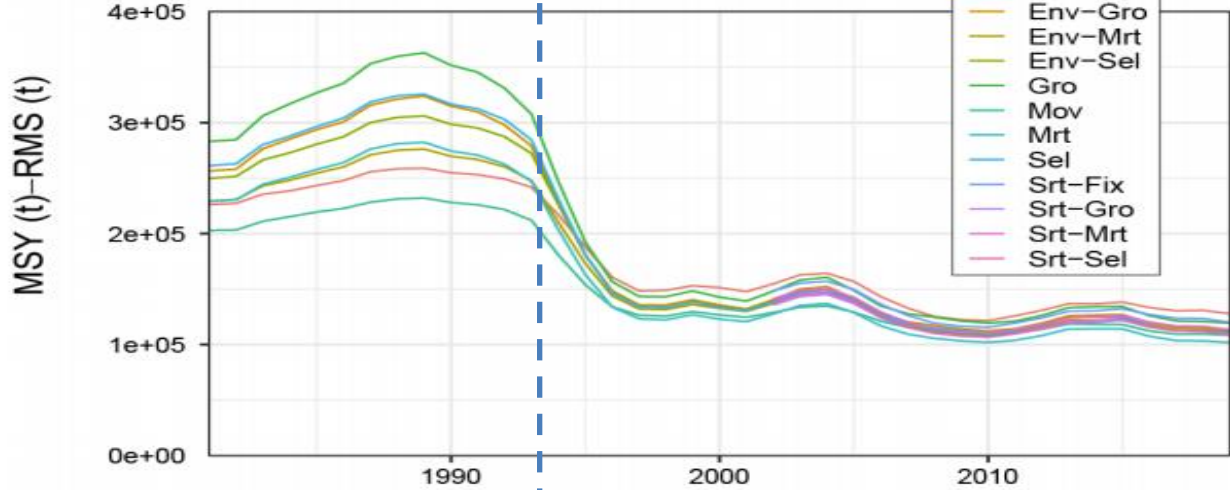
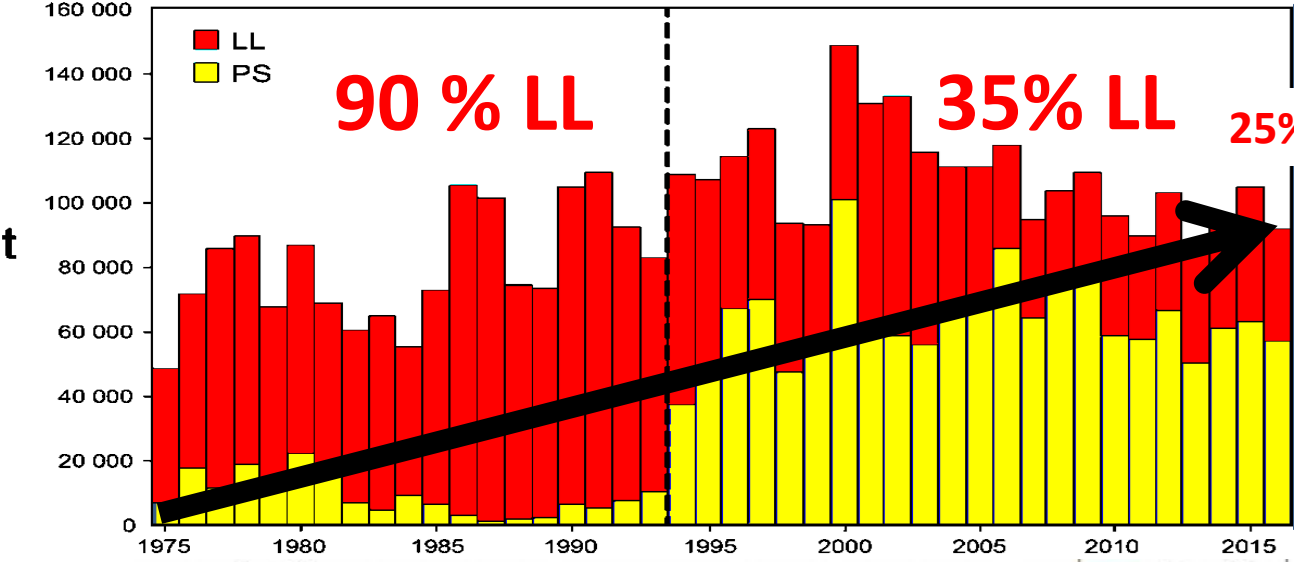
- Biomass (B) and Fishing mortality rate (F) corresponding to maximum sustainable yield (B_{MSY} and F_{MSY})
- MSY varies with selectivity of different gears and changes in catch by gear



Decrease in Longline (Bigeye tuna)

Expansion of Purse Seine

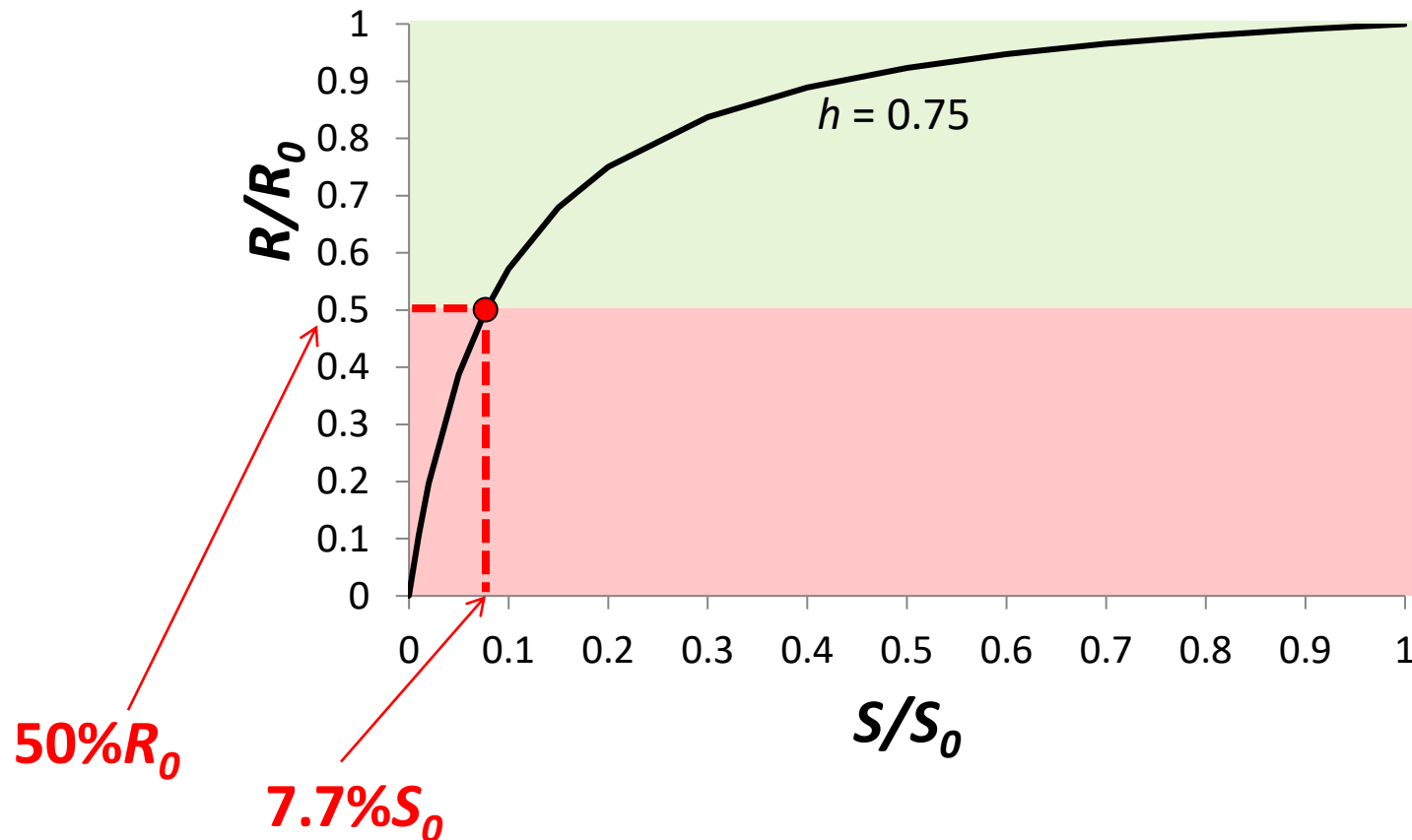
Increased TOTAL catch



IATTC Limit Reference Point

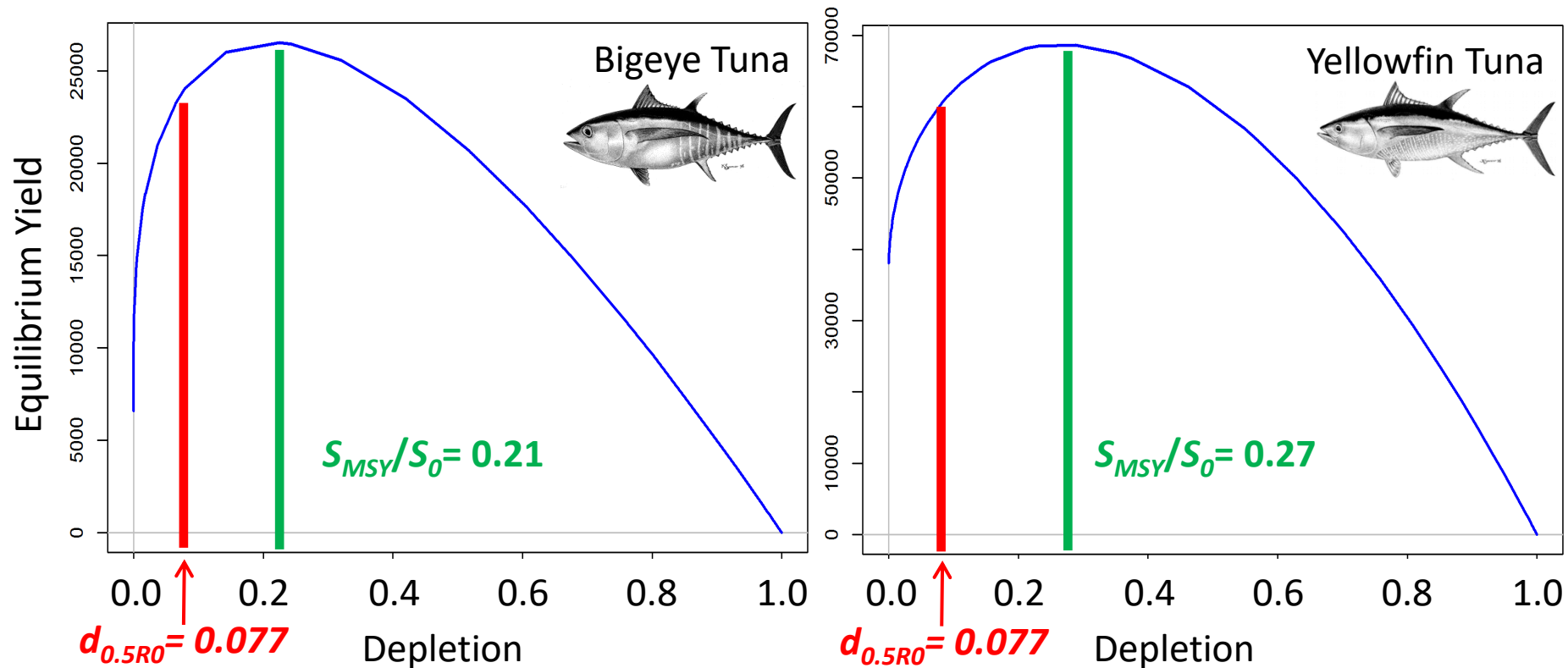
- **Limit (LRP):**

- B and F associated with a 50% reduction in unfished recruitment ($50\%R_0$) using a conservative stock-recruitment relationship (steepness, or $h = 0.75$).



MSY Reference Points

- B_{MSY} : Biomass at which Maximum Sustainable Yield, MSY , is achieved.
- Shape depends on model and biology (M, h, growth) and selectivity

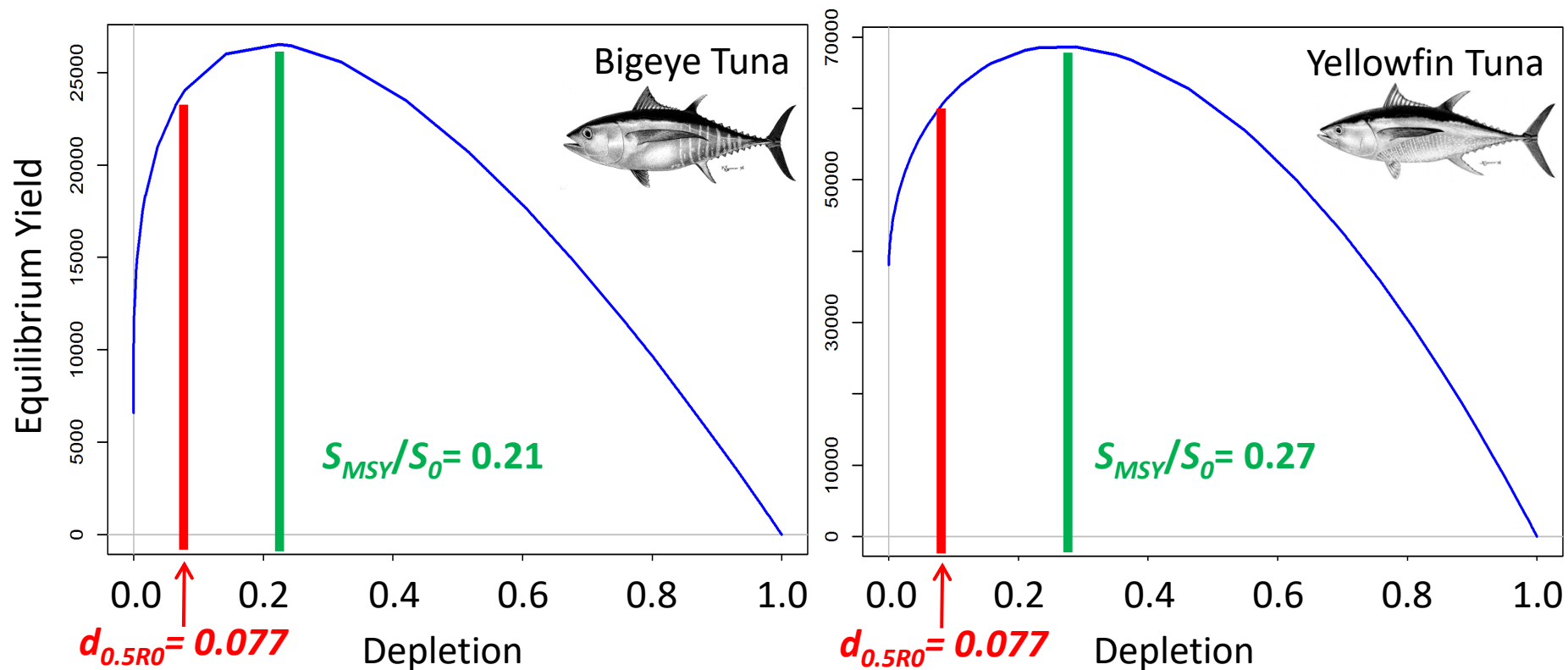


Other Limit Reference Points

- $20\%B_0$ – e.g. consider no policy with greater than 10% probability of dropping below $20\% B_0$ over a 20-year projection period.
- $20\%B_0$ commonly used LRP based on work by Beddington and Cooke (1983); Francis (1992) and Myers *et al.* (1994).
- However, $20\%B_0$ produces very close to MSY for most fish stocks. Thorson *et al.* (2011) found that B_{MSY} ranged from 26–46% B_0 for 147 fish stocks
- Problems with approaches based on a fixed proportion of B_0 : arbitrary, too cautious for some species, not cautious enough for other species.

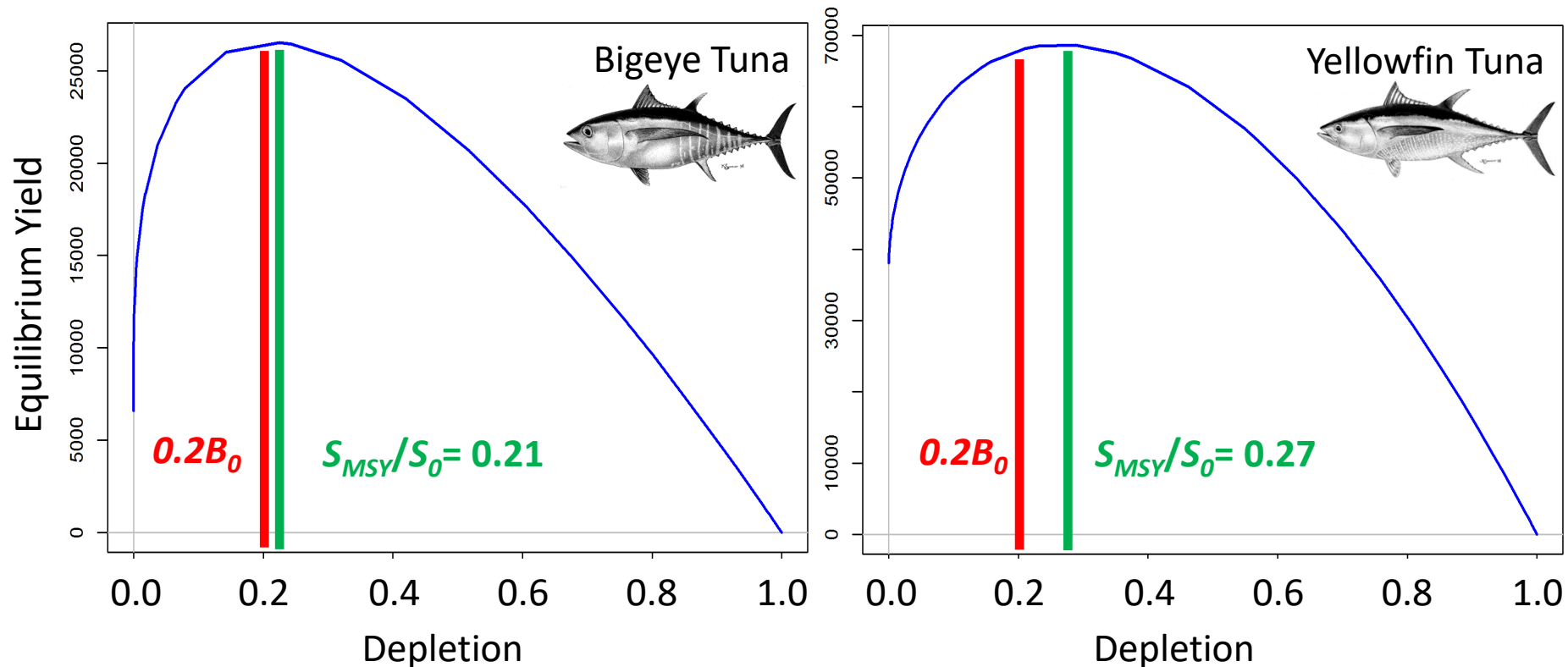
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Tropical tuna reference points, Harvest Control Rules, tuna RFMOs

Element	RFMO	CCSBT	IATTC	ICCAT	IOTC	WCPFC
LRP		None	$F_{0.5R0}$ and $B_{0.5R0}$ with steepness of 0.75. Relates to a depletion of $0.077B_0$. (interim limits)	N. Atlantic swordfish: $0.4 B_{MSY}$ (interim limit)	Tropical tunas: $0.4 B_{MSY}$ ($0.5 B_{MSY}$ for BET) (interim limits) and $1.4 * F_{MSY}$ $1.3 * F_{MSY}$ SKJ $0.2SSB_0$ and F $0.2 * SSB_0$	Tropical tunas and S. Pacific albacore: $0.2 SB_{F=0}$ ($0.2B_0$) evaluated using recent recruitment levels
TRP		Interim 30%TRO achieved with 50% probability by 2035	B_{MSY} and F_{MSY}	"Green" quadrant of Kobe plot seems a target zone, but no specific TRP adopted.	Tropical tunas, albacore B_{MSY} and F_{MSY}	None for BET nor YFT Skipjack $0.5B_{F=0}$
HCR		Empirical (gene-tagging, CPUE and Close-Kin Mark Recapture indices)	Model-based: Reduce F to F_{MSY} if it exceeds this value. If 10% or greater of exceeding the limit	None	Model-based for SKJ None for BET and YFT	None

Summary

- Potential issues of specifying reference points that may not relate to specific life histories of stocks
- IATTC current TRP are model-based biomass and fishing mortality at MSY
 - MSY has changed over time, BET
 - No model estimate of MSY quantities for SKJ
- LRP cannot be evaluated in isolation of other elements of strategy (TRP, HCR), harvest strategy
- Which LRPs are appropriate depends on management action to be applied if the limit is exceeded.

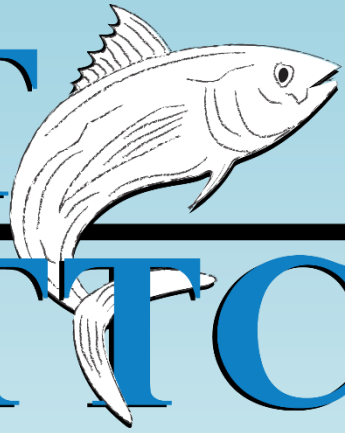


Questions for Discussion

- **Dynamic & Equilibrium Reference Points?** Do we adjust for changes in recruitment history?
 - Dynamic targets F_{MSY} and B_{MSY} (probability around them not defined, 50%?)
 - Equilibrium limits for F and B (not to be exceeded, 10% probability)
 - Finding corresponding Probability values relative to risk but not so low that are difficult estimate appropriately
 - Relate interpretation of limits or triggers to the action to take
- Should we consider additional control points in addition to Target and Limit Reference points, for example to create precautionary buffers to scientific or implementation uncertainty?
 - Should F_{MSY} only be considered a target? Limit? Buffer? Relationship between limit and recovery to target?
 - Consider terminology such as HCR control parameters vs. RP
- Suggestions by the US to be emailed to Staff
- Control points of HCR vs Limit and Target reference points



CIAT IATTC



Questions?