Reference Points

3rd IATTC Tropical Tuna MSE Workshop, *by videoconference*, December 08-09, 2022

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.
  - May or may not be part of a Harvest Control Rule

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)

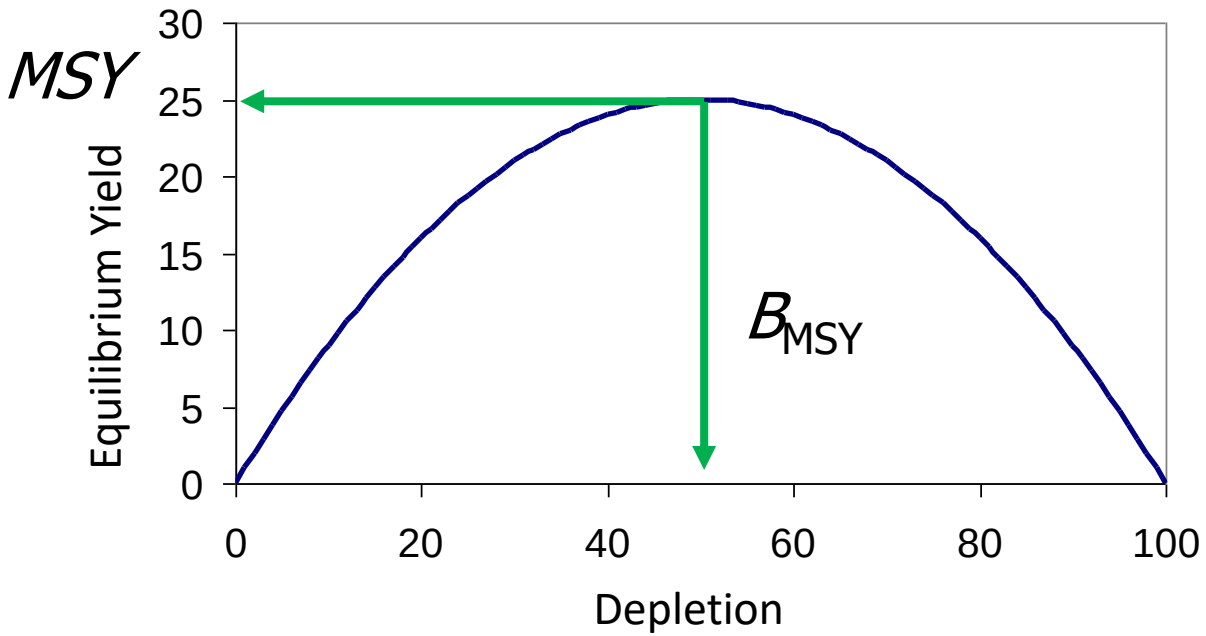
Spawner Biomass-per-Recruit Reference Points

- **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

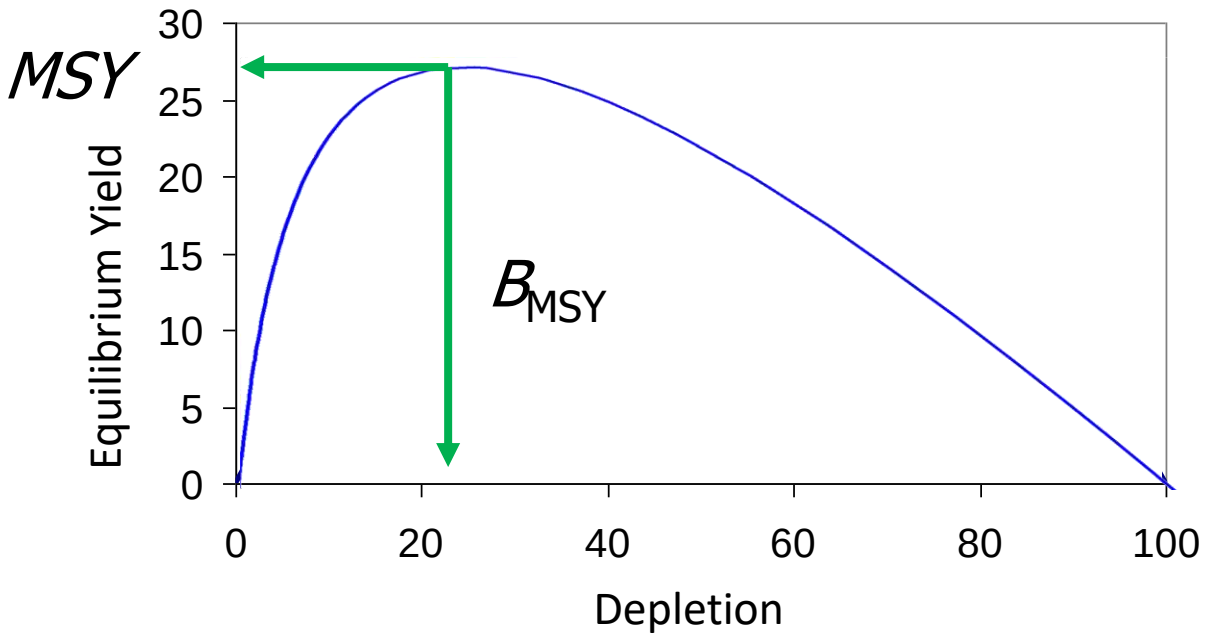
MSY Reference Points

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



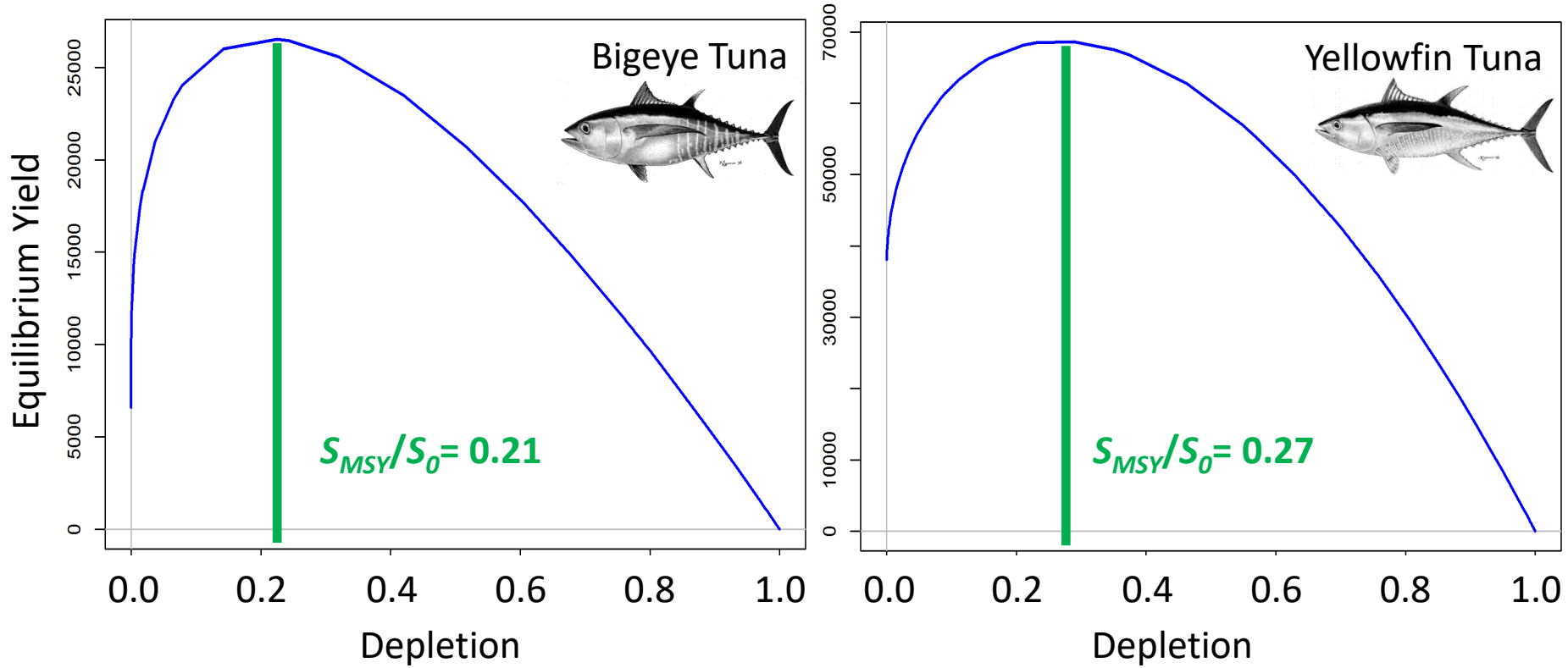
MSY Reference Points

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



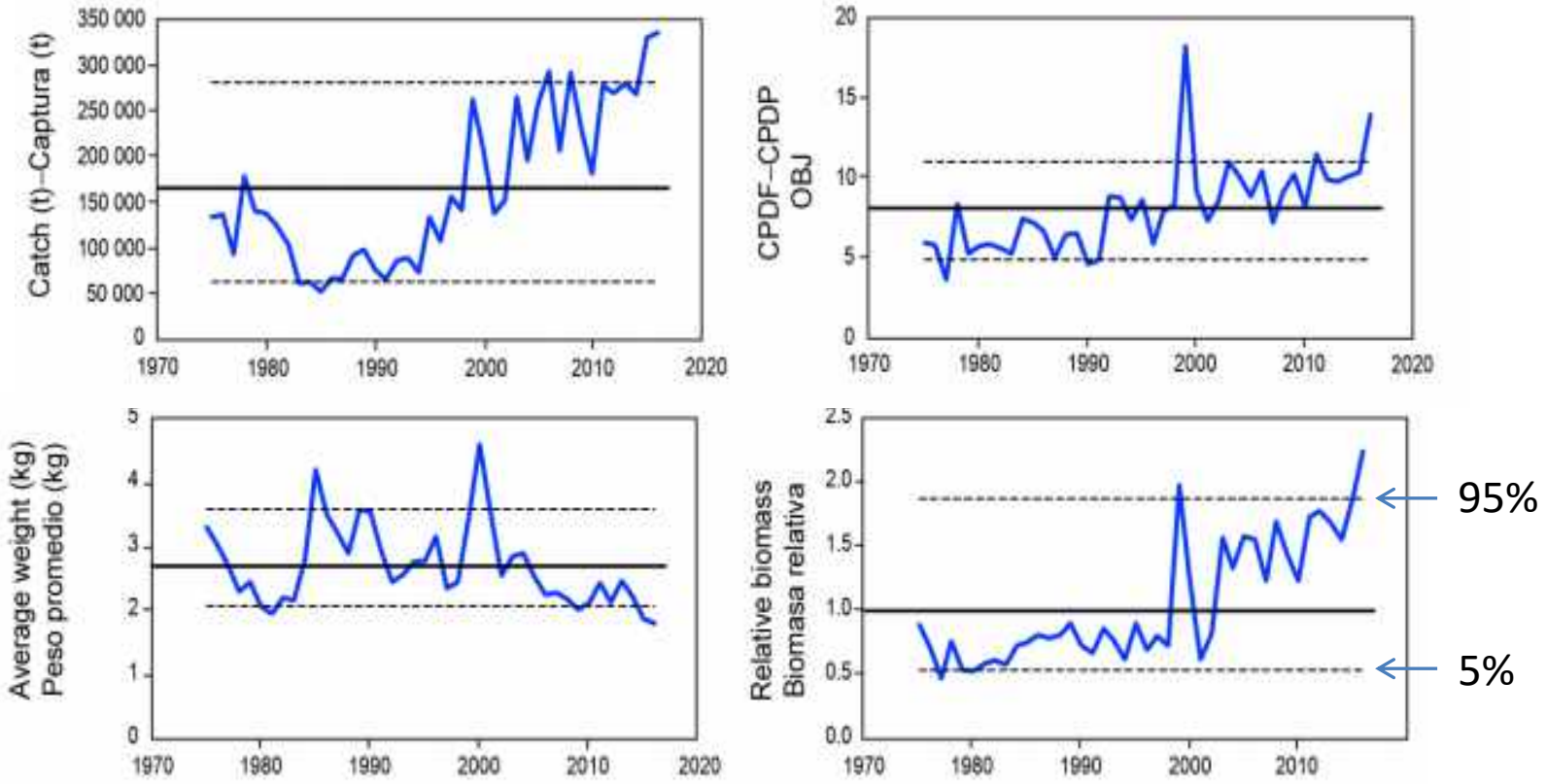
MSY Reference Points

- 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)



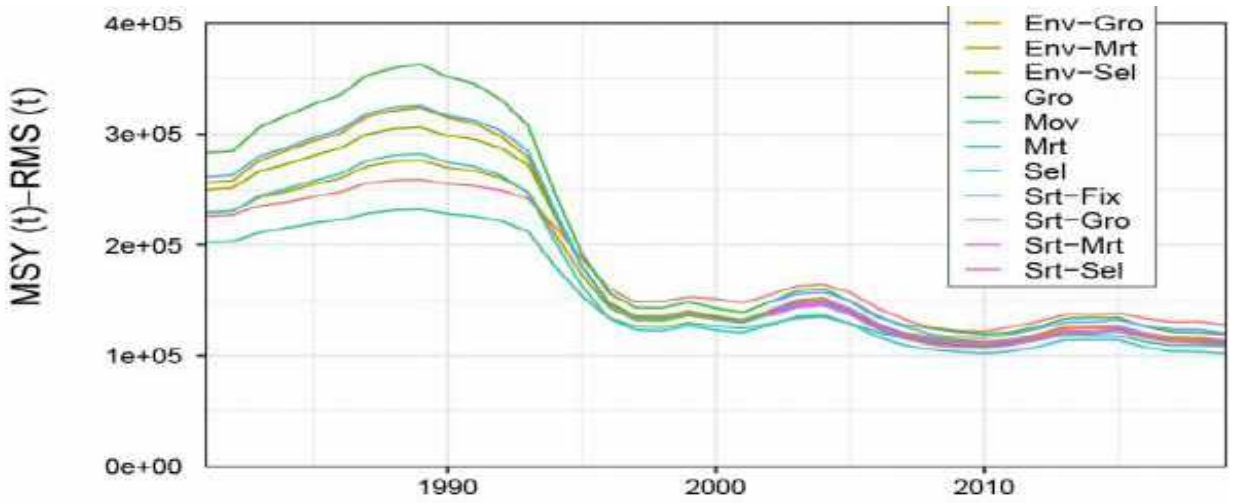
- PROS: Easier to compute, understand and communicate.
- CONS: Not commonly used, potential confounding of fishery and population processes, not clear if they are robust. Need evaluation

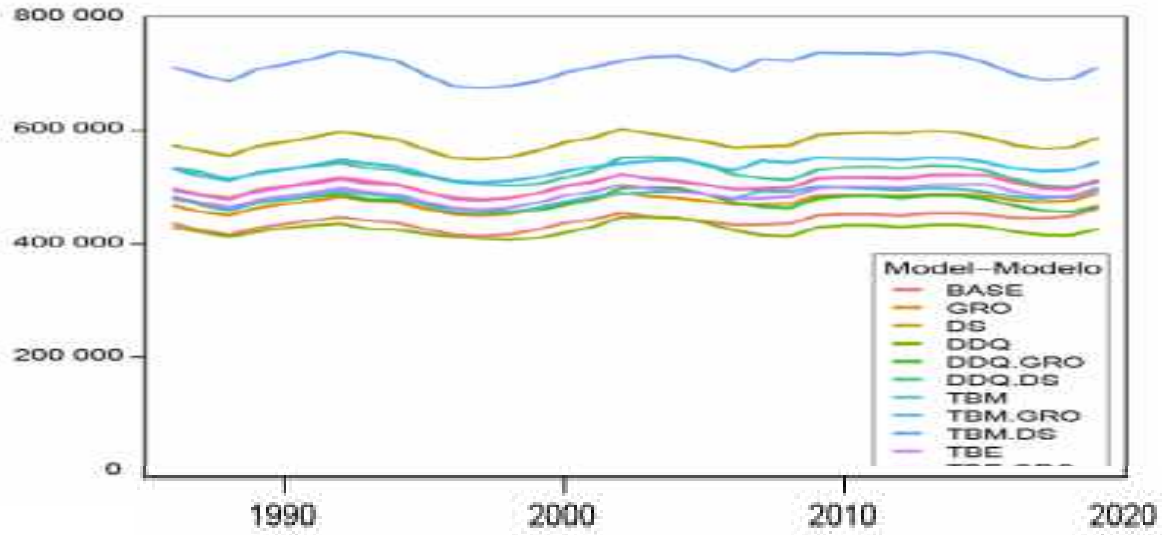
IATTC Target and Limit Reference Points

- 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).

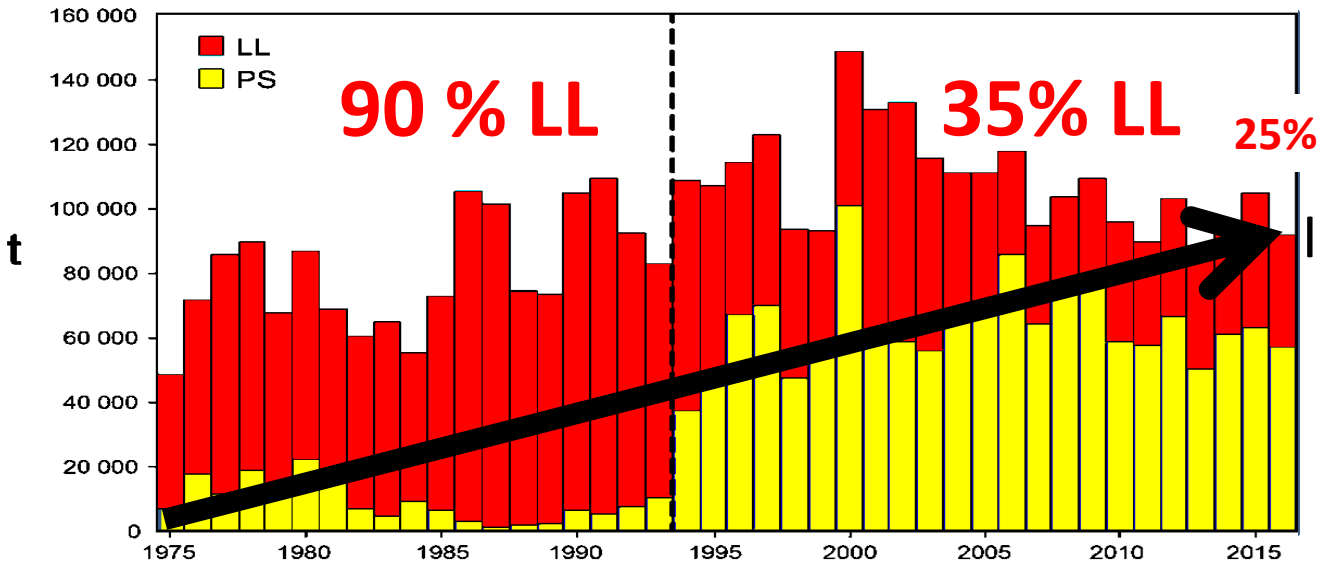
IATTC Target Reference Point

- 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

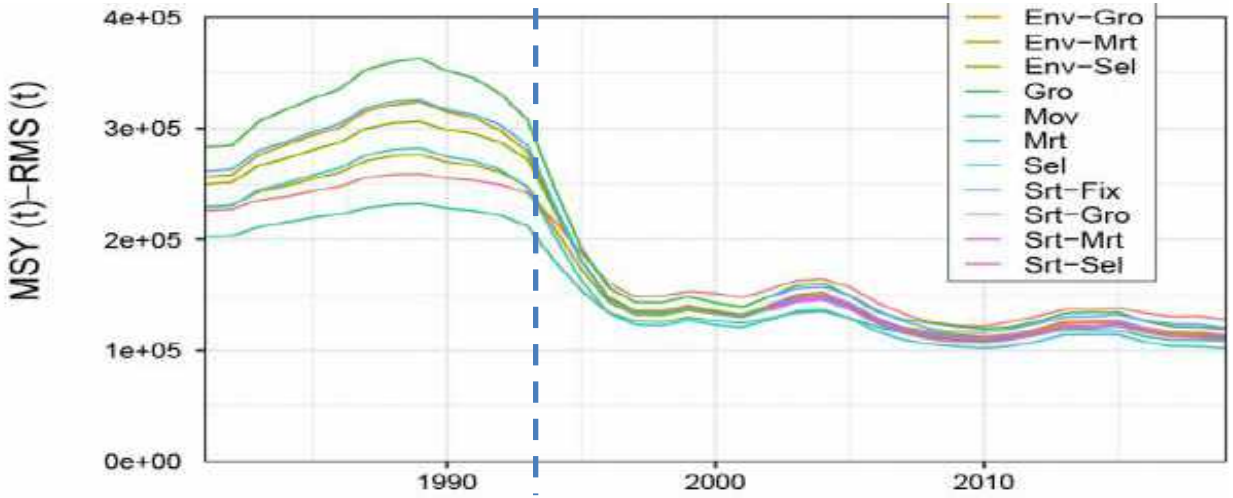




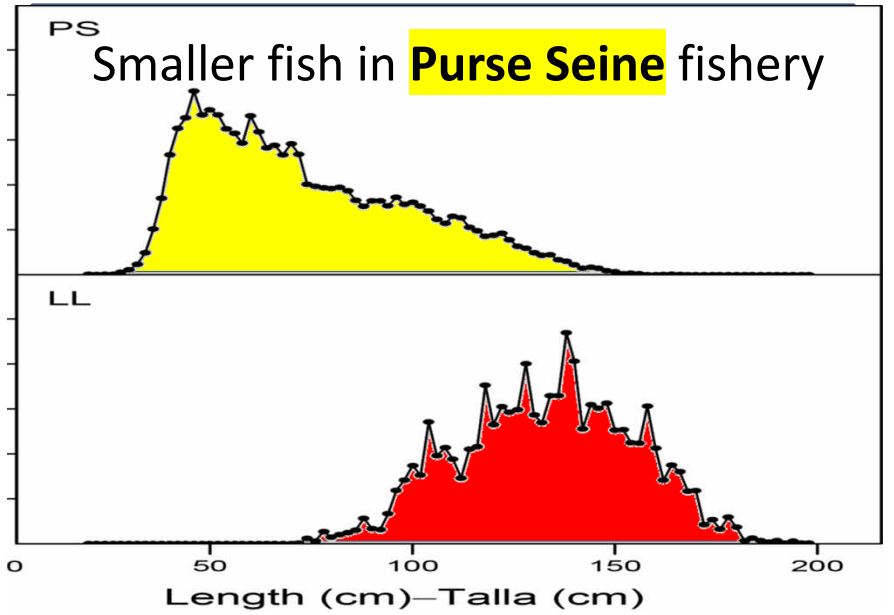
Decrease in Longline (Bigeye tuna)



Increased **TOTAL** catch



Expansion of **Purse Seine**



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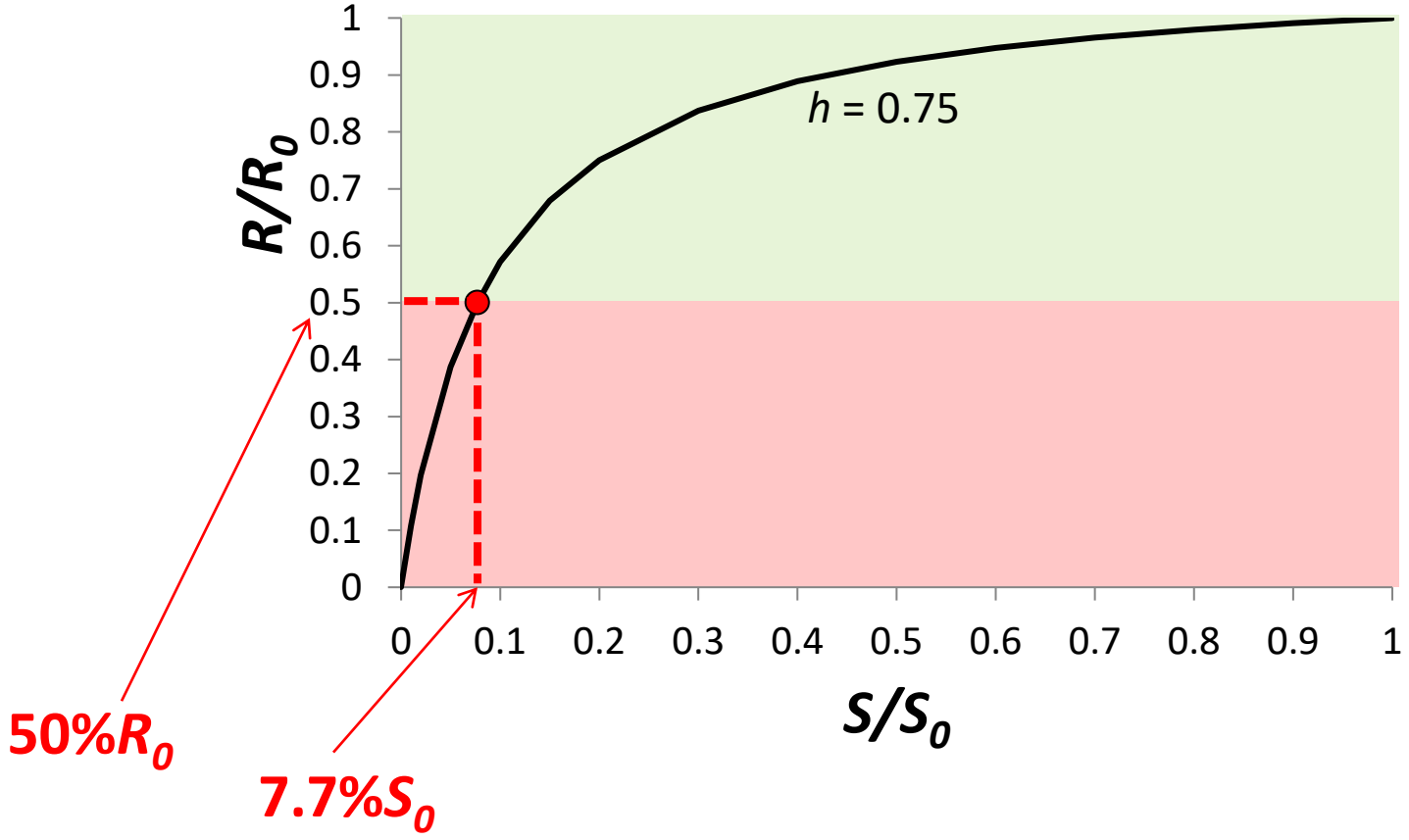

MSY Reference Points

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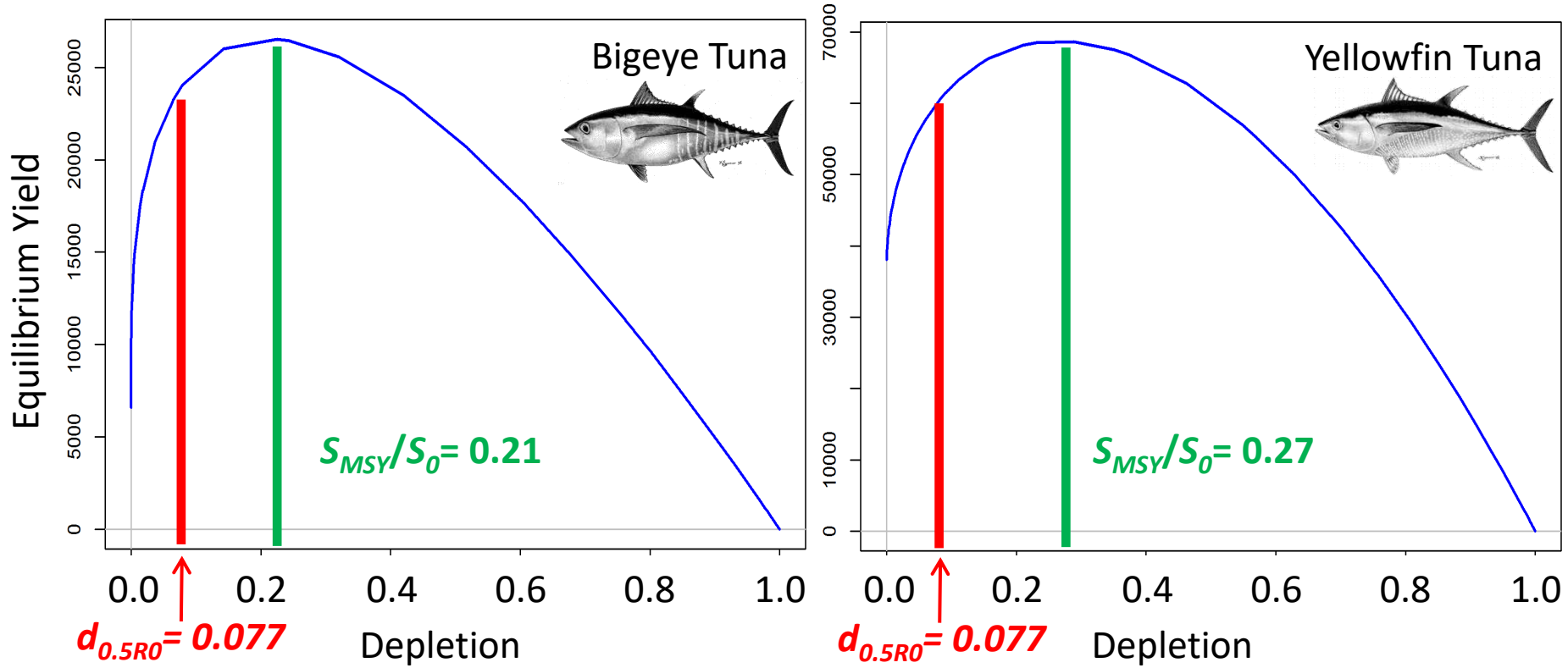

Other Limit Reference Points

- 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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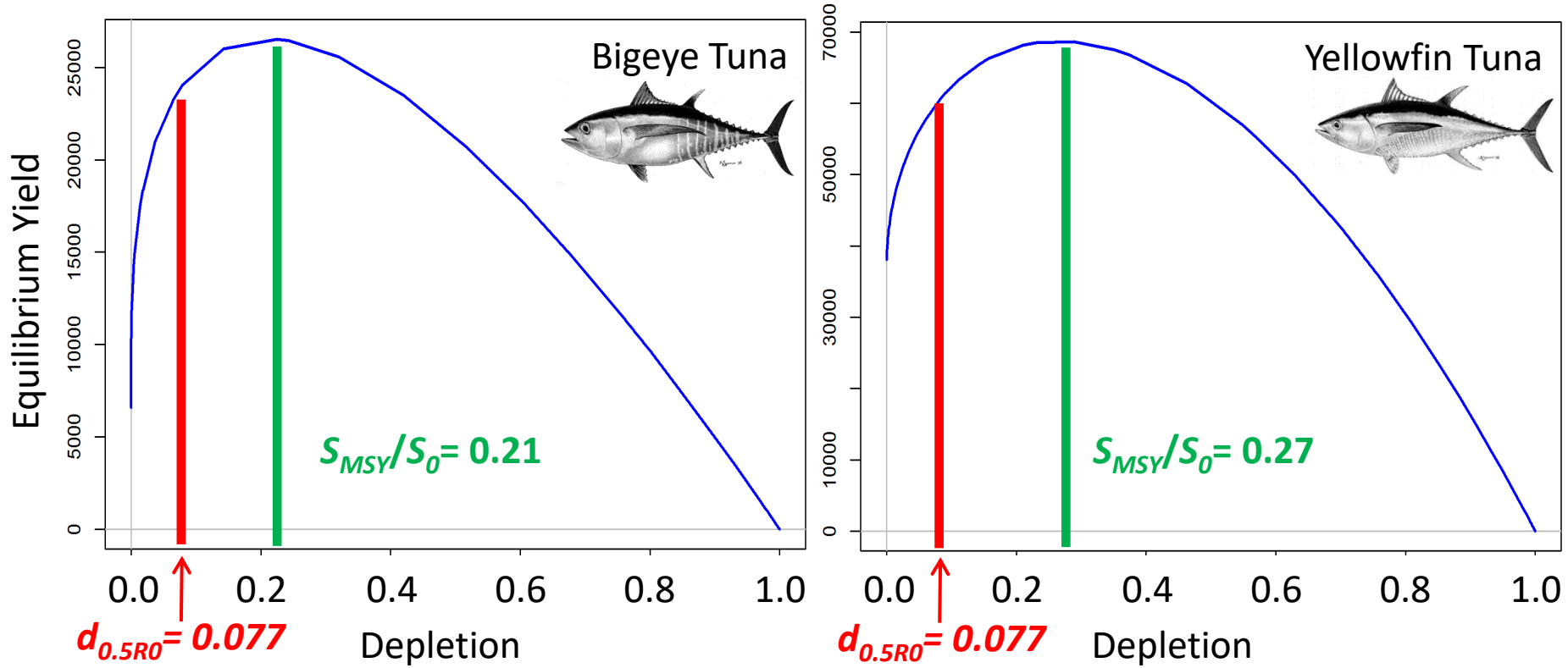

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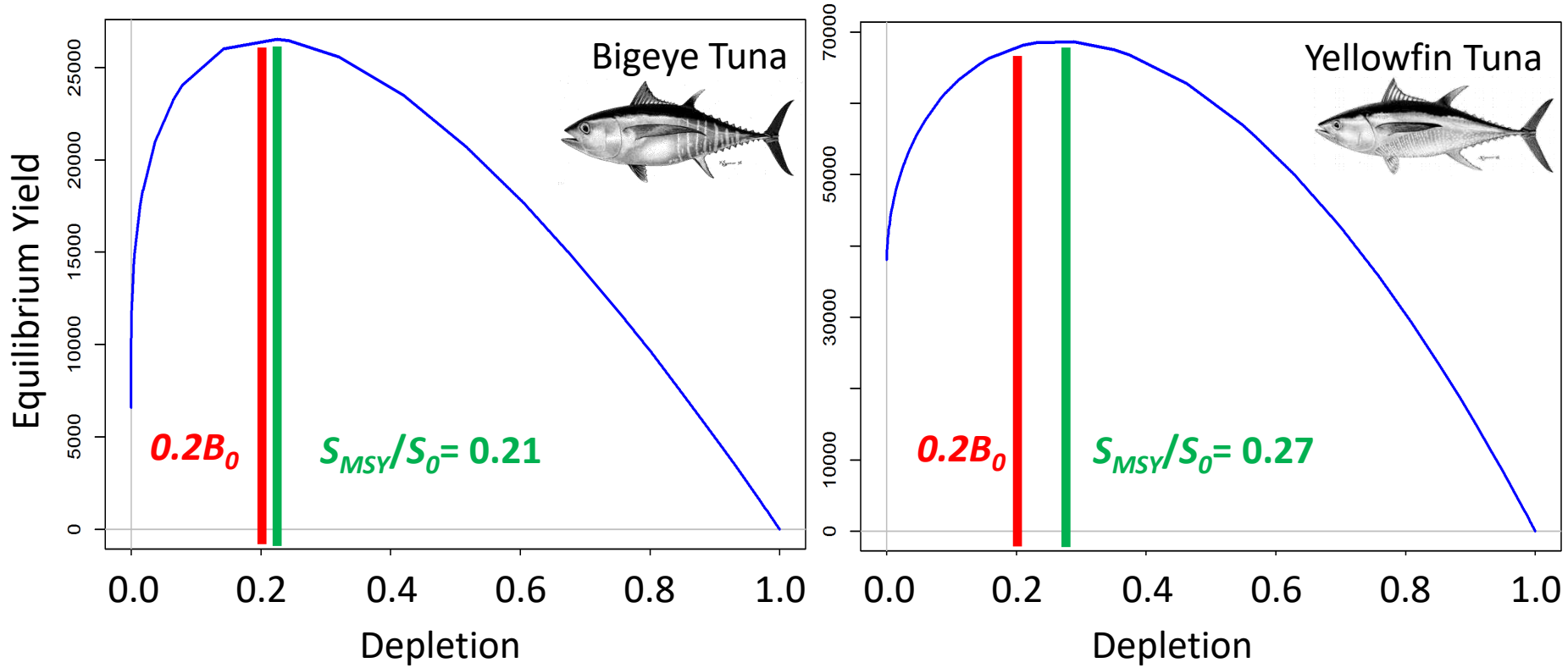

Tropical tuna reference points, Harvest Control Rules, tuna RFMOs

RFMO / Element	CCSBT	IATTC	ICCAT	IOTC	WCPFC
LRP	None	$F_{0.5R0}$ and $B_{0.5R0}$ with steepness of 0.75. Relates to a depletion of 0.077B0. (interim limits)	Pez espada N. Atlantico: 0.4 B_{RMS} (limite interino) Bluefin 40% of dynSSB$_{MSY}$	Atunas tropicales: 0.4 B_{RMS} (BET 0.5 B_{RMS}) y 1.4*F_{RMS} 1.3*F_{RMS} SKJ 0.2SSB_0 y F 0.2*SSB_0	Atunes tropicales y S. Pacific albacora: 0.2 $SB_{F=0}$ (0.2B_0) evaluado usando niveles de reclutamiento recientes
TRP	Interim 30%TRO achieved with 50% probability by 2035	B_{MSY} and F_{MSY}	Cuadrante “Verde" de grafica de Kobe	Atunas tropicales, albacora B_{RMS} and F_{RMS}	Ninguno para BET ni YFT Skipjack 0.5$B_{F=0}$
HCR	Empirical (gene-tagging, CPUE and Close-Kin Mark Recapture indices)	Model-based: Reduce F to F_{MSY} if it exceeds this value. Si 10% o mayor probabilidad de exceeder el limite	Empirica para Atlantic bluefin tuna	Modelo-basada para SKJ, BET	Ninguno

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
  - $F_{multiplier}$ for YFT with large increase in 2020
  - 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 from previous Workshops

- 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

Alternative Reference Points to consider for BET MSE

- Dynamic & Equilibrium Reference Points
  - –Dynamic targets F_{MSY} and B_{MSY} (probability around them not defined, 50%, 60%, 75%?)
  - –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
- 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?
- Control points of HCR vs Limit and Target reference points
  - –Consider terms such as HCR control parameters (defining management action) vs. RP (defining status)
- Suggestions by the US emailed to Staff

Proposed Reference Points

Based on submission by the USA delegation

Target RP	**Threshold**	**Limit RP**
*F*40 and *F*30 $SSB_{40\%}$ and $SSB_{30\%}$		F_{MSY}; 0.5*B_{MSY}
*F*40 and *F*30	SSB30% or SSB20%	F_{MSY}; 0.5*B_{MSY}
*F*40 or *F*30	SSB30% or SSB20%	$F_{0.5R0}$ and $S_{0.5R0}$, where h = 0.75 ($S_{0.5R0}$ is equivalent to **7.7% SSB_0**)

CIAT
IATTC

Questions?