REFERENCE POINTS, DECISION RULES, AND MANAGEMENT STRATEGY EVALUATION FOR TUNAS AND ASSOCIATED SPECIES IN THE EASTERN PACIFIC OCEAN

Mandate

- The Antigua Convention commits the IATTC to applying the precautionary approach, in accordance with the United Nations Fish Stocks Agreement (UNFSA)
- The UNFSA states that reference points and decision rules should be used
- The UNFSA further defines how reference points should be used in decision rules:
  - "Fishery management strategies shall ensure that the **risk of exceeding limit reference points is very low**. If a stock falls below a limit reference point or is at risk of falling below such a reference point, conservation and management action should be initiated to facilitate stock recovery. Fishery management strategies shall ensure that target reference points are not exceeded on average." (Annex II UNFSA 1995)
- The UNFSA provides minimum standards for some reference points
  - "The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points." (Annex II UNFSA 1995)
- and decision rules:
  - "For stocks which are not overfished, fishery management strategies shall ensure that **fishing mortality does not exceed that which corresponds to maximum sustainable yield**" (Annex II UNFSA 1995)
- Both the UNFSA and the Antigua Convention explicitly state that the amount of uncertainty should be taken into consideration when taking management action, and therefore it should be part of the decision rule

IATTC reference points

- The IATTC has historically used an informal decision rule that is based F_{MSY}
- Implying that F_{MSY} is a target reference point (TRP).
- This is **inconsistent with the precautionary approach**, which states that F_{MSY} is a limit reference point (LRP), and LRPs should have a low probability of being exceeded.
- The spawning biomass corresponding to maximum sustainable yield (B_{MSY}) has also been used as an informal reference point, but it is not clear if B_{MSY} has been used as a target or a limit reference point.
- These informal reference points are based on the original IATTC Convention of 1949, which states that the goal of management is to maintain stocks at levels that support maximum sustainable yield:
  - "… to facilitate maintaining the populations of these fishes at a level which will permit maximum sustained catches year after year …" (1949 IATTC Convention)
  - "Recommend from time to time, on the basis of scientific investigations, proposals for joint action by the High Contracting Parties designed to keep the populations of fishes covered by this Convention at those levels of abundance which will permit the maximum sustained catch." (1949 IATTC Convention)
- One interpretation of the 1949 Convention is that the biomass must be at or above B_{MSY} otherwise MSY cannot be taken.

Reference points

- The precautionary approach states
  - Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low
  - The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points
- LRP based on fishing mortality should be at most F_{MSY}, and the TRP considerably lower than F_{MSY}.
- By analogy any biomass-based LRP should be at least B_{MSY}, and the TRP should be considerably higher than B_{MSY}.
- TRPs should be defined based on the assessment uncertainty

Reference points: uncertainty

- The calculation of MSY and the associated reference points requires knowledge of several biological (*e.g.* growth, natural mortality, stock-recruitment relationship) and fishery (*e.g.* selectivity) related quantities.

- In particular, the stock-recruitment relationship is difficult to estimate

- Precautionary reference points based on spawner per recruit (SPR)

- An alternative approach is to estimate the MSY based quantities assuming a precautionary value for the steepness of the stock-recruitment relationship.
    - Zhu *et al.* (2012) showed that, due to the yield curve being flat when steepness is high, the risk of loss in equilibrium yield is lower if steepness is under-estimated rather than over-estimated. However, there may be loss in short-term yield if fishing mortality has to be reduced.

- For some stocks, the absolute level of the population size and fishing mortality is difficult to estimate and standard reference points are not appropriate.
    - Reference points based on historical biomass or fishing mortality levels may provide LRPs based on the assumption that those levels occurred in the past and the population remained sustainable, but the outcome is unknown if they are exceeded.

Reference points

Ref. point	Limit/Target	Quantity	Description
F_{MSY}	Limit	F	F that corresponds to MSY
B_{MSY}	Limit	B	F that corresponds to MSY
$SPR_{x\%}$	Target/Limit	B	B that corresponds to $SPR/SPR_{F=0} = x$
$F_{SPRx\%}$	Target/Limit	B	F that corresponds to $SPR/SPR_{F=0} = x$
$B_{MSYx\%}$	Target	B	The (upper) x% of the CI for B that corresponds to MSY
$F_{MSYx\%}$	Target	F	The (lower) x% of the CI for F that corresponds to MSY
$B_{x\%}$	Limit	B	The (lower) x percentile of the historic biomass estimates
$F_{x\%}$	Limit	F	The (upper) x percentile of the historic fishing mortality estimates
$B_{MSYh=x}$	Target	B	The biomass corresponding to MSY when steepness of the stock-recruitment relationship is set at a precautionary level
$F_{MSYh=x}$	Target	F	The fishing mortality corresponding to MSY when steepness of the stock-recruitment relationship is set at a precautionary level

Decision Rules

- Specifies the action that is taken given the current status of the fishery.
- A common decision rule is fishing mortality as a function of biomass, using biomass-based reference points to control changes in the fishing mortality. F
- The minimum standards outlined in the precautionary approach can be used to define a decision rule based on the following guidelines:
  - B_{MSY} should be considered a limit;
  - The risk of exceeding the limit reference point should be very low;
  - Fishing mortality should not exceed F_{MSY}.
- A simple rule could be to set the fishing mortality rate at a precautionary level (*e.g.* $F_{MSYx\%}$ or $F_{MSYh=x}$) independent of the biomass level.
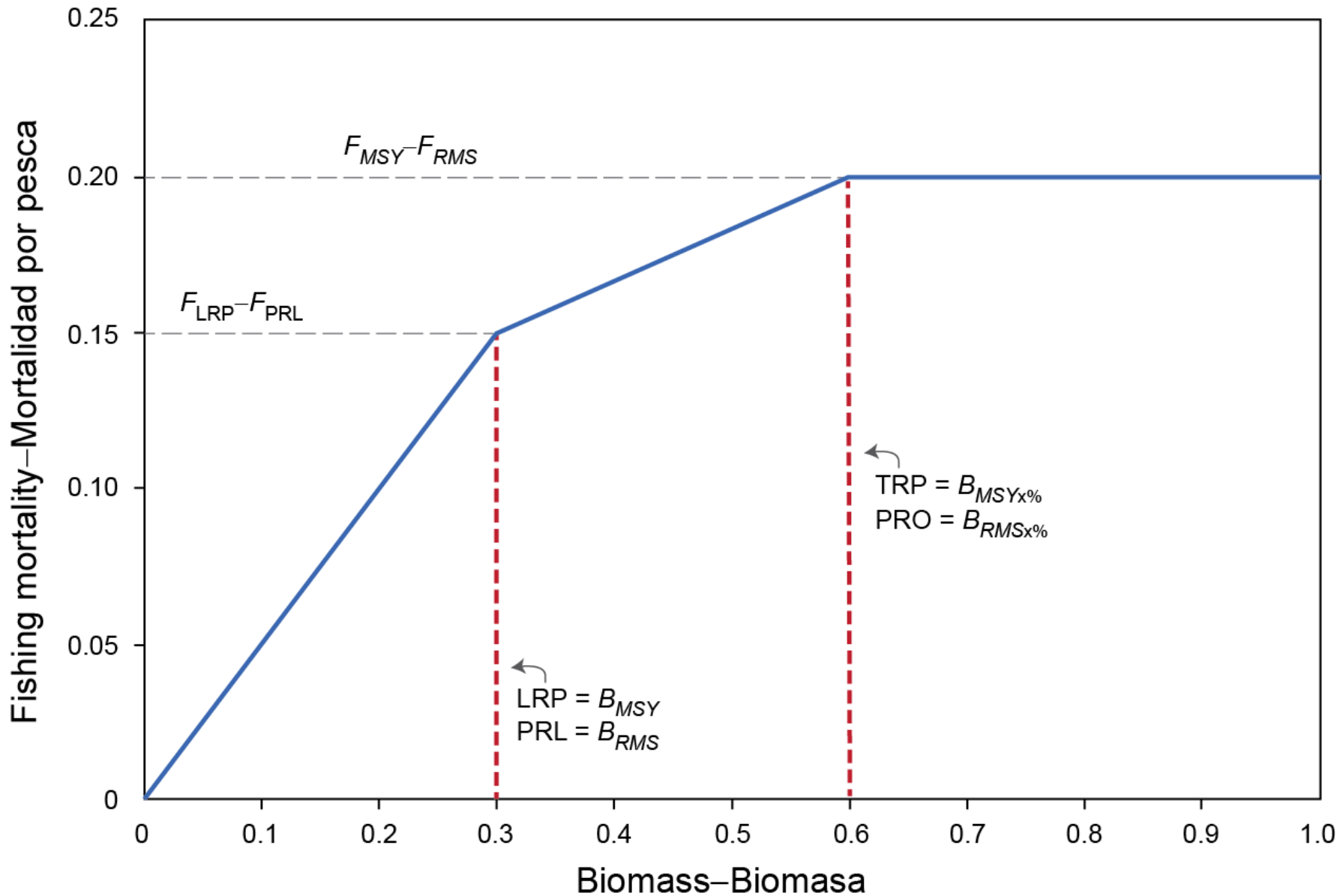
Discussion

- The Antigua Convention commits the IATTC to apply the precautionary approach, in accordance with the United Nations Fish Stocks Agreement (UNFSA), which requires the use of reference points and decision rules.

- It also puts several constraints on the construction of the reference points and decision rules.

- Many aspects of the decision rules are arbitrary and it is not possible to make objective decisions about these aspects based on scientific information alone.

- Comprehensive management strategy evaluation should be used to identify the most appropriate reference points and decision rules.

- To encourage the development of a set of candidate decision rules. Following the precautionary approach, the LRP = B_{MSY} and the fishing mortality above the TRP is F_{MSY}.

Possible reference points for a decision rule

Quantity	Candidate	Description
TRP	$B_{MSY,h=0.75}$	B_{MSY} calculated with steepness of the stock-recruitment relationship set at 0.75
	$B_{MSY,20\%}$	The 20% percentile of the confidence interval of B_{MSY}
	$B_{MSY,F=0.9FMSY}$	Equilibrium biomass calculated fishing at 90% of F_{MSY}
F_{LRP}	$F_{MSY,h=0.75}$	F_{MSY} calculated with steepness of the stock-recruitment relationship set at 0.75
	$F_{MSY,20\%}$	The 20% percentile of the confidence interval of F_{MSY}
	$0.9F_{MSY}$	F_{MSY} multiplied by 0.9
$B_{F=0}$	0	Biomass is equal to zero
	B_{min}	The lowest observed biomass