Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

CIAT
IATTC

PROPOSED CANDIDATE HARVEST STRATEGY FOR BIGEYE TUNA IN THE EASTERN PACIFIC OCEAN

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Outline

1. Introduction
   - Background
   - Purpose

2. Reference points

3. Harvest Strategy
   - Management objectives
   - Harvest control rule
   - Estimation model
   - Management actions
   - Exceptional circumstances
   - Other tropical tuna species

Introduction: main tasks

- Clarify the definition and use of reference points with respect to harvest strategies
- Present the staff's proposed candidate harvest strategy
- Discuss the components of harvest strategies

Introduction: goal

- Create a list of fully specified alternative candidate harvest strategies
  - Motivate the development of alternative harvest strategies
  - The staff's candidate and its components can be used as a starting point for defining alternative candidate harvest strategies

Questions and discussion

Questions and discussions after each section

Introduction: using best available science

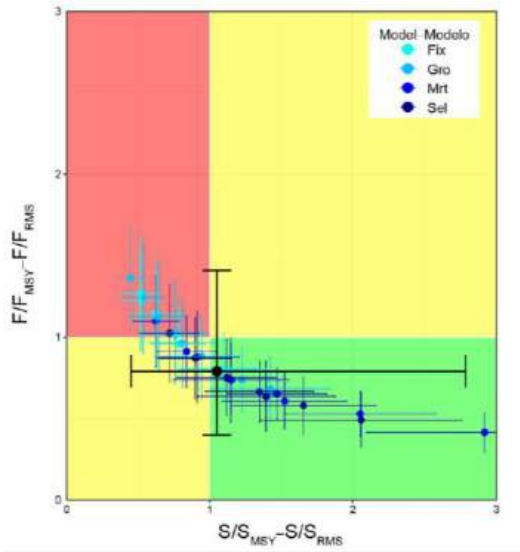
- Based on understanding of
  - Stock dynamics
  - Fisheries
  - Stock assessment performance
  - MSEs of other stocks
    - (e.g., Pacific bluefin, IOTC bigeye)
- Ensures all candidate harvest strategies have potential
- Makes most use of limited resources for MSE testing

Reference points

- Uses
  - Stock status
  - Trigger Management action
  - Harvest control rule parameters
  - Performance metrics
- Types
  - Target: desirable state
    - Aim to ensure long-term sustainability of the stock and fishery
  - Limit: undesirable biological state
    - E.g., critically low biomass levels that could lead to recruitment failure
    - Requires immediate management action
    - Very low probability of being breached (UN-FSA)
  - Biomass
  - Fishing mortality

Reference points: Stock status

- Categorize stocks by their exploitation status
  - Overfished
  - Overfishing
- Stock status summaries (e.g., Kobe plots)
- Fishery certification and ecolabeling programs (e.g. MSC certification)
- MSY-related quantities used traditionally
- Whether considered targets or limits, and overfished or overfishing, has evolved over time.
- Harvest strategy objectives not necessarily align with stock status



Reference points: Trigger Management action

- IATTC adjusts fishing closures to achieve FMSY
- Informal harvest strategy (C-23-06) requires a rebuilding plan when the limit reference points are exceeded with a 10% probability

Reference points: Harvest control rule parameters

- Incorporating reference points into an HCR helps drive the stock toward target levels and away from limits.
- May be inappropriate when
  - The desired probability of exceeding those reference points differs from 50%
  - The estimation model (EM) is “biased” with respect to average of the possible alternative states of nature (i.e., the operating models used for testing within an MSE).
- HCR may have completely independent control points that define the shape of the HCR
- Limit reference point may be treated as an exceptional circumstance

Reference points: Performance metrics

- Reference points can be used to develop metrics for evaluating the performance of HCRs within a MSE framework
- Specific definitions of stock status may not necessarily be the objective of management (e.g., the desired biomass may be higher than the overfished level due to economic, social, or ecosystem considerations)
- Relevant performance metrics or additional performance metrics may differ from the stock status reference points

Reference points: IATTC Target

- Adopted interim limit and target reference points (Resolution C-16-02 and its amendment C-23-06)
- Used in the IATTC's interim HCR for tropical tunas (Resolution C-16-02 amended by C-23-06):
- **Target Reference points:**
  - **D**ynamic S_{MSY}
  - F_{MSY}.
  - Staff proposed new "proxy" reference points for tropical tuna $S_{30\%}$ (SAC-15-05),
    - Used as proxies for skipjack
  - Interim HCR "… *attempt to prevent the fishing mortality rate (F) from exceeding the best estimate of the rate corresponding to the maximum sustainable yield (FMSY)* …"

Reference points: IATTC Limit

- **Limit Reference points:**
  - 7.7% of equilibrium virgin spawning biomass ($S_{7.7\%}$; based on a conservative steepness of *h*: 0.75 and 50% reduction in recruitment)
  - Fishing mortality associated with $S_{7.7\%}$ ($F_{7.7\%}$).
- Use in informal harvest strategy
  - *"If the probability that F will exceed the limit reference point (FLIMIT) is greater than 10%, … management measures shall be established that have a probability of at least 50% of reducing F to the target level (FMSY) or less, and a probability of less than 10% that F will exceed FLIMIT."*
  - *"If the probability that the spawning biomass (S) is below the limit reference point (SLIMIT) is greater than 10%, … management measures shall be established that have a probability of at least 50% of restoring S to the target level (dynamic SMSY) or greater, and a probability of less than 10% that S will descend to below SLIMIT in a period of two generations of the stock or five years, whichever is greater."*

Reference points: Harmonization with WCPFC

- Resolution C-24-01 paragraph
  - *"The IATTC shall continue efforts to promote compatibility between the conservation and management measures adopted by the IATTC and WCPFC in their goals and effectiveness …"*
- WCPFC limit reference point
  - $dS_{20\%}$: 20 percent of the estimated recent (last 10 years) average spawning potential in the absence of fishing
  - Tuna stocks have declined below S20% without catastrophic reduction in recruitment (e.g., Pacific bluefin; EPO bigeye)
  - May be more related to definitions of overfished and overfishing
  - More suited as a control point in a HCR
- IATTC limit reference points
  - $S_{7.7\%}$ and $F_{7.7\%}$
  - Expected to cause a large reduction in recruitment
  - Breached with very low probability
  - Requires rebuilding plan
  - More suited as an exceptional circumstance in a harvest strategy

Reference points: Use in a harvest strategy

- Target reference points
  - S30% and F30% proposed based on a more global definition of MSY (SAC-15-05)
  - Takes into account
    - Selectivity of different gear types
    - Possibility of a stock-recruitment relationship
  - Harvest strategy objective (S30%)
  - Fishing at F30% gets you to S30%
  - HCR maximum fishing mortality (Fmax = F30%)
- Limit reference points
  - S20%
    - Stock size that is undesirable, but not catastrophic
    - Control point for the HCR when fishing mortality decreases
  - S7.7%
    - Additional strict management action (e.g. a rebuilding plan) needs to be taken when there is a very low probability the limit has been breached
    - Exceptional circumstance

Reference points: Discussion

"Reference" points for use in the HS:

HS Objective: $S_{30\%}$

HCR Fmax: $F_{30\%}$

HCR control point: $S_{20\%}$

Exceptional circumstances limit: $P(S < S_{7.7\%}) \geq 10\%$

Puntos de "referencia" para su uso en la EE:

Objetivo EE: $S_{30\%}$

Fmax RCE: $F_{30\%}$

Punto de control RCE: $S_{20\%}$

Límite de circunstancias excepcionales: $P(S < S_{7.7\%}) \geq 10\%$.

Harvest Strategy: introduction

- Management objectives
- Type of strategy
- Management cycle
- Harvest control rule
- Estimation model
- Management actions
- Exceptional circumstances
- Other tropical tuna species

Harvest Strategy: Management objectives

- General objectives are defined in Article VII (c) of the IATTC's Antigua Convention, which states:
  - *"…to ensure the long-term conservation and sustainable use … and to maintain or restore the populations of harvested species at levels of abundance which can produce the maximum sustainable yield…"*
- Clearly, this implies that a minimum objective is to ensure that biomass remains at or above the level that produces maximum sustainable yield (MSY)
- Defining MSY can be complex.
  - MSY is dependent on the assumptions of selectivity
  - Historical changes in the catches of fishing fleets with very different selectivities (e.g. before the mid 1990s most of the BET catches were taken by longline consisting of adult bigeye, while after the 1990s most of the BET catches are taken by purse-seine consisting of juvenile BET).
- Implies a corresponding fishing mortality objective (FMSY)
- Additional objectives
  - Catch or effort levels, sometimes in reference to historical benchmarks
  - Stability in catch or effort
  - Avoidance of low biomass levels that could impair recruitment (e.g., the IATTC limit reference point of S7.7%)
- Align with those discussed by stakeholders during the IATTC MSE workshops

Harvest Strategy: Management objectives

- Purse seine vessels
  - IVT: Purse-seiners that catch large amounts of bigeye are penalized with additional closure days
  - Bigeye tuna is regarded as an “undesirable” or “bycatch” species
  - High catches of bigeye tuna in the purse seine fishery not a target objective
- Longline fisheries
  - High catch may be an objective for distant water longline fisheries, which have historically targeted bigeye in the EPO.
  - Catch is linked to the level of spawning biomass. Therefore, an objective for spawning biomass can also support the objective of longline catch.
- SMSY ≈ 22%
  - Only slightly above the LRP of S20% used at WCPFC.
  - IATTC staff previously recommended S30% as an alternative proxy

Harvest Strategy: Management objectives discussion

Objectives:

Maintain stock at or above $S_{30\%}$: $S \geq S_{30\%} \geq S_{MSY}$

Maintain stock above limit RP with very high probability: $S >> S_{7.7\%}$

Maintain F below reference level: $F \leq F_{2019\text{-}2021}$

Long term stability of catch and effort

Reduction in the closure of the purse-seine fishery

Elimination of the *corralito*

Objetivos:

Mantener la población en o por encima de $S_{30\%}$: $S \geq_{30\%} \geq S_{RMS}$

Mantener la población por encima del RP límite con muy alta probabilidad: $S >> S_{(7.7\%}$

Mantener F por debajo del nivel de referencia: $F \leq F_{2019\text{-}2021}$

Estabilidad a largo plazo de la captura y el esfuerzo

Reducción de la veda de la pesquería cerquera

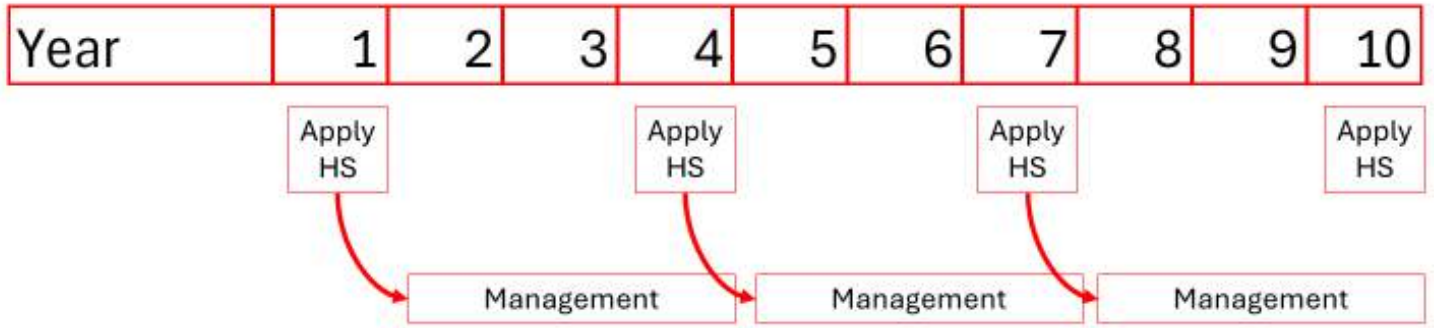
Eliminación del corralito

Harvest Strategy: Type of strategy

- Objective of maintaining stock status around the target reference point ($S_{30\%}$)
- Target is not relative to historical level (can't use empirical)
- No index of abundance from unexploited
- Dynamic spawning biomass needs to take recruitment into consideration
- Requires a stock assessment model

Harvest Strategy: Management cycle

- 3-year period fixed management
- Provides stability
- Used previously by the IATTC
- Employed by other t-RFMOs



Harvest Strategy: Harvest control rule

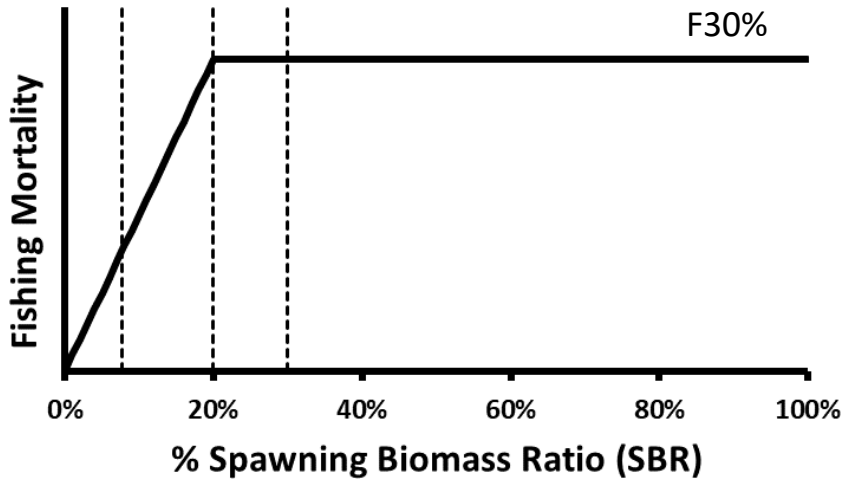
- **Guiding principles**
- Simple and designed to achieve the management objectives;
- F_{target} will cause the biomass to fluctuate around S_{target}
  - Assessment model reliably estimates fishing mortality
  - No probability statement (e.g. 75%)
  - (Tuning)
  - Even if $S < S_{target}$
- Action should be taken before a limit reference point is exceeded
- $S_{control}$ too close to the S_{target} may result in higher catch variability
- Management actions should not change abruptly

Harvest Strategy: Harvest control rule

- **Guiding principles**
- At low biomass levels (near the limit reference point), management actions should be guided by exceptional circumstances, not the HCR.
  - HCR is designed to keep the biomass away from these levels
  - Likely that the stock or fishery dynamics is different than tested in the MSE
  - EM is not performing correctly
  - HCR may have to be specified for all levels of biomass to facilitate MSE testing
- Fishing mortality should not exceed historically observed levels.

Harvest Strategy: Harvest control rule

- Fmax = F0.30%
  - Corresponding to target reference point
- Scontrol = S20%
  - Support stock rebuilding
  - Below the target to enhance catch and effort stability
  - Equal to the LRP used by the WCPFC
- The maximum allowed change is 10 days
  - Reduce variability in catch and effort
  - Prevent adverse outcomes
  - 15% of the current closure (not F)
- Fcur = average of the most recent three years
  - Minimize biases in recent year estimates and smooths out random fluctuations.



Harvest Strategy: Harvest control rule discussion

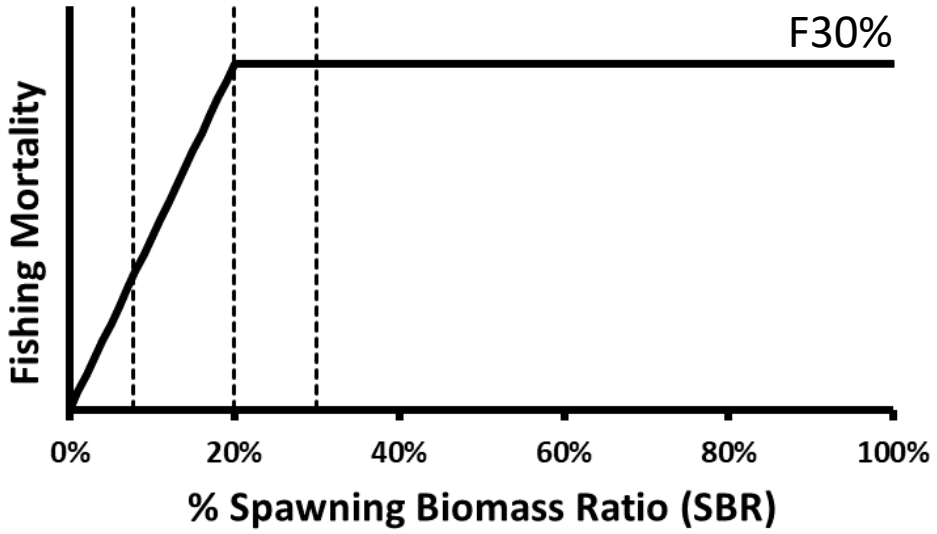
Harvest Control Rule: F_{30}-S_{20}

F_{MAX}: $F_{30\%}$

$S_{control}$: dynamic $S_{20\%}$

$S_{F=0}$: 0

Maximum allowed change (closure days): 10 days



Regla de control de extracción: F_{30}-S_{20}

F_{MAX}: $F_{30\%}$

$S_{control}$: $S_{20\%}$ dinámica

$S_{F=0}$: 0

Cambio máximo permitido (días de veda): 10 días

Harvest Strategy: Estimation model

- **Guiding principles**
- Assessment model is too computationally intensive for MSE testing
- EM should retain key features of assessment model
  - Ensure reliability and robust performance under untested circumstances
  - Longline CPUE index represents adult fish, while catch is primarily juveniles
  - Age-structured model is required
- The EM must accurately estimate fishing mortality for the life-stages managed by the HCR (i.e. juveniles).
- Estimates of abundance and F should not be highly sensitive to the addition of new years of data
- Needs to model recruitment variability
- Catch should be removed at correct size of fish (when not fitting composition data)

Harvest Strategy: Estimation model

- ASPM
  - Simplest assessment model that incorporates age-structure
  - Does not provide a good fit to the abundance index
- ASPM-Rdev
  - Estimates high F and low abundance (so recruitment explains fluctuations in index)
  - Predicted catch composition dominated by unrealistically small fish
- ASPM-Rdev+
  - Includes length composition data for the abundance index (which assumes dome-shape selectivity) and for the longline fishery (which assumes asymptotic selectivity)
  - Estimates their selectivities
  - Used for Pacific bluefin tuna

Harvest Strategy: Estimation model

- Uses base reference model
  - Management based on a risk assessment using an ensemble of models
  - Ensembles are used for the operating models
  - Single model needs to be chosen as the EM
- Pacific bluefin MSE showed that ASPM-Rdev+ EM performed poorly under regime shifts in recruitment
  - Large amount of catch consists of small fish
  - EM lacks information about recruitment
  - Biased estimates of fishing mortality
  - No reliable index of juvenile bigeye tuna abundance
  - F30%/Fcur is generally precise and unbiased
  - Effort-based management is more robust to changes in recruitment and assessment uncertainty

Harvest Strategy: Estimation model discussion

Estimation model (ASPM-Rdev+):

Age structured production model
Estimated recruitment
Fit to a subset of the length composition data
Base reference model assumptions

Data used:
Catch by fishery
Longline CPUE: Spatiotemporal standardized index of abundance
Length composition: Longline index and fishery

Modelo de estimación (ASPM-Rdev+):

Modelo de producción estructurado por edad
Reclutamiento estimado
Ajuste a un subconjunto de datos de composición por talla
Supuestos del modelo de referencia de base

Datos utilizados:
Captura por pesquería
CPUE de palangre: índice de abundancia estandarizado espaciotemporal
Composición por talla: Índice de palangre y pesquería

Harvest Strategy: Management actions

- Currently management
  - Temporal closures for purse seine vessels
  - Catch limits for longline vessels
  - Bigeye tuna Individual Vessel Thresholds (IVT)
  - Limits on fleet capacity, full retention requirements, limits on active FADs, Corralito
- Effort controls are preferable
  - Tropical tunas exhibit variable recruitment
  - Assessment uncertainty
- Temporal closures is the most appropriate approach
- The duration of the fishing season modified F_{HCR}/F_{cur}
- F_{cur} is based on the three most recent years
- Adjusted for increases in fleet capacity
- IVT program introduces complexity into the relationship between F and the closure
  - Fishing mortality likely to increase slower than open days
  - EM used in the HCR framework adjust for this nonlinearity over time.

Harvest Strategy: Management actions discussion

Management actions (calculation of PS closure days):

$$Closure_{new} = 365 - (365\text{-}Closure_{old})(F_{HCR}/Fcur)(C_{old}/C_{new})$$

Medidas de ordenación (cálculo de los días de veda de la pesquería PS):

$$Veda_{nueva} = 365 - (365\text{-}Veda_{antigua})\,(F_{RCE}/F_{act})(C_{antigua}/C_{nueva})$$

Harvest Strategy: Exceptional circumstances

- Ensure that factors not covered under the harvest strategy do not cause irreparable harm to the stock or fishery
- If triggered
  - Existing management measures remain in force, or
  - Management reverted to the 2025 levels, where specified
  - Until new management measures are agreed upon by the Commission

Harvest Strategy: Exceptional circumstances

- $P(S < S_{7.7\%}) > 10\%$ or $P(F > F_{7.7\%}) > 10\%$ based on the risk analysis from a full assessment, a rebuilding plan will be developed (Resolution C-23-06)
- $F_{HCR} > F_{2019\text{-}2021}$ then $F_{2019\text{-}2021}$ is substituted for F_{HCR}
- Harvest strategy is no longer appropriate
  - Full assessment
    - Regular
    - Changes in fishing operations or in stock biology
  - Updated MSE
  - Status indicators
  - Harvest strategy re-evaluated

Harvest Strategy: Exceptional circumstances

- Loss of critical data
  - Enhanced Monitoring Program (EMP) needs to be maintained to ensure the HS is effective
  - Longline CPUE index of abundance (or other data used in the EM)
- Closure exceeds 72 days
  - Alternative measures considered
- Longline catch exceeds its TAC it is re-evaluated
- Other tropical tuna stocks requires stricter management measures
- Reliable skipjack tuna assessment needed
  - Reduced closure mean higher skipjack F
  - Management will revert to 2025 levels
  - Requires tagging program initiated in 2026

Harvest Strategy: Exceptional circumstances discussion

Exceptional circumstances:

- The IATTC limit reference point is exceeded with a probability greater than 10%
- F_{HCR} is greater than the 2019-2021
- When a benchmark assessment, MSE, or indicators suggests the HCR is inappropriate
- Data becomes unreliable
- The EMP program (or its proposed alternative, the IPSP) is not continued or the IVT is evaluated to be ineffective
- The purse seine closure resulting from application of the HCR is more than 72 days
- Either yellowfin or skipjack requires stricter management
- Longline catch exceeds its TAC
- A reliable skipjack tun assessment is not available

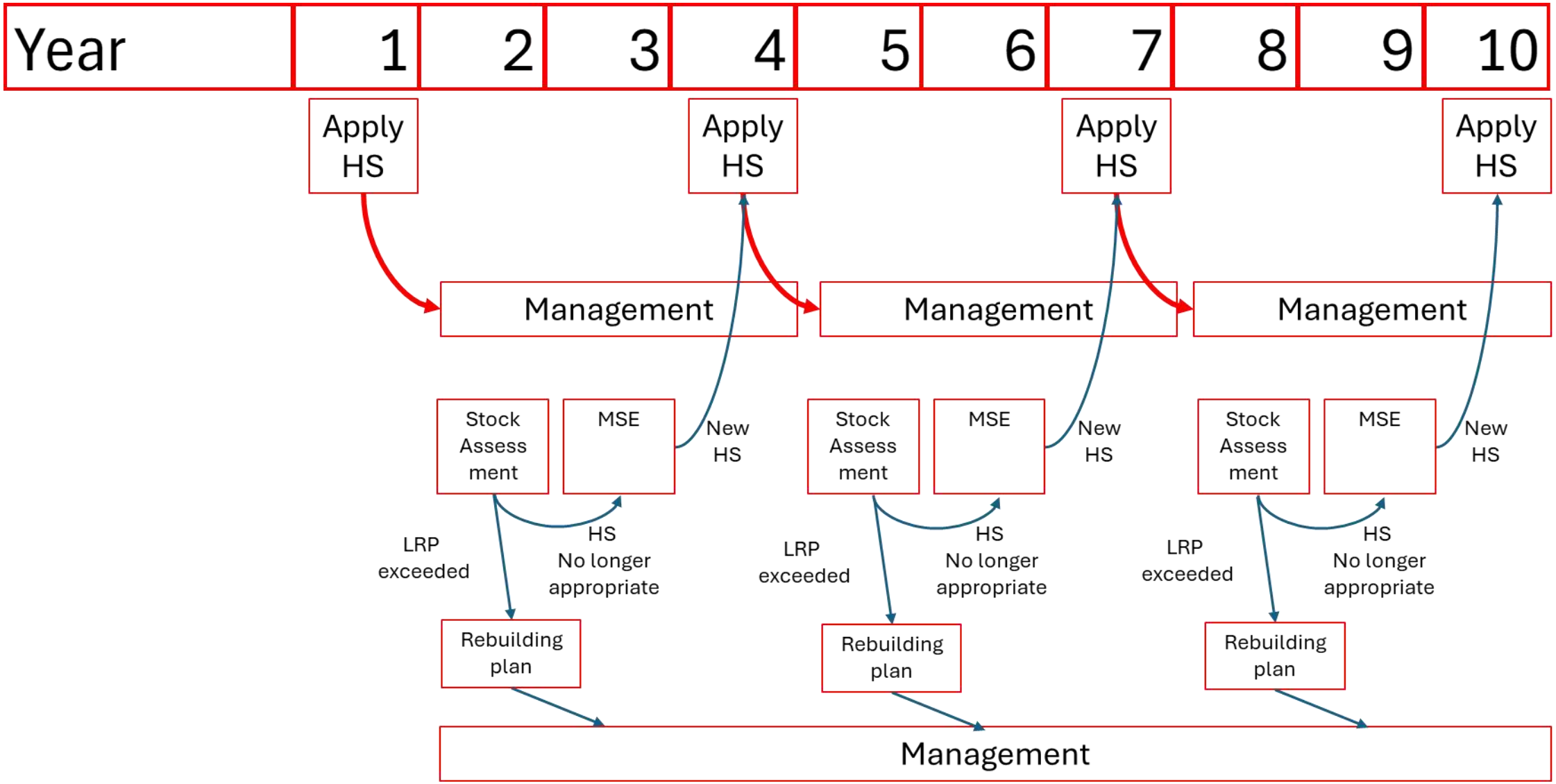
Circunstancias excepcionales:

- El punto de referencia límite de la CIAT se rebasa con una probabilidad superior al 10%.
- F_{RCE} es superior a la de 2019-2021.
- Cuando una evaluación de referencia, EEO o indicadores sugieran que la RCE es inadecuada.
- Los datos dejan de ser fiables.
- El PRM (o su alternativa propuesta, el PMIP) no se mantiene o el programa de UIB se considera ineficaz.
- La veda de la pesquería cerquera resultante de la aplicación de la RCE es superior a 72 días.
- El aleta amarilla o el barrilete requieren una ordenación más estricta.
- La captura de palangre rebasa su CTP.
- No se dispone de una evaluación fiable del barrilete.

Harvest Strategy: Other tropical tuna species

- Current HCR (Resolution C-23-06) will be applied to yellowfin and skipjack
- If either of these species requires a longer closure than bigeye it will be applied
- The HCR for each species updated as MSEs becomes available
- Changes to management not recommended unless a reliable skipjack tuna assessment is available
  - Depends on tagging program initiated in 2026

Harvest Strategy: Chronogram



Summary

"Reference" points for use in the HS:
HS Objective: $S_{30\%}$
HCR Fmax: $F_{30\%}$
HCR control point: $S_{20\%}$
Exceptional circumstances limit: $P(S < S_{7.7\%}) \geq 10\%$

Harvest Control Rule: F_{30}-S_{20}
F_{MAX}: $F_{30\%}$
$S_{control}$: dynamic $S_{20\%}$
$S_{F=0}$: 0
Maximum allowed change (closure days): 10 days

Exceptional circumstances:
- The IATTC limit reference point is exceeded with a probability greater than 10%
- F_{HCR} is greater than the 2019-2021
- When a benchmark assessment, MSE, or indicators suggests the HCR is inappropriate
- Data becomes unreliable
- The EMP program (or its proposed alternative, the IPSP) is not continued or the IVT is evaluated to be ineffective
- The purse seine closure resulting from application of the HCR is more than 72 days
- Either yellowfin or skipjack requires stricter management
- Longline catch exceeds its TAC
- A reliable skipjack tun assessment is not available

Objectives:
Maintain stock at or above $S_{30\%}$: $S \geq S_{30\%} \geq S_{MSY}$
Maintain stock above limit RP with very high probability: $S >> S_{7.7\%}$
Maintain F below reference level: $F \leq F_{2019\text{-}2021}$
Long term stability of catch and effort
Reduction in the closure of the purse-seine fishery
Elimination of the *corralito*

Estimation model (ASPM-Rdev+):

Age structured production model
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Base reference model assumptions

Data used:
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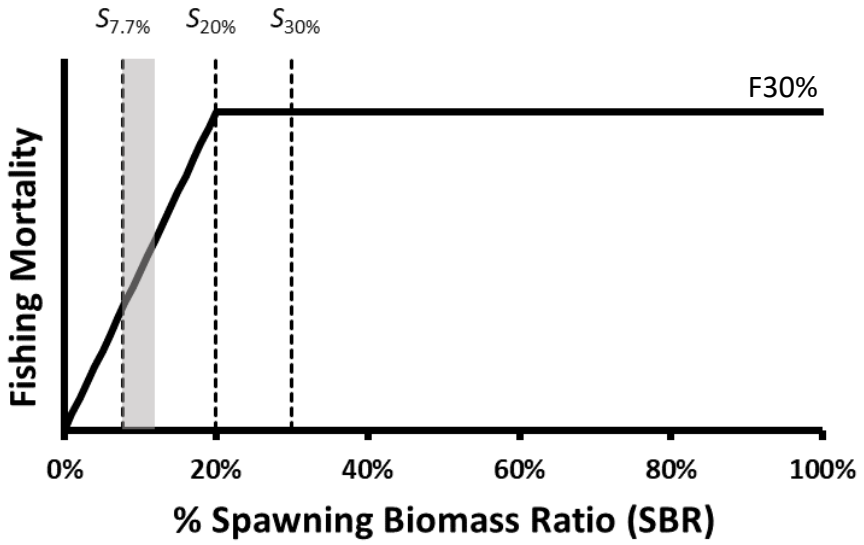


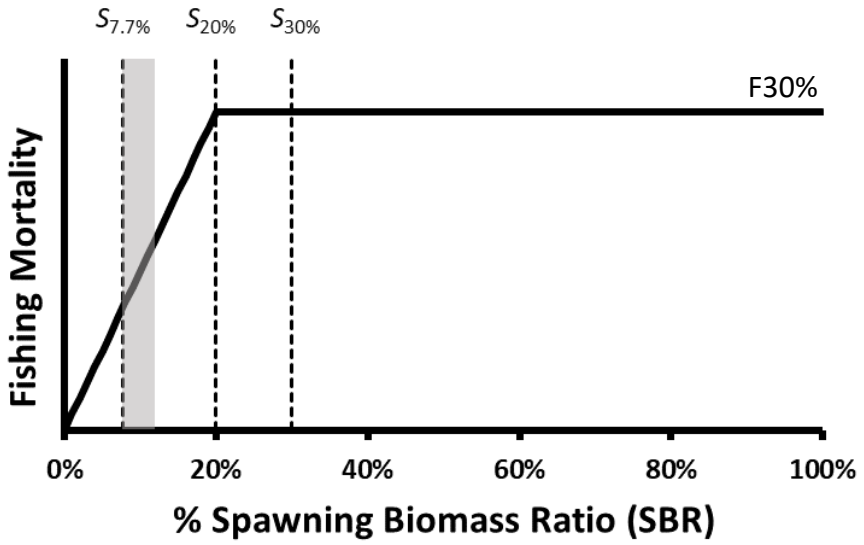
Management actions (calculation of PS closure days):

$Closure_{new} = 365 - (365\text{-}Closure_{old})(F_{HCR}/Fcur)(C_{old}/C_{new})$

Summary

Puntos de "referencia" para su uso en la EE:
Objetivo EE: $S_{30\%}$
Fmax RCE: $F_{30\%}$
Punto de control RCE: $S_{20\%}$
Límite de circunstancias excepcionales: $P(S < S_{7.7\%}) \geq 10\%$.

Objetivos:
Mantener la población en o por encima de $S_{30\%}$: $S \geq S_{30\%} \geq S_{RMS}$
Mantener la población por encima del RP límite con muy alta probabilidad: $S >> S_{(7.7\%}$
Mantener F por debajo del nivel de referencia: $F \leq F_{2019\text{-}2021}$
Estabilidad a largo plazo de la captura y el esfuerzo
Reducción de la veda de la pesquería cerquera
Eliminación del corralito



Regla de control de extracción: F_{30}-S_{20}
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Cambio máximo permitido (días de veda): 10 días

Modelo de estimación (ASPM-Rdev+):

Modelo de producción estructurado por edad
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Supuestos del modelo de referencia de base

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Composición por talla: Índice de palangre y pesquería

Medidas de ordenación (cálculo de los días de veda de la pesquería PS):

$Veda_{nueva} = 365 - (365\text{-}Veda_{antigua}) (F_{RCE}/F_{act})(C_{antigua}/C_{nueva})$

Circunstancias excepcionales:

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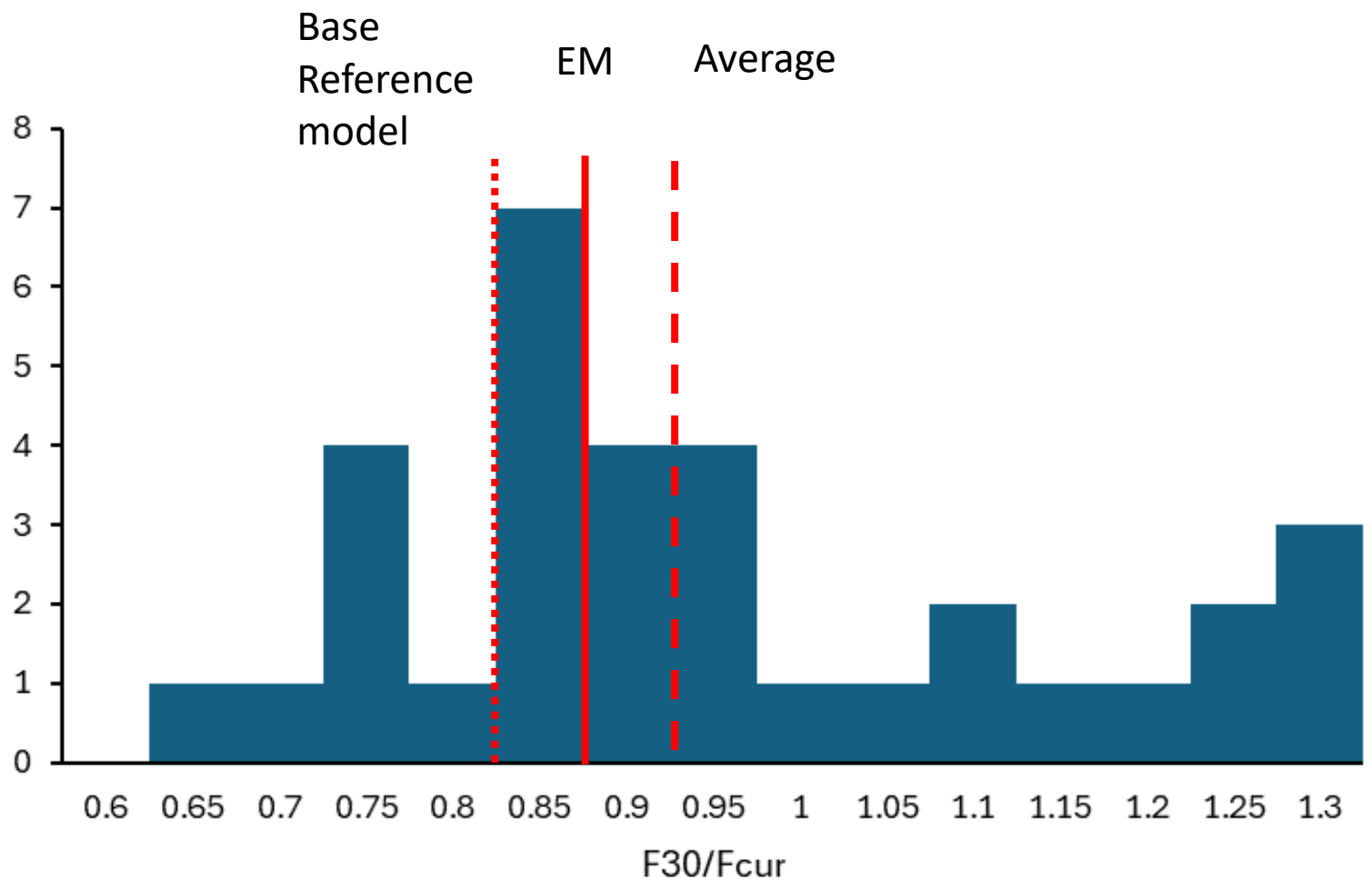
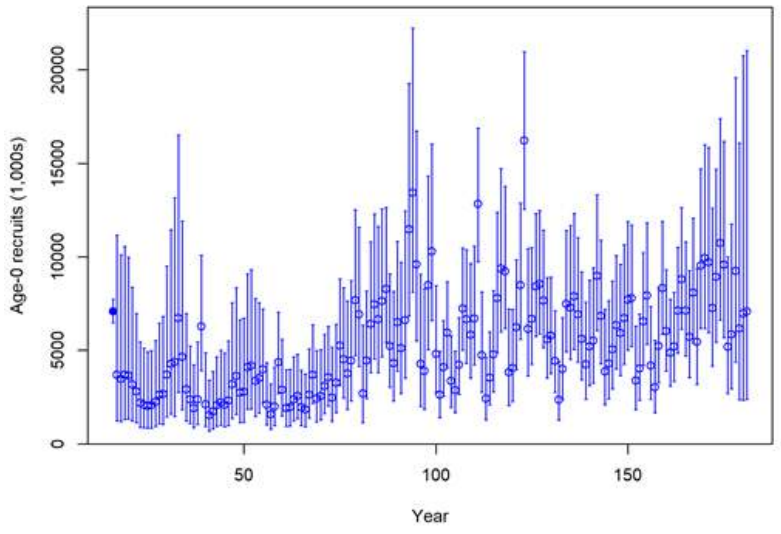
Questions

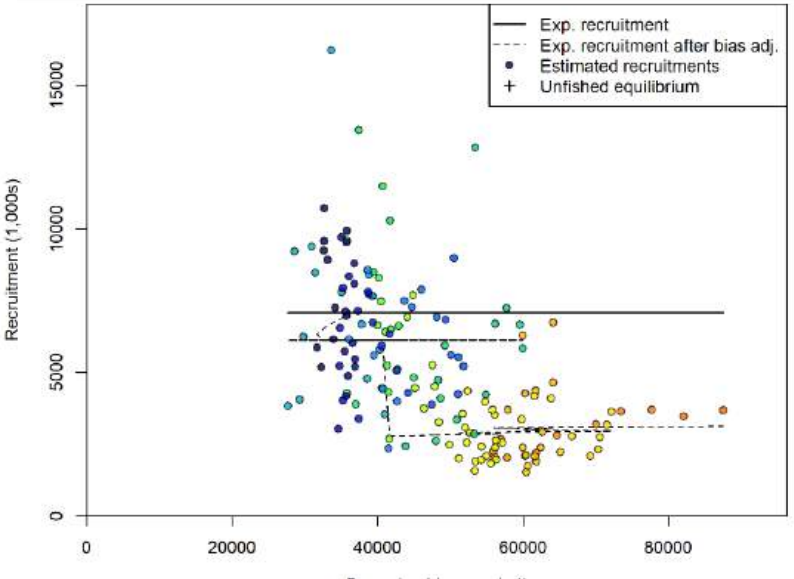
Tuning: 2024 assessment (2021-2023 Fcur)



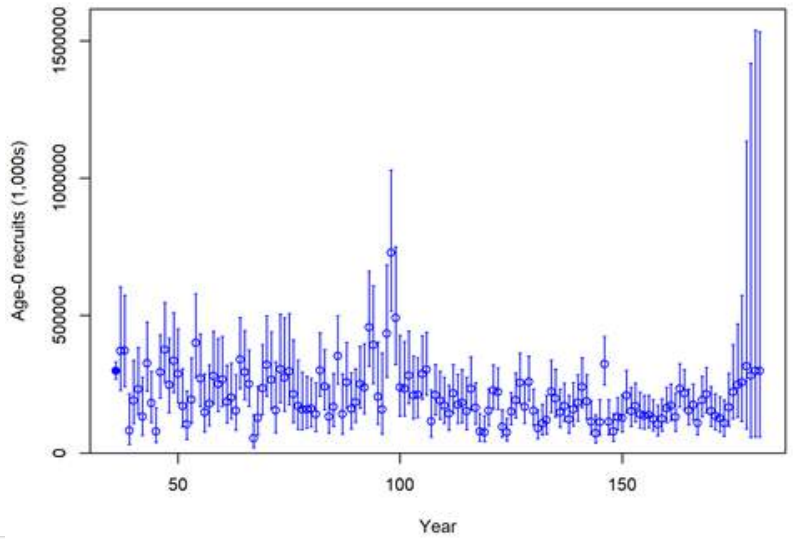
Stock-Recruitment: BET, YFT, and PBF

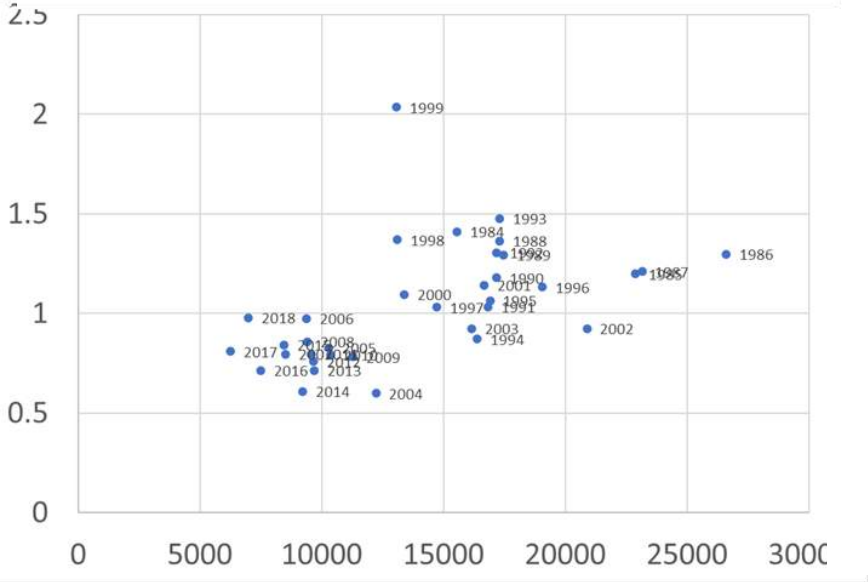
BET



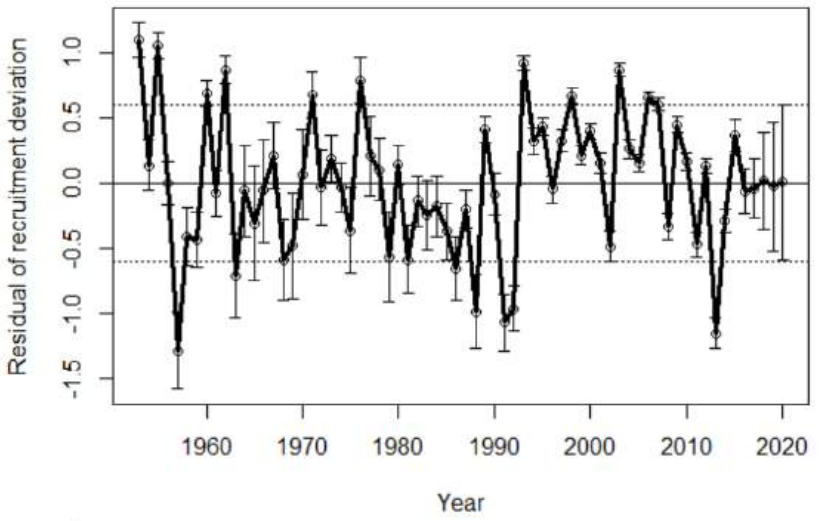


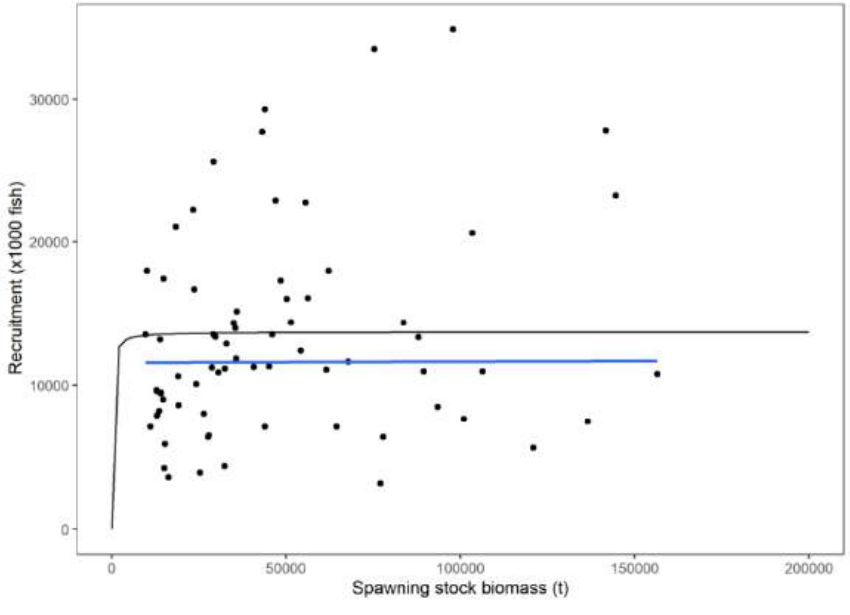
YFT





PBF





S_{MSY}/S_0 for BET and YFT

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.
TABLA 1. Rangos de S_{RMS}/S_0 estimados en las evaluaciones de las poblaciones de patudo (SAC-11-06, Tabla 7) y aleta amarilla (SAC-11-07, Tabla 8).

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

Around 0.3

Selectivity

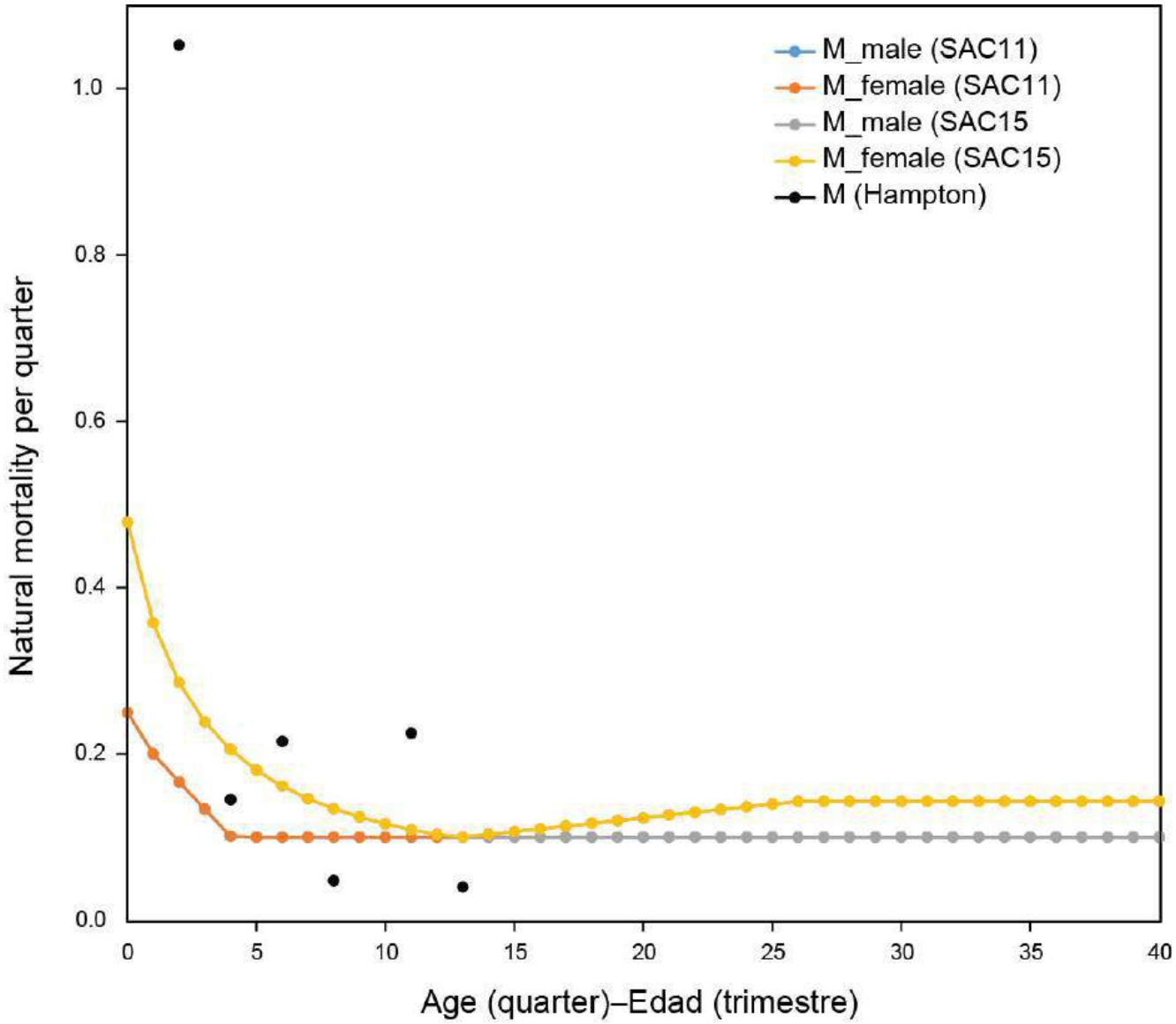
Table 1 Estimates of MSY and associated quantities for yellowfin tuna in the EPO using different fishing methods.

Fishing method	MSY	S/S_0	Effort multiplier
Current mixture	248	0.23	1.19
Longline	425	0.26	66.47
Dolphin associated	337	0.26	3.06
Free-swimming schools	199	0.14	4.72
Floating objects	144	0.13	7.60

The effort multiplier is the proportion of the current effort for that fishing method that is required to produce MSY if no other methods are used.

Maunder, M.N. 2002. The relationship between fishing methods, fisheries management and the estimation of MSY. Fish and Fisheries, 3: 251-260.

Natural mortality



Introduction: background

- The Staff has an ongoing MSE project to identify and evaluate harvest strategies
  - Stakeholder education
  - Identify management objectives
  - Develop candidate harvest strategies
  - Test harvest strategies
- No harvest strategies are fully specified
- No harvest strategies are tested
- Resolution C-24-01 paragraph 43

  "… The staff, consulting with the SAC, shall then present for the Commission's consideration in 2025 a candidate harvest strategy for bigeye tuna …"

Harvest Strategy: Harvest control rule discussion