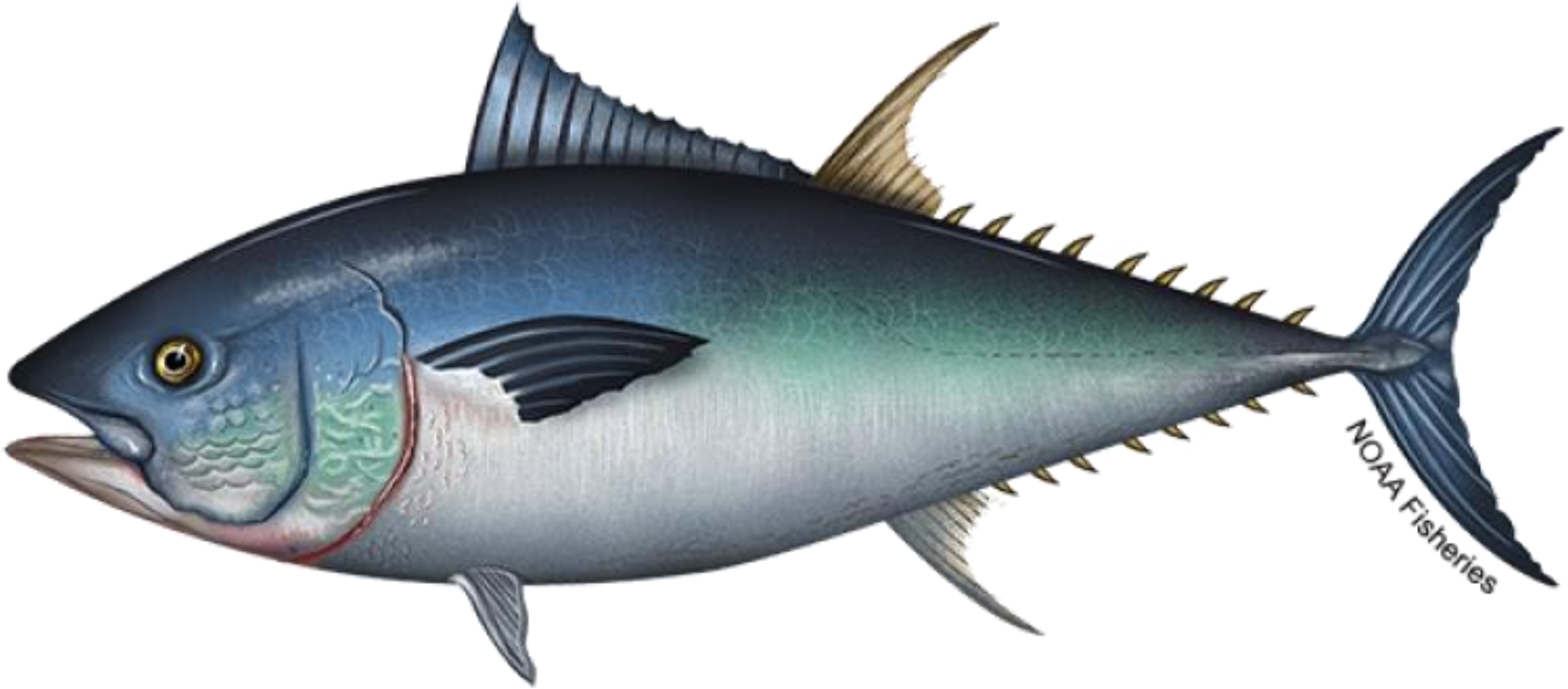
Pacific Bluefin Tuna Management Strategy Evaluation

ISC Pacific Bluefin Tuna Working Group

Presented by Desiree Tommasi

Outline

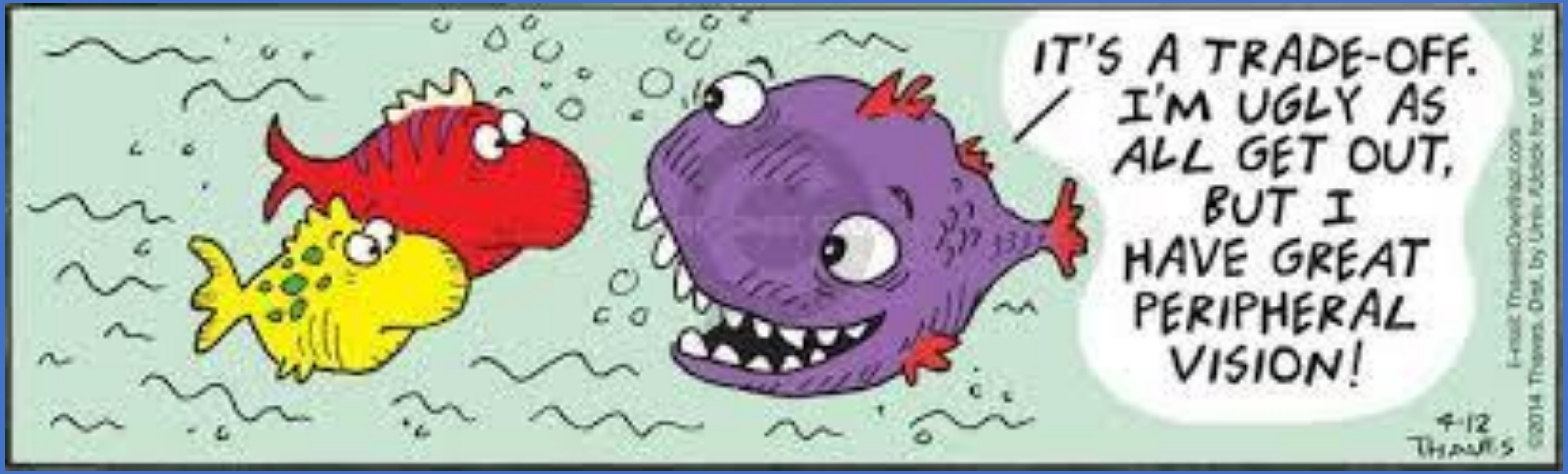
- MSE Loop
- Estimation model
- HCRs
- TAC calculation
- Impact ratio tuning
- Management Objectives and Performance indicators



Overview of MSE Loop

What is Management Strategy Evaluation?

MSE is a process to evaluate the trade offs and performance of candidate harvest strategies under a range of uncertainties using computer simulations

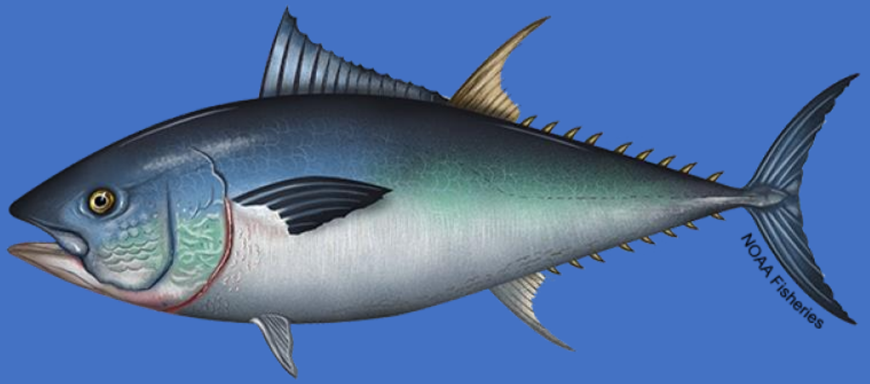


Goal of Pacific Bluefin Tuna MSE

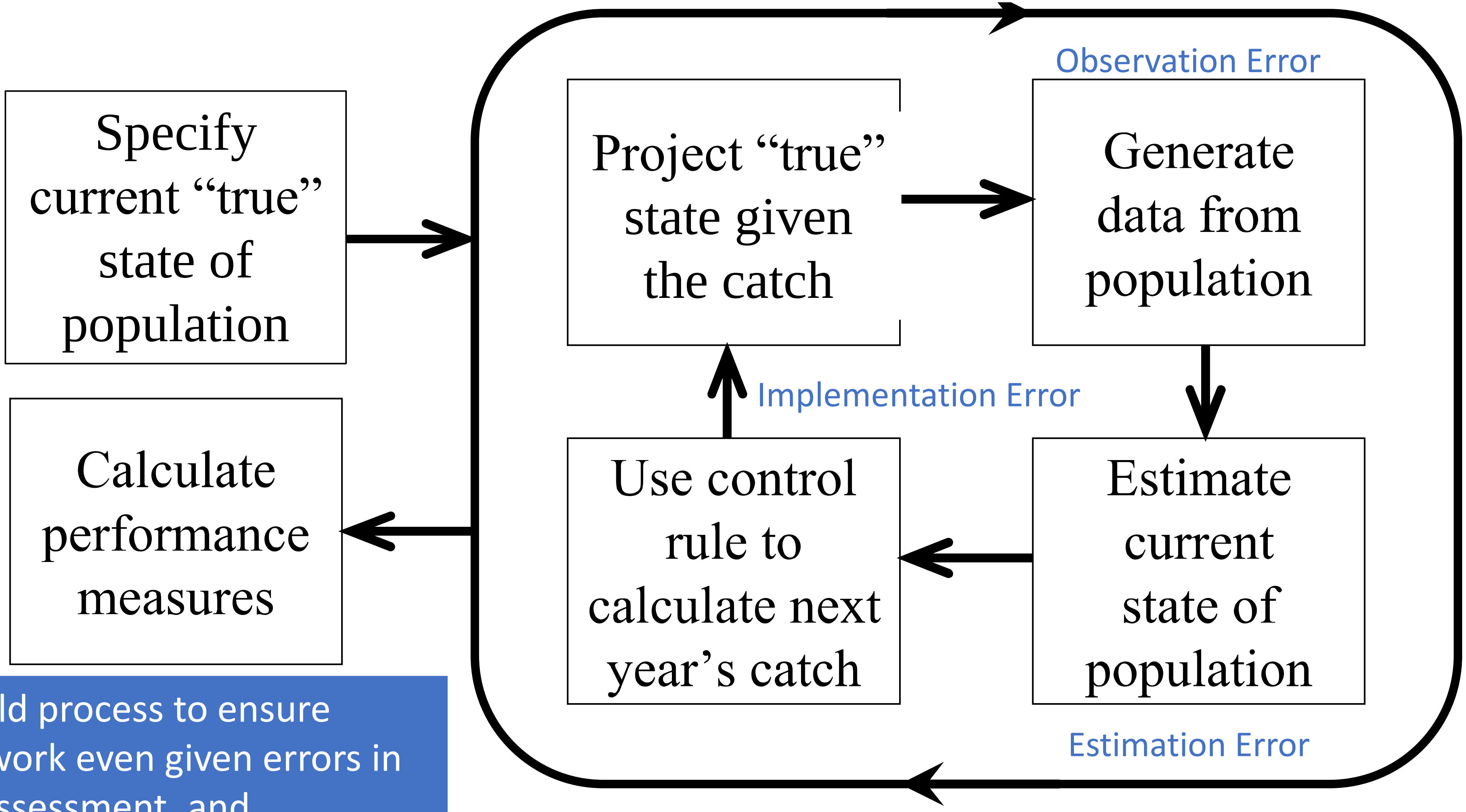
Help inform development of a long-term harvest strategy for PBF now that the stock has rebuilt to the second rebuilding target of 20%$SSB_{F=0}$

What the Pacific Bluefin Tuna MSE does

Examines performance of candidate harvest strategies for PBF relative to the set of management objectives agreed-upon with stakeholders given uncertainty using a closed loop computer simulation



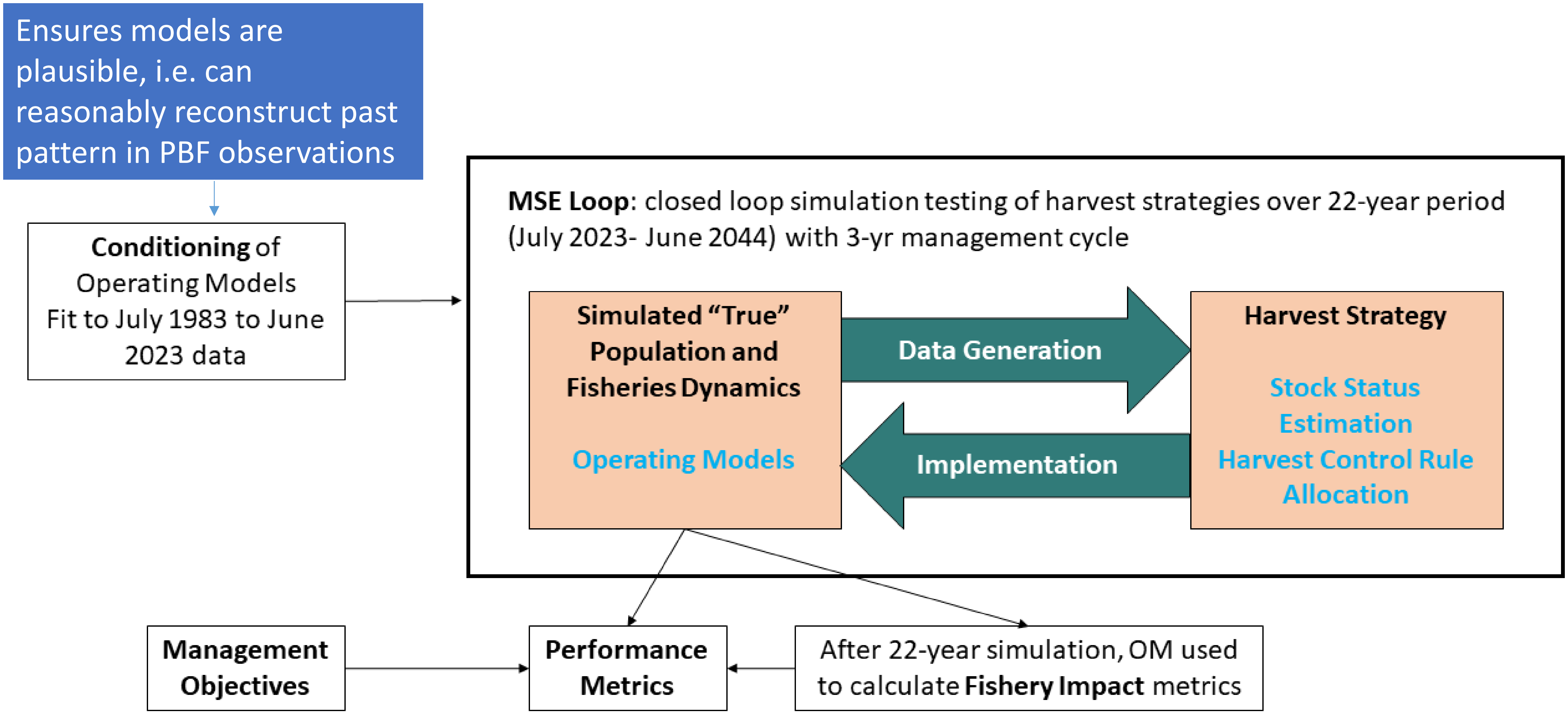
MSE uses a feedback loop and considers different sources of uncertainty



MSE recreates real world process to ensure harvest strategies will work even given errors in the observations, the assessment, and implementation

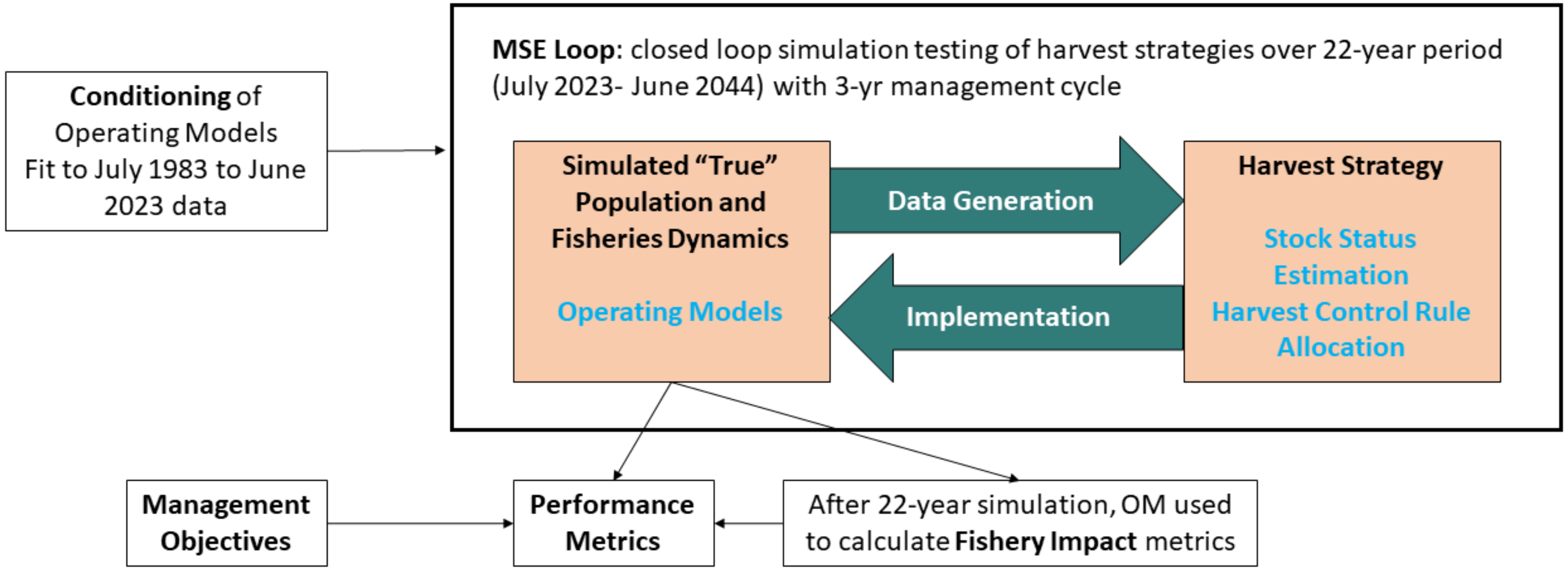
From A'mar et al. 2008

PBF MSE Feedback Loop



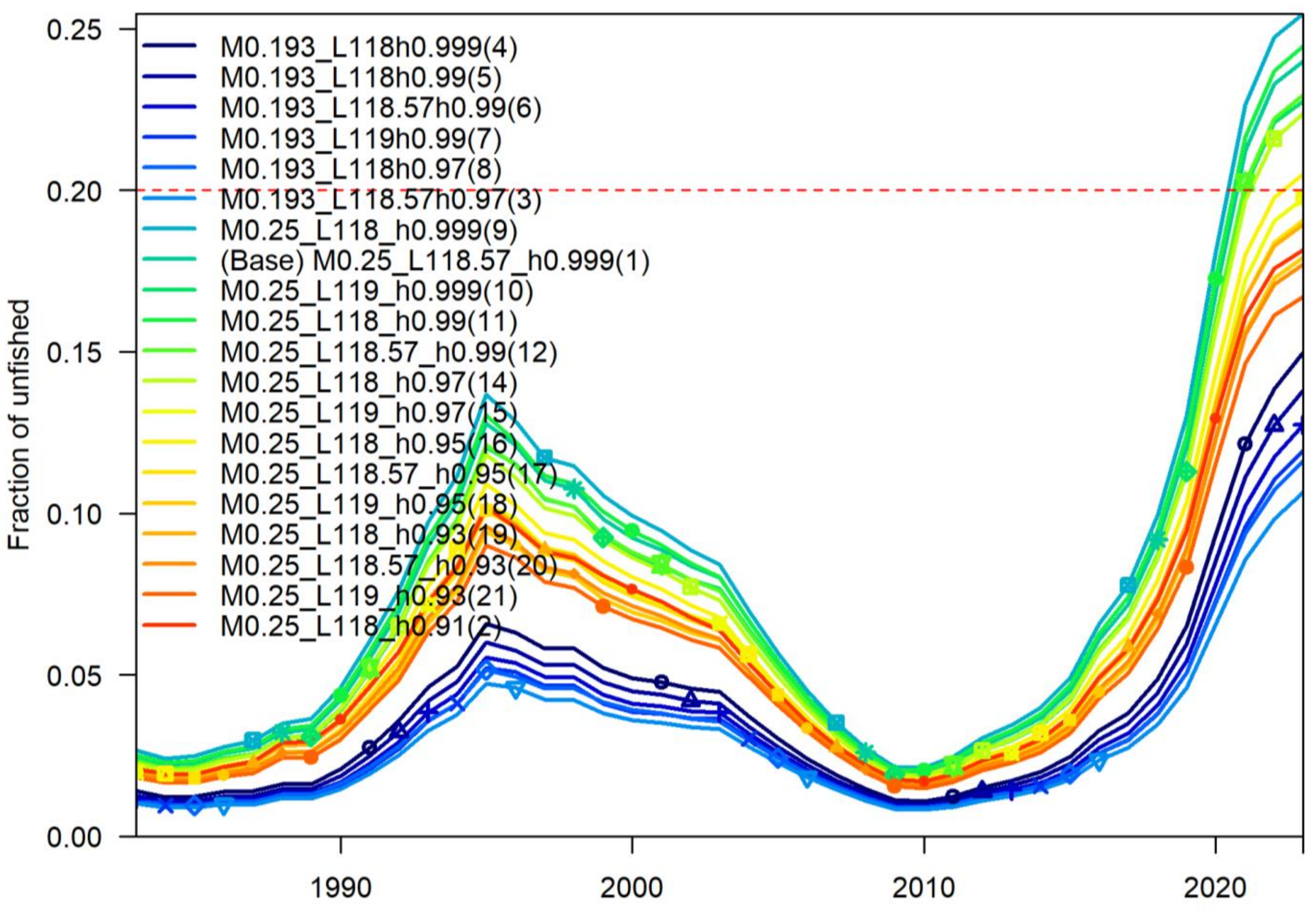
Key Ingredients of PBF MSE Loop

1. Set of Operating Models (OMs)
2. Estimation Model (EM)
3. Candidate Harvest Control Rules (HCRs)
4. Performance Metrics and Management Objectives



PBF Operating Models

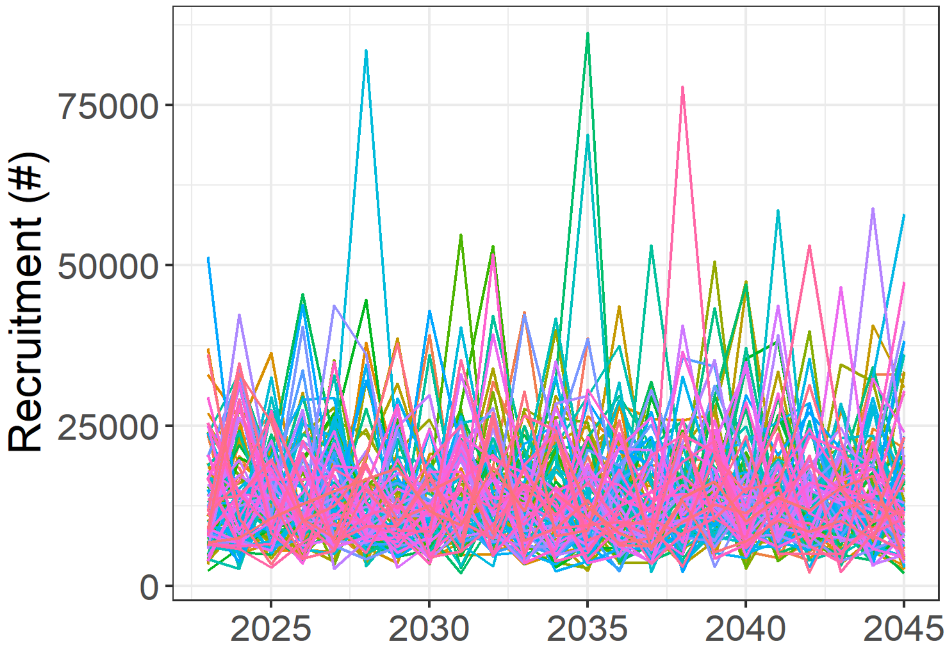
- 20 reference OMs - Plausible versions of true dynamics of the system
- Represent the range of uncertainty in stock productivity - different "what if" scenarios in terms of biology
- Considering a range of "what if" scenarios helps account for uncertainty in defining HCRs
- Also 3 robustness tests – still plausible but less likely scenarios

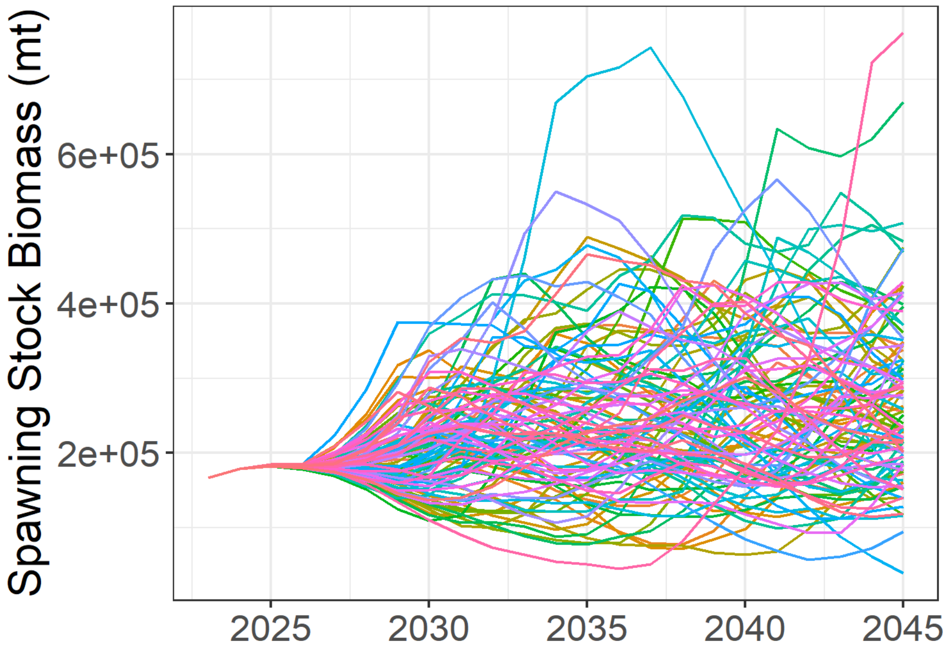


Uncertainty in Future Recruitment

- 100 different future recruitment trajectories tested for each OM – process uncertainty

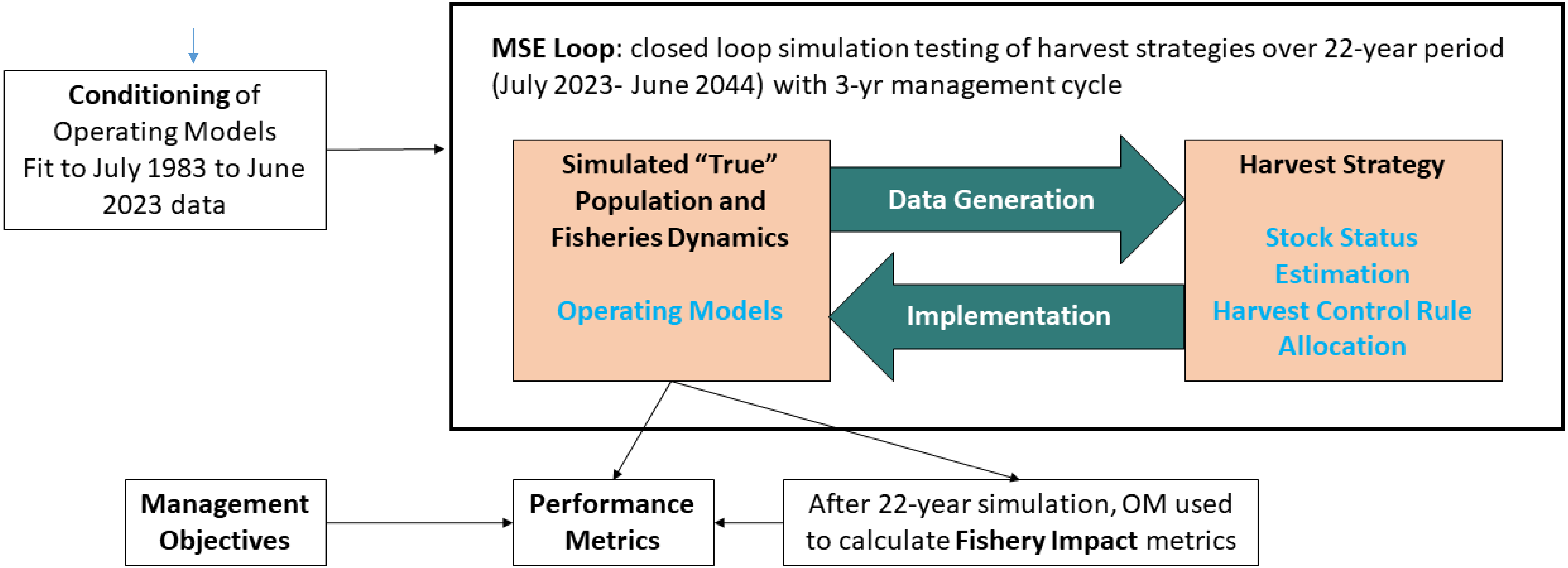
100 different runs for each OM and each HCR



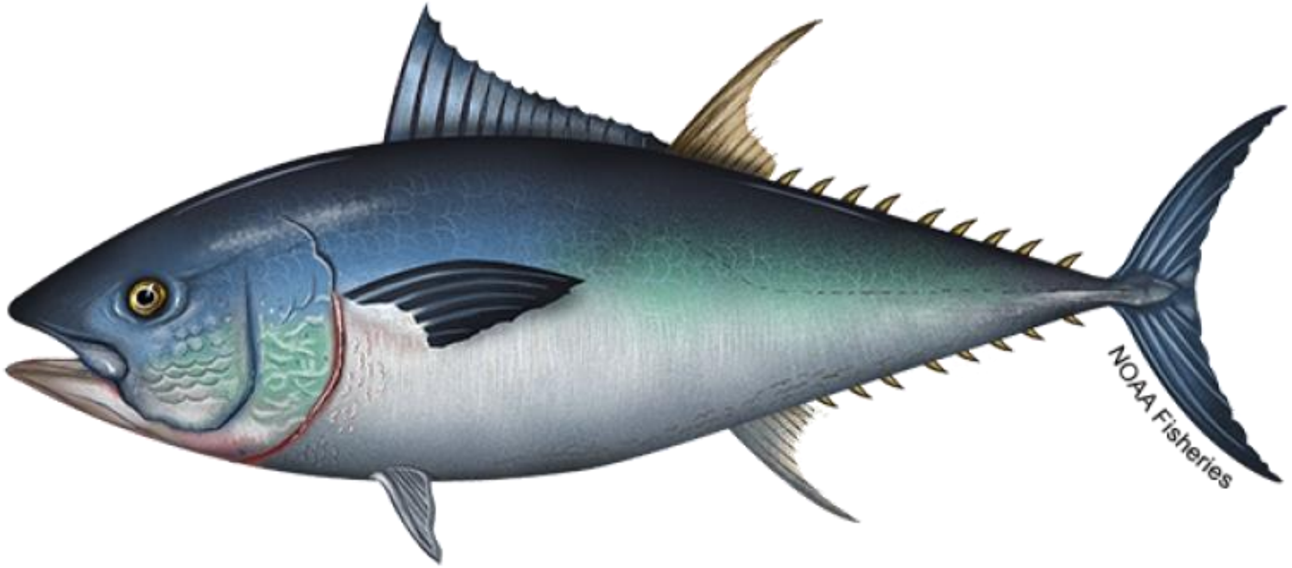


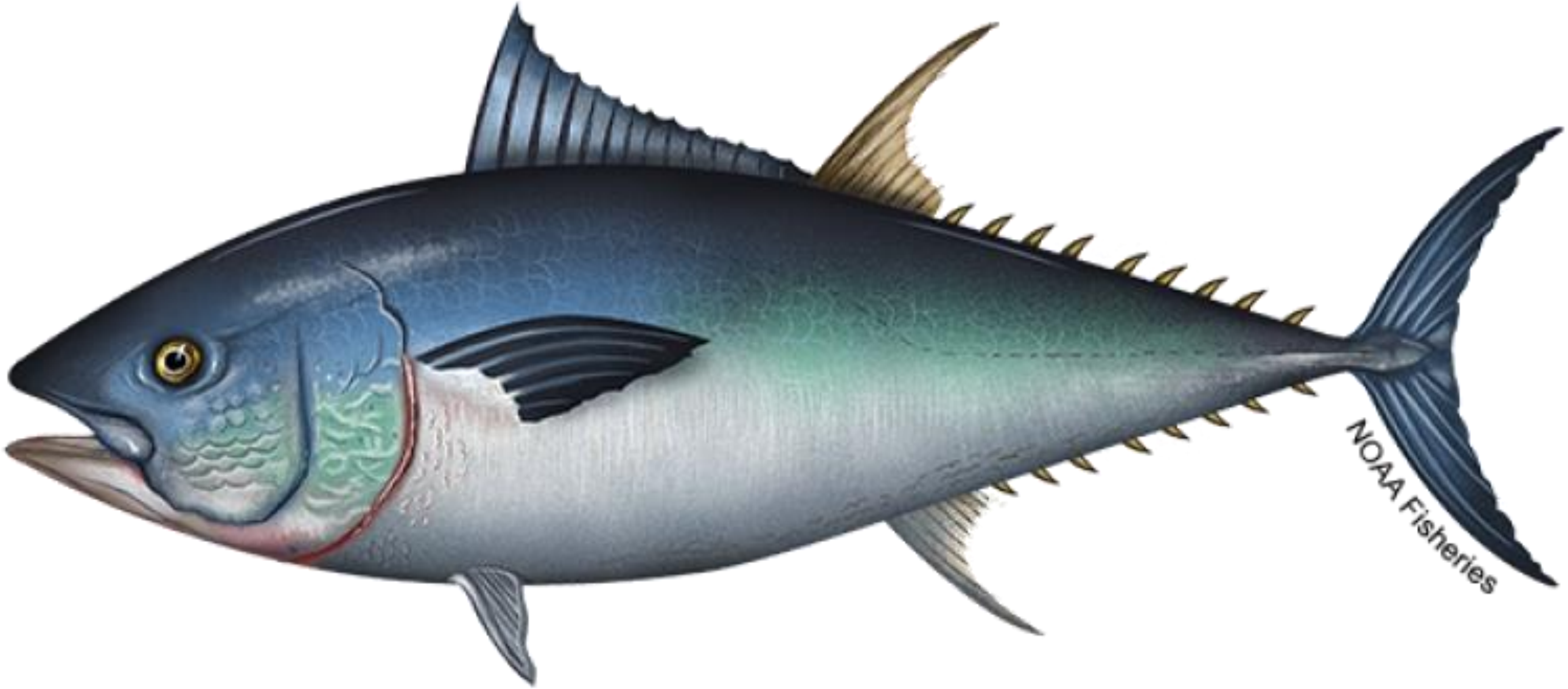
Total Number of Closed Loop Simulations

Reference Set: 12 HCRs x 20 OMs x 2 impact ratios x 100 iterations = 48,000
Robustness Set: 12 HCRs x 3 OMs x 2 impact ratios x 100 iterations = 7,200



Questions?

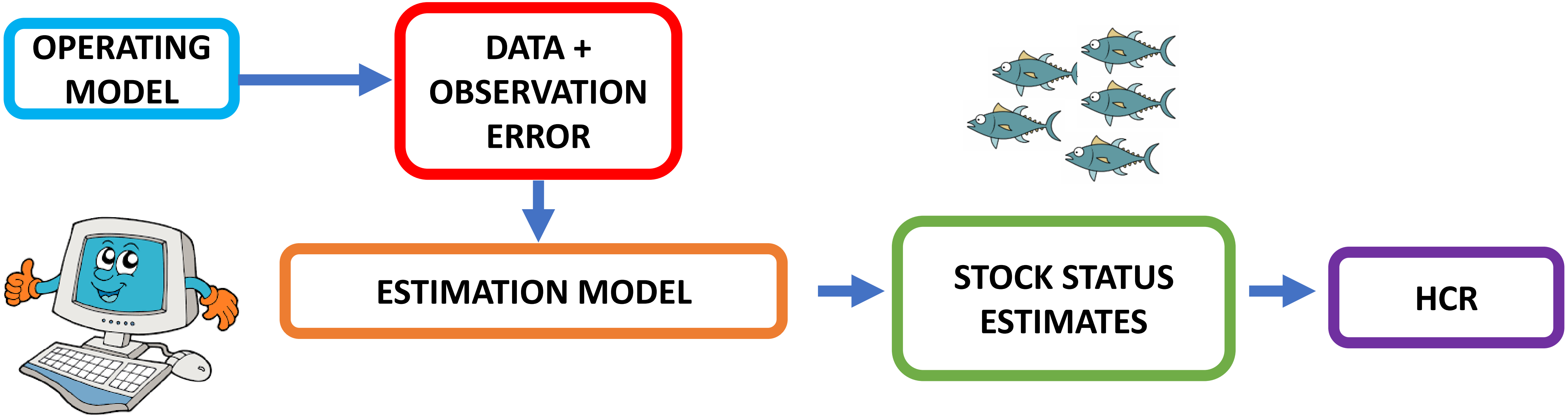




Estimation Model

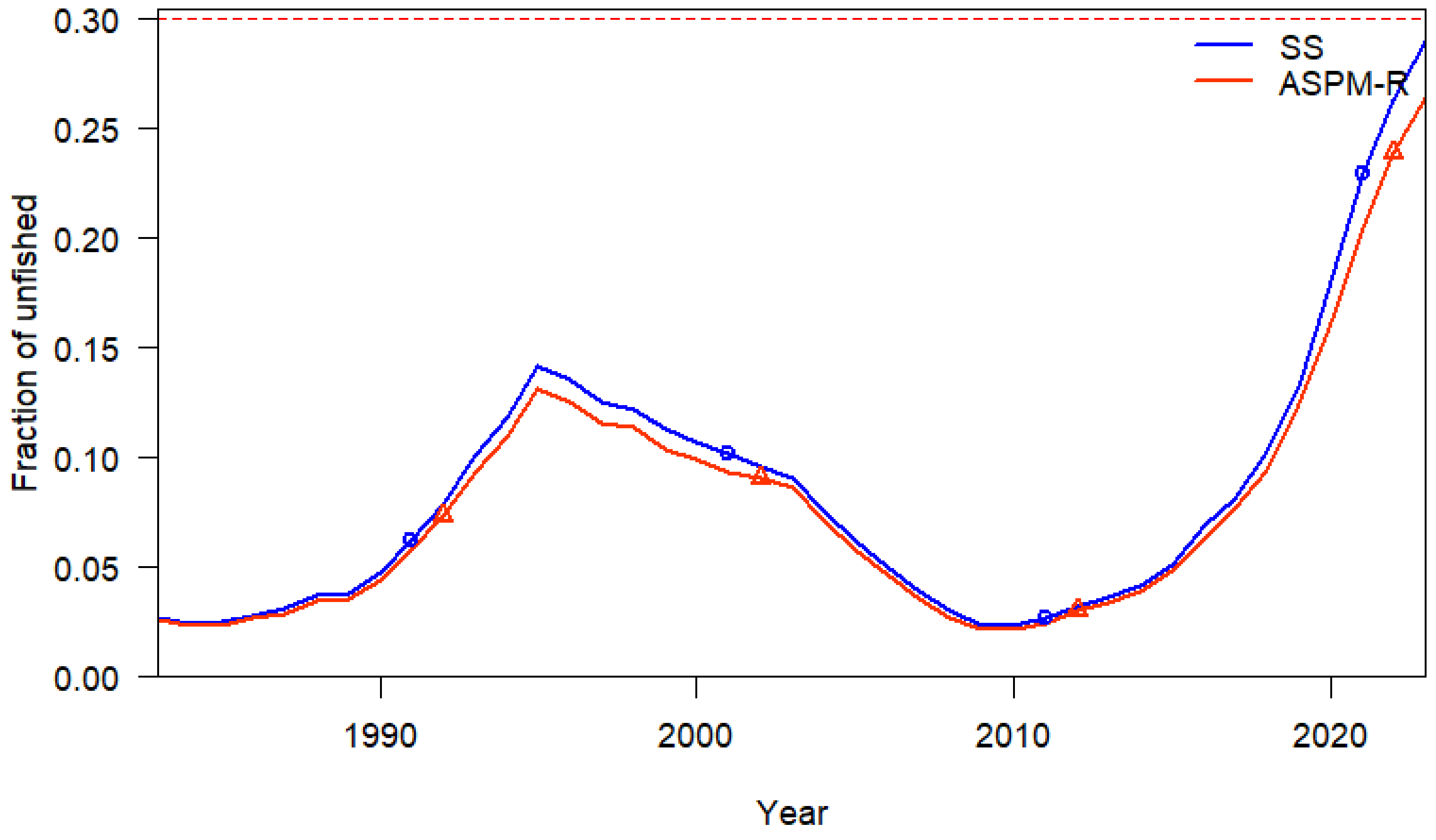
Estimation Model

- Simulated stock assessment model
- Based on age structured production model similar to 2024 assessment
- Uses data (catch, abundance index, size composition), with error as in the real world, from each OM
- Estimate of stock status – SSB relative to unfished SSB



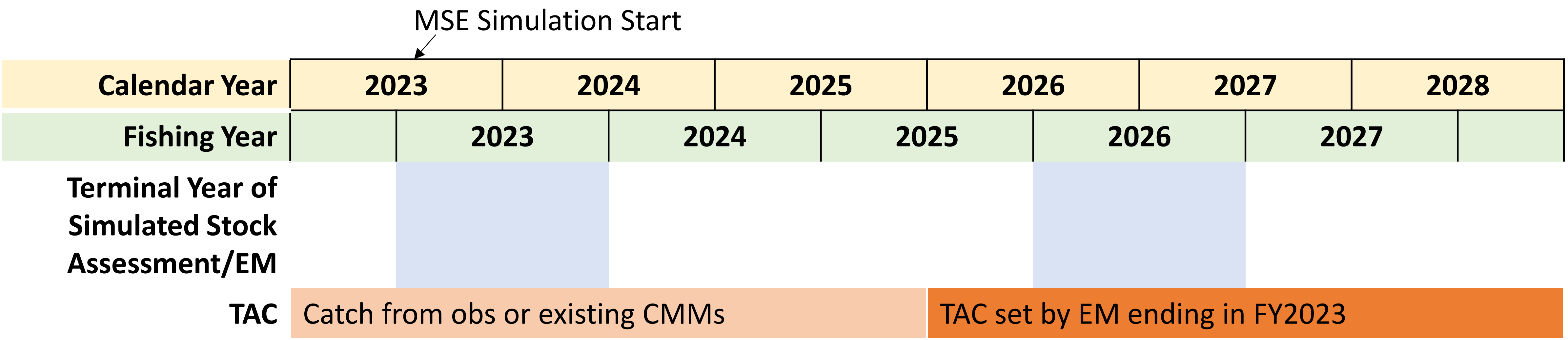
Estimation Model

Comparison of EM (ASPM-R) to full assessment



Estimation Model

- In the MSE, there is a realistic lag between the end of the assessment and the implementation of a resulting TAC
- E.g. current 2025 PBF catch limits based on assessment with data only up to fishing year 2022 (June 2023)
- First simulated stock assessment in MSE ends in fishing year 2023 to set a TAC starting in calendar year 2026
- 3 years management cycle - TAC stays fixed for 3 years



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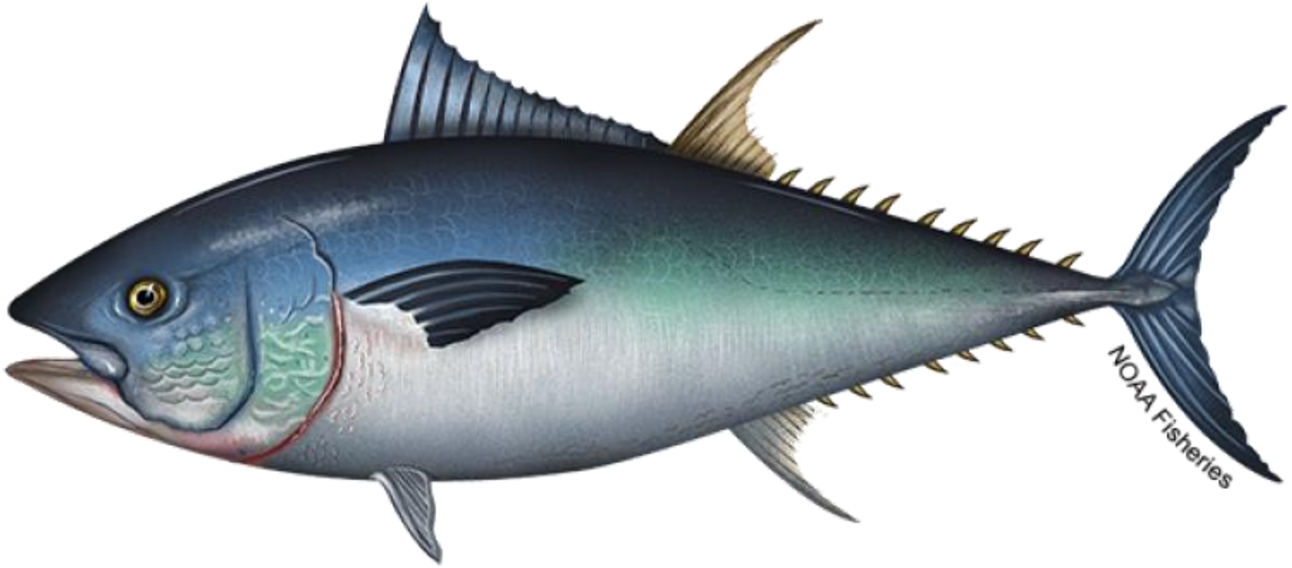
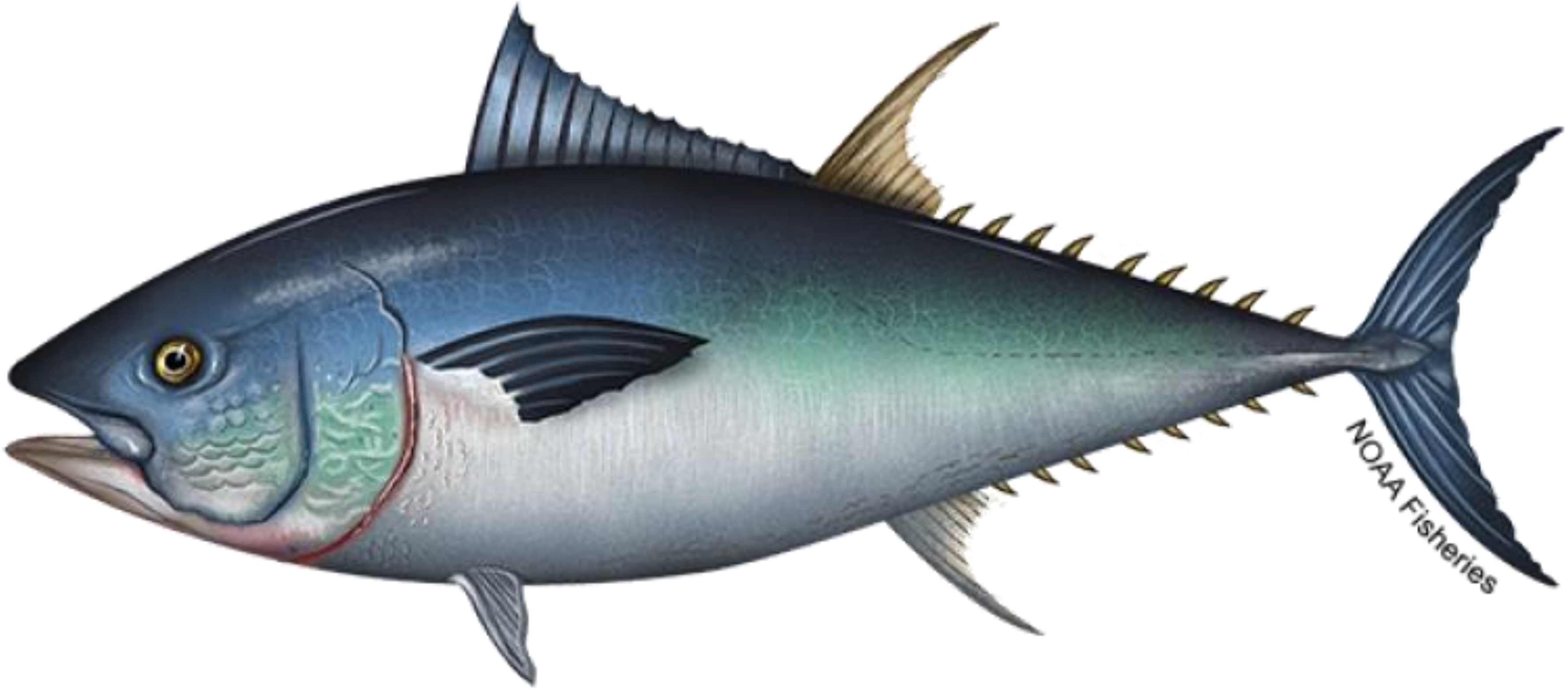




Candidate Harvest Control Rules

Harvest Control Rule

Specifies management action given stock status estimates in relation to **reference points**

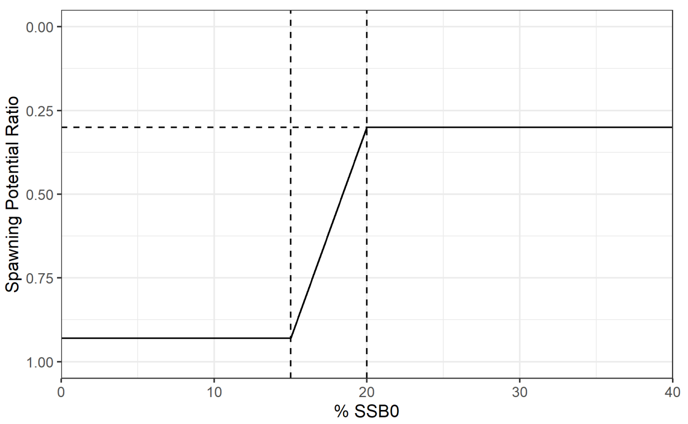
CATCH

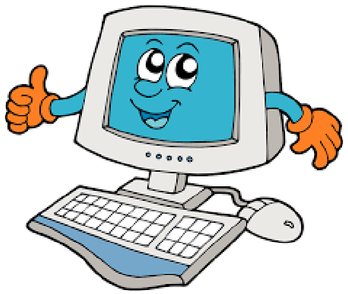
CPUE

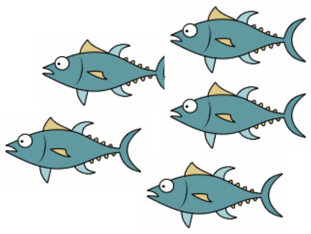
BIOLOGY
Age,
Growth,
Maturity

ESTIMATION MODEL

STOCK STATUS ESTIMATES







Reference Points – Definition

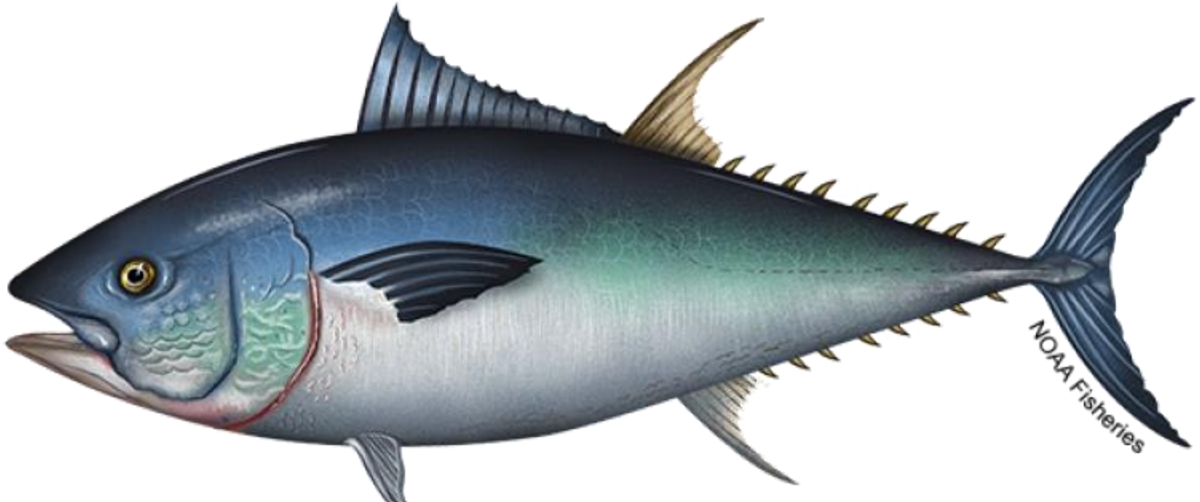
Benchmarks current stock level and fishing intensity are compared to

- Limit Reference Point (LRP)
  - Should not be exceeded with a high probability (generally no greater than 20%)
- Target Reference Point (TRP)
  - Refer to a state management wants to achieve
- Threshold Reference Point
  - It represents an additional control point below which a management action is undertaken to bring the stock back to a target state faster
  - Its value is generally between that of the TRP and LRP.
  - Helps avoid reaching the LRP where severe management action is taken

No PBF Reference Points adopted by WCPFC/IATTC, but there is an interim HCR

If the SSB projection indicates that SSB will be below 20%SSB $_{F=0}$ with a probability of 60%, management measures shall be modified to increase the SSB to at least 20%SSB$_{F=0}$ with 60 % probability

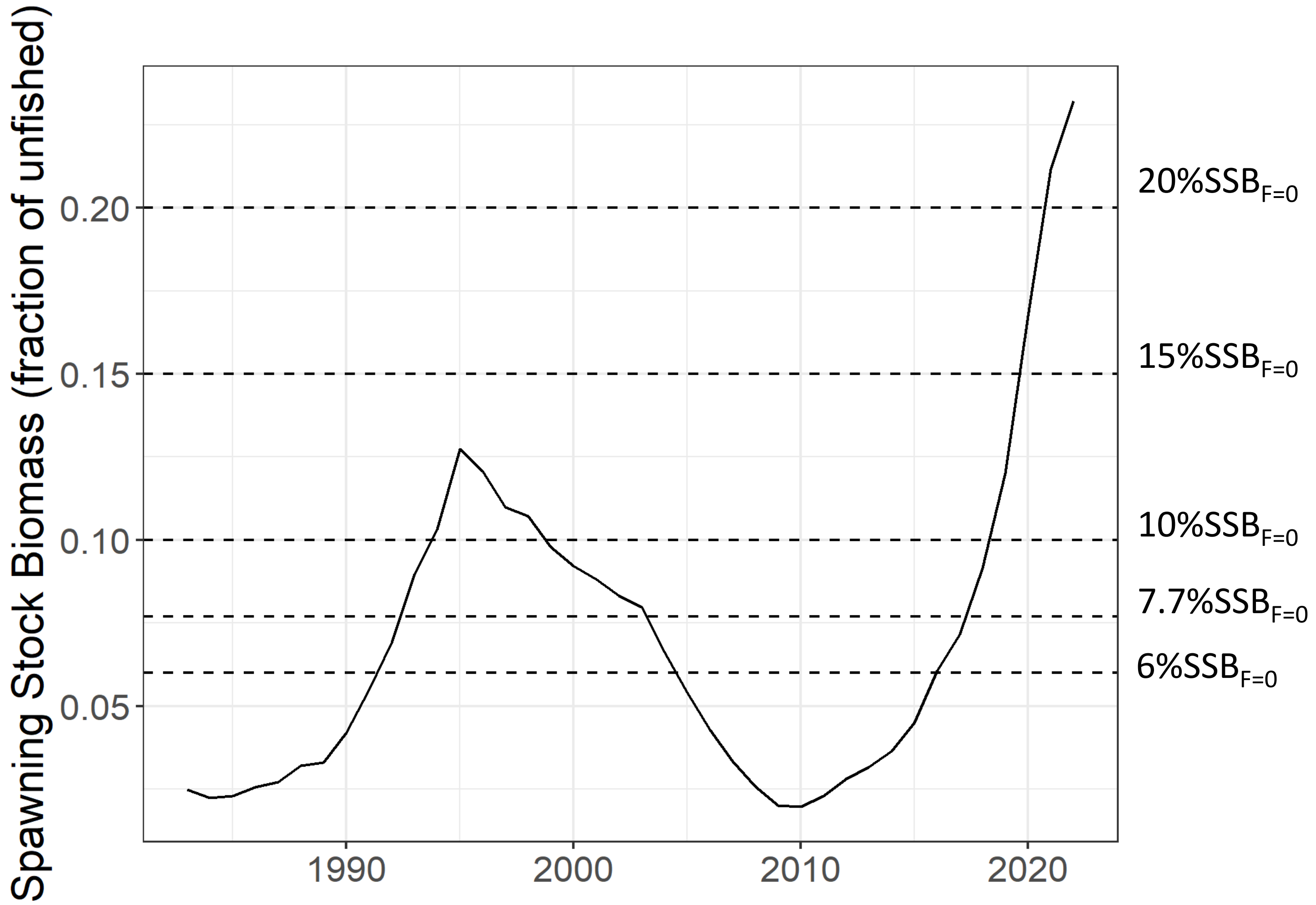
20%SSB$_{F=0}$ acts as a threshold reference point



Limit Reference Points (LRPs) put forward by the JWG and tested in the PBF MSE

1. $20\%SSB_{F=0}$ - 20% of unfished spawning biomass
2. $15\%SSB_{F=0}$ - 15% of the unfished spawning biomass
3. $10\%SSB_{F=0}$ - 10% of the unfished spawning biomass
4. $7.7\%SSB_{F=0}$ - 7.7% of the unfished spawning biomass
   - Spawning biomass which produces a 50% reduction in recruitment relative to unfished levels with a conservative productivity assumption (h=0.75) (IATTC C-16-02)
5. Median SSB 1952-2014
   - 40,725 mt from ISC 2022 stock assessment model, which estimated SSB from 1952 to 2020
   - Corresponds to 6.3% of the unfished spawning biomass
   - WCPFC initial rebuilding target

How do the proposed limit reference points compare to historical trends in SSB?

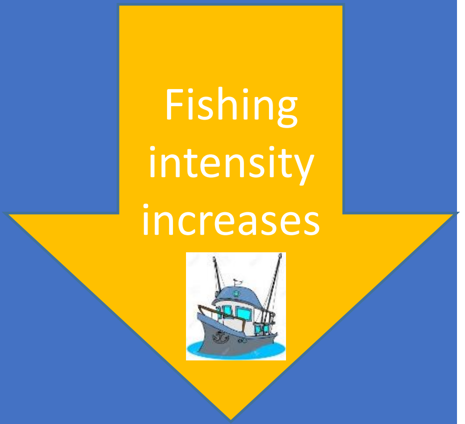


Relative SSB from 2024 ISC PBF stock assessment has been below 20%SSB0 until 2021, when it reached the rebuilding target

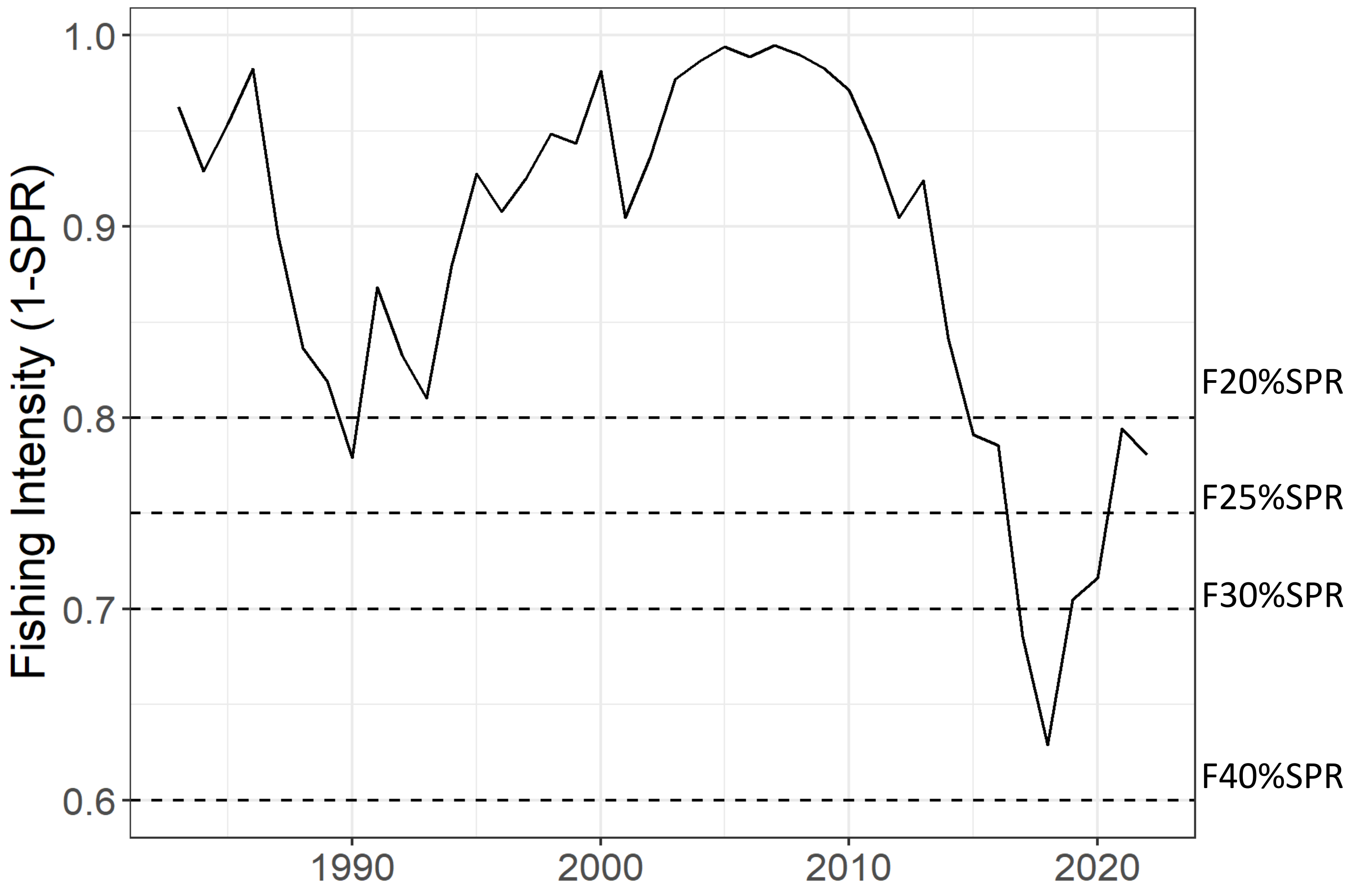
Target Reference Points (TRPs) put forward by the JWG and tested in the PBF MSE

- Based on fishing intensity, so referred to as F_{target}
- A fishing intensity of F40 would result in approximately 40% of the unfished SSB per recruit (also referred to as spawning potential ratio, SPR)
- This is approximately equivalent to an harvest rate of 60%

1. F40%SPR - fishing intensity corresponding to an SPR of 40%
2. F30%SPR - fishing intensity corresponding to an SPR of 30%
3. F25%SPR - fishing intensity corresponding to an SPR of 25%
4. F20%SPR - fishing intensity corresponding to an SPR of 20%



How do proposed target reference points compare to historical trends?

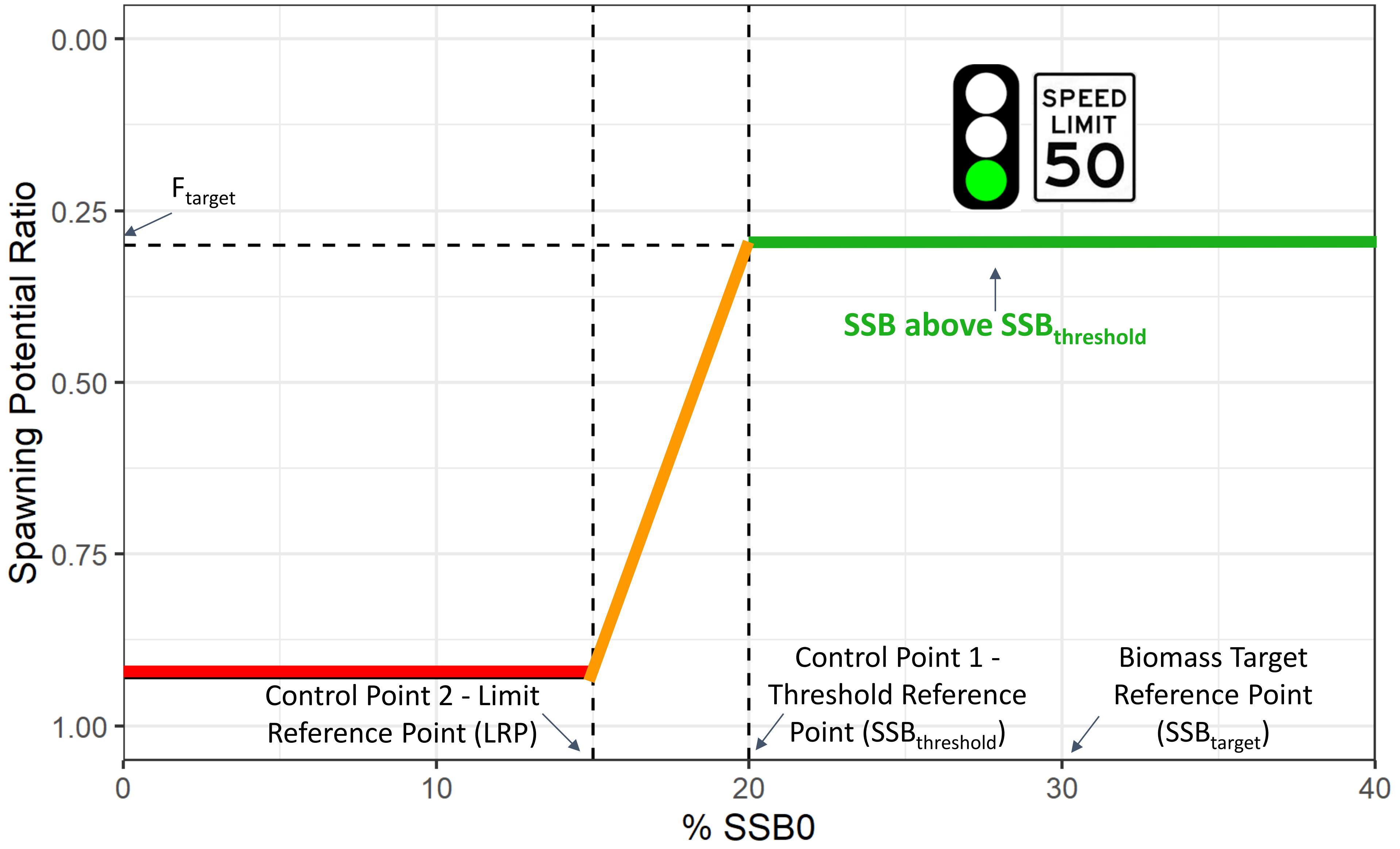


According to the latest 2024 ISC stock assessment, fishing intensity has historically been mostly above F20 until 2015. It has never been below F40

Threshold Reference Points put forward by the JWG and tested in PBF MSE

1. $25\%SSB_{F=0}$
   - 25% of unfished spawning biomass
2. $20\%SSB_{F=0}$
   - 20% of unfished spawning biomass
3. $15\%SSB_{F=0}$
   - 15% of unfished spawning biomass

Harvest Control Rule for PBF MSE with 2 biomass control points
HCR 1 proposed by JWG as example



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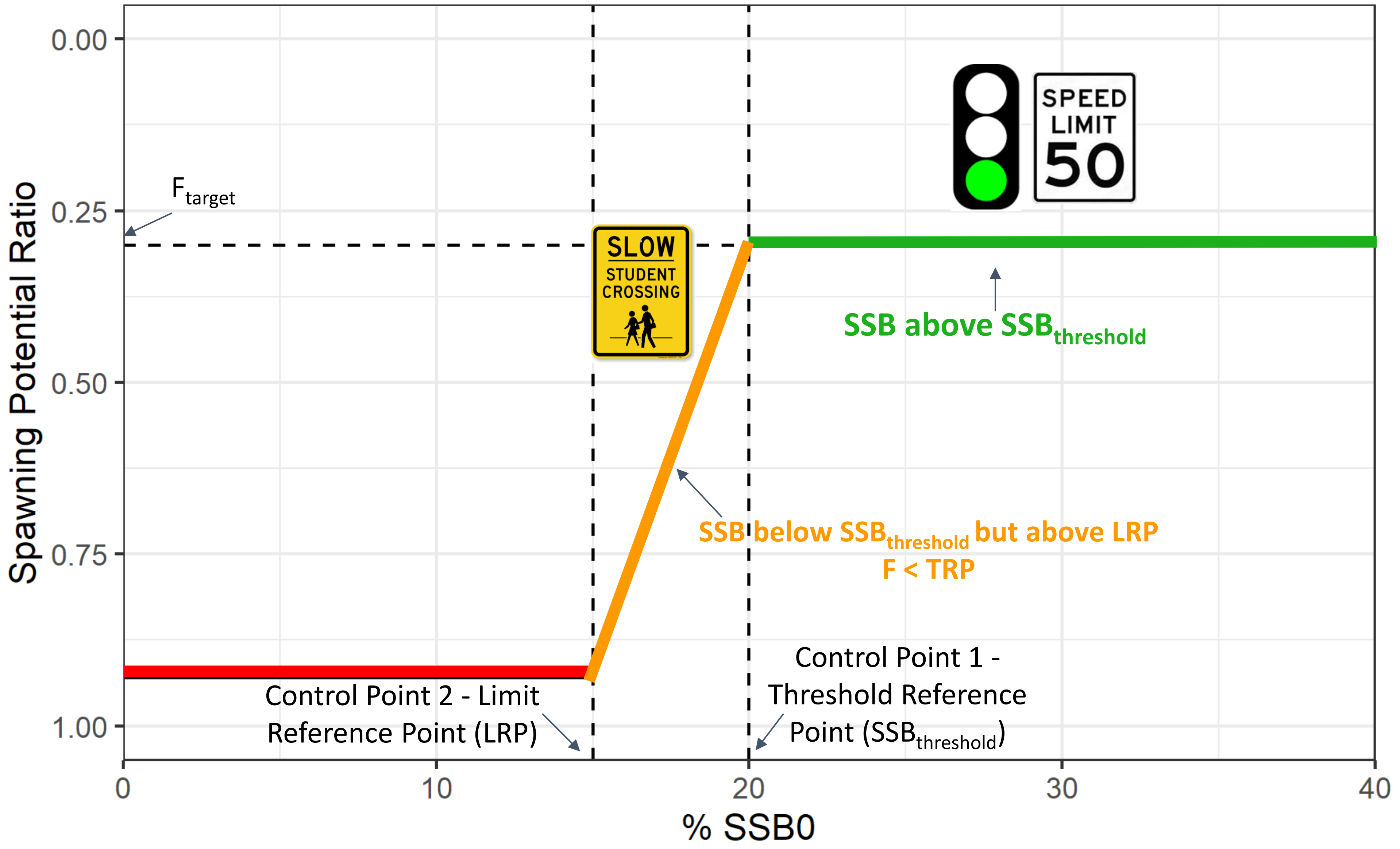

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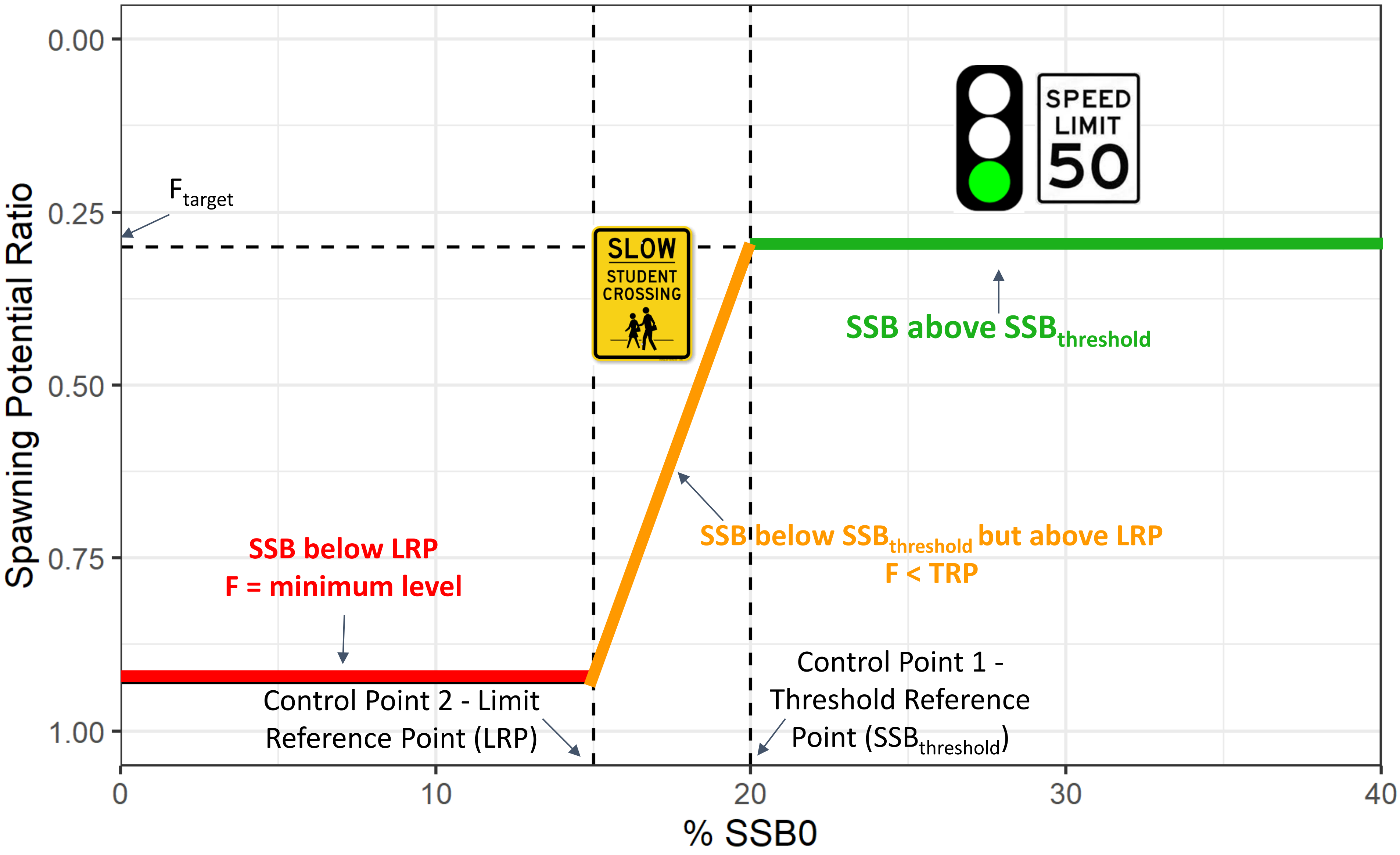
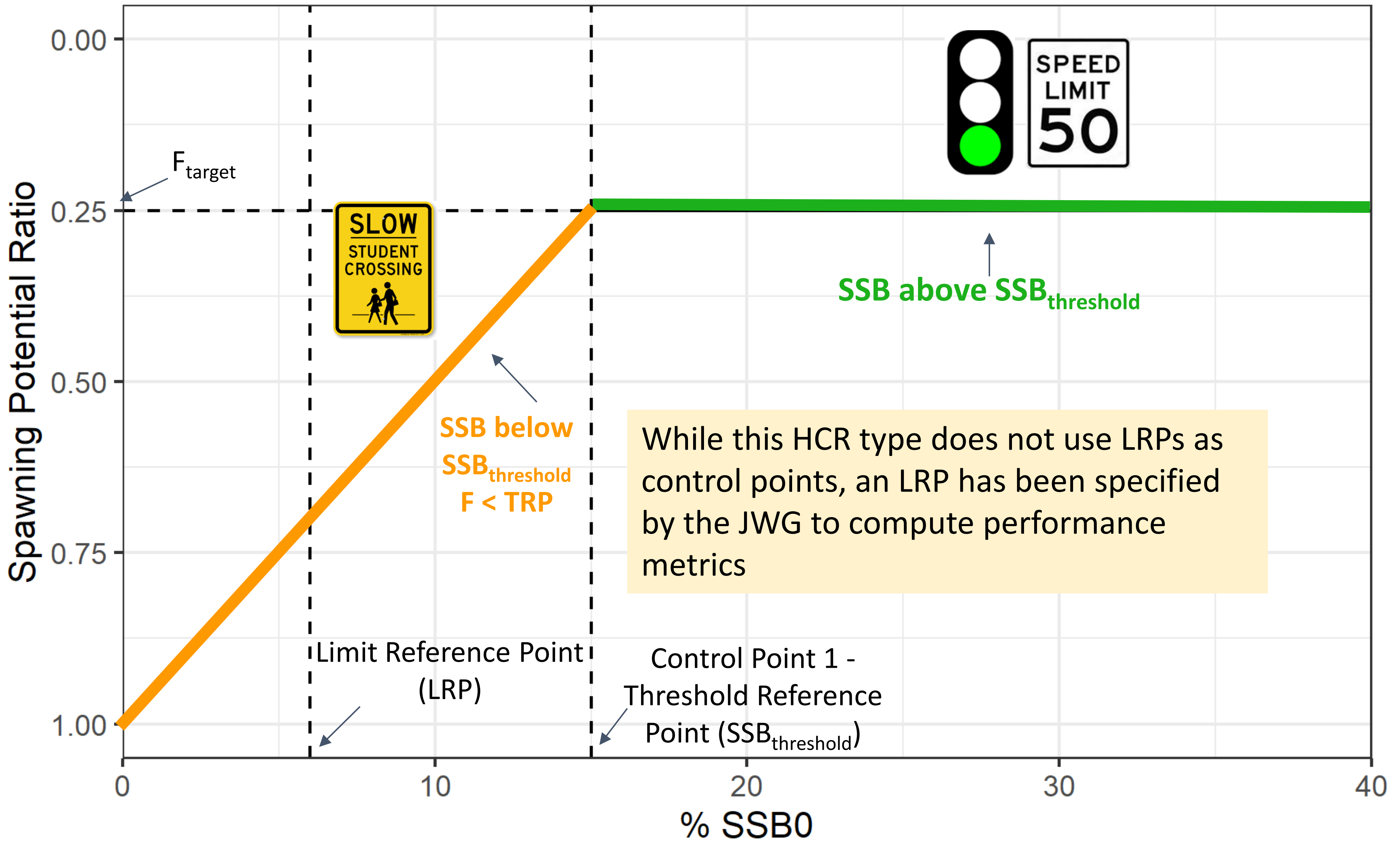


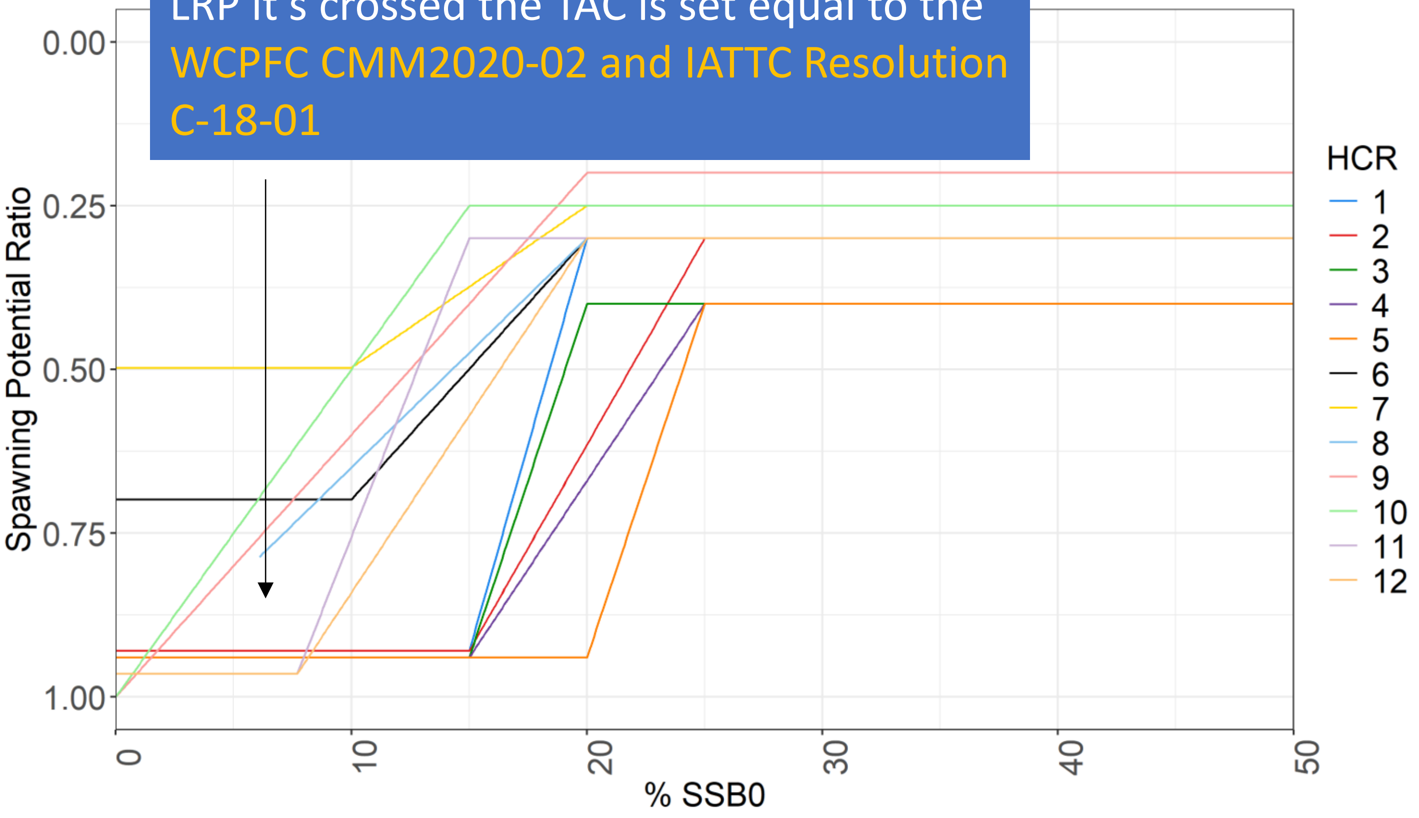
Harvest Control Rule for PBF MSE with 1 biomass control points
HCR 10 proposed by JWG as example



PBF Candidate Harvest Control Rules Proposed by JWG

HCR Number	F_{target}	SSB Control Point 1 (ThRP)	SSB Control Point 2 (LRP)	Number of SSB control points	F_{min}
1	FSPR30%	20%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
2	FSPR30%	25%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
3	FSPR40%	20%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
4	FSPR40%	25%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
5	FSPR40%	25%$SSB_{F=0}$	20%$SSB_{F=0}$	2	10%F_{target}
6	FSPR30%	20%$SSB_{F=0}$	10%$SSB_{F=0}$	2	FSPR70%
7	FSPR25%	20%$SSB_{F=0}$	10%$SSB_{F=0}$	2	FSPR50%
8	FSPR30%	20%$SSB_{F=0}$	Median SSB 1952-2014	2	CMM limits
9	FSPR20%	20%$SSB_{F=0}$	NA	1	NA*
10	FSPR25%	15%$SSB_{F=0}$	NA	1	NA*
11	FSPR30%	15%$SSB_{F=0}$	7.7%$SSB_{F=0}$	2	5%F_{target}
12	FSPR30%	20%$SSB_{F=0}$	7.7%$SSB_{F=0}$	2	5%F_{target}

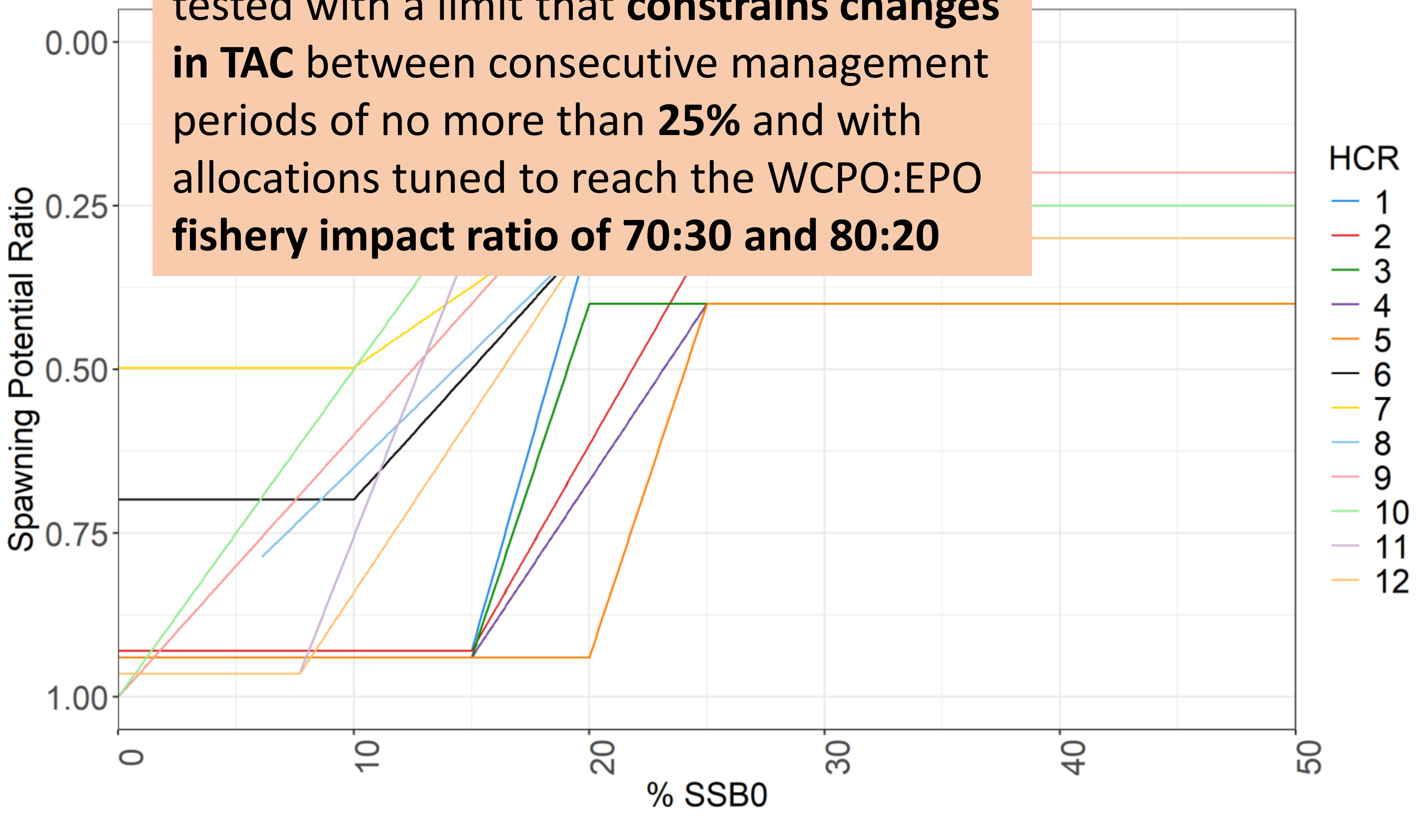
HCR8 does not have an F_{min} but once the LRP it's crossed the TAC is set equal to the WCPFC CMM2020-02 and IATTC Resolution C-18-01



*Note that while HCRs 9 and 10 do not use LRPs as control points, an LRP of median SSB 1952-2014 (~6%SSB0) has been specified by the JWG to compute performance metrics

Candidate Harvest Control Rules

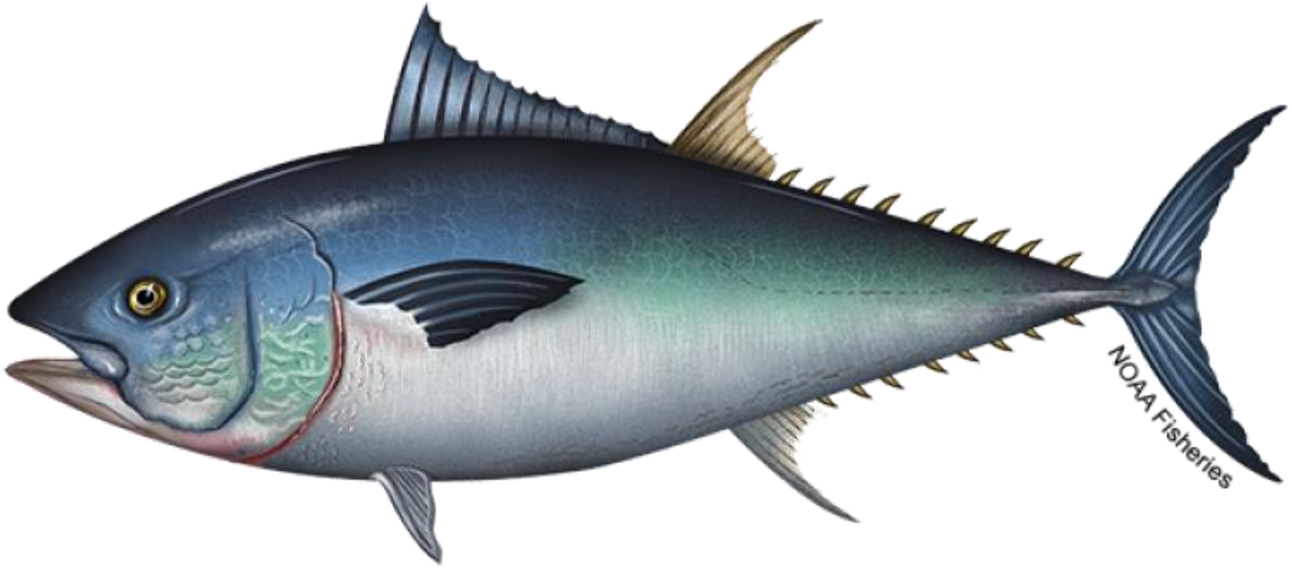
HCR Number	F_{target}	SSB Control Point 1 (ThRP)	SSB Control Point 2 (LRP)	Number of SSB control points	F_{min}
1	FSPR30%	20%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
2	FSPR30%	25%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
3	FSPR40%	20%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
4	FSPR40%	25%$SSB_{F=0}$	15%$SSB_{F=0}$	2	10%F_{target}
5	FSPR40%	25%$SSB_{F=0}$	20%$SSB_{F=0}$	2	10%F_{target}
6	FSPR30%	20%$SSB_{F=0}$	10%$SSB_{F=0}$	2	FSPR70%
7	FSPR25%	20%$SSB_{F=0}$	10%$SSB_{F=0}$	2	FSPR50%
8	FSPR30%	20%$SSB_{F=0}$	Median SSB 1952-2014	2	CMM limits
9	FSPR20%	20%$SSB_{F=0}$	NA	1	NA*
10	FSPR25%	15%$SSB_{F=0}$	NA	1	NA*
11	FSPR30%	15%$SSB_{F=0}$	7.7%$SSB_{F=0}$	2	5%F_{target}
12	FSPR30%	20%$SSB_{F=0}$	7.7%$SSB_{F=0}$	2	5%F_{target}

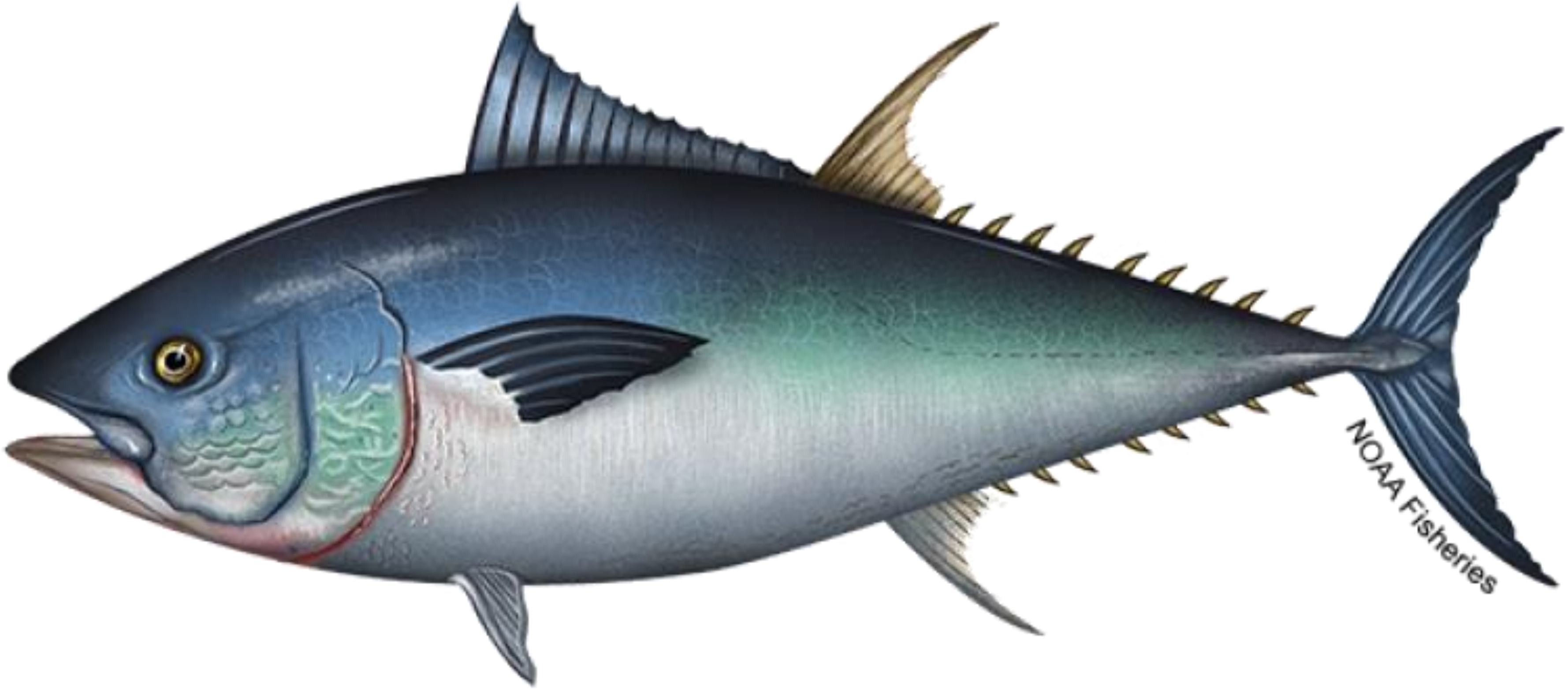


The JWG also specified that HCRs shall be tested with a limit that **constrains changes in TAC** between consecutive management periods of no more than **25%** and with allocations tuned to reach the WCPO:EPO **fishery impact ratio of 70:30 and 80:20**

*Note that while HCRs 9 and 10 do not use LRPs as control points, an LRP of median SSB 1952-2014 (~6%SSB0) has been specified by the JWG to compute performance metrics

Questions?

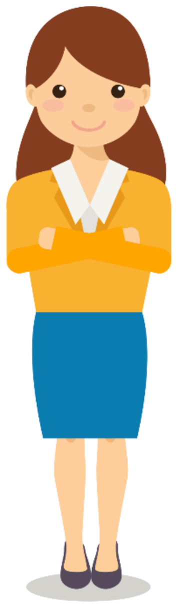




TAC Calculation

How Do the HCRs Work?

So the HCRs set an F?

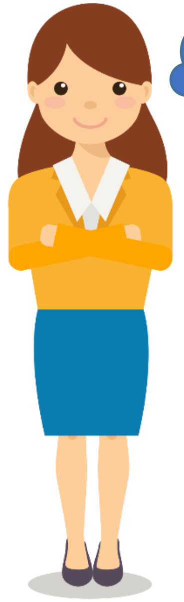


Yes, given stock status, the estimation model finds the a multiplier of the current F that would achieve the F specified by the HCR given a specified F allocation across fleets, selectivity and biology

Step 1: Find the F by fleet that will meet the F_{target}

How Do the HCRs Work?

But I manage the stock with a TAC, how is the F translated into a TAC?



Step 2: Find the TAC by fleet

The TAC is found by using the F at age by fleet and season, terminal year numbers at age, natural mortality at age, and weight at age.

How do the HCRs Work?

Step 3: Check if the TAC change is > 25%

Given inputs:
Allocation across fleets
Selectivity
Biology

F multiplier to meet specified F

TAC by region and size category

EPO TAC – includes recreational catches

WCPO small fish TAC

WCPO large fish TAC

Is each TAC within ± 25% of previous TAC?

yes

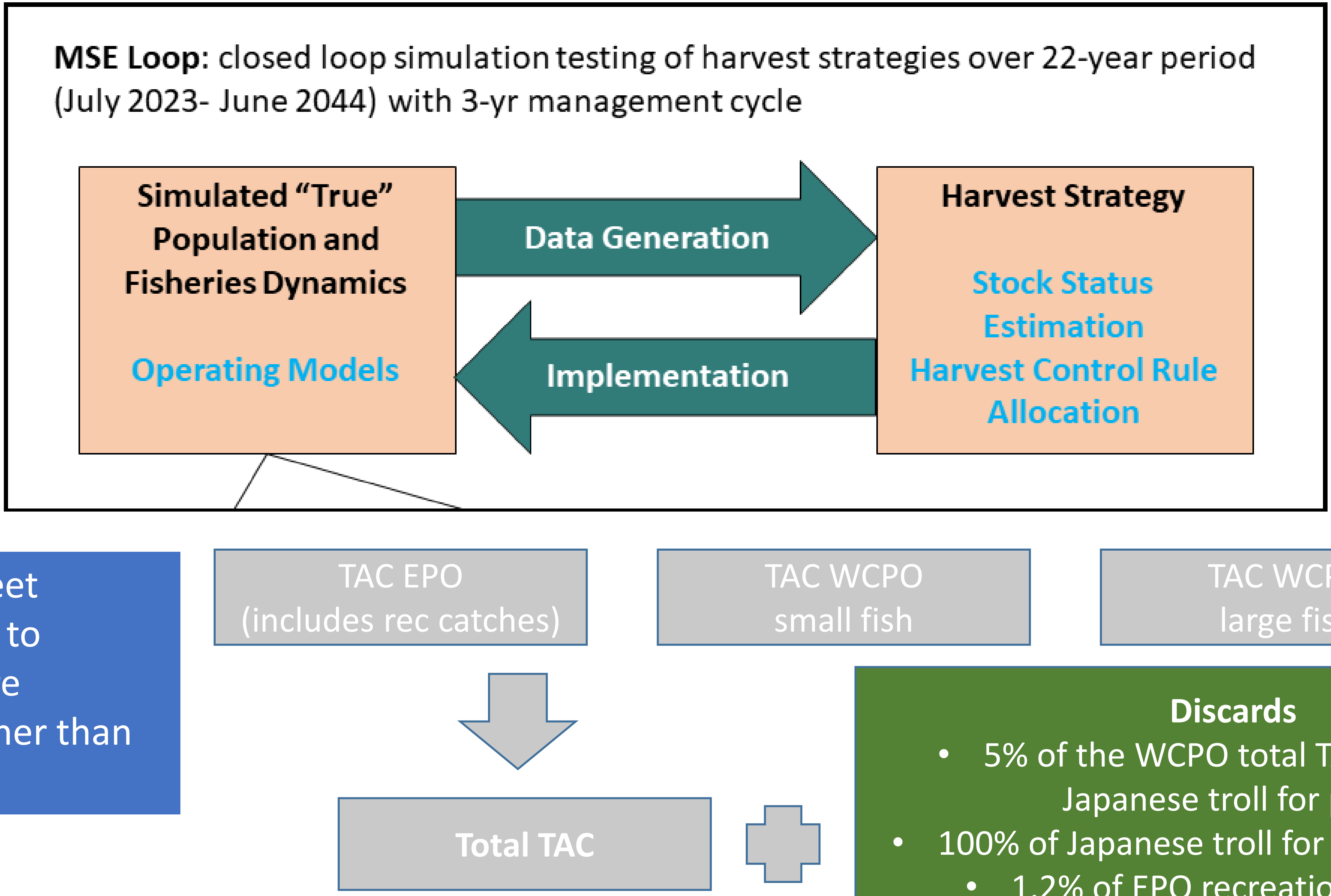
Use HCR **TAC**

no

Use ± 25% of previous **TAC**

Allocation and selectivity set to current 2015-2022 – agreed by JWG

Implementation Error

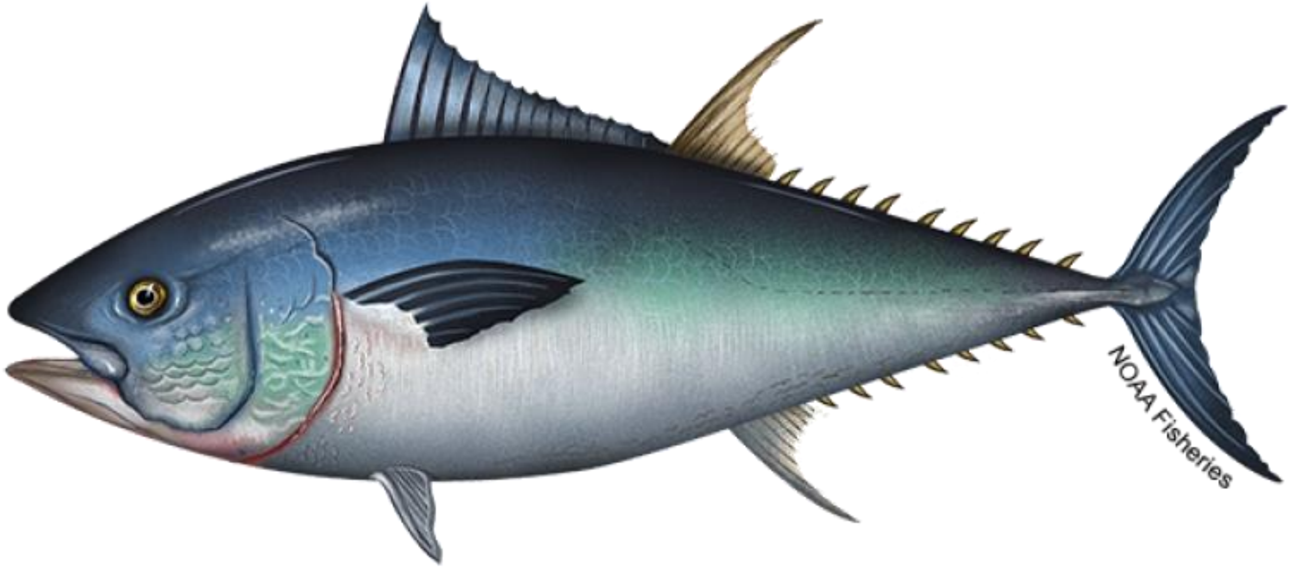


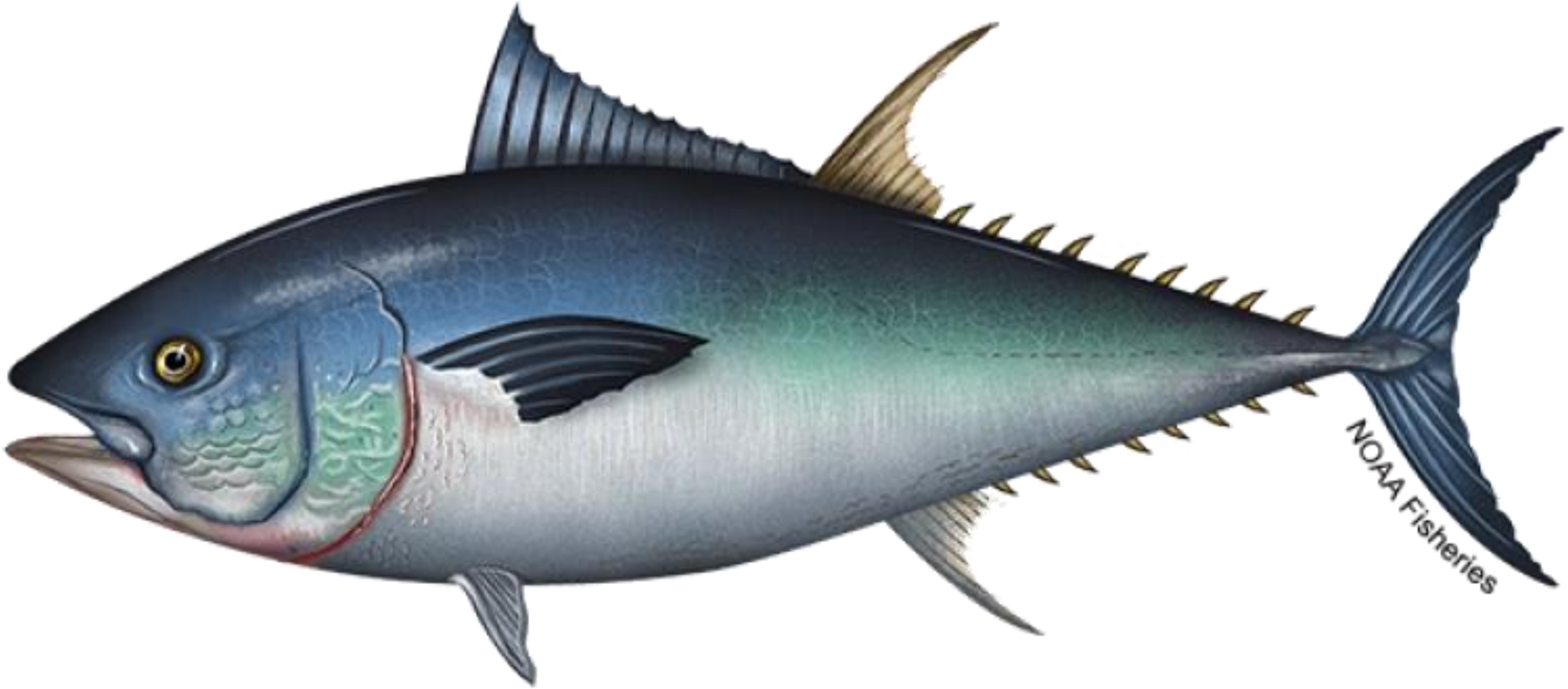
HCR sets TAC by fleet segments, but due to discards catches are assumed to be higher than set by HCR

Discards

- 5% of the WCPO total TAC except for Japanese troll for penning
- 100% of Japanese troll for penning catches
- 1.2% of EPO recreational catches

Questions?

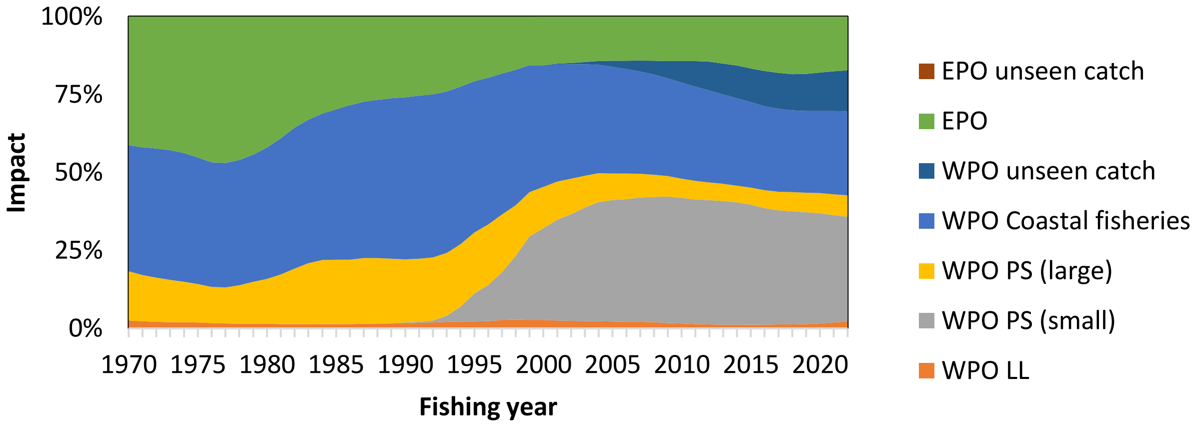




Impact Ratio Tuning

Fishery Impact

- Examines effect of a particular fishery group on SSB
- Computed by simulating what the SSB would have been in the absence of catches from that fishery group
- Depends not only on the amount of catch of that fishery group but also on the size composition of that catch
- JWG asked that HCRs be evaluated in MSE with allocations tuned to reach a WCPO:EPO fishery impact ratio of 70:30 or 80:20 in the terminal year of the evaluation period



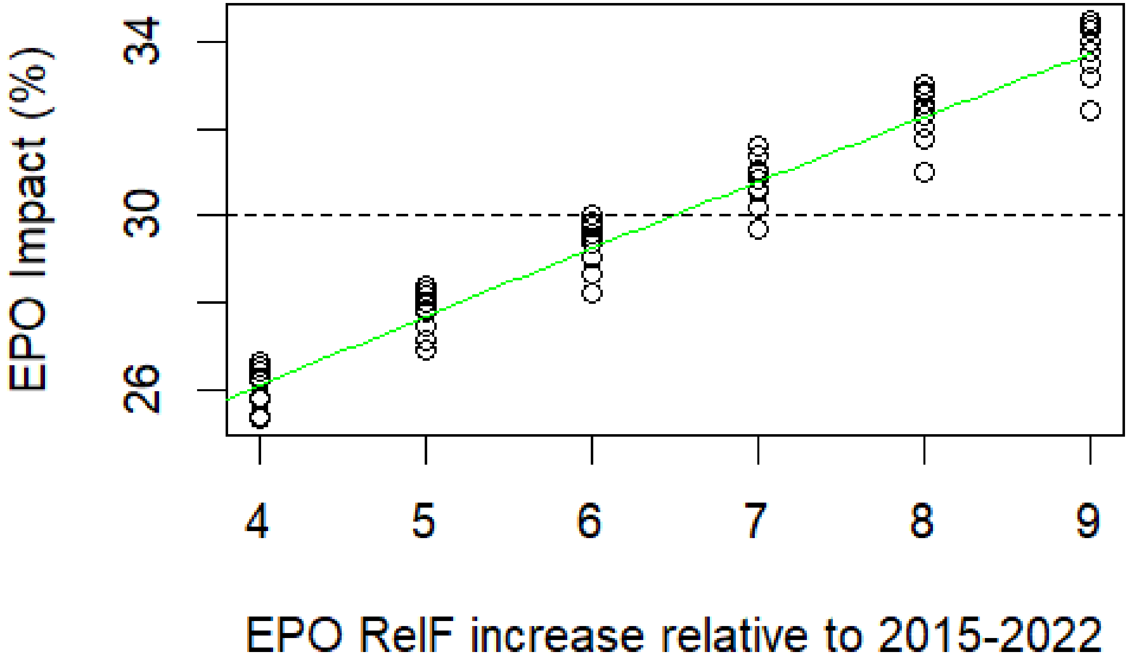
In 2022, EPO:WCPO impact was about 17:83
From 2024 ISC PBF Stock Assessment

Fishery Impact

- Proportional fishery impact is the fishery impact of a particular fishery group relative to the impact of all the fisheries combined
- Depends on the relative exploitation pattern across fleets (i.e. allocation)
- The current (2015-2022) allocation baseline leads to an EPO:WCPO impact ratio close to 80:20 in the base case OM
- The ISC PBF WG developed a method to determine what the relative EPO:WCPO exploitation pattern should be to meet a pre-determined impact ratio between the EPO and WCPO (see Tommasi and Lee 2024)

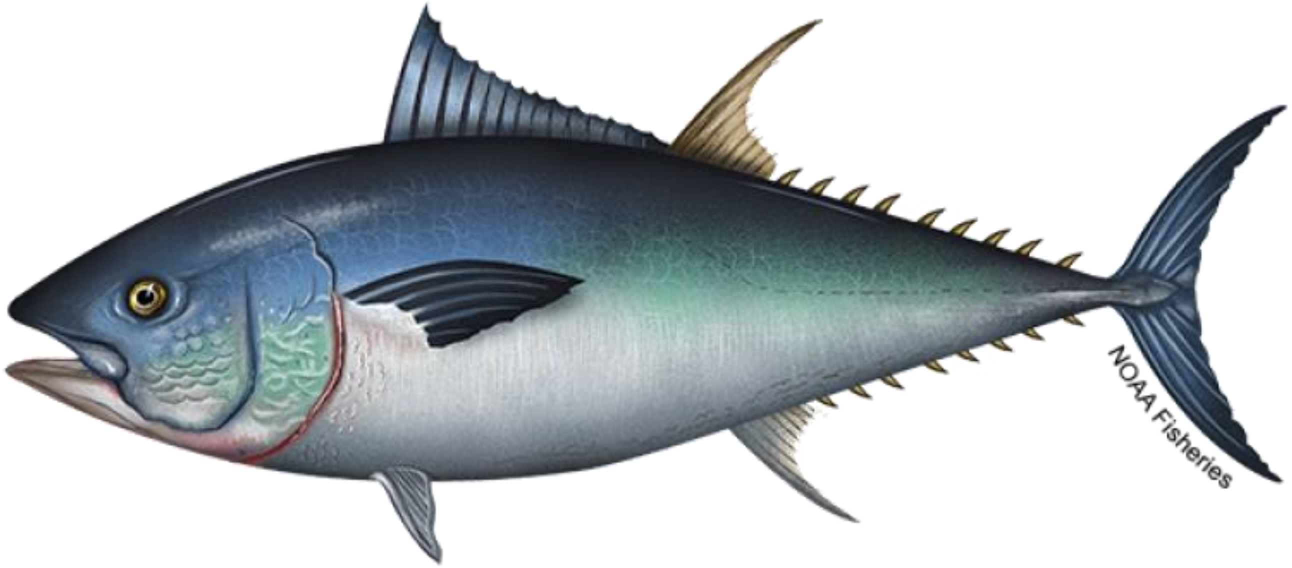
Fishery Impact Tuning

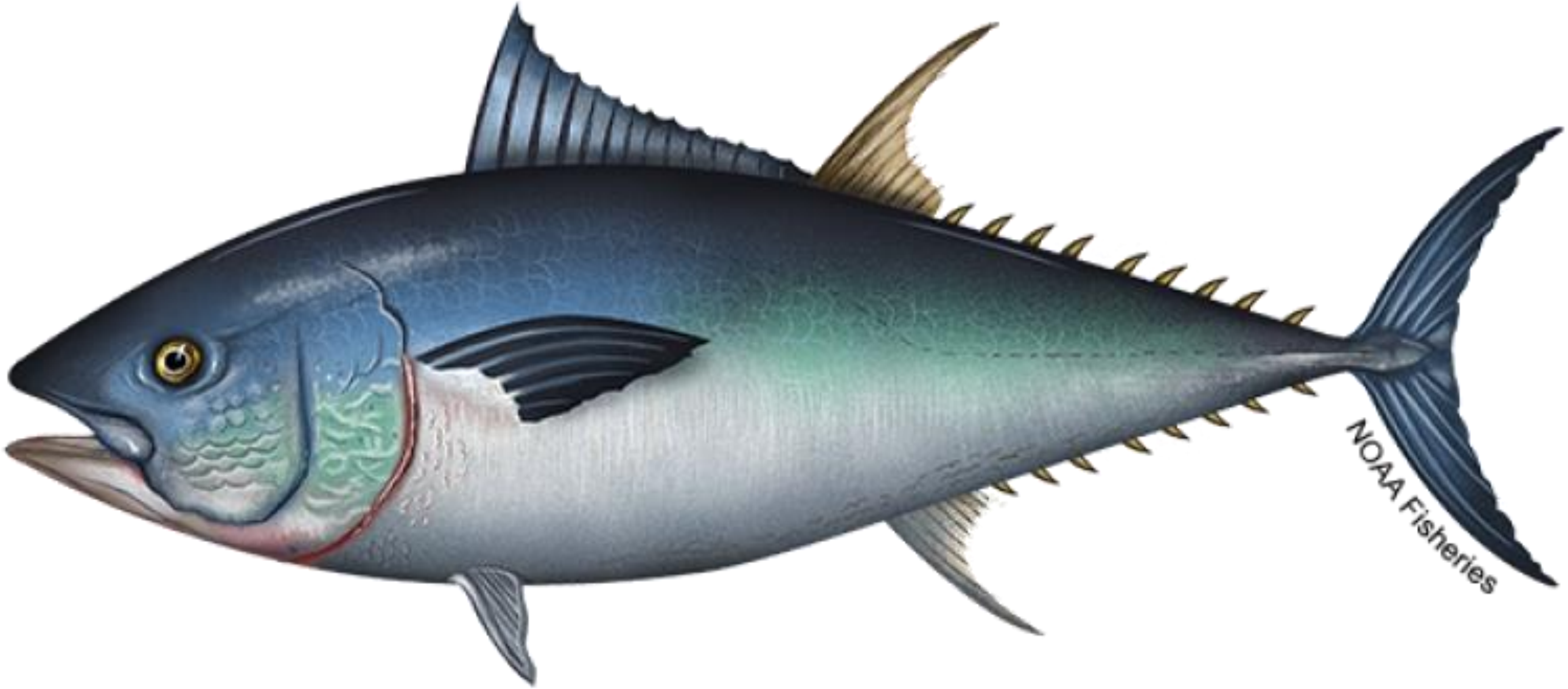
- Method used to tune EPO:WCPO exploitation pattern to obtain a 30:70 EPO:ECPO impact ratio



For an EPO proportional impact of 30, increase EPO relative exploitation pattern by 6.5

Questions?





Management Objectives and Performance Indicators

PBF Management Objectives

1. There should be a less than 20% probability of the stock falling below the LRP
2. To maintain fishing mortality at or below F_{target} with at least 50% probability
3. To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the is stock below the LRP
4. Maintain an equitable balance in proportional fishery impact between the WCPO and EPO
5. To maximize yield over the medium (5-10 years) and long (10-30 years) term, as well as average annual yield from the fishery
6. To increase average annual catch across all fisheries in the WCPO and EPO

PBF Performance Indicators

- Quantitative indicators used to evaluate each HCR
- Represent management objectives

CANDIDATE OPERATIONAL MANAGEMENT OBJECTIVES AND PERFORMANCE INDICATORS FOR PACIFIC BLUEFIN TUNA

Category	Operational Management Objective	Performance Indicator
Safety	There should be a less than 20%[4] probability of the stock falling below the LRP	Probability that SSB< LRP in any given year of the evaluation period
Status	To maintain fishing mortality at or below FTarget with at least 50% probability	Probability that F≤FTARGET in any given year of the evaluation period Probability that SSB is below the equivalent biomass depletion levels associated with the candidates for FTARGET
Stability	To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the stock is below the LRP[5]	Percent change upwards in catches between management periods excluding periods when SSB<LRP Percent change downwards in catches between management periods excluding periods when SSB<LRP
Yield	Maintain an equitable balance in proportional fishery impact between the WCPO and EPO	Median fishery impact (in %) on SSB in the terminal year of the evaluation period by fishery and by WCPO fisheries and EPO fisheries
	To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual yield from the fishery.	Expected annual yield over years 5-10 of the evaluation period, by fishery. Expected annual yield over years 10-30 of the evaluation period, by fishery. Expected annual yield in any given year of the evaluation period, by fishery.
	To increase average annual catch in all fisheries across WCPO and EPO	

Questions?