Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission




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RISK ANALYSIS FOR YELLOWFIN TUNA: MODELS AND THEIR WEIGHTS

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Document SAC-11-INF-J

Outline

- Introduction
- Weighting methods
- Results
- Conclusion
- Next steps

The staff's pragmatic risk analysis approach

Described in Maunder et al. 2020 (SAC-11- INF-F):

1. **Identify alternative hypotheses** (‘*states of nature*’) about the population dynamics of the stock that address the main issues in the assessments
   - YFT: SAC-11 INF-J; BET: SAC-11 INF-F
2. **Implement stock assessment models representing alternative hypotheses**
   - YFT: SAC-11-07; BET: SAC-11-06
3. **Assign relative weights to each hypothesis (model)**
   - **YFT: SAC-11 INF-J**; BET: SAC-11 INF-F
4. **Compute combined probability distributions for management quantities using model relative weights**
   - SAC-11-08

Assigning model weights

- Level 1 (hypothesis of population mixing) is weighted independently solely on experts opinion
- Level 2 is weighted based on several criteria:
  - Expert opinion
  - Convergence
  - Fit to data
  - Plausible parameter estimates
  - Plausible model results
  - Model diagnostics
  - Recruitment shift metric
  - Empirical selectivity vs. estimated selectivity
- Level 3 (steepness hypothesis) is weighted independently solely on experts opinion

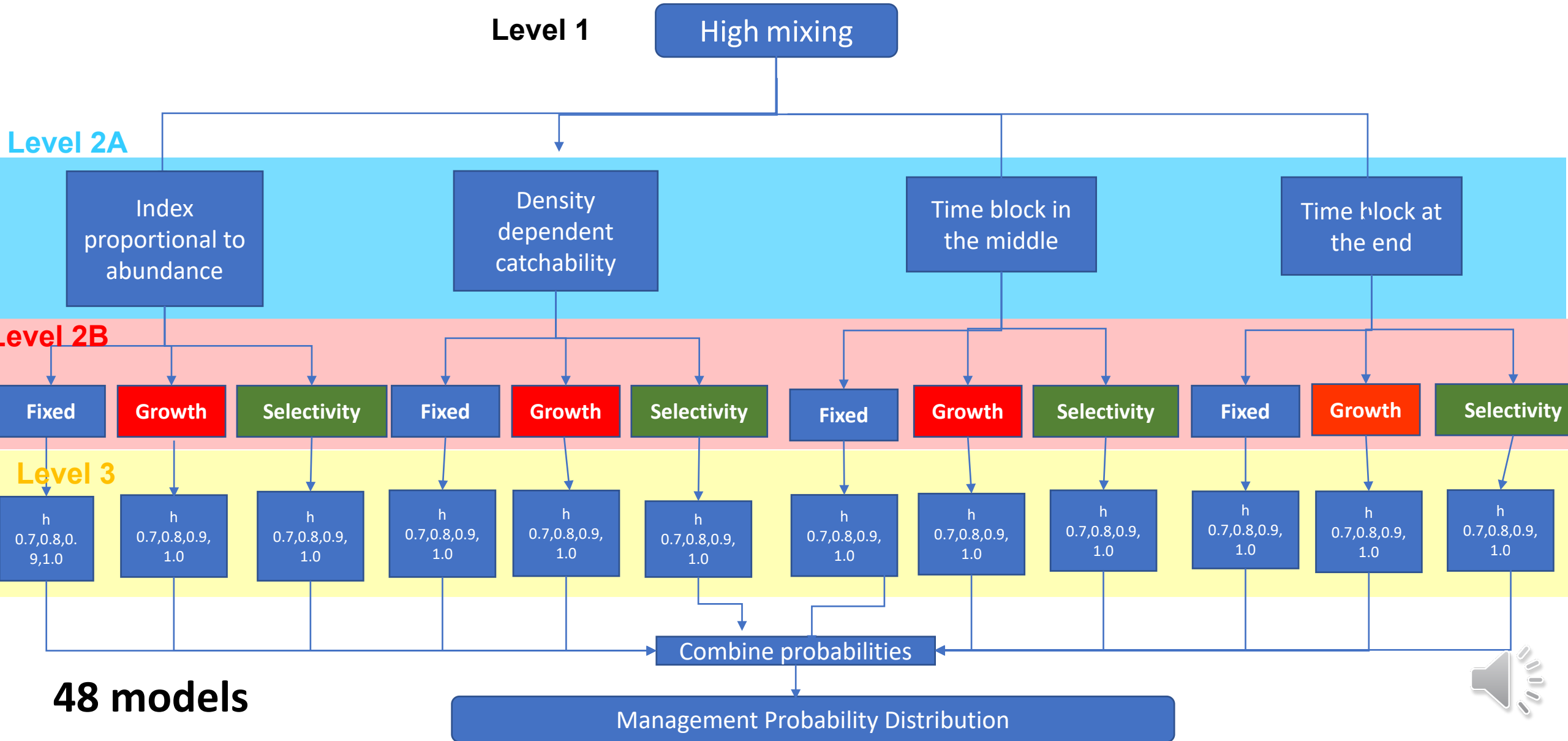
Weighting of the set of reference models

- Scoring done by the IATTC staff (stock assessment authors)

- Weight categories
  - None: 0
  - Low: 0.25
  - Medium: 0.5
  - High: 1

- Rescaled weights to sum to 1

Models incluided: levels 2 and 3 hypothese



48 models

Set of reference models in the risk analysis

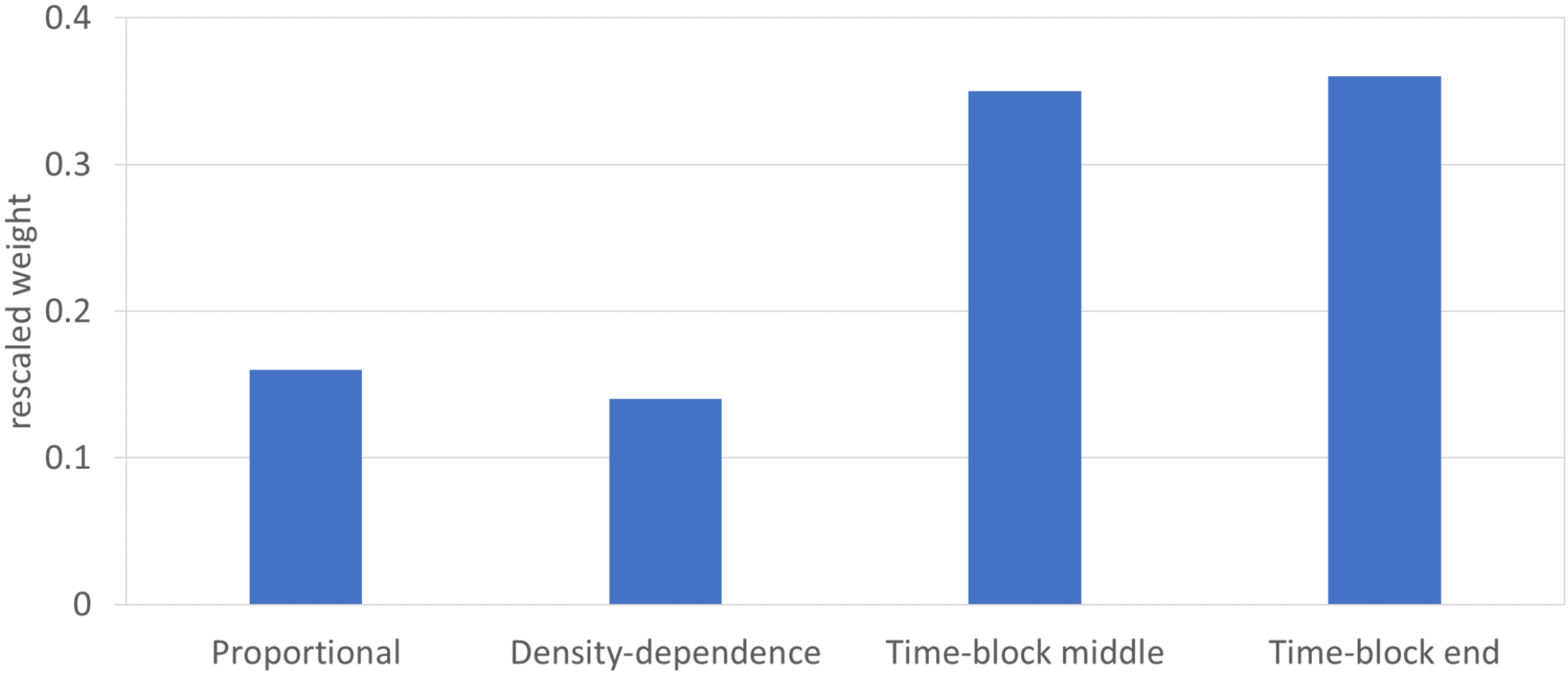
	Hypotheses		Steepness of the stock-recruitment curve h=0.7 h=0.8 h=0.9 h=1
	Level 2A	**Level 2B**	
1	Proportional	Fixed	48 models
2		Est Growth	
3		Est Select	
4	Density dependence	Fixed	
5		Est Growth	
6		Est Select	
7	Time block middle	Fixed	
8		Est Growth	
9		Est Select	
10	Time block end	Fixed	
11`		Est Growth	
12		Est Select	

Results: W(Experts)

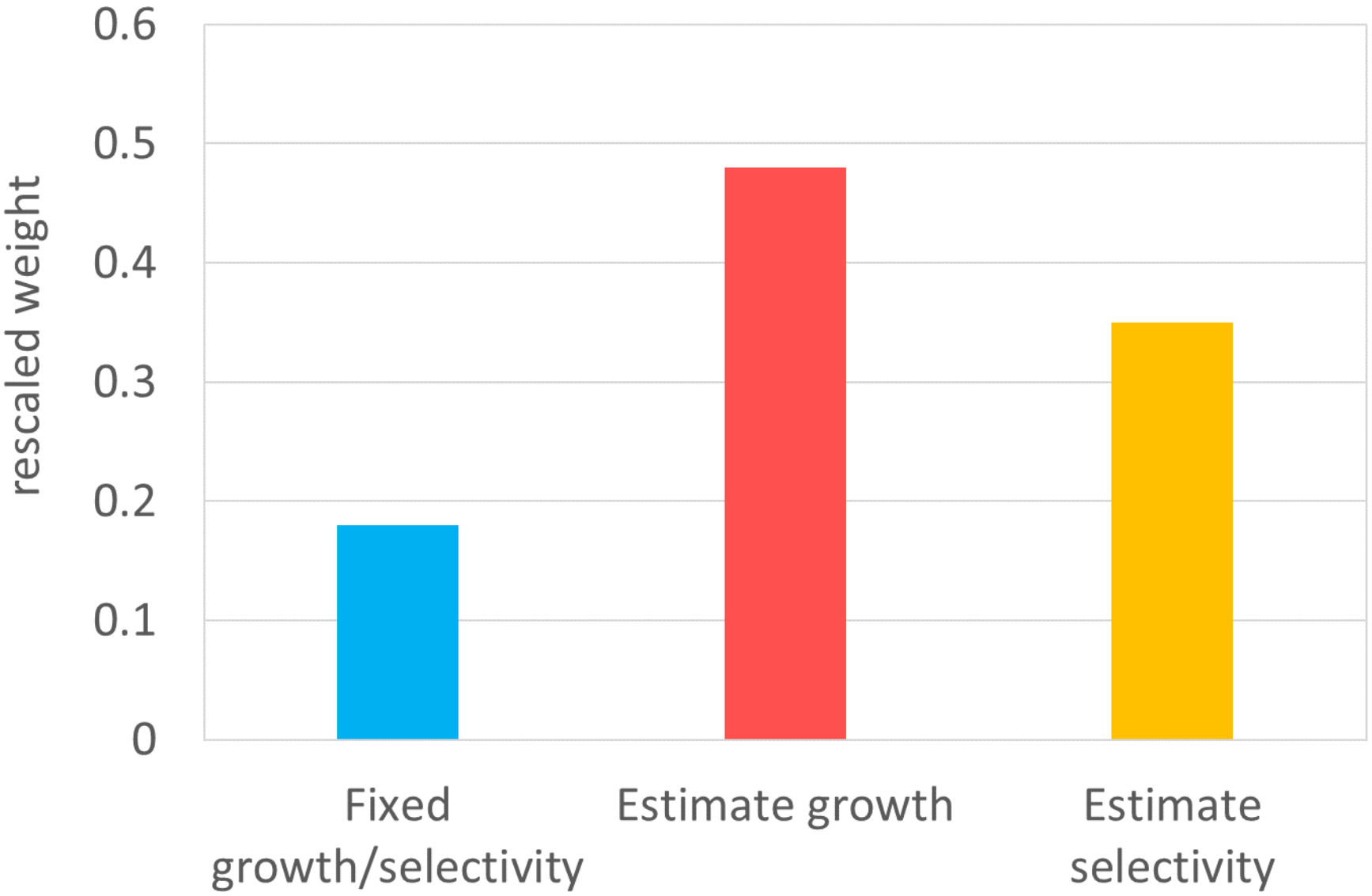
The weight of each hypothesis by each expert *a priori:*

- Weights developed independently for levels 2A and 2B
- Joint weight computed

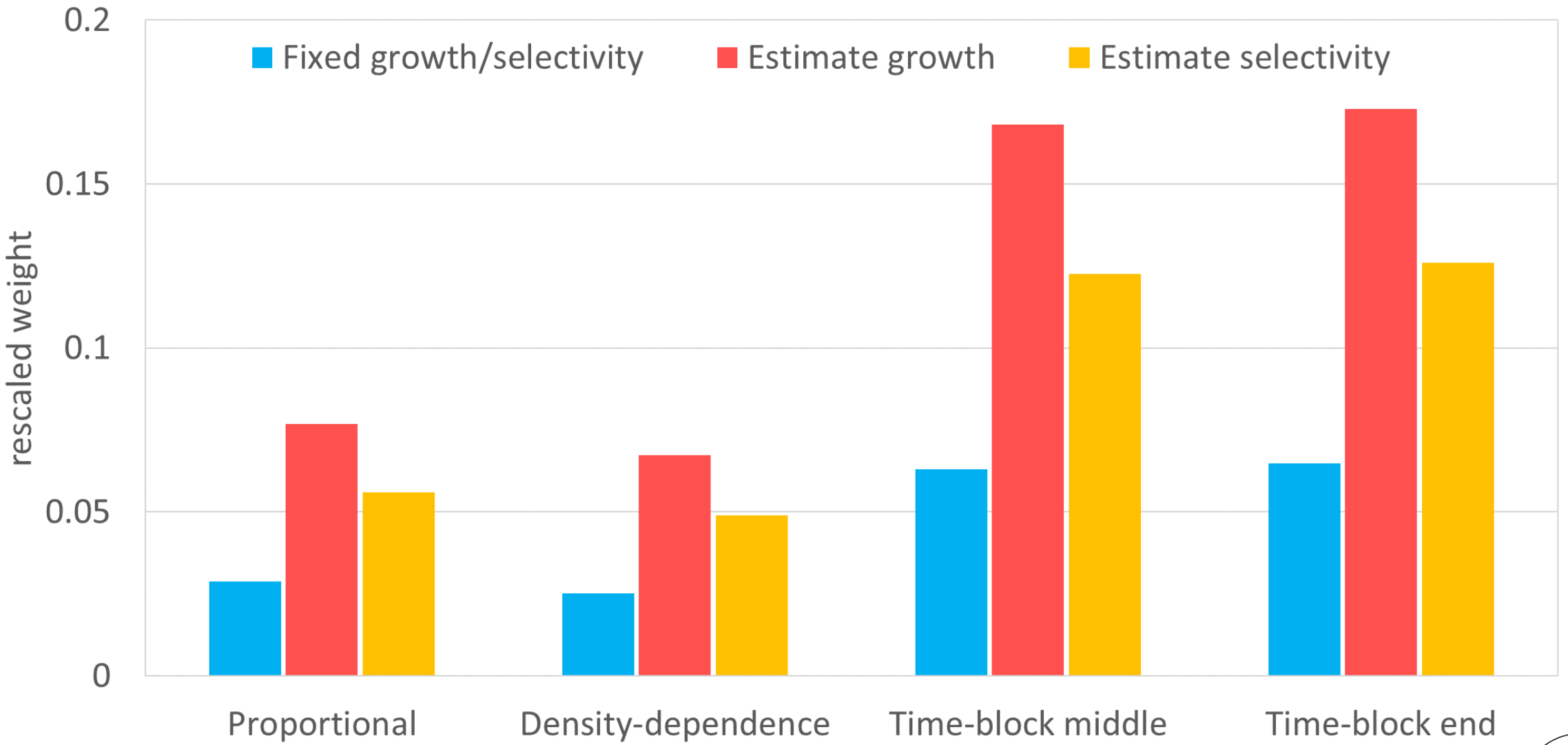
W(Experts): Level 2A – index of abundance



W(Experts):Level 2B – length composition fits



W(Expert): Hypotheses level 2A and 2b combined



Results: W(Convergence)

The converge of the estimation algorithm:

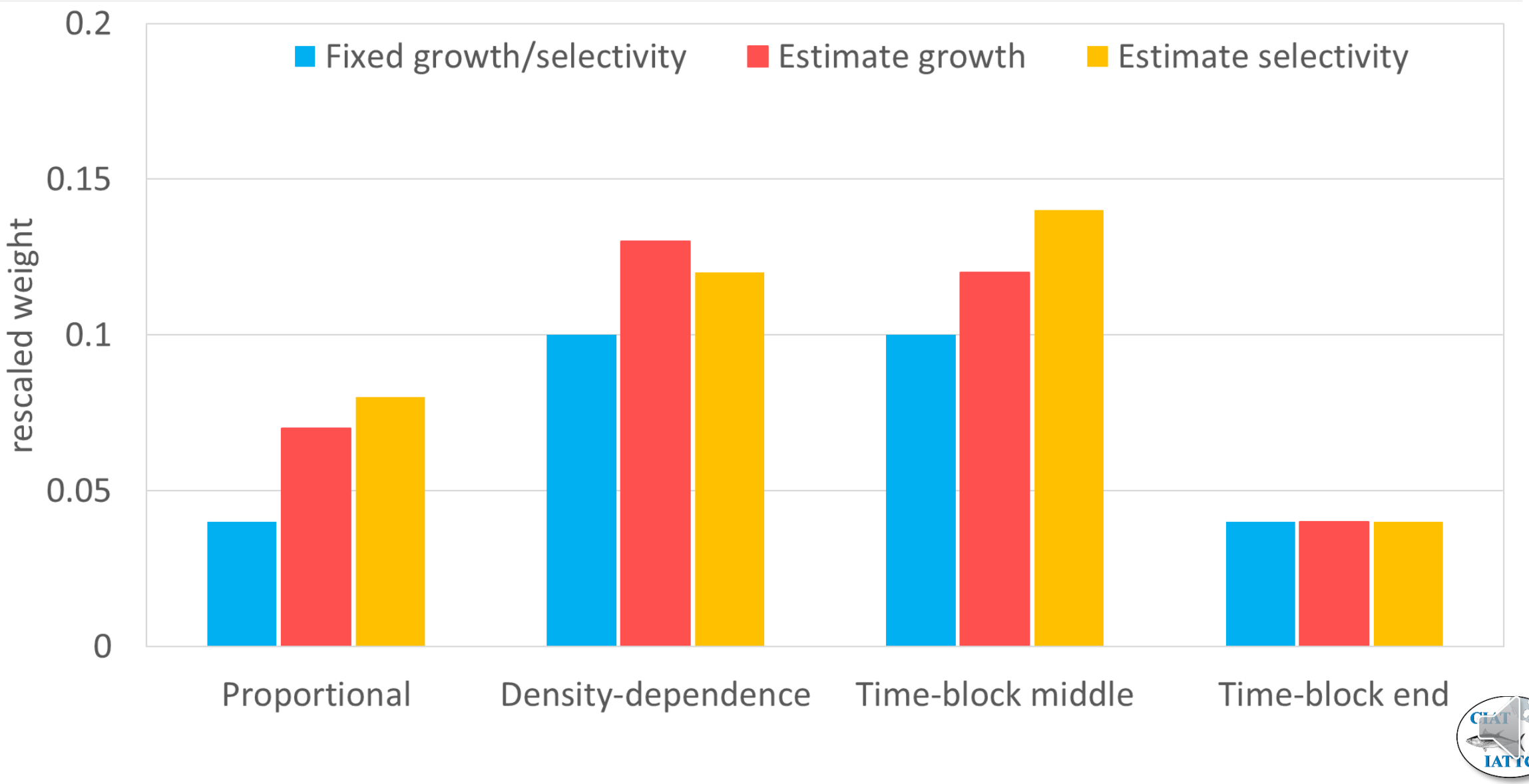
- All models converged
- Equal weight given to all models

W(Fit)

The support of the data to each hypothesis:

- No conditional length-at-age data
- Approximation: Akaike Information Criterion (AIC)
- Linear weight from worst (0.25) to best models (1)

W(Fit)


0.2
0.15
0.1
0.05
0
rescaled weight
Fixed growth/selectivity
Estimate growth
Estimate selectivity
Proportional
Density-dependence
Time-block middle
Time-block end

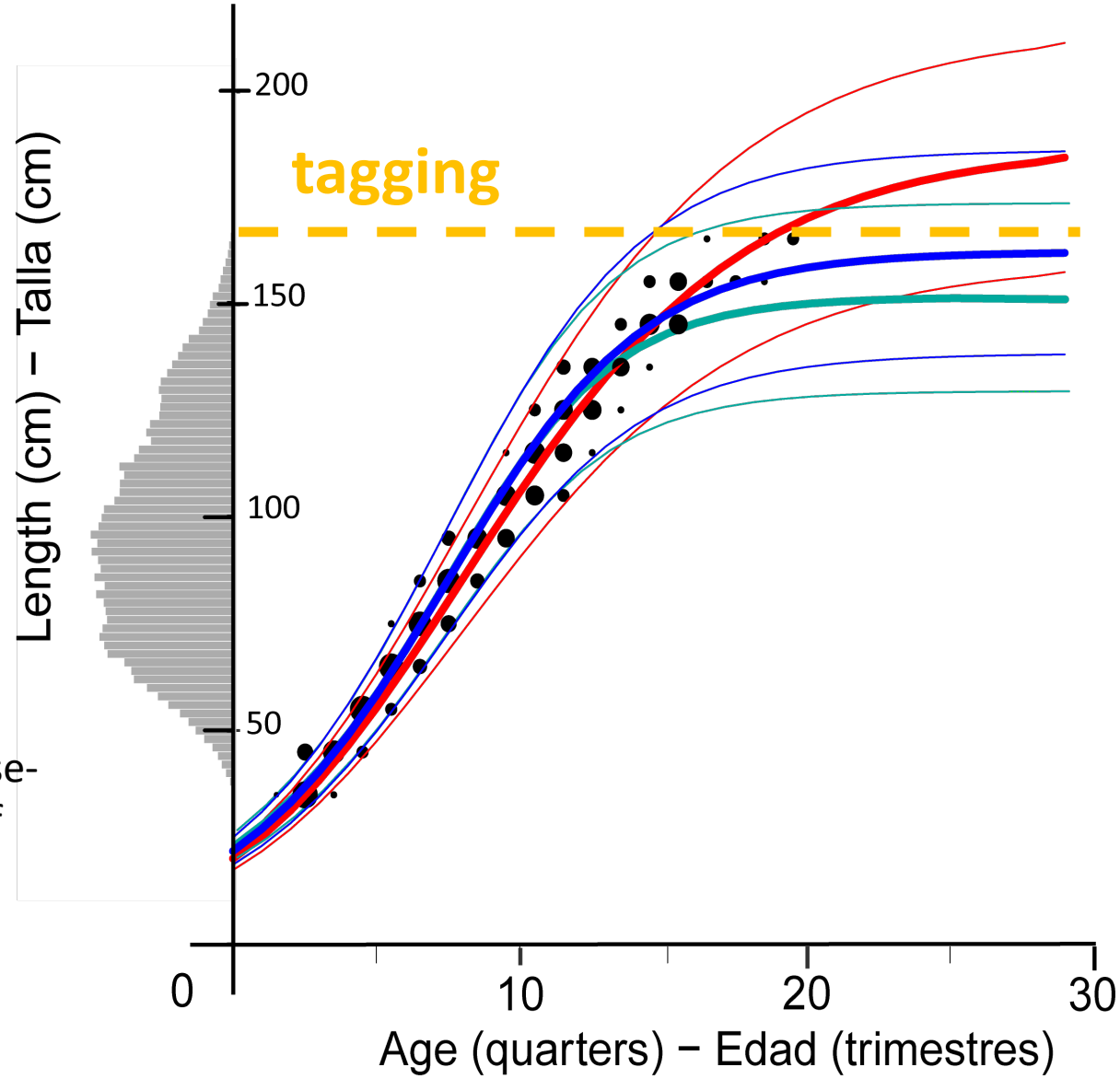
W(Plausible parameters)

The realism of the estimates of the parameters:

- Are the parameters realistic compared to expert judgement, theory, other data not used in the model?

W(Plausible parameters): growth

Length frequency of dolphin associated purse-seine fisheries north of 5° N



Fixed growth

Estimated growth

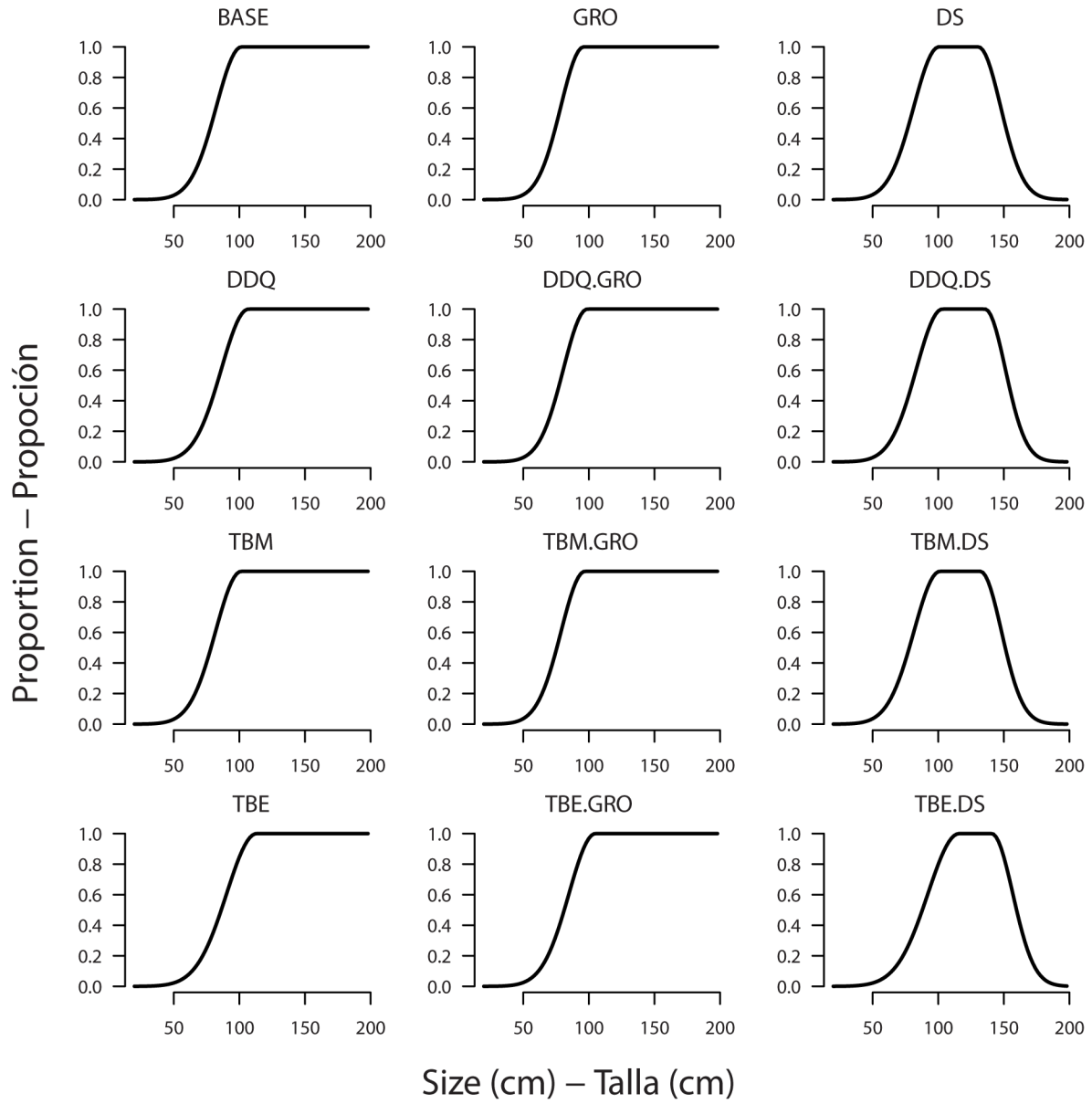
TBE.GRO

GRO / TBM.GRO

Number of otoliths

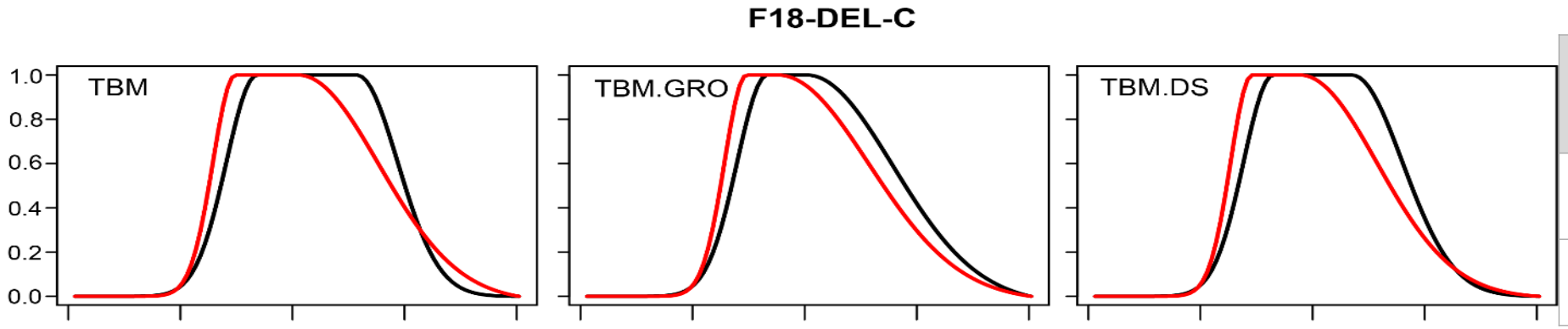
- 5
- 10

W(Plausible parameters): selectivity

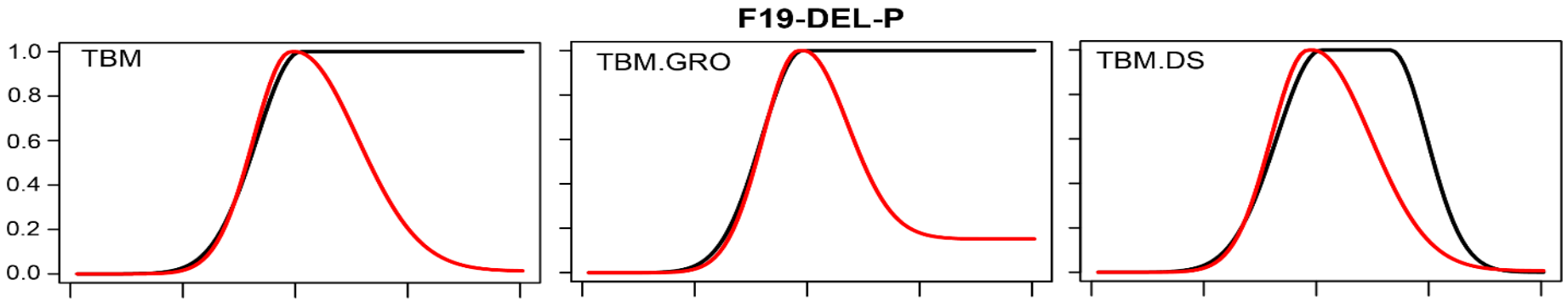


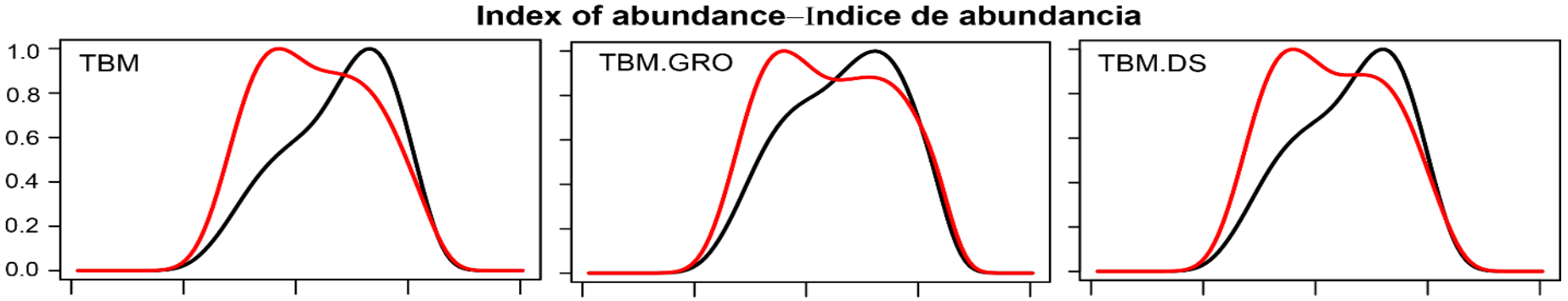
Fishery F19-DEL_P

W(Plausible parameters): catchability and selectivity



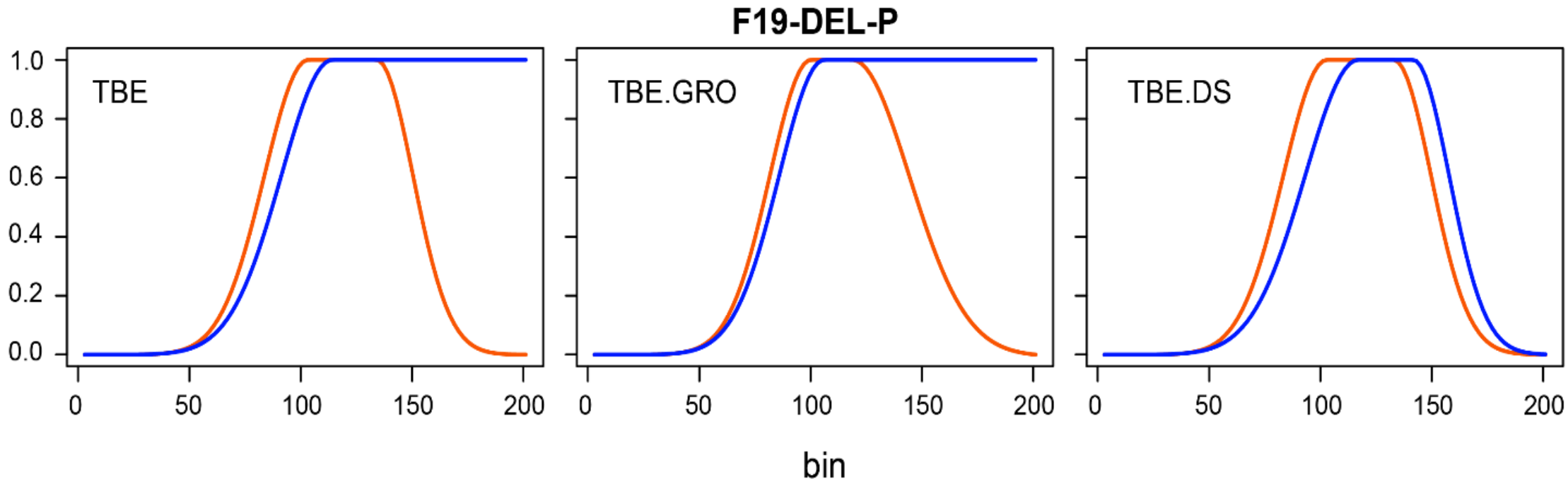
$q_{2001\text{-}2003.Q2}/q$		
TBM	TBM.GRO	TBM.DS
1.64	1.82	1.74





W(Plausible parameters): catchability and selectivity

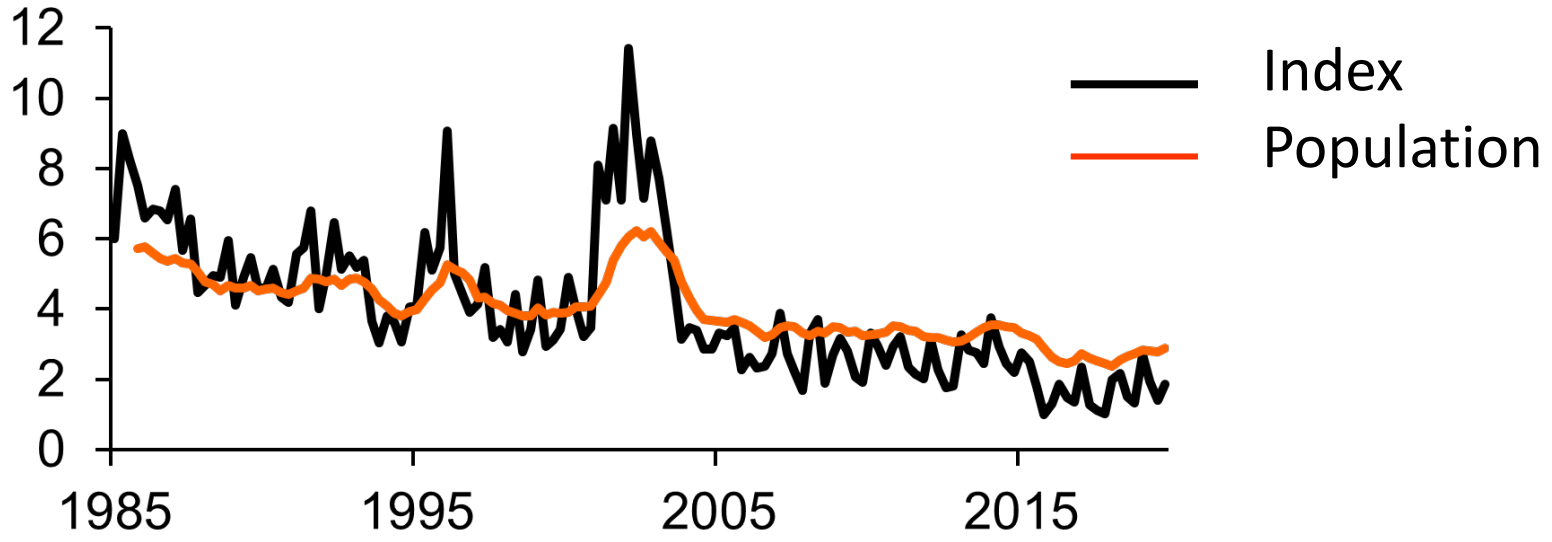
$q_{2015\text{-}2019}/q$		
TBE	TBE.GRO	TBE.DS
0.91	0.92	0.86



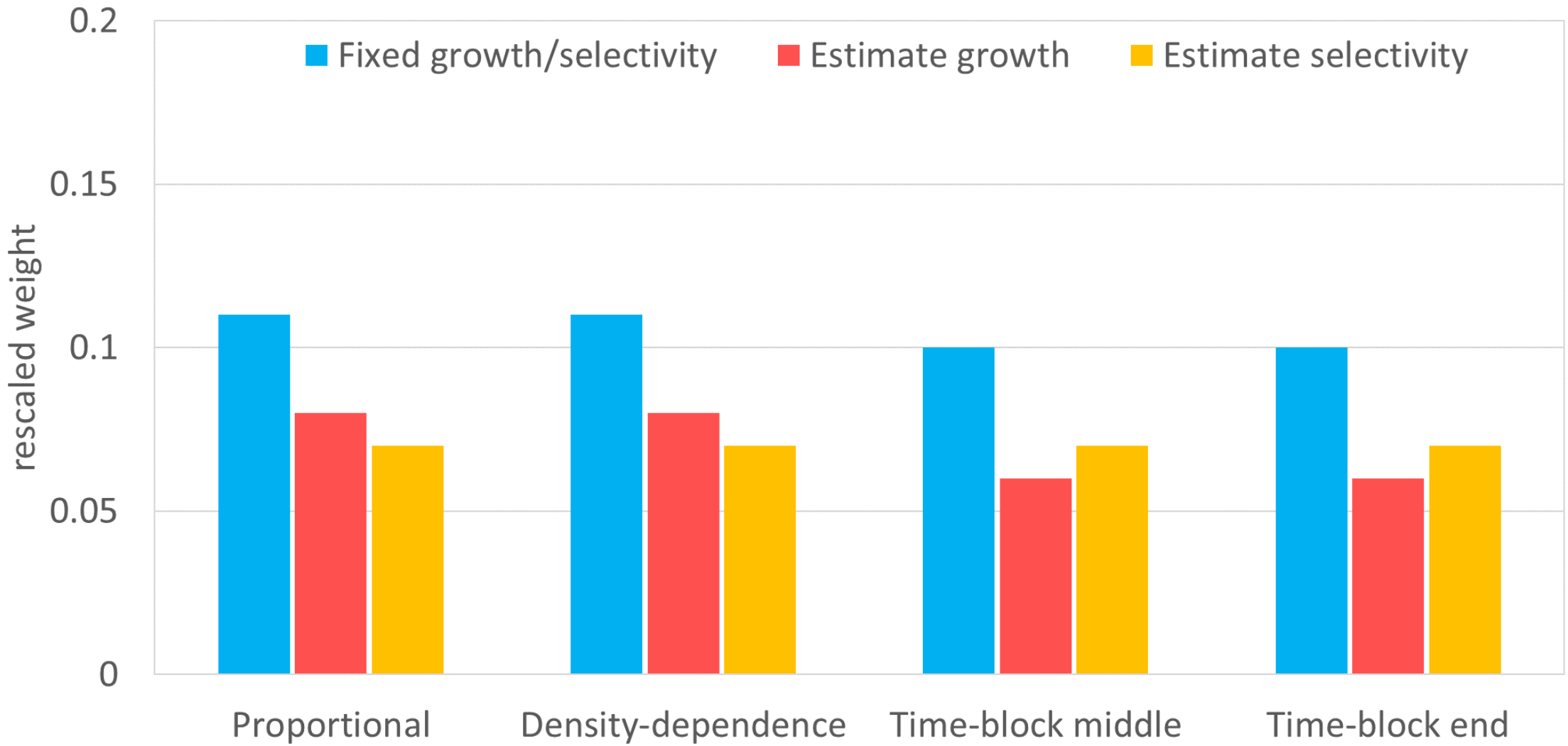
W(Plausible parameters): catchability

Density-dependence parameter *c*		
DDQ	DDQ.GRO	DDQ.DS
1.7	2.2	2.1

Example with *c*=2



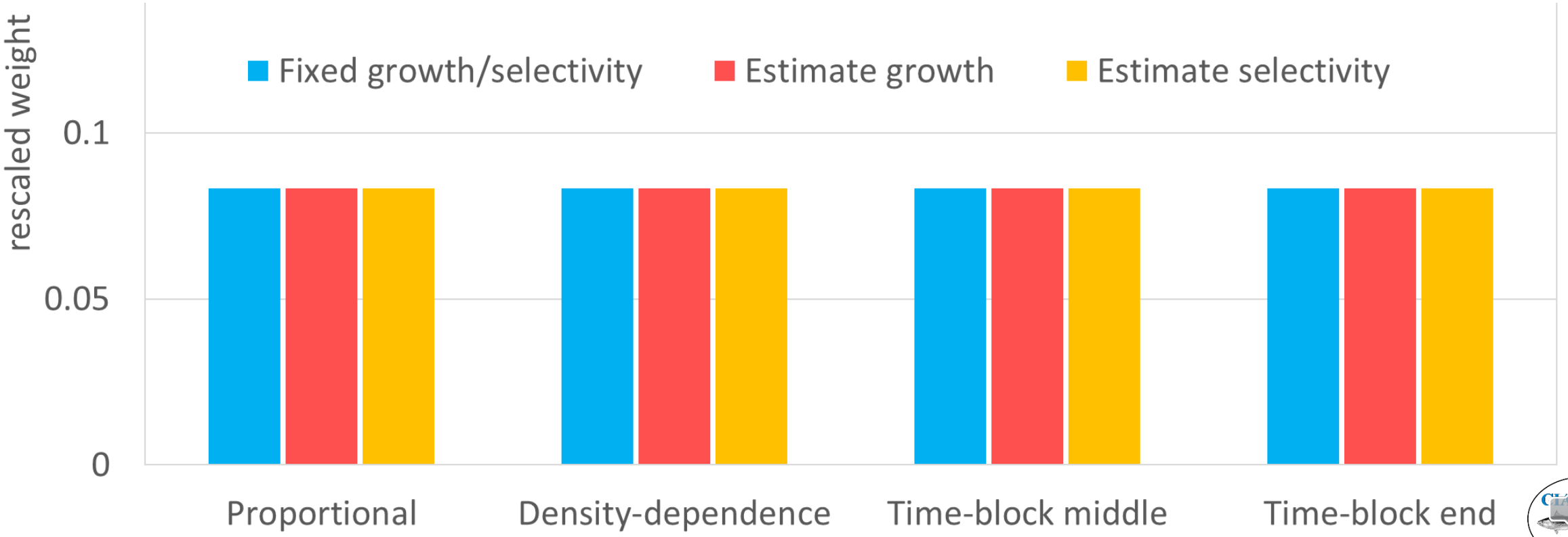
Results: W(Plausible parameters)



Results: W(Plausible results)

The plausibility of the results:

- Based on initial fishing mortality and initial equilibrium catch estimates.
- Initial biomass hard to judge

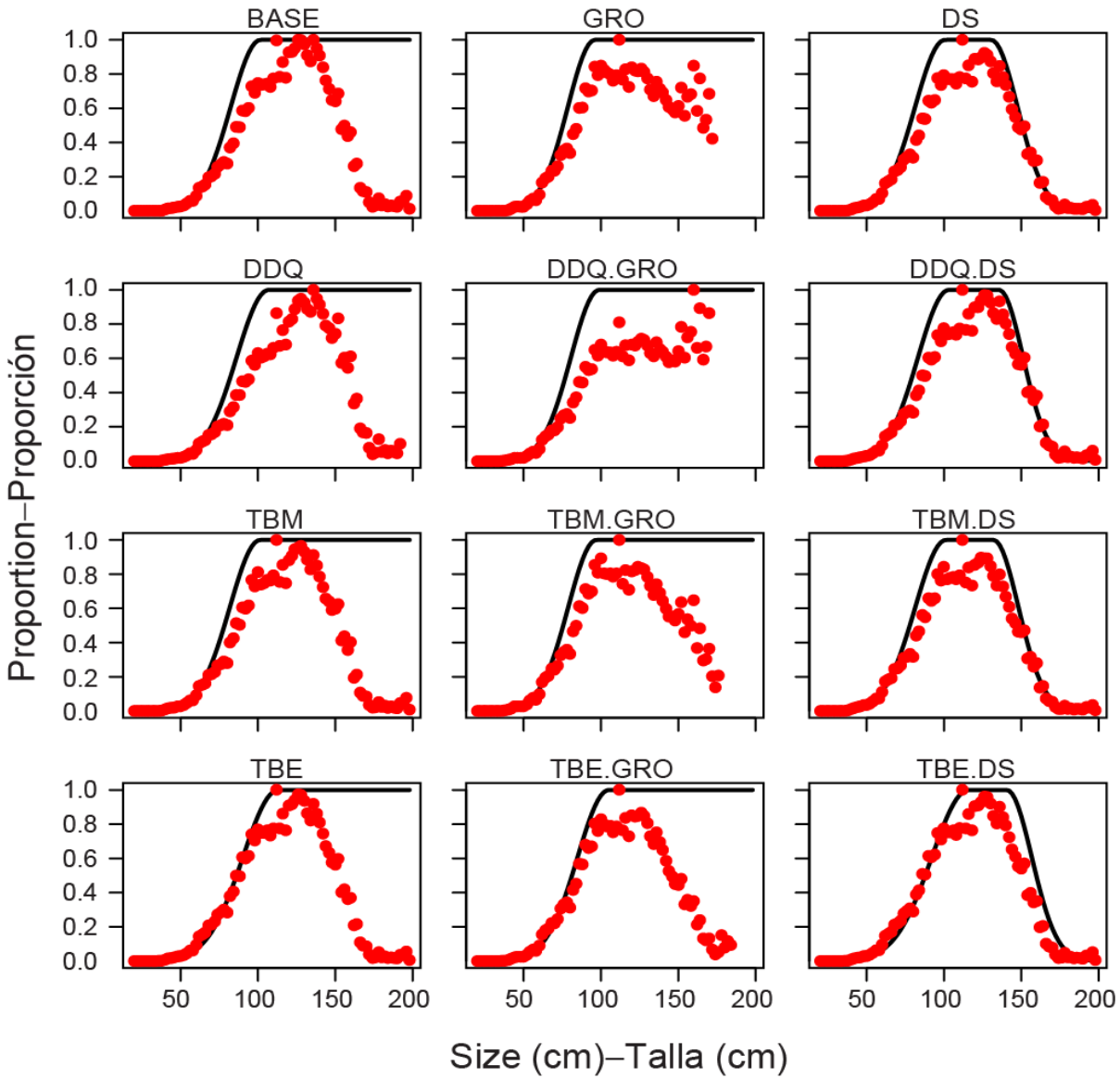


W("Empirical" selectivity)

Compares the "empirical" selectivity with estimated selectivity

- "Empirical" selectivity is the catch in numbers by length divided by the estimated abundance in numbers by length
- Focuses on larger fish that are more influential
- Fits are generally good except for the F19-DEL-P fishery
- Selectivity for this fishery was the basis for weighing under this criterion.

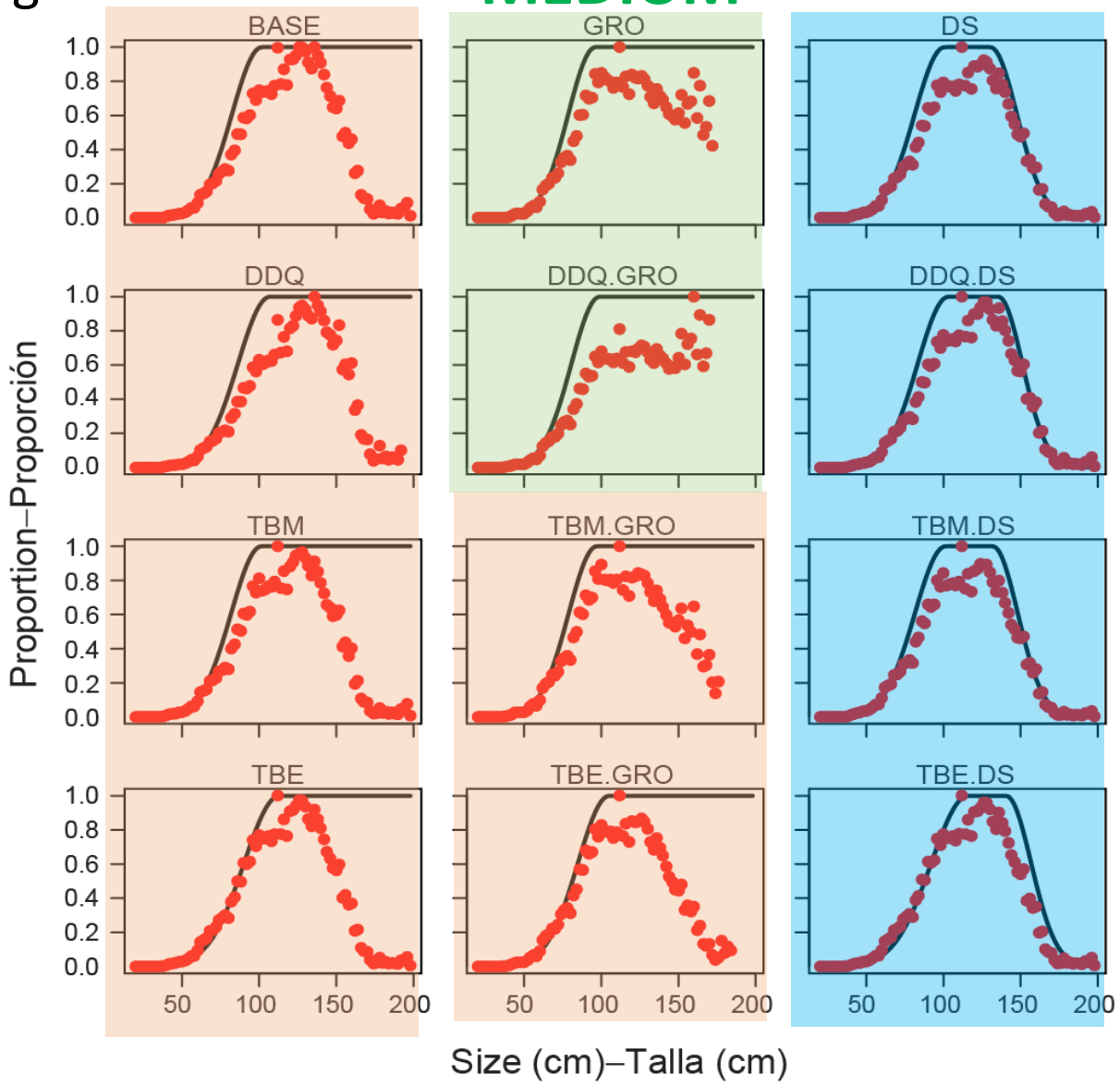
W("Empirical" selectivity)



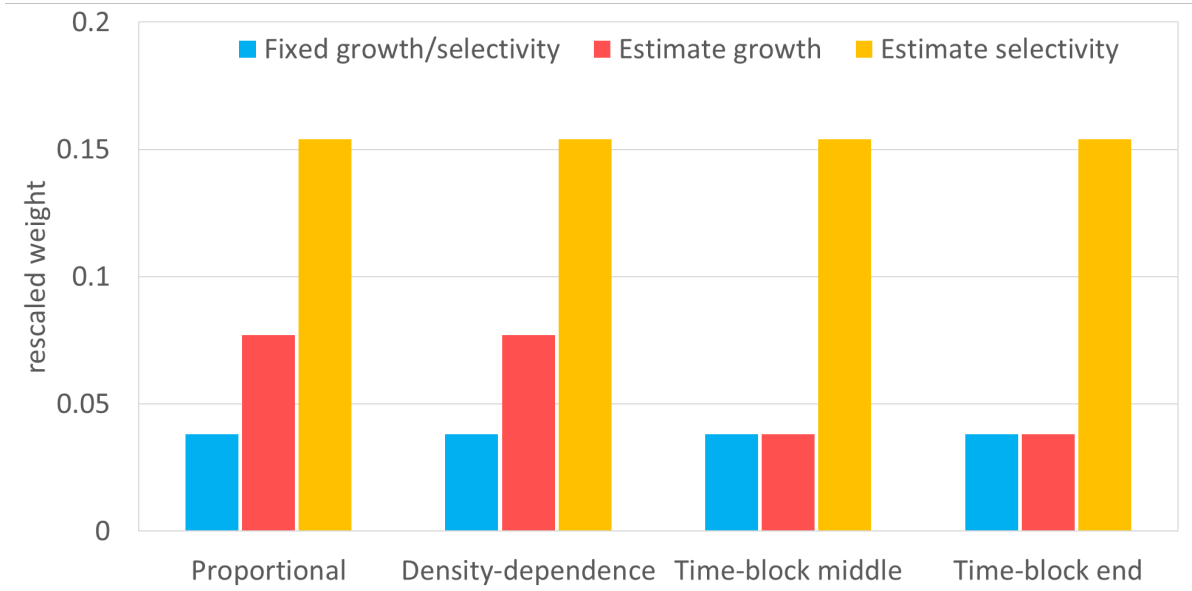
Fishery F19-DEL_P

W("Empirical" selectivity)

Weight: **LOW** **MEDIUM** **HIGH**



Fishery F19-DEL_P



W(Diagnostics)

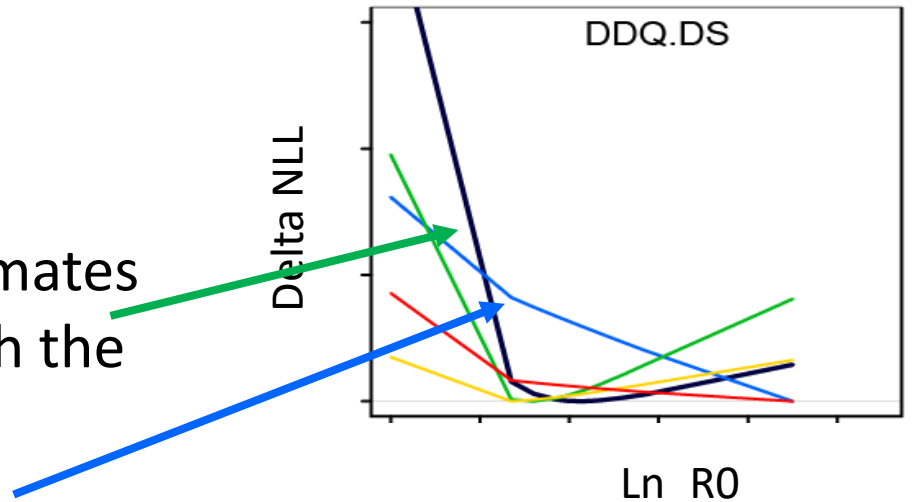
- Reliability of the model based on diagnostics
- For h=1 models
- Three components summed:
  - ASPM, CCA, R0 profile (algorithm in Figure 1 of SAC-11 INF-F)
  - Retrospective analysis
  - Residual patterns

W(ASPM, R0 profile, CCA)

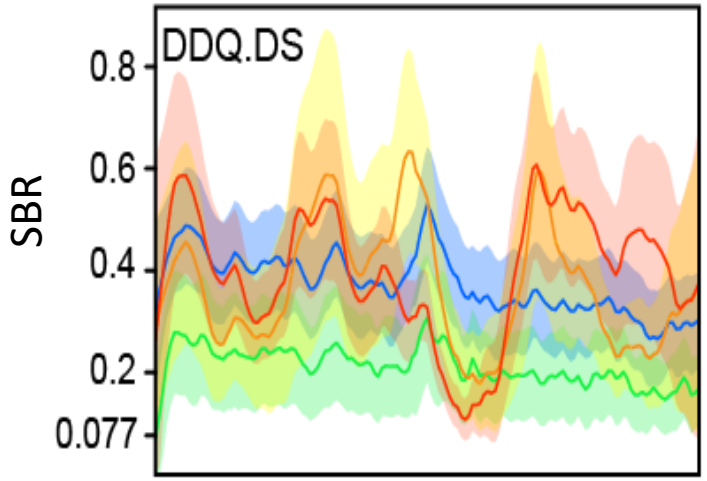
Weight:

LOW

- R0 profile:
  - Length frequencies control estimates
  - The index is **NOT** consistent with the sizes
- ASPM-R, CCA:
  - Recruitment is variable
  - ASPM-R confidence intervals are not small
  - The information in the length frequencies is necessary to estimate recruitment



Ln_R0 likelihood profile

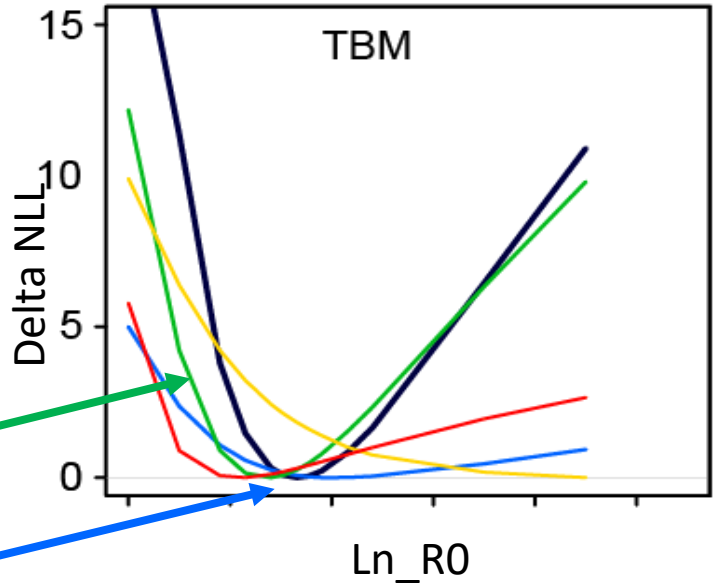


W(ASPM, R0 profile, CCA)

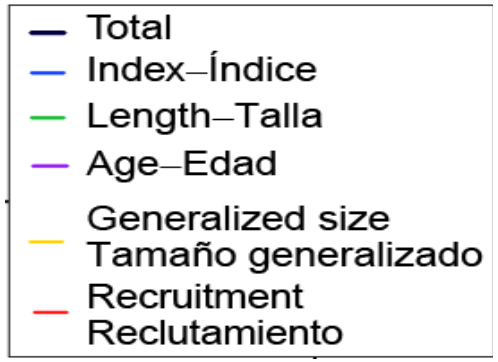
Weight

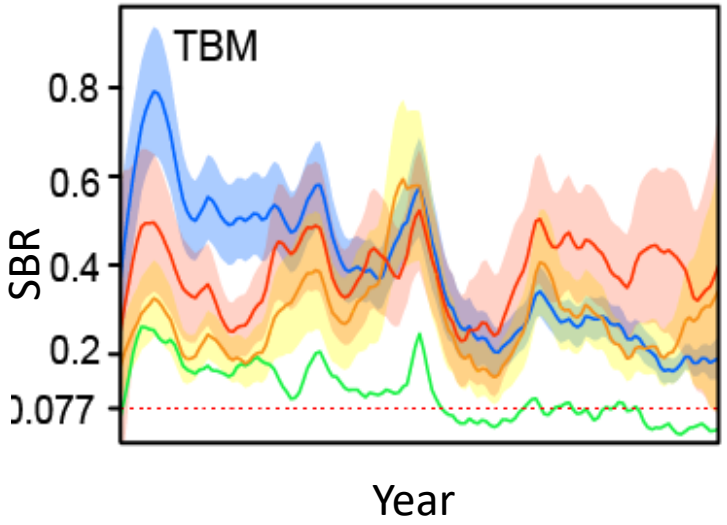
MEDIUM

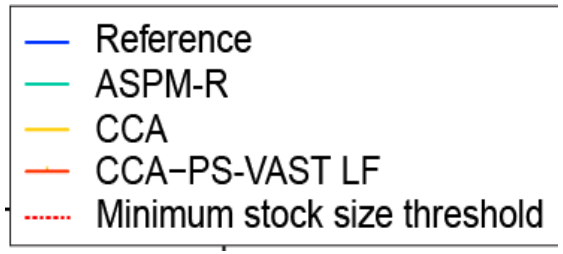
- Perfil de R0:
  - Length frequencies control estimates
  - The index **IS** consistent with the length
- ASPM-R, CCA:
  - Recruitment is variable
  - ASPM-R confidence intervals are not small (there was no Hessian matrix, variation is considered to be large)
  - The information in the length frequencies is necessary to estimate recruitment



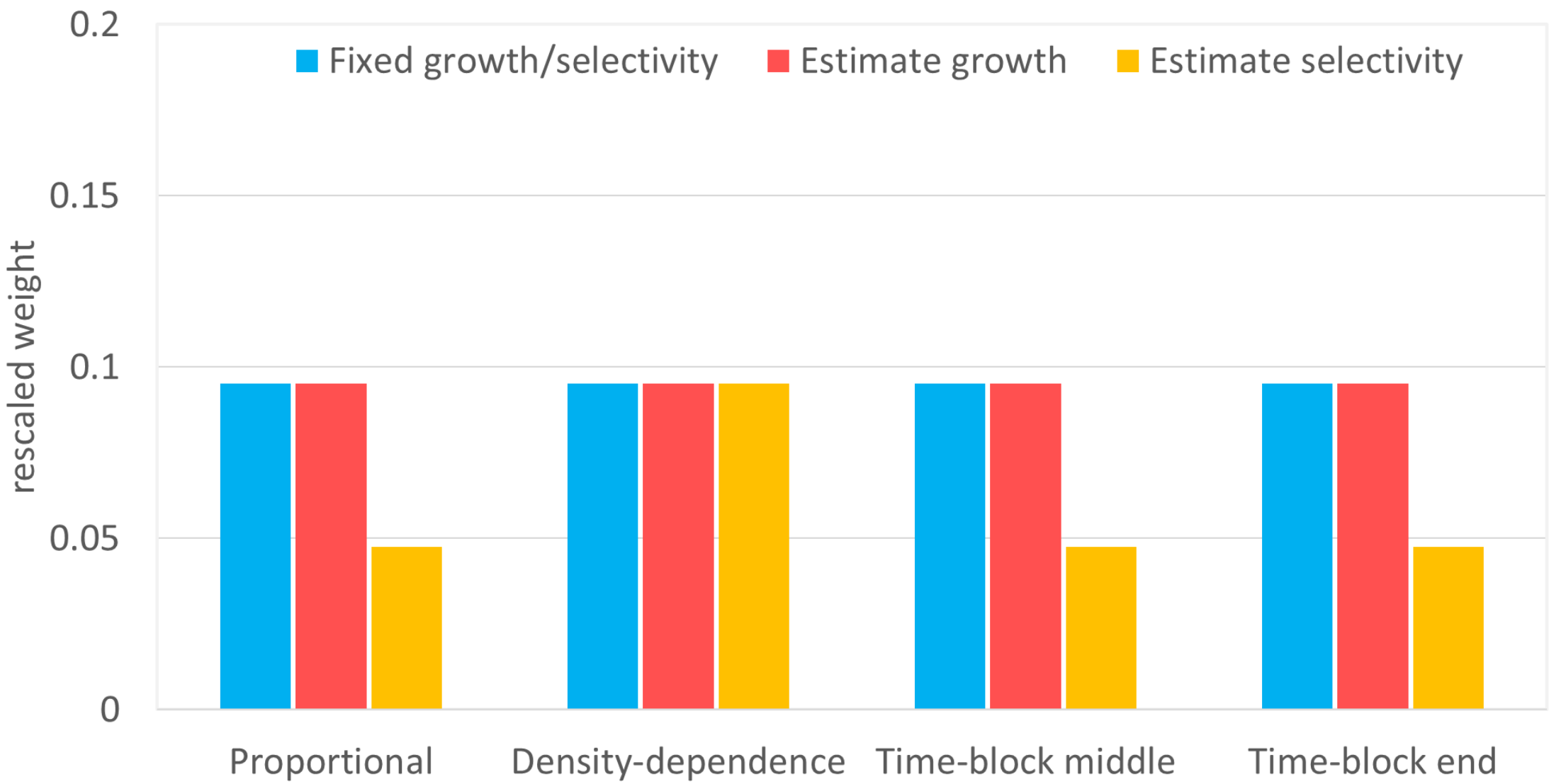
Ln_R0 likelihood profile







W(ASPM, R0 profile, CCA)

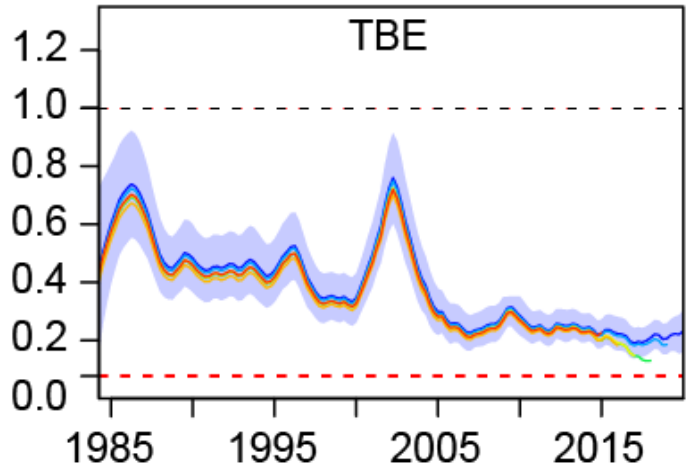


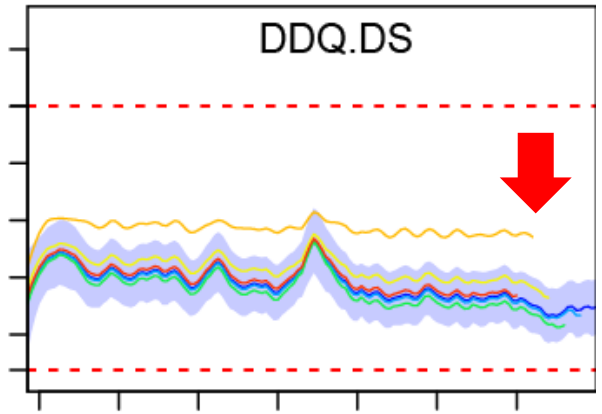
W(Retrospective analyses)

HIGH weight

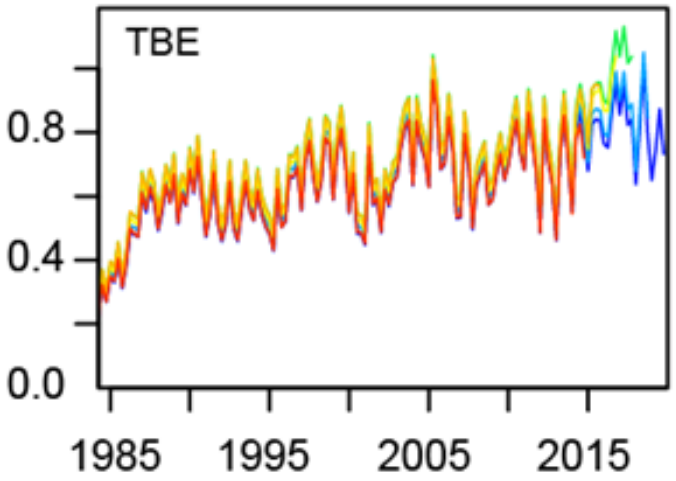
ZERO weight

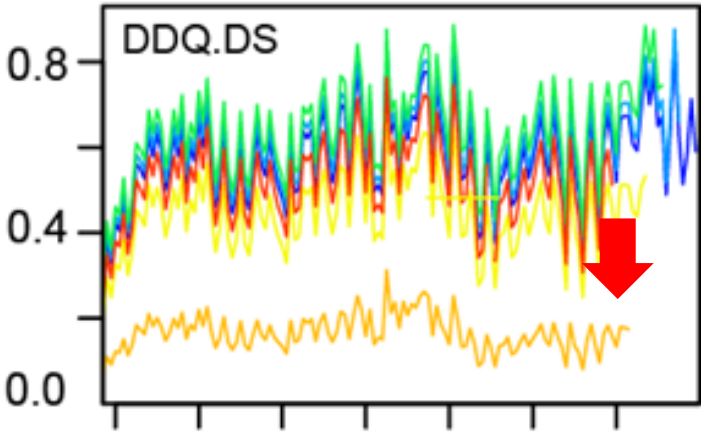
SBR



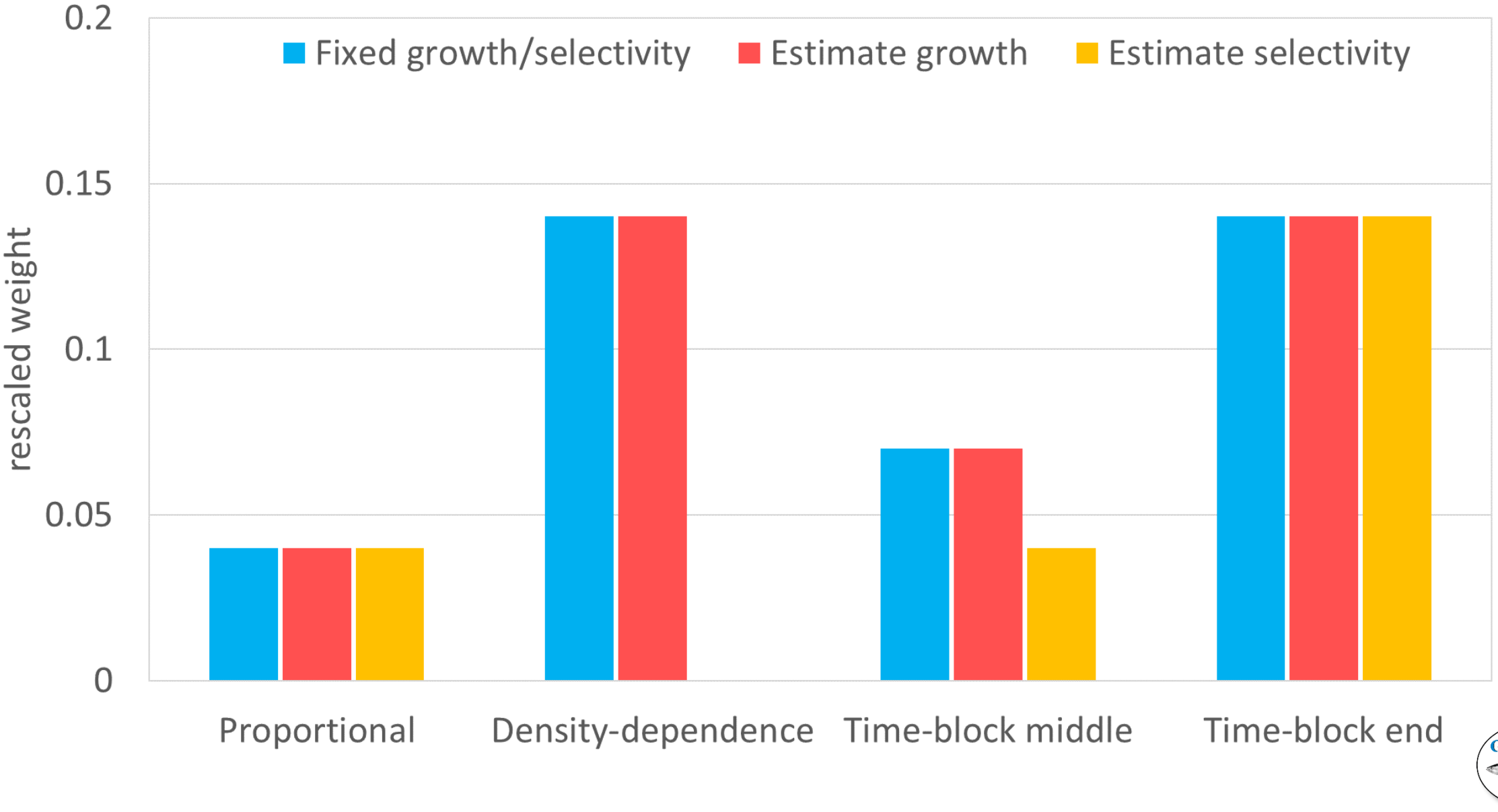


F proxy



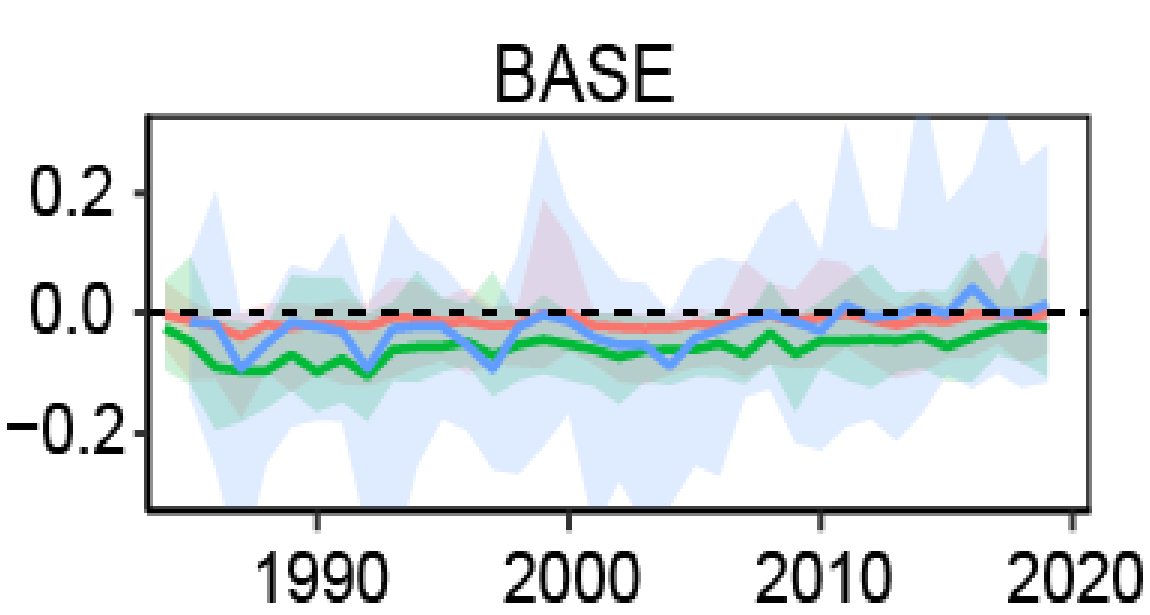


W(Retrospective)

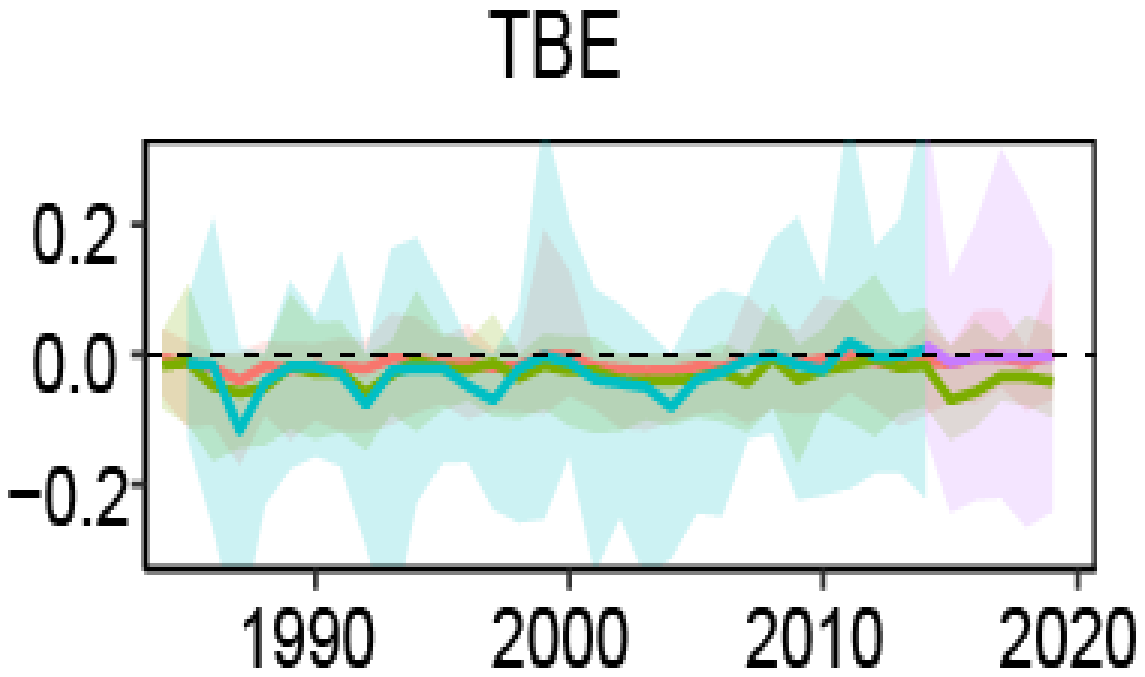


W(Composition residuals)

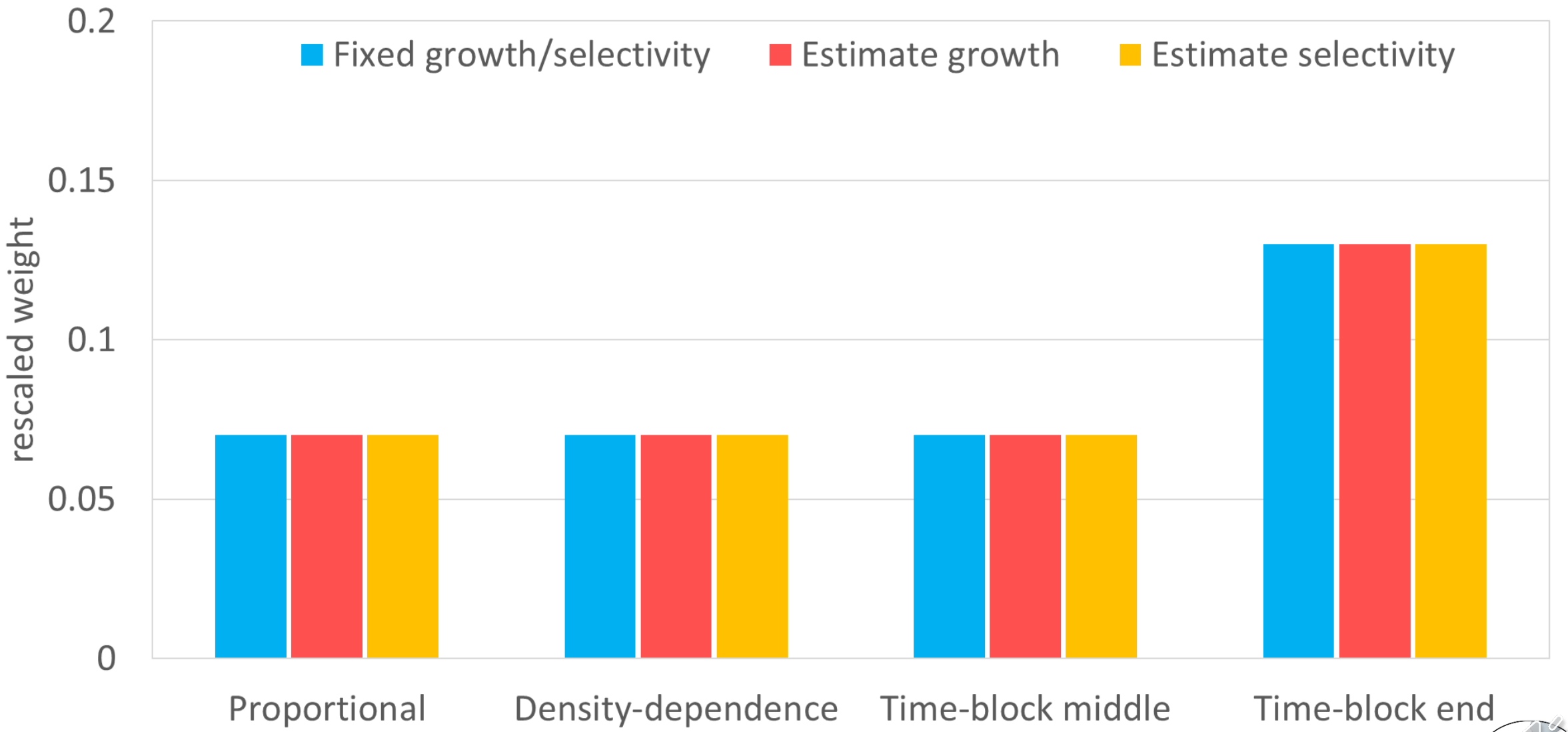
MEDIUM weight



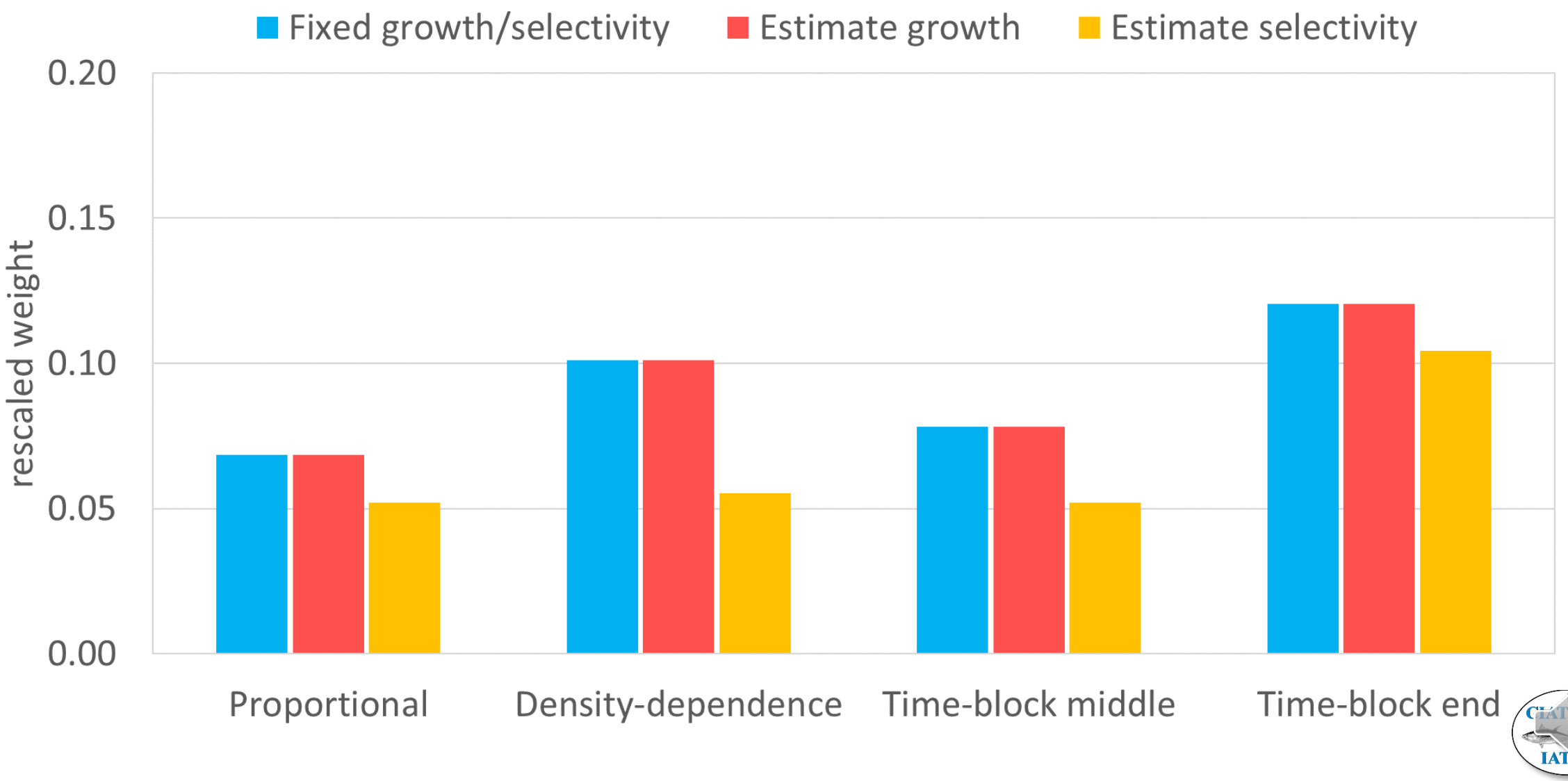
HIGH weight



W(Composition residuals)



W(Diagnostics)= W(ASPM,R0 profile,CCA) + W(retrospective) + W(residuals)

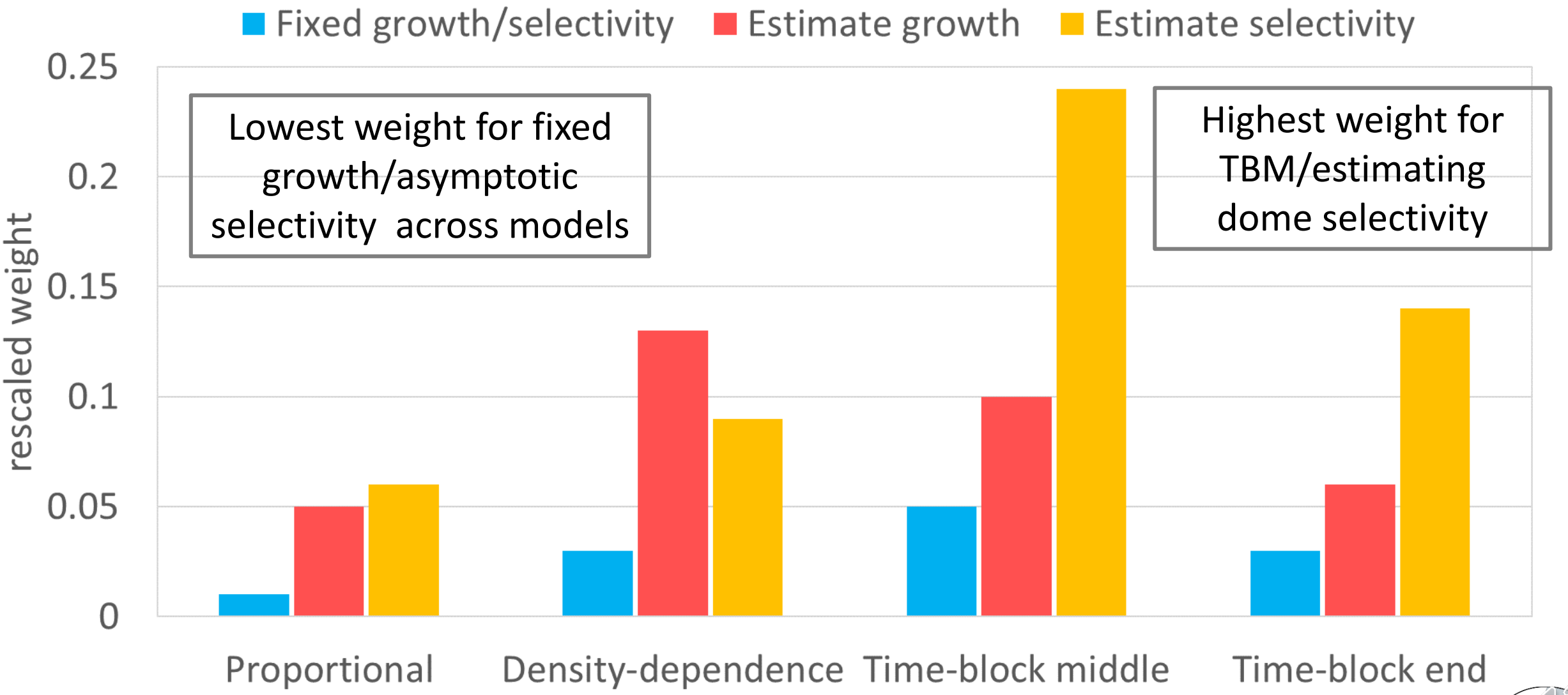


Combined weights

The combination of the weights in each category:

- Weights are multiplied
- Weights are rescaled to sum to 1

Combined weights

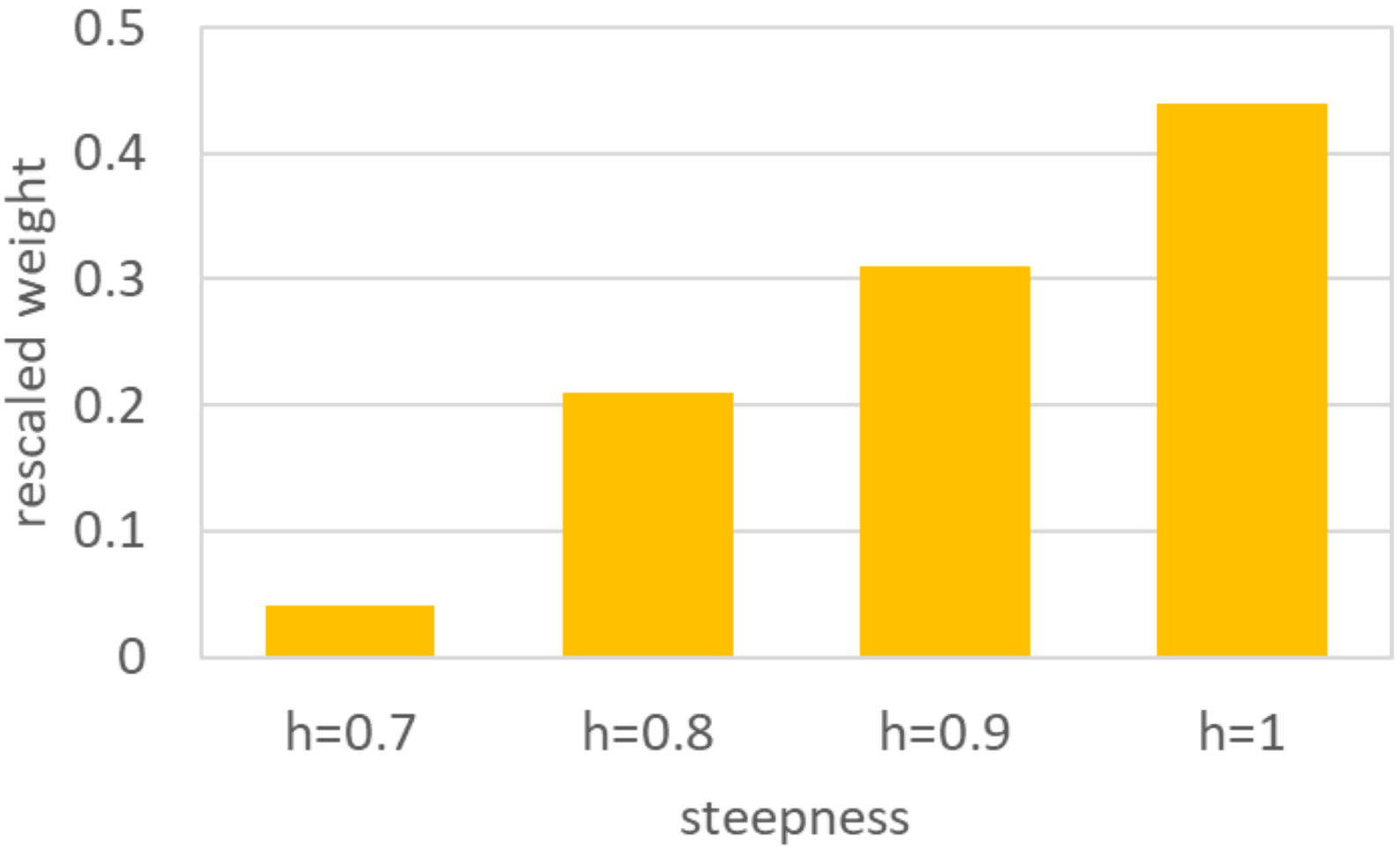


Weights(Steepness)

The weight given to different steepness values regardless of the model:

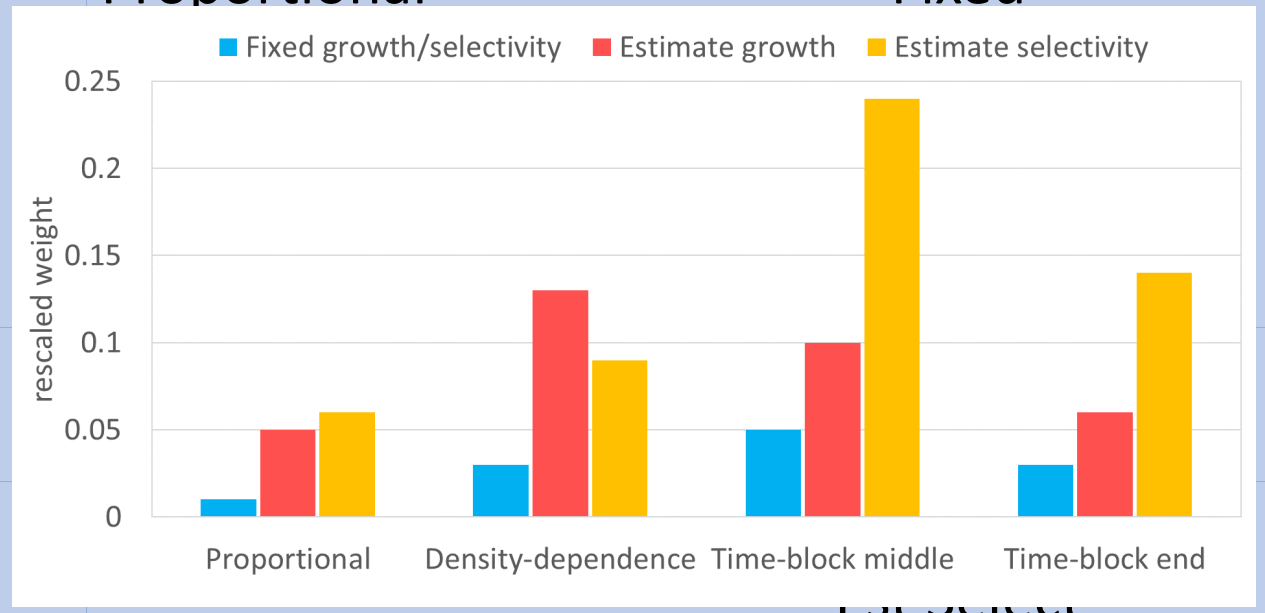
- Each expert weighted each value
- Asked to take into consideration evidence regarding steepness
- Weights combined

Weights(Experts) Steepness



Final weights

	Hypotheses	
	Level 2A	**Level 2B**
1	Proportional	Fixed
2		
3		
4		
5		
6		
7		
8		
9		
10	Time block end	Fixed
11		Est Growth
12		Est Select



X

Steepness of the stock-recruitment curve

h=0.7 h=0.8 h=0.9 h=1

=W(for each of the 48 models)

Conclusions

- Model weights are necessary to combine its results and estimate probabilities of exceeding reference points
- The approach developed by the staff allows for a systematic review of several aspects of model performance
- The novel approach is more appropriate than the simple model averaging
- Of the overarching hypotheses, only the high mixing hypotheses was evaluated, the spatial structure was incorporated in a pragmatic way.

Next step in the risk analysis approach

Described in Maunder et al. 2020 (SAC-11- INF-F):

1. **Identify alternative hypotheses** (‘*states of nature*’) about the population dynamics of the stock that address the main issues in the assessments
   - YFT: SAC-11 INF -J; BET: SAC-11 INF-F
2. **Implement stock assessment models representing alternative hypotheses**
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3. **Assign relative weights to each hypothesis (model)**
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4. **Compute combined probability distributions for management quantities using model relative weights**
   - **SAC-11-08**

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Thank you