

# Update of the status of the Bluefin tuna Management Strategy Evaluation



Update of the evaluation of the management strategy (MSE) for bluefin tuna in the eastern Atlantic and the Mediterranean of the ongoing ICCAT process for the adoption of management procedures (MP) for this stock-

Eider Andonegi

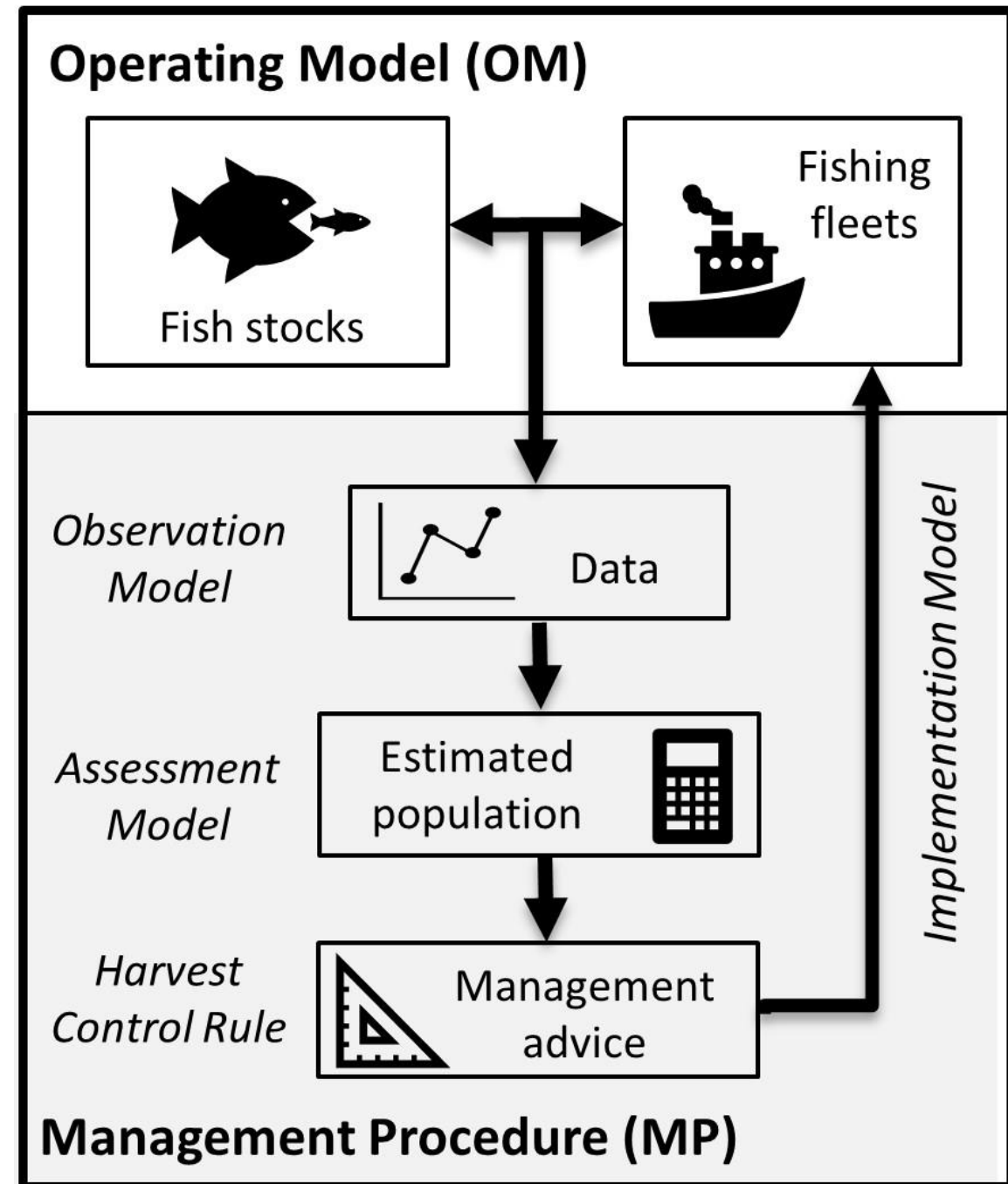
AZTI – Marine Research

# Management Strategy Evaluation What is that?



# MSE

- A simulation approach that formalizes the introduction of uncertainty into the decision-making process
- The objective is to identify the management strategies that are robust to uncertainty before they are put in place



# Differences with Stock Assessment (SA)

## SA

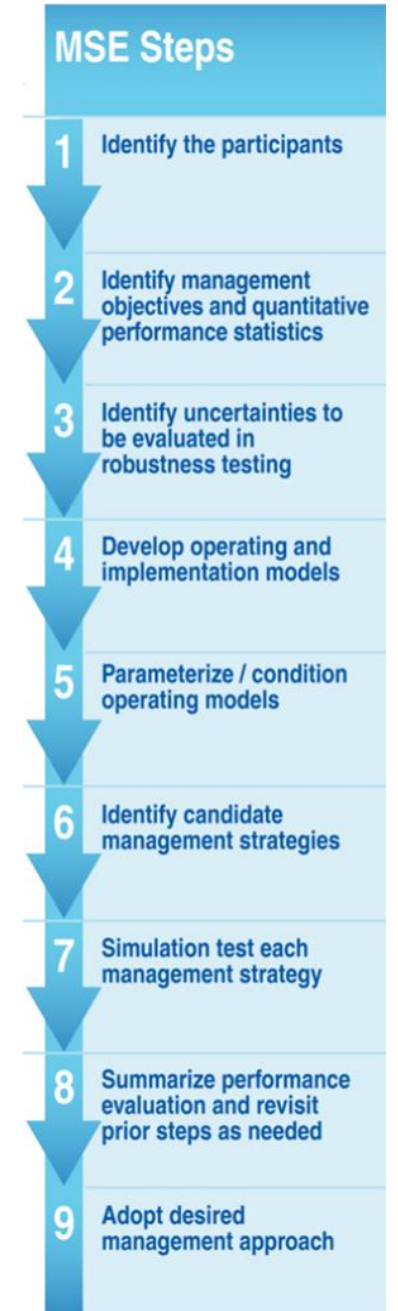
- Uses one model that is somehow proven to be the best available one, based on the best available knowledge and data.
- Not good to address uncertainty

## MSE

- Uses one or multiple operating models
- Could be similar to the ones used in SA
- Addresses uncertainty:
  - a. process uncertainty,
  - b. estimation uncertainty,
  - c. model uncertainty,
  - d. observation uncertainty,
  - e. implementation uncertainty

# MSE - Steps

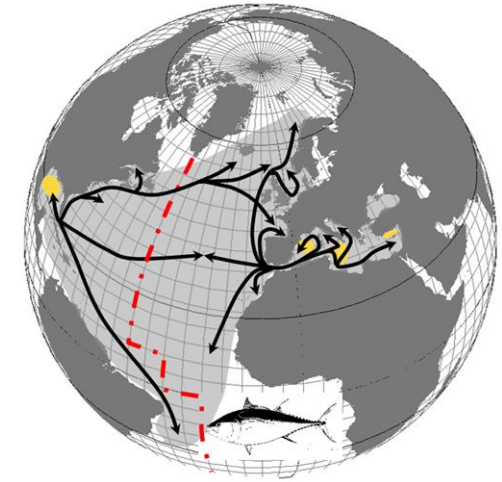
- 🐟 Identification of management objectives
- 🐟 Identification of statistical indicators of performance
- 🐟 Hypotheses for operating models (OMs)
- 🐟 Conditioning of the OMs using data and knowledge
- 🐟 Weighting of hypotheses depending plausibility
- 🐟 Identifying candidate management procedures (MPs) / harvest strategies (HS)
- 🐟 Projecting the OMs forward in time using the MPs as a feedback controller: impact of management
- 🐟 Identifying the elements of MPs that best meet management objectives



# MSE for Atlantic BFT

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# Some background on Bluefin



## Atlantic Bluefin tuna (*Thunnus thynnus*; ABFT) is challenging

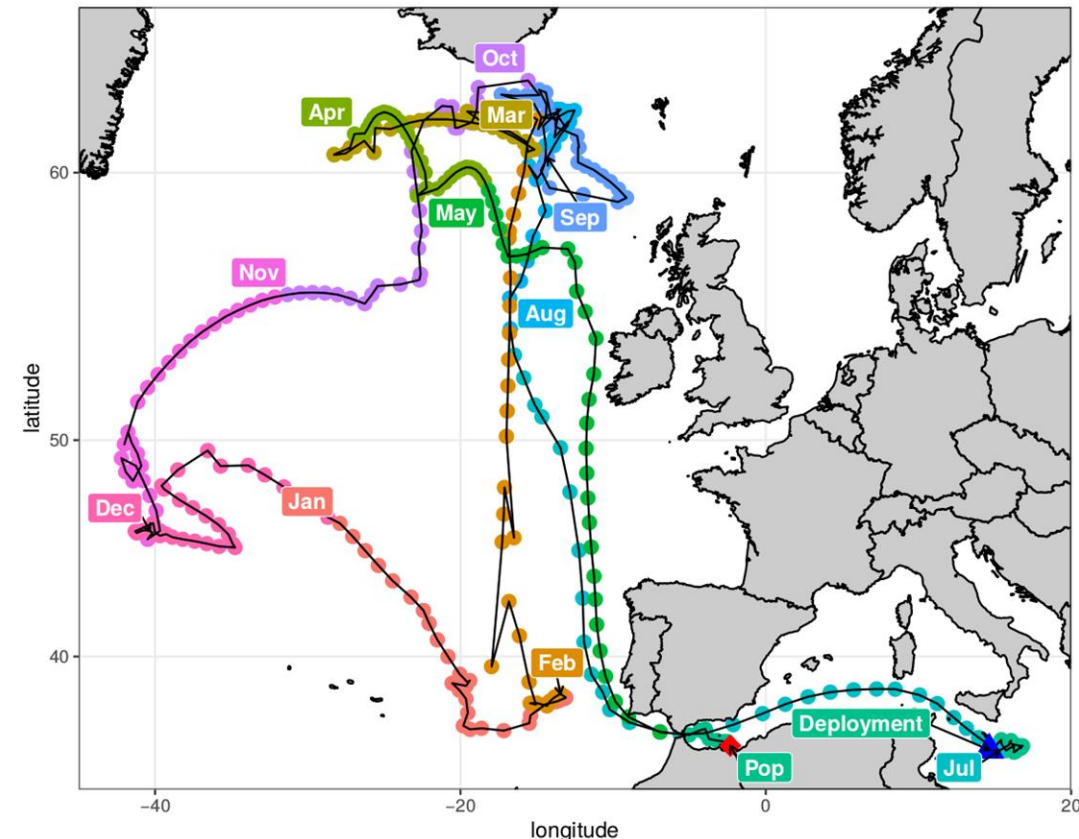
- Emblematic large migratory species: complex spatial dynamics
- Migration in and out of the Med, not fully understood

## Exploitation

- Very valuable fishery
- Complex exploitation history
- International fishery >20 countries
- Specific exploitation process (Fattening farms)

## Management

- Managed in two independent stocks: East and West
- Stocks are mixing, pop structure still under research
- Western fishery catch eastern fish
- 90% of total catch are Eastern, Western smaller stock
- 60% of East TAC = Med Purse seiners



# BFT MSE – How is it organized?

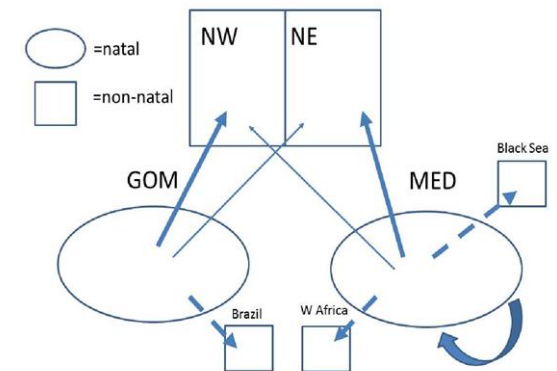
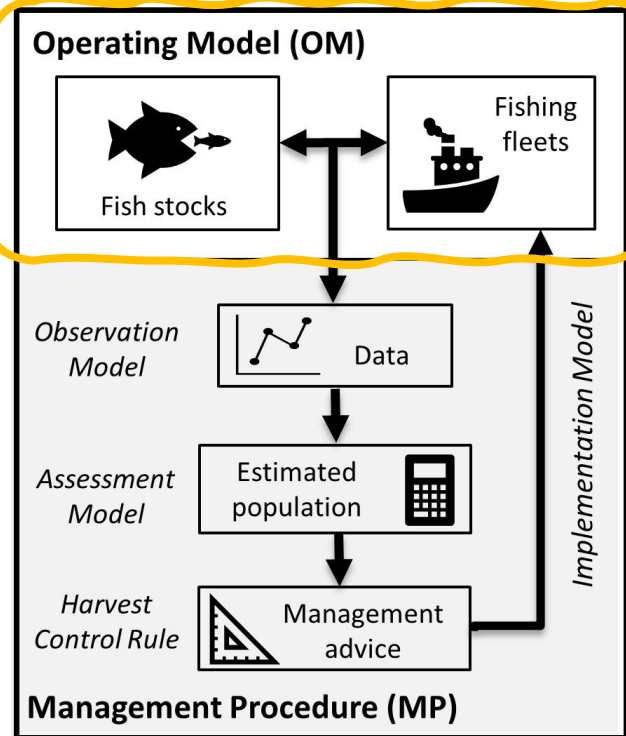
- Funded within the ICCAT research program (GBYP)
- One contractor in charge of the implementation
- Developed a complete R package
- Small technical group that reports to the BFT Group, which makes the key decisions



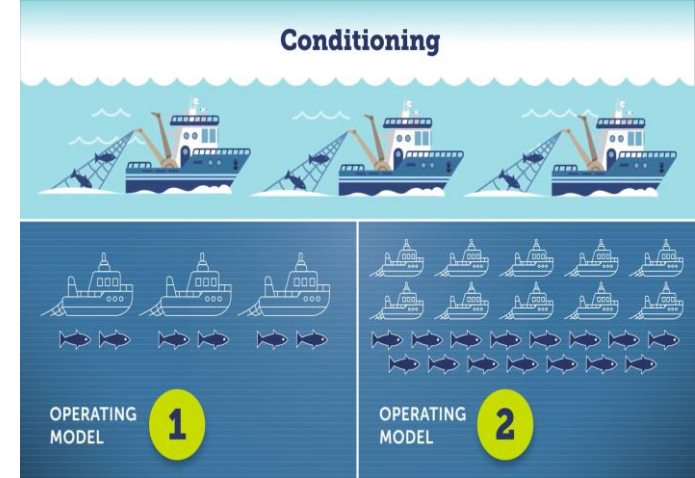
# BFT MSE – The Operating Model(s) - OM



- Simulates the real stock and the fishery under certain hypothesis about their dynamics and interactions.
- Modifiable Multi-stock Model ('M3') - age structured.
- Informed using biological parameters such as growth, maturity, natural mortality, etc.
- Equations complicated by the spatial and the quarterly temporal structure.



# BFT MSE – OM: fitting to data



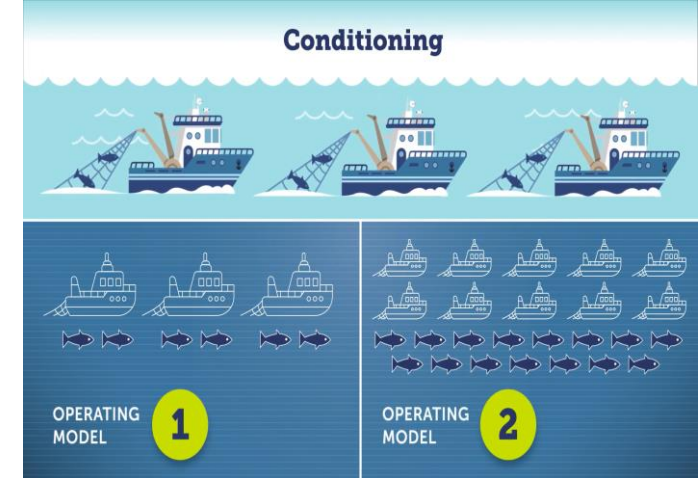
 Fishery-dependent information – CPUEs

No	Fleet	Area (East, Med, West)	Country	2017	2018	2019	2020
1	LLOTH	Med	all others except Japan	1183.780	1809.660	2068.916	2310.204
1	LLOTH	East	all others except Japan	303.116	344.944	471.857	548.716
1	LLOTH	West	all others except Japan	223.705	288.546	288.546	288.546
18	LLJPN	East	Japan	1910.610	2279.000	2528.000	2801.000
18	LLJPN	West	Japan	345.827	407.480	407.480	407.480
4	BBnew	East	France and Spain in Bay of Biscay	867.174	1063.048	1176.124	1298.459
7	PSMEDnew	Med	All PS except Croatia in Med	13883.699	16293.163	18652.732	20837.709
8	PSNOR	Med	Norway	47.140	97.782	224.711	282.064
9	PSHRV	Med	Croatia	586.634	687.673	760.820	839.954
11	PSWnew	West	USA,Canada	0	0	0	0
13	TPnew	East	Spain,Morocco and Portugal	3362.447	4141.503	4616.081	5118.636
14	RRCan	West	Canada	344.120	427.690	427.690	427.690
15	RRUSAFS	West	USA	197.541	261.130	261.130	261.130
16	RRUSAFB	West	USA	597.108	878.632	878.632	878.632

# BFT MSE – OM: fitting to data

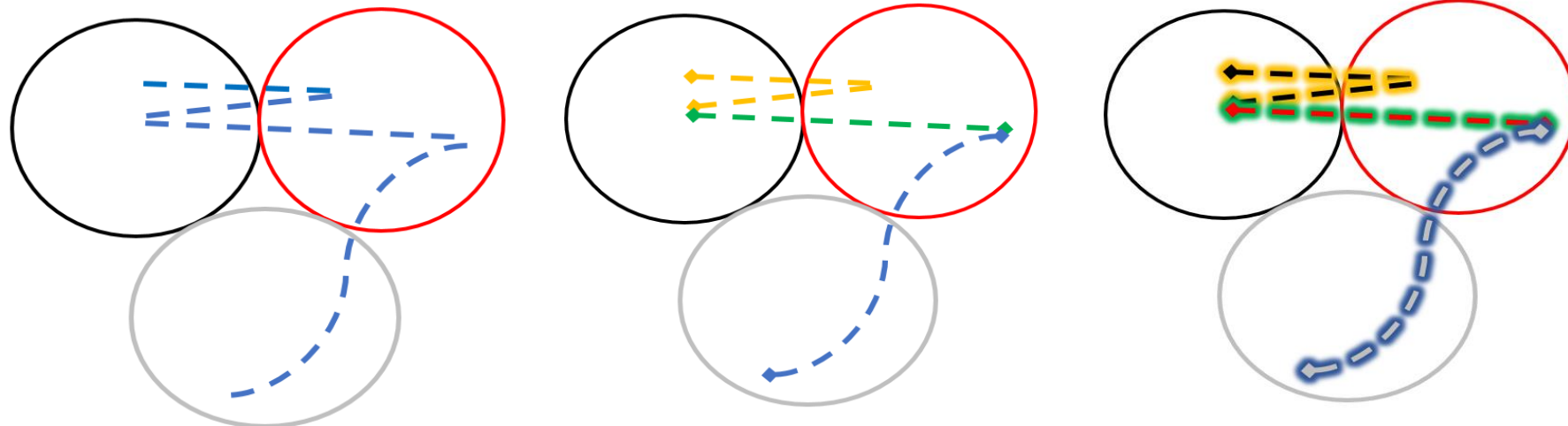
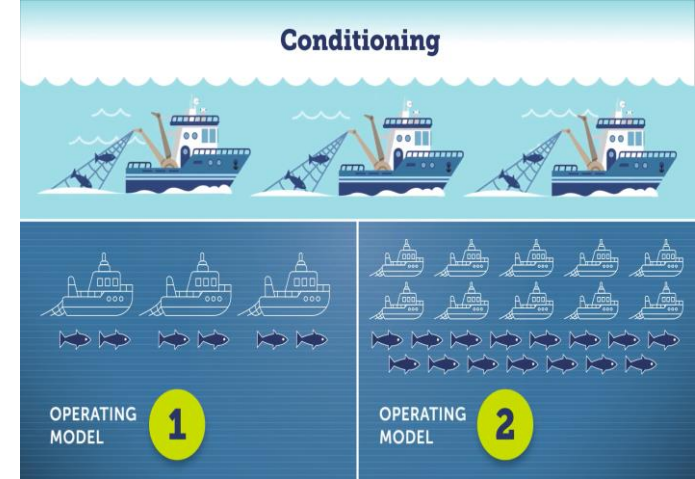
🐟 Fishery- independent information:

	Type
1	French aerial survey past
2	French aerial survey recent
3	Western Med Larval survey
4	Canadian acoustic survey
5	USA Larval survey
6	Aerial survey – GBYP*



# BFT MSE – OM: fitting to data

## E-TAGs for Spatial Transitions



- NOAA, DFO, WWF, AZTI, UNIMAR, IEO, UCA, FEDERCOOPESCA, COMBIOMA, GBYP, IFREMER, Stanford University: 1307 tags, 598 tag transitions

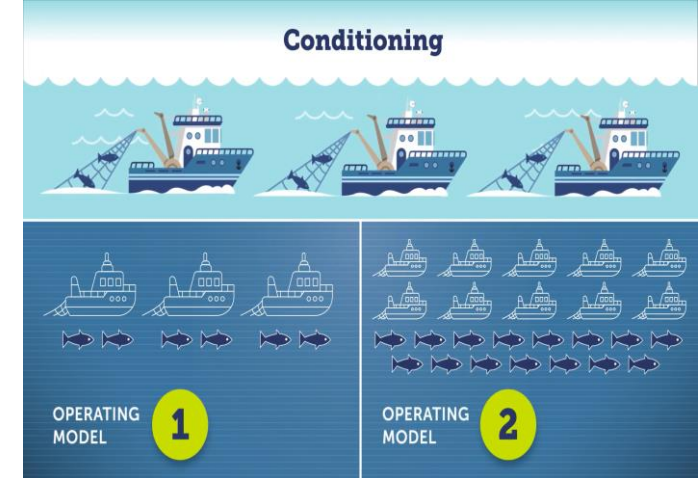
# BFT MSE – OM: fitting to data

🐟 Stock of Origin data from :

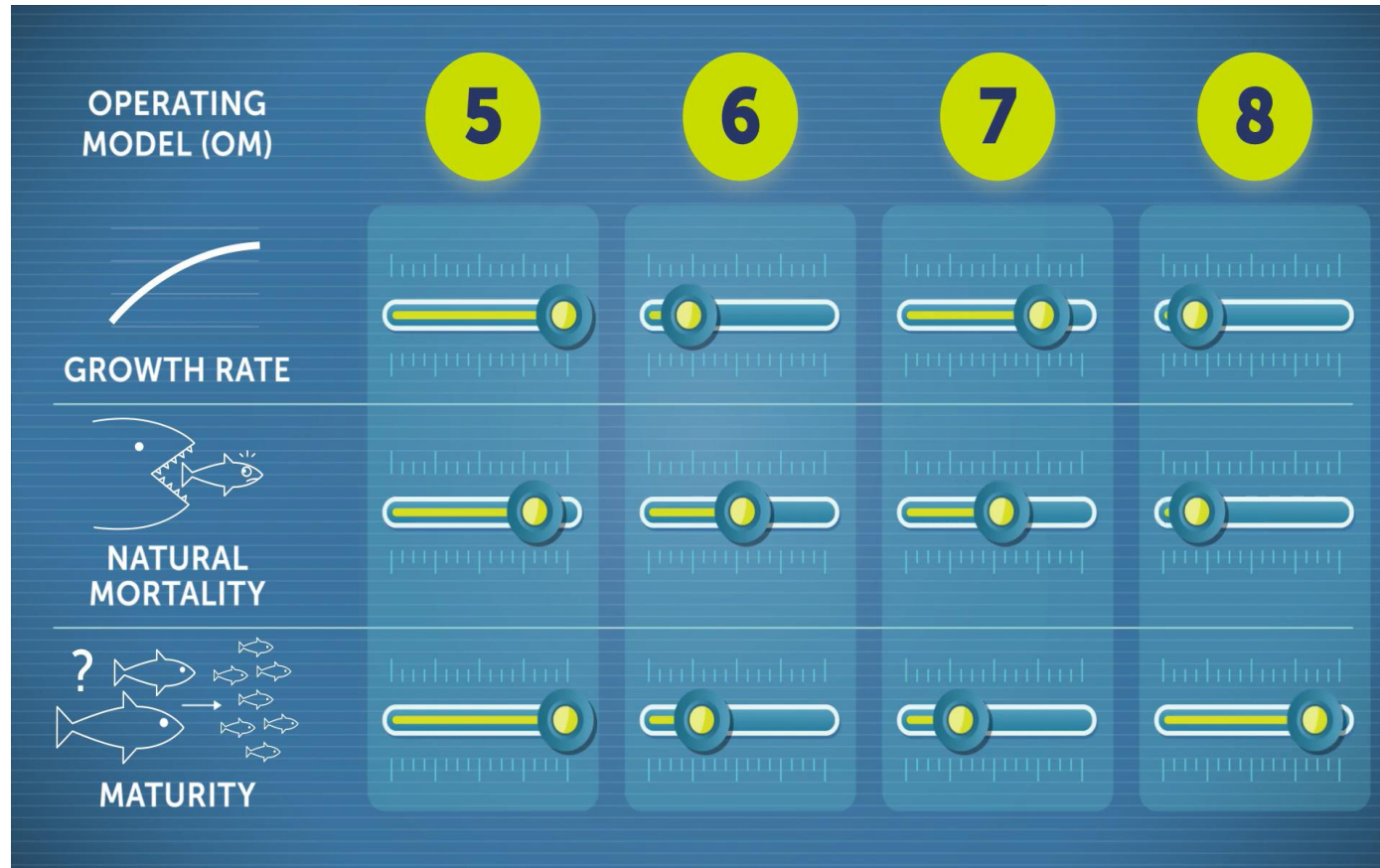
- OTOLITHS MICROCHEMISTRY
- GENETICS

🐟 Others

- Length-comp
- Total catch
- Index of SSB



# BFT MSE – OM: Uncertainty axes





# BFT MSE – OM: Uncertainty axes

Factor: Recruitment		
	Western stock	Eastern stock
level 1	B-H with h=0.6 (“high R0”) switches to h = 0.9 (“low R0”) starting from 1975	50-87 B-H h=0.98 switches to 88+ B-H h=0.98
level 2	B-H with h=0.6 fixed, high R0	B-H with h=0.7 fixed, high R0
level 3	Historically as in level 1. In projections, “low R0” switches back to “high R0” after 10 years	Historically as in level 1. In projections, 88+ B-H with h=0.98 switches back to 50-87 B-H with h=0.98 after 10 years
Factor: Spawning fraction/Natural mortality rate for both stocks		
level A	Younger spawning (E+W same)/High natural mortality	
level B	Older spawning (different for the 2 stocks)/Low natural mortality (with senescence)	
Factor: Scale		
	West area	East area
level --	15kt	200kt
level -	15kt	400kt
level +	50kt	200kt
level +-	50kt	400kt
level ++		
Factor: Length composition weighting in likelihood		
level L	0.05	
level H	1	



Reference Grid:  
48 OMs

Length Comp Wt		L							
Scale		--	+		+-		++		
Spawn. Frac. / M		A	B	A	B	A	B	A	B
Recruitment: 1		OM_1	OM_4	OM_7	OM_10	OM_13	OM_16	OM_19	OM_22
Recruitment: 2		OM_2	OM_5	OM_8	OM_11	OM_14	OM_17	OM_20	OM_23
Recruitment: 3		OM_3	OM_6	OM_9	OM_12	OM_15	OM_18	OM_21	OM_24
Length Comp Wt		H							
Scale		--	+		+-		++		
Spawn. Frac. / M		A	B	A	B	A	B	A	B
Recruitment: 1		OM_25	OM_28	OM_31	OM_34	OM_37	OM_40	OM_43	OM_46
Recruitment: 2		OM_26	OM_29	OM_32	OM_35	OM_38	OM_41	OM_44	OM_47
Recruitment: 3		OM_27	OM_30	OM_33	OM_36	OM_39	OM_42	OM_45	OM_48

# BFT MSE – OM: Robustness test

WHY? Because we want our CMPs to be robust to potentially less probable realities

Priority	Robustness test description
1	Western stock growth curve for eastern stock.
2	Catchability Increases. CPUE-based indices are subject to a 2% annual increase in catchability in the future.
3	Unreported overages. Future catches in both the West and East areas are 20% larger than the TAC as a result of IUU fishing (not known and hence not accounted for by the CMP).
4	High western mixing. The old mixing axis factor level 2: 20% western stock biomass in East area on average from 1965-2016.
5	'Brazilian catches'. Catches in the South Atlantic, including relatively high takes during the 1950s and 60s, are reallocated from the western stock to the eastern stock.
6	Time varying mixing. Eastern stock mixing alternates between 2.5% and 7.5% every three years.
7	Non-linear indices. Hyperstability in OM fits to data is simulated in projection years for all indices.
8	Persistent change in mixing. Eastern mixing increases from 2.5% to 7.5% after 10 years.
9	Varying time of regime change in R3.
10	Intermediate parameter levels for M, growth, maturity, scale, regime shifts.
11	Zero eastern stock mixing. No Eastern stock in the West area.
12	Upweight US_RR_66_144



# BFT MSE – OM: Plausibility weighting

🐟 Delphi approach

🐟 through an online Poll (deadline February 14<sup>th</sup>)

🐟 Poll characteristics:

- Blind
- Reflecting authorship
- Default score for levels within an axis, and justification required when differing from it

🐟 Eligible participants: restricted to the attendees of 2020 December BFT meeting

🐟 recruitment level R3 was considered less plausible than the other two R levels

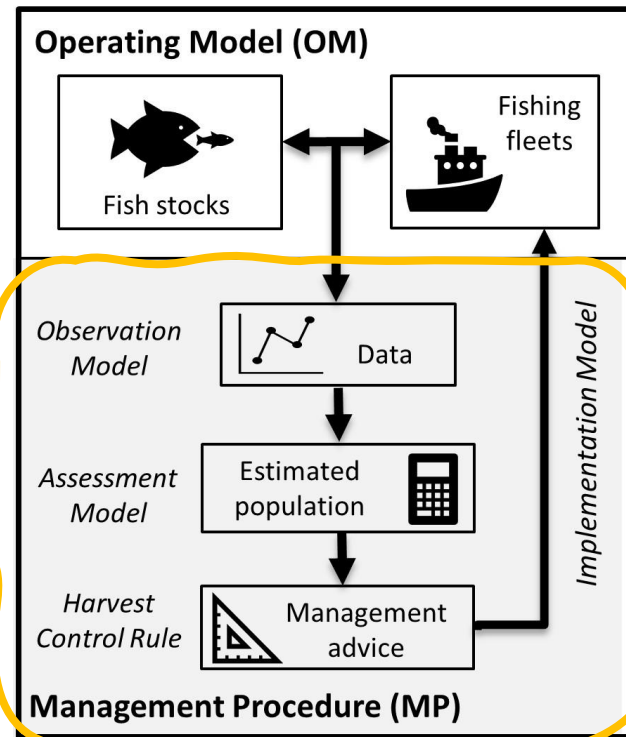
🐟 Process in standby

# BFT MSE – The Management Procedure(s) – MP / Harvest Strategies (HS)



Simulates different processes:

- 🐟 Data collection: observation model
- 🐟 Assessment: Estimation/assessment model – status estimator
- 🐟 Advice: Harvest Control Rules (HCR)
- 🐟 Implementation.



# BFT MSE – The Management Procedure(s) - MP

CMP ID Codes	Indices used		Formulae for calculating TACs	References
FZ	JPN LL NEAtI2, FR AER SUV2, W-MED LAR SUV	CAN SWNS RR, US RR 66-144, US-MEX GOM PLL	TACs are product of stock-specific F0.1 estimates and estimate of US-MEX GOM PLL for the West and W-MED LAR SUV for the East.	SCRS/2020/144 SCRS/2021/122
AI	All	All	Artificial intelligence MP that fishes regional biomass at a fixed harvest rate.	SCRS/2021/028
BR	MOR POR TRAP, JPN LL NEAtI2, FR AER SUV2, W-MED LAR SUV	CAN SWNS RR, US RR 66-144, JPN LL West2, US-MEX GOM PLL, GOM LAR SUV	TACs set using a relative harvest rate for a reference year (2018) applied to the 2-year moving average of a combined master abundance index. In recent refinement, the weighting range across individual indices on the East area master index has been reduced, given that this resulted in improved resource conservation performance.	SCRS/2021/121 SCRS/2021/152
EA	MOR POR TRAP, JPN LL NEAtI2, FR AER SUV2, W-MED LAR SUV	US RR 66-144, JPN LL West2, US-MEX GOM PLL, GOM LAR SUV	Adjust TAC based on ratio of current and target abundance index.	SCRS/2021/032 SCRS/2021/P/046
LW	JPN LL NEAtI2, W-MED LAR SUV	US-MEX GOM PLL, GOM LAR SUV	TAC is adjusted based on comparing current relative harvest rate to reference period (2019) relative harvest rate.	SCRS/2021/122
NC	MOR POR TRAP	US-MEX GOM PLL	TAC is updated using an average of an index in recent years compared to an average in previous years. The scale of TAC increase/decrease is controlled based on the trend in catches and indices.	SCRS/2021/122
PW	JPN LL NEAtI2, W-MED LAR SUV	US-MEX GOM PLL, GOM LAR SUV	TAC is adjusted based on comparing current relative harvest rate to reference period (2019) relative harvest rate.	SCRS/2021/155
TC	MOR POR TRAP, JPN LL NEAtI2, GBYP AER SUV BAR, W-MED LAR SUV	US RR 66-144	TAC is adjusted based on $F/F_{MSY}$ and $B/B_{MSY}$ (model-based).	SCRS/2020/150 SCRS/2020/165
TN	JPN LL NEAtI2	JPN LL West2	Both area TACs calculated based on their respective JPN LL moving averages.	SCRS/2020/151 SCRS/2021/041

# BFT MSE – The Management Procedure(s) - MP

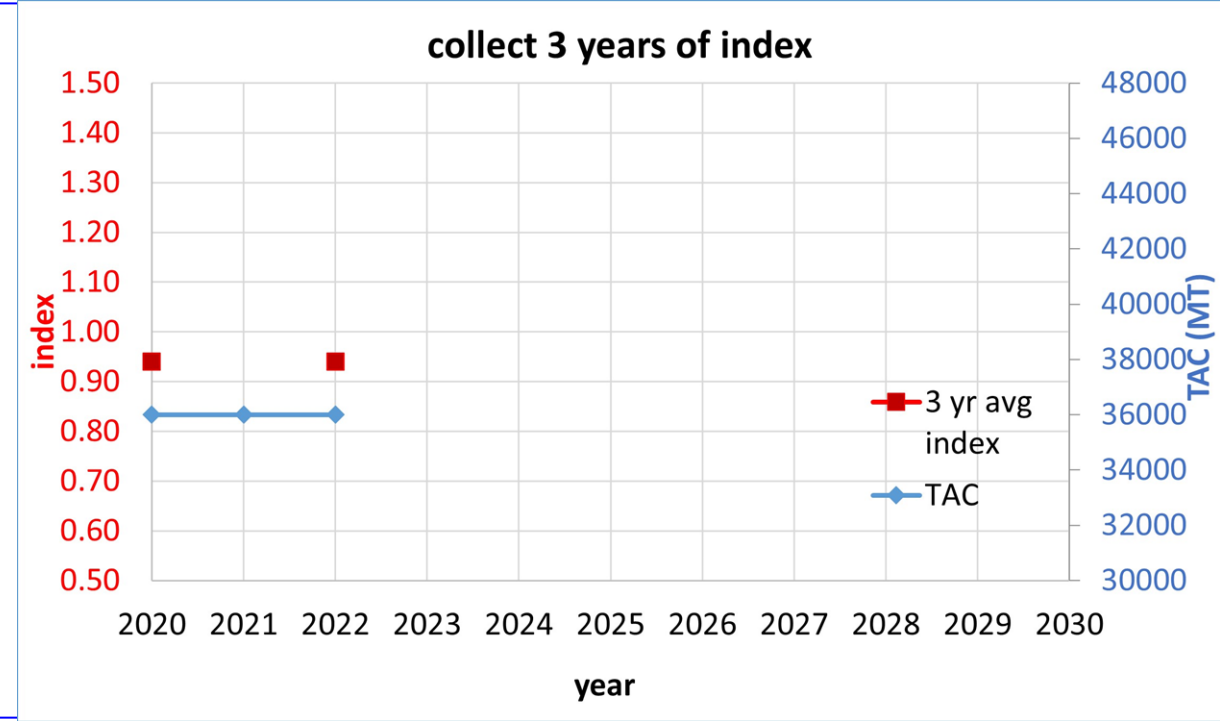
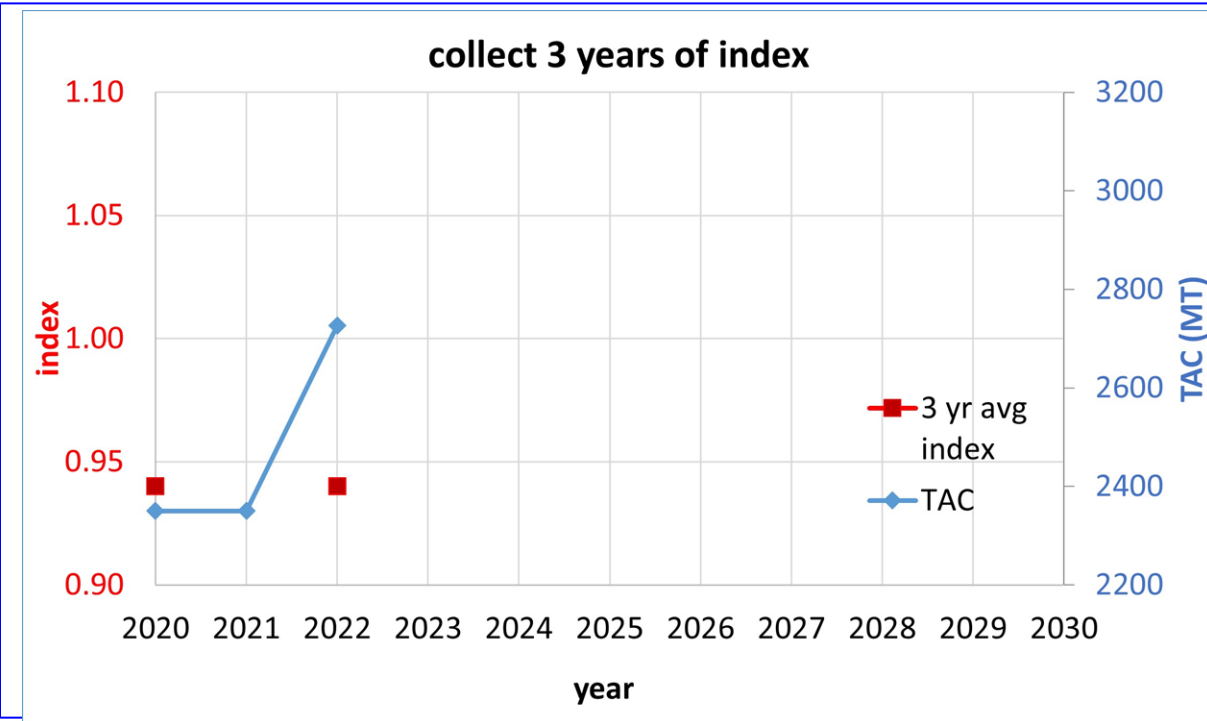
How is the process?

# Conceptual vision for a Bluefin Management Procedure

WEST

EAST

collect 3 years of index



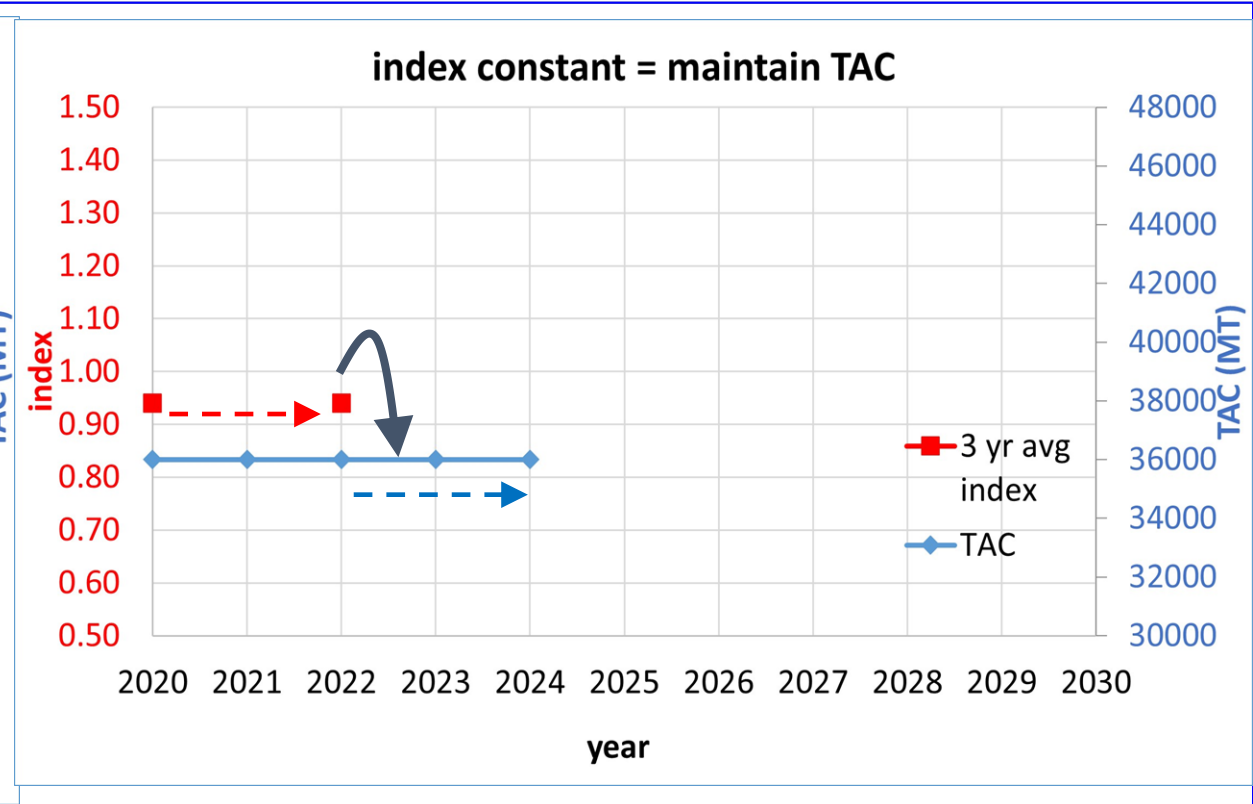
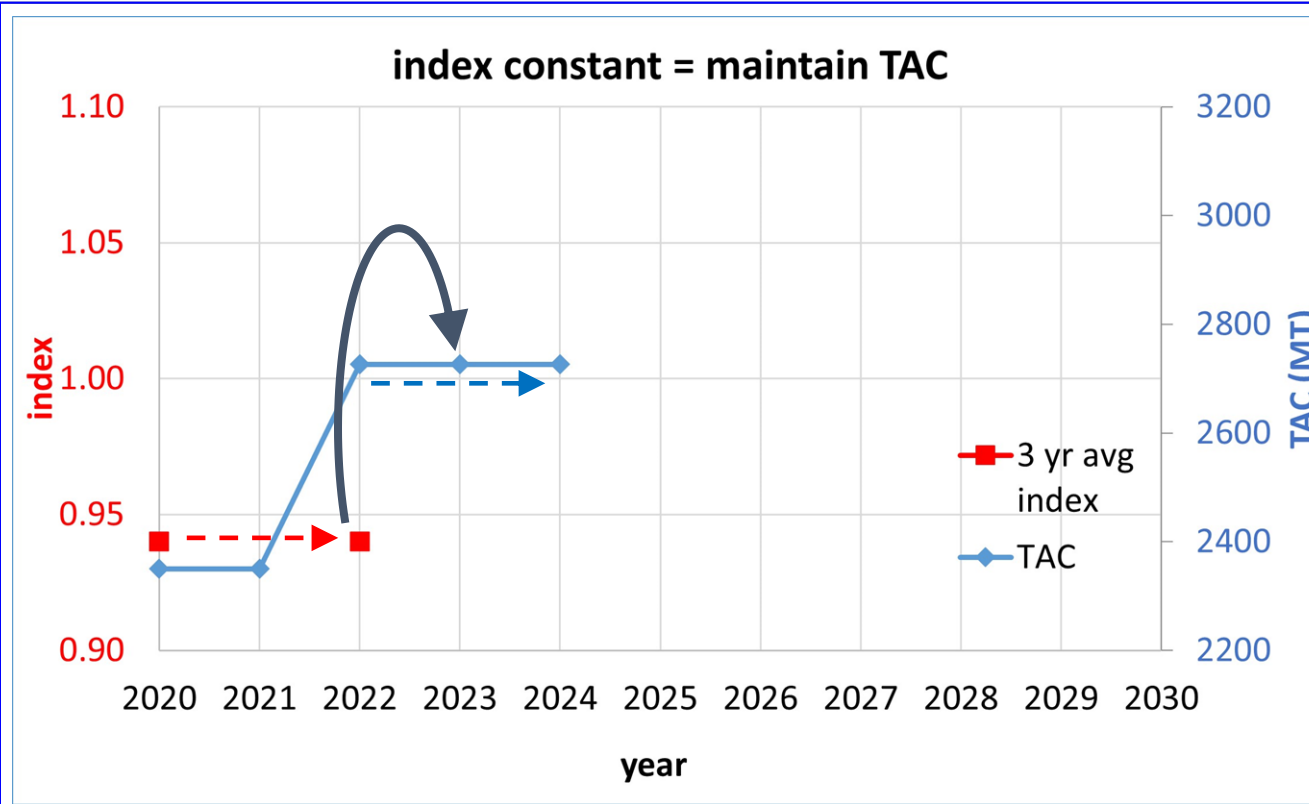
- Empirical management procedure based on index
- SCRS collects data, applies MP
- Commission sets TACs (East and West) based upon MP advice
- TACs remain unchanged for  $X$  years

# Conceptual vision for a Bluefin Management Procedure

WEST

EAST

index constant = maintain TAC



\* Note that this is simply for illustration purposes and does not imply what would actually happen in the future; different CMPs may have differential responses to indices.

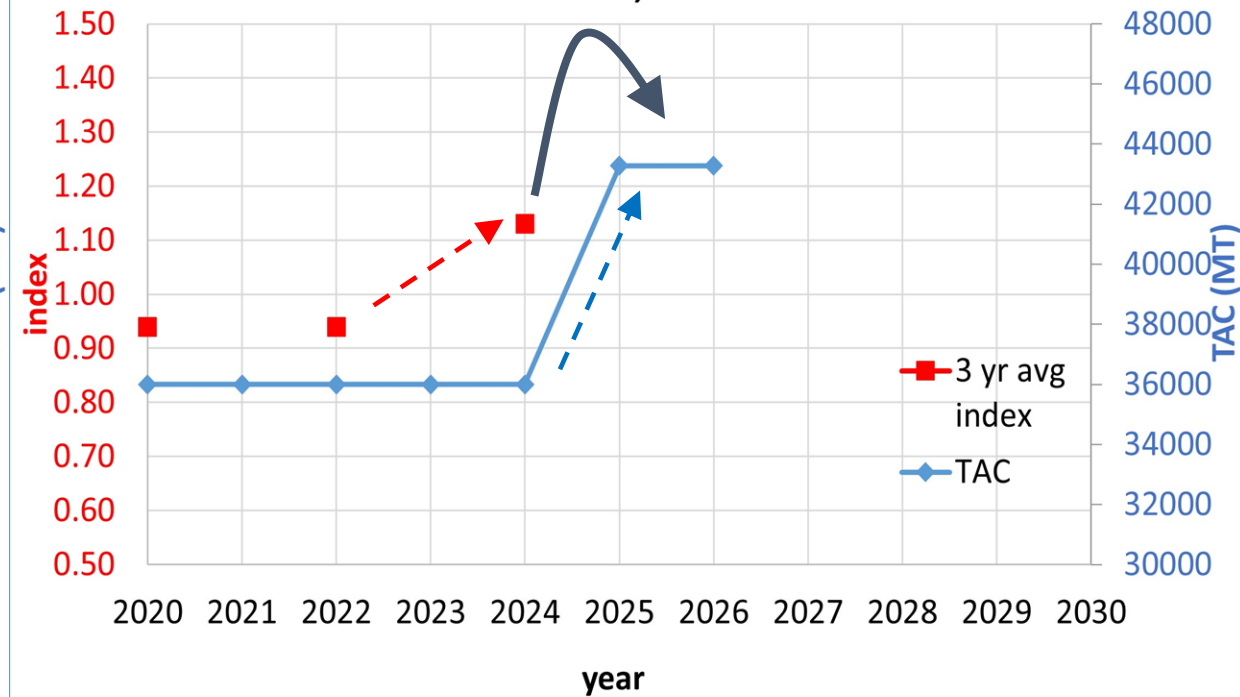
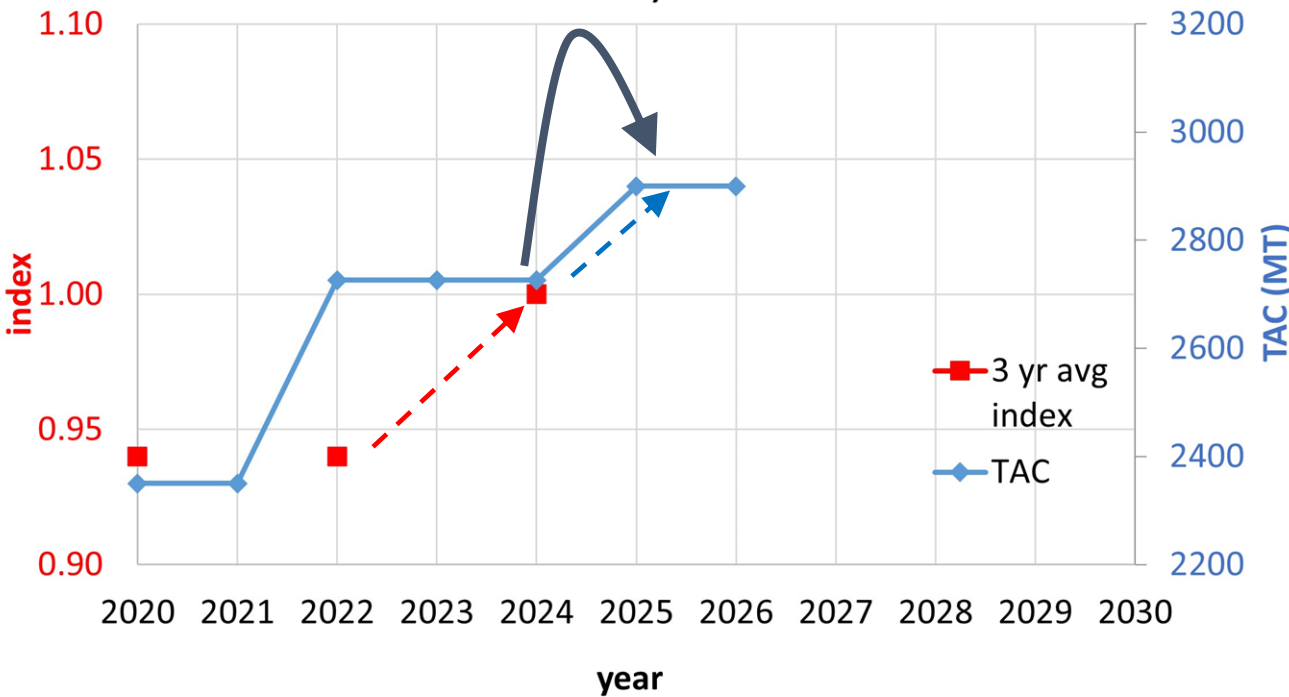
# Conceptual vision for a Bluefin Management Procedure

WEST

EAST

Index increases; TAC increases

Index increases; TAC increases

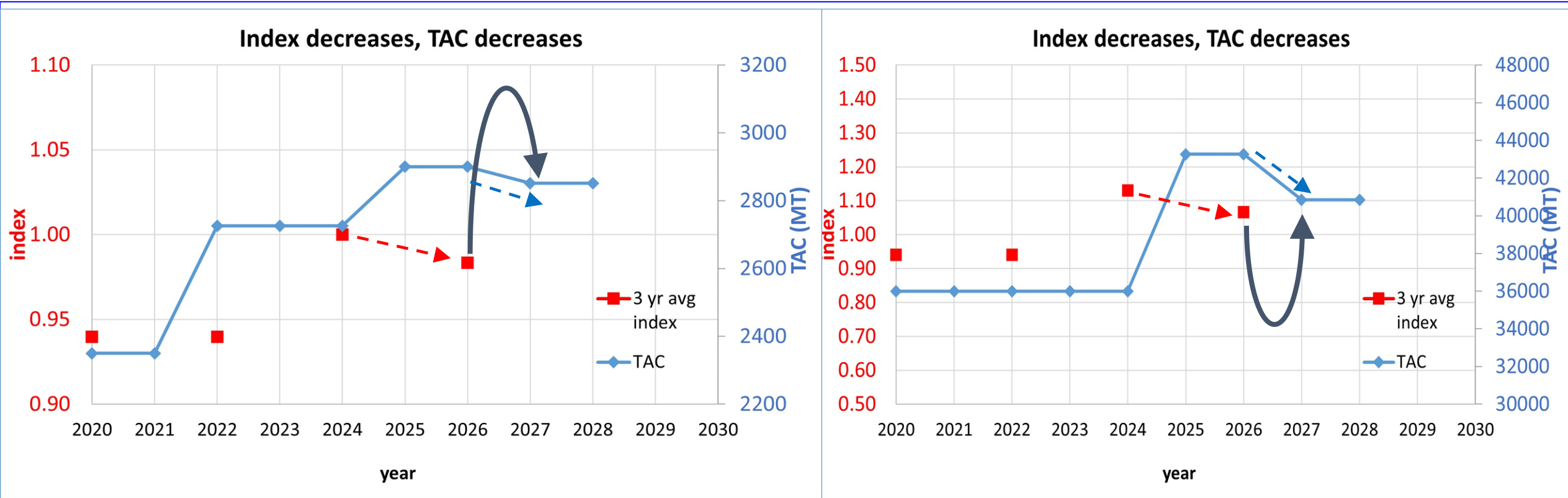


# Conceptual vision for a Bluefin Management Procedure

WEST

index decreases, TAC decreases

EAST



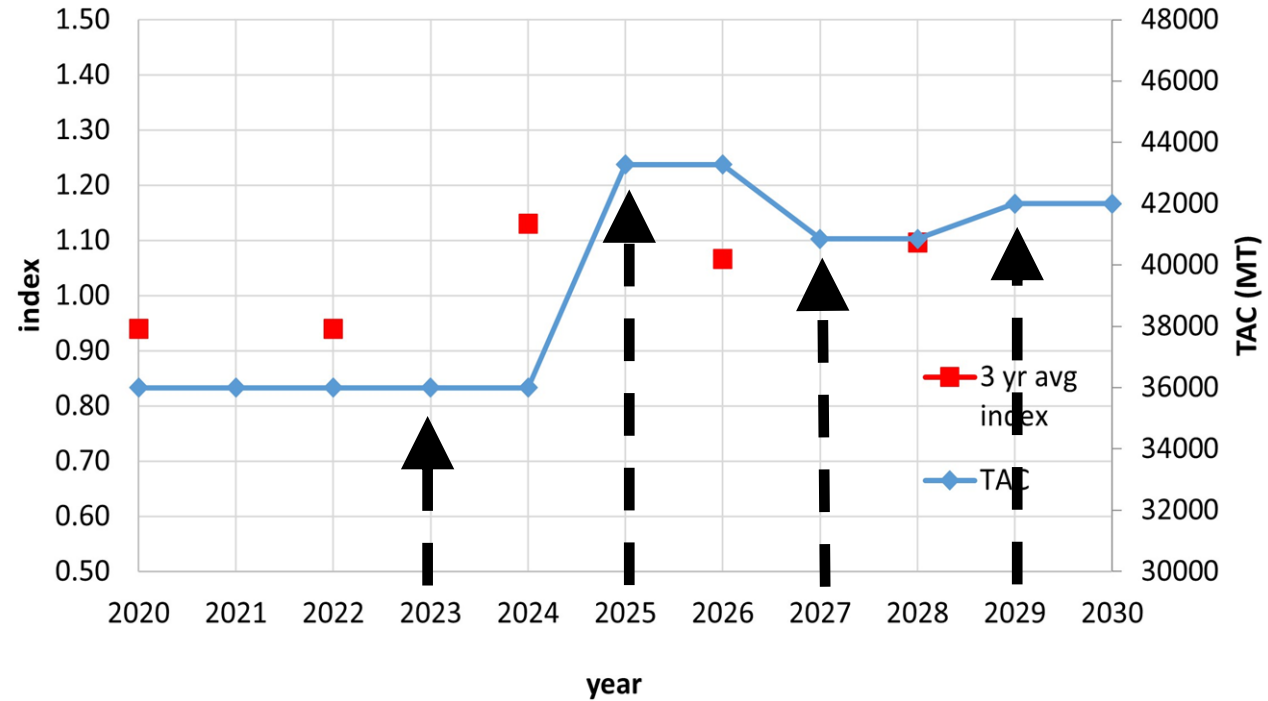
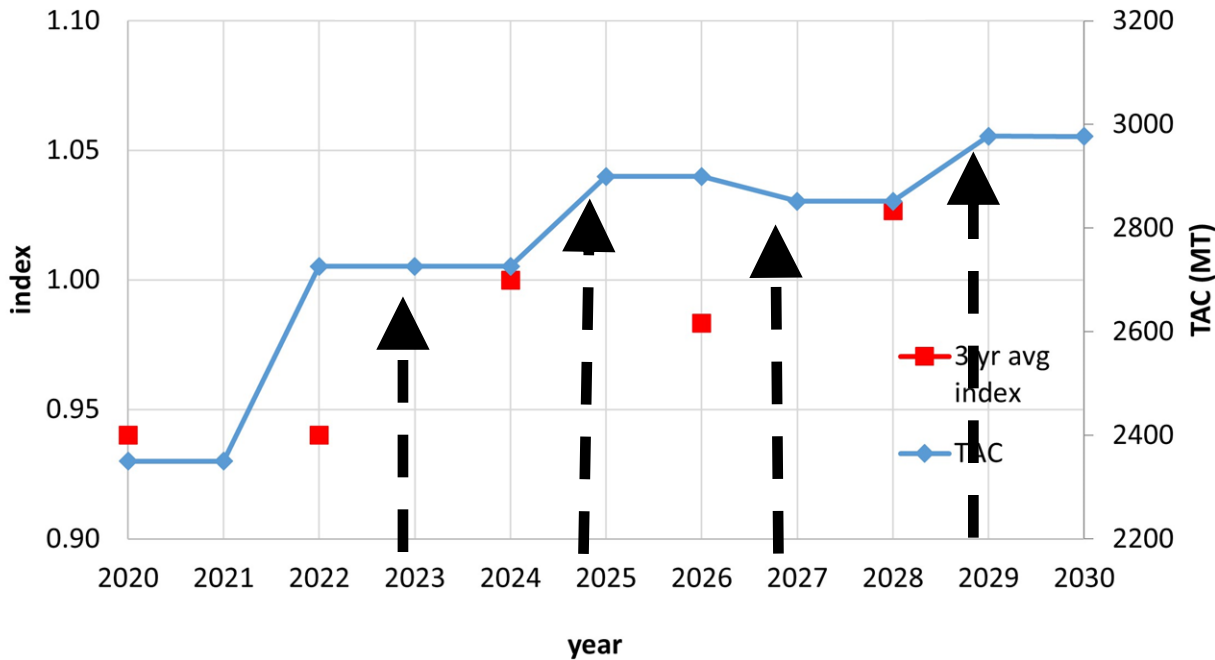


# Conceptual vision for a Bluefin Management Procedure

WEST

EAST

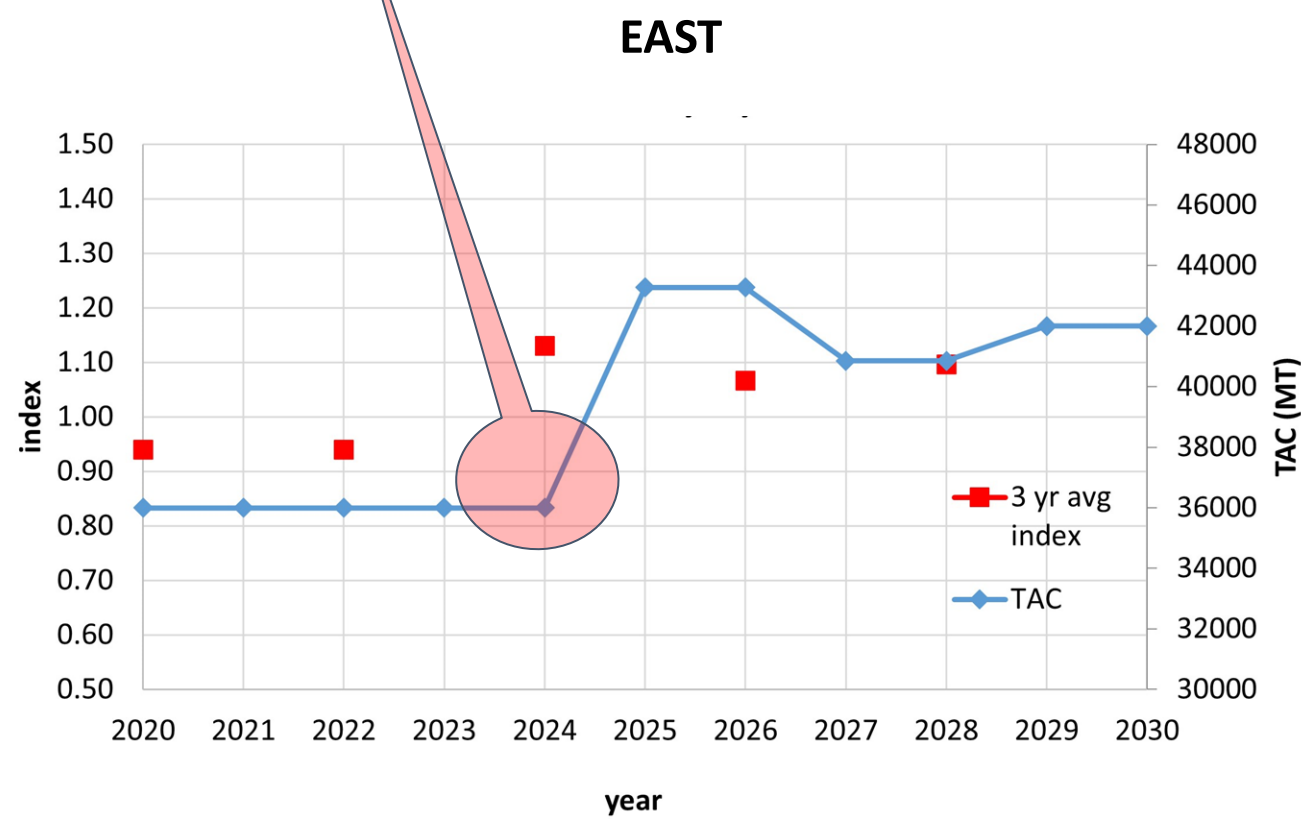
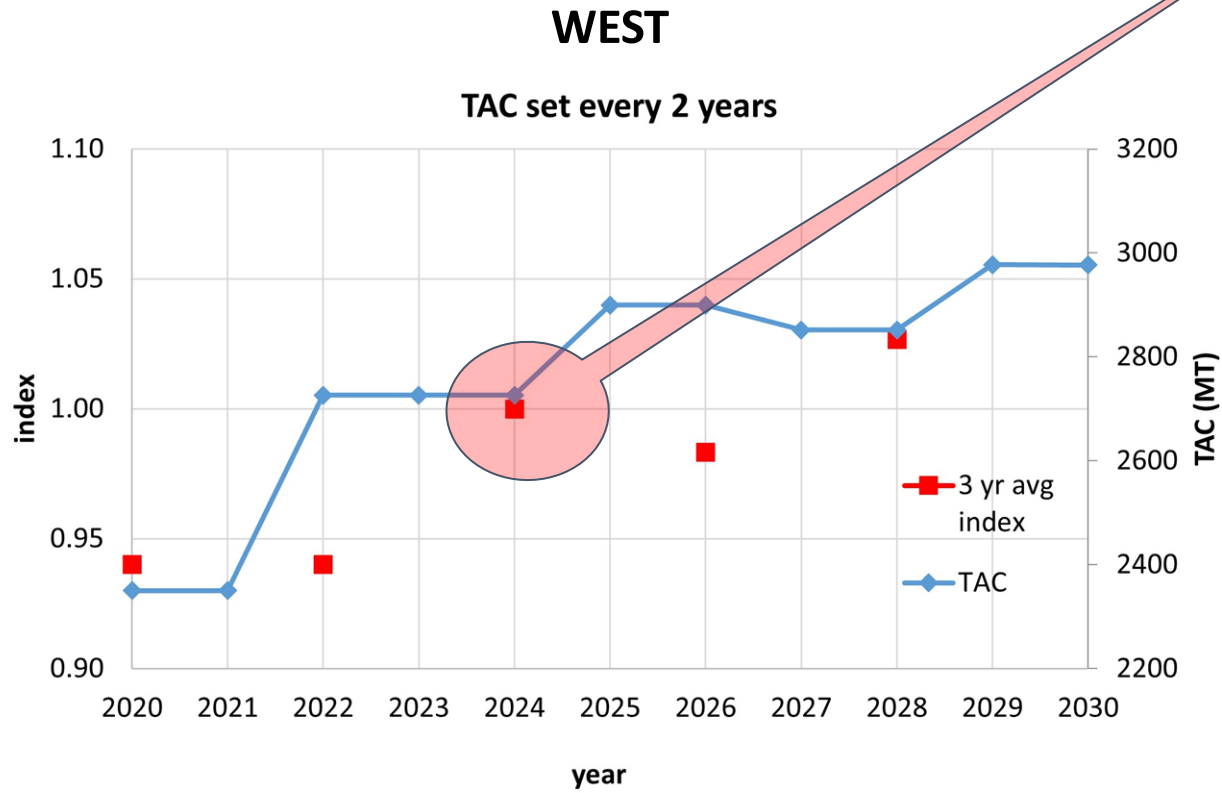
TAC set every two years



At pre-specified intervals, Commission adopts new TACs (both East and West), based on pre-agreed **Management Procedure**.

# What will then affect our future TAC?

1. Previous TAC
2. Indices used
3. Responsiveness of MP to indices







# BFT MSE – The Management Procedure(s) - MP

How do we assess  
their performance?

# BFT MSE – Statistical indicators for performance

(Used to evaluate achievement of management objectives)

## Management Objectives (MOs)

-  *Status*: The stock should have a greater than [\_\_]% probability of occurring in the green quadrant of the Kobe matrix
-  *Safety*: There should be a less than [\_\_]% probability of the stock falling below  $B_{LIM}$  (to be defined)
-  *Yield*: Maximize overall catch levels
-  *Stability*: Any increase or decrease in TAC between management periods should be less than [\_\_]%


## Performance Statistics for Status MO


- **AvgBr** – Average Br [i.e., biomass ratio, or spawning stock biomass (SSB) relative to dynamic  $SSB_{MSY}$ ] over projection years 11-30
- **Br30** – Br in year 30 of projections
- **OFT** – Overfished Trend, SSB trend if  $Br30 < 1$ .
- [F statistic – once finalized]

# BFT MSE – Statistical indicators for performance


(Used to evaluate achievement of management objectives)

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## Performance Statistic for Safety MO


- **LD** – Lowest depletion (i.e., SSB relative to dynamic  $SSB_{msy}$ ) over the projection period

# BFT MSE – Statistical indicators for performance


(Used to evaluate achievement of management objectives)

## Management Objectives (MOs)

 *Status:* The stock should have a greater than [\_\_]% probability of occurring in the green quadrant of the Kobe matrix

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 *Yield:* Maximize overall catch levels

 *Stability:* Any increase or decrease in TAC between management periods should be less than [\_\_]%


## Performance Statistic for Yield MO


- **AvC10** – Mean catches (t) over first 10 years
- **AvC30** – Mean catches (t) over 30 years

# BFT MSE – Statistical indicators for performance


(Used to evaluate achievement of management objectives)

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 *Stability:* Any increase or decrease in TAC between management periods should be less than [\_\_]%

## Performance Statistic for Stability MO

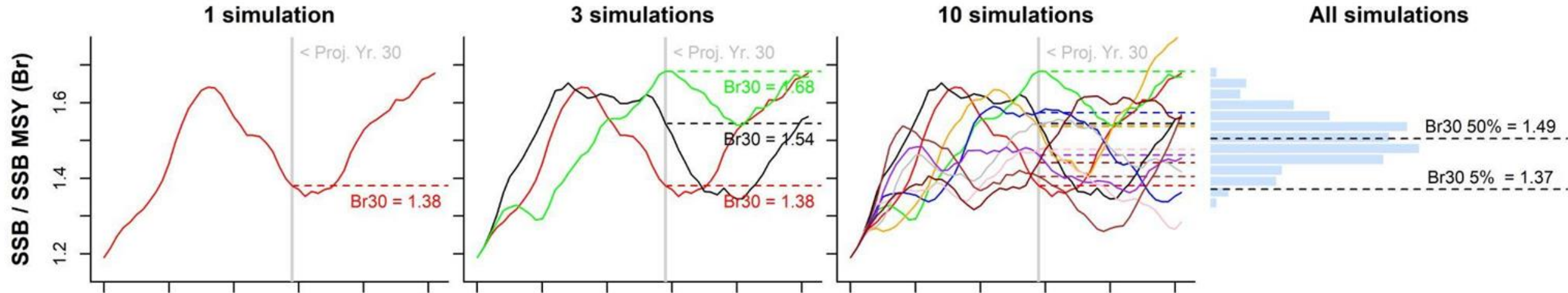
- **VarC** – % Variation in TAC between management periods

# BFT MSE – The Management Procedure(s) - MP

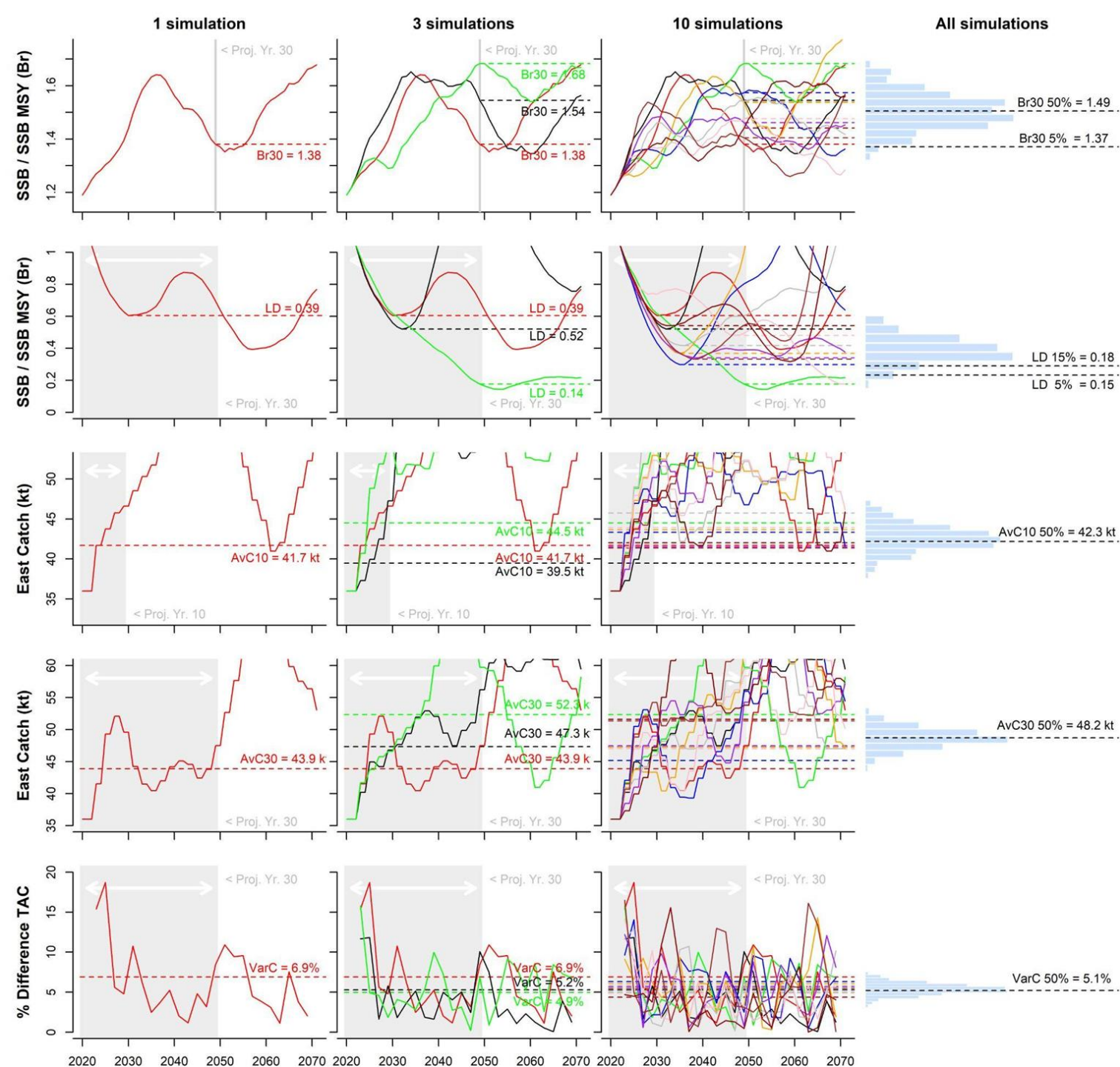
How does it work?



# 1. Run simulations & assess performance



**Br30:** spawning biomass relative to dynamic SSB<sub>MSY</sub> in projection year 30



**Br30:** spawning biomass relative to dynamic  $SSB_{MSY}$  in projection year 30

**LD:** Lowest depletion (spawning biomass relative to dynamic  $SSB_{msy}$ )

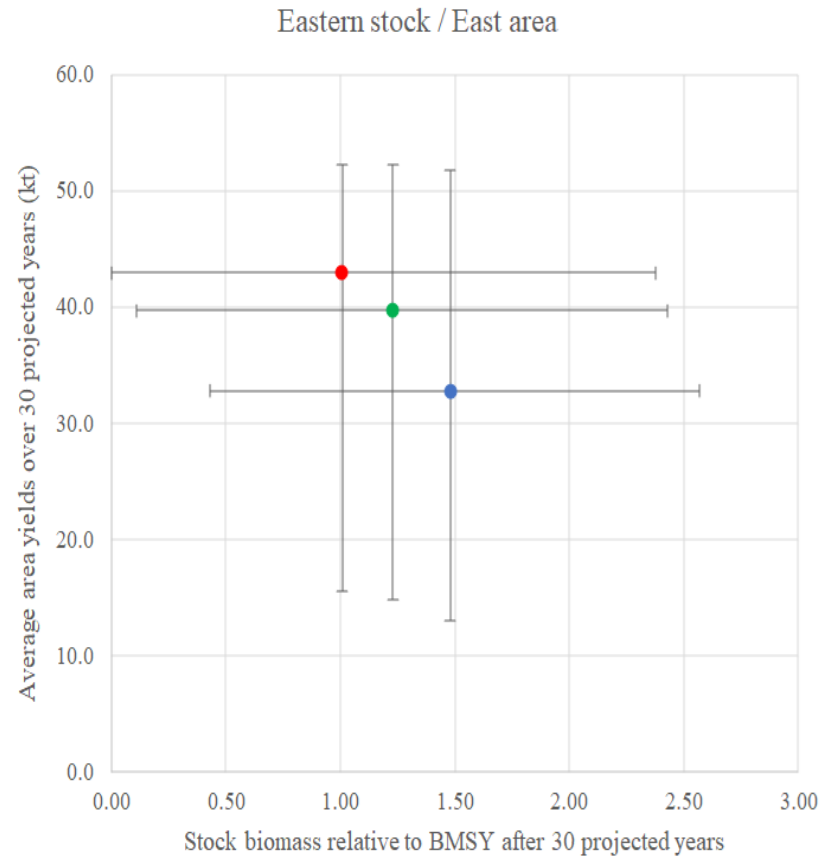
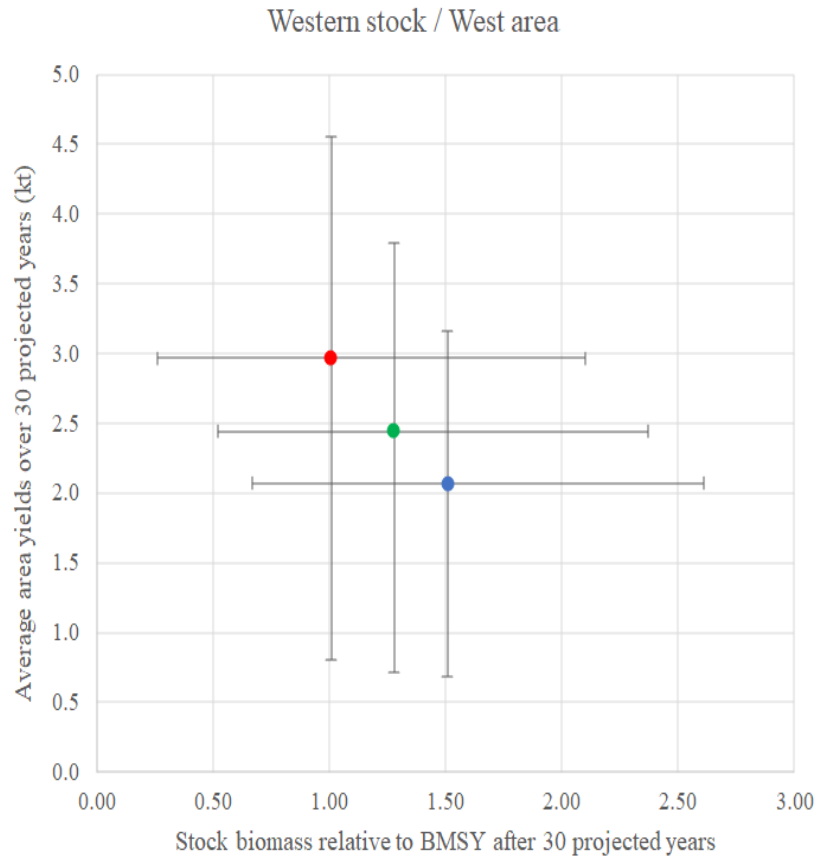
**AvC10:** Average catch years 1-10, measures short term yield

**AvC30:** Average catch years 1-30, measures long term yield

**VarC:** Average % Variation in TAC between management periods

# 2. Evaluate trade-offs

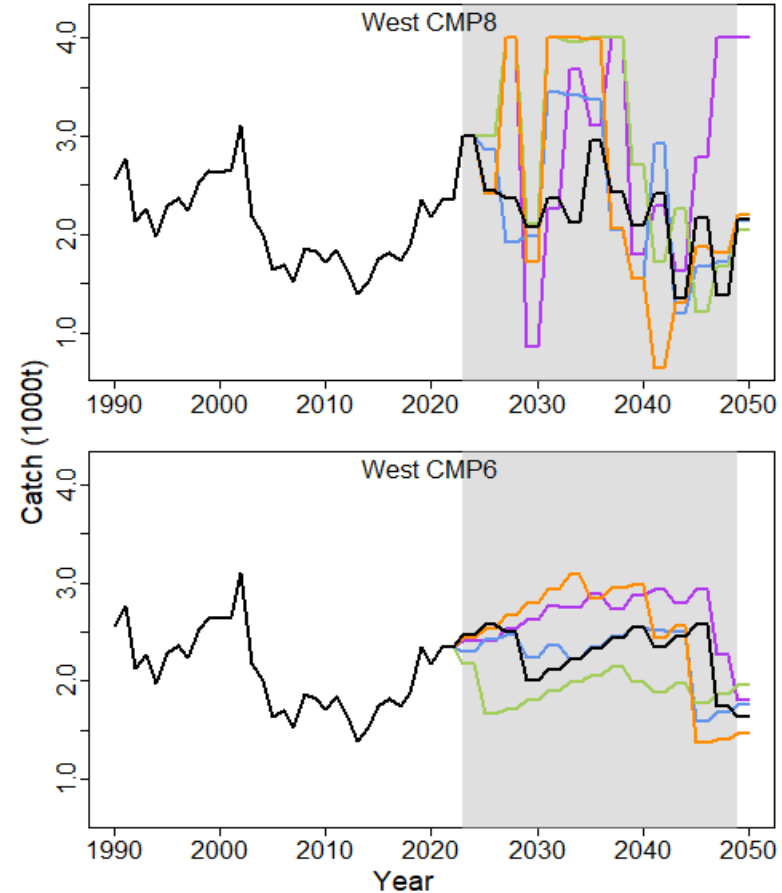
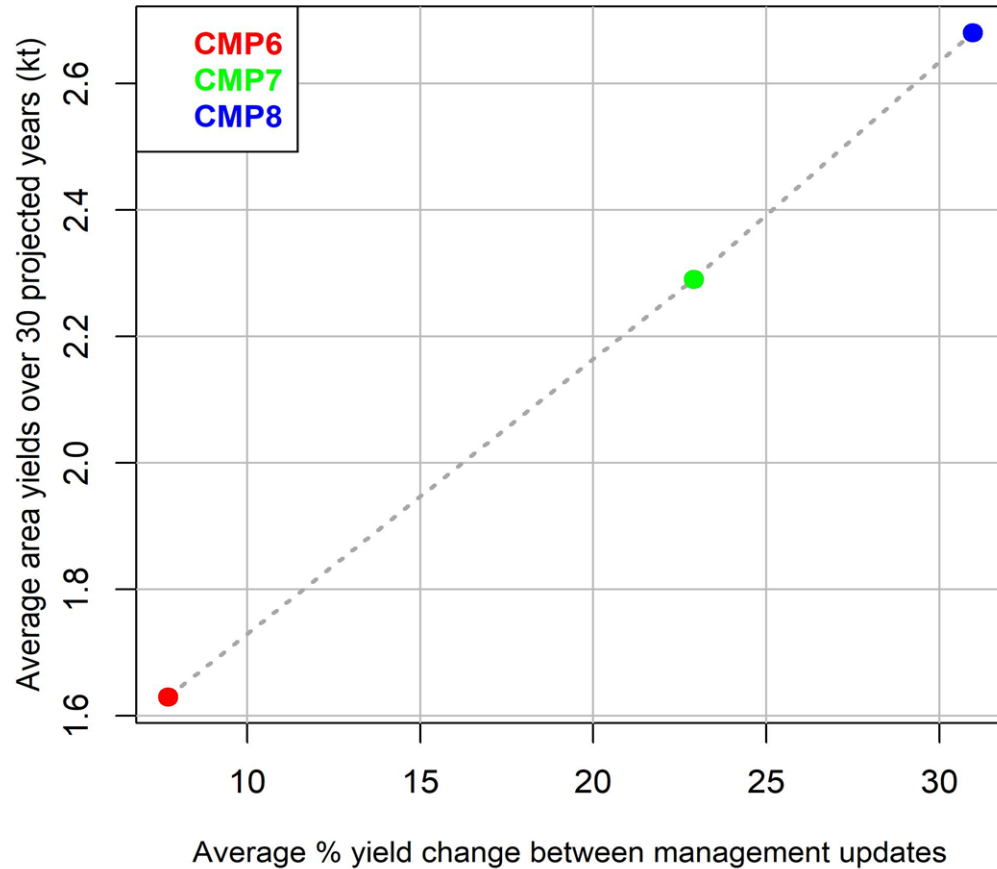
## A) Stock status vs yield



There is a compromise between yield and risk for the status of the stocks.

# 2. Evaluate trade-offs

## B) Yield vs variability in yield



The higher the yield, the higher the variability in yield

# BFT MSE – The Management Procedure(s) - MP

How to deal with  
the different CMPs?

# Relative Ranking of CMPs – an illustrative example

West	Br30 target	VarC (median)	AvC10 (median)	AvC30 (median)	LD (5th percentile)	LD (15th percentile)
CMP1	1.25	13.79	3.09	2.87	0.22	0.43
CMP2	1.25	11.36	2.05	2.21	0.26	0.48
CMP3	1.25	15.97	2.96	2.53	0.02	0.25
East	Br30 target	VarC (median)	AvC10 (median)	AvC30 (median)	LD (5th percentile)	LD (15th percentile)
CMP1	1.50	16.72	39.06	37.65	0.30	0.55
CMP2	1.50	11.41	34.74	28.50	0.33	0.52
CMP3	1.50	13.95	41.48	30.29	0.07	0.29

- Within column, green= best, yellow = intermediate, red = worst
- color scale represents relative performance; red does not necessarily indicate unacceptable performance
- Key take home: **Not every CMP may be the top in every category**
- Different statistics may be ‘weighted’ differentially



An aerial photograph of a coastal town. In the foreground, a large, multi-story building complex with a red roof and white walls is situated on a rocky peninsula. The building has several gabled sections and a central courtyard. To the right of the building, a dense forest of green trees covers a hillside. In the background, a town with various buildings, including a tall apartment-style building, is visible. A river or inlet flows through the town, and a bay with many small boats is on the right. The water is a mix of blue and brown, suggesting a mix of fresh and salt water. The overall scene is bright and sunny, with a warm, golden light.

**Questions?**

**EXTRA MATERIAL**



# A potential management Advice Framework

Management Procedure sets TACs for 2 (or possibly 3) years for both East and West by modifying previous TACs based on recent indices

Exceptional circumstance provisions specify situations when MP can be overridden, e.g. index outside range tested, inability to update an index for multiple years, natural disasters, etc

Less frequent stock assessments will occur on a predetermined interval as 'health or status' checks and to inform reconditioning for MP review

MP review/revision and MSE 'reconditioning' which includes refitting to new data, incorporation of new information or new methodology would be considered (groundbreaking science, exceptional circumstances, etc) at predetermined intervals.

year	event
2022	Management Procedure Sets 2 year East and West TACs
2023	Define Exceptional Circumstances Provisions
2024	Management Procedure Sets 2 year East and West TACs
2025	Stock Assessment- health check (exact timing TBD)
2026	Management Procedure Sets 2 year East and West TACs
2027	MSE reconditioning, possible start in 2026 (TBD)
2028	Management Procedure Sets 2 year East and West TACs
2029	TACs as set in 2028

# Extra material – Roles in and Steps of the Management Strategy Evaluation process

	Scientists	Managers (Stakeholders <i>advise</i> )	status
Operating models	Construct, <b>adopt</b> reference grid and robustness set	<i>advise</i>	<i>completed</i>
	<b>Adopt</b> plausibility weights for OMs	<i>advise</i>	<i>completed</i>
Management objectives	Provide input on initial operational MOs	<b>Adopt</b> conceptual MOs ( <i>Res. 18-03</i> ) <b>Refine</b> interim operational Management Objectives	March 4, 1 <sup>st</sup> Panel 2 meeting
	Provide input for refined MOs	<b>Agree</b> final Operational Management Objectives	May 9, 2 <sup>nd</sup> Panel 2 meeting
Management Procedures	Propose Candidate MPs	Provide initial <i>advice</i> on performance preferences of Candidate MPs in line with MOs.	April BFT meeting/ May 9, 2 <sup>nd</sup> Panel 2 meeting
	Test performance of CMPs	<b>Identify</b> preferred CMP; <b>Adopt</b> MP	October 14, 3 <sup>rd</sup> Panel 2 meeting/ Nov 14-21, 2022 Commission
	<i>Advise</i> on Exceptional circumstances	<b>Adopt</b> ‘rules’ for Exceptional circumstances	Commission 2023 (addressed in 2023 because the EC will be specific to the MP adopted in 2022)

# Glossary



<https://harveststrategies.org/what-are-harvest-strategies/glossary/>

# Other interesting links

[Harveststrategies.org](https://harveststrategies.org) MSE outreach materials (multiple languages)



**What are Harvest Strategies?**

Harvest strategies are an essential tool in making sustainable fisheries management decisions. Adopting harvest strategies leads to...

[Learn more](#)

**HS Case Studies**

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**RESOURCES**

WHAT IS MSE?

**DATA VISUALIZATION TOOLS**

**HS UPDATE**

**Webinar focused on how harvest strategies will help the EU secure sustainable tuna fisheries**

[Learn more](#)

Splash Page: <https://iccat.github.io/abft-mse/> (English only)

## Atlantic Bluefin Tuna MSE

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28 July, 2021



### Documentation

[Trial Specifications Doc \(.docx\)](#) [CMP Developers Guide \(.html\)](#)  
[Trial Specifications Doc \(.pdf\)](#)

### Shiny App

[Latest version](#) [Legacy \(2020\) version](#)

### R package

[ABTMSE R Package](#)

### Operating Model Reports

#### Summary Reports

[Low length comp fit OM comparison \(.html\)](#) [High length comp fit OM comparison \(.html\)](#)

#### Index Statistic Summary Reports

[Low length comp fit index stats \(.html\)](#) [High length comp fit index stats \(.html\)](#)

#### Individual OM Diagnostic Reports

[Reference Grid OM summary and individual reports \(.html\)](#) [Robustness Set OM OM summary and individual reports \(.html\)](#)

### Meeting reports

[September 2020 Second Intersessional Meeting of the ICCAT ABT MSE technical group \(ENG\)\(.pdf\)](#)  
[April 2021 First Intersessional Meeting of the Bluefin Tuna Species Group \(ENG\)\(.pdf\)](#)

### Acknowledgements

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# Summary of Next Steps, 2022 ICCAT official and unofficial meetings (yellow are Panel 2/Commission meetings)

Date	Meeting (virtual or TBD)	Objectives	
2022	March 4	1 <sup>st</sup> Panel 2 meeting on BFT MSE(virtual)	<ol style="list-style-type: none"> <li>1. SCRS to present updated MSE framework and CMPs.</li> <li>2. Panel 2 to provide feedback and guidance on additional changes to the CMPs.</li> <li>3. Panel 2 to refine initial operational management objectives.</li> </ol>
	March/April	informal SCRS BFT MSE Tech Group meeting (virtual)	<ol style="list-style-type: none"> <li>1. Address Panel 2 feedback</li> <li>2. Prepare material for BFT Species group</li> </ol>
	April 18-26	EBFT Data Prep (virtual) to include MSE topics	<ol style="list-style-type: none"> <li>1. BFTSG to update performance statistics based on initial operational management objectives, if necessary.</li> <li>2. BFTSG to provide feedback and approval of final MSE robustness trials.</li> <li>3. BFTSG to do initial cull of CMPs.</li> <li>4. BFTSG to develop presentation to Panel 2 on progress</li> </ol>
	May 3-6	SCRS BFT MSE Technical Group meeting (virtual)	<ol style="list-style-type: none"> <li>1. MSE Technical Group to present changes to CMPs based on Panel 2/Commission input.</li> </ol>
	May 9	2 <sup>nd</sup> Panel 2 meeting on BFT MSE (virtual)	<ol style="list-style-type: none"> <li>1. SCRS to present final MSE framework and draft suggestions for culled list of CMPs.</li> <li>2. Panel 2 to provide feedback on MSE and guidance on additional changes to the CMPs.</li> <li>3. Panel 2 to agree on final operational management objectives.</li> </ol>
	July 4-12	EBFT Assessment (virtual)	
	July (TBD)	Informal SCRS BFT MSE Tech Group meeting (virtual)	<ol style="list-style-type: none"> <li>1. MSE Technical Group to collate and address Panel 2 feedback.</li> <li>2. CMP developers to present revised results, incorporating feedback.</li> </ol>

# 2022 ICCAT official and unofficial meetings (yellow are Panel 2/Commission meetings)

Date		Meeting (virtual or TBD)	Objectives
2022	September 5-9	SCRS BFT MSE Technical Group meeting (virtual)	<ol style="list-style-type: none"> <li>1. MSE Technical Group to present updated CMP results.</li> <li>2. BFTSG to provide feedback.</li> <li>3. CMP developers to present revised results, incorporating feedback.</li> <li>4. BFTSG to cull the CMPs to a maximum of three.</li> </ol>
	September 19-24	SCRS BFT Species Group (TBD)	<ol style="list-style-type: none"> <li>1. BFTSG &amp; SCRS to review and endorse final CMPs results.</li> <li>2. BFTSG &amp; SCRS to select one to three final CMPs for presentation to Panel 2.</li> </ol>
	September 26-3 Oct	SCRS Plenary (TBD)	<ol style="list-style-type: none"> <li>1. SCRS to select one to three final CMPs for presentation to the Panel 2.</li> </ol>
	October 14	3 <sup>rd</sup> Panel 2 meeting BFT MSE (virtual)	<ol style="list-style-type: none"> <li>1. SCRS to present final CMPs, with all final specifications, for review.</li> <li>2. Panel 2 to select a CMP to recommend for Commission adoption.</li> </ol>
	November 14-21	Annual Commission meeting (TBD)	<ol style="list-style-type: none"> <li>1. Commission to adopt a fully specified MP, including final operational management objectives.</li> </ol>

## Appendix I. Key terminology in MSE

**Limit reference point (LRP):** A benchmark for an indicator that defines an undesirable biological state of the stock such as the  $B_{lim}$  or the biomass limit which is undesirable to be below. To keep the stock safe, the probability of violating an LRP should be very low.

**Management objectives:** Formally adopted social, economic, biological, ecosystem, and political (or other) goals for a stock and fishery. They include high-level or conceptual objectives often expressed in legislation, conventions or similar documents. They must also include operational objectives that are specific and measurable, with associated timelines. When management objectives are referenced in the context of management procedures, the latter, more specific definition applies, but sometimes conceptual objectives are adopted first (e.g., Rec. 18-03 for ABFT).

**Management procedure (MP):** Some combination of monitoring, assessment, harvest control rule and management action designed to meet the stated objectives of a fishery, and which has been simulation tested for performance and adequate robustness to uncertainties. Also known as a harvest strategy.

**Management strategy evaluation (MSE):** A simulation-based, analytical framework used to evaluate the performance of multiple management procedures relative to the pre-specified management objectives.

**Operating model (OM):** A model representing a plausible scenario for stock and fishery dynamics that is used to simulation test the management performance of CMPs. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery, thereby testing the robustness of management procedures.

**Performance statistic:** A quantitative expression of a management objective used to evaluate how well an objective is being achieved by determining the proximity of the current value of the statistic to the objective. Also known as a performance metric or performance indicator.

**Reference Grid:** The operating models that represent the most important uncertainties in stock and fishing dynamics, which are used as the principal basis for evaluating CMP performance. The reference operating models are specified according to factors (e.g., natural mortality rate) that have multiple levels (possible scenarios for each factor, e.g., high / low natural mortality rate). Reference operating models are organized in a usually fully crossed orthogonal 'grid' of all factors and levels.

**Robustness Set:** Other potentially important uncertainties in stock and fishing dynamics may be included in a Robustness Set of operating models that provide additional tests of CMP performance robustness. They can be used to further discriminate between CMPs. Compared to the Reference Grid operating models, the Robustness Set models will be typically less plausible and/or influential on performance.