Management Strategy Evaluation for bigeye tuna in the eastern Pacific Ocean

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Inter-American Tropical Tuna Commission

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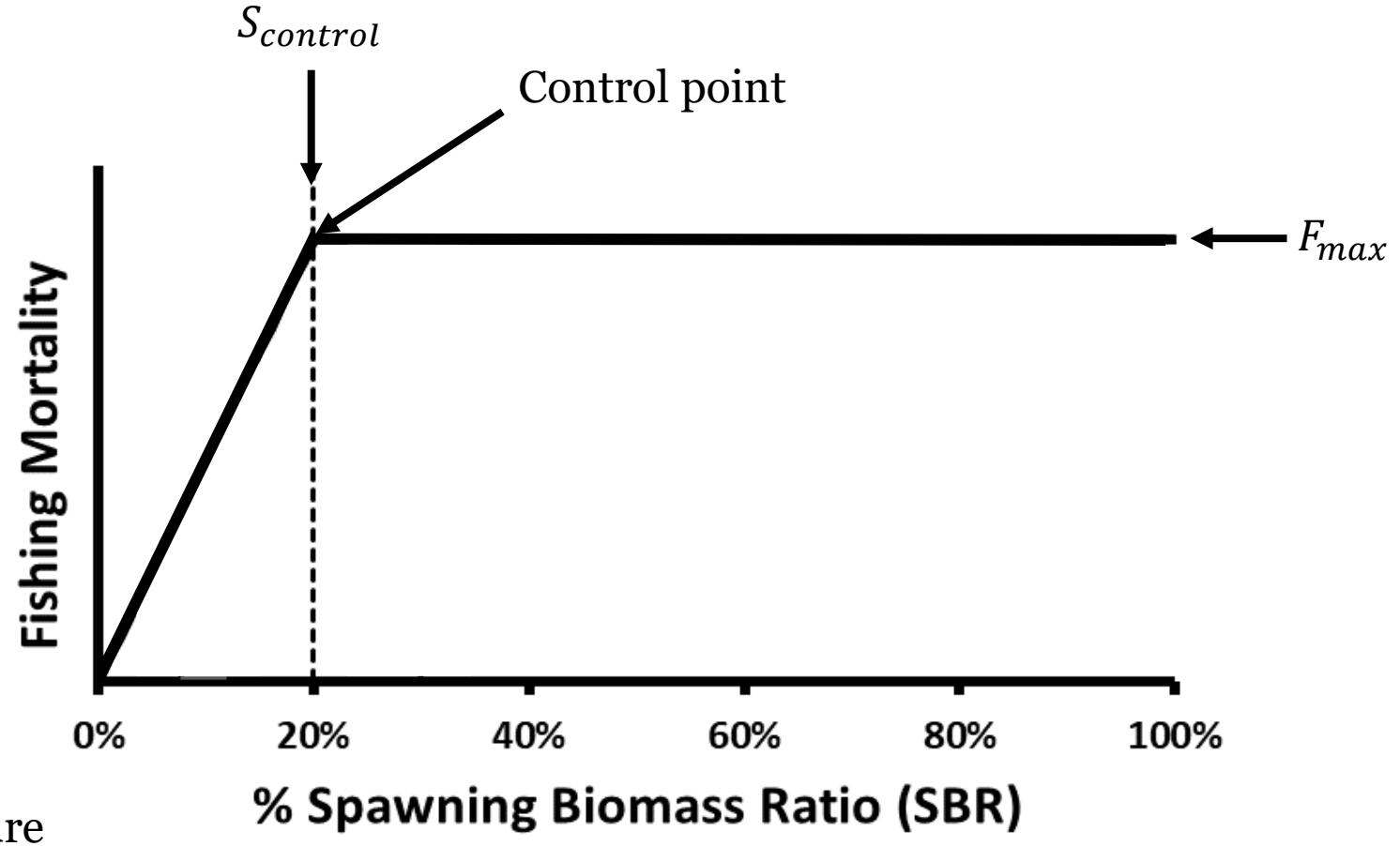
MSE specifications

- Operating models represent hypotheses about the true population dynamics
- The Operating model ensemble for bigeye in the EPO consists of the 36 reference models developed for the 2024 risk analysis
- The estimation model uses simulated fishery data to estimate perceived stock status and trends for the harvest control rule
- The estimation model for bigeye in the EPO is the ASPM_Rdevs+ version of the tuned base reference model
- The MSE simulates 21 years from 2025 to 2046, including seven 3-year management cycles
- Recruitment variability and observation error are both included in the MSE
- Implementation error (CV=0.1) is included in the MSE
- 1,200 iterations per HCR – full MSE results

Harvest control rule: example

Component	HCR
F_{max}	$F_{30\%}$
$S_{control}$	$S_{20\%}$
Range for closure change (day): $S > S_{control}$	-10 to 10
Range for closure change (day): $S < S_{control}$	-10 to 20
Name	F30-S20



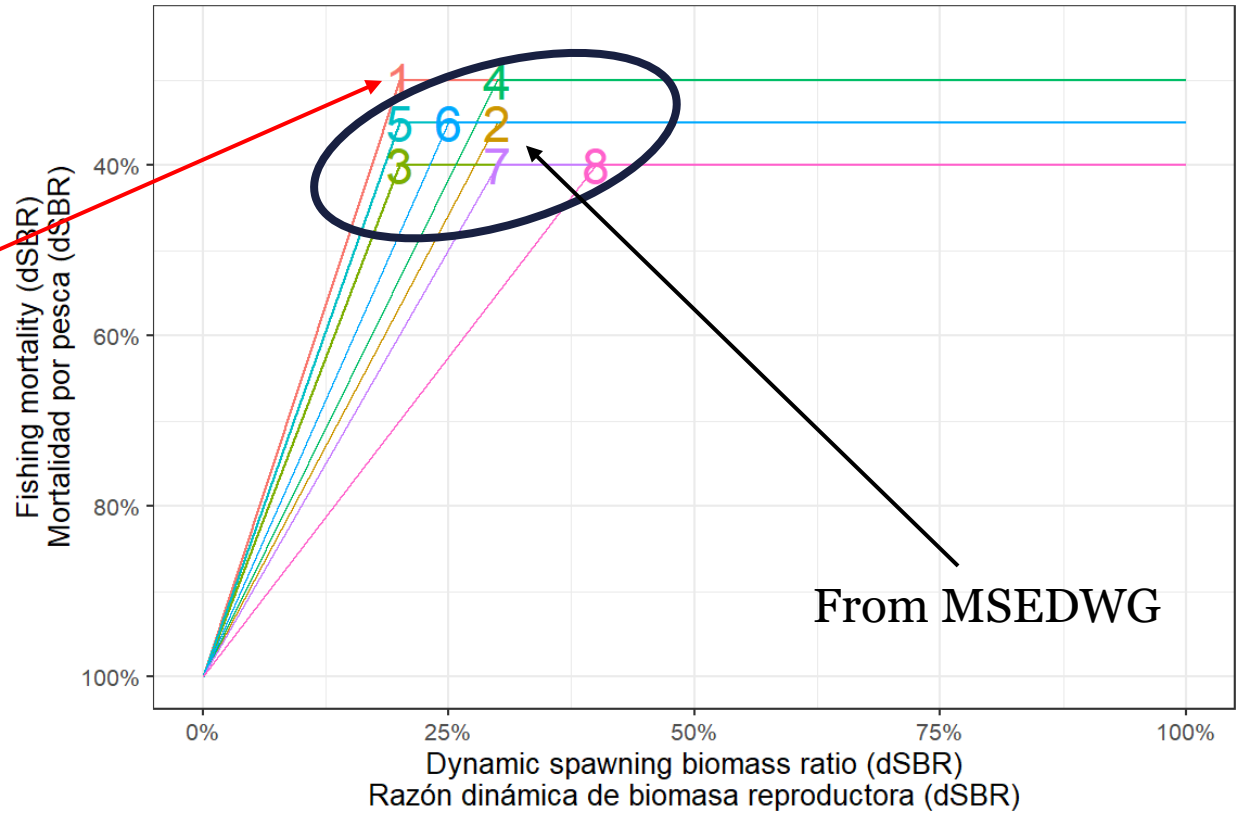
- $F_{max} = F_{30\%}$ and $S_{control} = S_{20\%}$
- Alternative HCRs can change these values
- Implement fishing mortality using days closure
- A 20-day cap when S < $S_{control}$ allows faster responses to depletion while preserving stability

Comparing eight candidate HCRs

Component	Staff	WG1	WG2	WG3	WG4	WG5	WG6	WG7
Number	1	2	3	4	5	6	7	8
F_{max}	$F_{30\%}$	$F_{35\%}$	$F_{40\%}$	$F_{30\%}$	$F_{35\%}$	$F_{35\%}$	$F_{40\%}$	$F_{40\%}$
$S_{control}$	$S_{20\%}$	$S_{30\%}$	$S_{20\%}$	$S_{30\%}$	$S_{20\%}$	$S_{25\%}$	$S_{30\%}$	$S_{40\%}$
Range for closure change (day): $S > S_{control}$	-10 to 10	-10 to 10	-10 to 10	-10 to 10	-10 to 10	-10 to 10	-10 to 10	-10 to 10
Range for closure change (day): $S < S_{control}$	-10 to 20	-10 to 20	-10 to 20	-10 to 20	-10 to 20	-10 to 20	-10 to 20	-10 to 20
Name	F30-S20	F35-S30	F40-S20	F30-S30	F35-S20	F35-S25	F40-S30	F40-S40

Comparing the eight candidate HCRs

From staff
F30-S20



Technical details can be found in SAC-17-05 (draft)

INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC ADVISORY COMMITTEE

17TH MEETING

La Jolla, California (USA)
08-12 June 2026

DOCUMENT SAC-17-05

MANAGEMENT STRATEGY EVALUATION FOR BIGEYE TUNA IN THE EASTERN PACIFIC OCEAN

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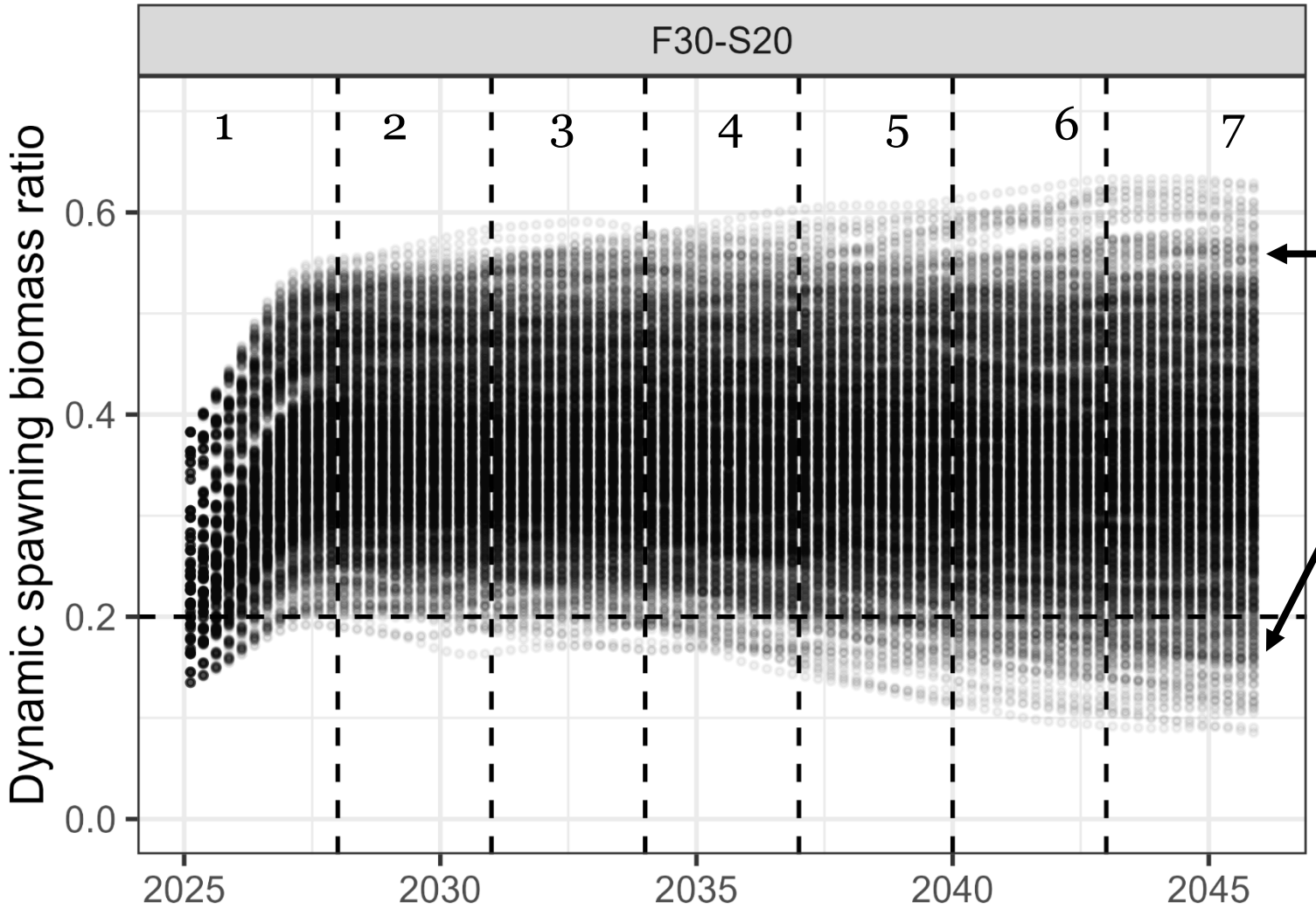
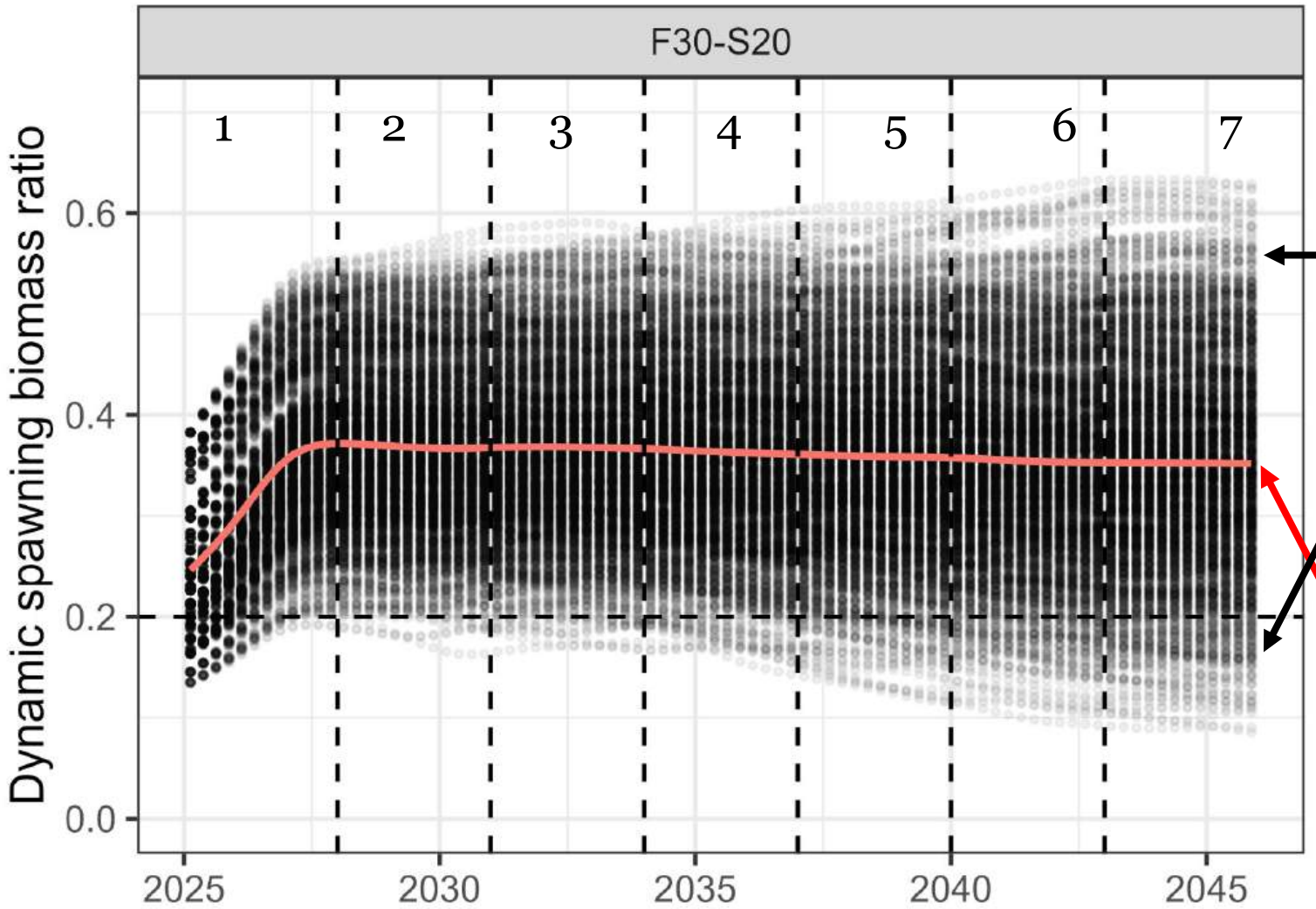
Results: dynamic SBR – how to read this figure?



Individual trajectories
(1,200 in total)

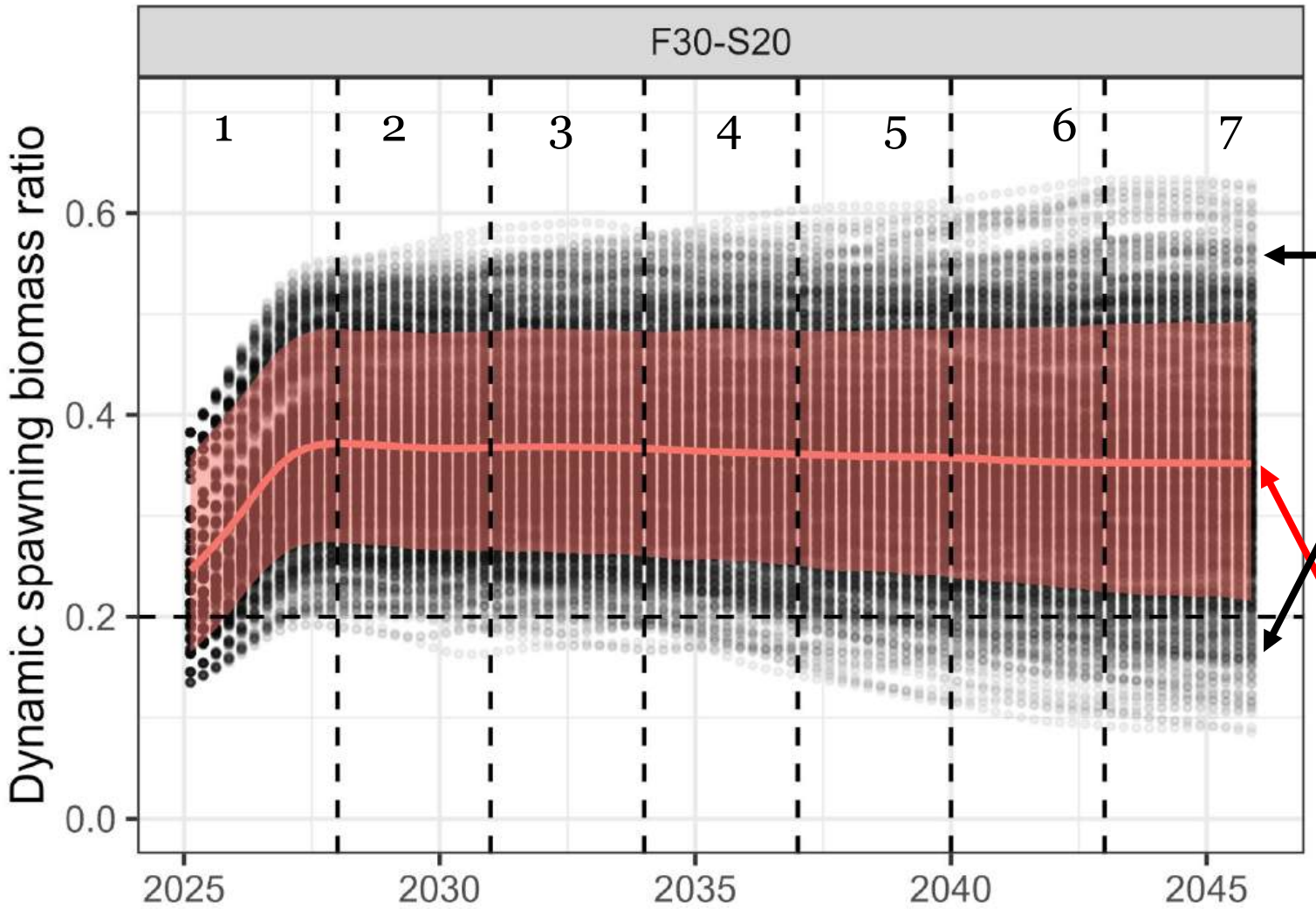
Results: dynamic SBR – how to read this figure?



Individual trajectories (1,200 in total)

Average trajectory

Results: dynamic SBR – how to read this figure?

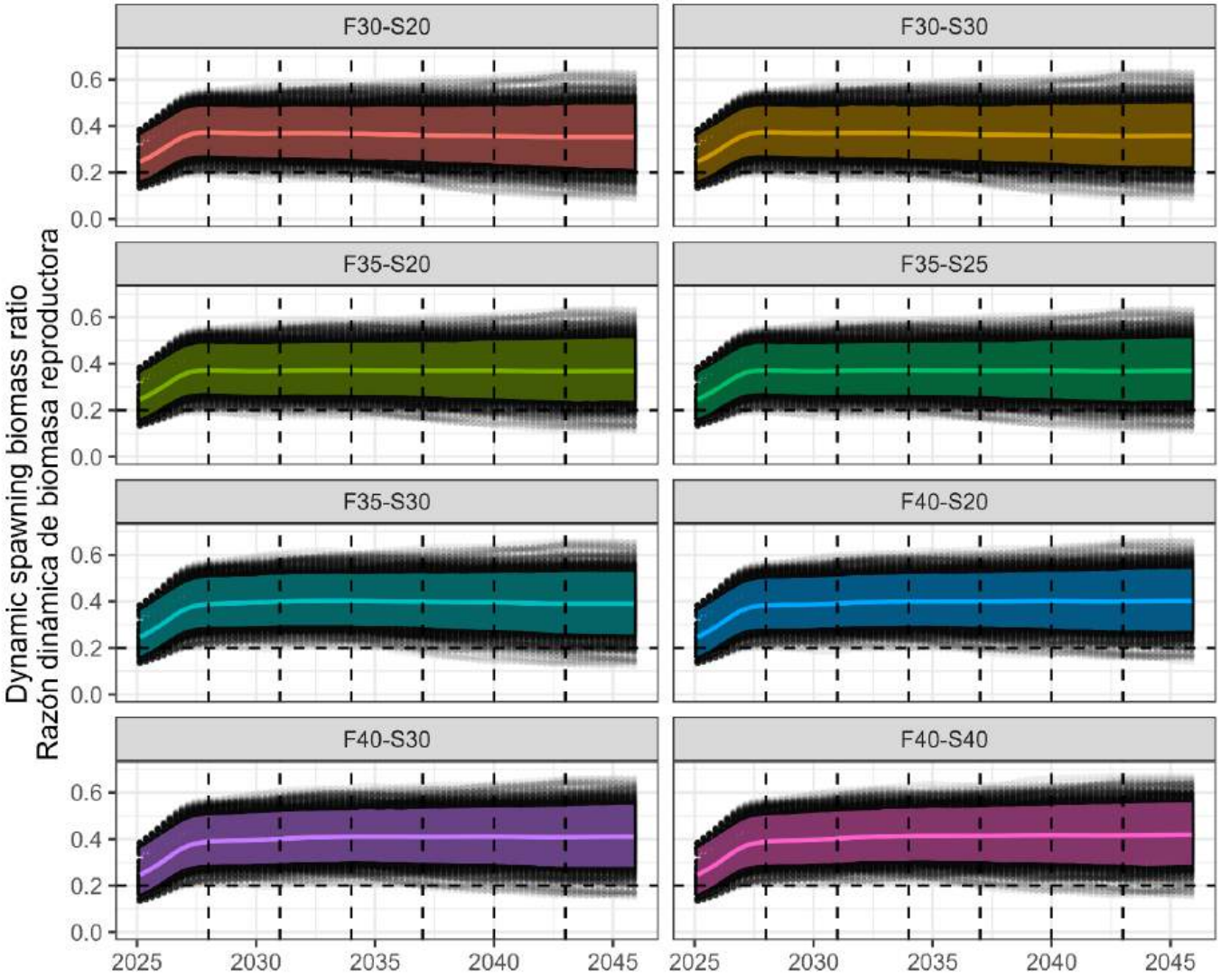


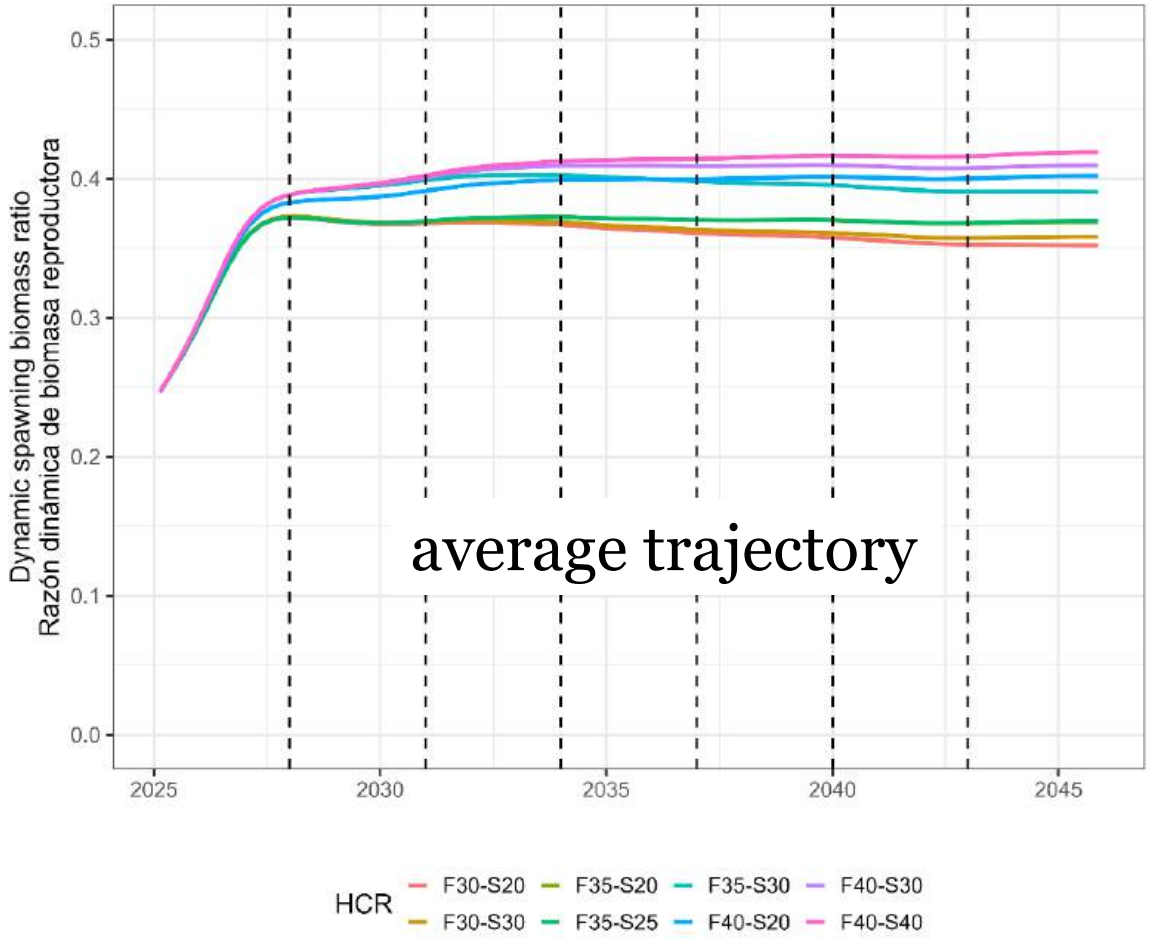
Individual trajectories
(1,200 in total)

10% to 90% percentiles
(covers 80% of individual trajectories)

Average trajectory

Results: dynamic SBR





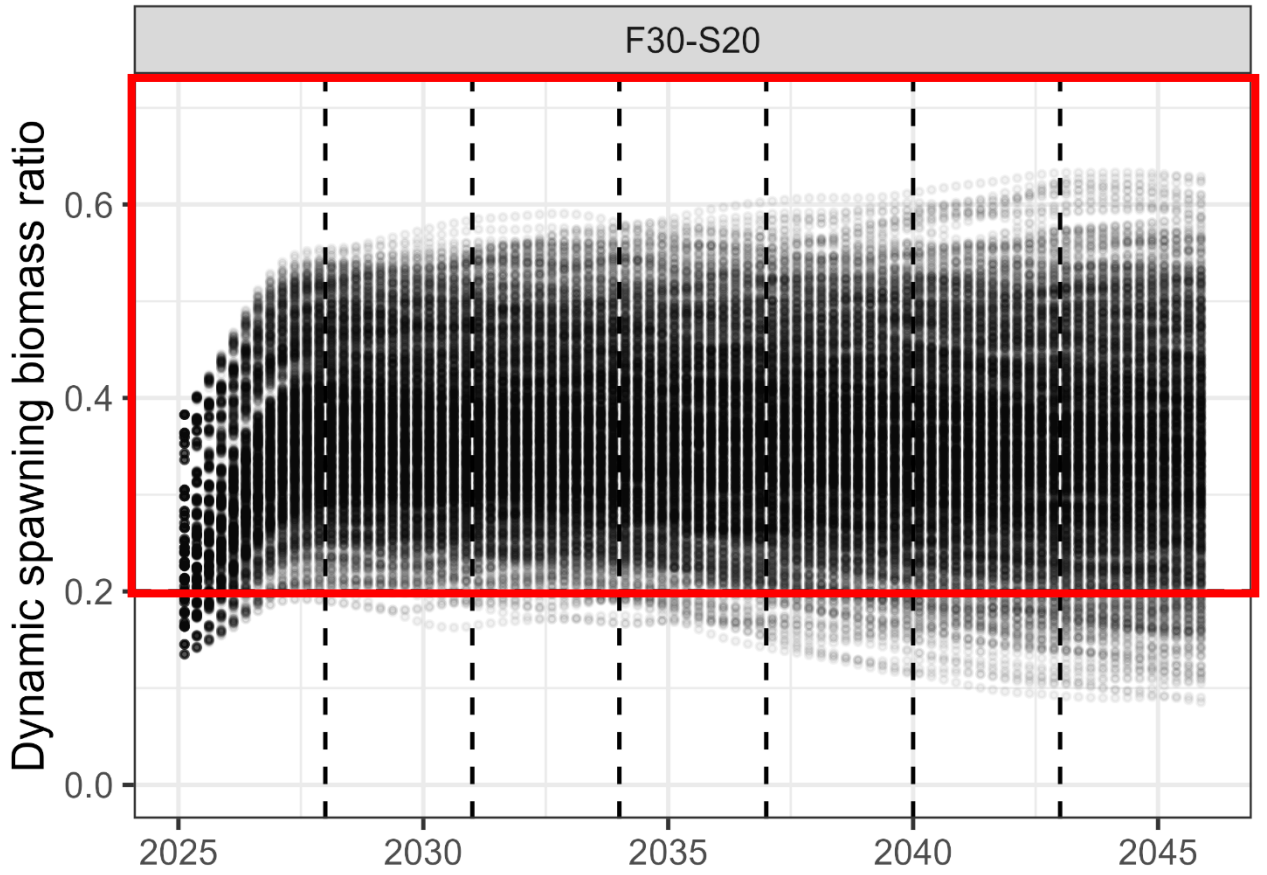
Performance indicators

Management objective	Performance indicator	Unit	Description
Safety	$p(dSBR > 0.2)$	%	The probability that dynamic spawning biomass ratio is larger than 0.2
	$p(SBR > 0.077)$	%	The probability that equilibrium spawning biomass ratio is larger than 0.077
	$p(SB > 0.5SB_{MSY})$	%	The probability that spawning biomass is larger than 50% of the spawning biomass at the maximum sustainable yield
Status	$p(Kobe\ in\ green)$	%	The probability that the stock is in the green quadrant of the Kobe plot
Stability	$AAV(catch)$	%	Average annual variability in annual catch
	$p(closure + 20)$	%	The probability that the closure will increase by 20 days
Yield	$PS\ catch$	ton	Average annual purse-seine catch
	$LL\ catch$	ton	Average annual longline catch
Effort	$closure$	day	Average fishery closure
Abundance	$CPUE$	%	The ratio of average longline CPUE to the average level for 2017-2019

Performance indicators: safety

The probability that dynamic spawning biomass ratio is larger than 0.2

HCR	**Prob (%) dSBR > 0.2**	Prob (%) SBR > 0.077	Prob (%) S > $0.5S_{MSY}$
F30-S20	**96.5**	99.9	99.9
F30-S30	**96.7**	99.9	99.9
F35-S20	**97.5**	100.0	100.0
F35-S25	**97.5**	100.0	100.0
F35-S30	**98.3**	100.0	100.0
F40-S20	**98.5**	100.0	100.0
F40-S30	**98.7**	100.0	100.0
F40-S40	**98.8**	100.0	100.0



Performance indicators: safety

The probability that dynamic spawning biomass ratio is larger than 0.2

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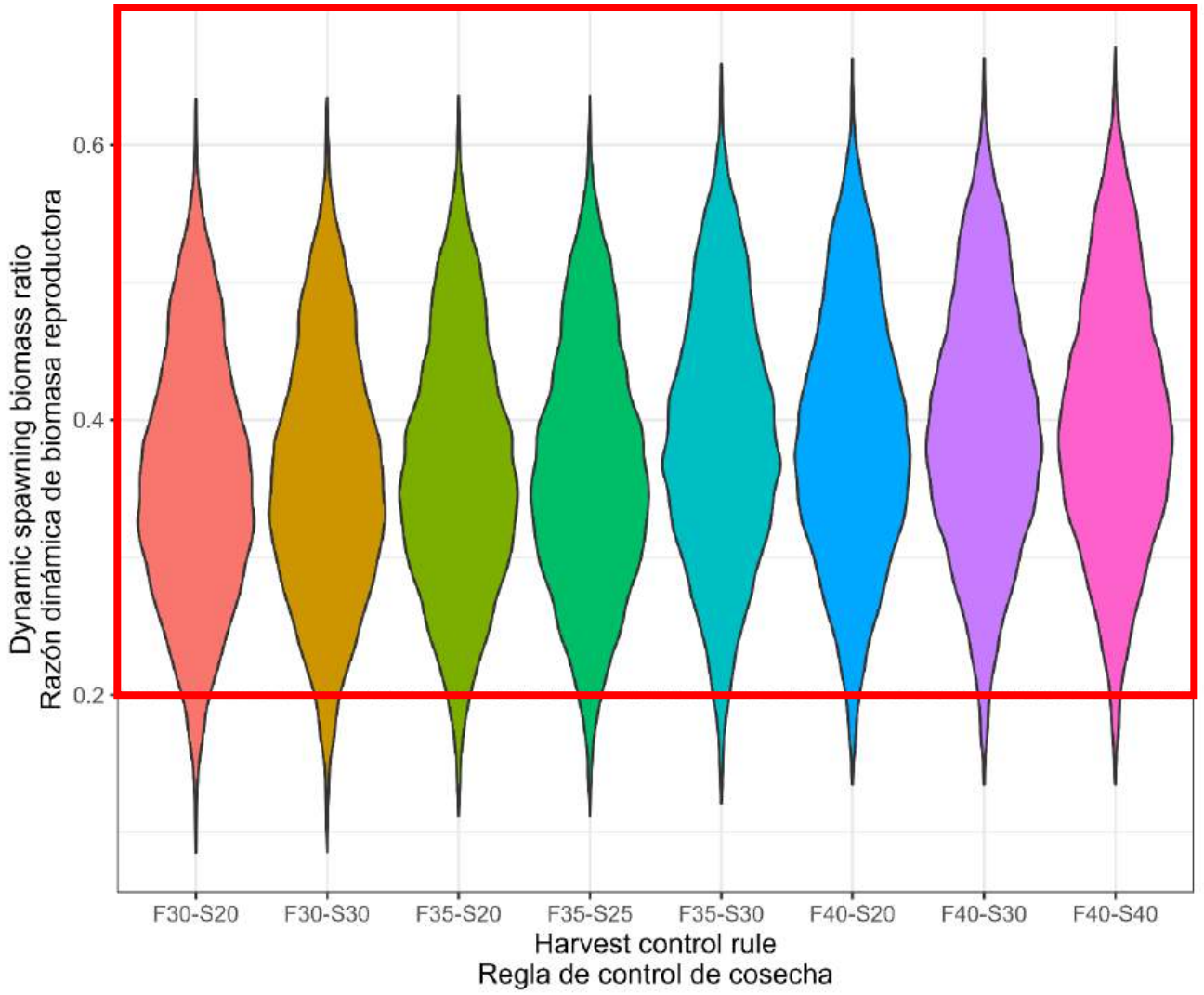
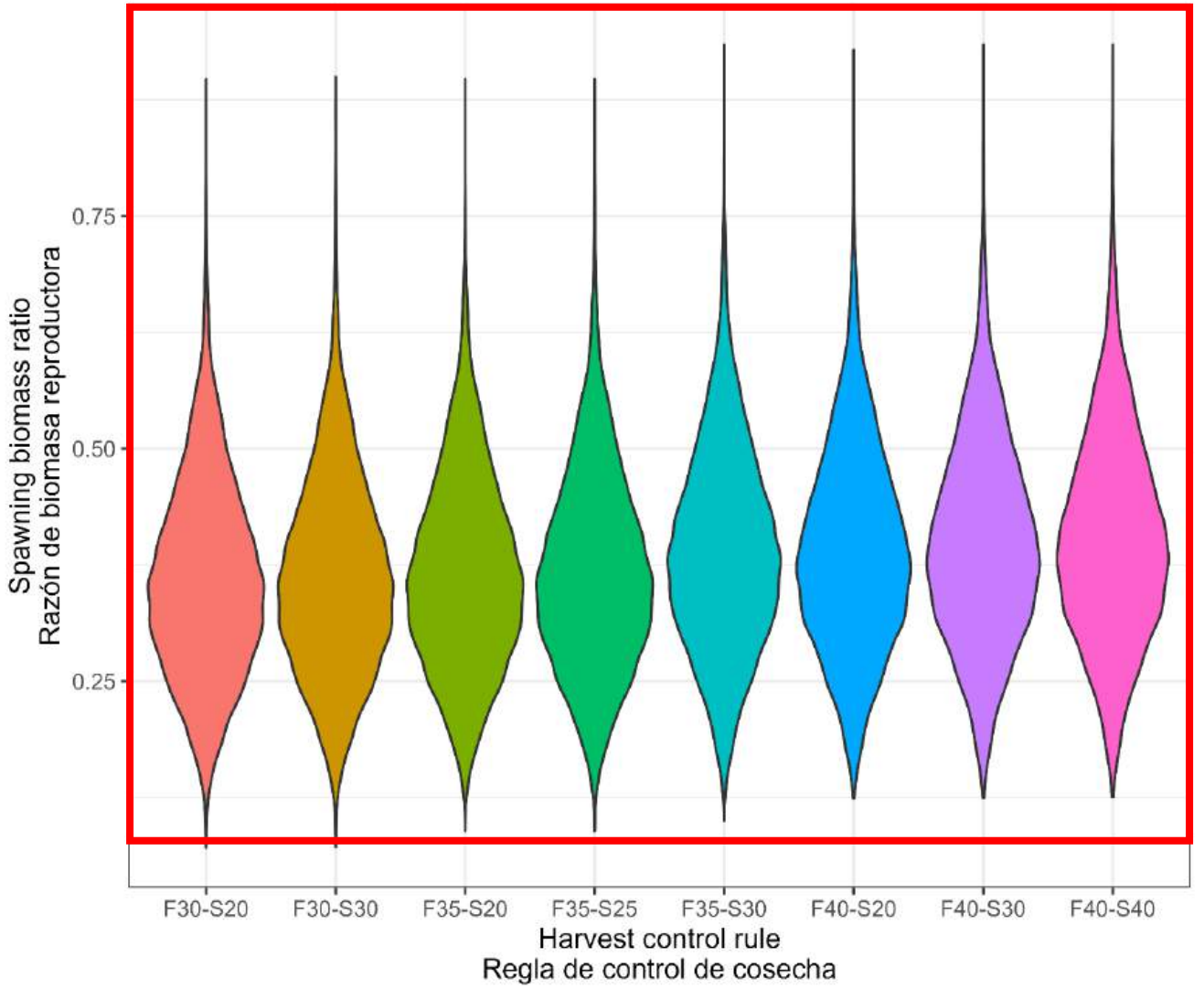
F40-S20	**98.5**	100.0	100.0
F40-S30	**98.7**	100.0	100.0
F40-S40	**98.8**	100.0	100.0



Performance indicators: safety

The probability that equilibrium spawning biomass ratio is larger than 0.077

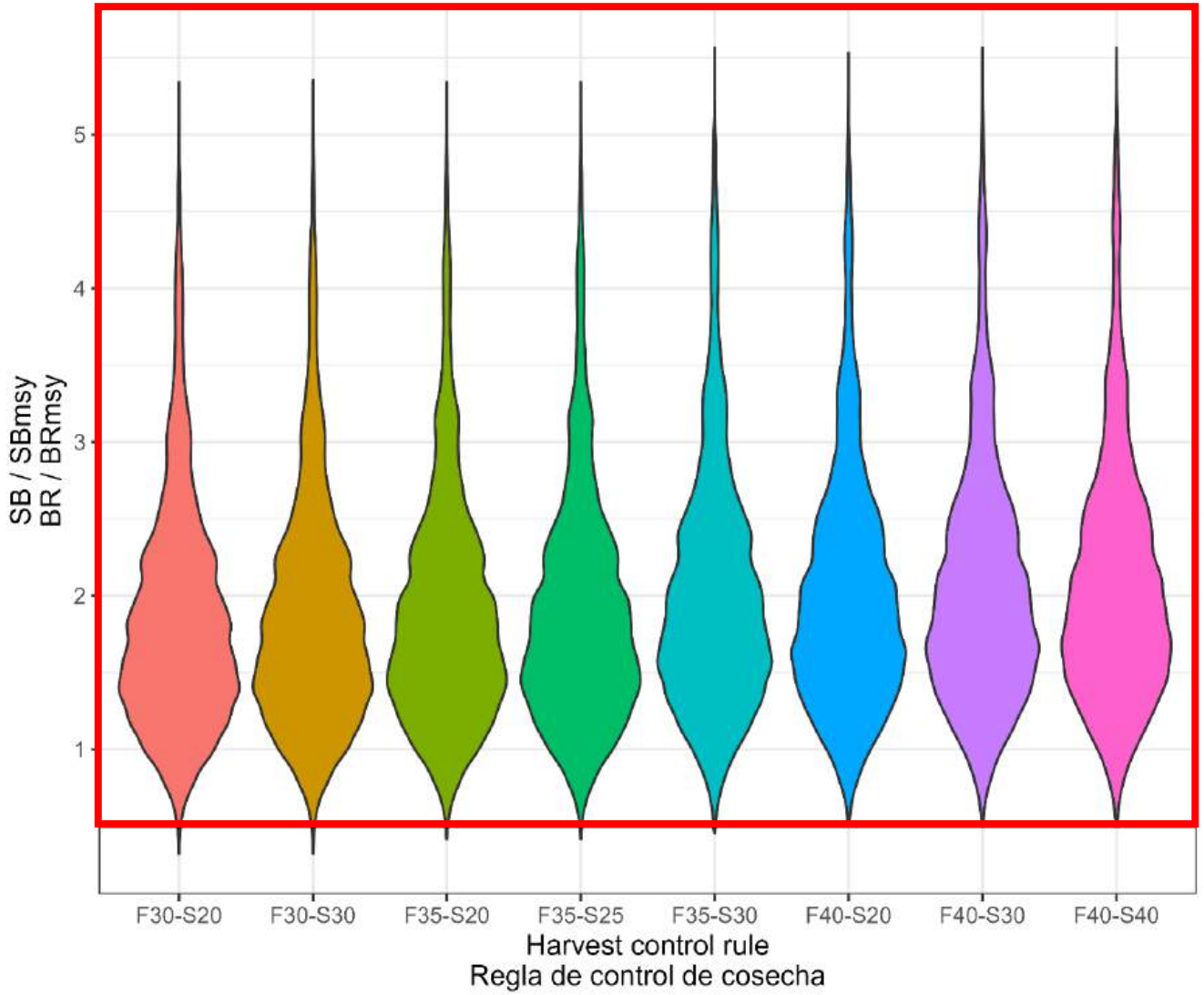
HCR	Prob (%) dSBR > 0.2	**Prob (%) SBR > 0.077**	Prob (%) S > $0.5S_{MSY}$
F30-S20	96.5	**99.9**	99.9
F30-S30	96.7	**99.9**	99.9
F35-S20	97.5	**100.0**	100.0
F35-S25	97.5	**100.0**	100.0
F35-S30	98.3	**100.0**	100.0
F40-S20	98.5	**100.0**	100.0
F40-S30	98.7	**100.0**	100.0
F40-S40	98.8	**100.0**	100.0



Performance indicators: safety

The probability that spawning biomass is larger than 50% of the spawning biomass at MSY

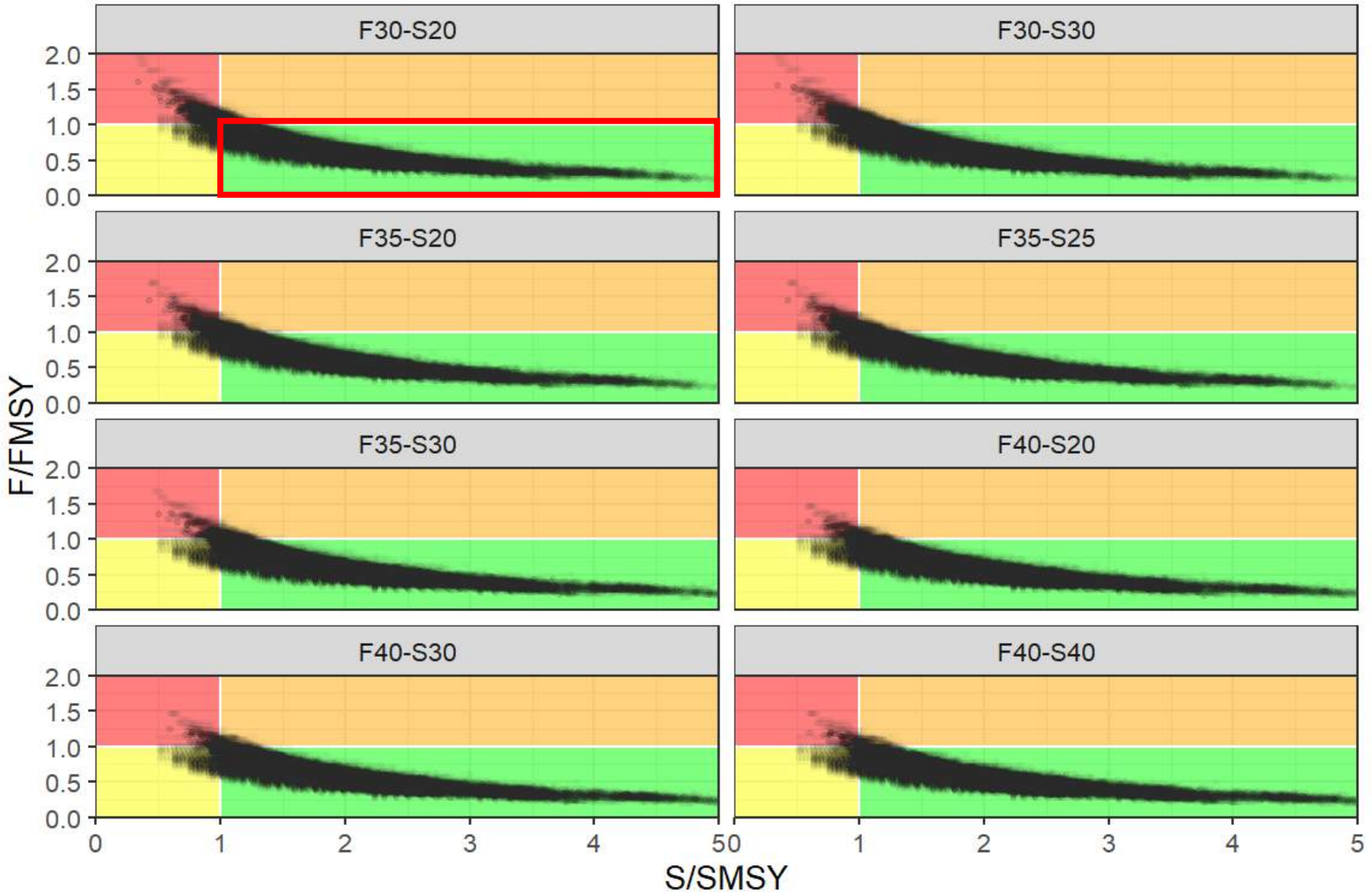
HCR	Prob (%) dSBR > 0.2	Prob (%) SBR > 0.077	**Prob (%) $S > 0.5S_{MSY}$**
F30-S20	96.5	99.9	**99.9**
F30-S30	96.7	99.9	**99.9**
F35-S20	97.5	100.0	**100.0**
F35-S25	97.5	100.0	**100.0**
F35-S30	98.3	100.0	**100.0**
F40-S20	98.5	100.0	**100.0**
F40-S30	98.7	100.0	**100.0**
F40-S40	98.8	100.0	**100.0**



Performance indicators: status

The probability that the stock is in the green quadrant of the Kobe plot

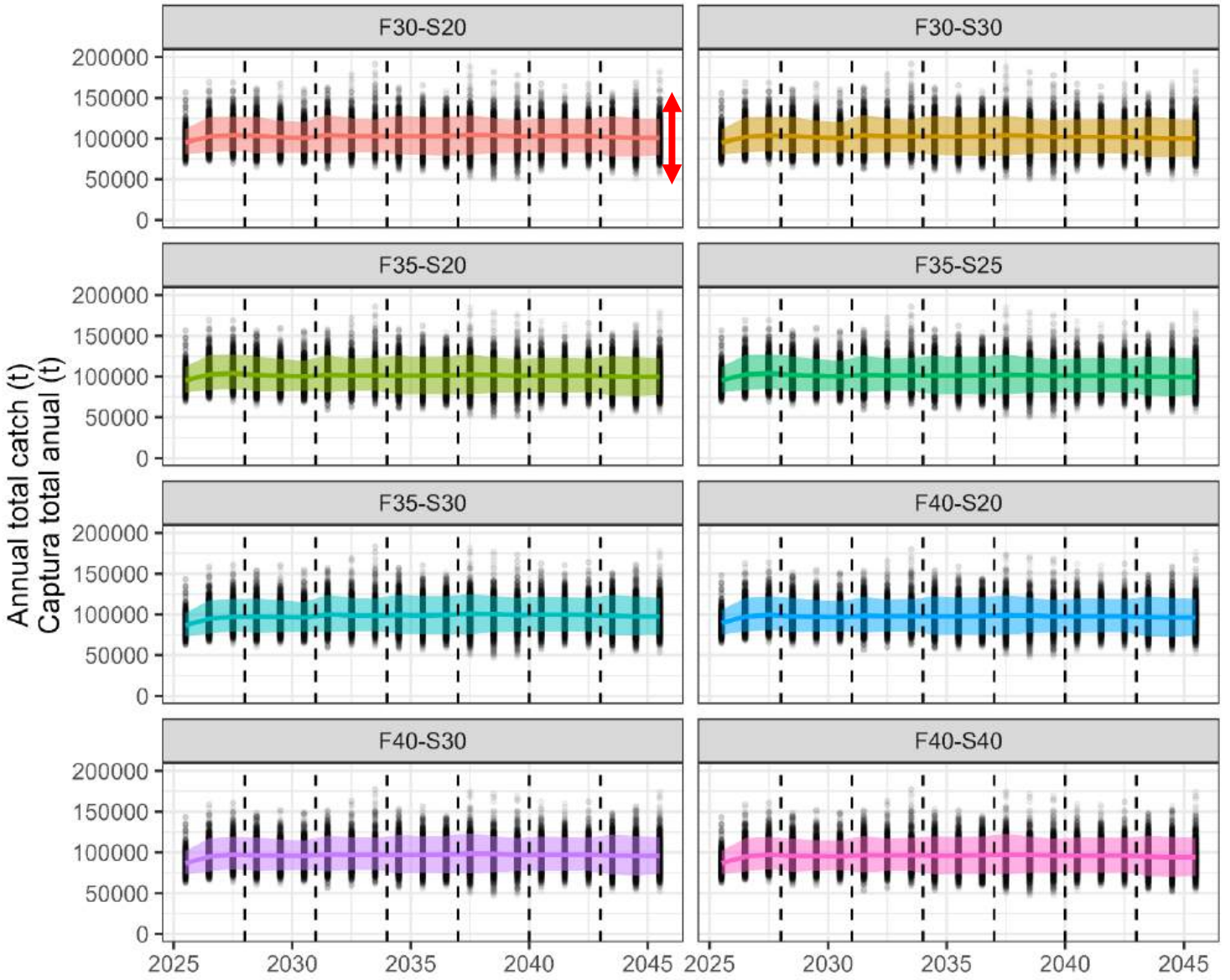
HCR	Prob (%) Kobe = green
F30-S20	89.6
F30-S30	90.0
F35-S20	91.6
F35-S25	91.6
F35-S30	94.0
F40-S20	94.6
F40-S30	95.2
F40-S40	95.5



Performance indicators: stability

Average annual variability in annual bigeye catch

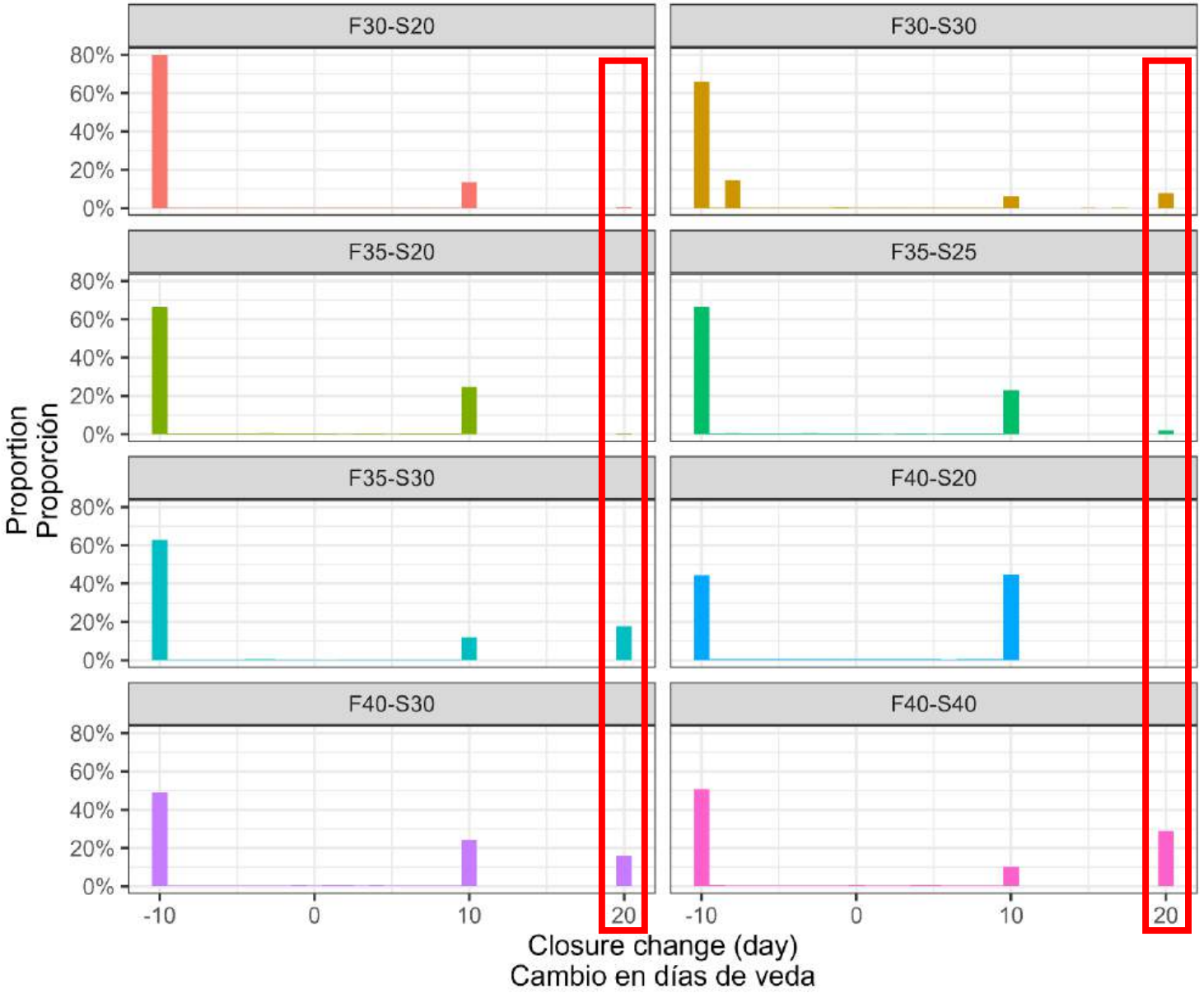
HCR	**AAV (%) in catch**	Prob (%) change = 20
F30-S20	**7.3**	0.8
F30-S30	**7.3**	7.7
F35-S20	**7.3**	0.4
F35-S25	**7.3**	1.9
F35-S30	**7.2**	17.6
F40-S20	**7.2**	0.1
F40-S30	**7.2**	16.3
F40-S40	**7.3**	28.9



Performance indicators: stability

The probability that the closure will increase by 20 days

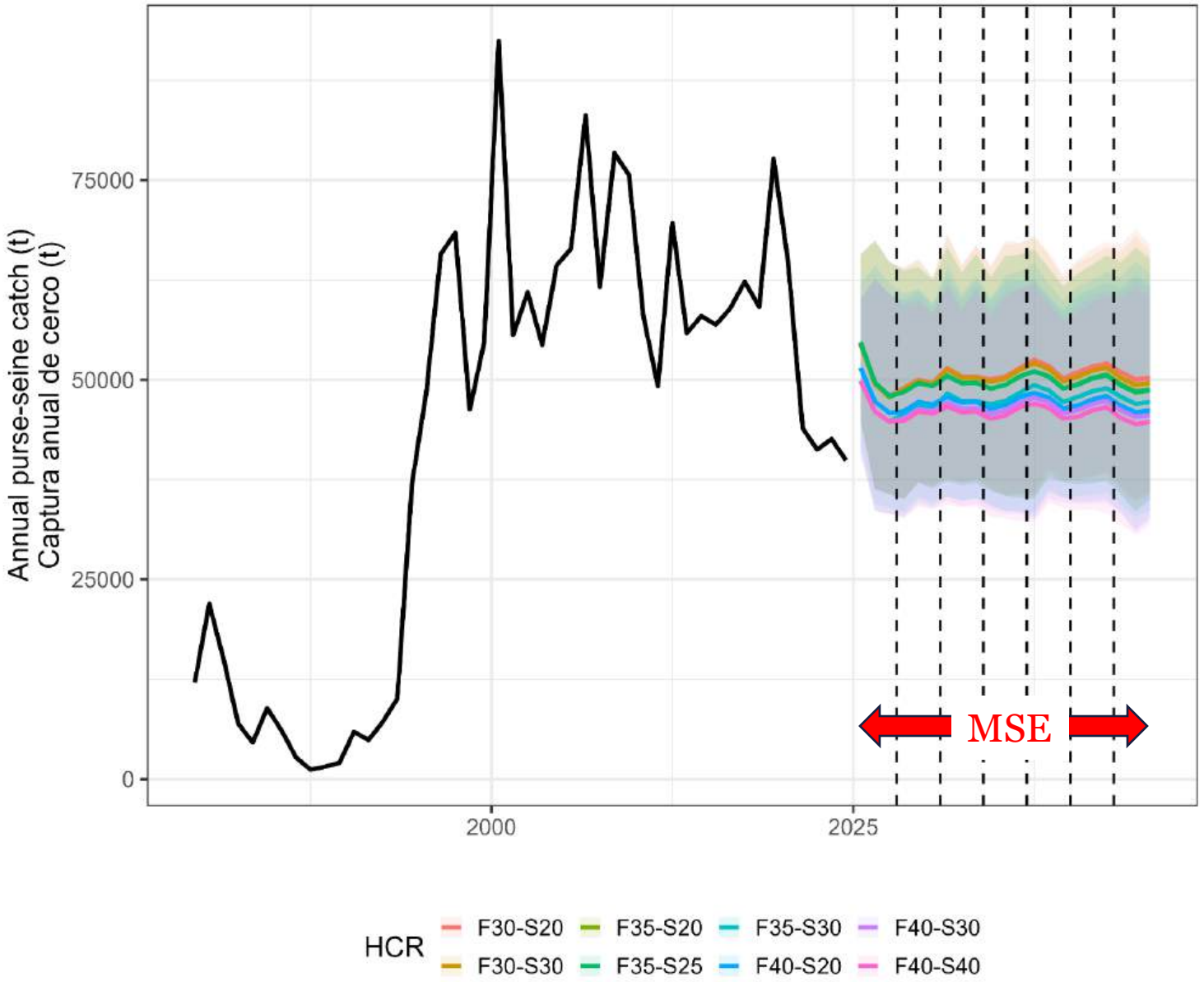
HCR	AAV (%) in catch	**Prob (%) change = 20**
F30-S20	7.3	**0.8**
F30-S30	7.3	**7.7**
F35-S20	7.3	**0.4**
F35-S25	7.3	**1.9**
F35-S30	7.2	**17.6**
F40-S20	7.2	**0.1**
F40-S30	7.2	**16.3**
F40-S40	7.3	**28.9**



Performance indicators: yield

Average annual purse-seine catch

HCR	**Annual PS catch (mt)**	Annual LL catch (mt)
F30-S20	**50722**	51663
F30-S30	**50384**	51509
F35-S20	**49785**	51277
F35-S25	**49746**	51250
F35-S30	**47514**	50533
F40-S20	**47221**	50258
F40-S30	**46456**	49966
F40-S40	**45911**	49624



Performance indicators: yield

Average annual longline catch

HCR	Annual PS catch (mt)	**Annual LL catch (mt)**
F30-S20	50722	**51663**
F30-S30	50384	**51509**
F35-S20	49785	**51277**
F35-S25	49746	**51250**
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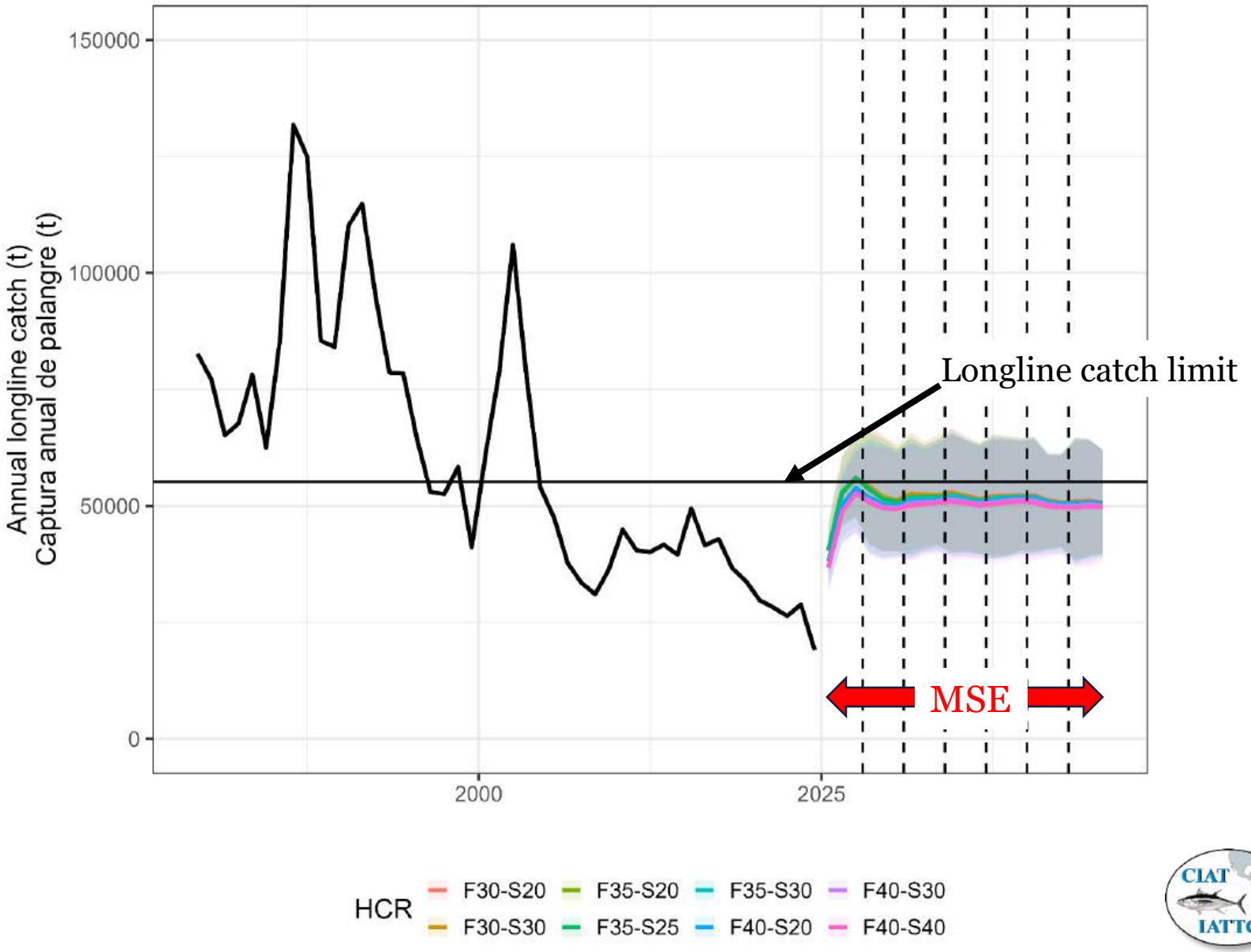
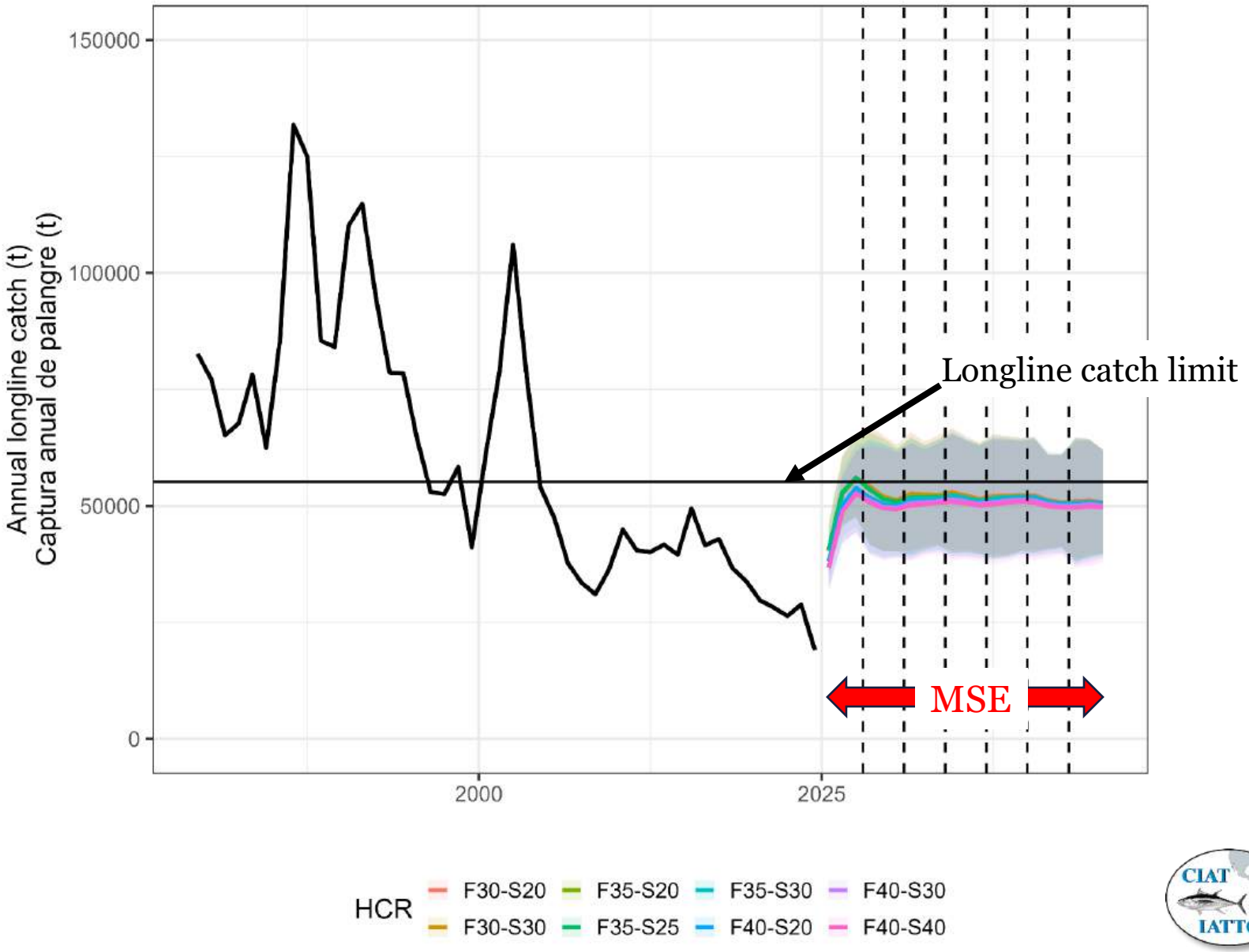


Performance indicators: yield

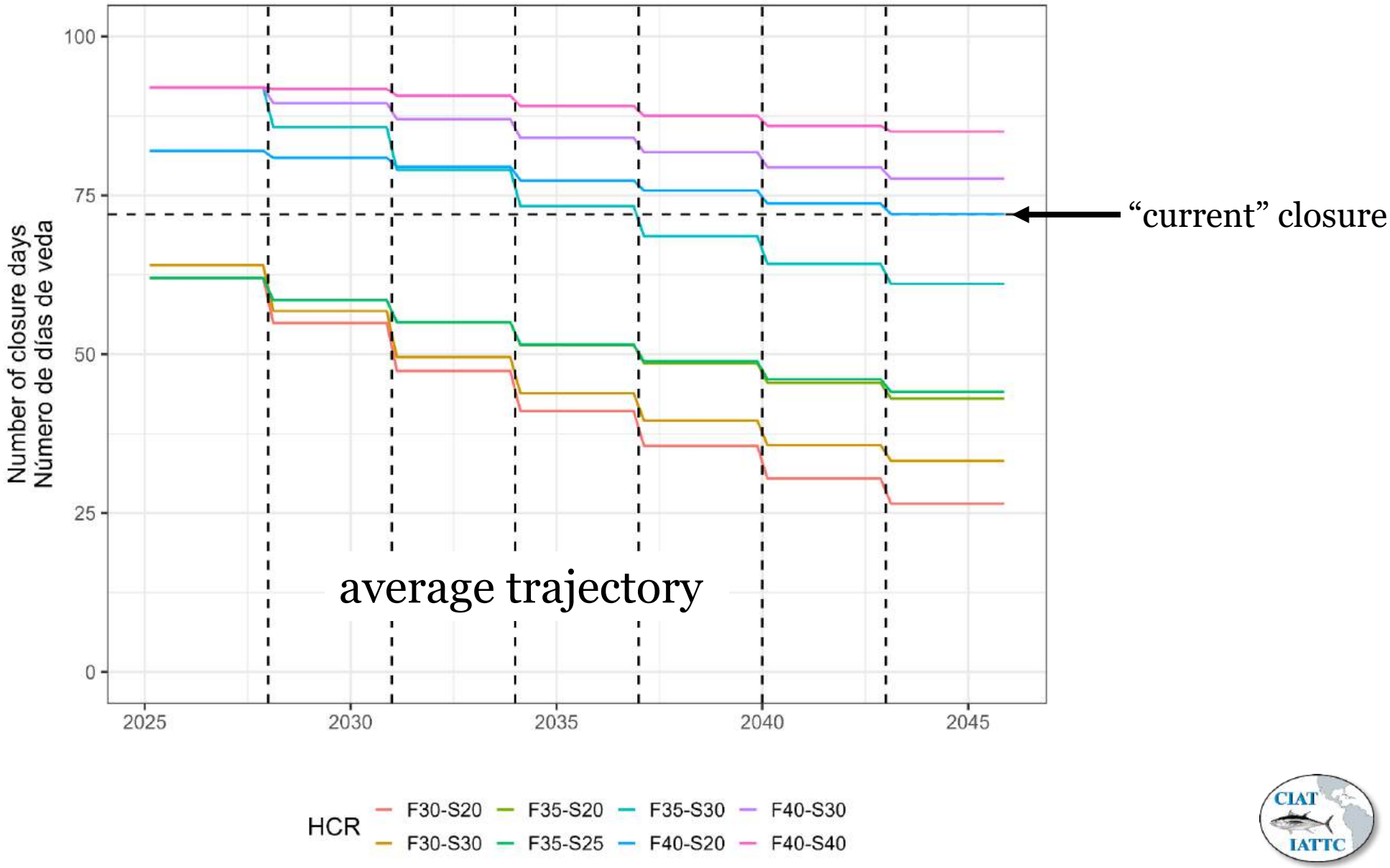
- The MSE cannot set a longline catch limit in simulations due to technical difficulties (unable to resolve in the near term)
- Simulations suggest that future longline catches could exceed the total limit in future years
- **The stock is expected to reach a more optimistic status than that simulated in the MSE**



Performance indicators: effort

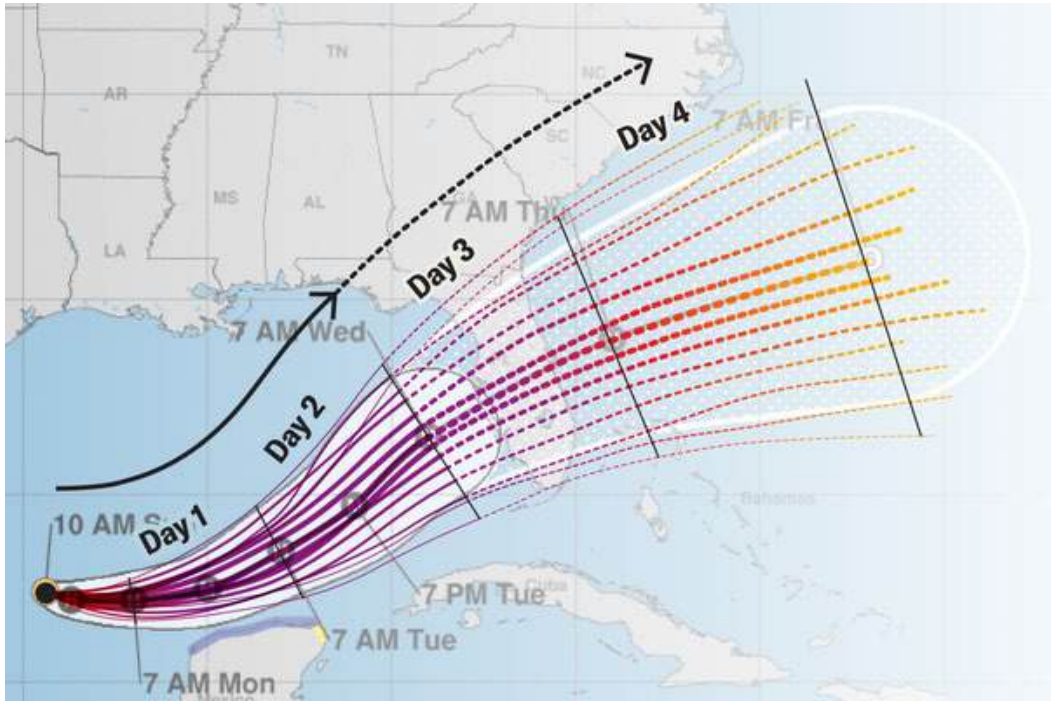
Average fishery closure

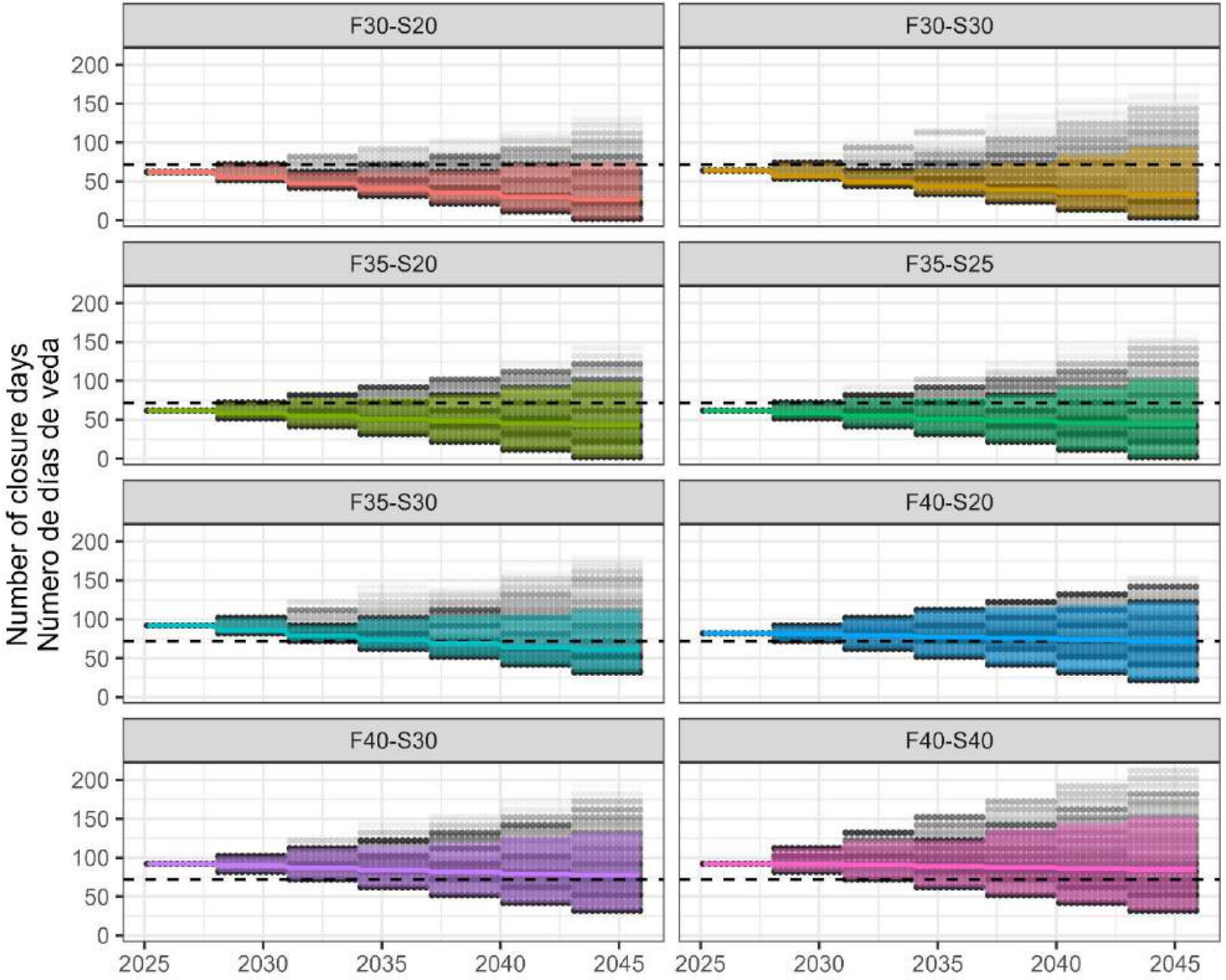
HCR	Average closure (day)
F30-S20	43
F30-S30	46
F35-S20	52
F35-S25	52
F35-S30	75
F40-S20	77
F40-S30	84
F40-S40	89



Performance indicators: effort

The further we project into the future, the more uncertain the projection becomes.

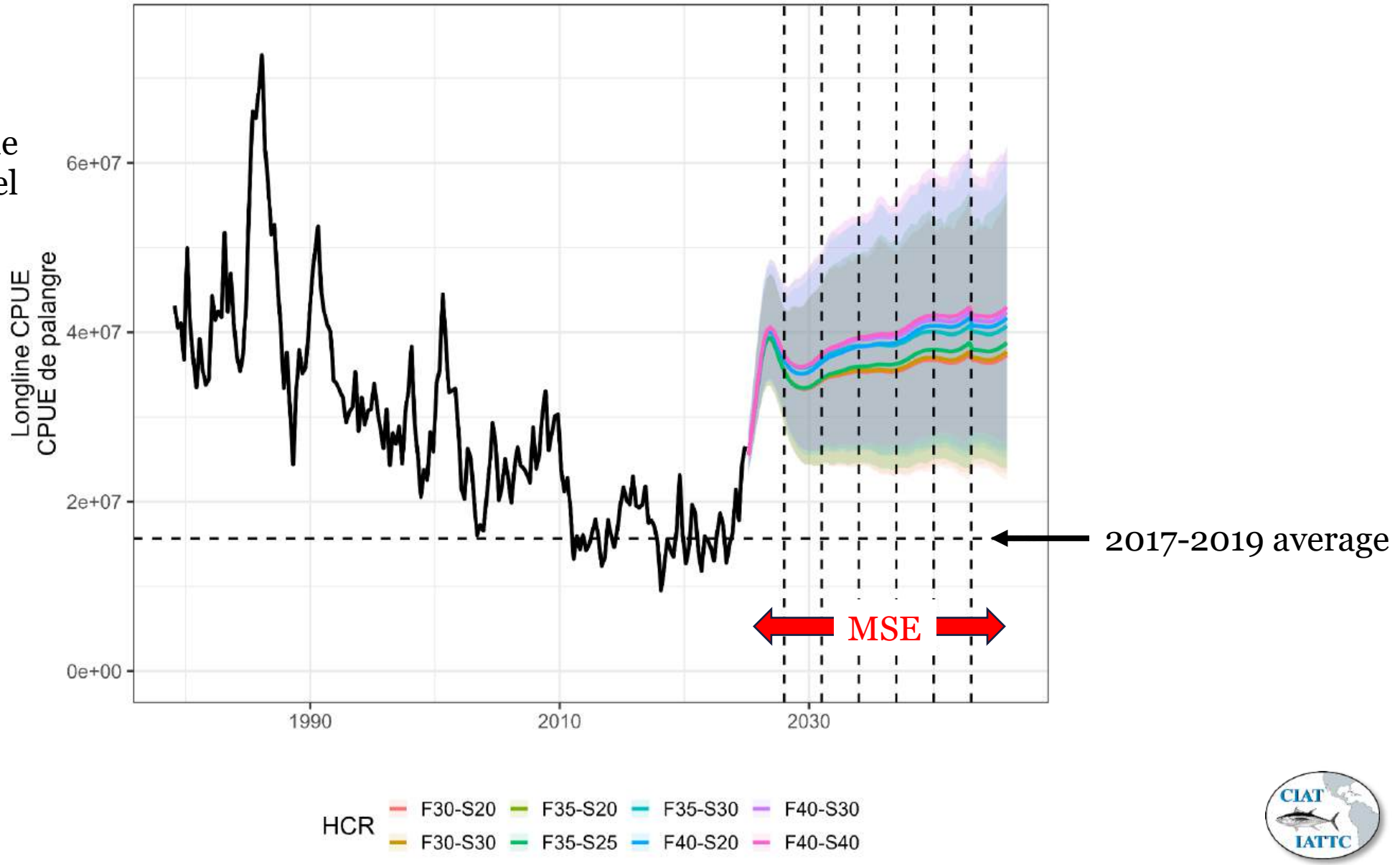




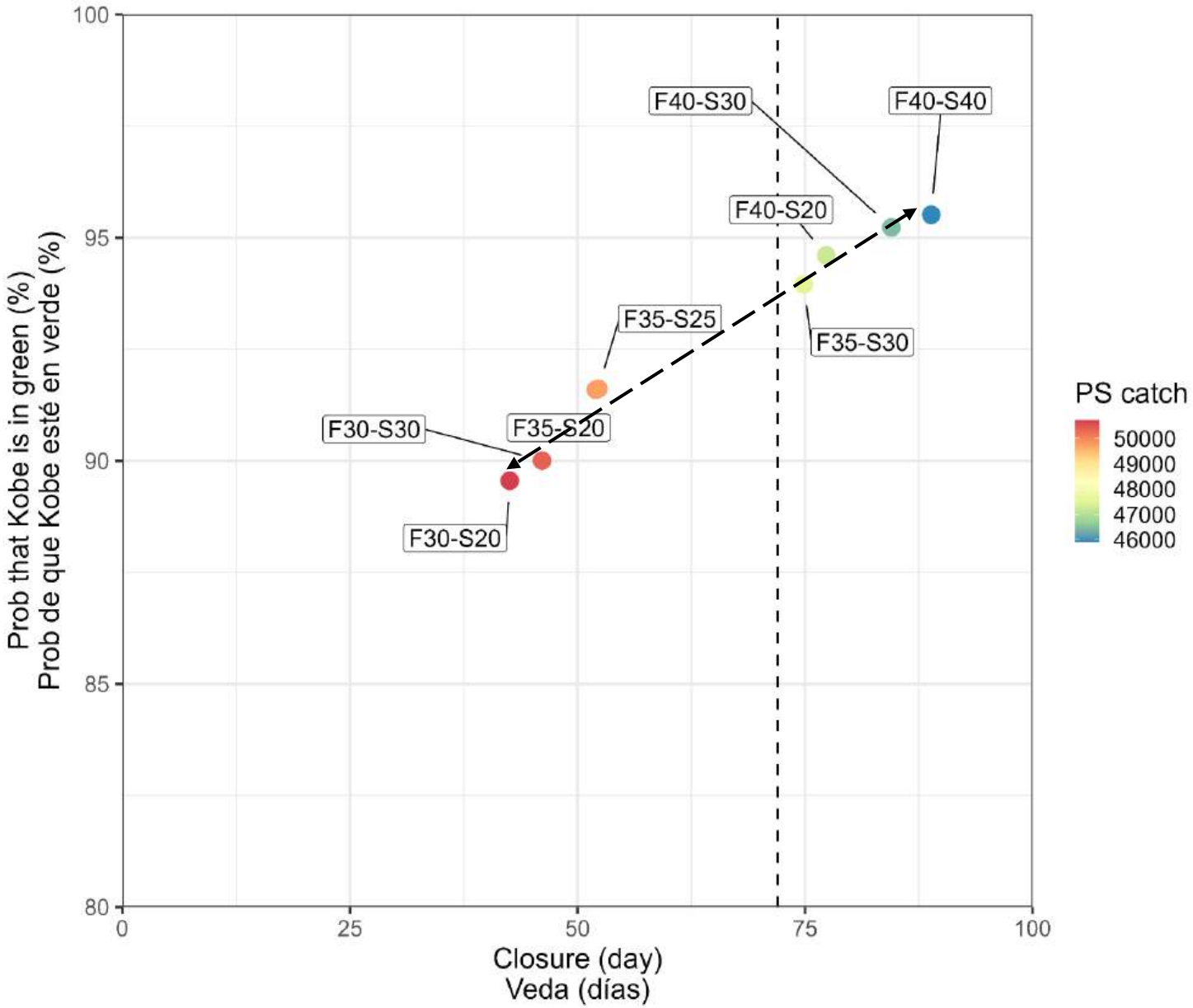
Performance indicators: abundance

The ratio of average longline CPUE to the 2017-2019 level

HCR	CPUE ratio
F30-S20	2.26
F30-S30	2.28
F35-S20	2.31
F35-S25	2.31
F35-S30	2.44
F40-S20	2.45
F40-S30	2.49
F40-S40	2.51



Trade-off: status vs. effort



Performance indicators: summary

Very low probability of breaching the limit reference points

Small contrast

HCR	Prob dSBR > 0.2	Prob SBR > 0.077	Prob S > $0.5S_{MSY}$	Prob Kobe = green	AAV in catch	Prob change = 20	Annual PS catch	Annual LL catch	Average closure	CPUE ratio
F30-S20	96.5	99.9	99.9	89.6	7.3	0.8	50722	51663	43	2.26
F30-S30	96.7	99.9	99.9	90.0	7.3	7.7	50384	51509	46	2.28
F35-S20	97.5	100.0	100.0	91.6	7.3	0.4	49785	51277	52	2.31
F35-S25	97.5	100.0	100.0	91.6	7.3	1.9	49746	51250	52	2.31
F35-S30	98.3	100.0	100.0	94.0	7.2	17.6	47514	50533	75	2.44
F40-S20	98.5	100.0	100.0	94.6	7.2	0.1	47221	50258	77	2.45
F40-S30	98.7	100.0	100.0	95.2	7.2	16.3	46456	49966	84	2.49
F40-S40	98.8	100.0	100.0	95.5	7.3	28.9	45911	49624	89	2.51

Take-home message

- MSE was conducted for bigeye in the EPO
- Eight alternative HCRs have been tested
- Three HCRs were identified that achieve:
  - Safety
  - Status
  - Decreased purse-seine closure days
  - Increased longline yield
  - Stability
- The three HCRs are:
  - F30-S20
  - F35-S20
  - F35-S25


Questions