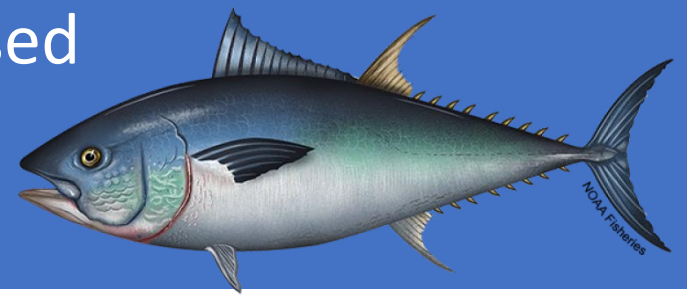
Preliminary Results of the Pacific Bluefin Tuna Management Strategy Evaluation

ISC Pacific Bluefin Tuna Working Group

Presented by Desiree Tommasi

Outline

- Total runs to complete and timeline
- What has been run so far
- Presentation of example results for base case
- How do results change for the lowest productivity scenario – OM3
- Example of how final results will be presented across all reference set OMs
- How results change when 30:70 impact ratio used



Total runs to complete and timeline

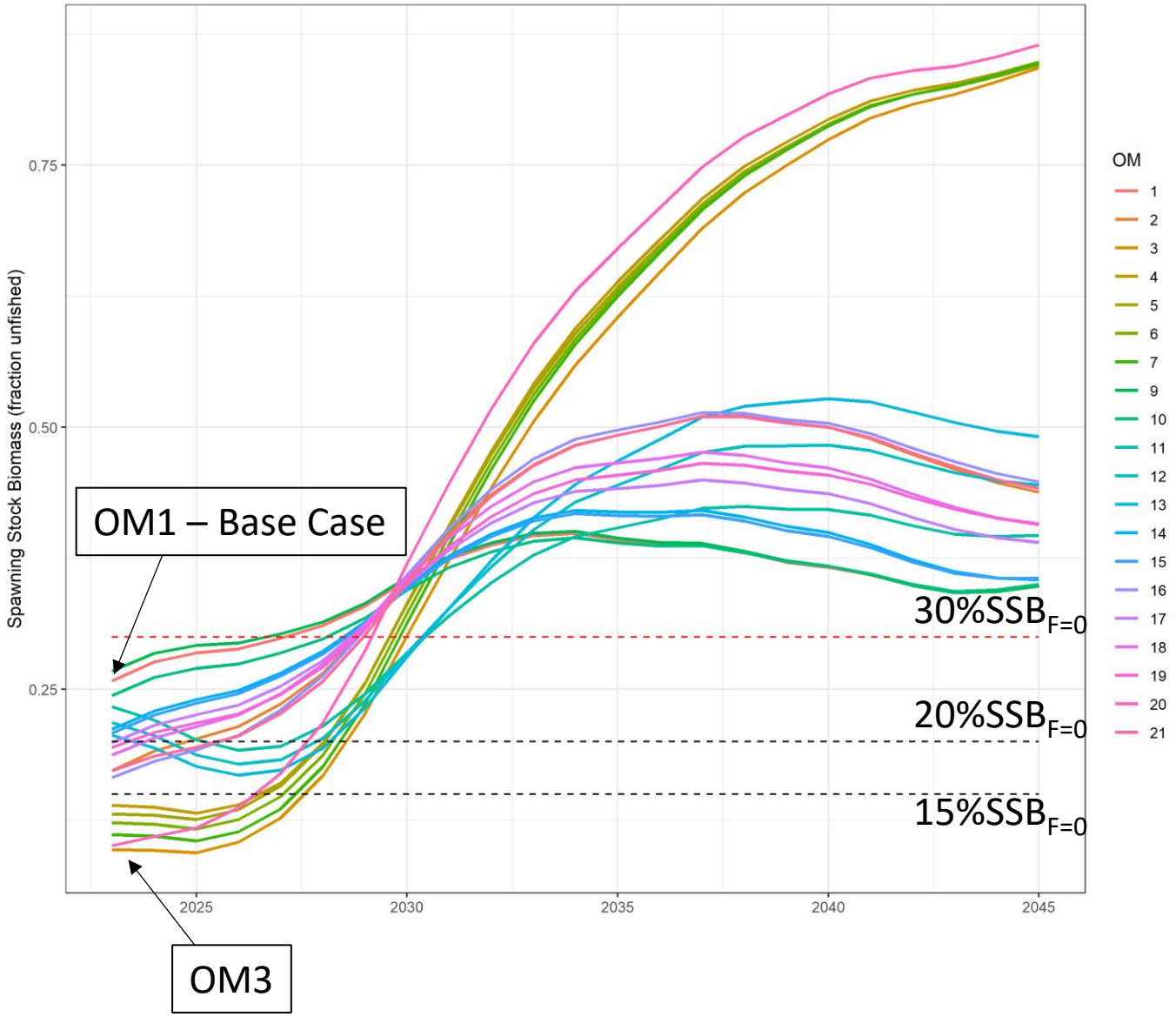
- 12 HCRs x 20 OMs x 2 impact ratios x 100 iterations = 48,000 runs
- With EM, 12 HCRs and 100 iterations takes 2 days to complete for 1 OM
- 1 simulated stock assessment (EM) x 8 steps x 12 HCRs x 20 OMs x 2 impact ratios x 100 iterations = 384,000 stock assessments
- 145 MB per stock assessment = more than 50 million MB of storage
- **Results take a lot of time and computing resources**
- Also 3 additional robustness tests
- Need all runs completed and analyzed by ISC PBF meeting in mid April
- MSE report to be presented to ISC plenary in June
- **Tight timeline, limited resources – we cannot add additional runs unless others are reduced**

What has been run so far

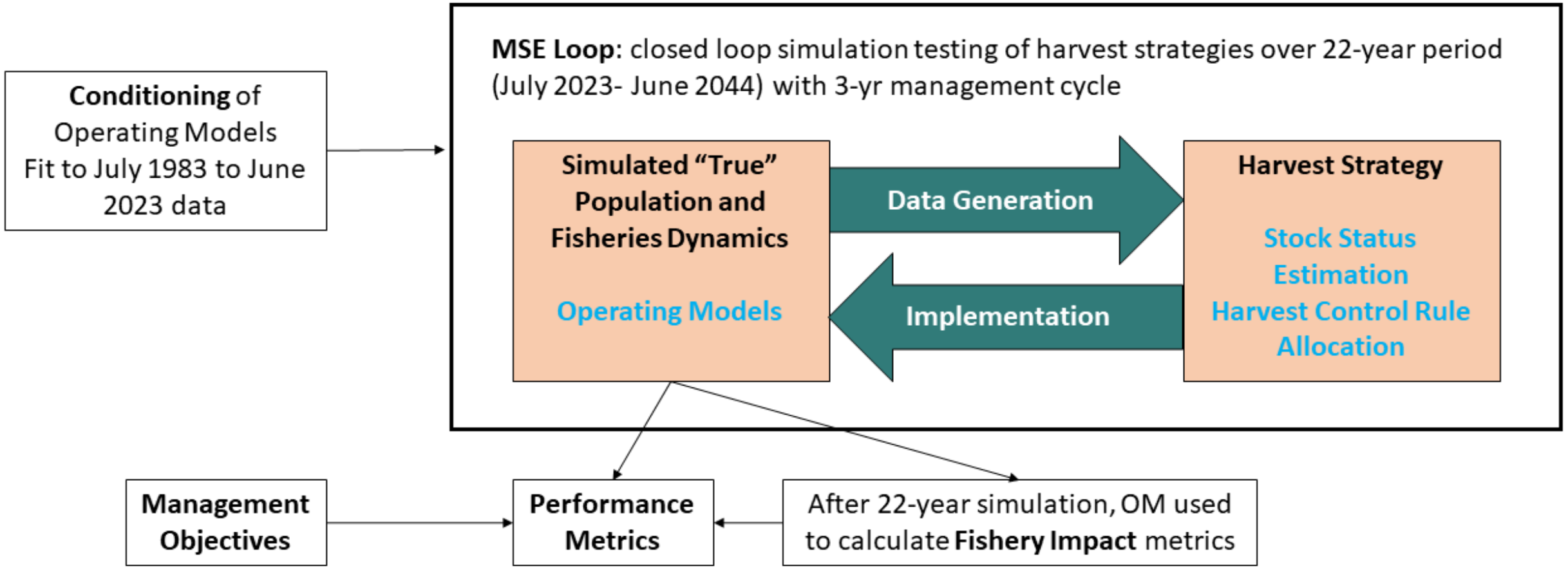
- At December ISC PBF meeting, final MSE set up and EM were agreed upon
- Completed and analyzed runs for **base case** (OM1) and least productive OM (**OM3**) for the **12 HCRs, 100 iterations, and 2 impact ratios**
- Output from these will be presented today to show example results
- Final results will be presented across all OMs, to assess how HCRs perform given uncertainty in stock productivity
- Also completed runs for all OMs and HCRs with a perfect assessment and these results will be used to show how final results will be presented across OMs

PBF Operating Models

- Represent the range of uncertainty in stock productivity - different "what if" scenarios in terms of biology
- In MSE, performance assessed across many iterations and all OMs to see on average which HCR performs best across all plausible realities

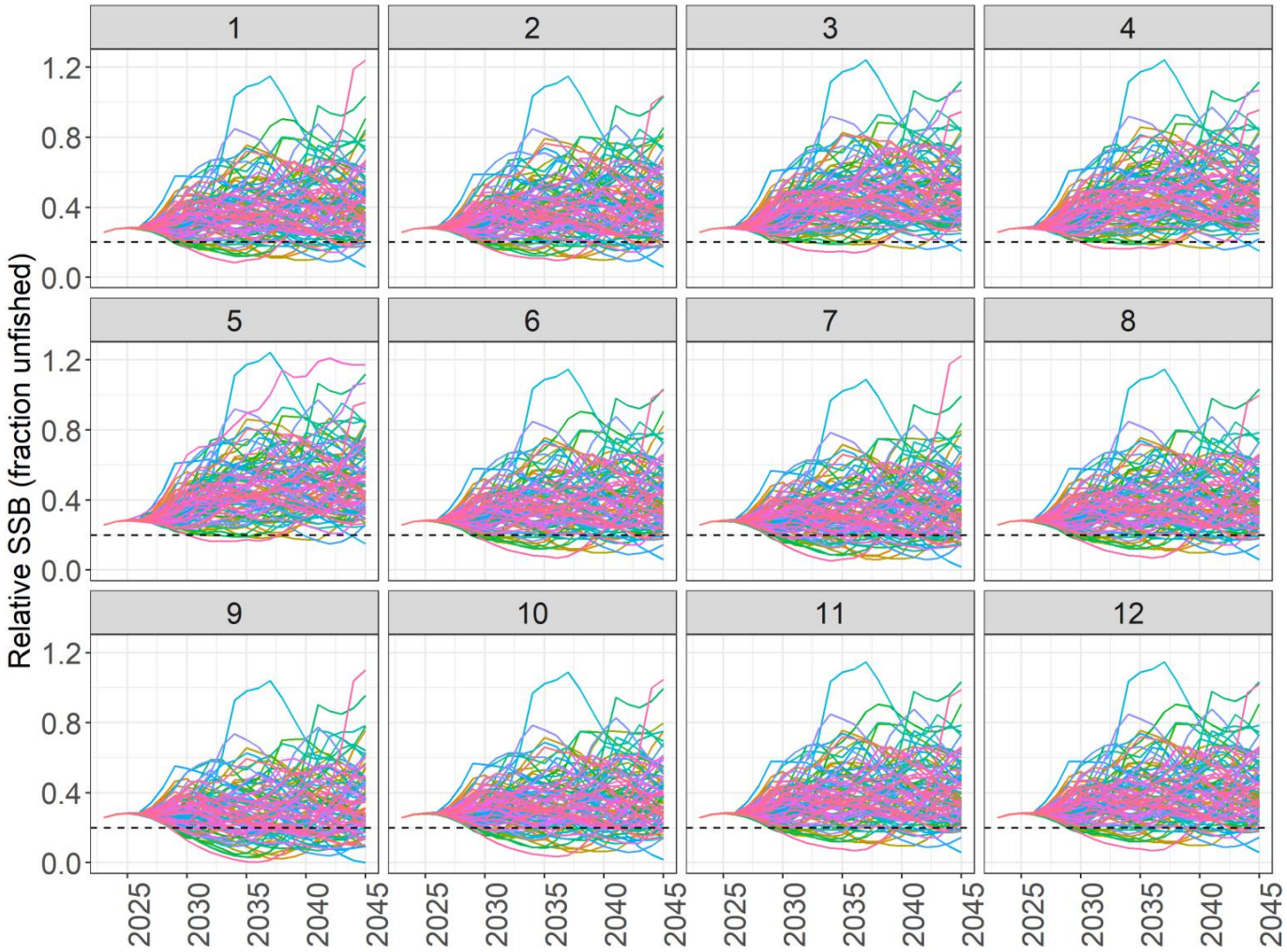


PBF MSE Feedback Loop



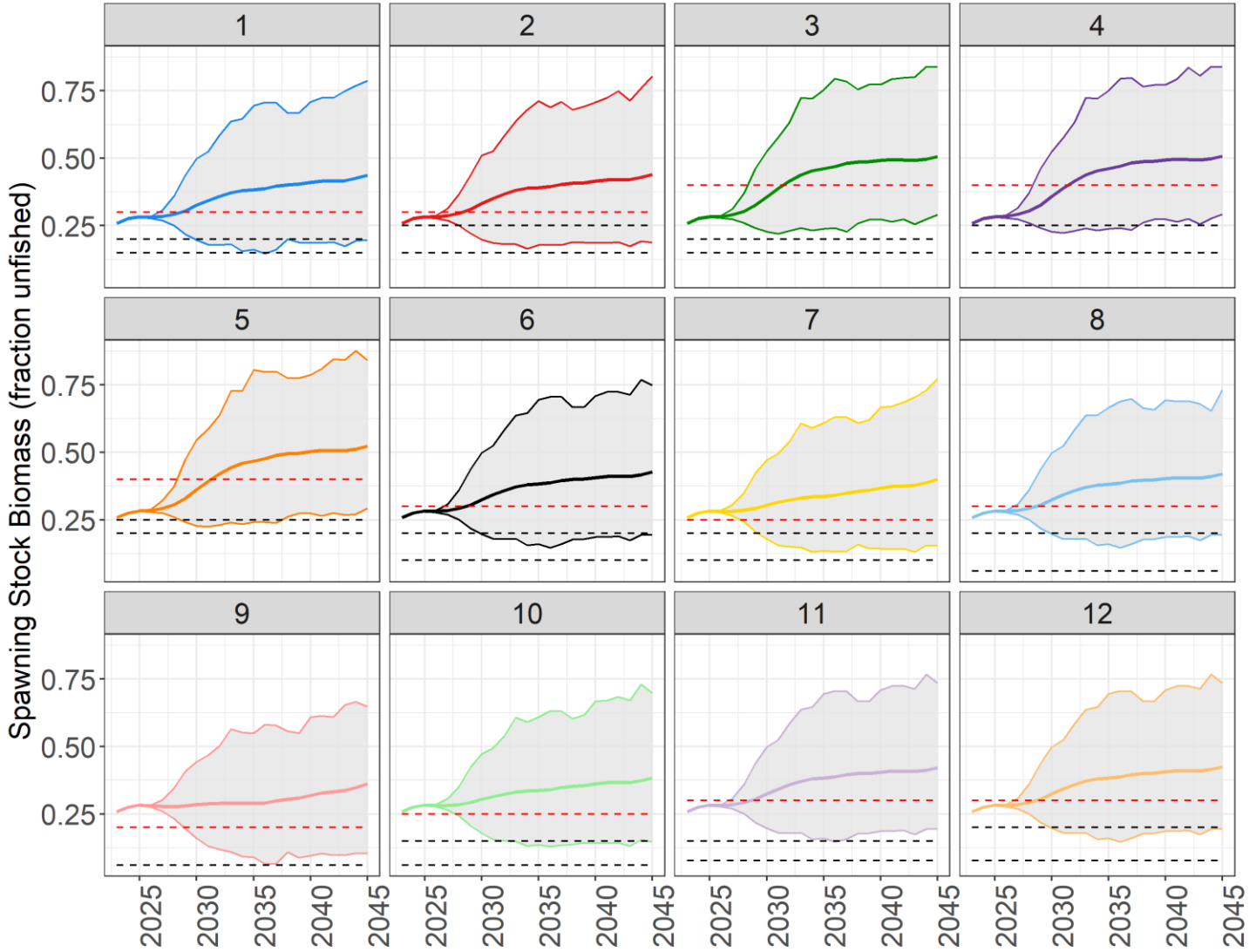
For each OM, 100 iterations are run – recruitment uncertainty

- SSB relative to unfished for the 100 iterations for the base case for each of the 12 HCRs
- The MSE also outputs timeseries of catch, catch per fleet segment, fishing intensity, SSB and any other variable required for performance indicators

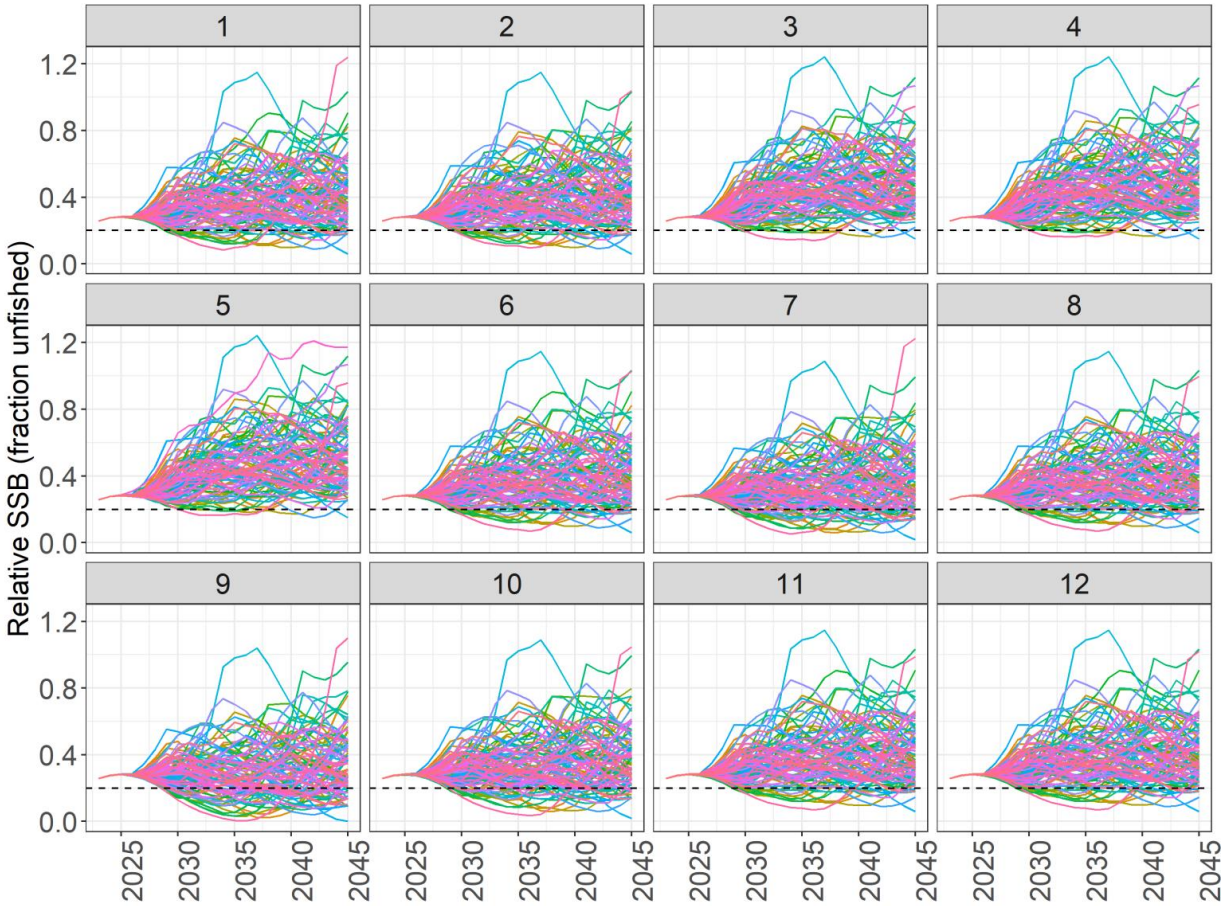


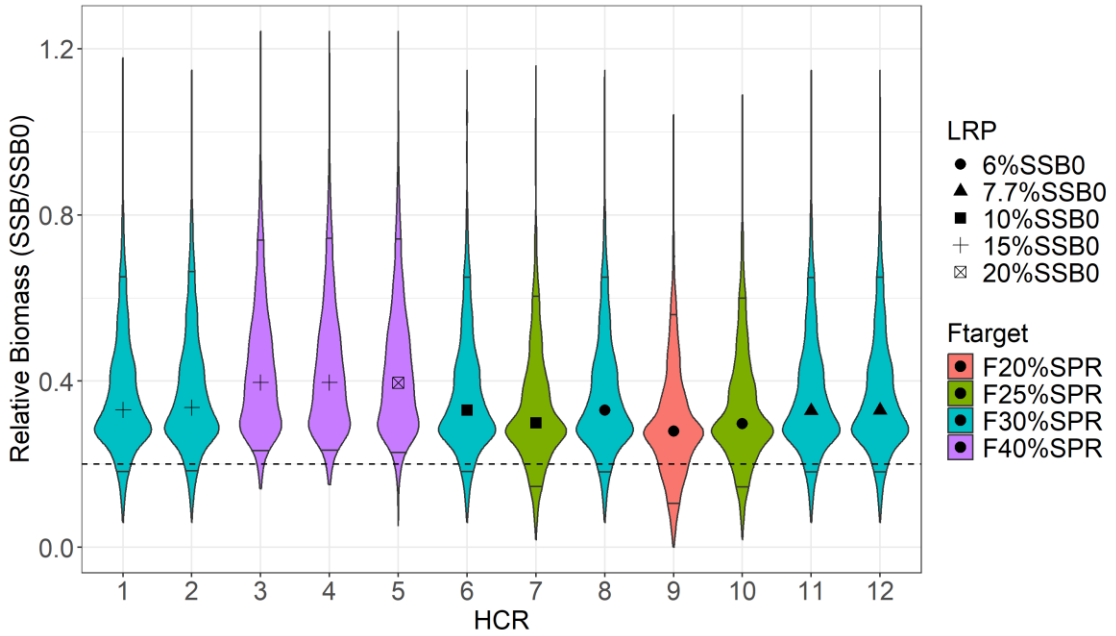
For each OM, 100 iterations are run – recruitment uncertainty

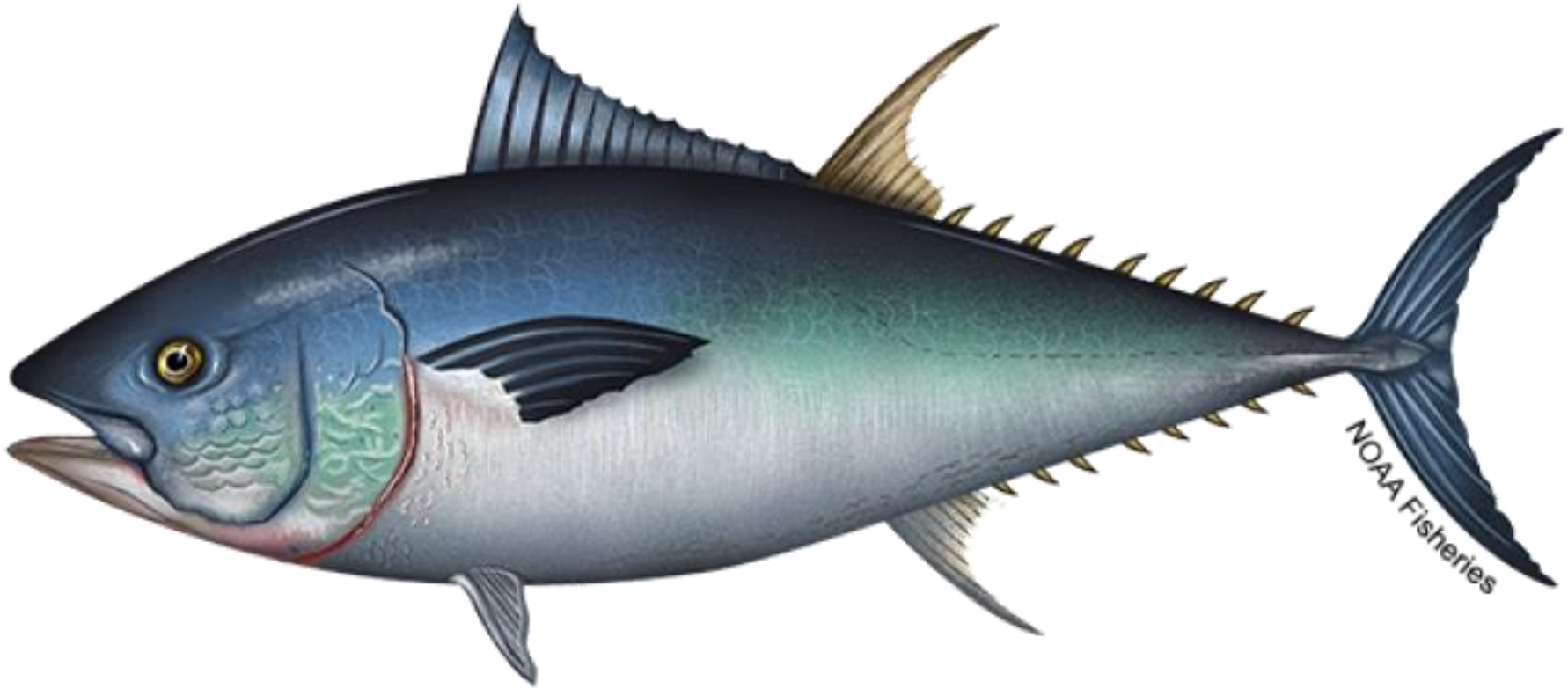
- Can be summarized in median and 5-95th quantiles to look at average behavior and uncertainty



For performance indicators, results summarized across iterations, simulation years, and OMs







Example Results for Base Case

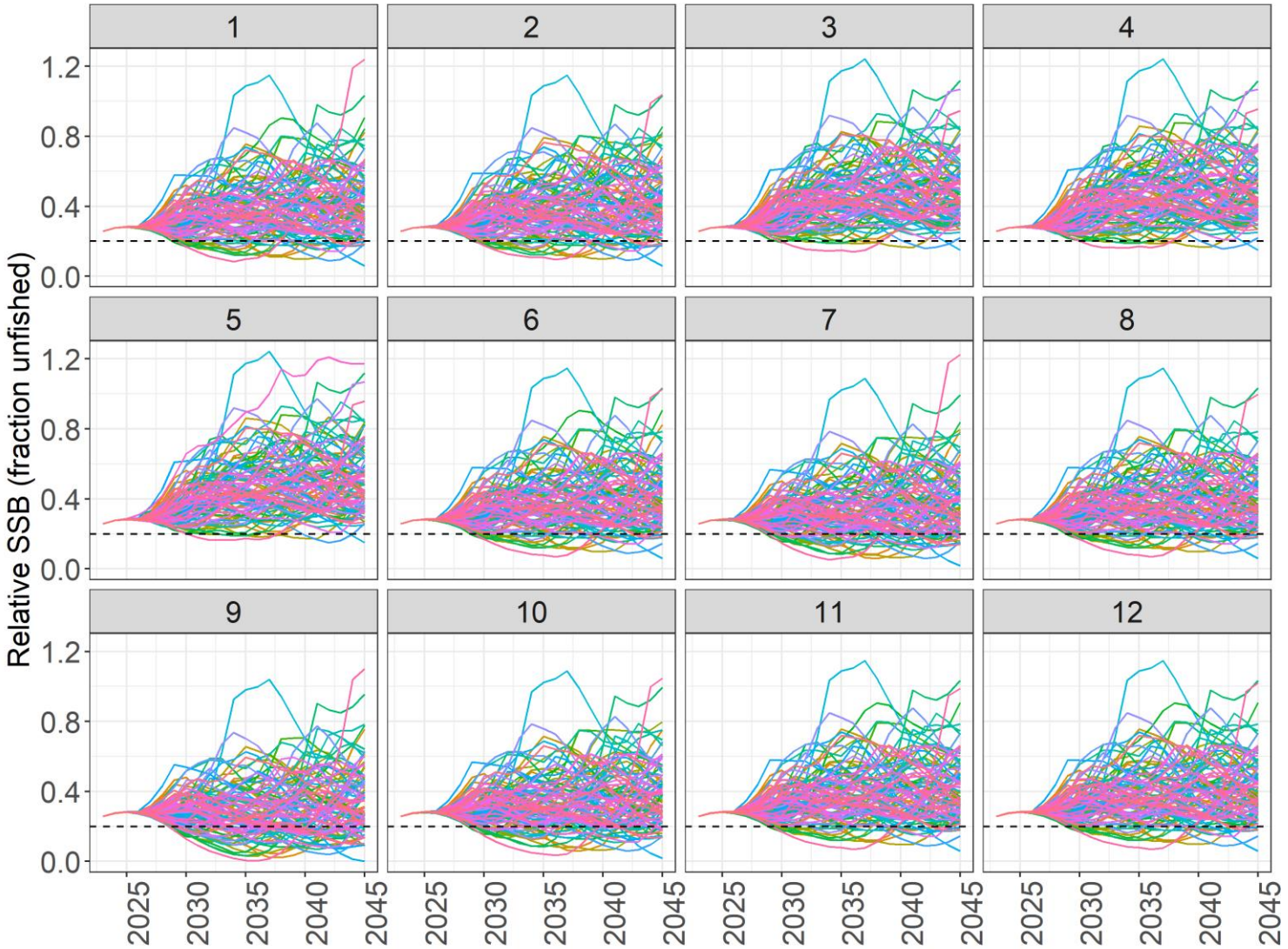
Presentation of example results from Base Case

- Showcase potential plots to summarize performance metrics agreed upon by the JWG
- Discuss which plots are helpful to interpret results and potential improvements

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	

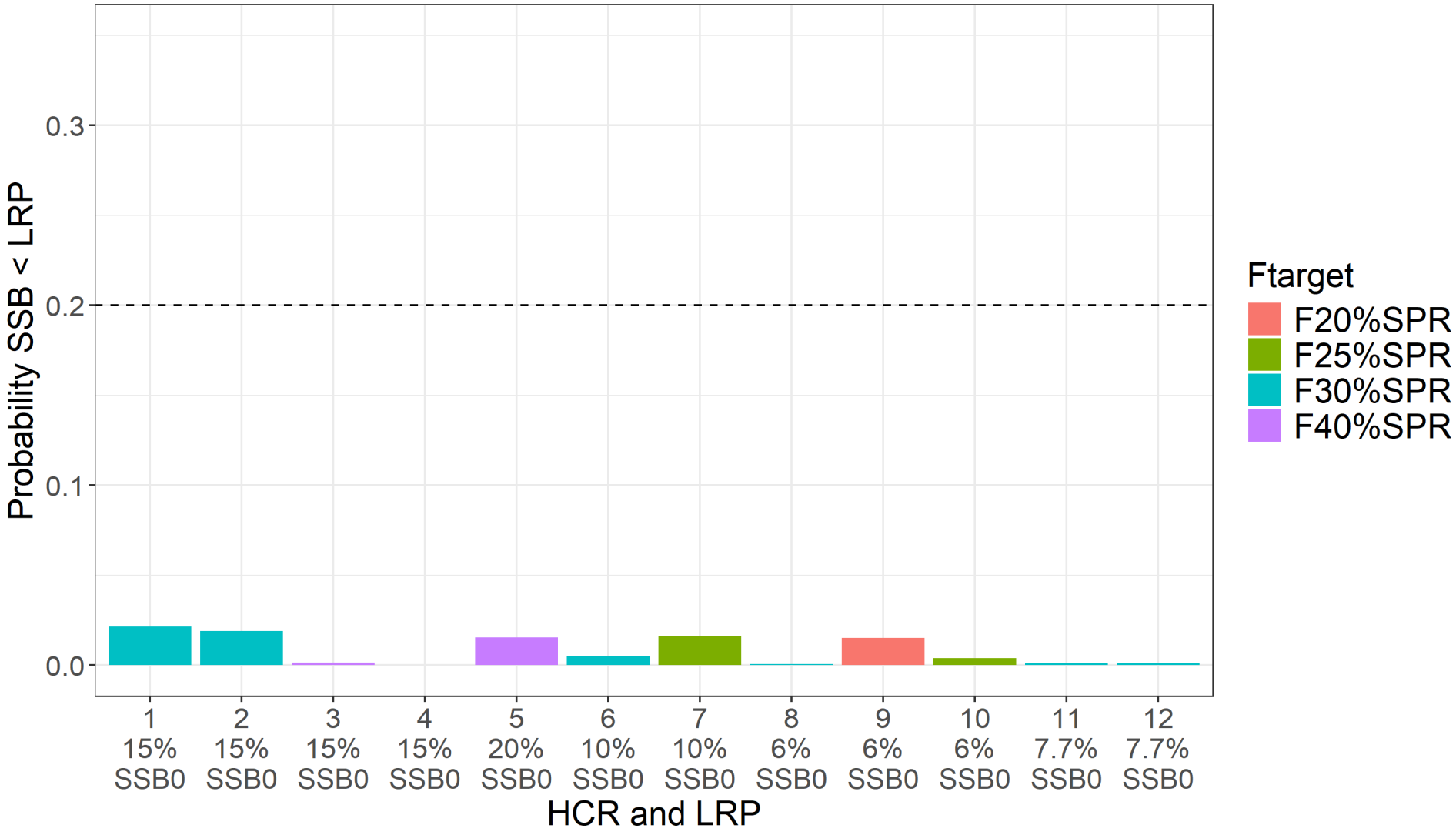
Relative SSB Worm Plots



- *OBJECTIVE: There should be a less than 20% probability of the stock falling below the LRP*
- *PERFORMANCE METRIC: Probability that SSB < LRP in any given year of the evaluation period*

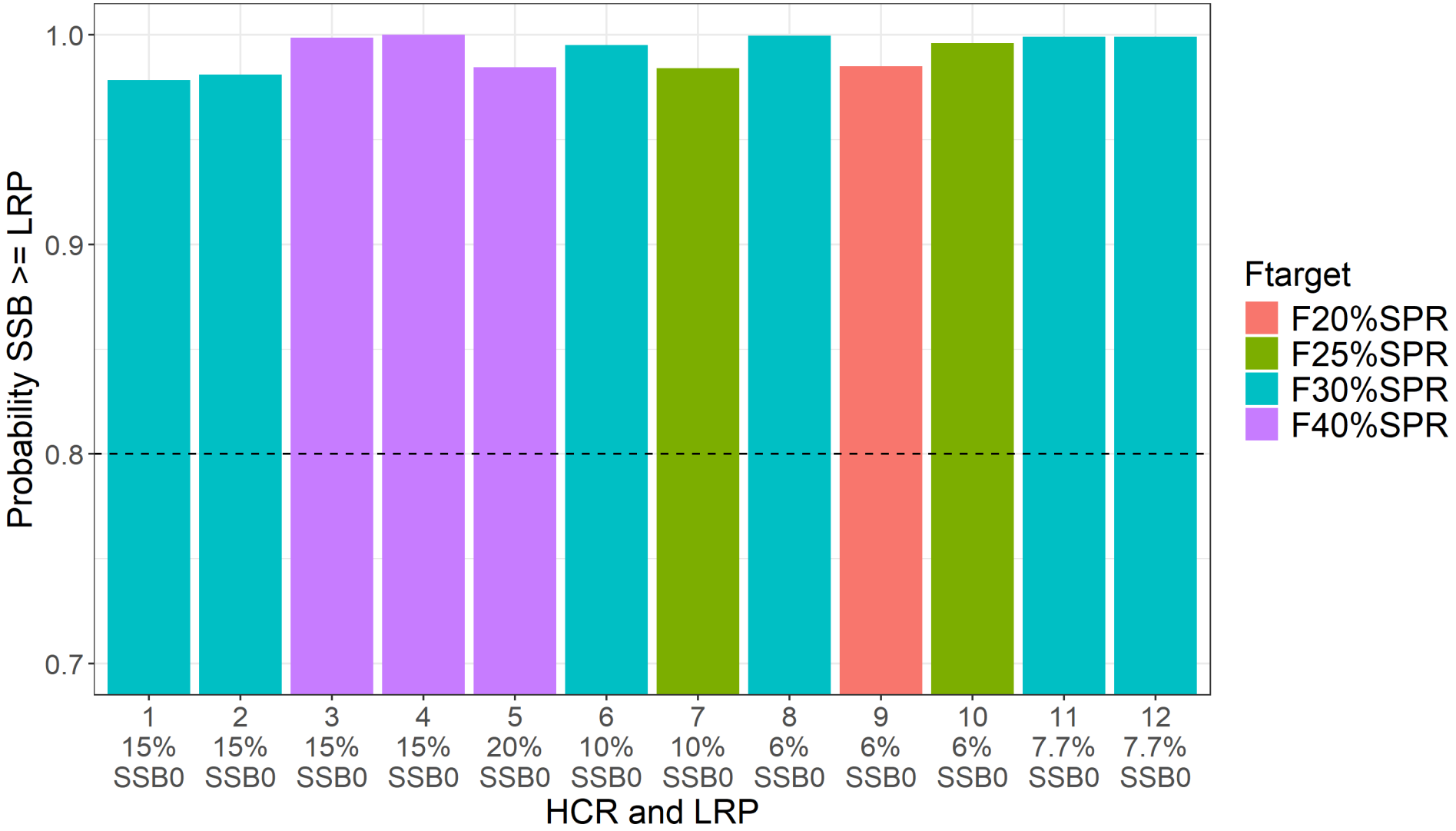
2nd Rebuilding target – 20%$SSB_{F=0}$

Safety Performance Metric



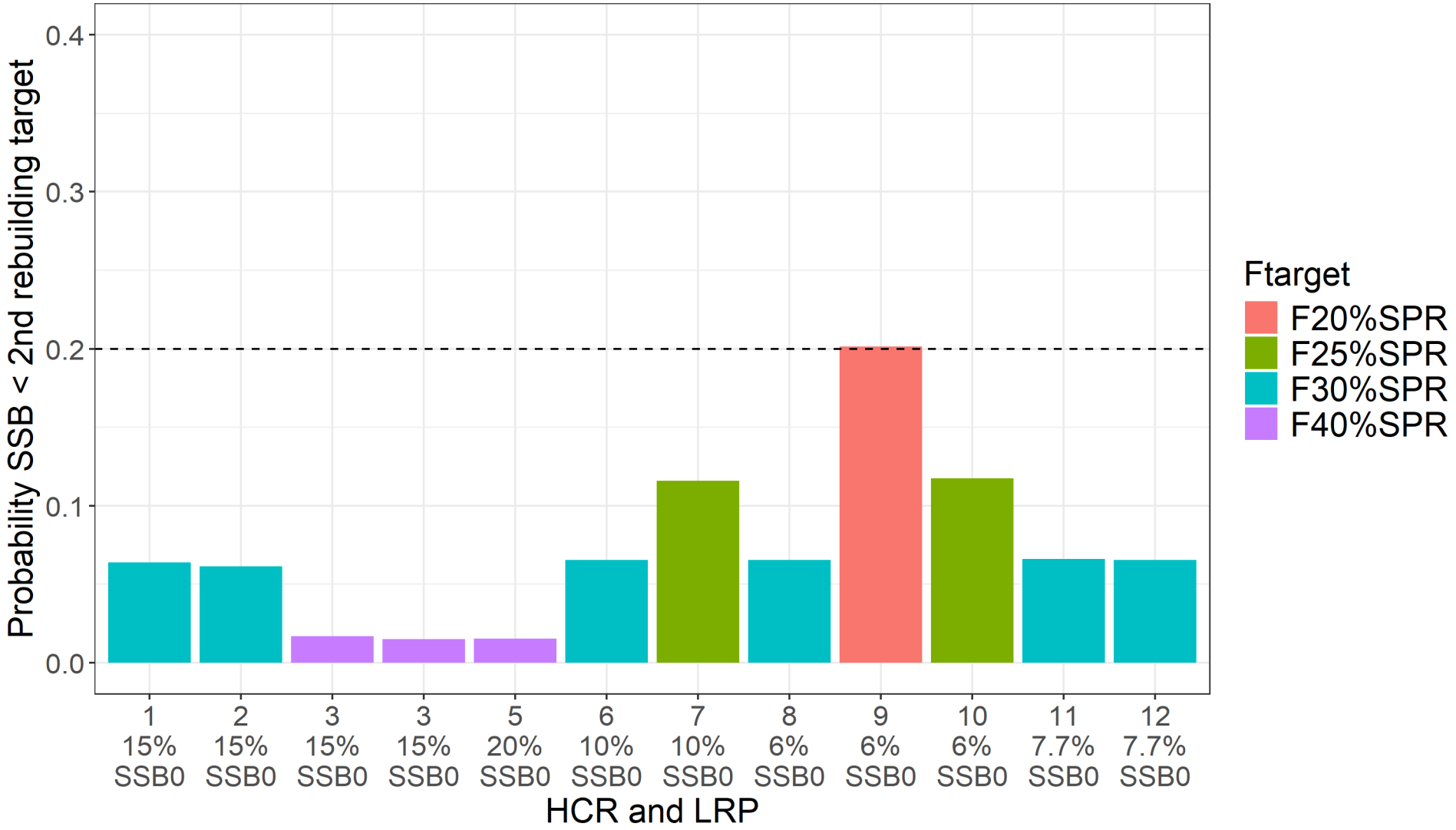
- *OBJECTIVE: There should be a less than 20% probability of the stock falling below the LRP*
- *PERFORMANCE METRIC: Probability that SSB < LRP in any given year of the evaluation period – Low is good*
- All HCRs have a probability of breaching their own LRP less than 20%

Safety Performance Metric - Reversed



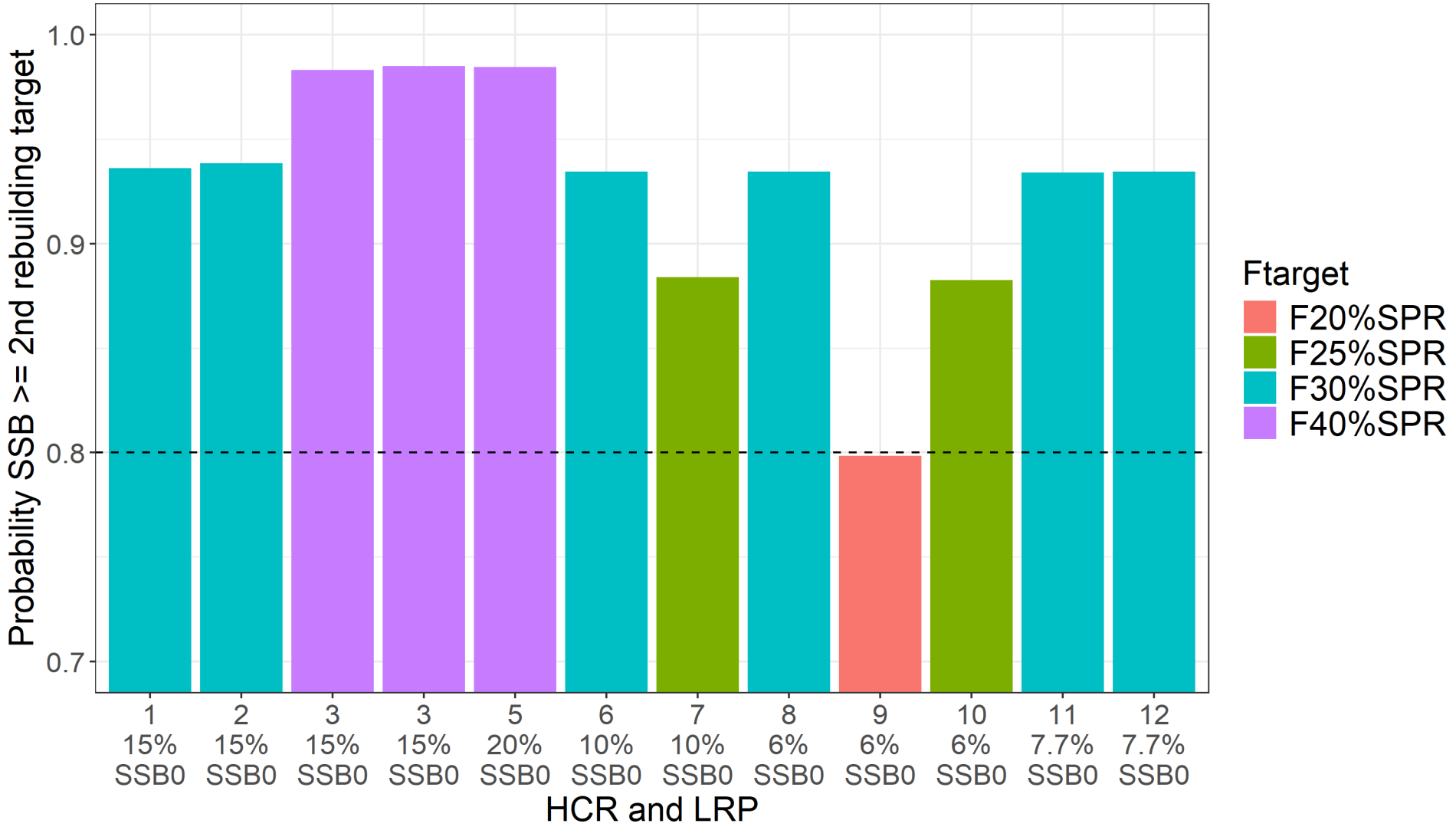
- *OBJECTIVE: There should be a less than 20% probability of the stock falling below the LRP*
- *Probability that SSB >= LRP in any given year of the evaluation period – High is good*
- All HCRs have a probability of higher than 80%

Safety Performance Metric – common reference point



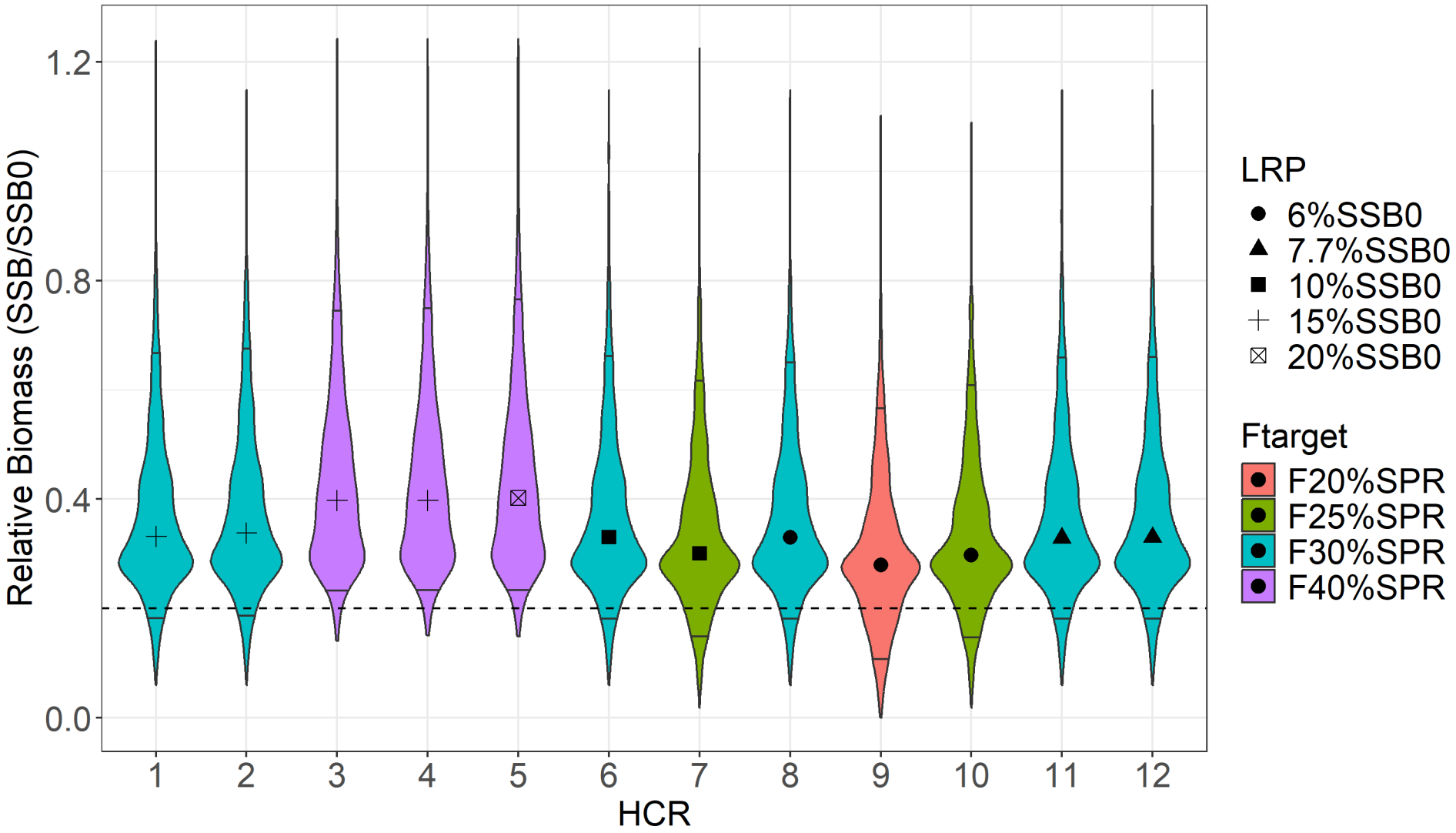
- Performance also compared against second rebuilding target of $20\%_{SSBF=0}$
- All HCRs have a probability of breaching the rebuilding target that is less than 20% except HCR9
- HCRs with the highest target fishing mortality do poorer

Safety Performance Metric Reversed – common reference point



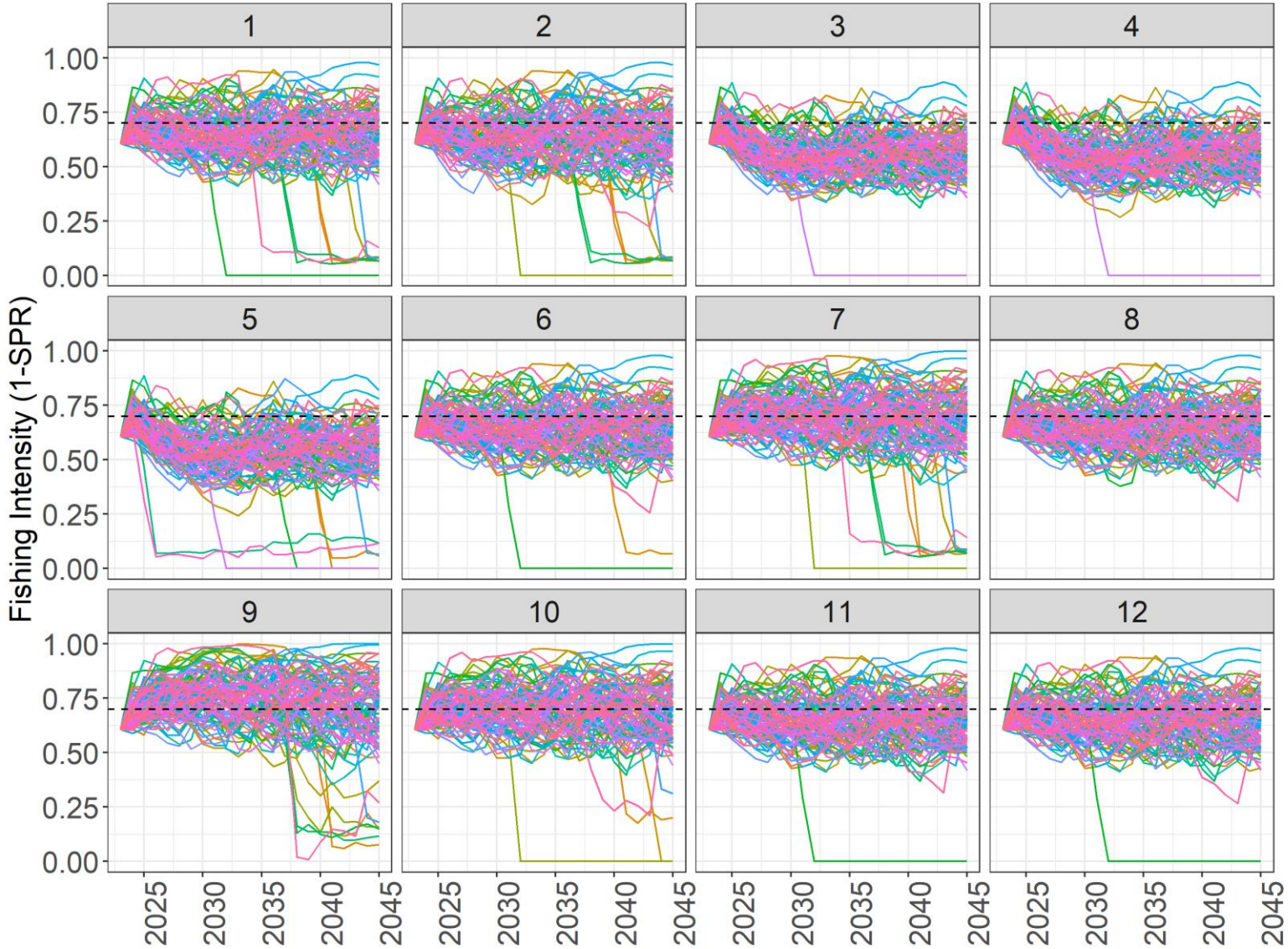
- Probability of SSB > second rebuilding target of $20\%_{SSBF=0}$ High is good
- All HCRs have a probability of SSB being at or above the rebuilding target that is higher than 80%
- HCRs with the highest target fishing mortality do poorer

Relative SSB Violin Plot



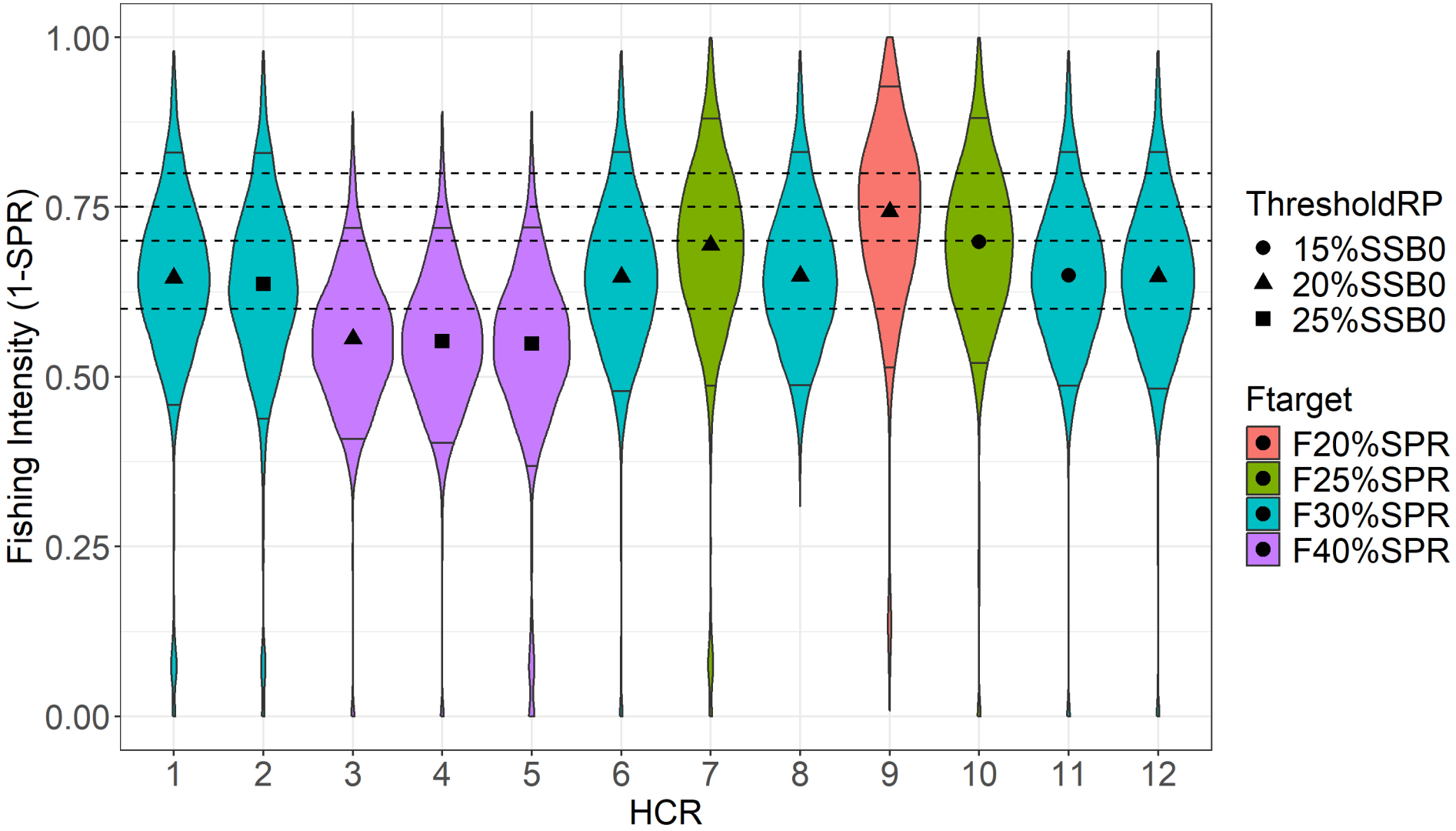
- HCRs with highest target fishing mortality have a lower median SSB and thus a higher probability of breaching the second rebuilding target

Fishing Intensity Worm Plots – OM1



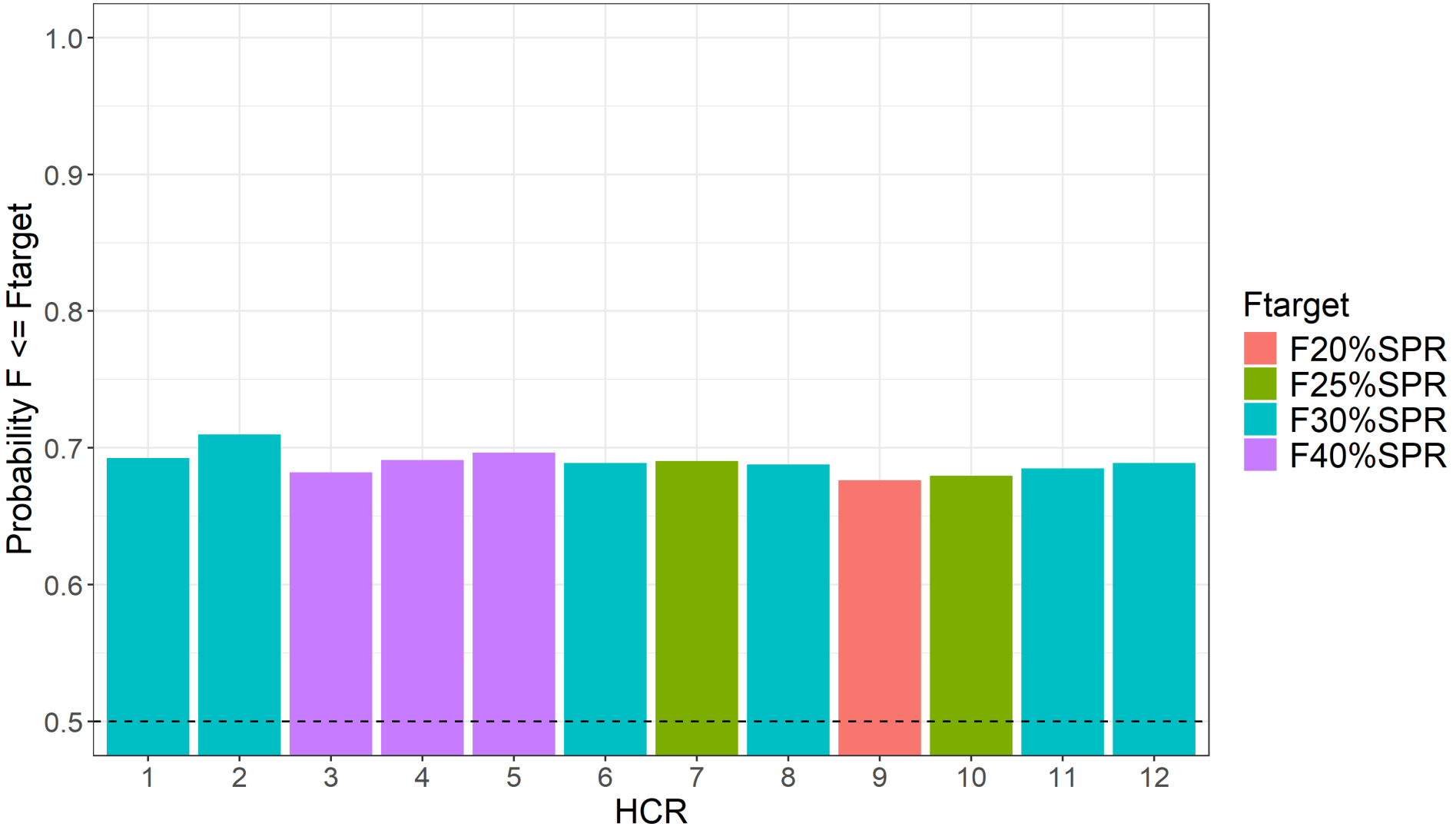
- *OBJECTIVE: To maintain fishing mortality at or below F_{target} with at least 50% probability*
- *PERFORMANCE METRIC: Probability that $F \leq F_{target}$ in any given year of the evaluation period*

Status Performance Metric 1



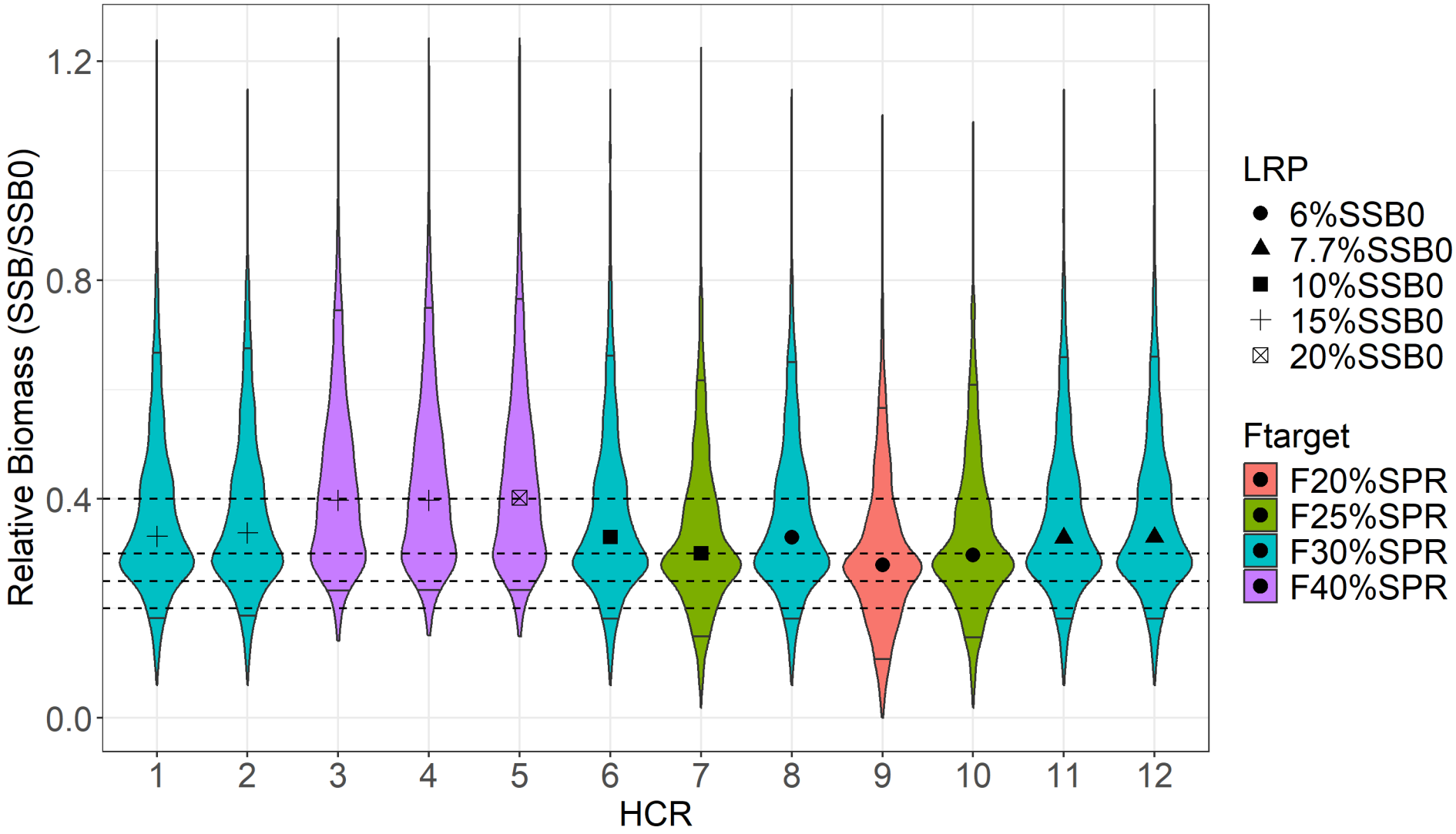
- For all HCRs, the median F remains below the F_{target}
- Due to estimation error and the 25%TAC increase limit

Status Performance Metric 1



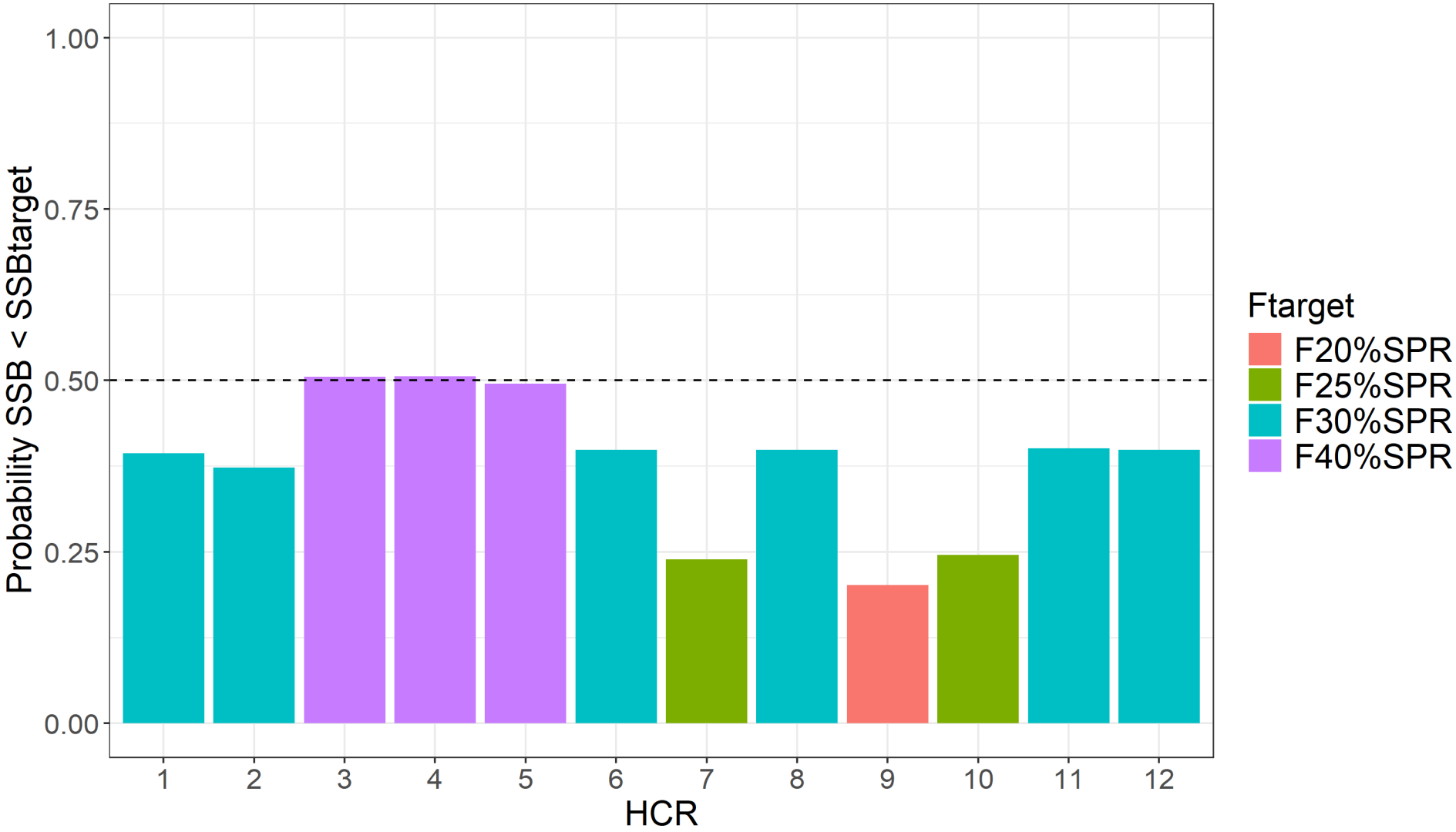
- *OBJECTIVE: To maintain fishing mortality at or below F_{target} with at least 50% probability*
- *PERFORMANCE METRIC: Probability that $F \leq F_{target}$ in any given year of the evaluation period*
- All HCRs have a probability of being lower or equal to their F_{target} that at least 50%

Status Performance Metric 2 -



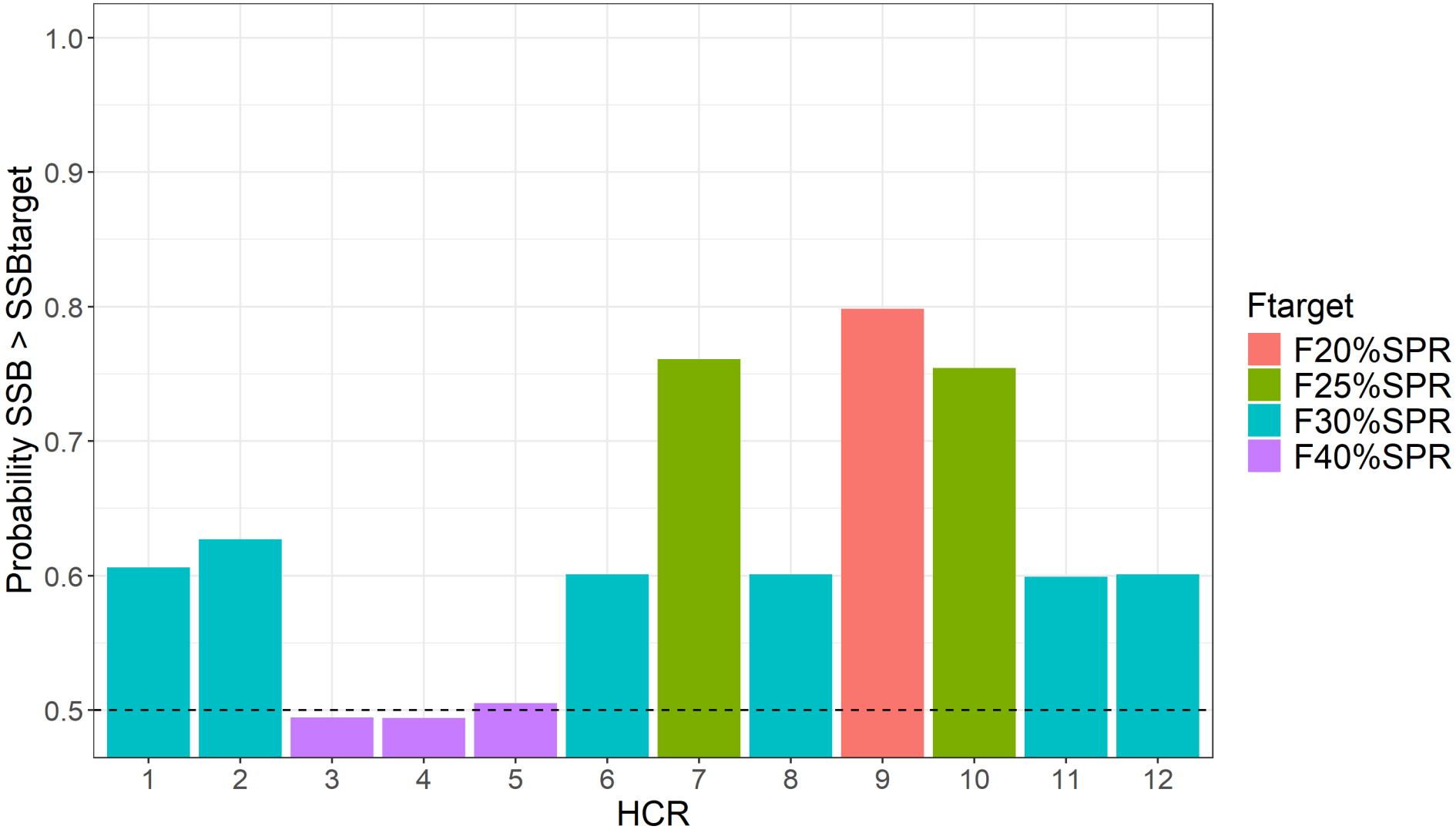
- For HCRs with an Ftarget of F40%SPR the median SSB is around the target. For the others, it is above
- Due to estimation error and the 25%TAC increase limit

Status Performance Metric 2



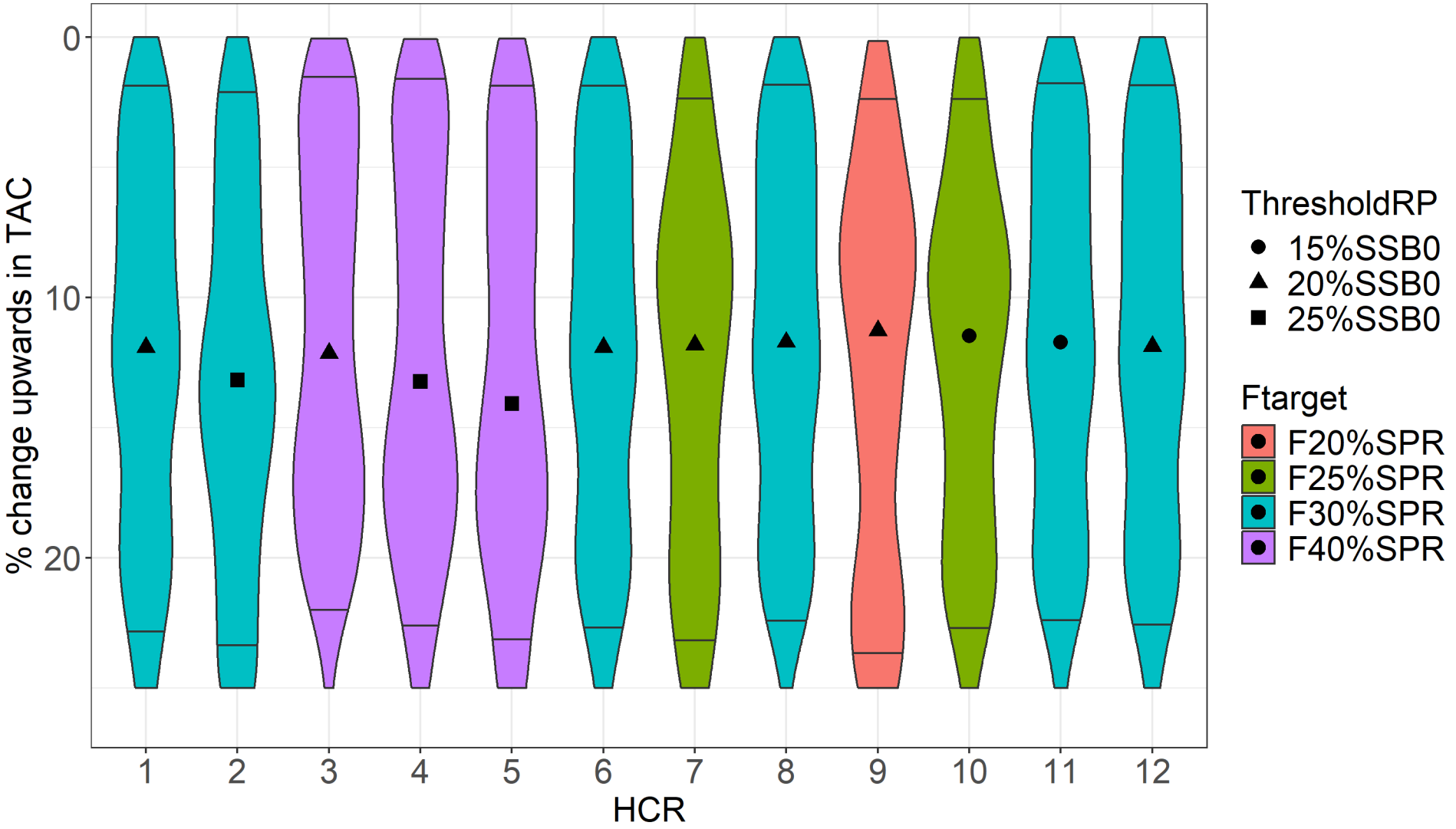
- *PERFORMANCE METRIC:* Probability that SSB < the equivalent biomass depletion levels associated with the candidates for F_{target} Ideally around 50%, less means SSB is higher than the target more than half the time

Status Performance Metric 2 - Reversed



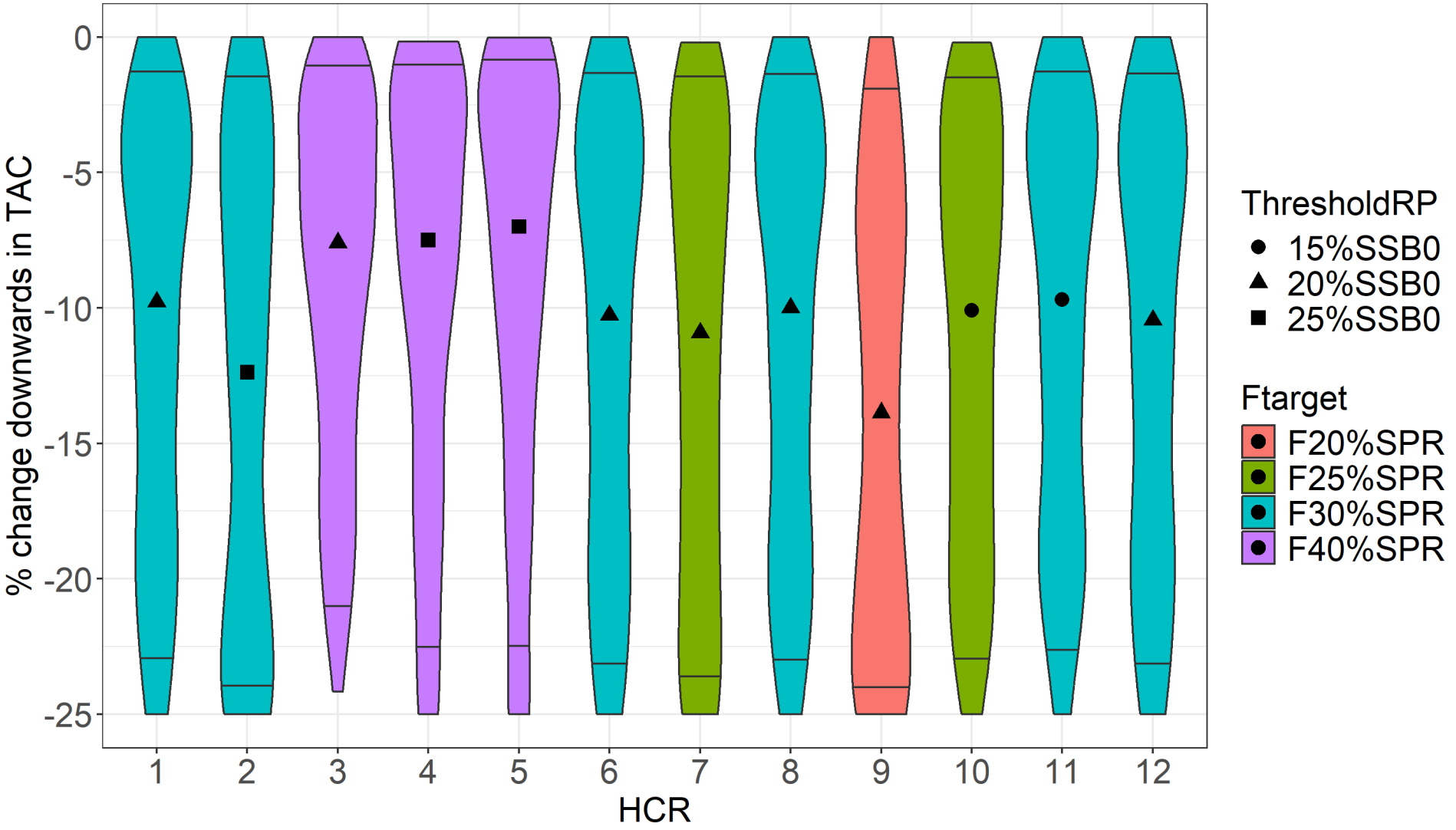
- *PERFORMANCE METRIC:* Probability that SSB > the equivalent biomass depletion levels associated with the candidates for F_{target} Ideally around 50%, Higher means SSB is higher than the target more than half the time

Stability Performance Metric 1



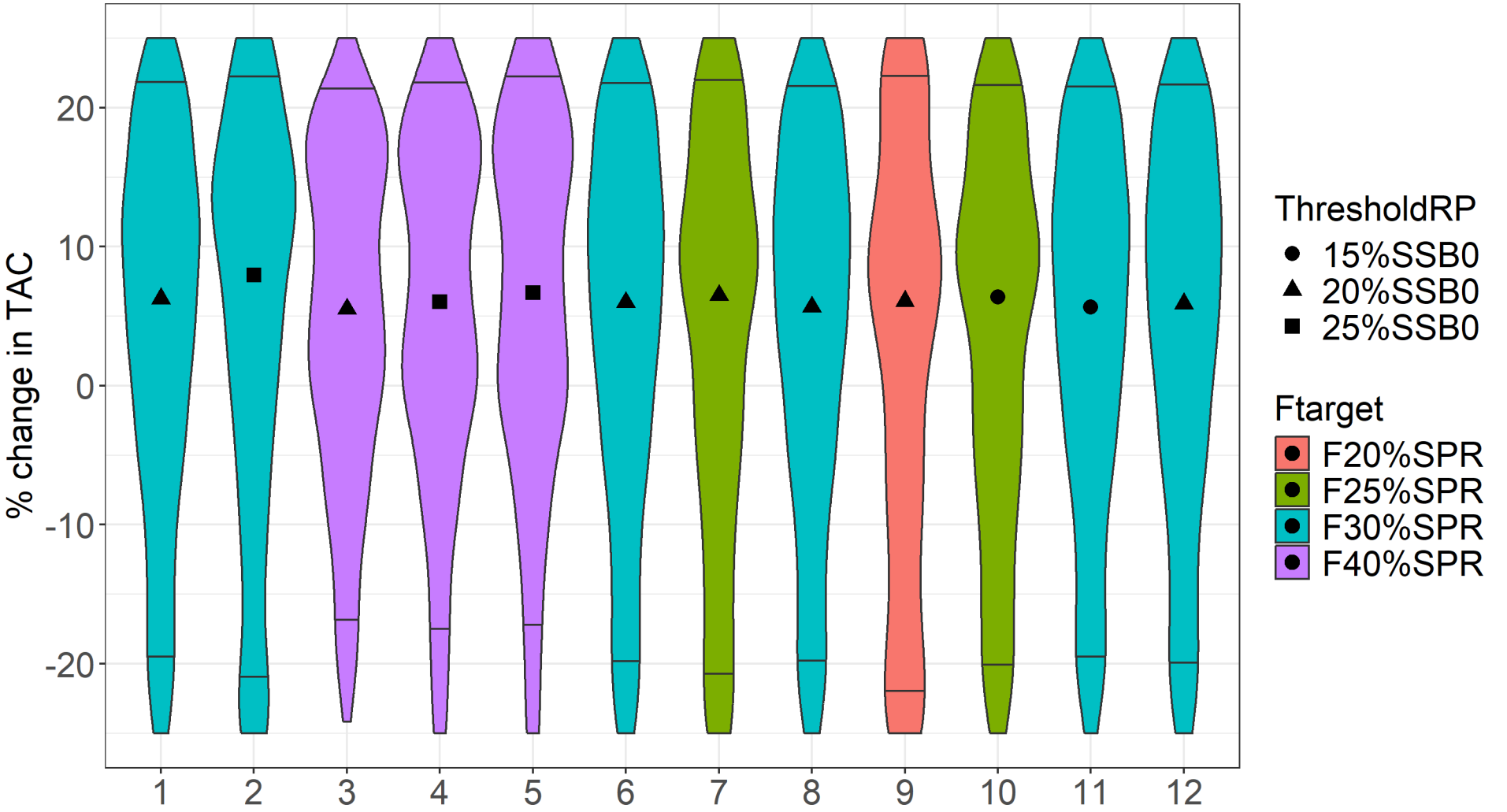
- *OBJECTIVE: To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the stock is below the LRP*
- *PERFORMANCE METRIC: Percent change upwards in catches between management periods excluding periods when SSB<LRP*
- The max % change upwards in catch was 25%

Stability Performance Metric 2



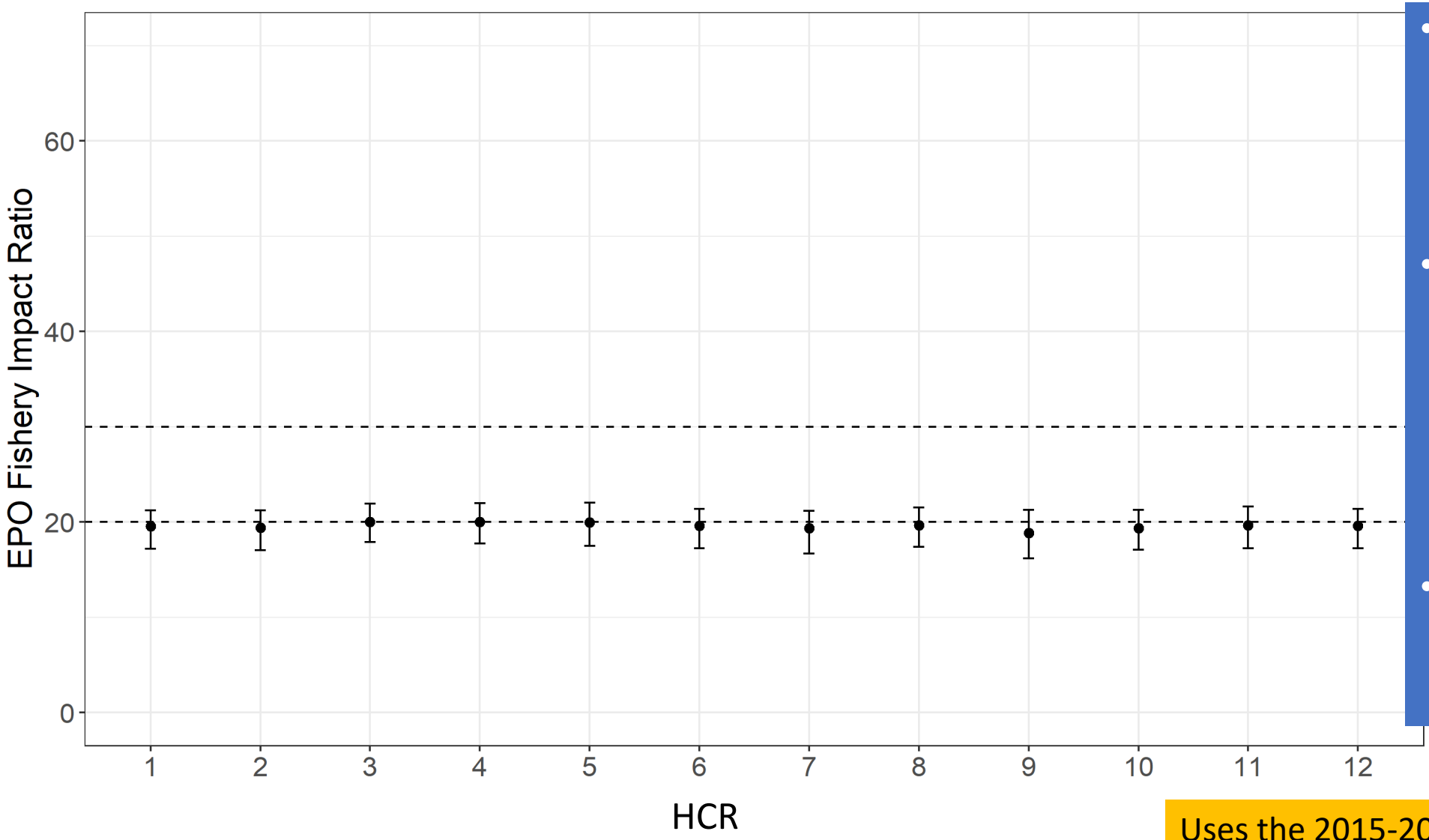
- *OBJECTIVE: To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the stock is below the LRP*
- *PERFORMANCE METRIC: Percent change downwards in catches between management periods excluding periods when SSB<LRP*
- The max % change downwards in catch was 25%

Overall Change in TAC



- *OBJECTIVE: 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*
- Comparable median change in TAC across HCRs
- More positive than negative changes

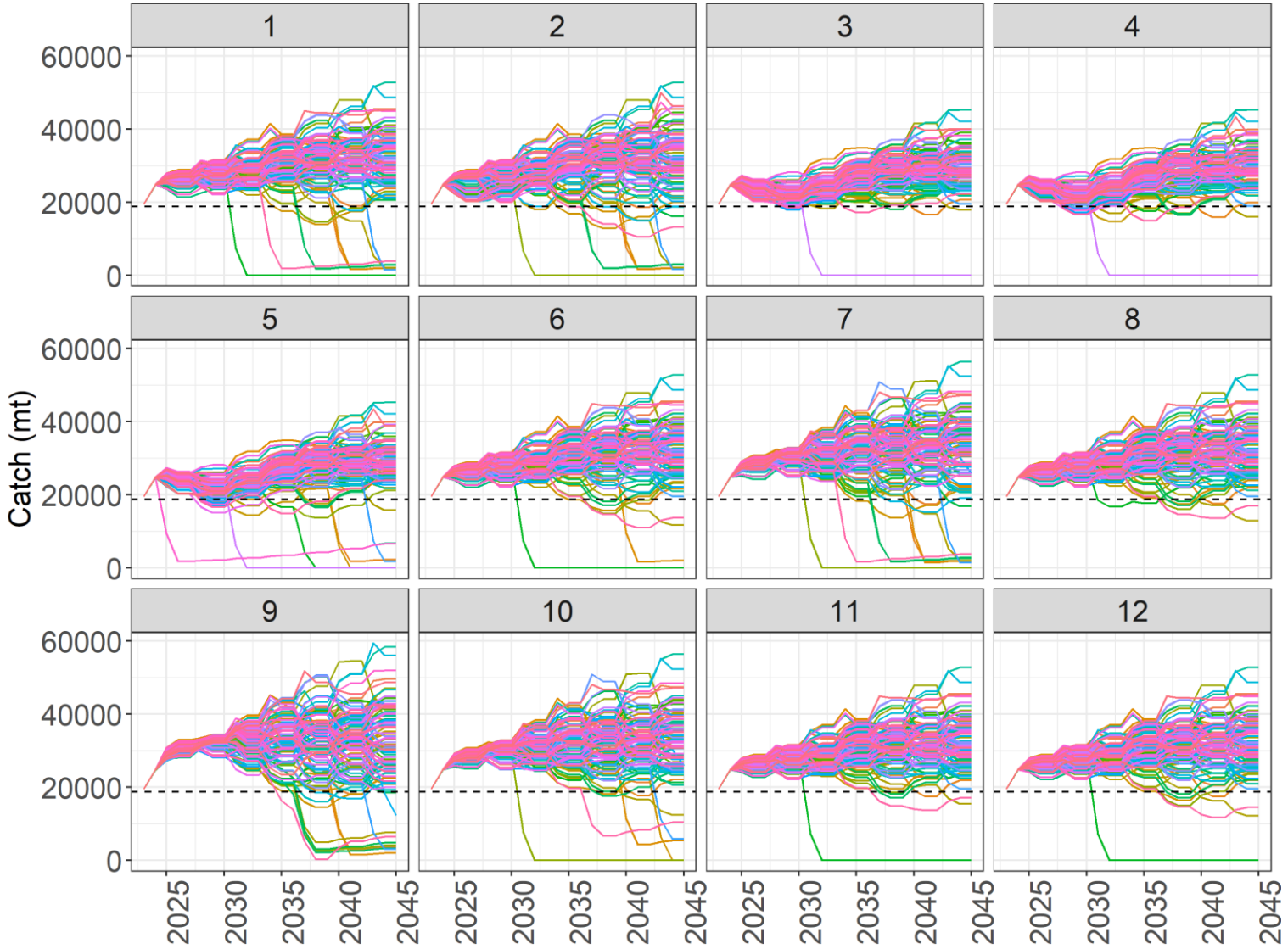
Yield Performance Metric 1



- *OBJECTIVE: Maintain an equitable balance in proportional fishery impact between the WCPO and EPO*
- *PERFORMANCE METRIC: Median fishery impact (in %) on SSB in the terminal year of the evaluation period by fishery and by WCPO fisheries and EPO fisheries*
- Median EPO:WCPO impact ranges from 19:81 to 20:80 across HCRs

Uses the 2015-2022 relative allocation baseline

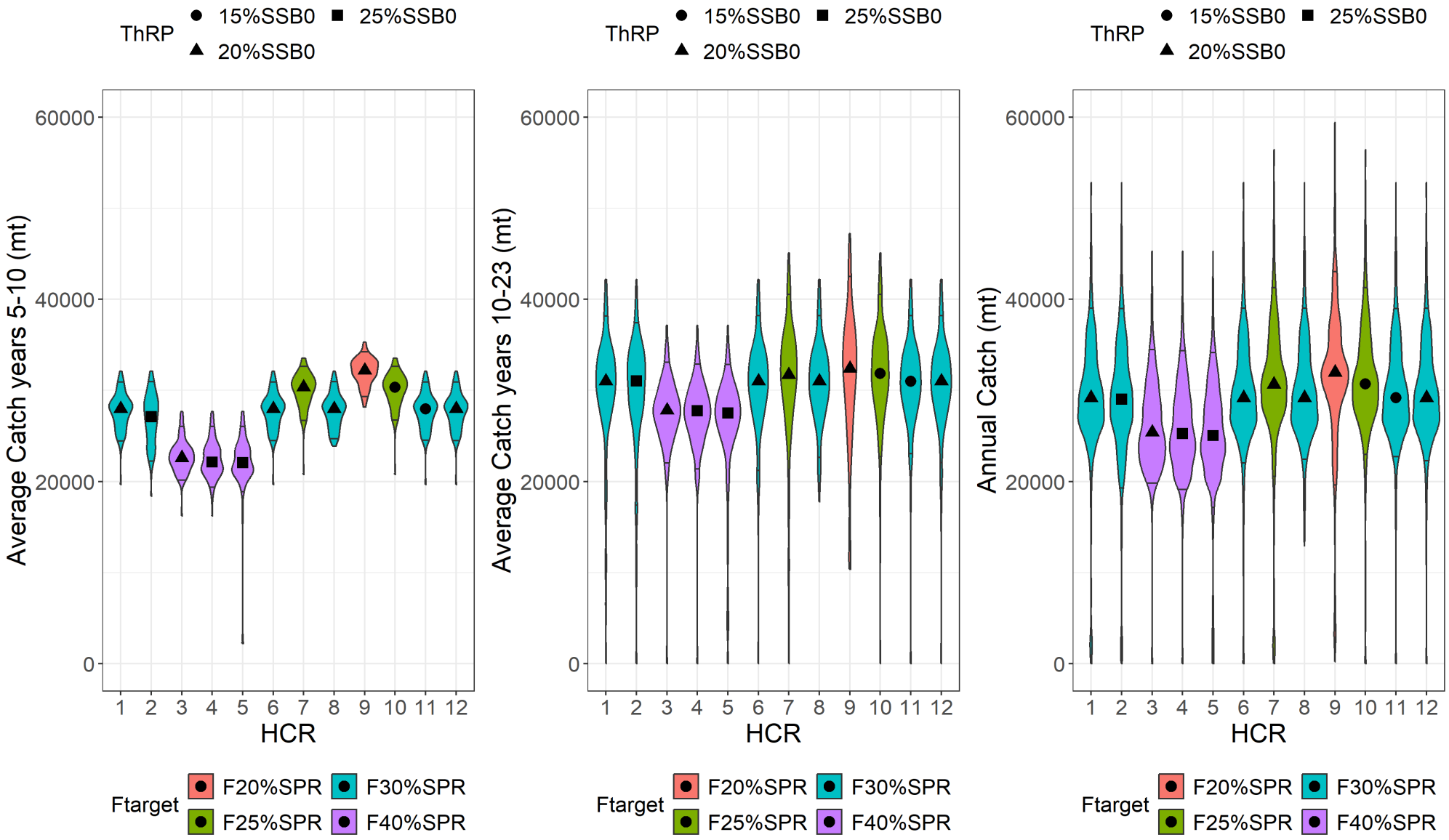
Total Catch Worm Plots



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Average historical catch

Yield Performance Metric 2-4 – Total Catch



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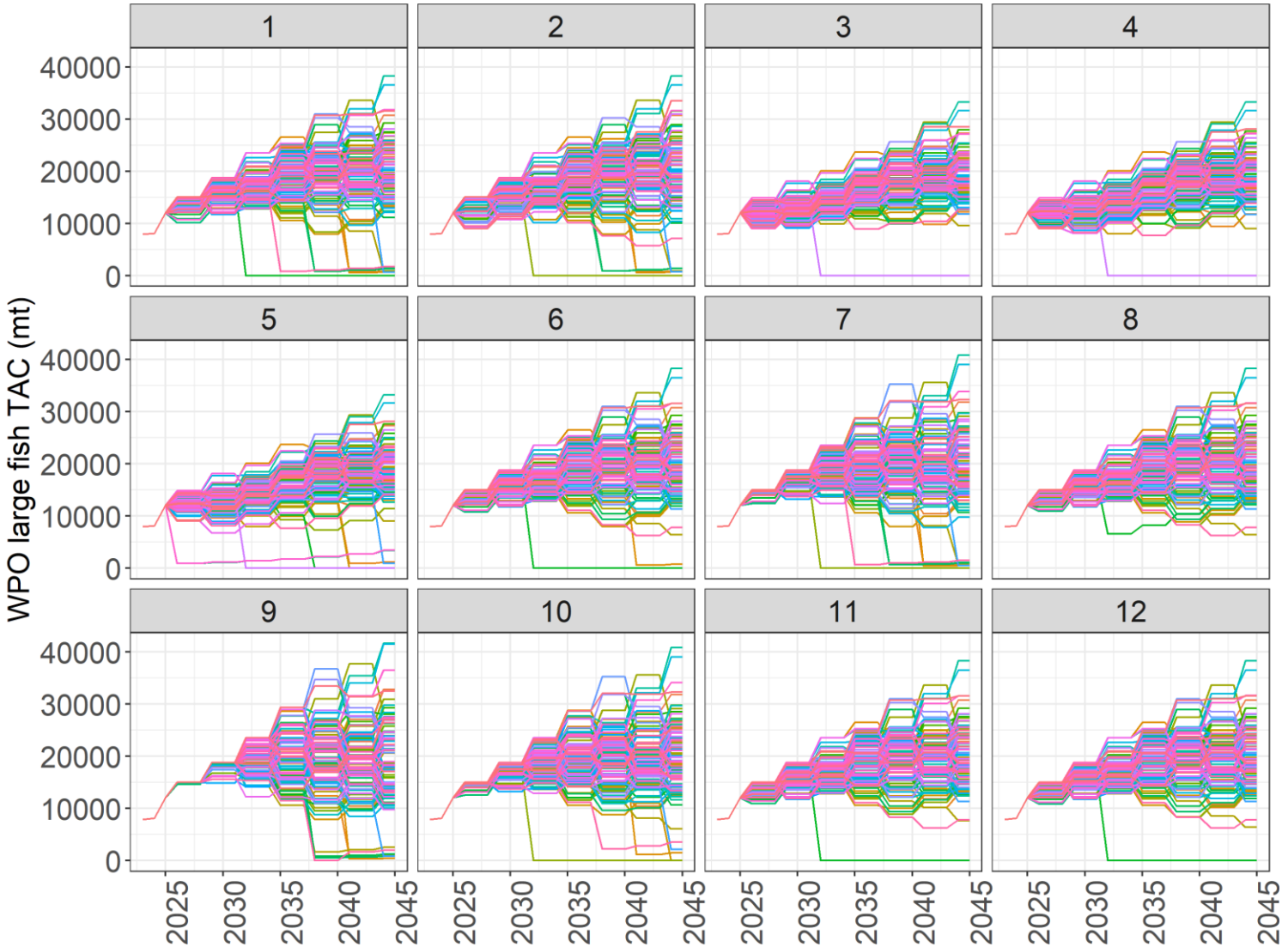
TAC WCPO large fish



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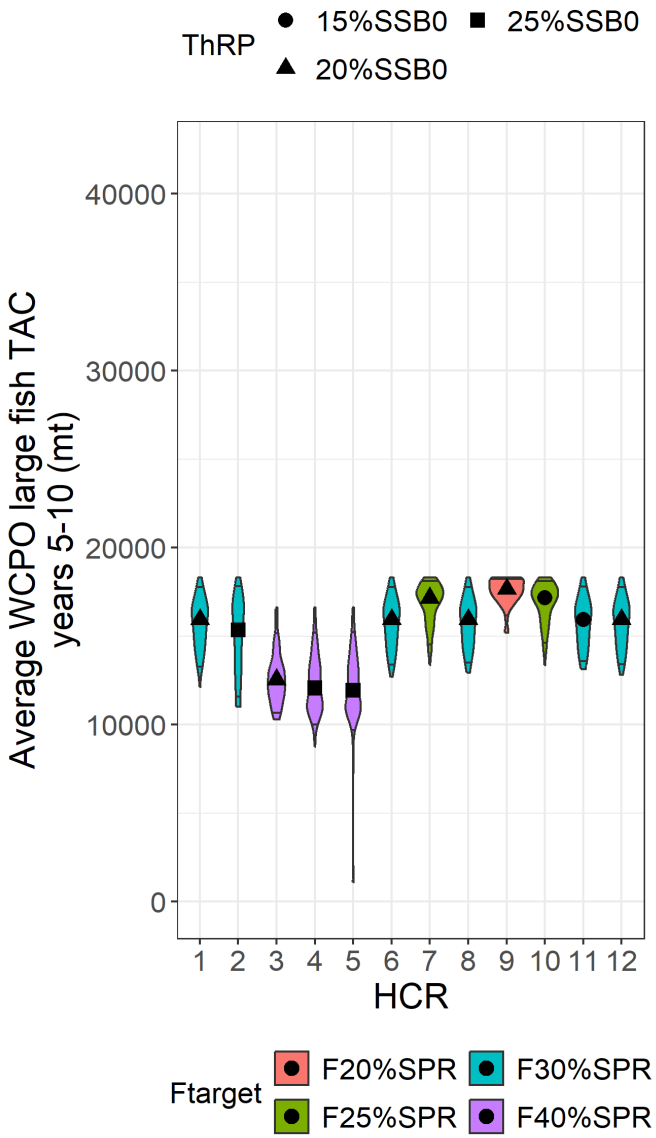
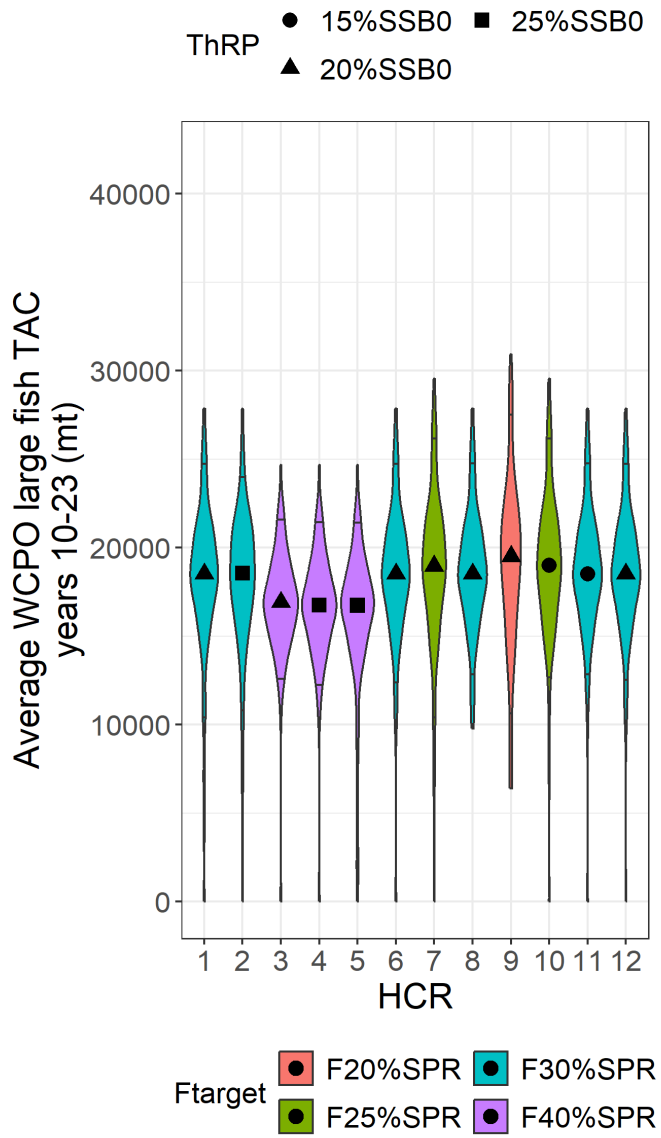
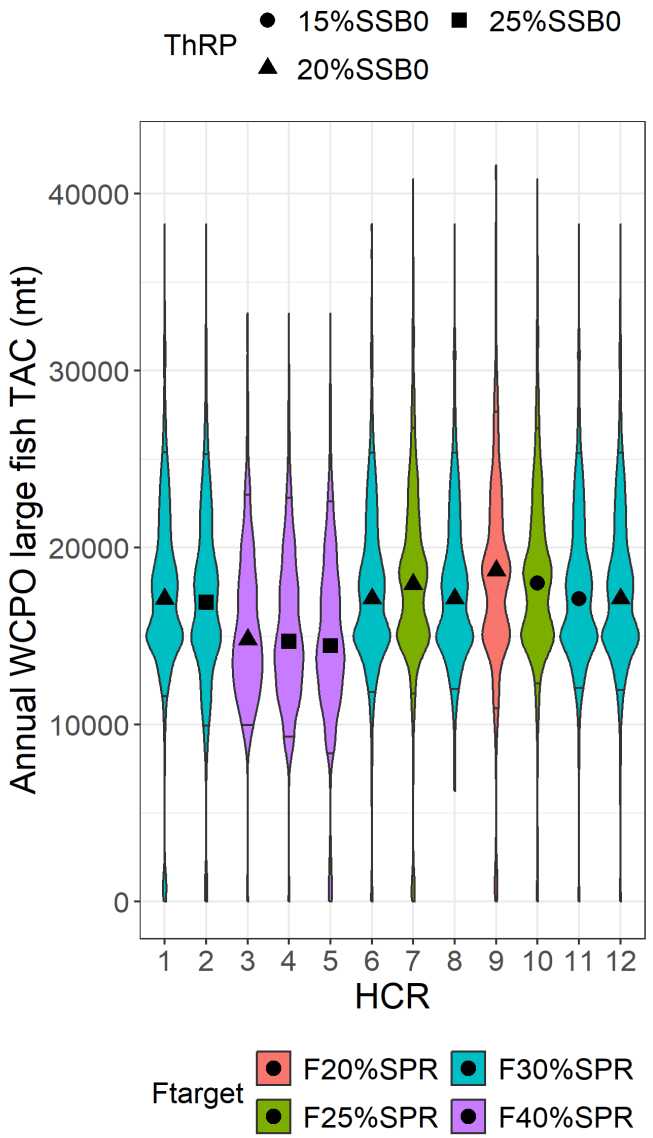
Yield Performance Metric 2-4 – WCPO large fish







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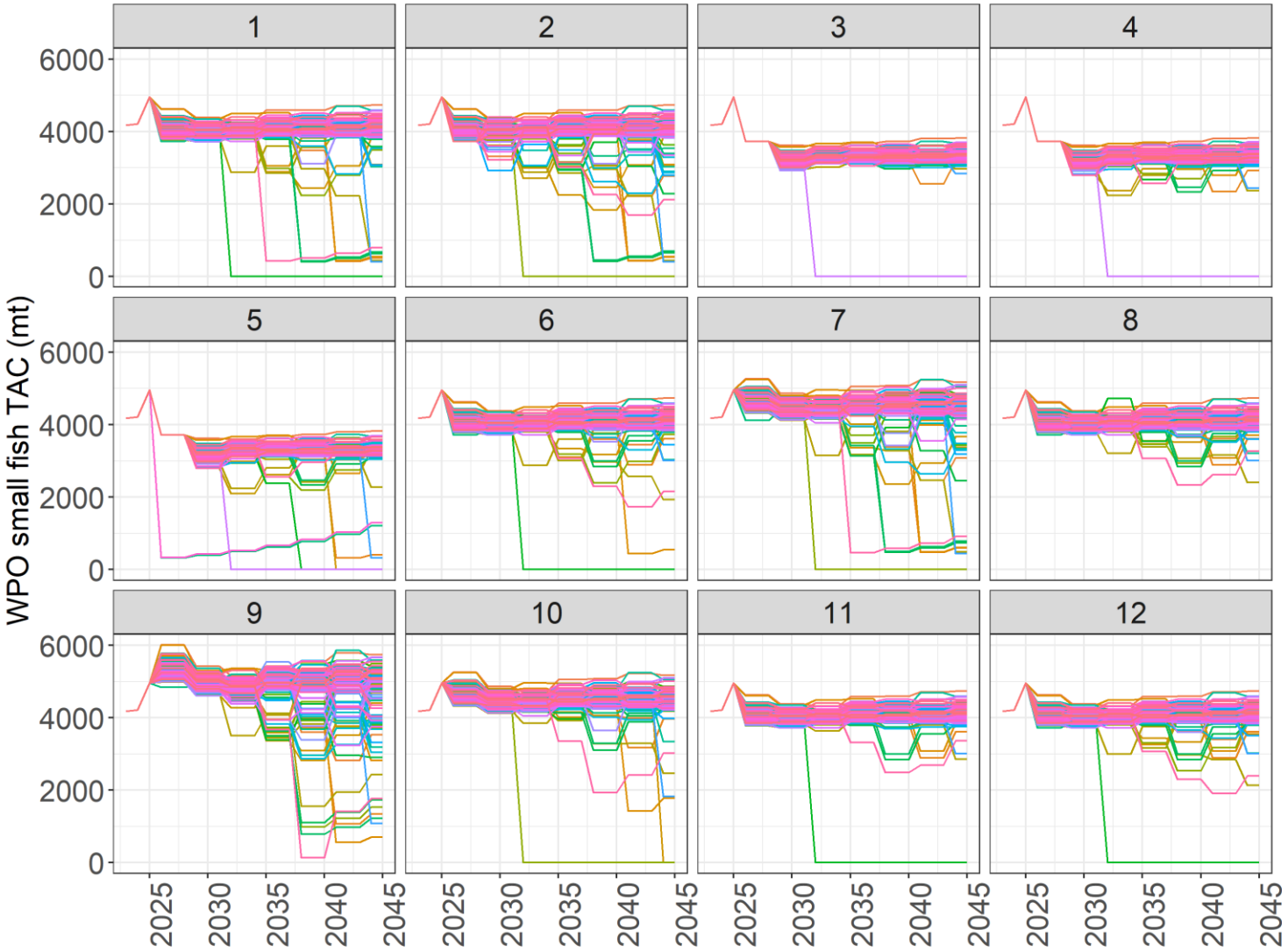
TAC WCPO small fish



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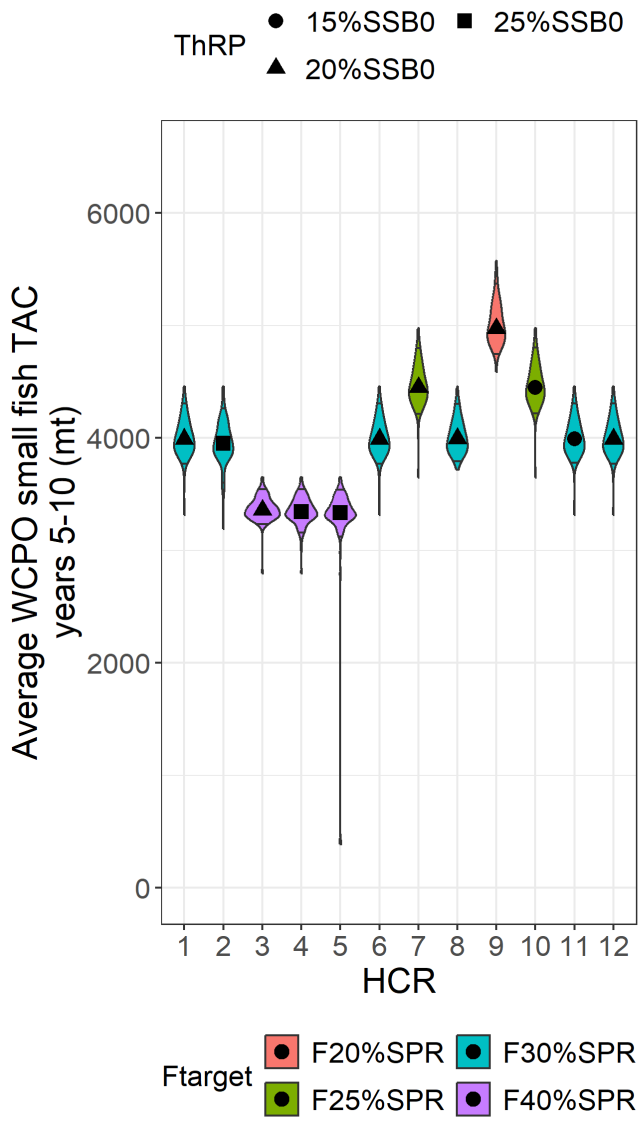
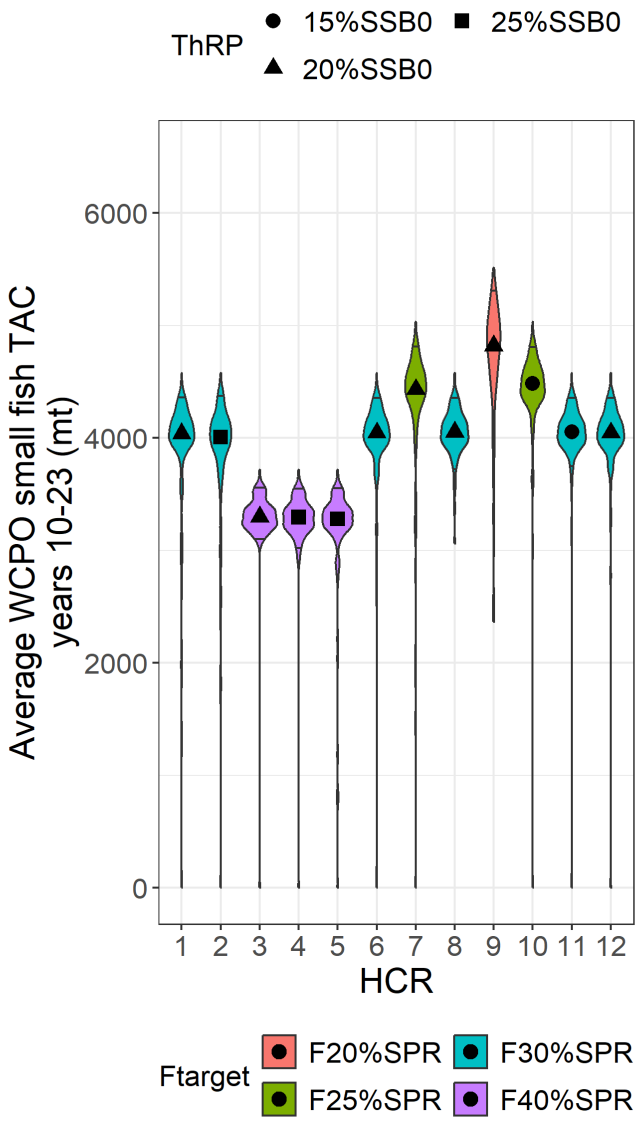
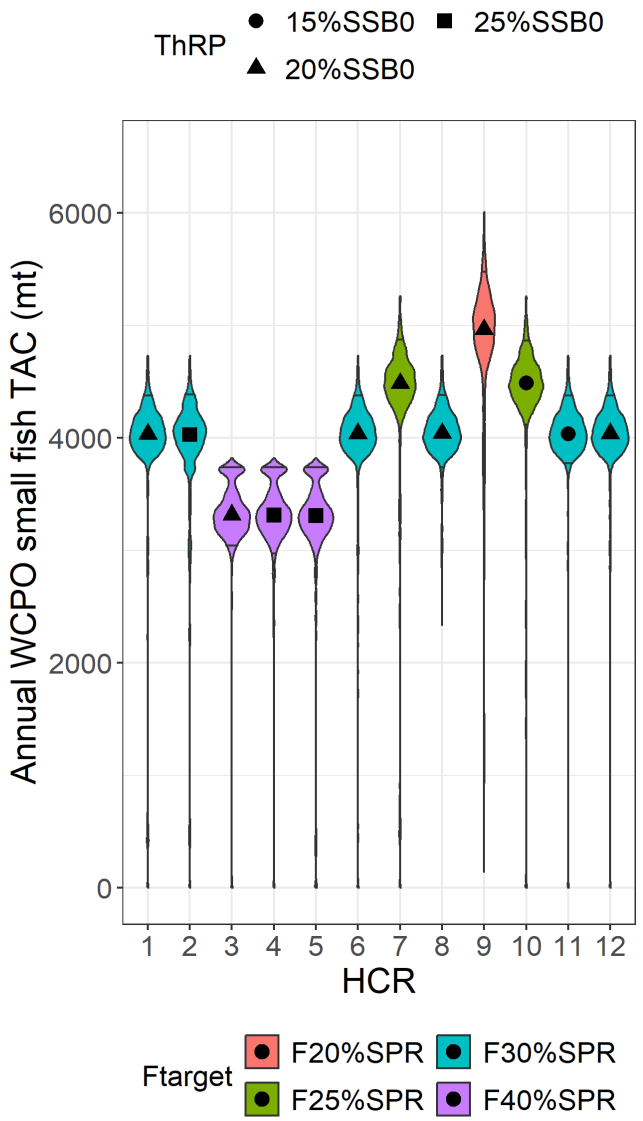
Yield Performance Metric 2-4 – WCPO small fish







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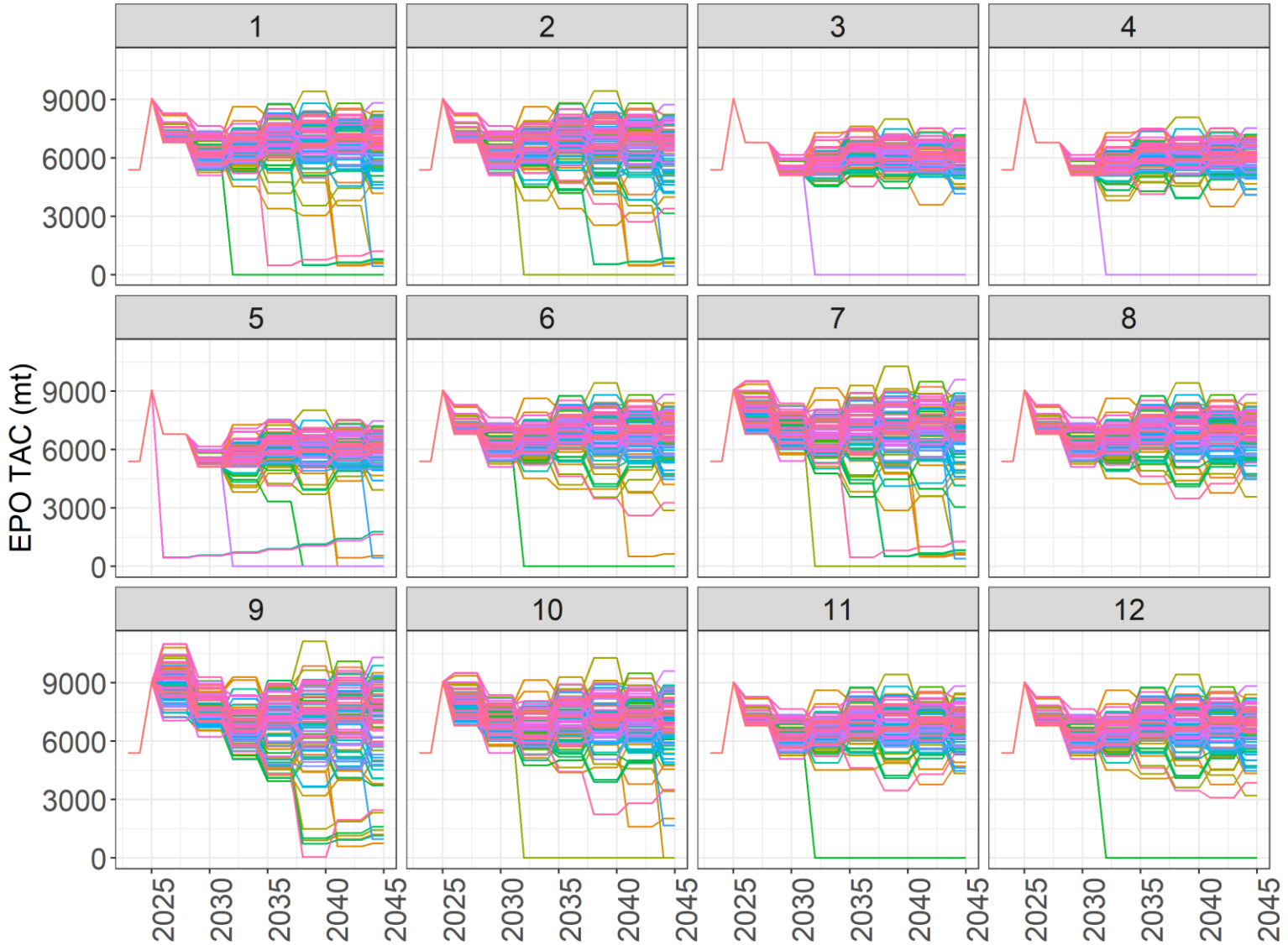
TAC EPO



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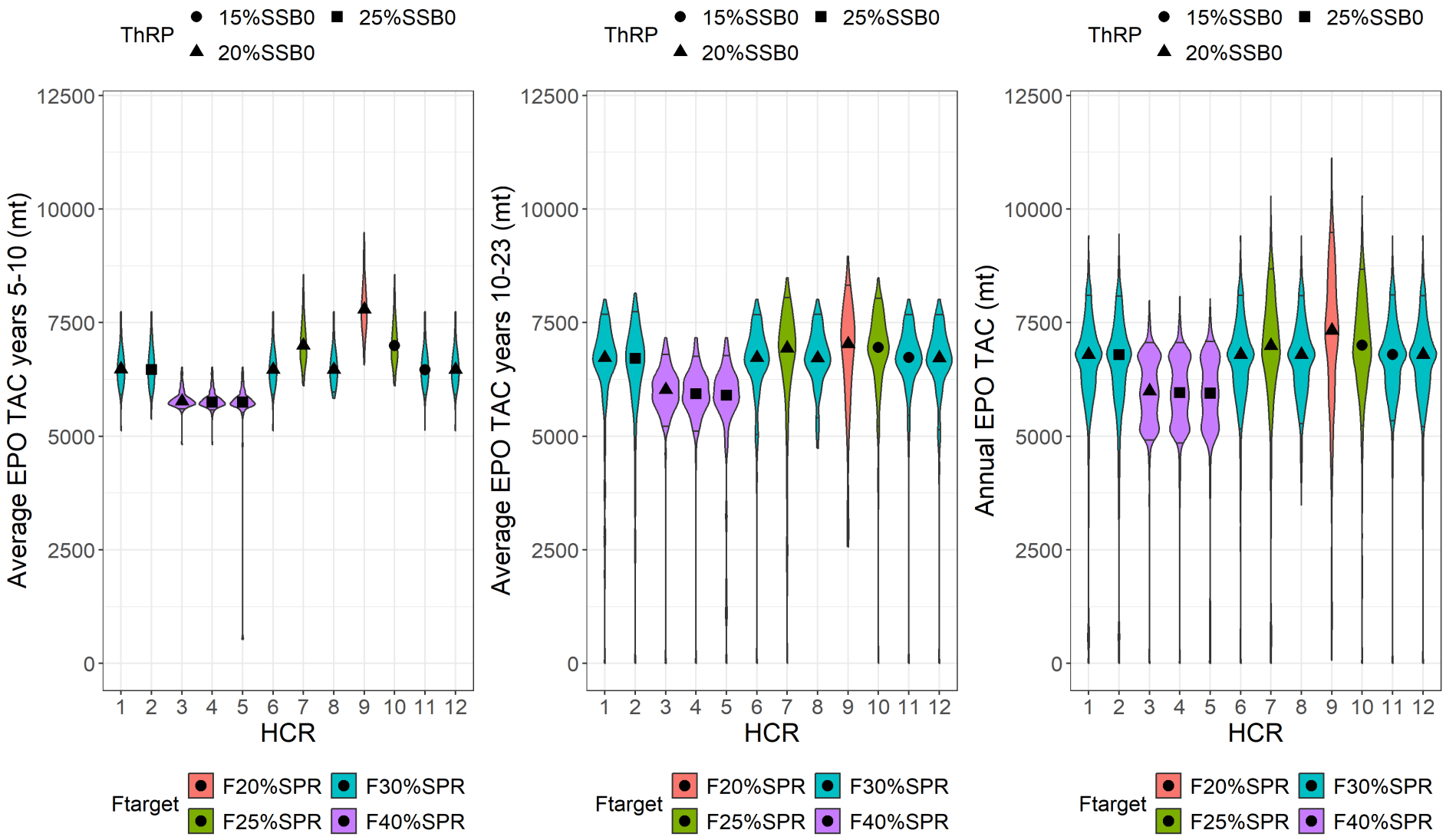
Yield Performance Metric 2-4 – EPO



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Tradeoff between Performance Indicators - Yield and Safety

HCRs with a similar F_{target} perform similarly

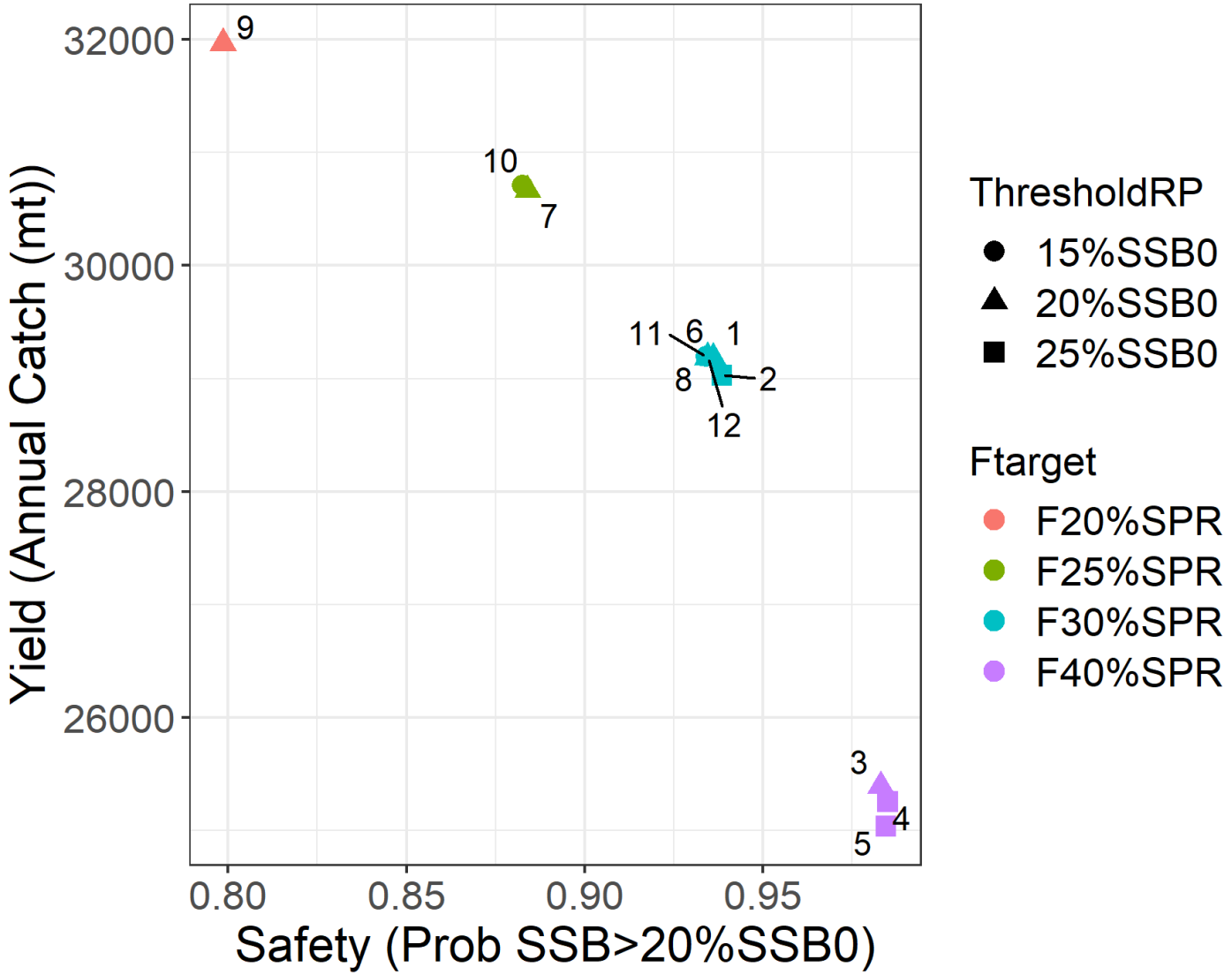


Table of Performance Indicators

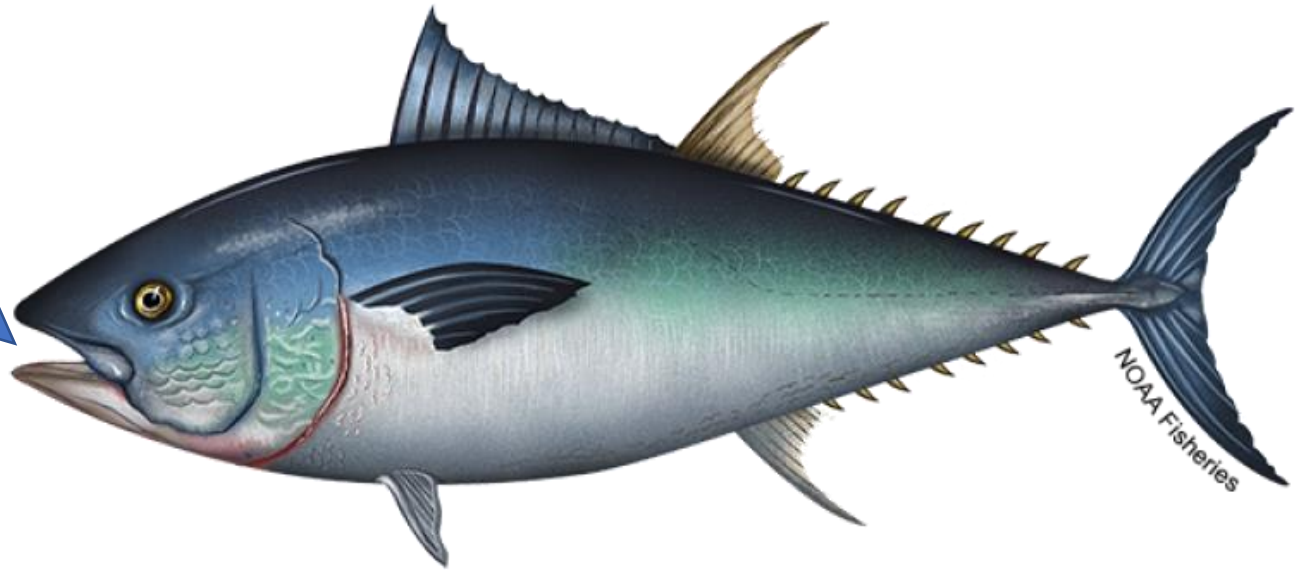
Performance Indicators

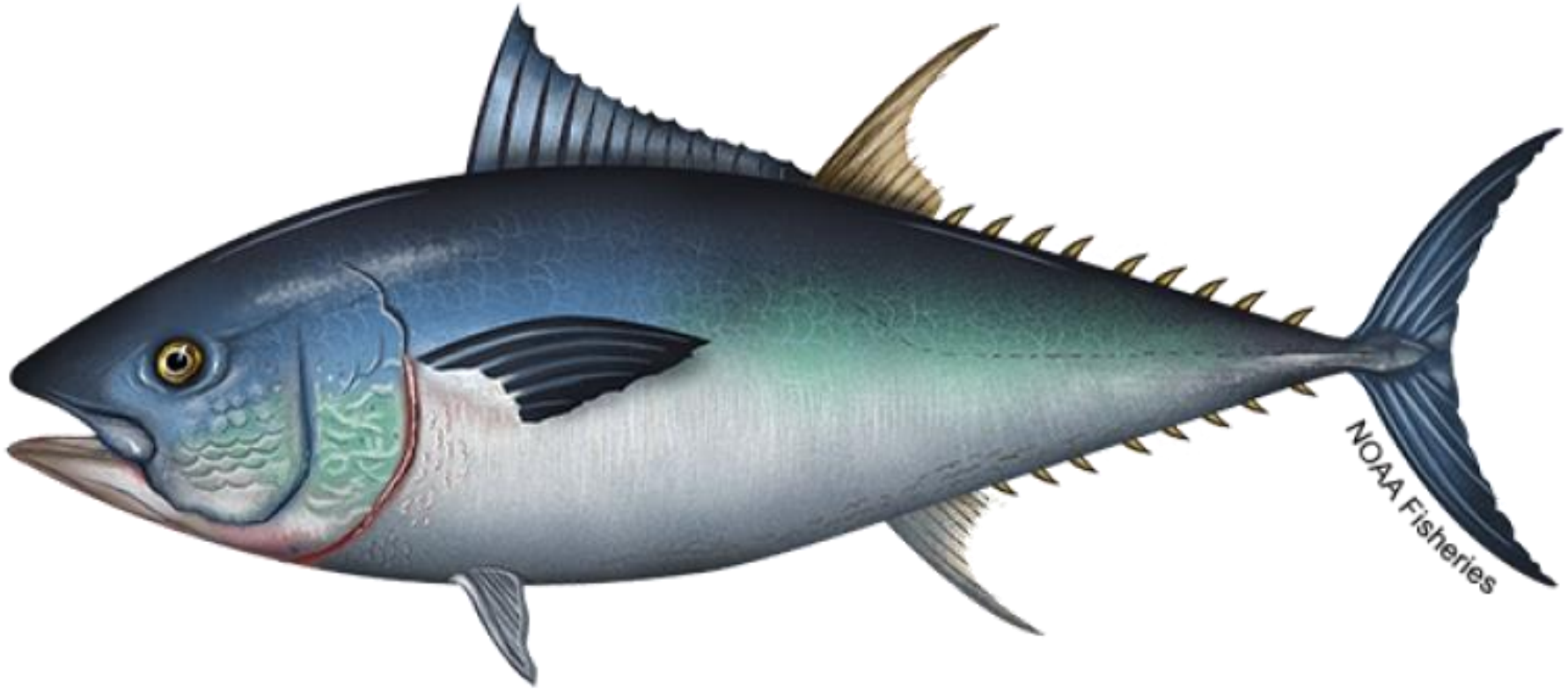
Base Case

	Prob SSB => LRP	Prob SSB => 20%SSBo	Prob F <= Ftarget	Prob SSB => SSBtarget	% change TAC +	% change TAC -	EPO Impact	Median annual catch	Median year 5-10 average catch	Median year 11-23 average catch	Median WCPO large fish annual catch	Median WCPO small fish annual catch	Median EPO annual catch	MP TAC
1	98	94	69	61	12	-10	20	29182	27981	31008	17105	4036	6794	NA
2	98	94	71	63	13	-12	19	29028	27112	31043	16923	4030	6794	NA
3	100	98	68	49	12	-8	20	25393	22596	27815	14820	3317	5994	NA
4	100	98	69	49	13	-7	20	25257	22137	27776	14700	3313	5958	NA
5	98	98	70	50	14	-7	20	25039	22064	27530	14461	3309	5944	NA
6	100	93	69	60	12	-10	20	29187	27981	31011	17118	4040	6794	NA
7	98	88	69	76	12	-11	19	30668	30355	31700	17939	4485	6993	NA
8	100	93	69	60	12	-10	20	29187	27981	31011	17118	4042	6794	NA
9	98	80	68	80	11	-14	19	31970	32189	32400	18716	4965	7327	NA
10	100	88	68	75	11	-10	19	30708	30355	31843	17997	4490	7002	NA
11	100	93	68	60	12	-10	20	29197	27981	31011	17118	4037	6794	NA
12	100	93	69	60	12	-10	20	29187	27981	31011	17118	4040	6794	NA

- Color reflects range of each column. Highest have dark green, lowest light yellow, different shades of green to yellow in between
- Highlights differences- E.g. Performance metric 1, 98 similar to 100 but colored very differently

Questions?
Suggestions?
Are there other plots you'd like to see?
What was unclear? What did you like?

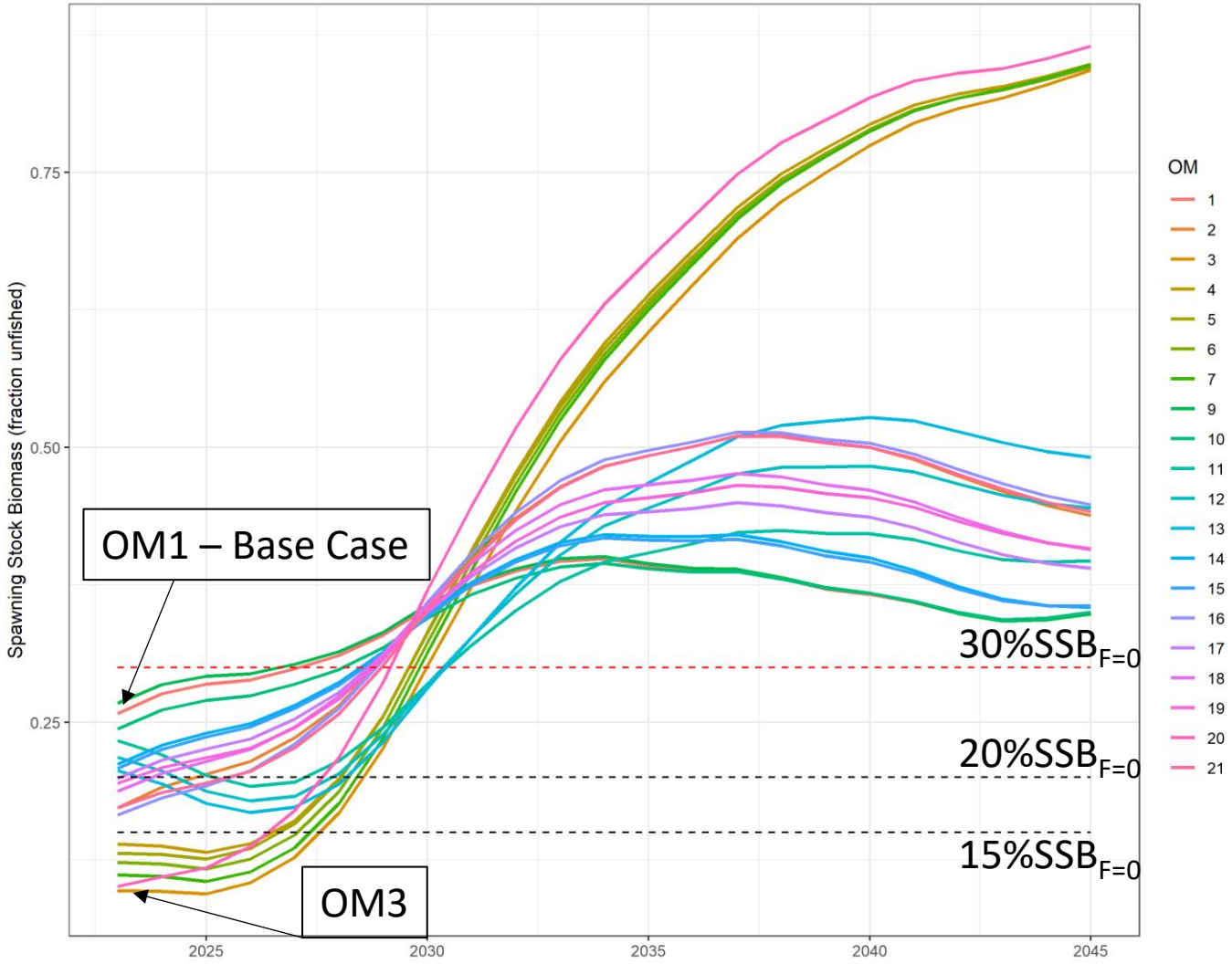




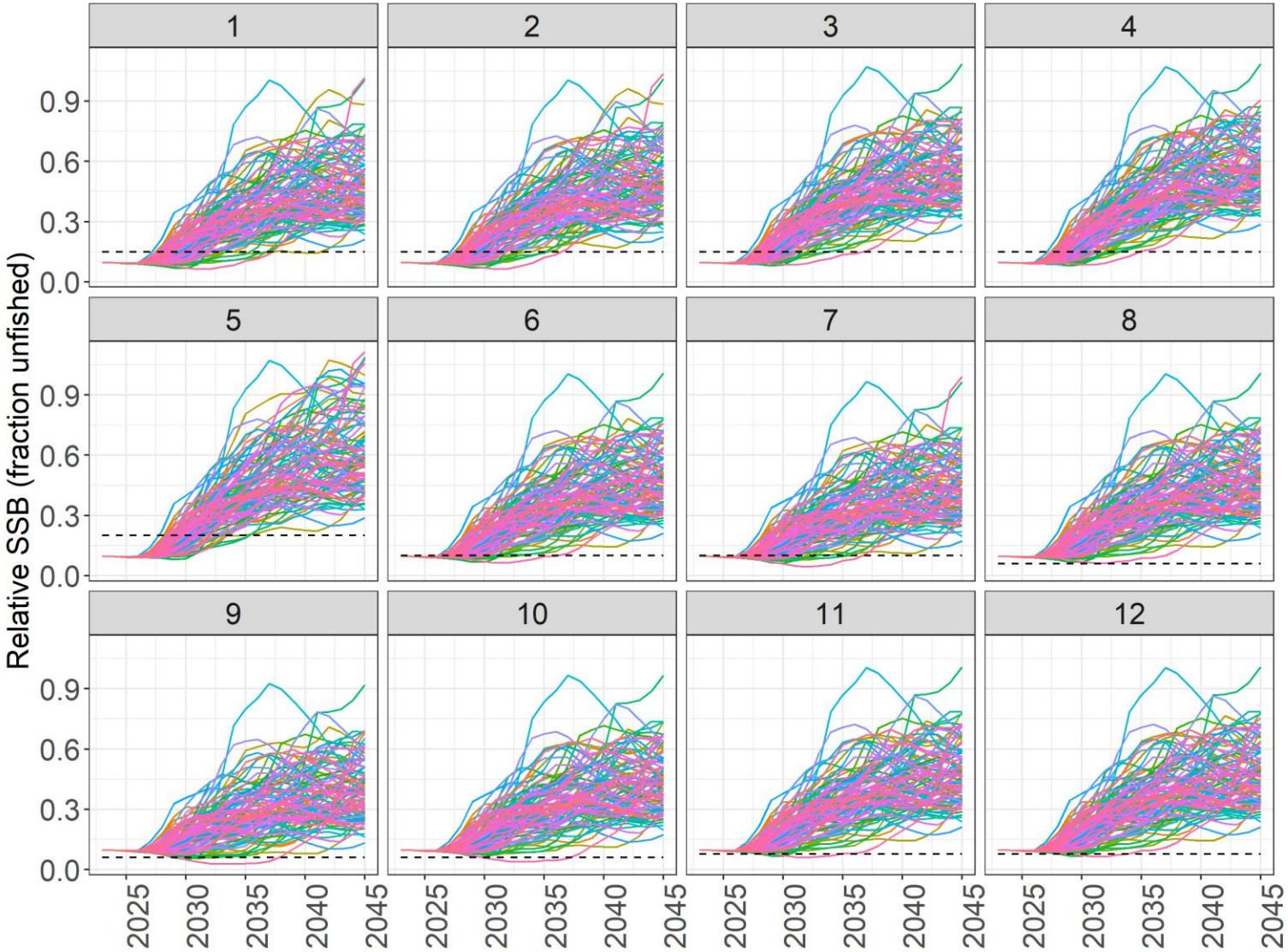
Example Results for OM3

How would results change if stock was less productive? – OM3

But remember that ultimately performance will be assessed across all OMs to see on average which HCR performs best across all plausible realities



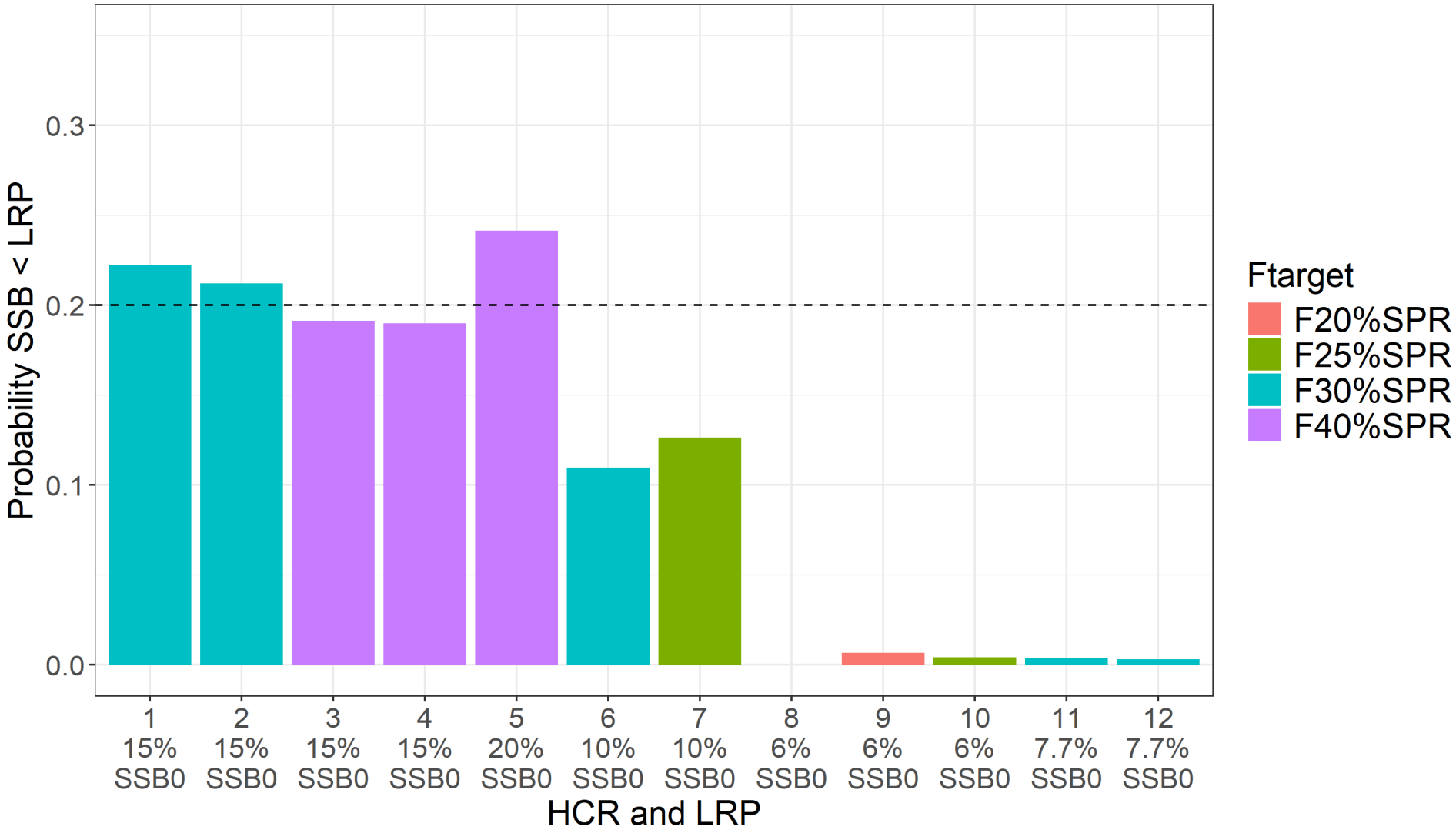
Relative SSB Worm Plots



- *OBJECTIVE: There should be a less than 20% probability of the stock falling below the LRP*
- *PERFORMANCE METRIC: Probability that SSB< LRP in any given year of the evaluation period*

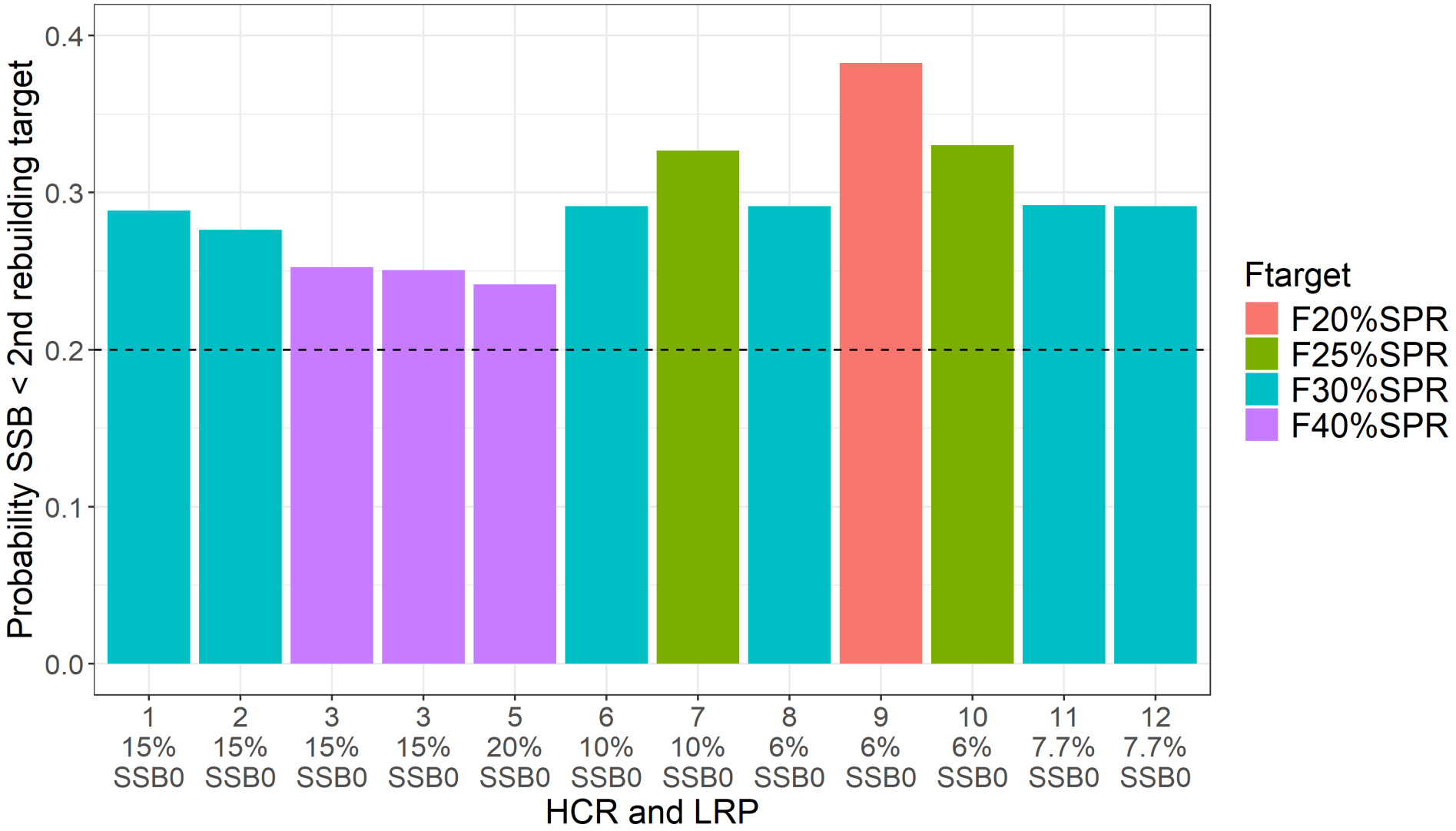
HCR specific LRP

Safety Performance Metric



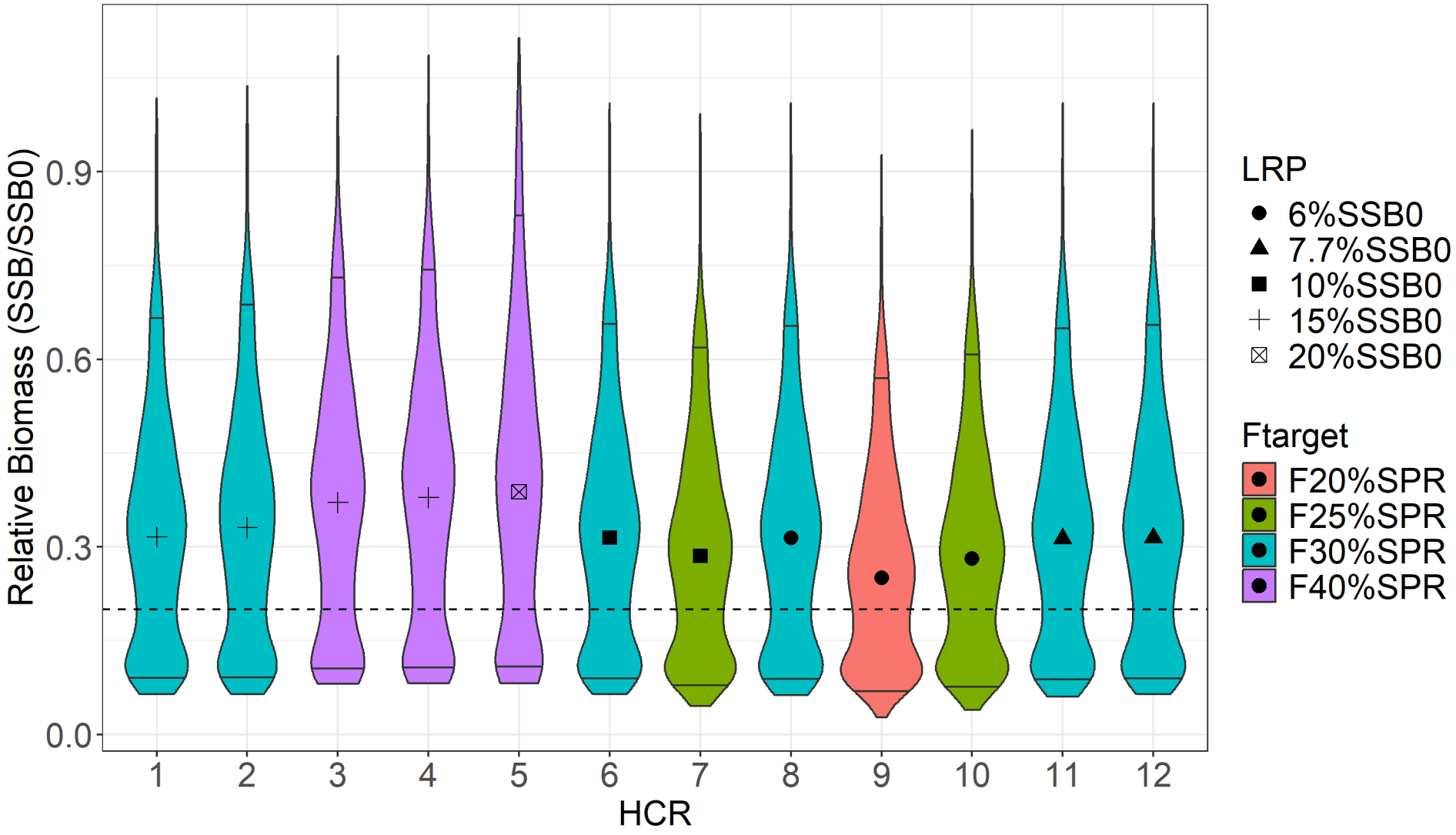
- *OBJECTIVE: There should be a less than 20% probability of the stock falling below the LRP*
- *PERFORMANCE METRIC: Probability that SSB< LRP in any given year of the evaluation period*
- *HCRs with the highest LRPs* have a higher probability of breaching their LRP due to low initial SSB

Safety Performance Metric – common reference point



- Performance also compared against second rebuilding target of 20%SSBF=0
- All HCRs have a probability of breaching the rebuilding target higher than 20%
- HCRs with the highest target fishing mortality do poorer

Safety Performance Metric

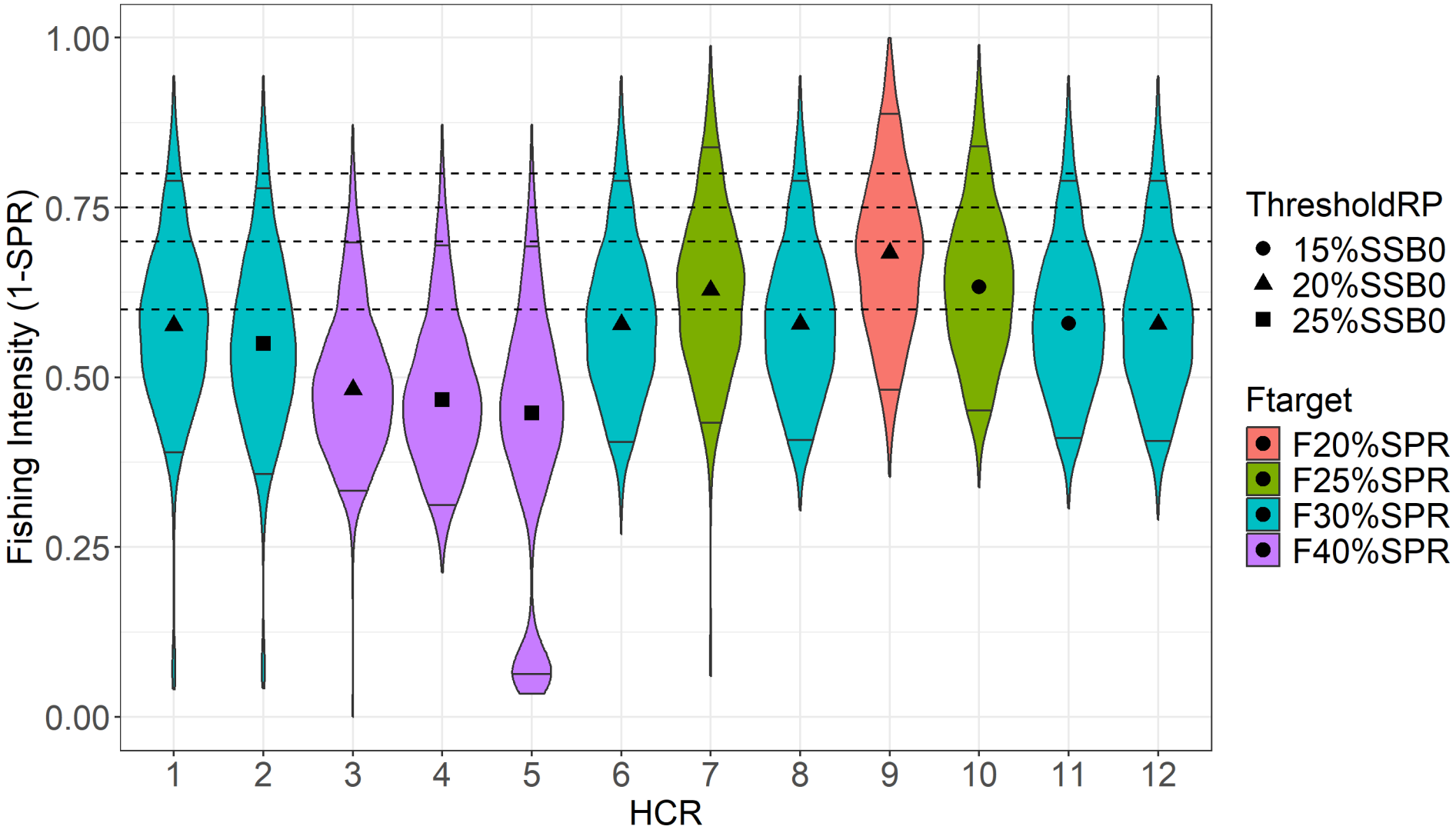


- HCRs with highest target fishing mortality have a lower median SSB and thus a higher probability of breaching the second rebuilding target

Fishing Intensity Worm Plots

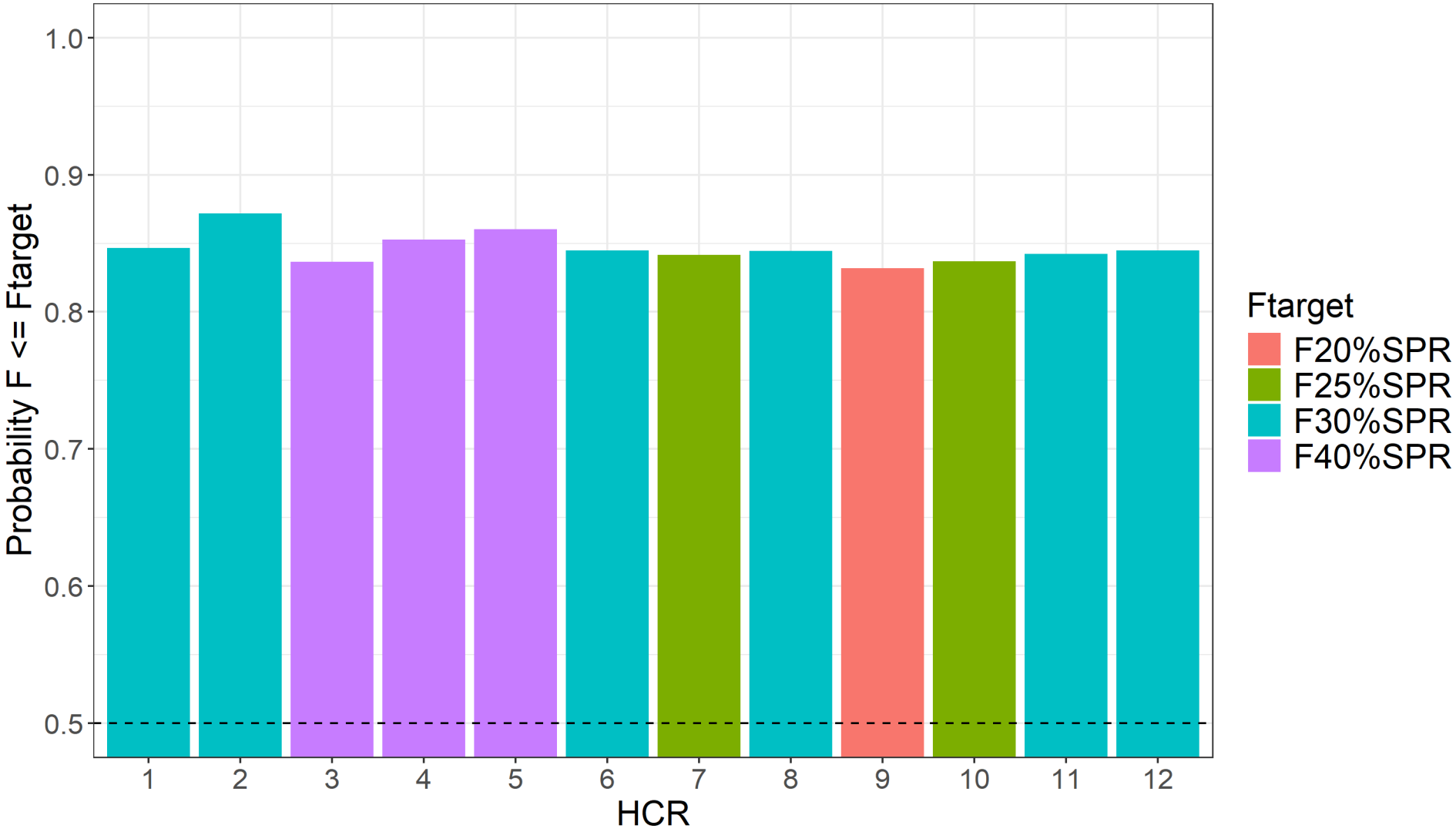
- *OBJECTIVE: To maintain fishing mortality at or below F_{target} with at least 50% probability*
- *PERFORMANCE METRIC: Probability that $F \leq F_{target}$ in any given year of the evaluation period*

Status Performance Metric 1



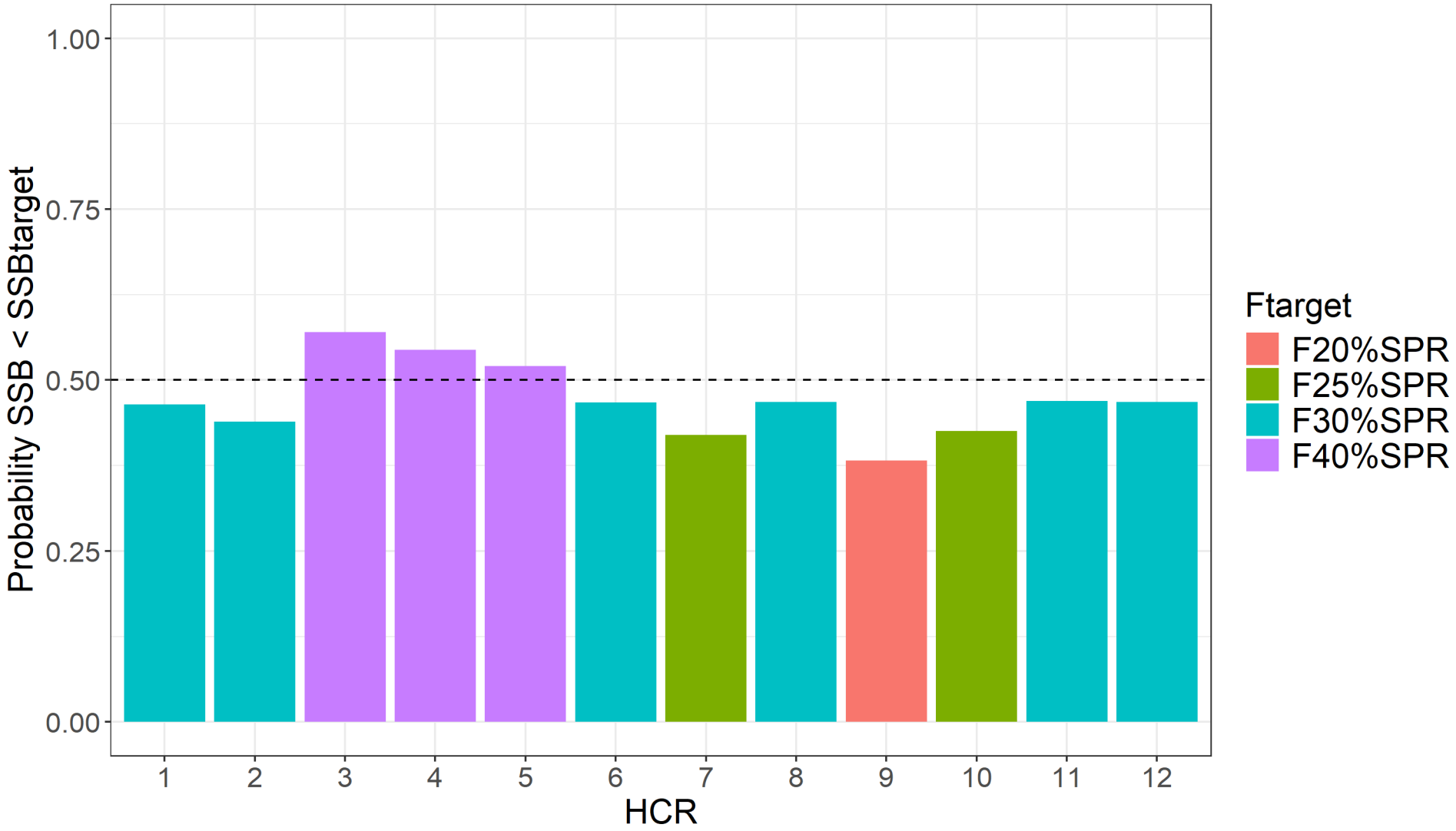
- For all HCRs, the median F remains below the F_{target}
- Due to estimation error and the 25%TAC increase limit

Status Performance Metric 1



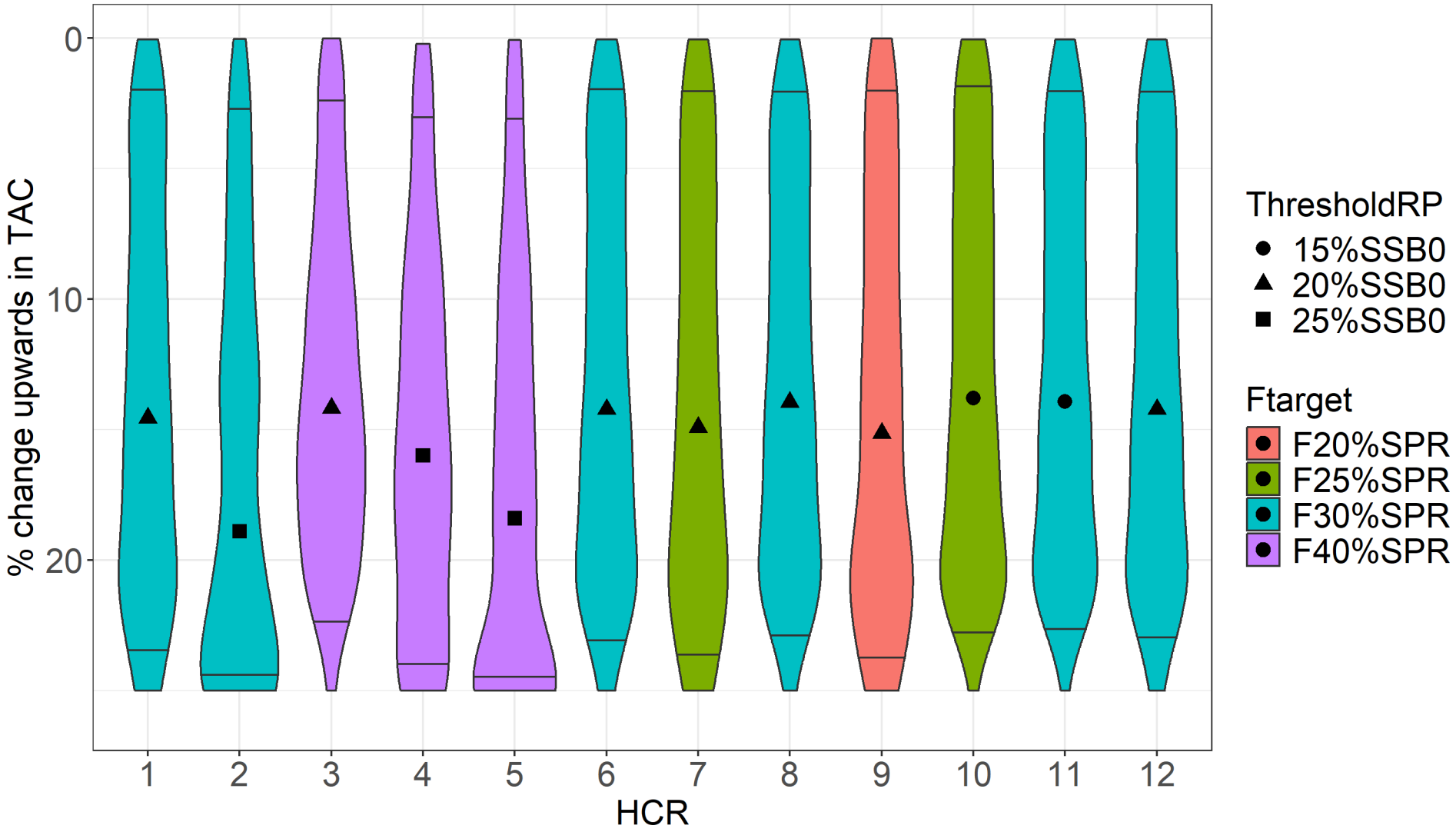
- *OBJECTIVE: To maintain fishing mortality at or below F_{target} with at least 50% probability*
- *PERFORMANCE METRIC: Probability that $F \leq F_{target}$ in any given year of the evaluation period*
- All HCRs have a probability of being lower or equal to their F_{target} that is well above 50%

Status Performance Metric 2



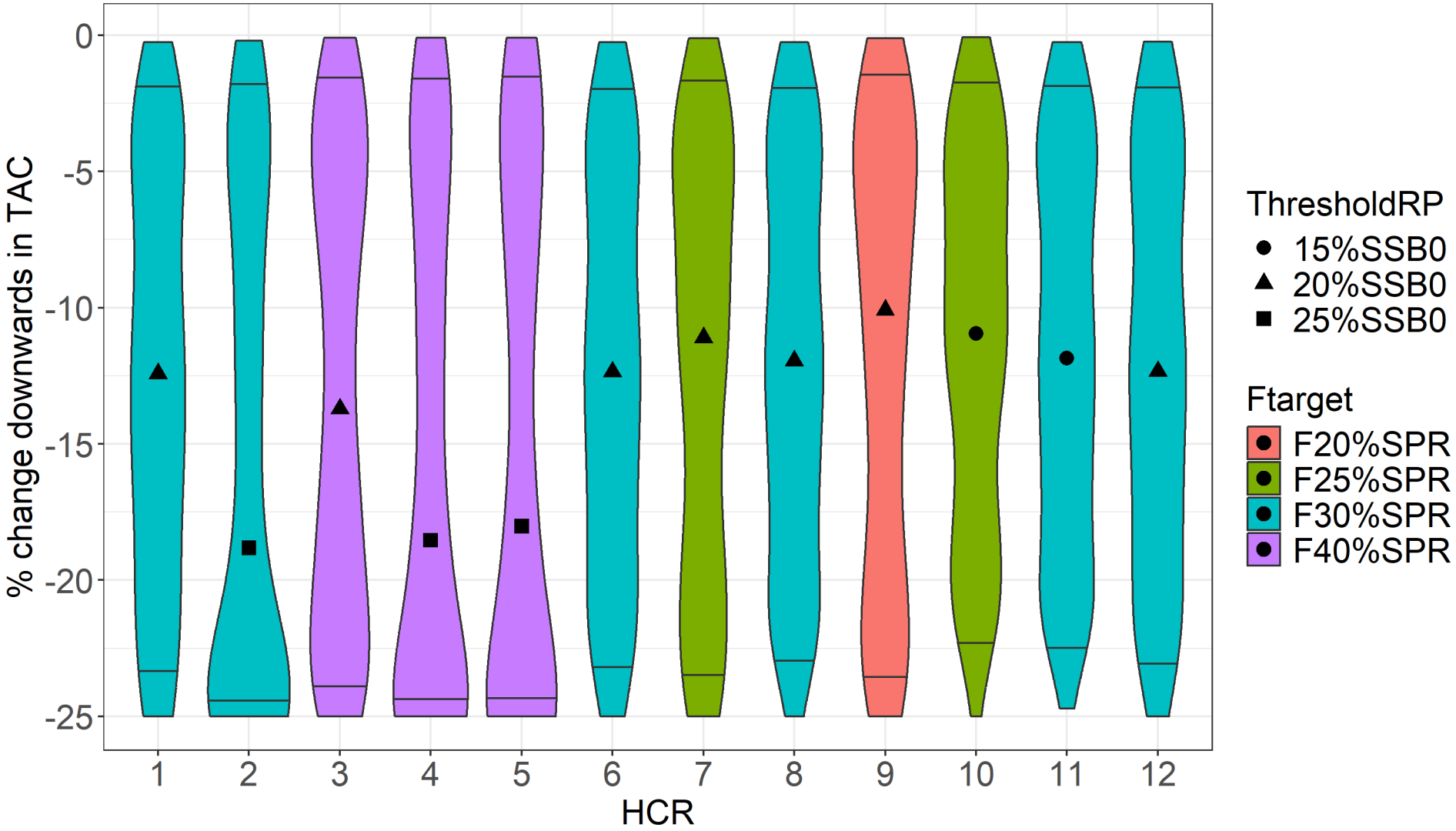
- *PERFORMANCE METRIC:* Probability that SSB < the equivalent biomass depletion levels associated with the candidates for F_{target}
- All HCRs except those with a F40%SPR F_{target} have a probability of SSB being lower than the SSB associated with the F_{target} that is 50% or below

Stability Performance Metric 1



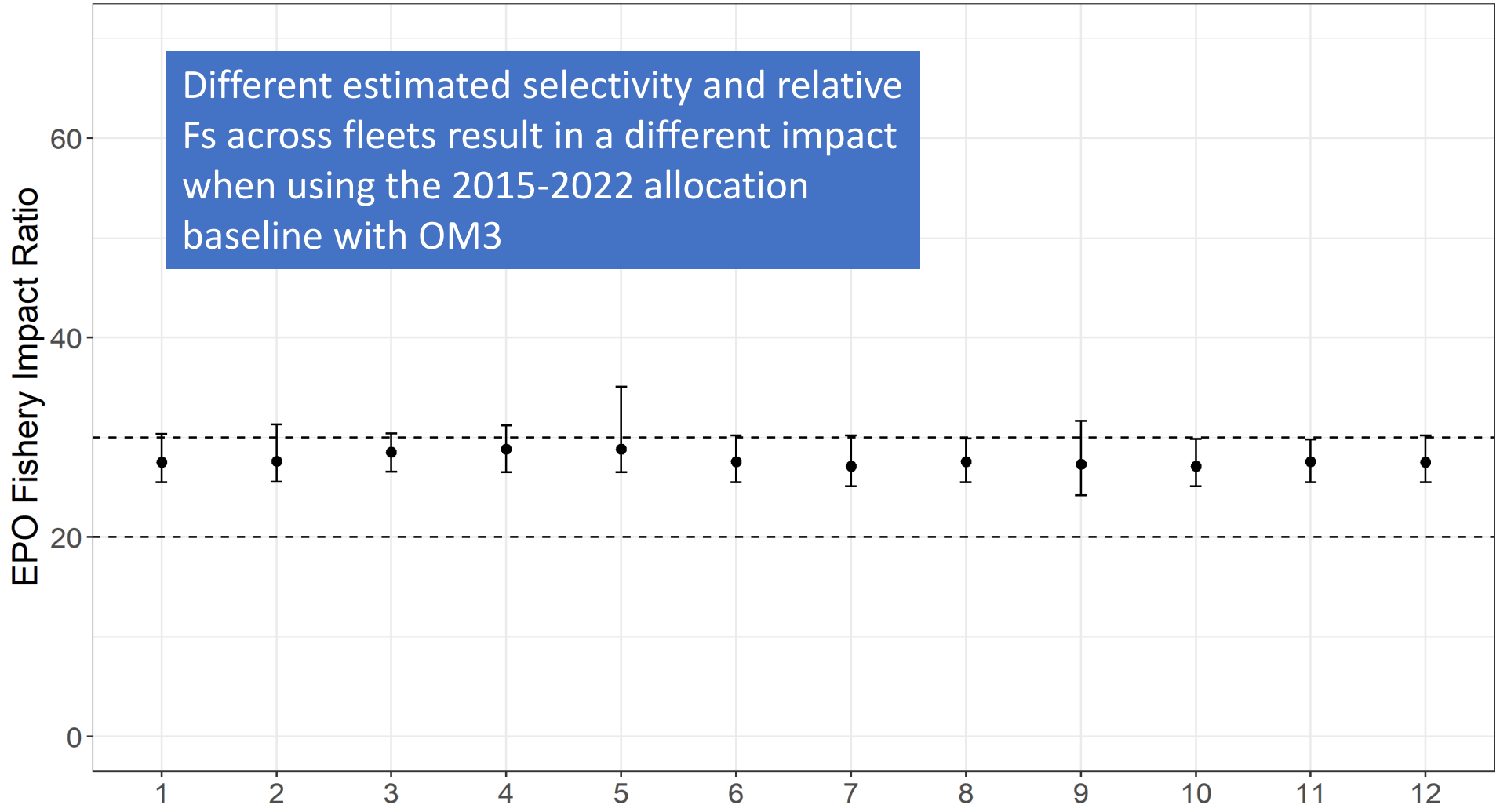
- *OBJECTIVE: To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the stock is below the LRP*
- *PERFORMANCE METRIC: Percent change upwards in catches between management periods excluding periods when SSB<LRP*
- The max % change upwards in catch was 25%

Stability Performance Metric 2



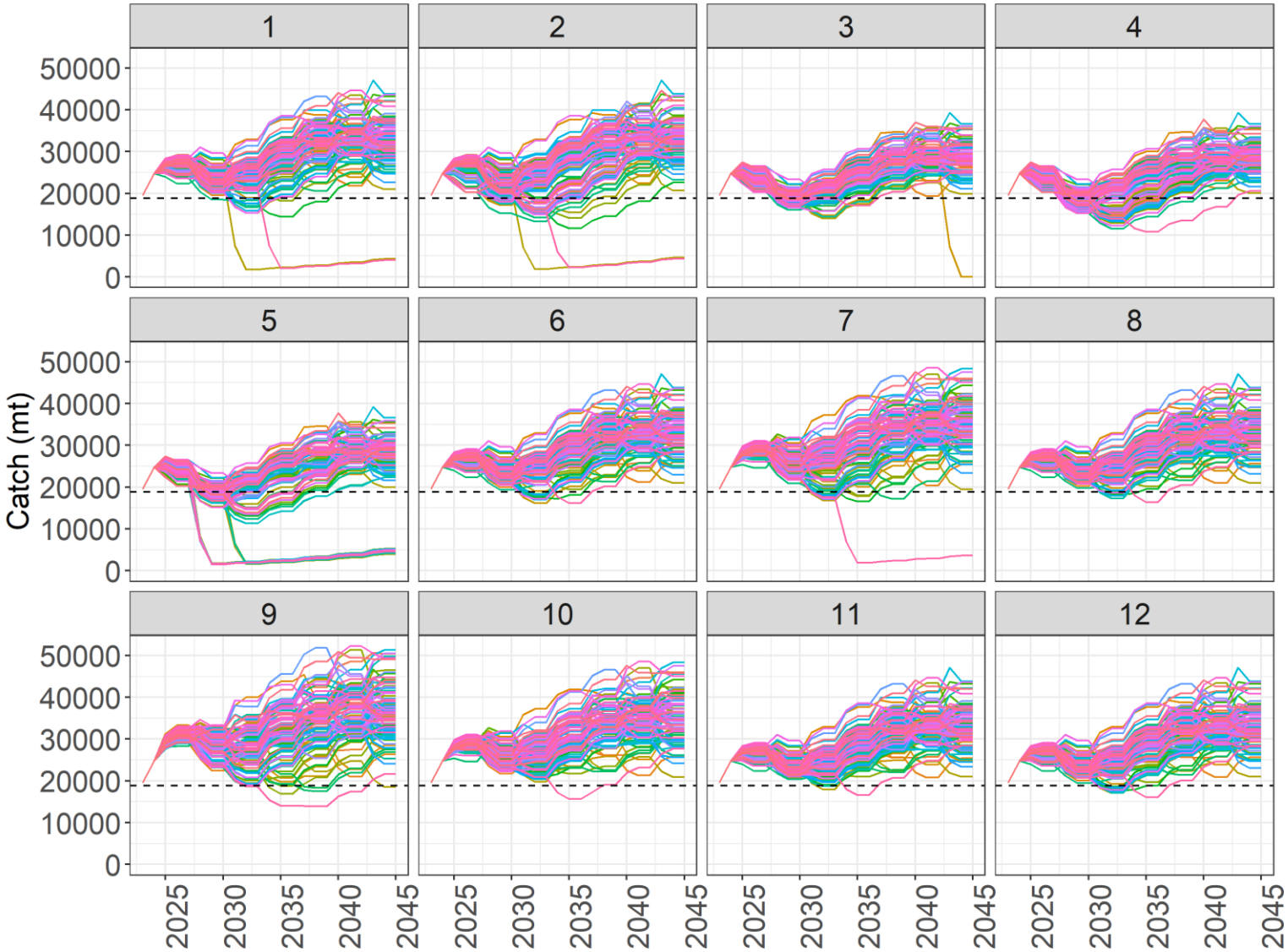
- *OBJECTIVE: To limit changes in overall catch limits between management periods to no more than 25%, unless the ISC has assessed that the stock is below the LRP*
- *PERFORMANCE METRIC: Percent change downwards in catches between management periods excluding periods when SSB<LRP*
- The max % change downwards in catch was 25%

Yield Performance Metric 1



- *OBJECTIVE: Maintain an equitable balance in proportional fishery impact between the WCPO and EPO*
- *PERFORMANCE METRIC: Median fishery impact (in %) on SSB in the terminal year of the evaluation period by fishery and by WCPO fisheries and EPO fisheries*
- Using the baseline 2015-2022 allocation with OM3 results in a median EPO:WCPO impact ranging from 27:73 to 29:71 across HCRs
- Using different OMs captures uncertainty in impact estimation

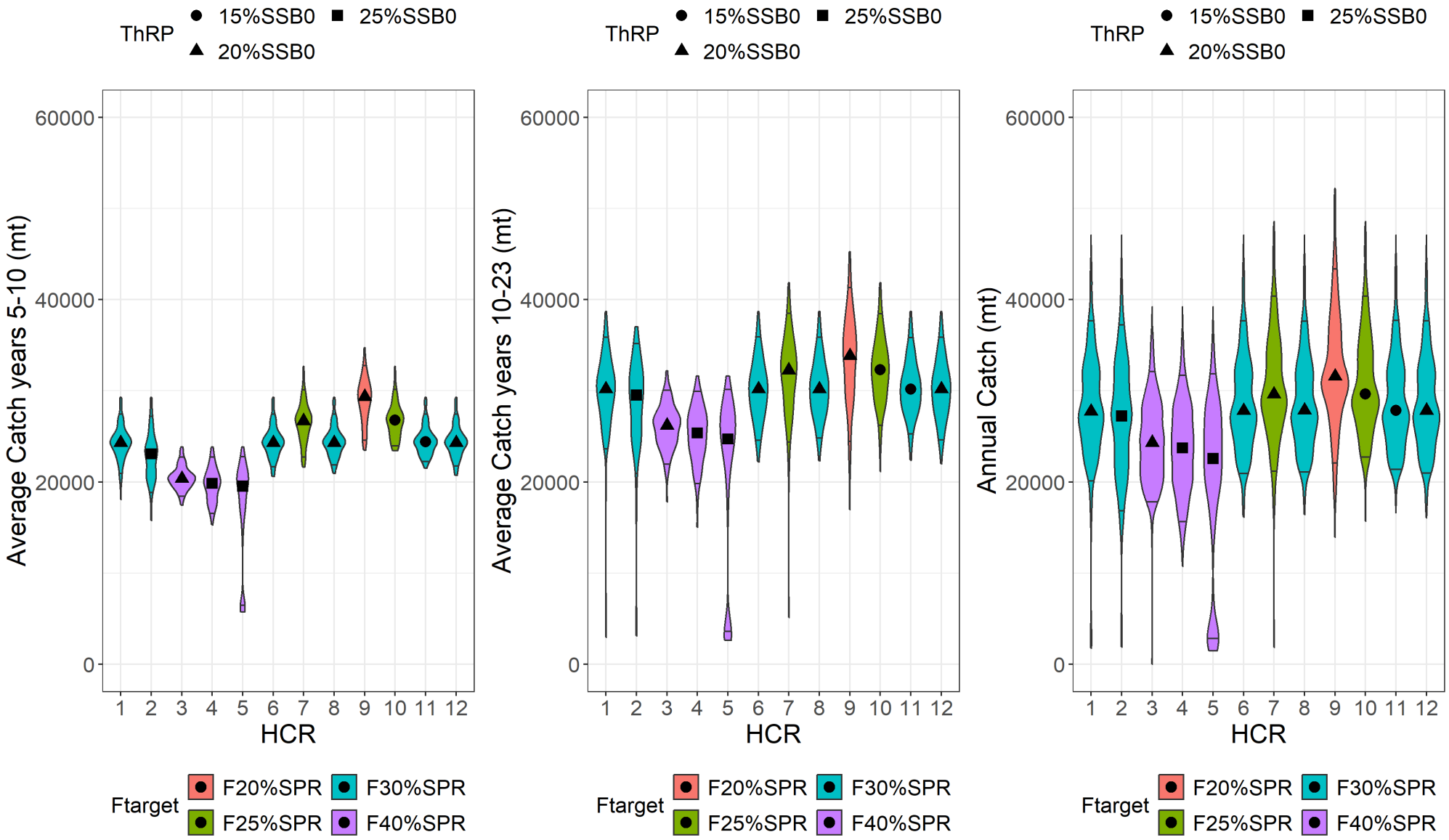
Total Catch Worm Plots



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Historical average catch

Yield Performance Metric 2-4 – Total Catch



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
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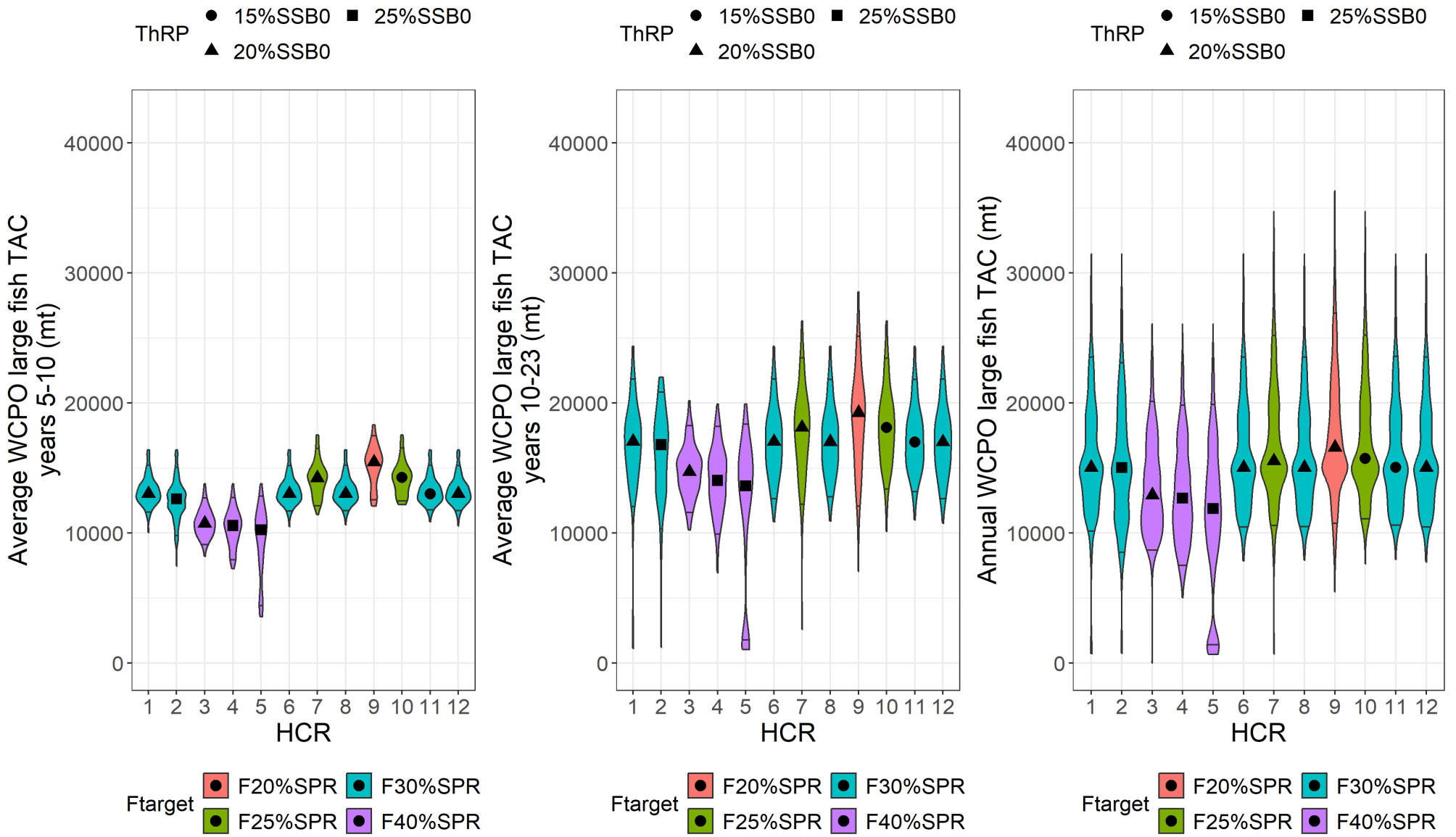
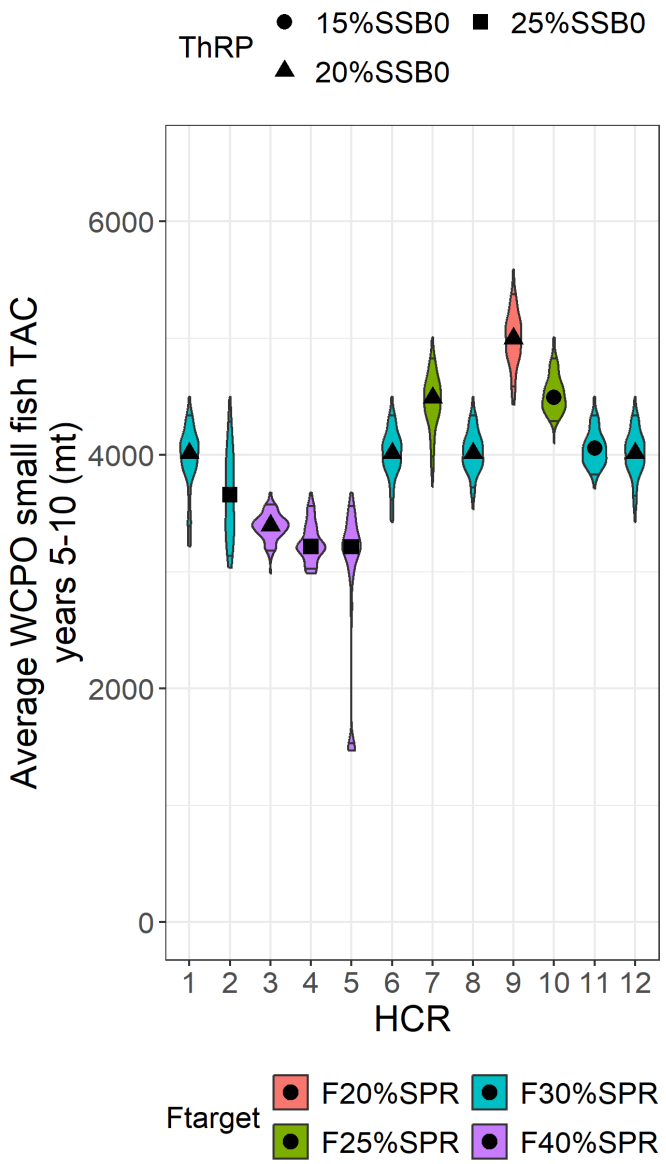
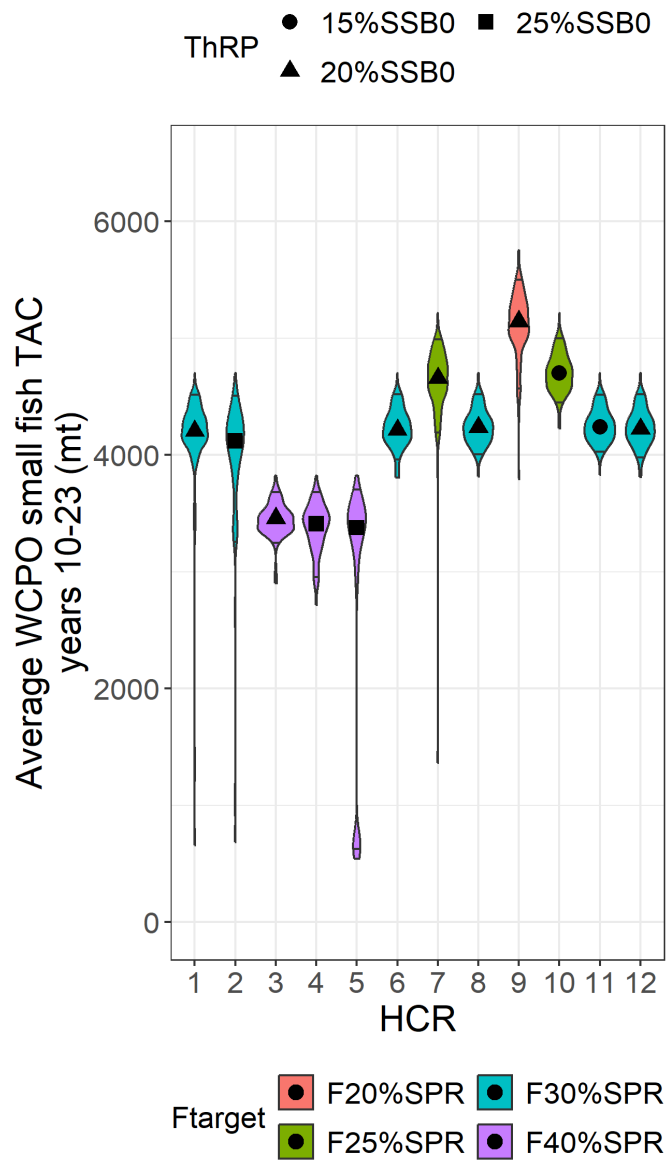
Yield Performance Metric 2-4 – WCPO large fish

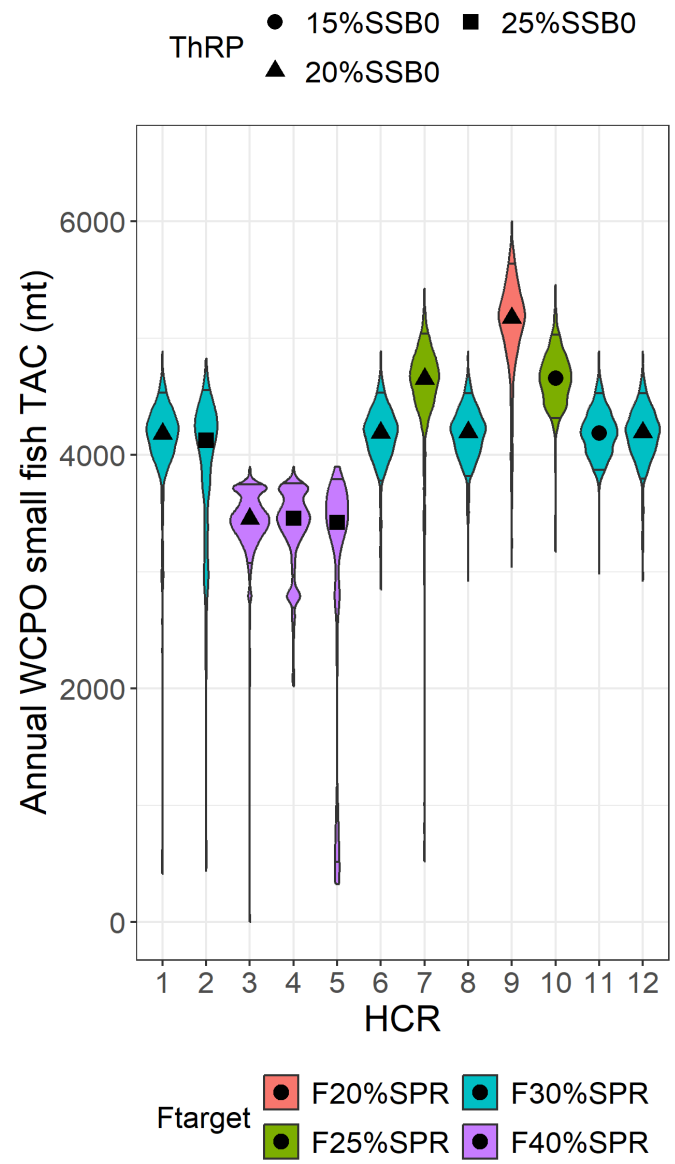


- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Yield Performance Metric 2-4 – WCPO small fish

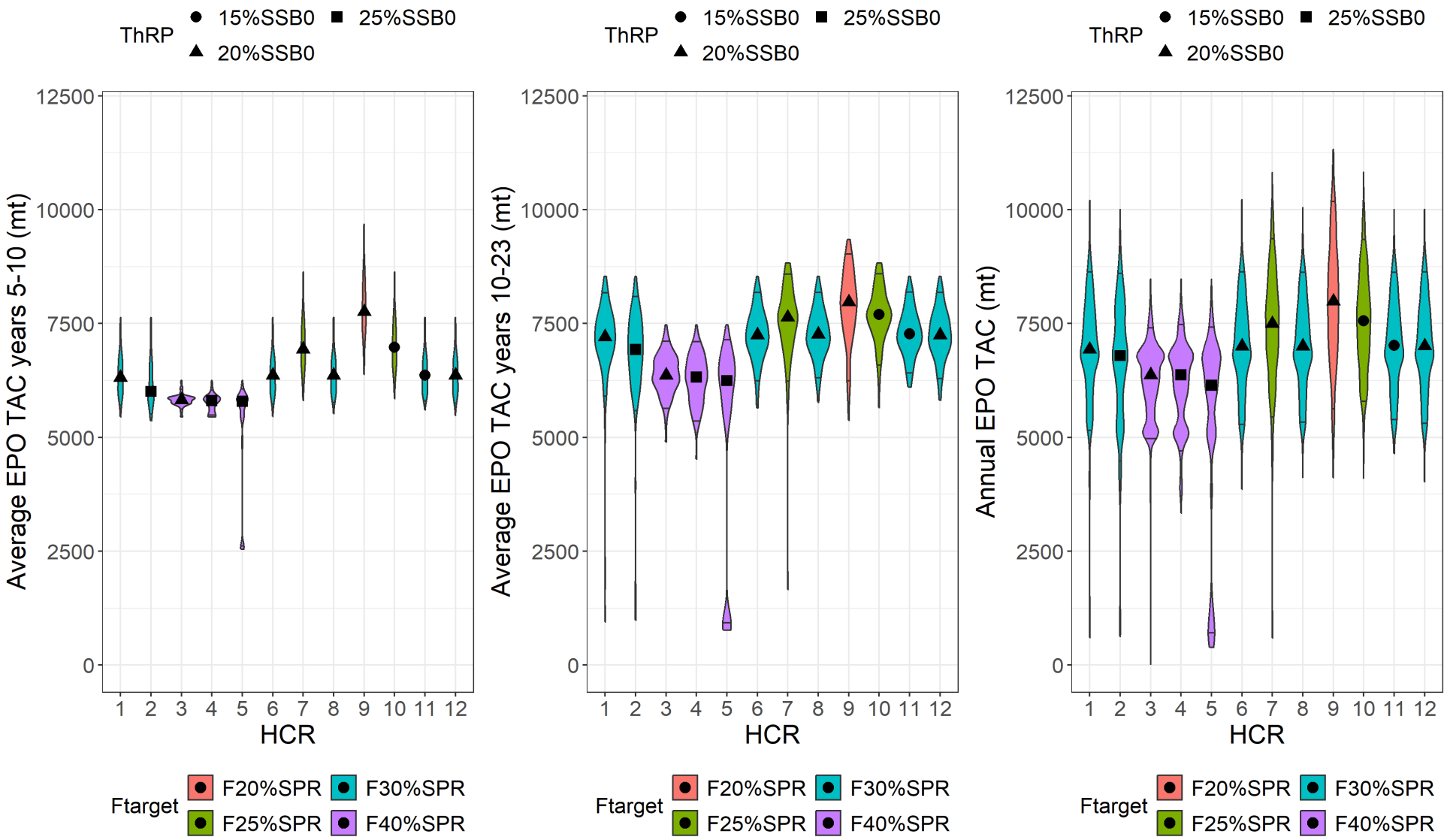






- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

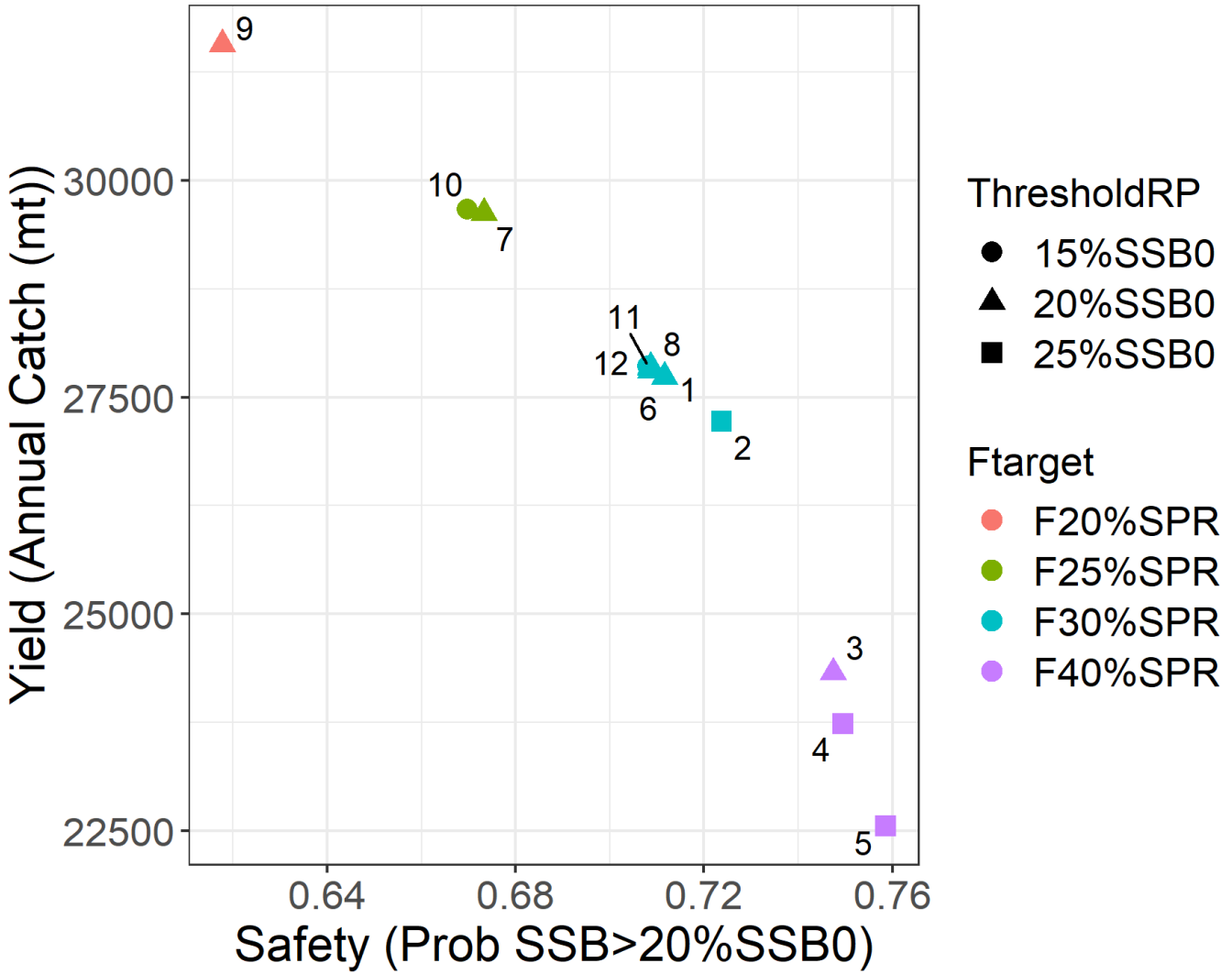
Yield Performance Metric 2-4 – EPO



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Tradeoff between Performance Indicators - Yield and Safety

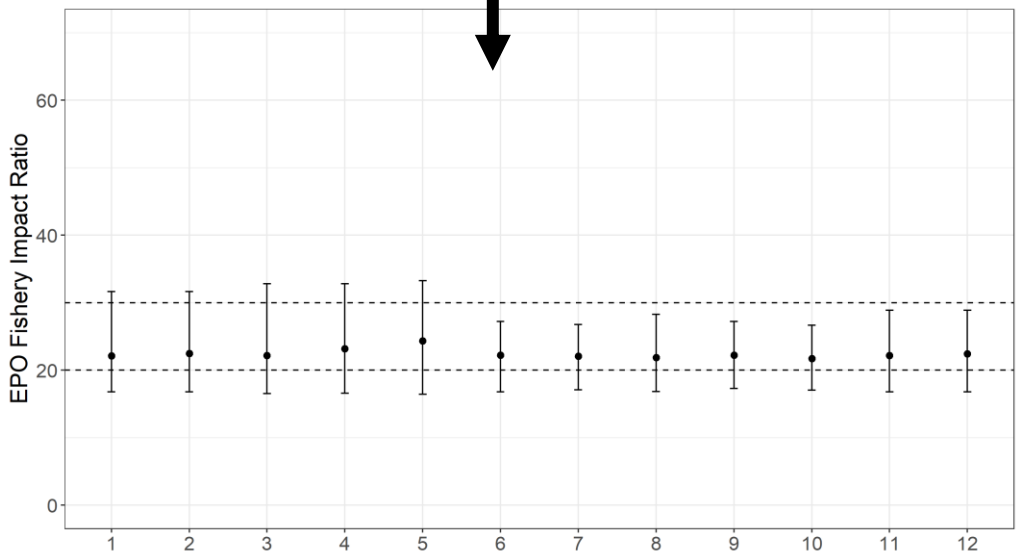
HCRs with a similar F_{target} perform similarly



Final Results will be presented across all 20 OMs – example output using simulations with no estimation error

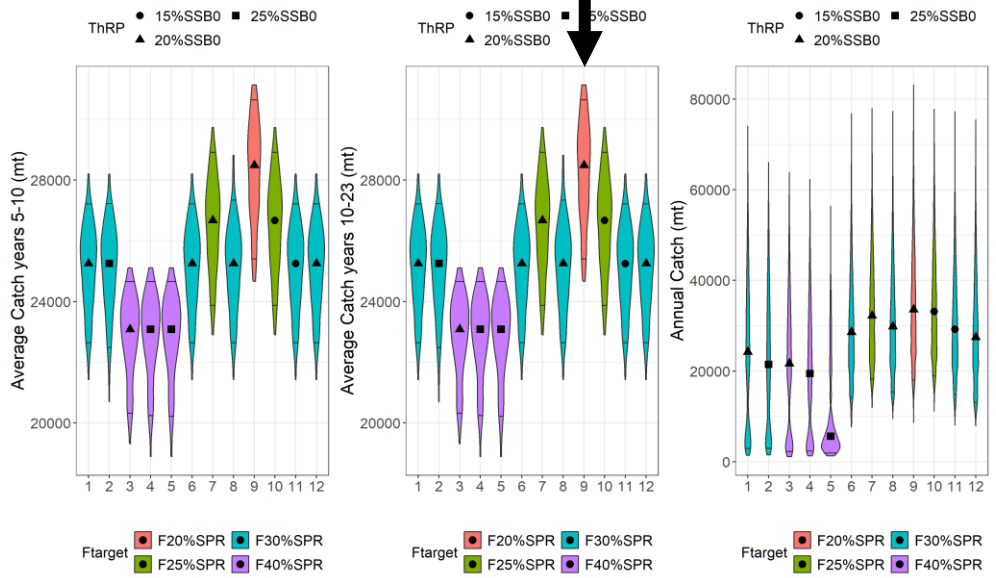
20 OPERATING MODELS

"True" Population dynamics

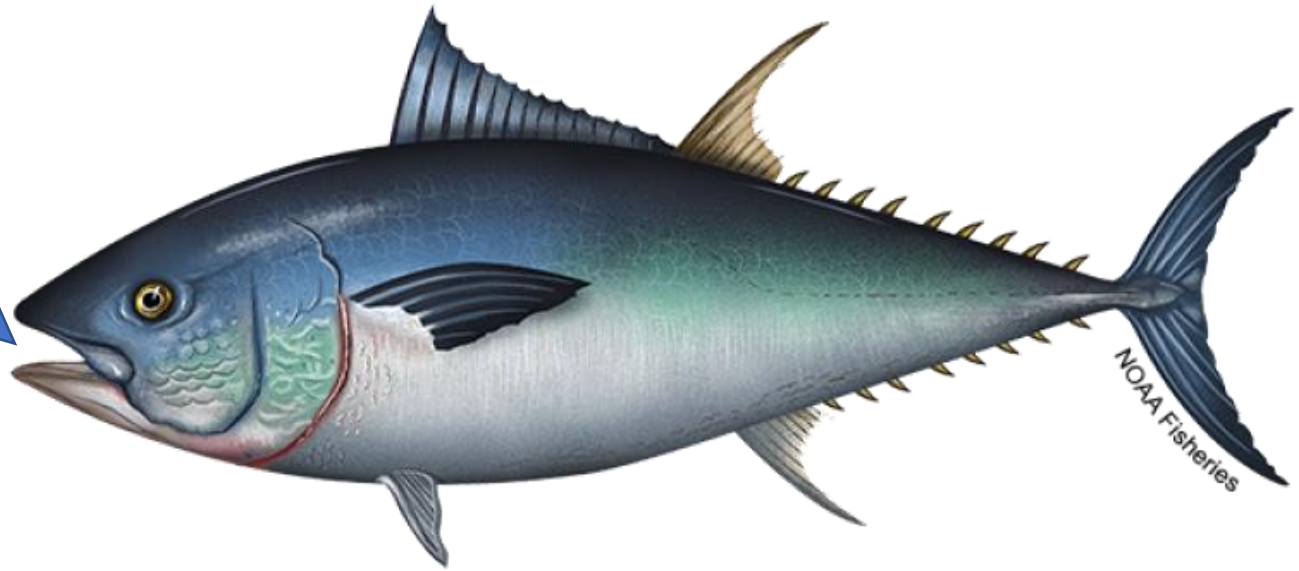


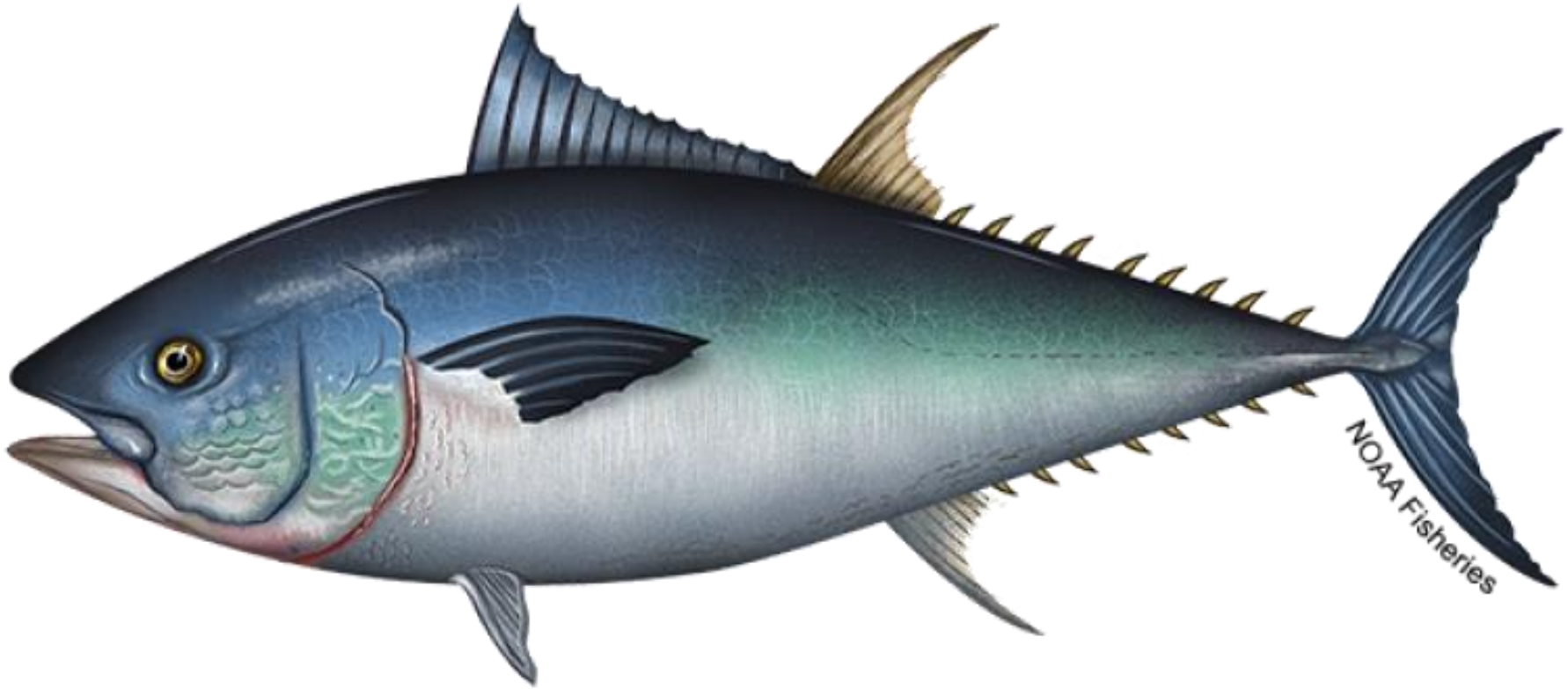
20 OPERATING MODELS

"True" Population dynamics



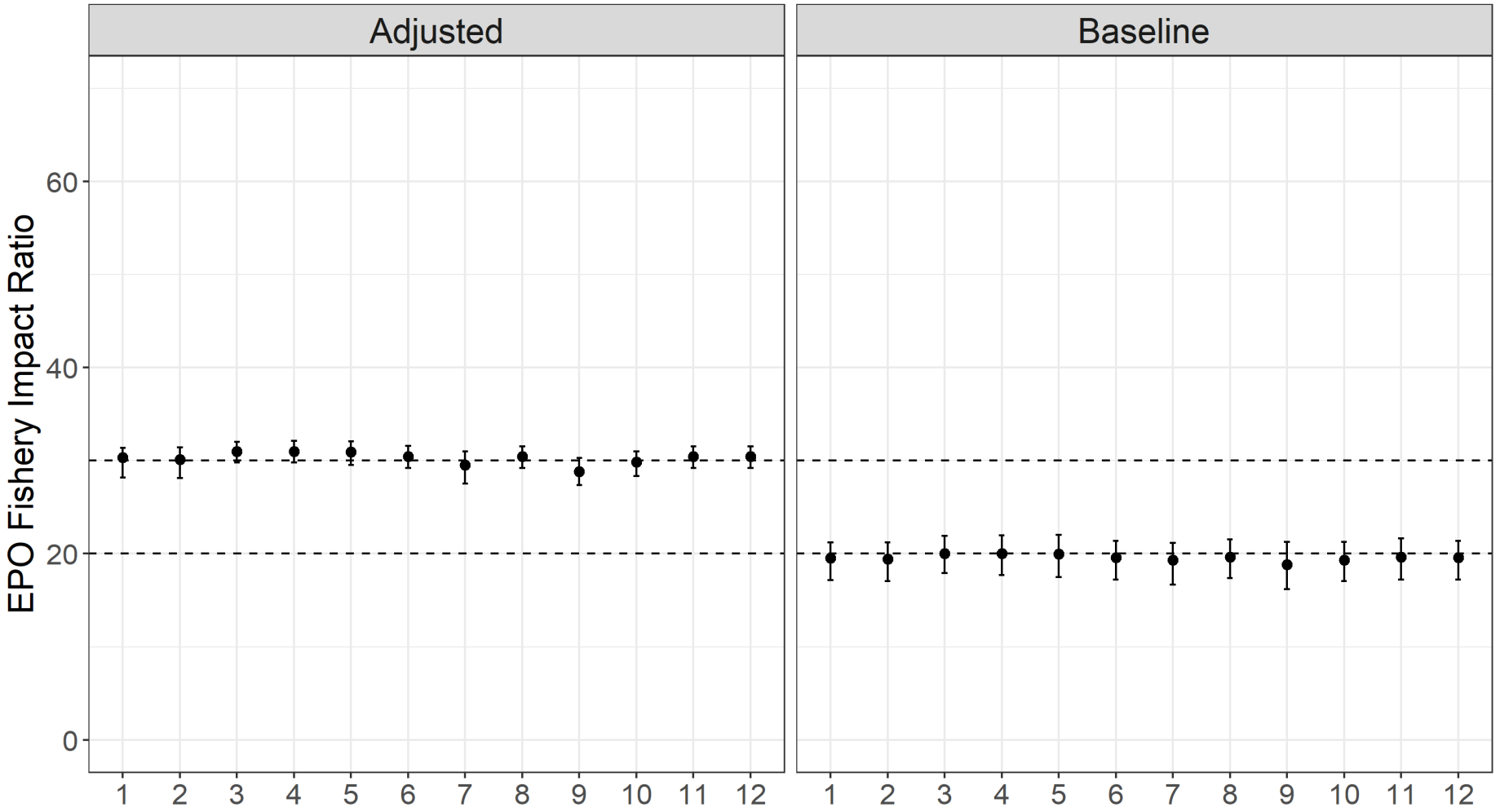
Questions?
Suggestions?
Are there other plots you'd like to see?
What was unclear? What did you like?





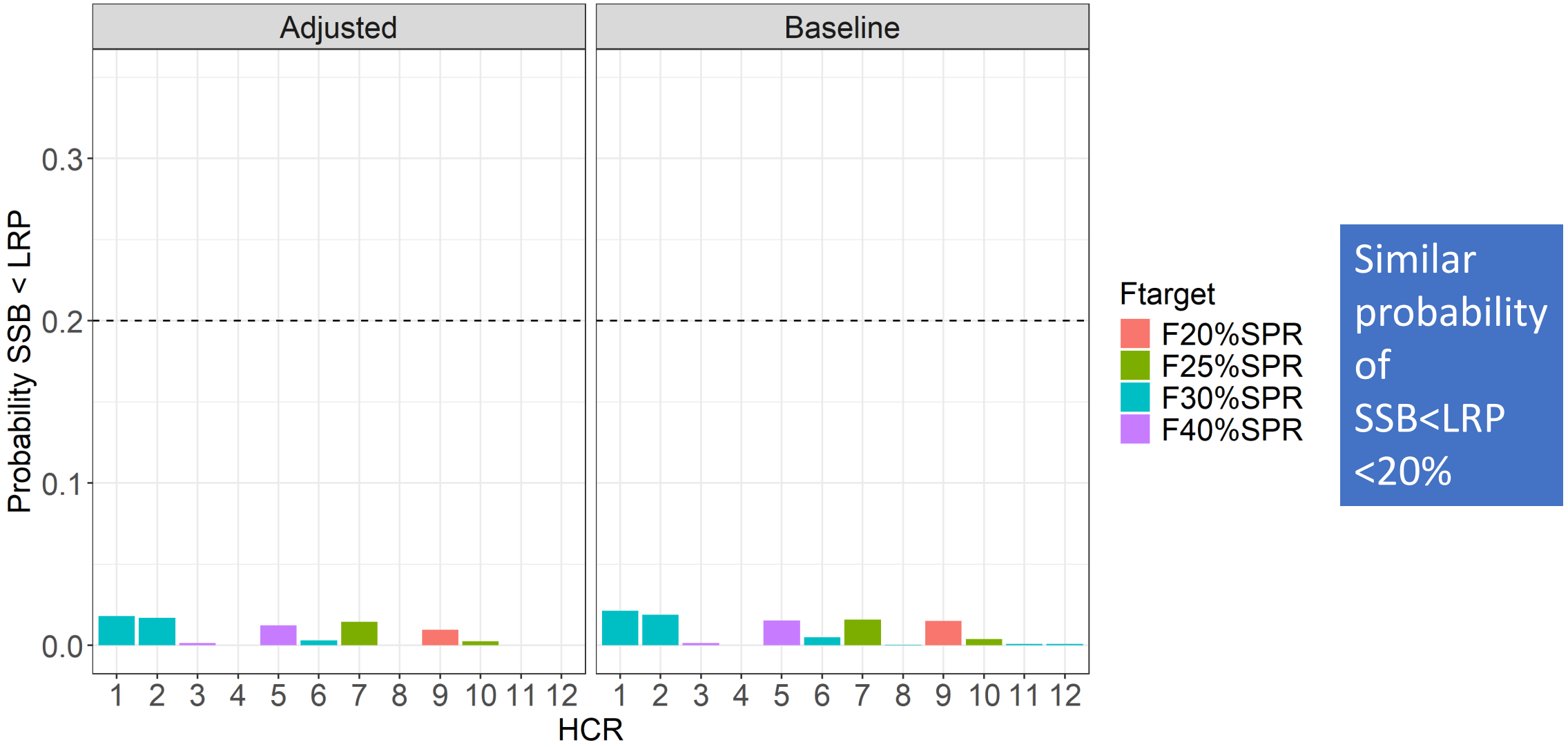
Results tuned to 30:70 EPO:WCPO Impact Ratio

Comparison of fishery impact with adjusted baseline to reach 30:70 impact ratio



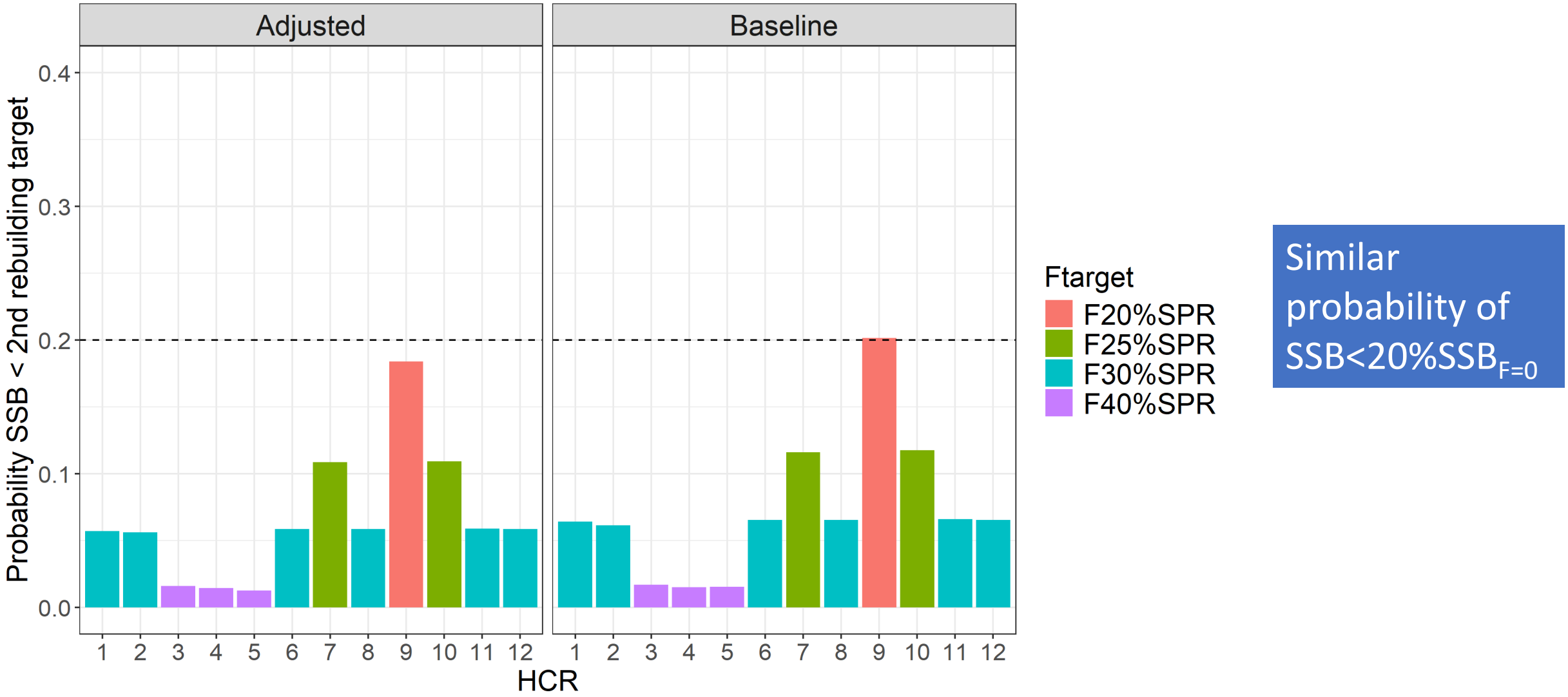
Median EPO impact is around 30 when tuned

Comparison of safety performance metrics with adjusted baseline to reach 30:70 impact ratio



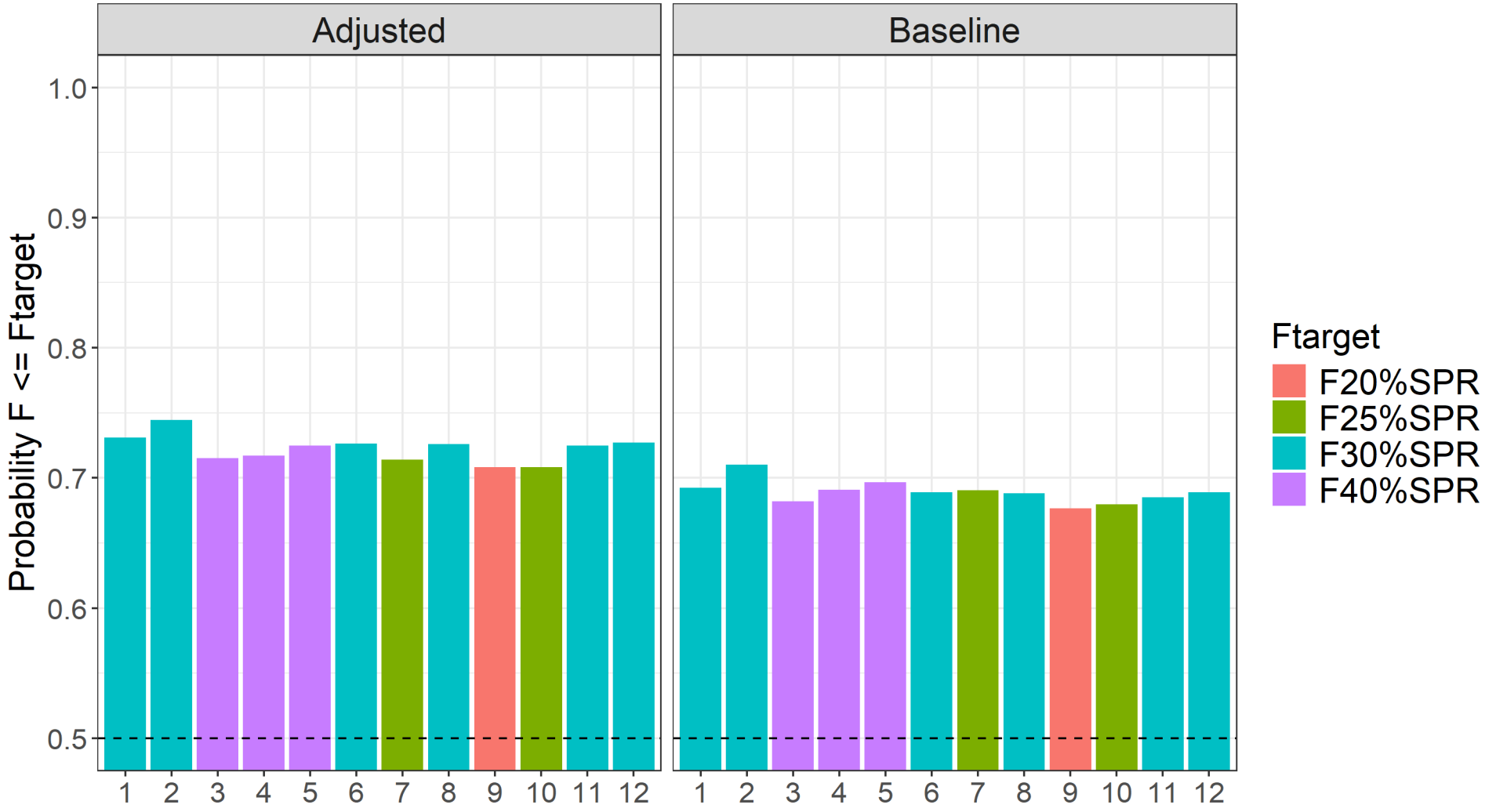
Similar probability of SSB<LRP <20%

Comparison of safety performance metrics with adjusted baseline to reach 30:70 impact ratio



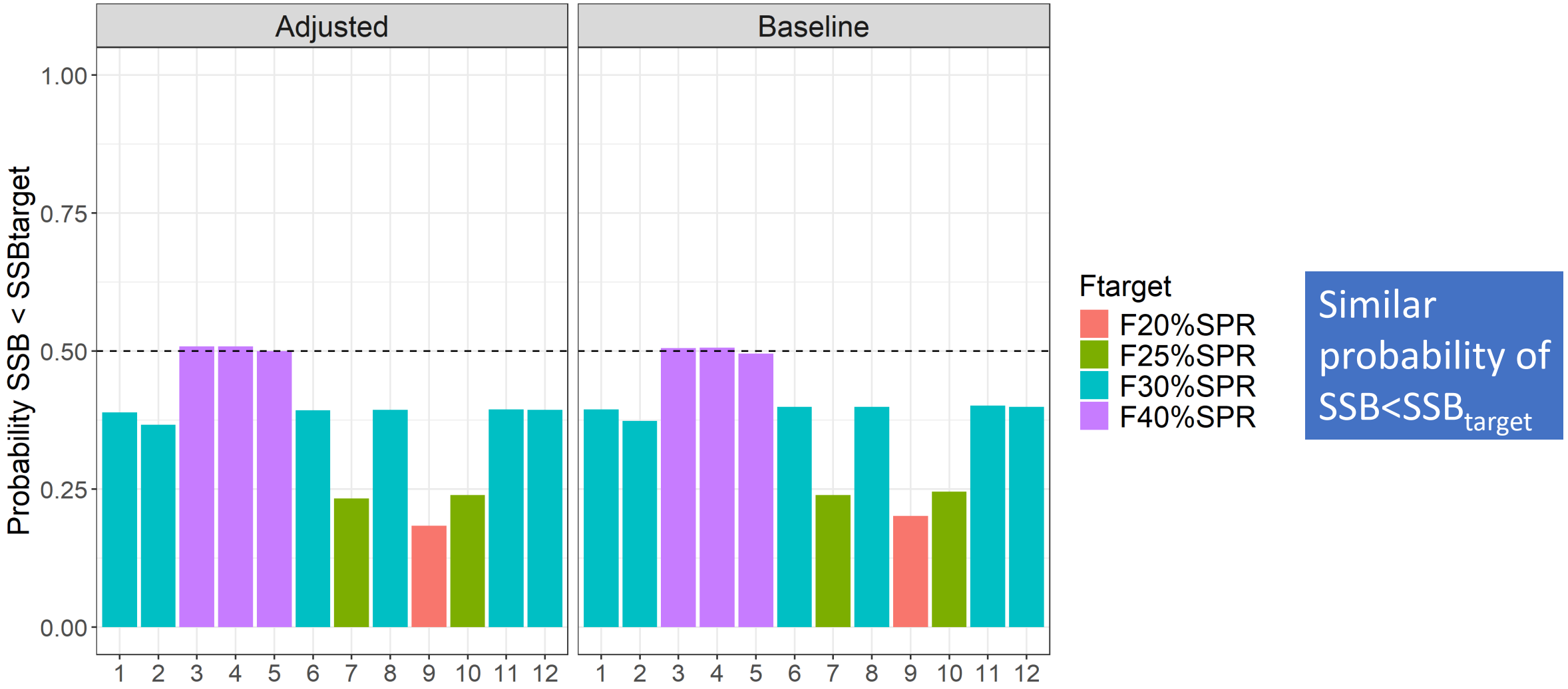
Similar probability of $SSB<20\%SSB_{F=0}$

Comparison of status performance metric



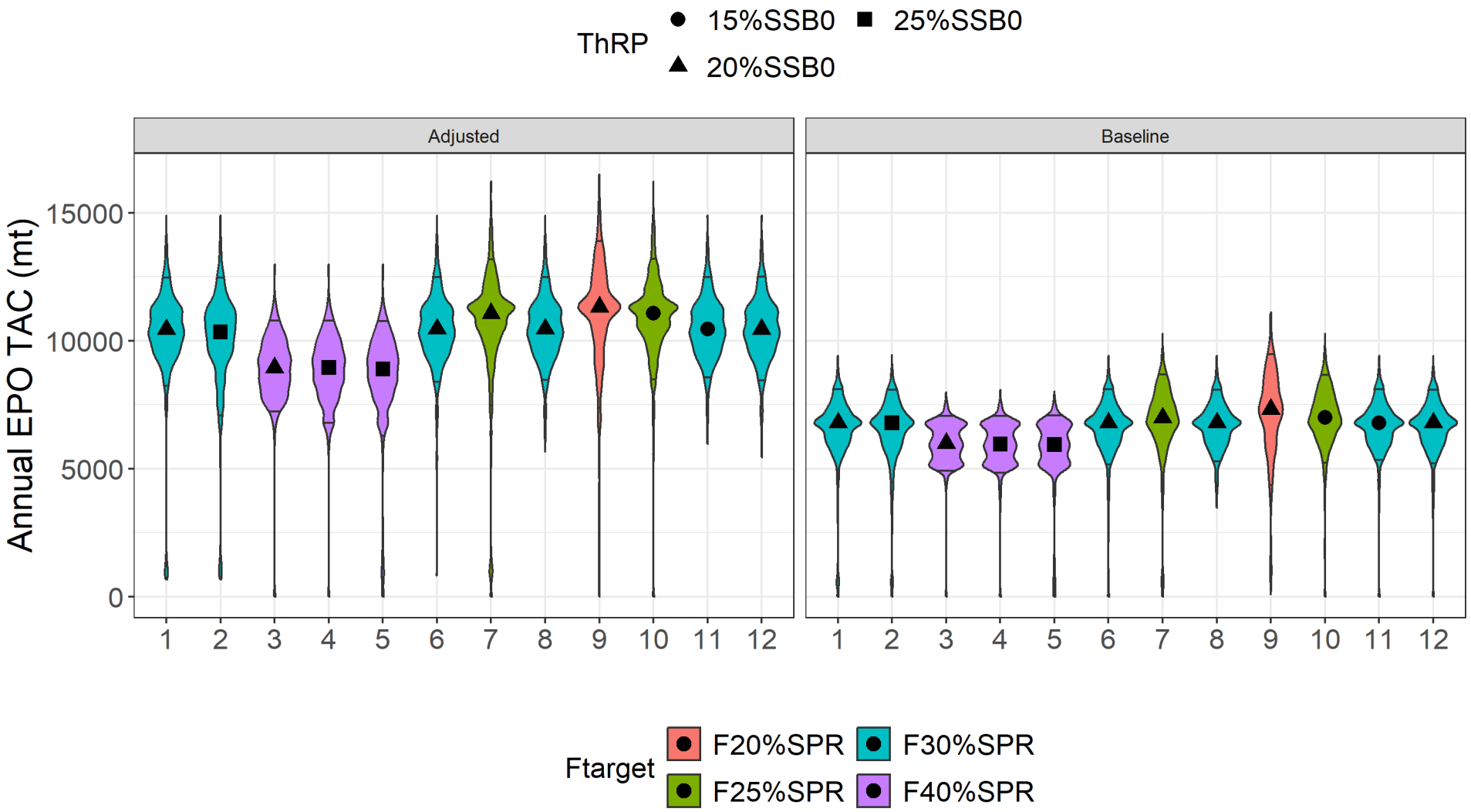
F at or below the F_{target} with a probability of at least 50% for both impact ratios

Comparison of status performance metric 2



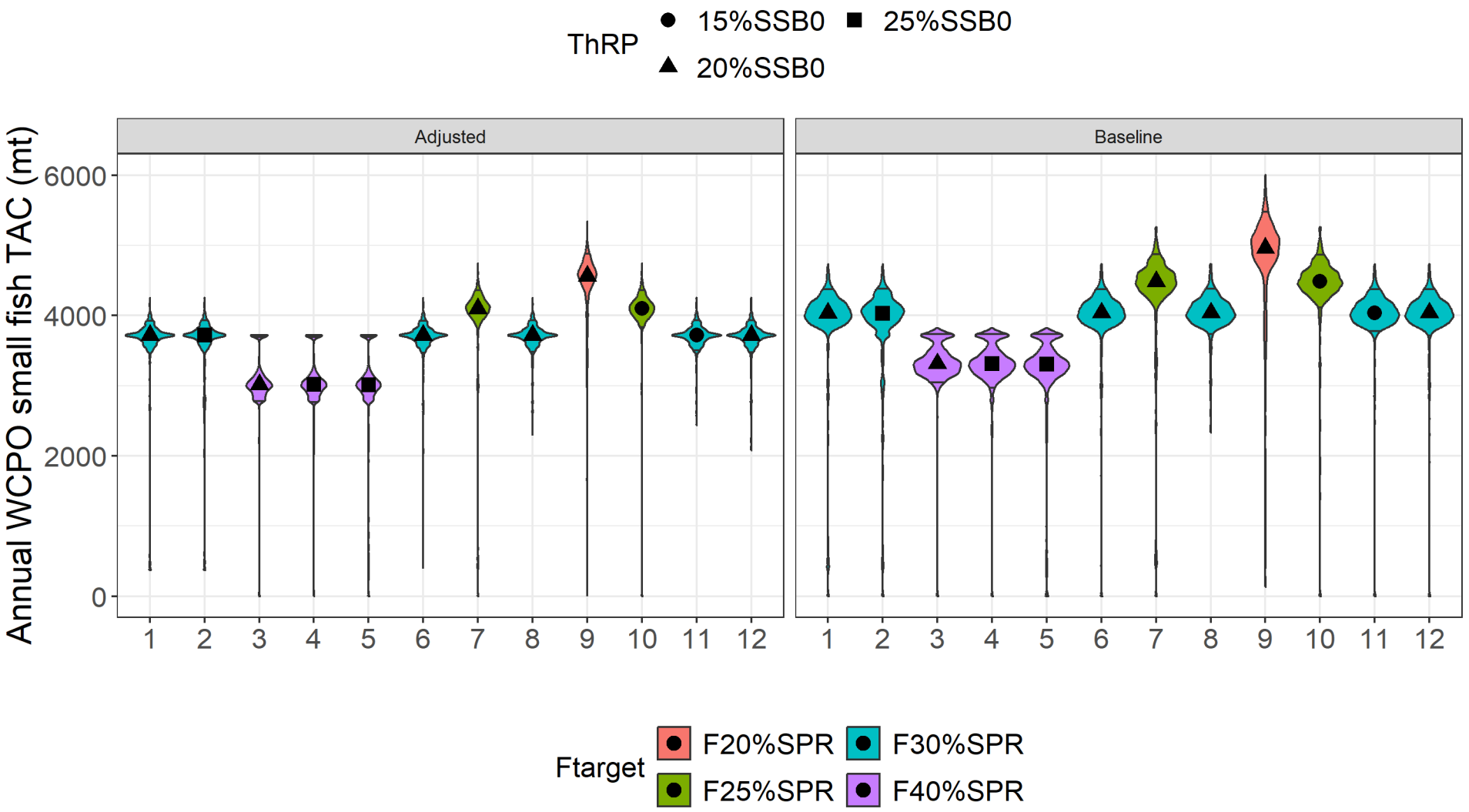
Similar probability of $SSB<SSB_{target}$

Comparison of EPO yield



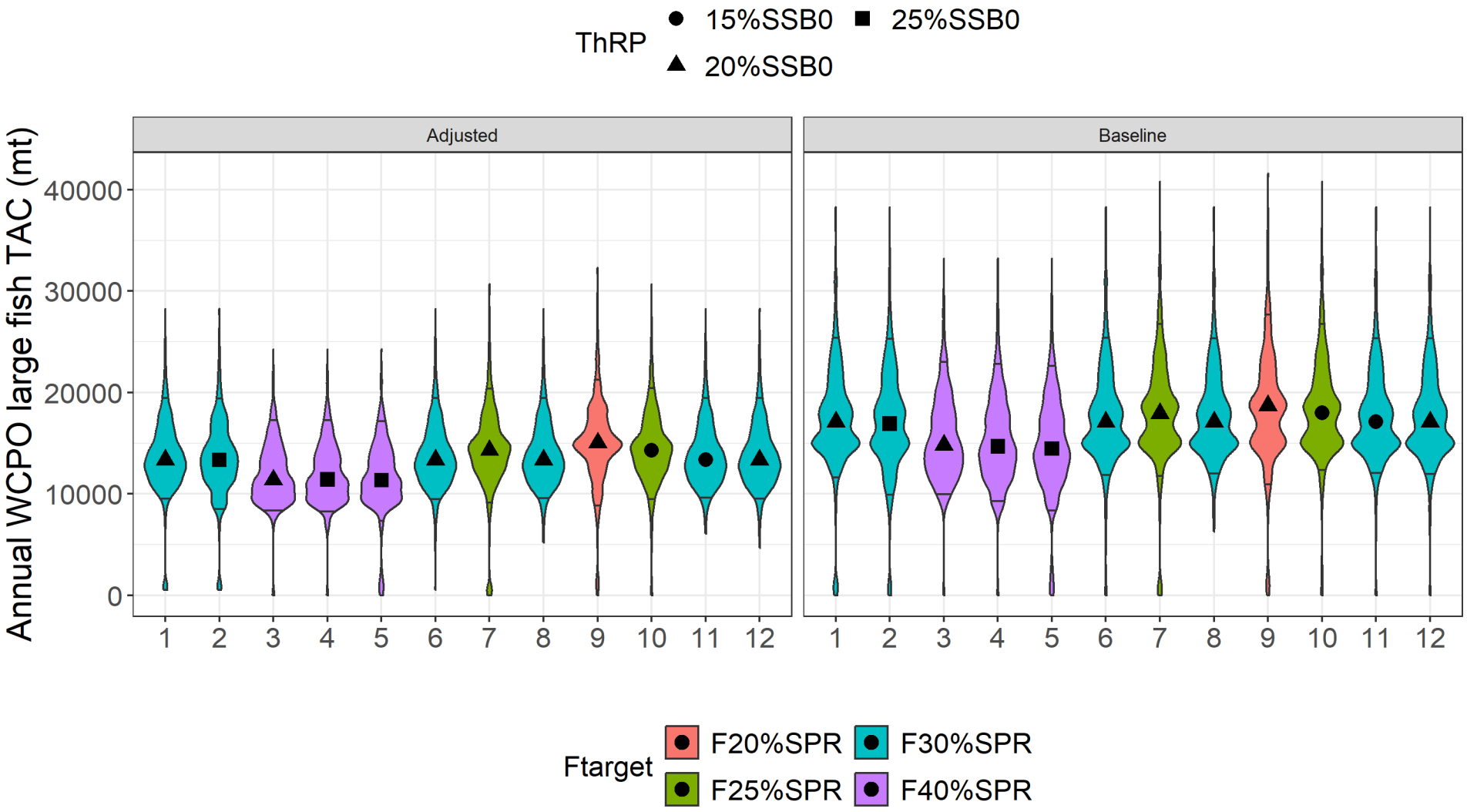
EPO yield higher for 70:30 impact ratio due to the increase in EPO relative exploitation

Comparison of WCPO small fish yield



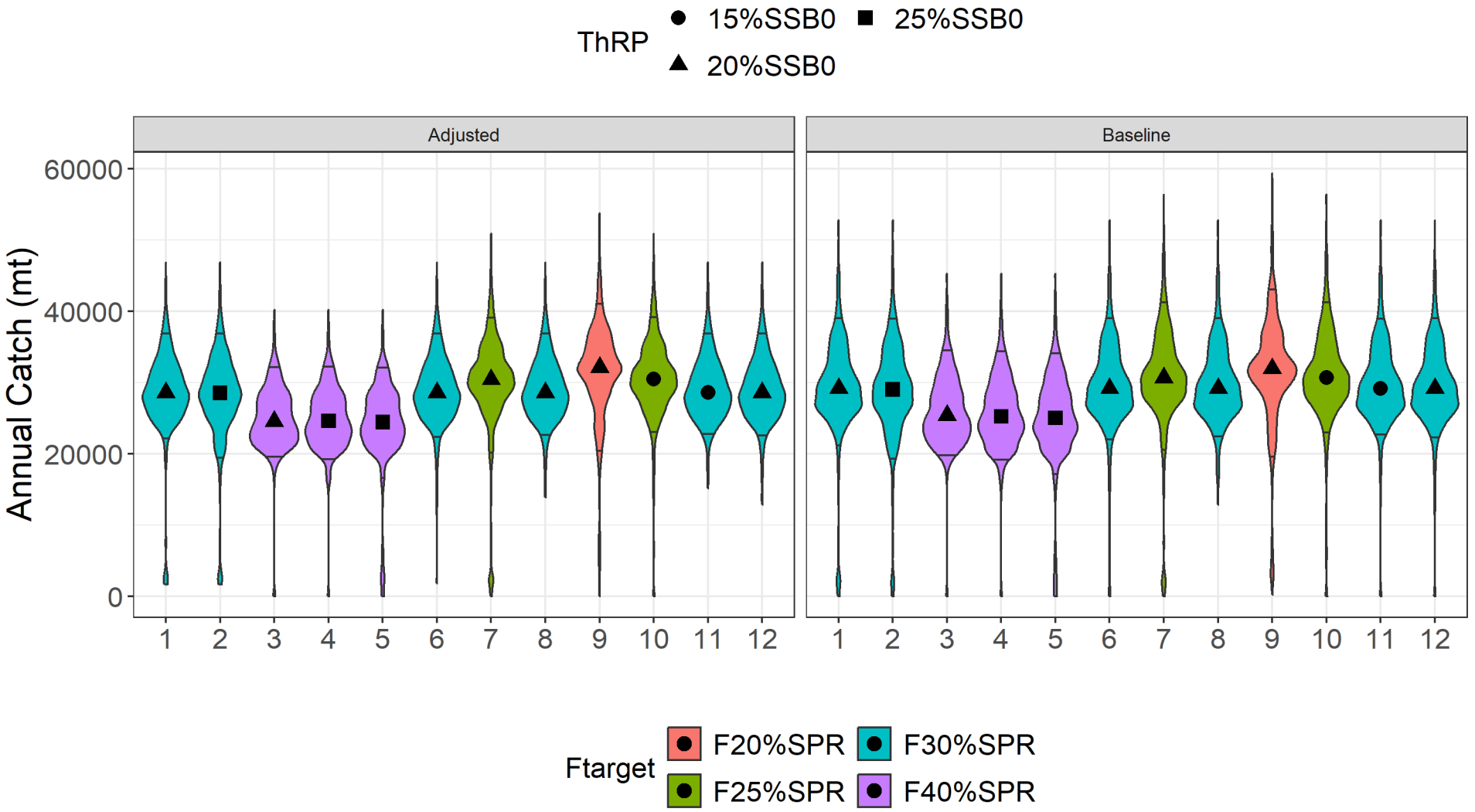
WCPO small fish catch metrics lower for 70:30 impact ratio due to the decrease in WCPO relative exploitation

Comparison of WCPO large fish yield



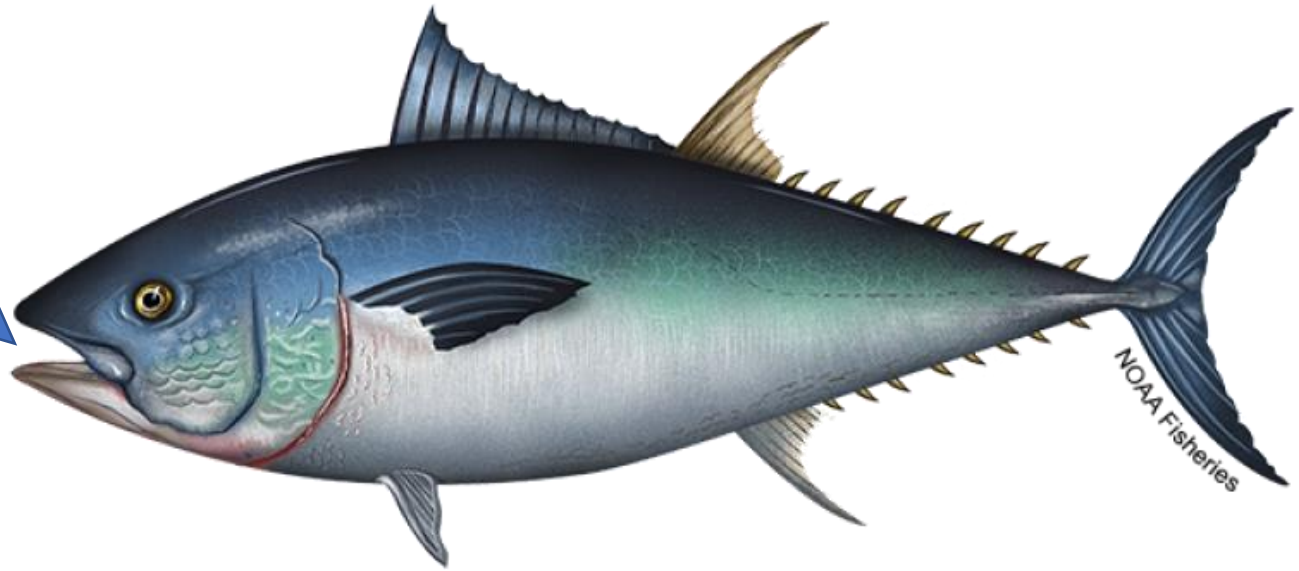
WCPO large fish catch metrics lower for 70:30 impact ratio due to the decrease in WCPO relative exploitation

Comparison of total yield

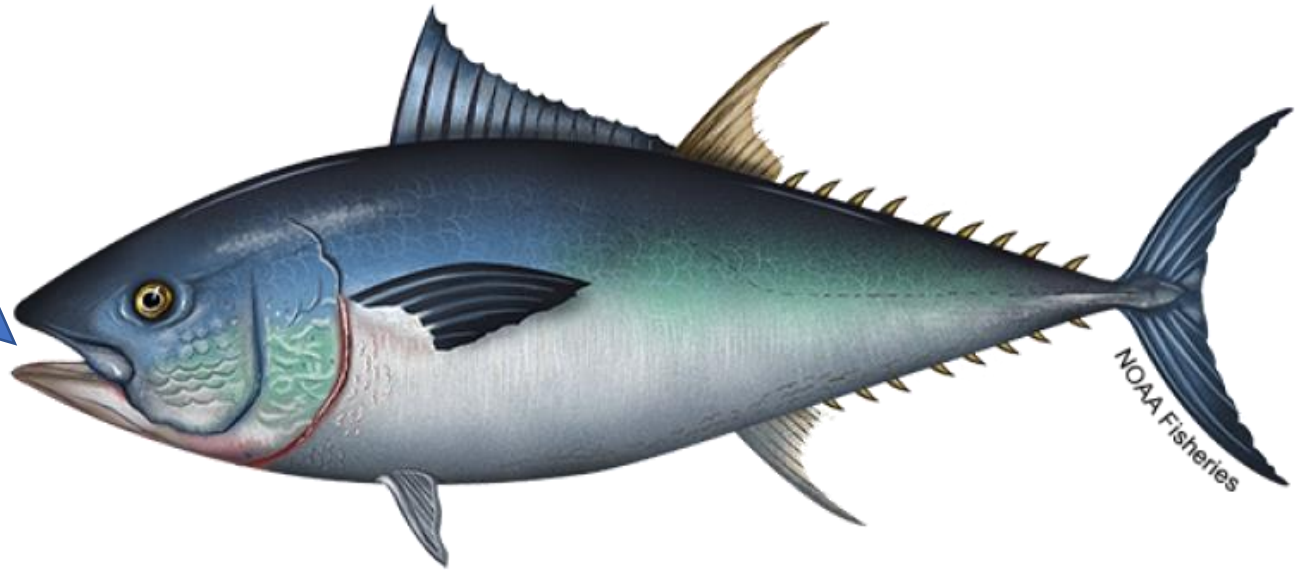


- Total Catch comparable
- Change in relative exploitation pattern only impacted EPO and WCPO yield performance metrics

Questions?
Suggestions?
Are there other plots you'd like to see?
What was unclear? What did you like?

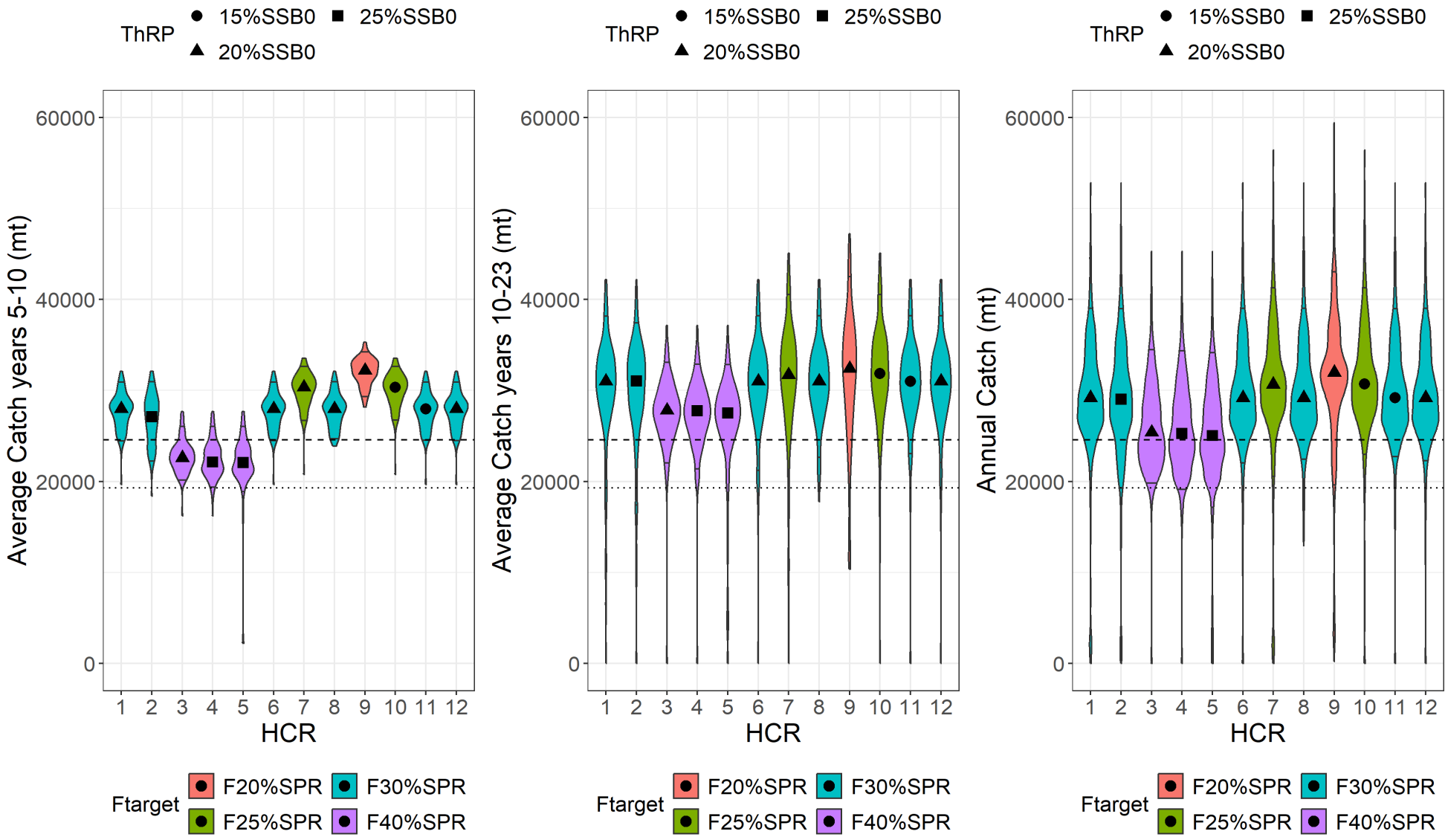


Thank you!



Optional Plots

Yield Performance Metric 2-4 – Total Catch



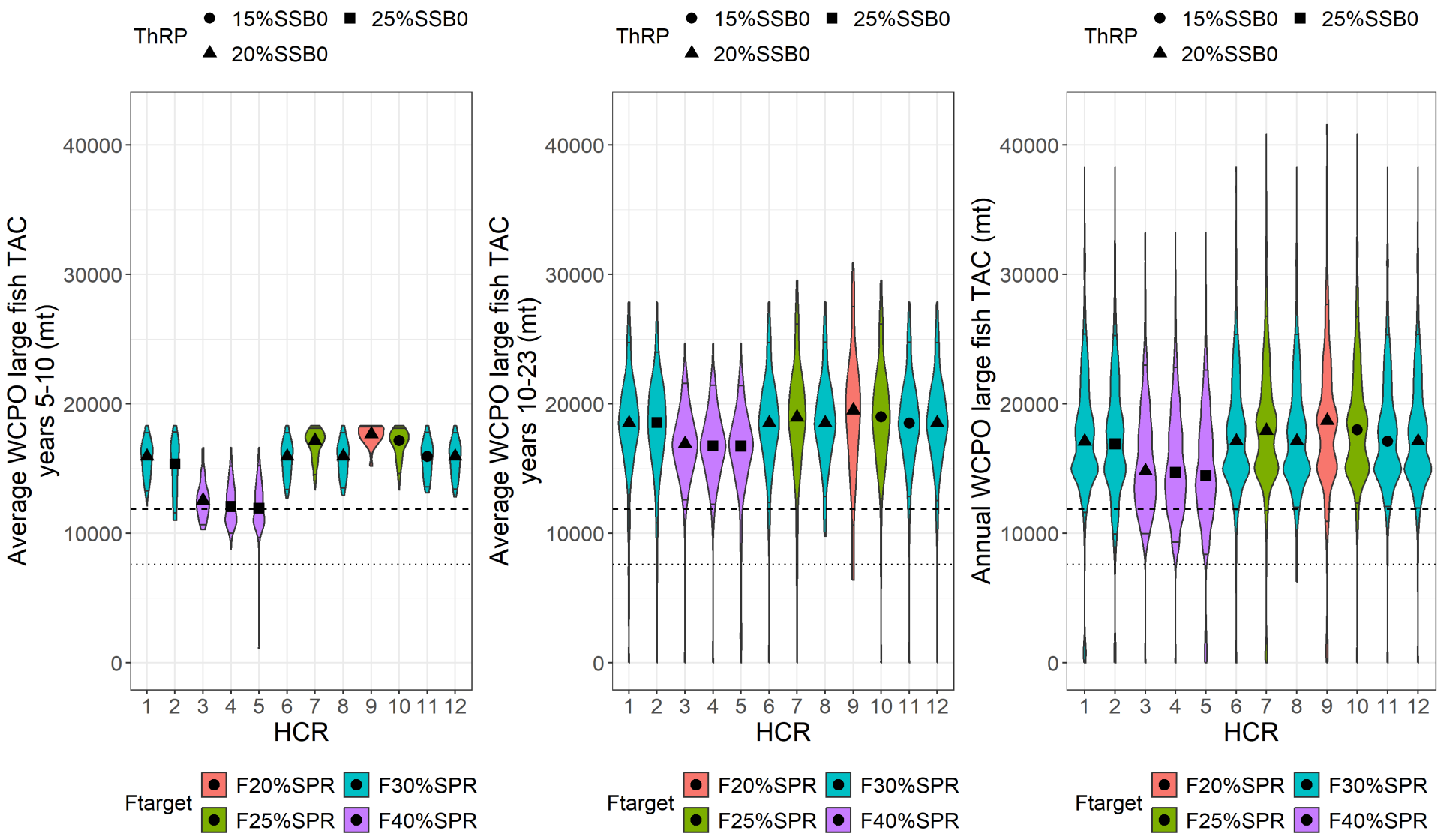
- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

CMM 23-02 + Resolution C-21-05 (one-year maximum)

CMM 24-01 + Resolution C-24-02 (one-year maximum)

*Note the MSE total catch also includes discards and EPO recreational catches

Yield Performance Metric 2-4 – WCPO large fish



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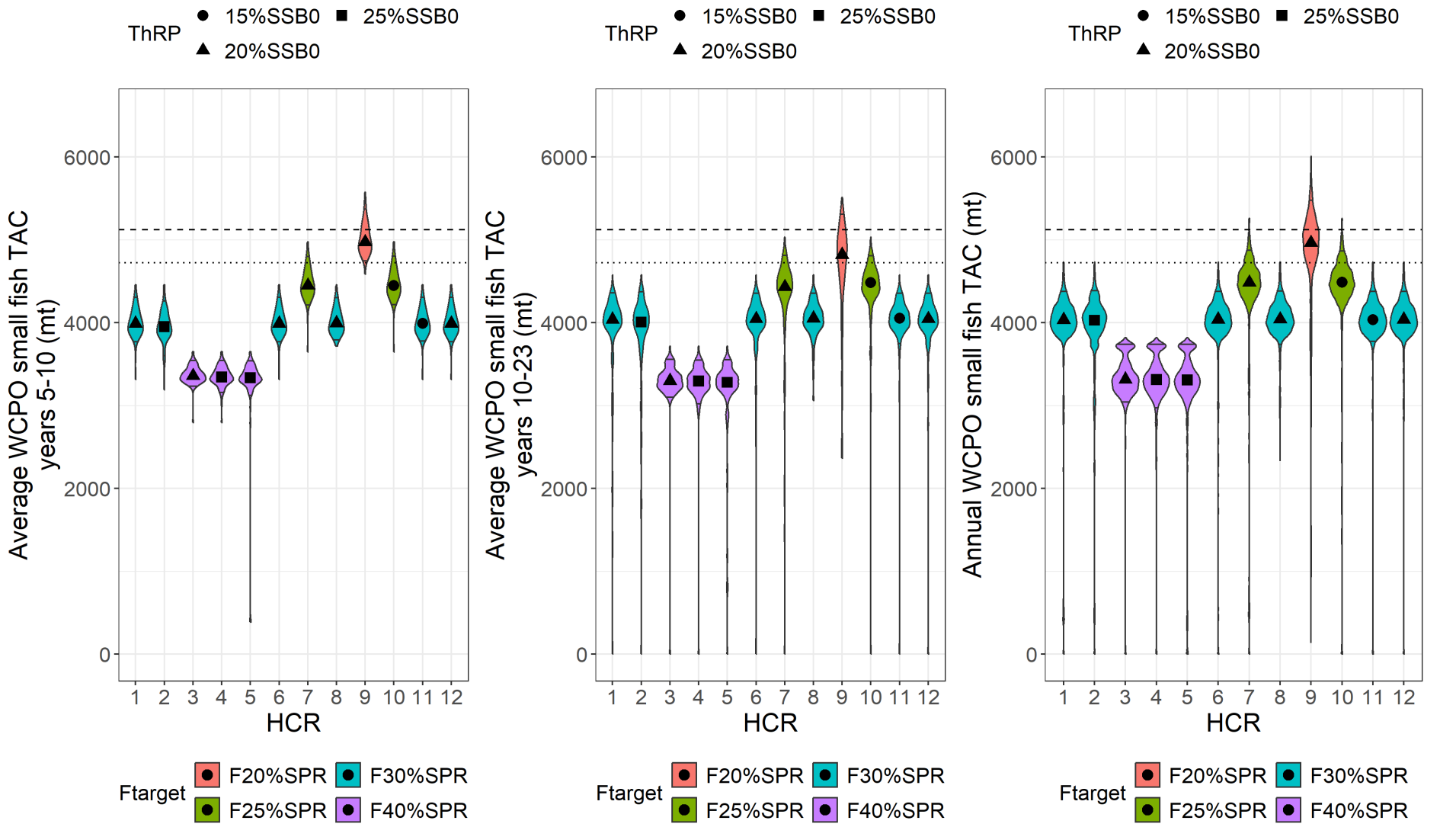
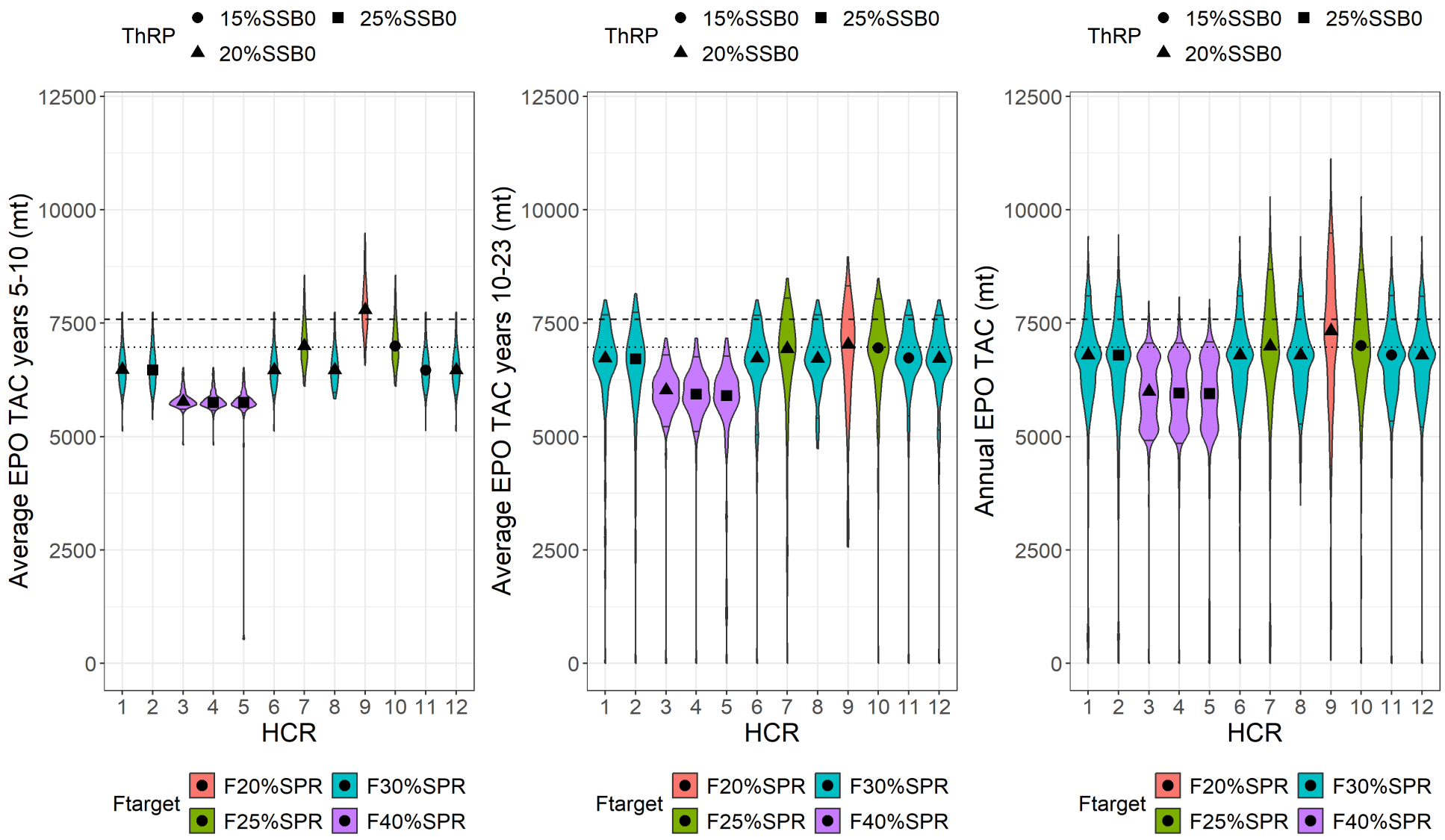
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Yield Performance Metric 2-4 – WCPO small fish



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Yield Performance Metric 2-4 – EPO



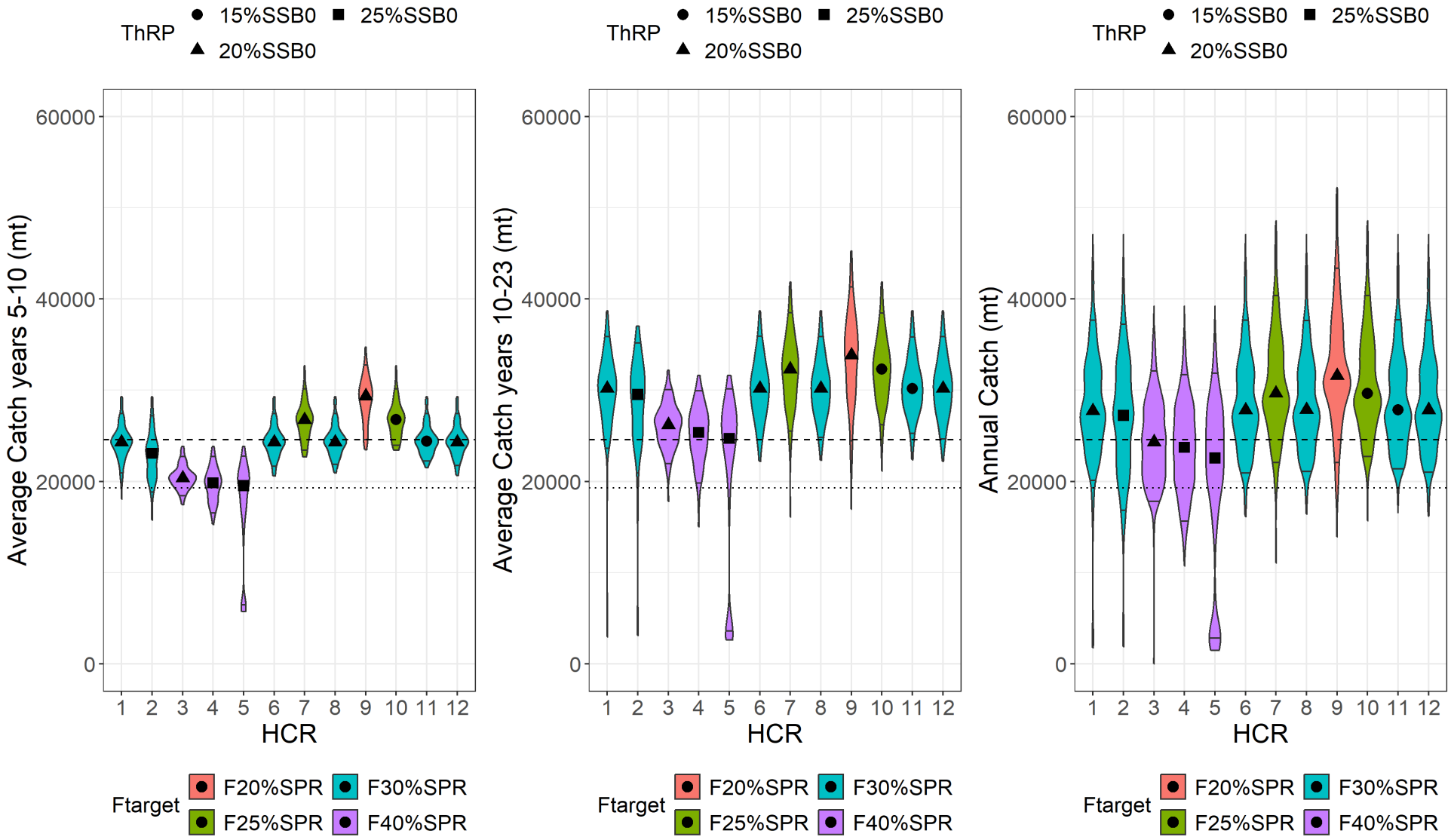
- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Resolution C-21-05 (one-year maximum)

Resolution C-24-02 (one-year maximum)

*Note the MSE total EPO TAC also includes EPO recreational catches

Yield Performance Metric 2-4 – Total Catch OM3



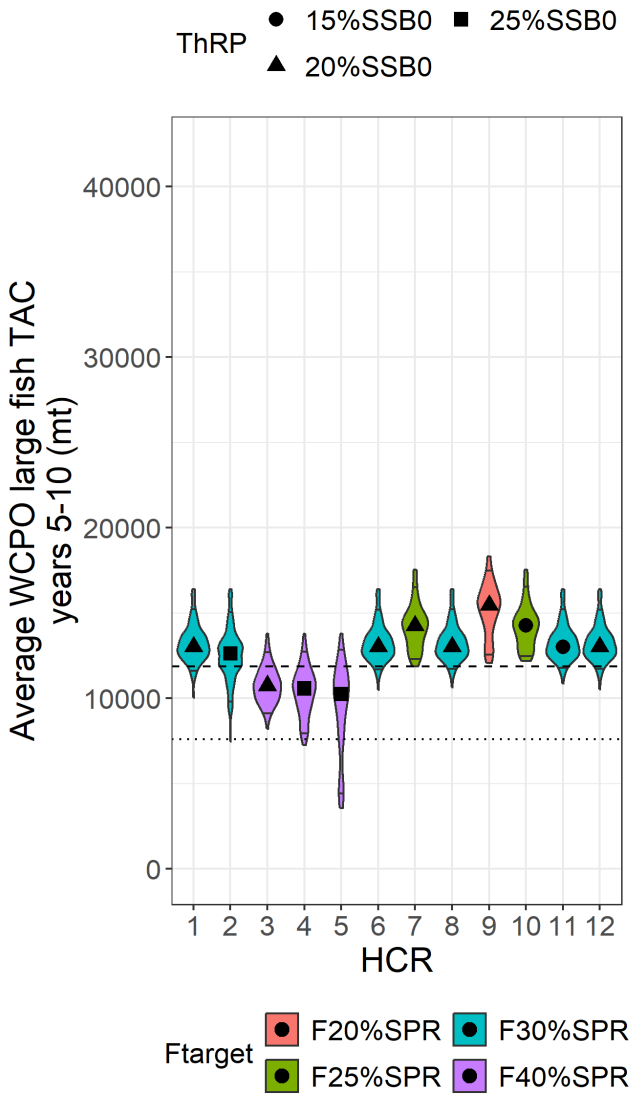
- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

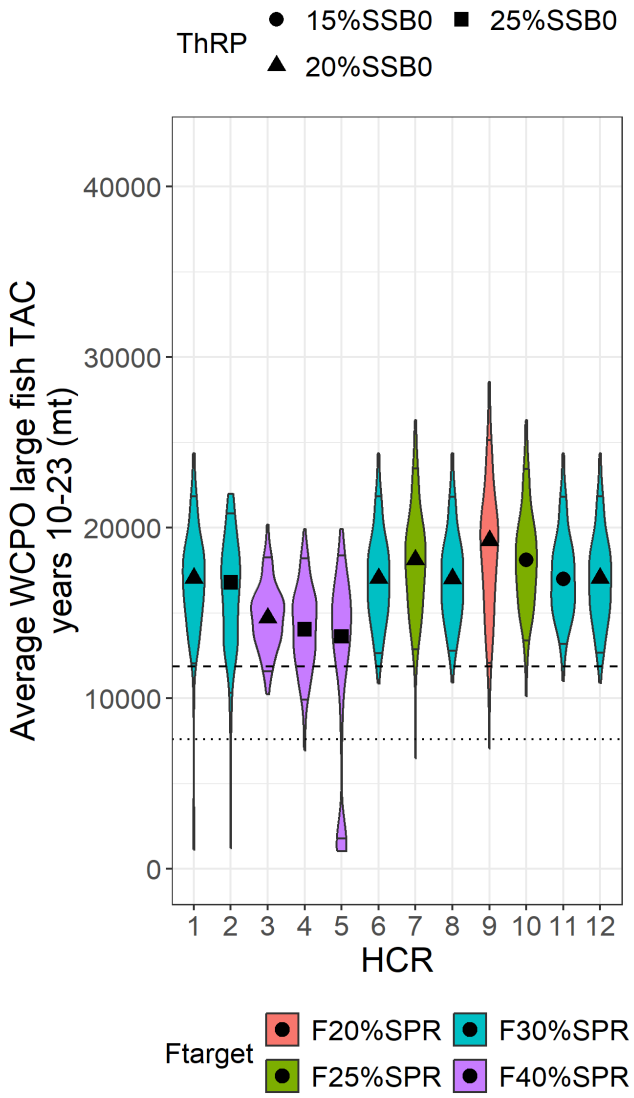
CMM 23-02 + Resolution C-21-05 (one-year maximum)

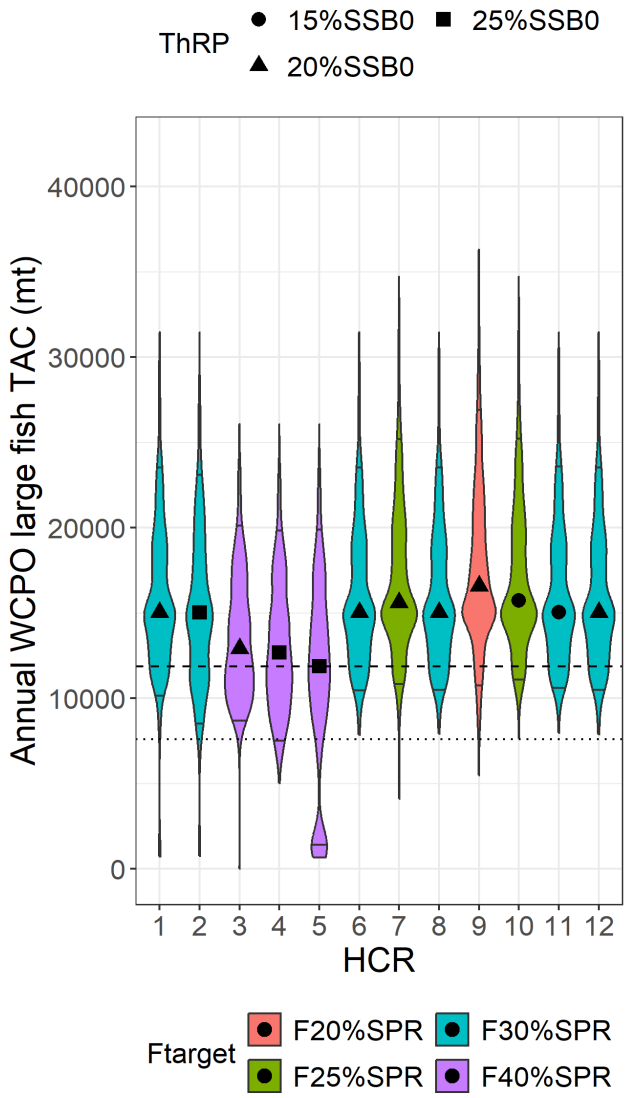
CMM 24-01 + Resolution C-24-02 (one-year maximum)

*Note the MSE total catch also includes discards and EPO recreational catches

Yield Performance Metric 2-4 – WCPO large fish OM3



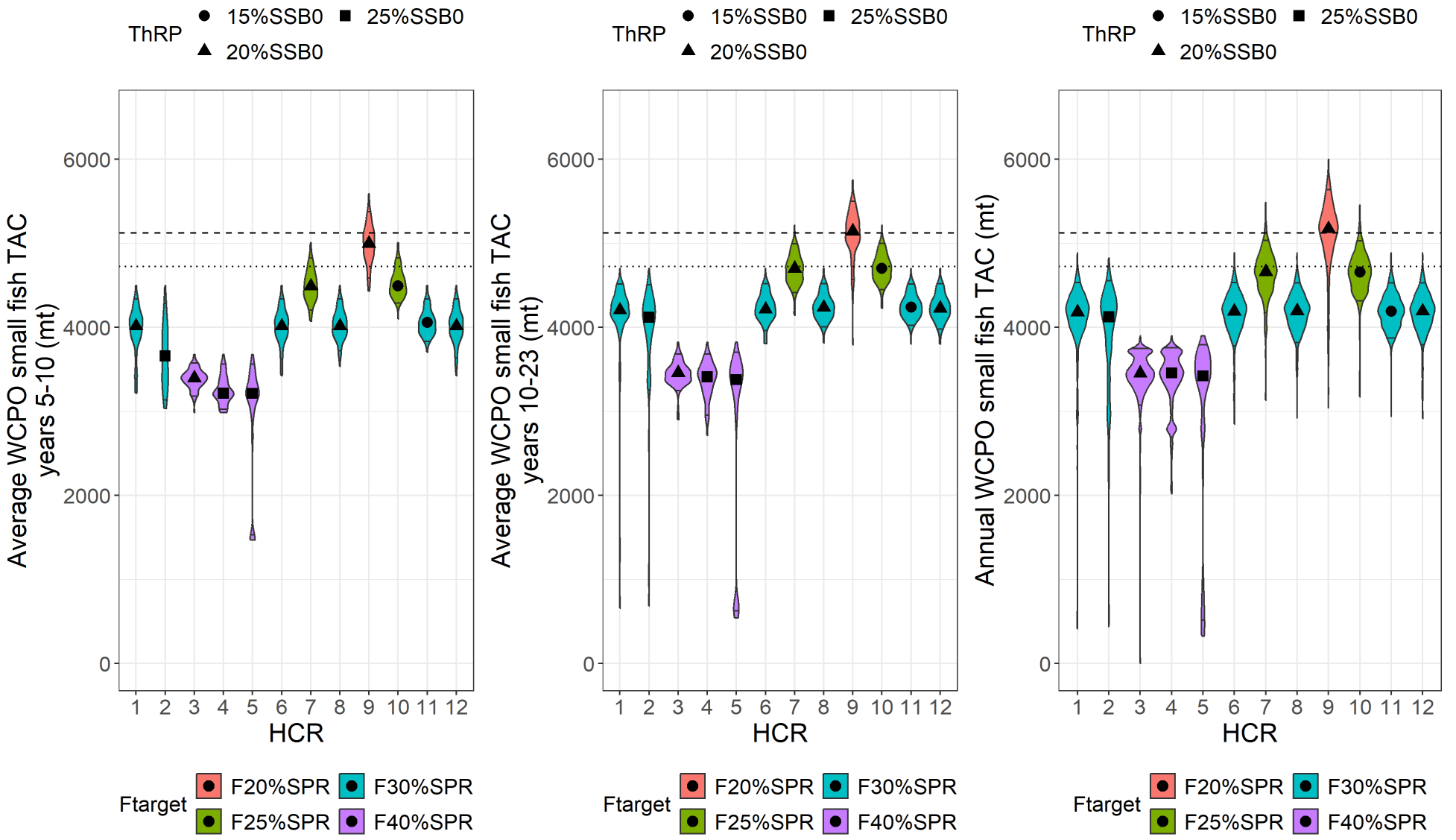




CMM 23-02 CMM 24-01

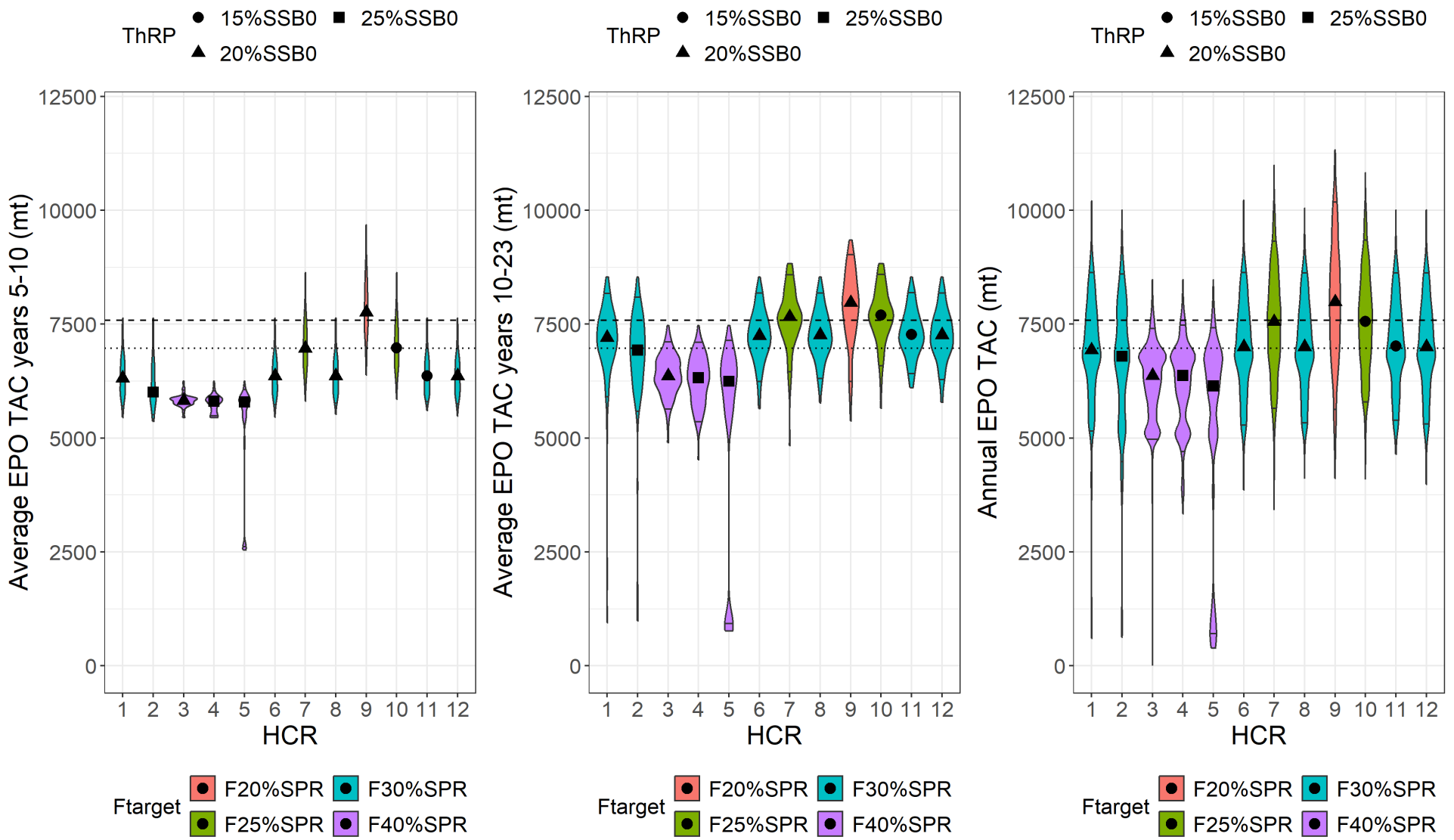
- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Yield Performance Metric 2-4 – WCPO small fish OM3



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Yield Performance Metric 2-4 – EPO OM3



- *OBJECTIVE: To maximize yield over the medium (5-10 years) and long (10-30 years) terms, as well as average annual catch yield from the fishery.*
- *OBJECTIVE: To increase average annual catch in all fisheries across WCPO and EPO*

Resolution C-21-05 (one-year maximum)

Resolution C-24-02 (one-year maximum)

*Note the MSE total EPO TAC also includes EPO recreational catches

Tradeoff between Performance Indicators - Yield and Safety