

Supplemental Materials for Data Rich but Model Resistant: An Evaluation of Data-Limited Methods to Manage Fisheries with Failed Age-based Stock Assessments

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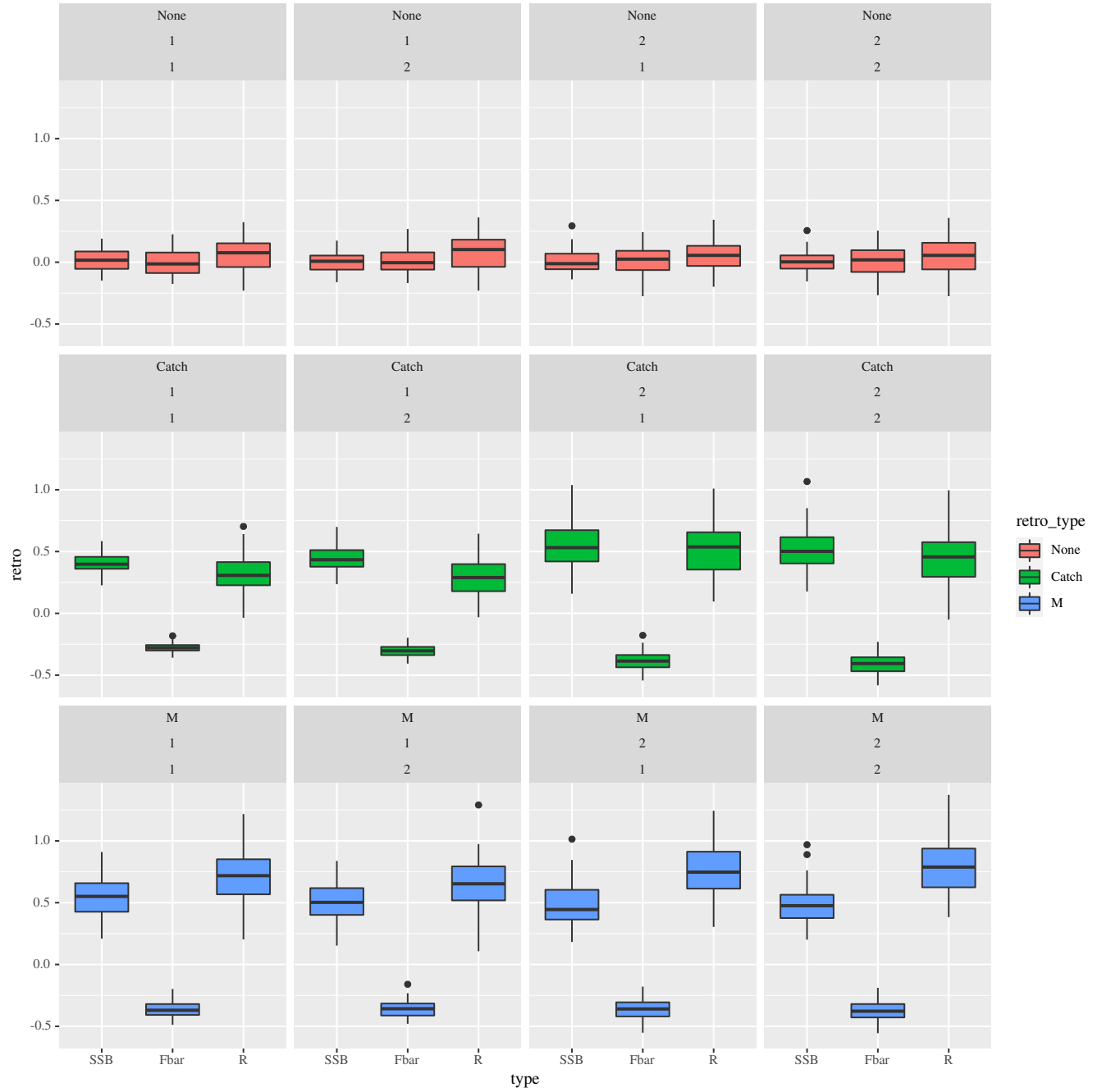


Figure S1. Distribution of 50 Mohn's rho values for no misspecification (top row), catch misspecification (middle row), and natural mortality misspecification (bottom row) for spawning stock biomass (SSB), fishing mortality rate (Fbar), and recruitment (R). Panels are defined by retrospective type (none, catch, natural mortality), fishing intensity (1=always overfishing, 2=overfishing reducing to Fmsy), and number of selectivity blocks (1 or 2).

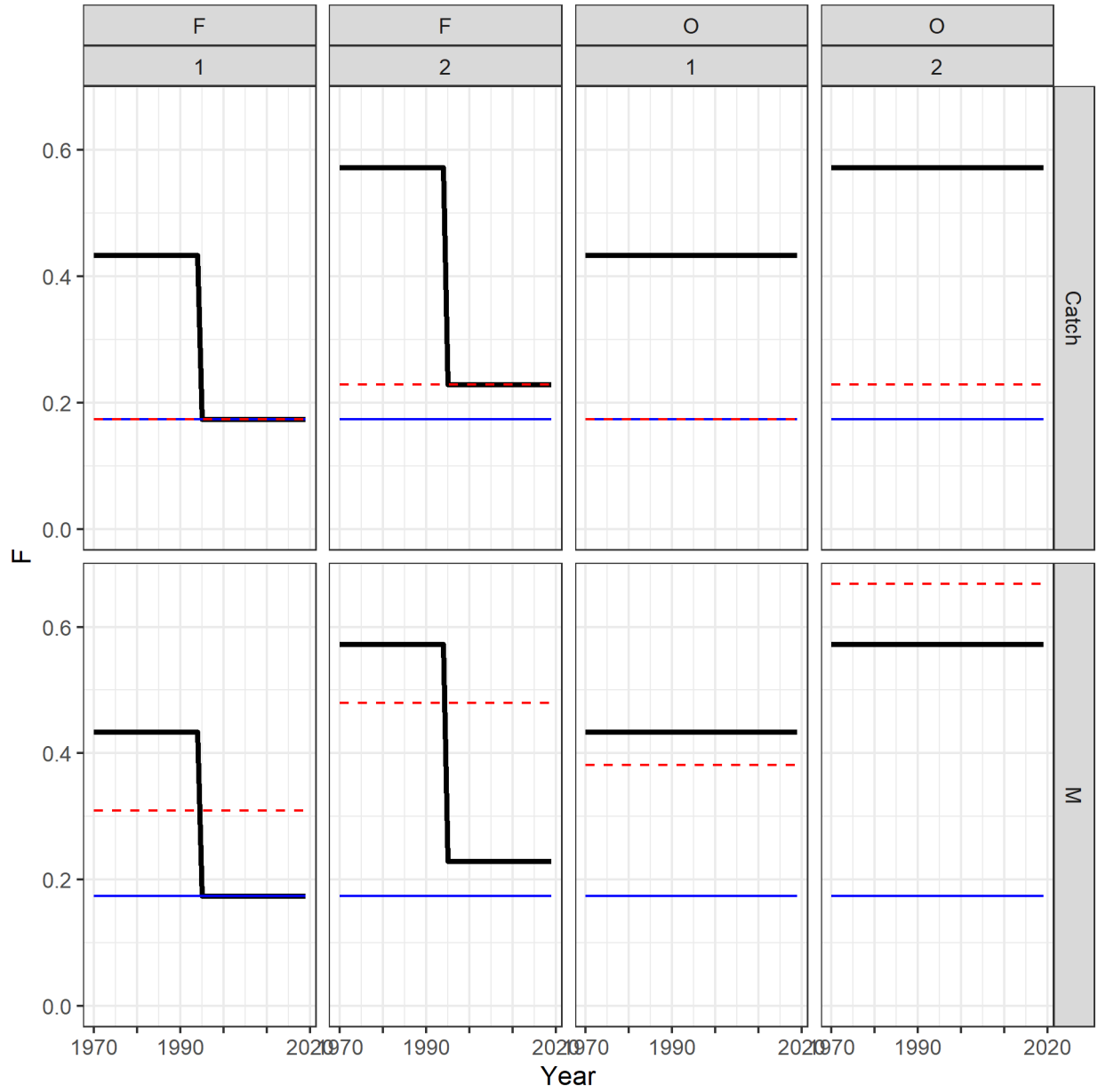


Figure S2. Fishing mortality rate (F) during the base period (black line) for the 8 combinations of F history (F = Fmsy in second half of base period, O = overfishing throughout), number of fishery selectivity blocks (1 or 2), and retrospective source (catch or natural mortality, M). The horizontal blue line denotes the F at maximum sustainable yield (Fmsy) computed from conditions in the first year of the base period (1970) while the red dashed horizontal line denotes the Fmsy computed from conditions in the terminal year in the base period (2019).

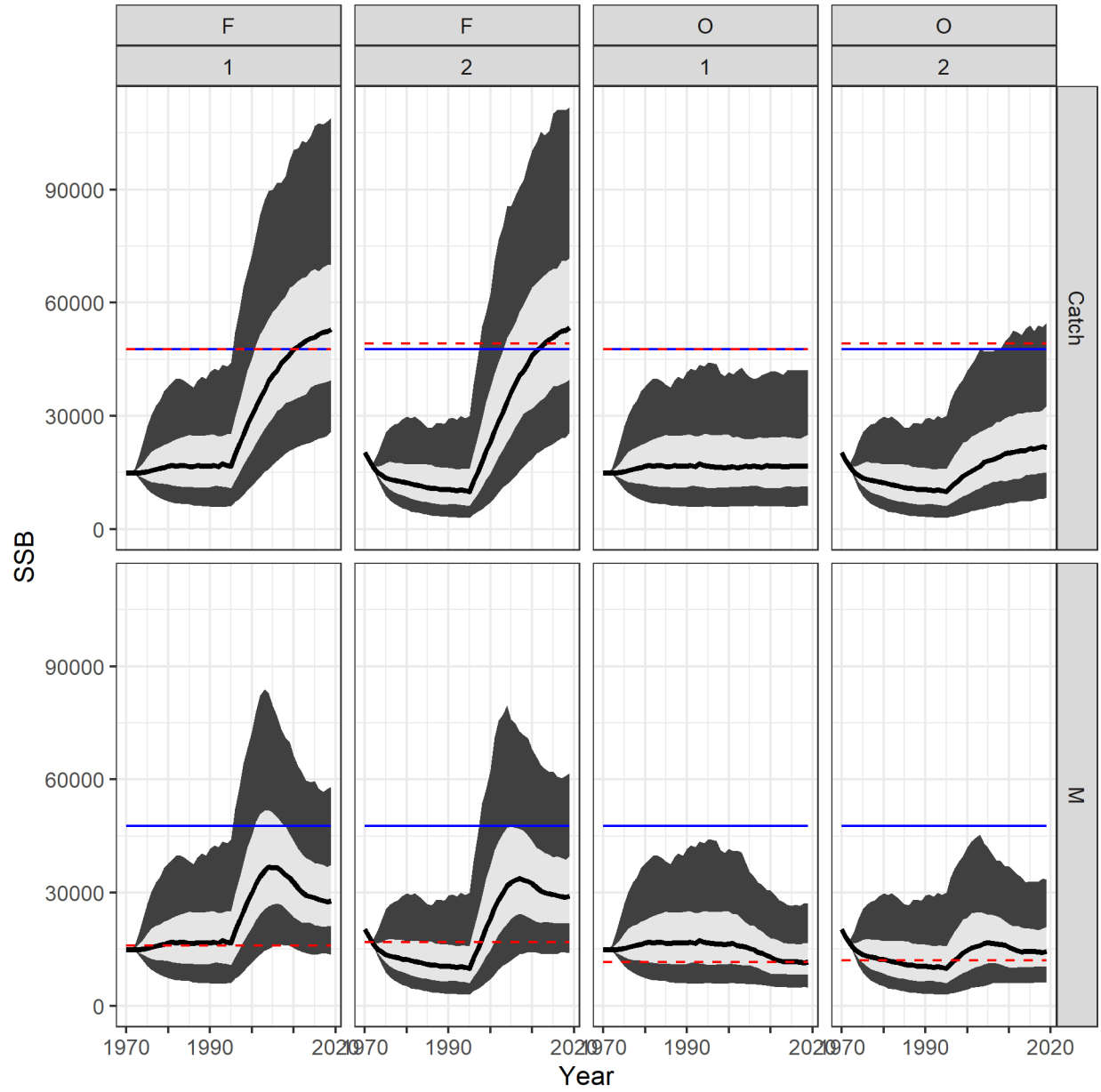


Figure S3. Spawning stock biomass (SSB) during the base period (black line) for the 8 combinations of F history (F = Fmsy in second half of base period, O = overfishing throughout), number of fishery selectivity blocks (1 or 2), and retrospective source (catch or natural mortality, M). The horizontal blue line denotes the F at maximum sustainable yield (Fmsy) computed from conditions in the first year of the base period (1970) while the red dashed horizontal line denotes the Fmsy computed from conditions in the terminal year in the base period (2019).

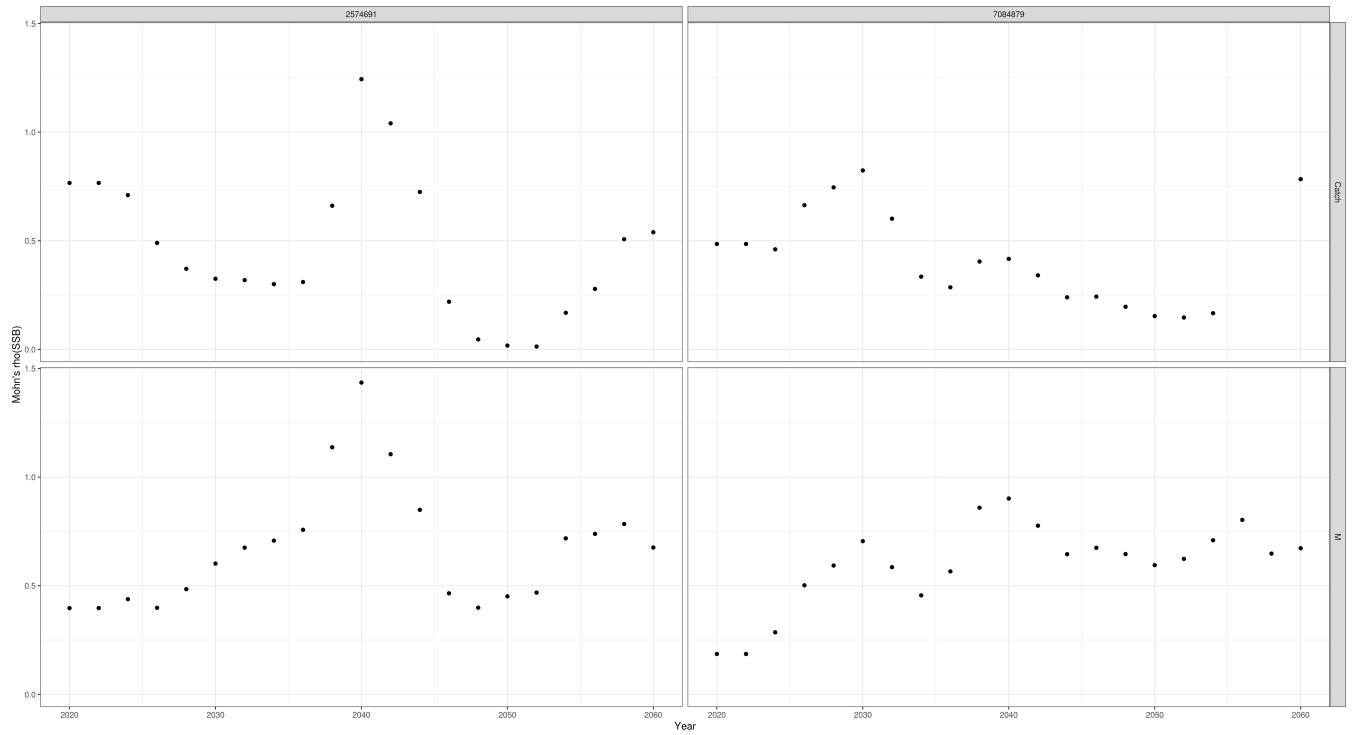
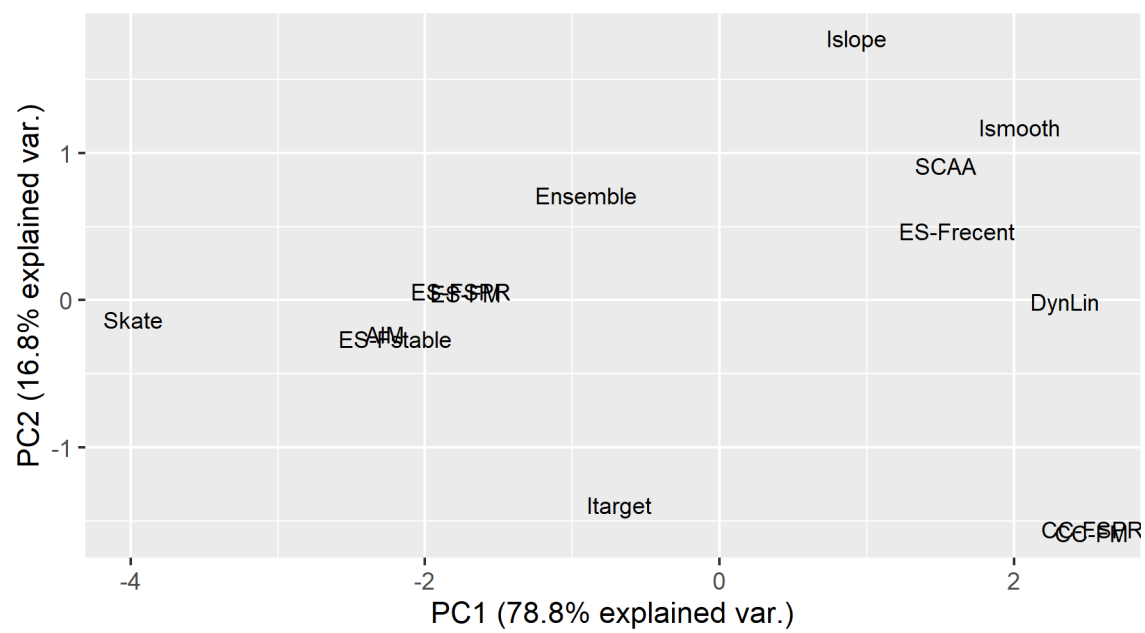


Figure S4. Mohn's rho for spawning stock biomass calculated from the statistical catch at age model during the feedback period of the simulations for two realizations (columns) and the two sources of retrospective (catch and natural mortality).



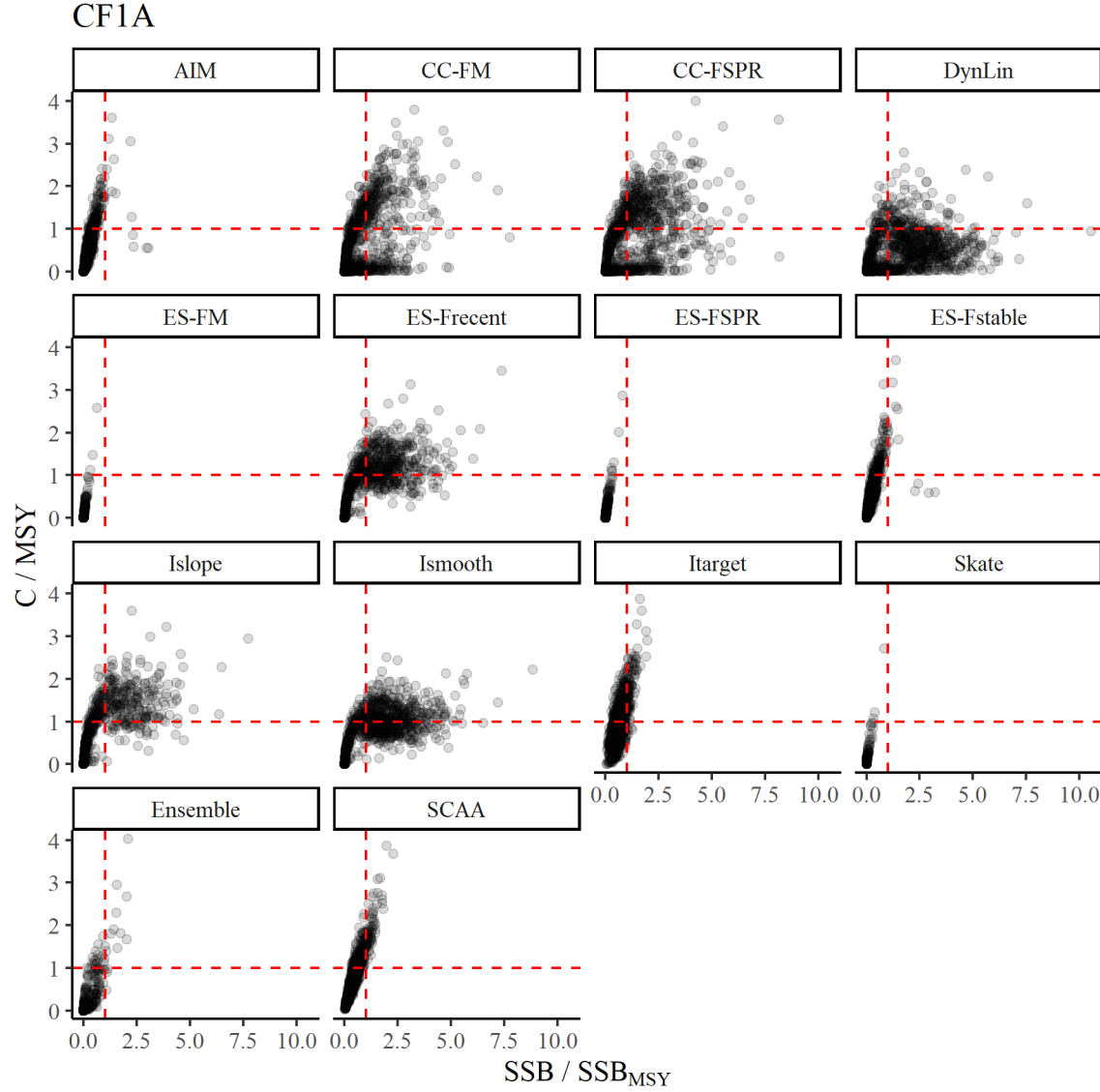


Figure S6. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

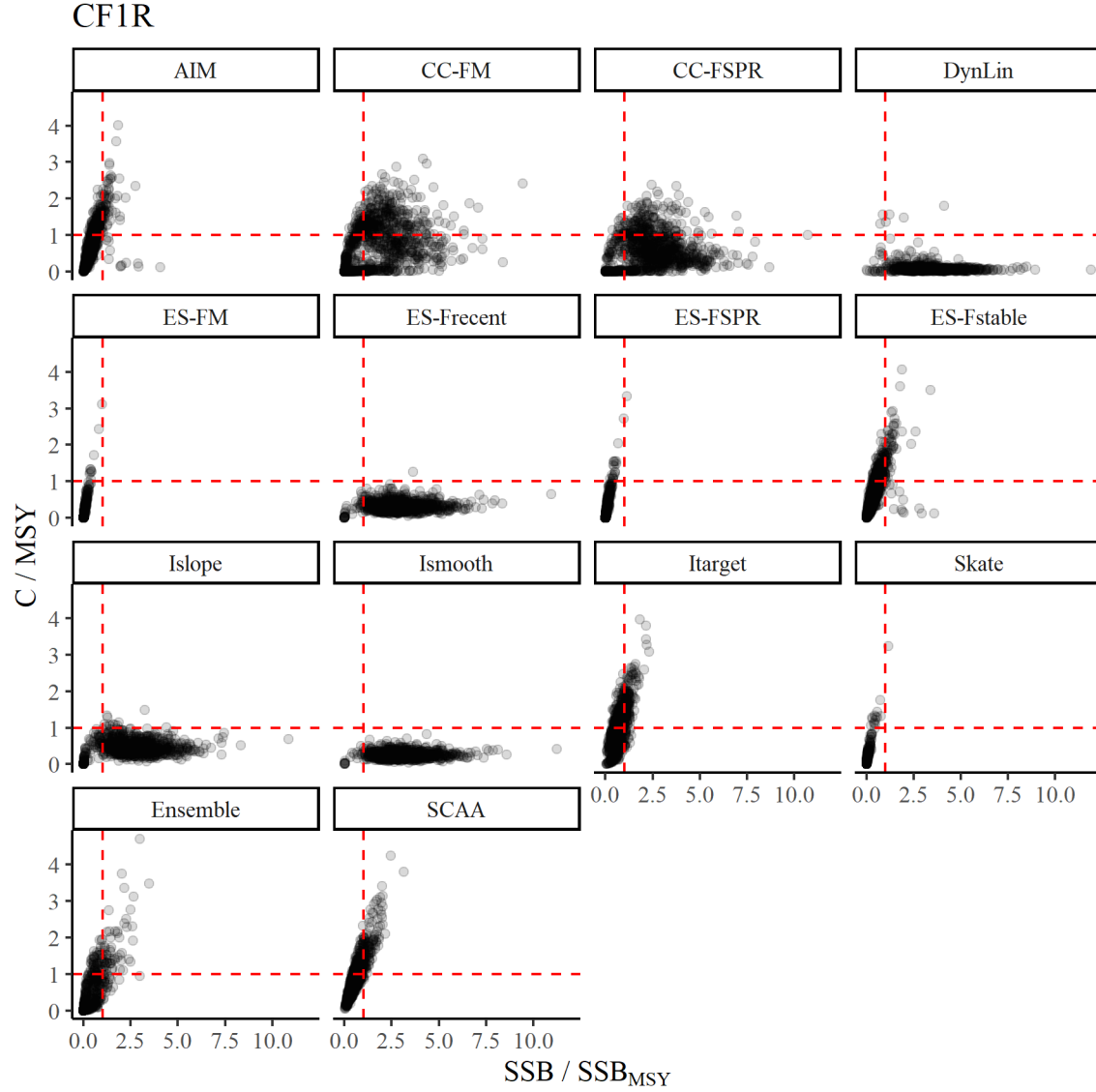


Figure S7. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

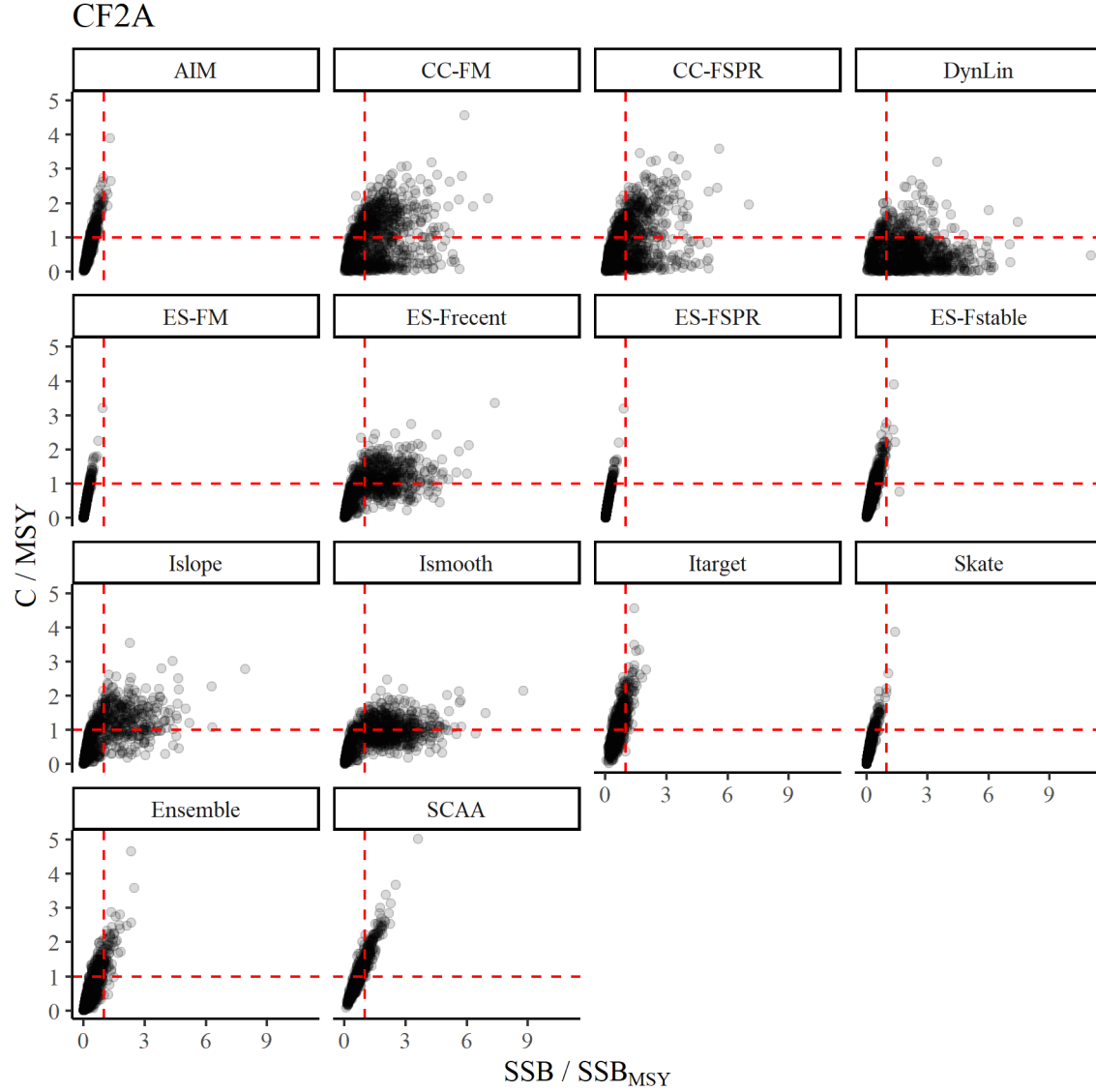


Figure S8. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

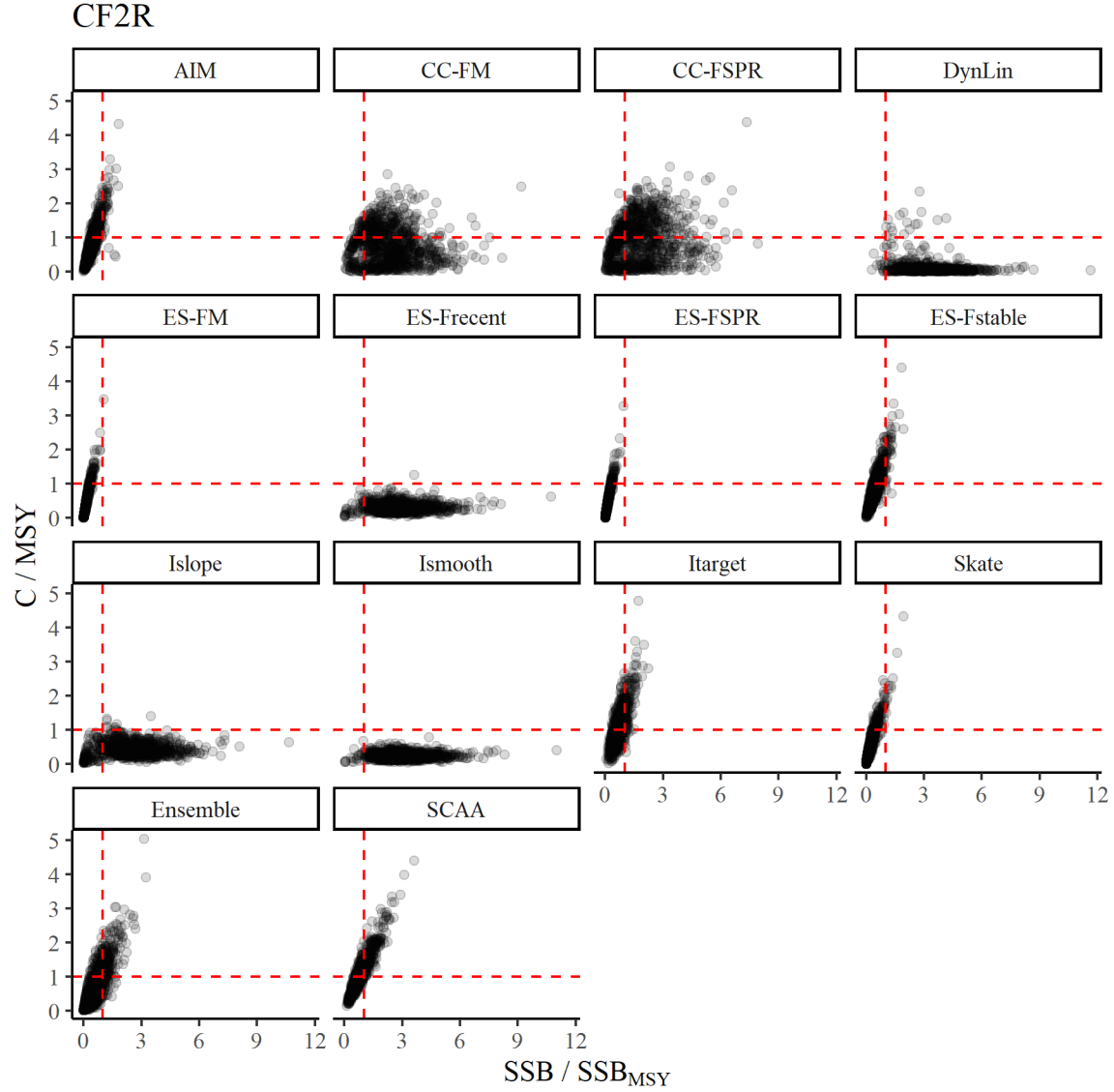


Figure S9. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

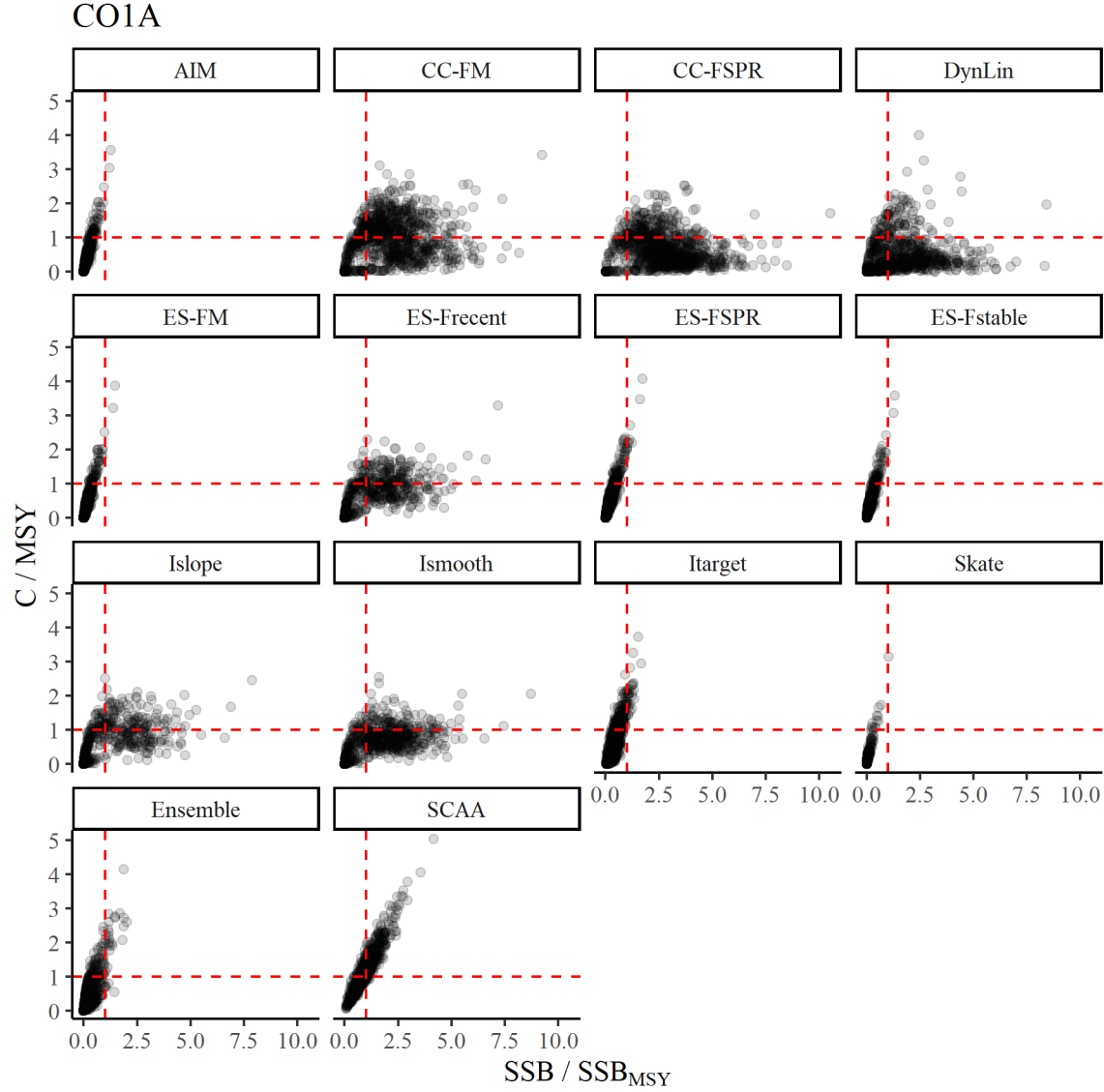


Figure S10. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

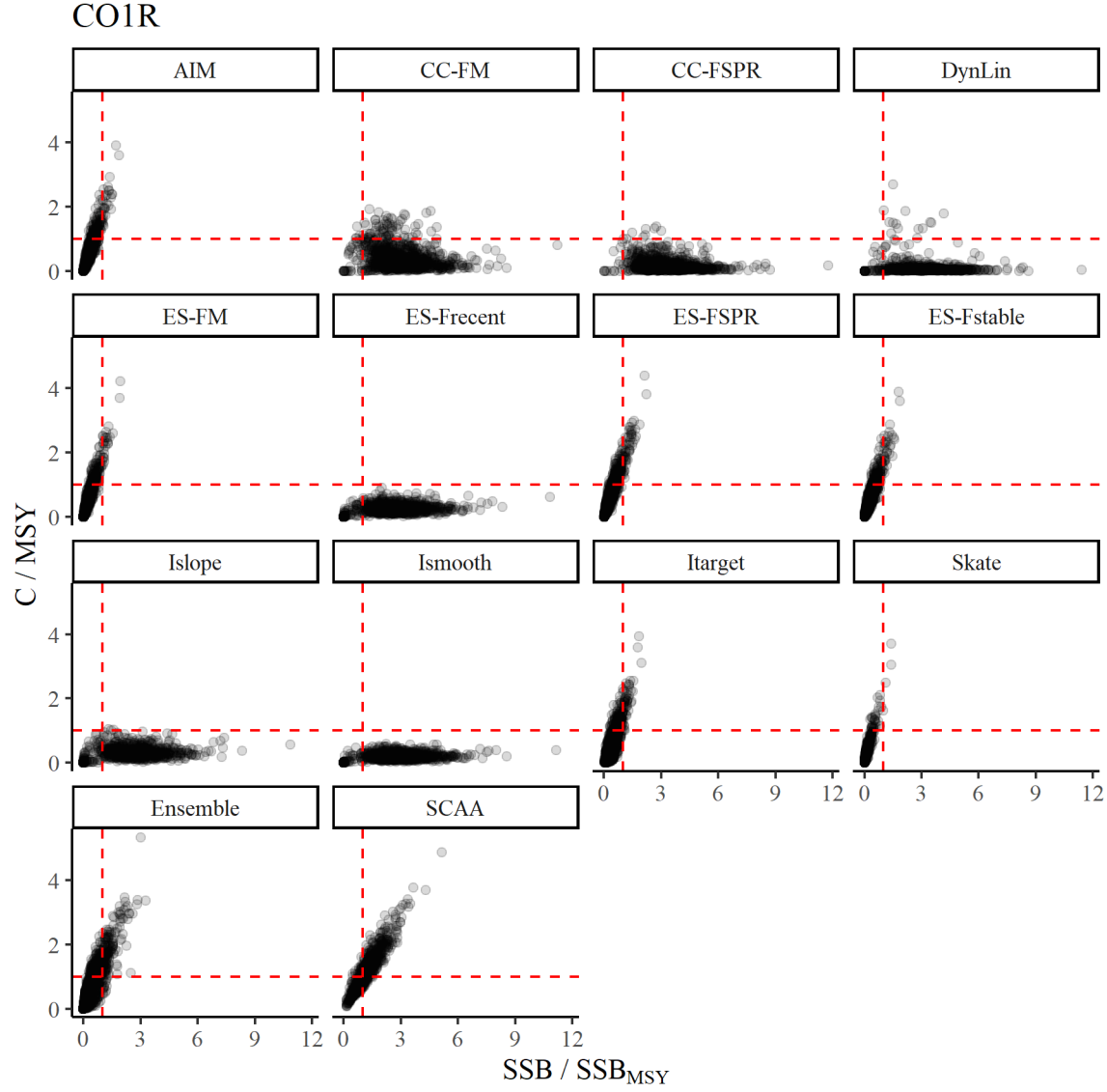


Figure S11. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

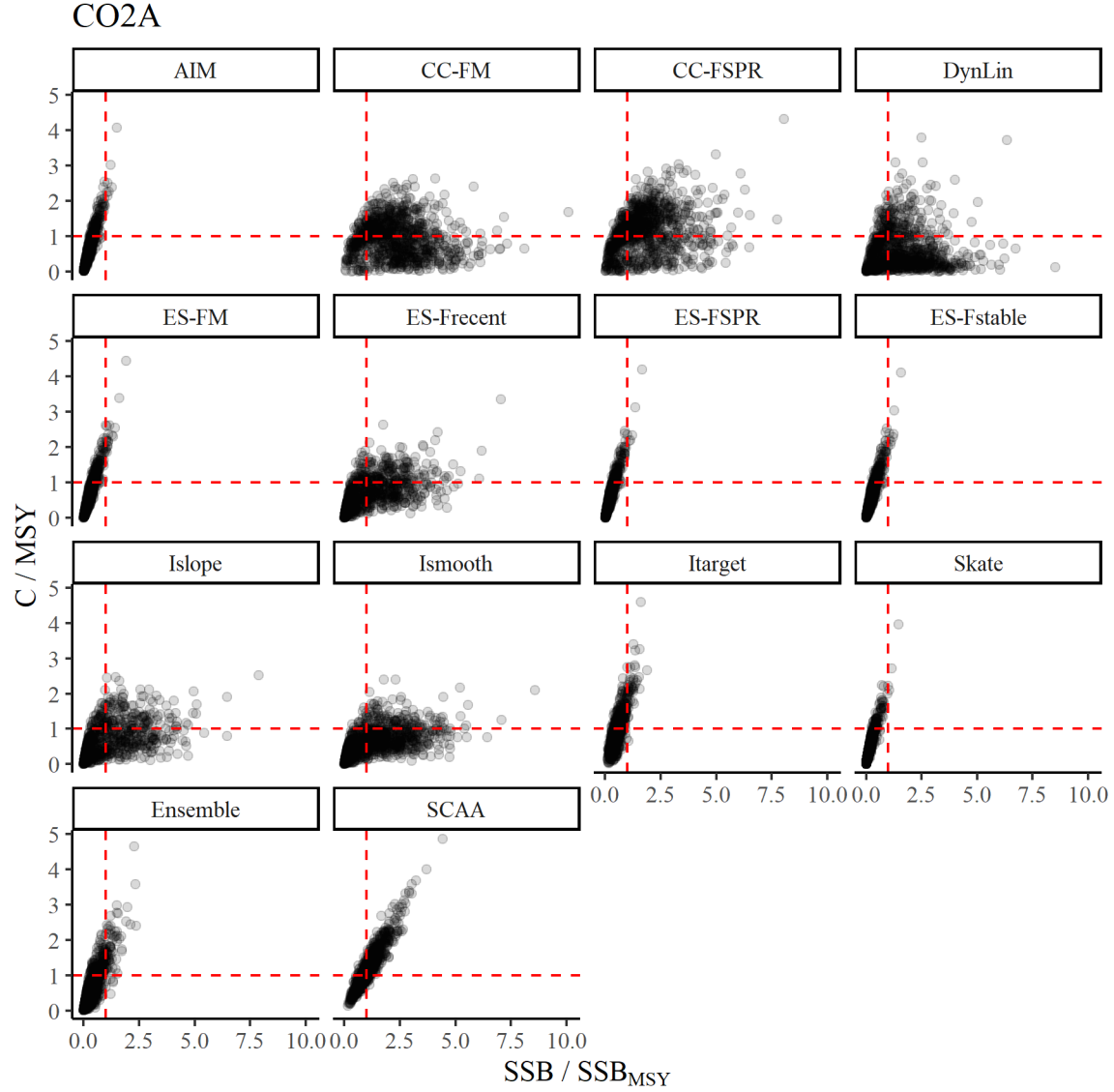


Figure S12. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

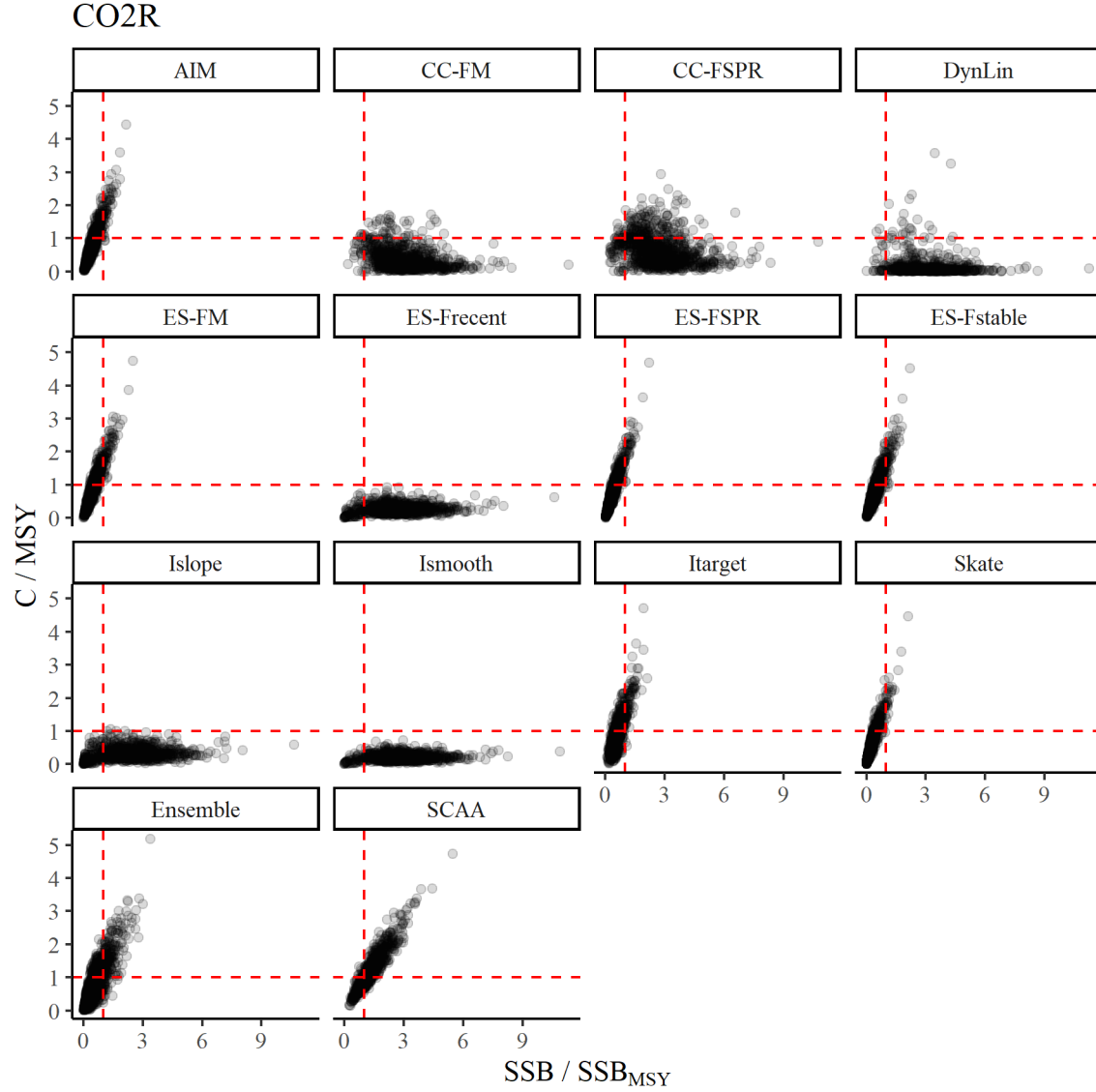


Figure S13. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

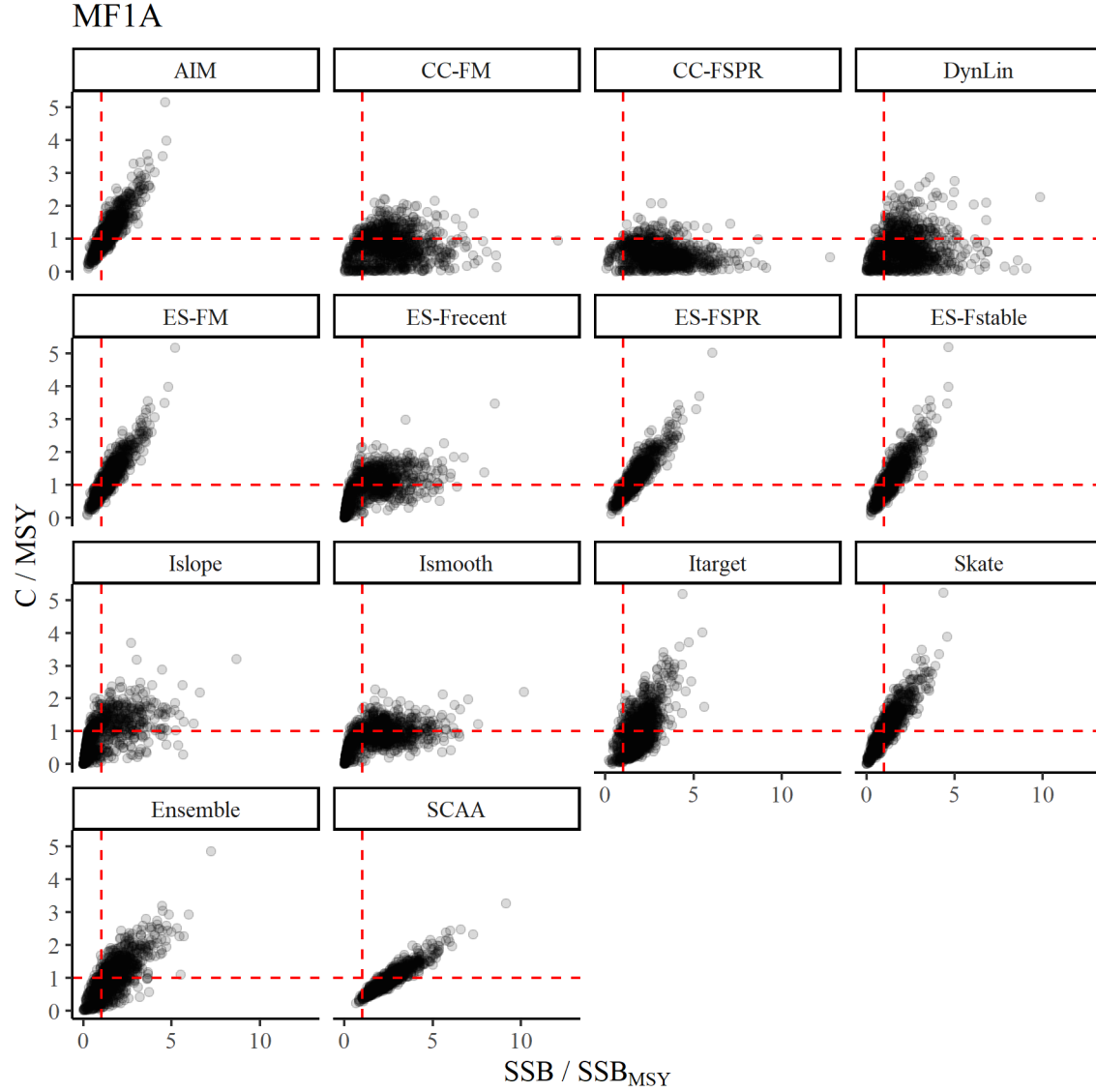


Figure S14. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

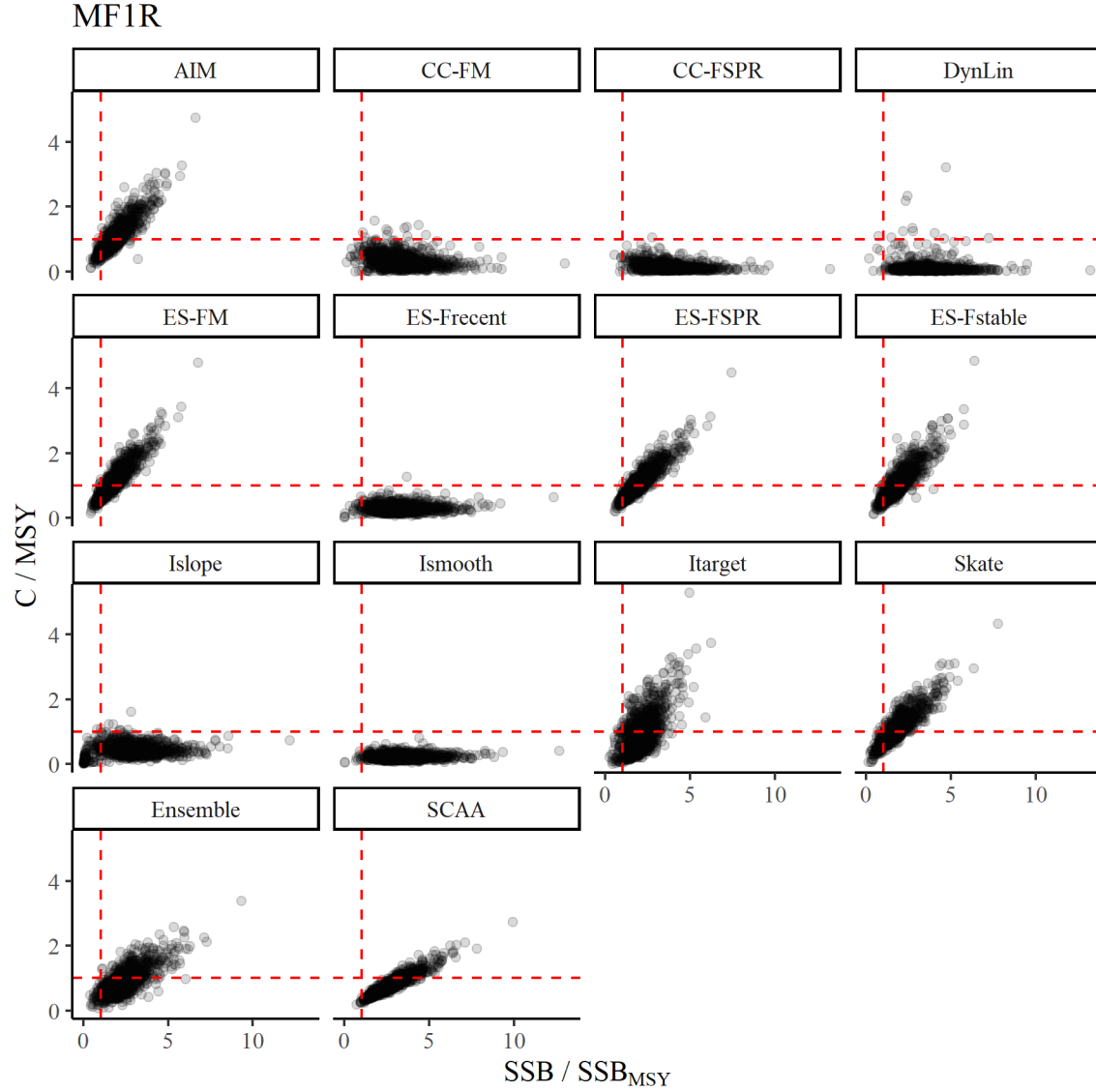


Figure S15. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

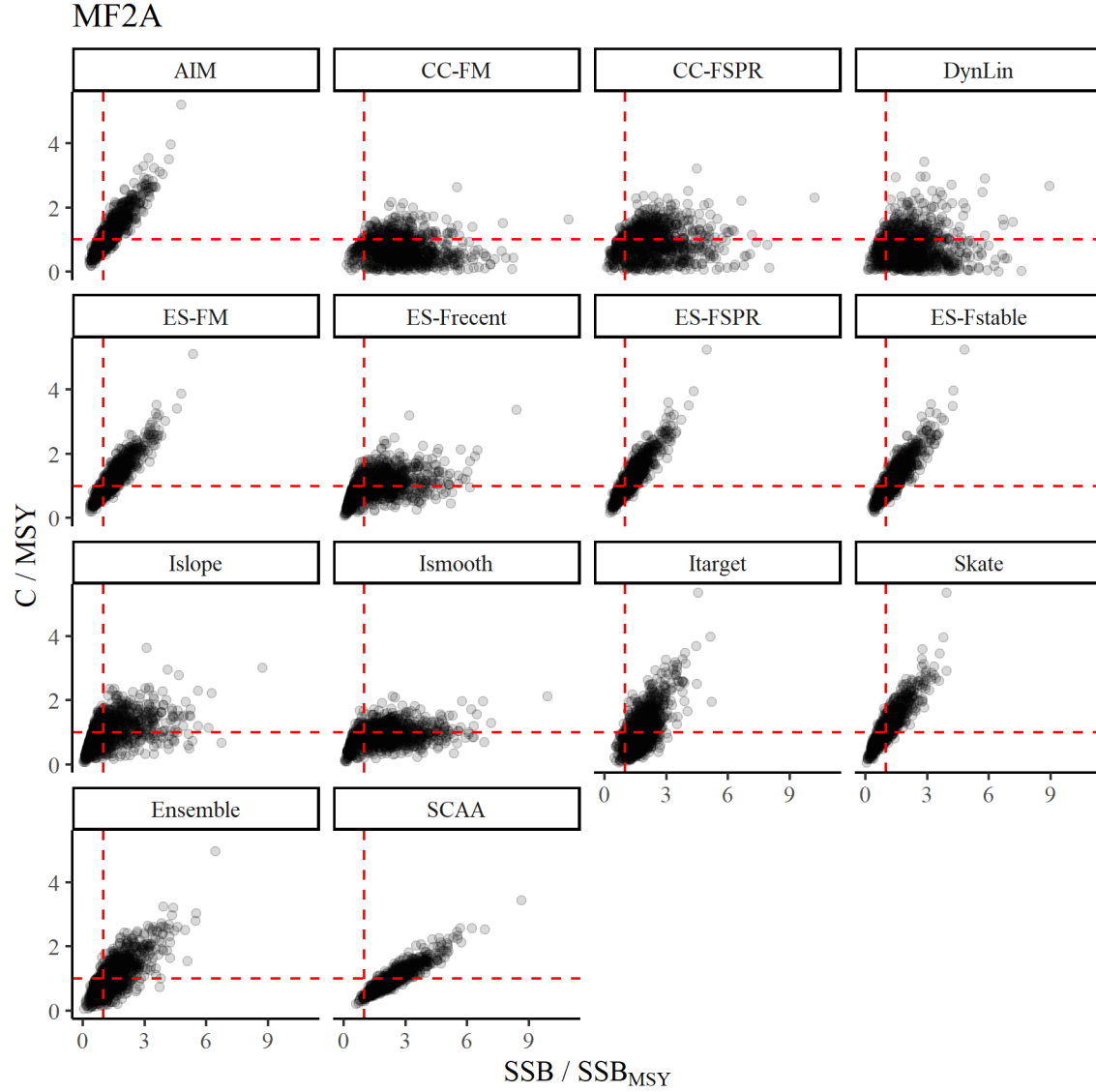


Figure S16. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

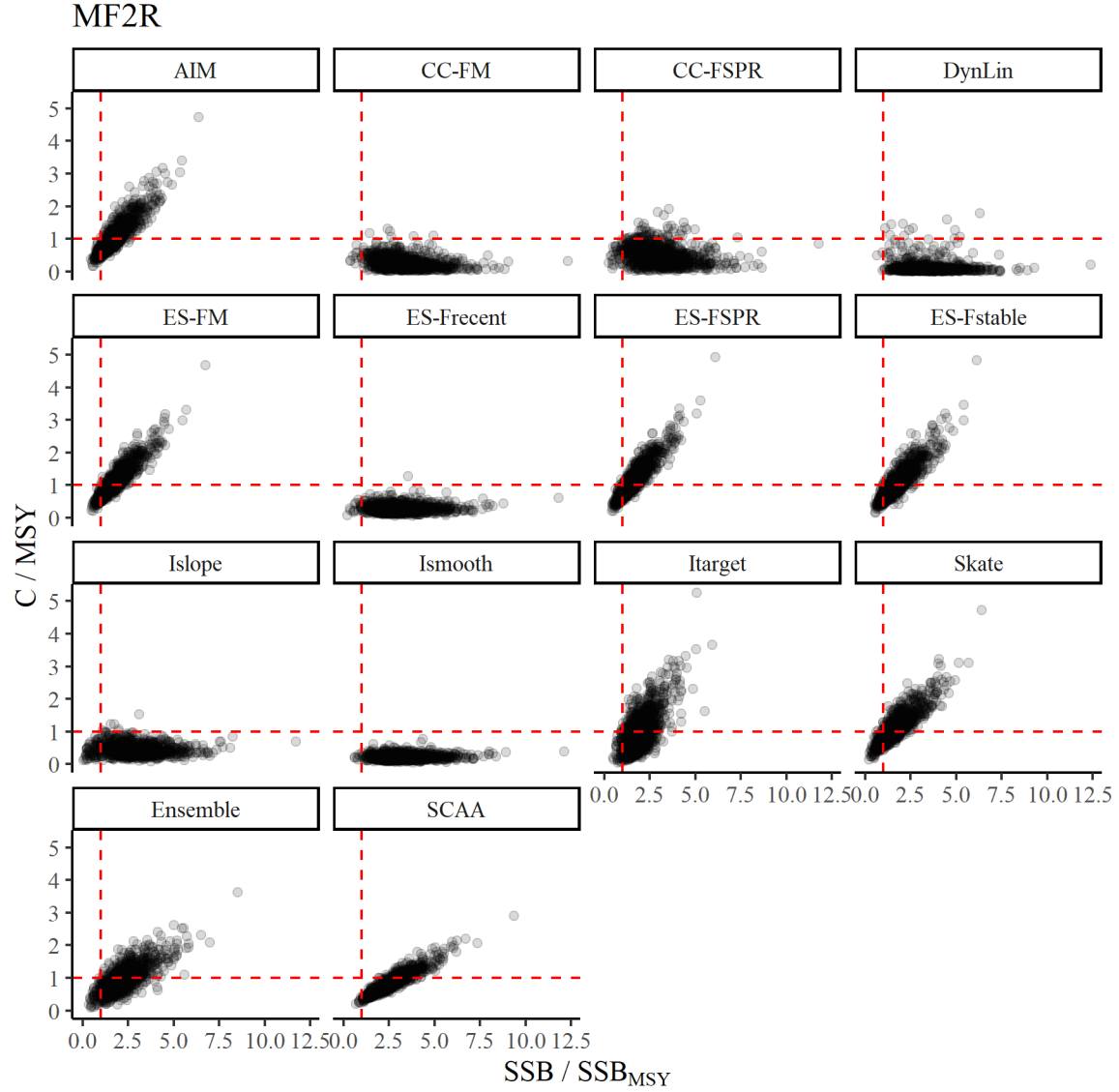


Figure S17. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

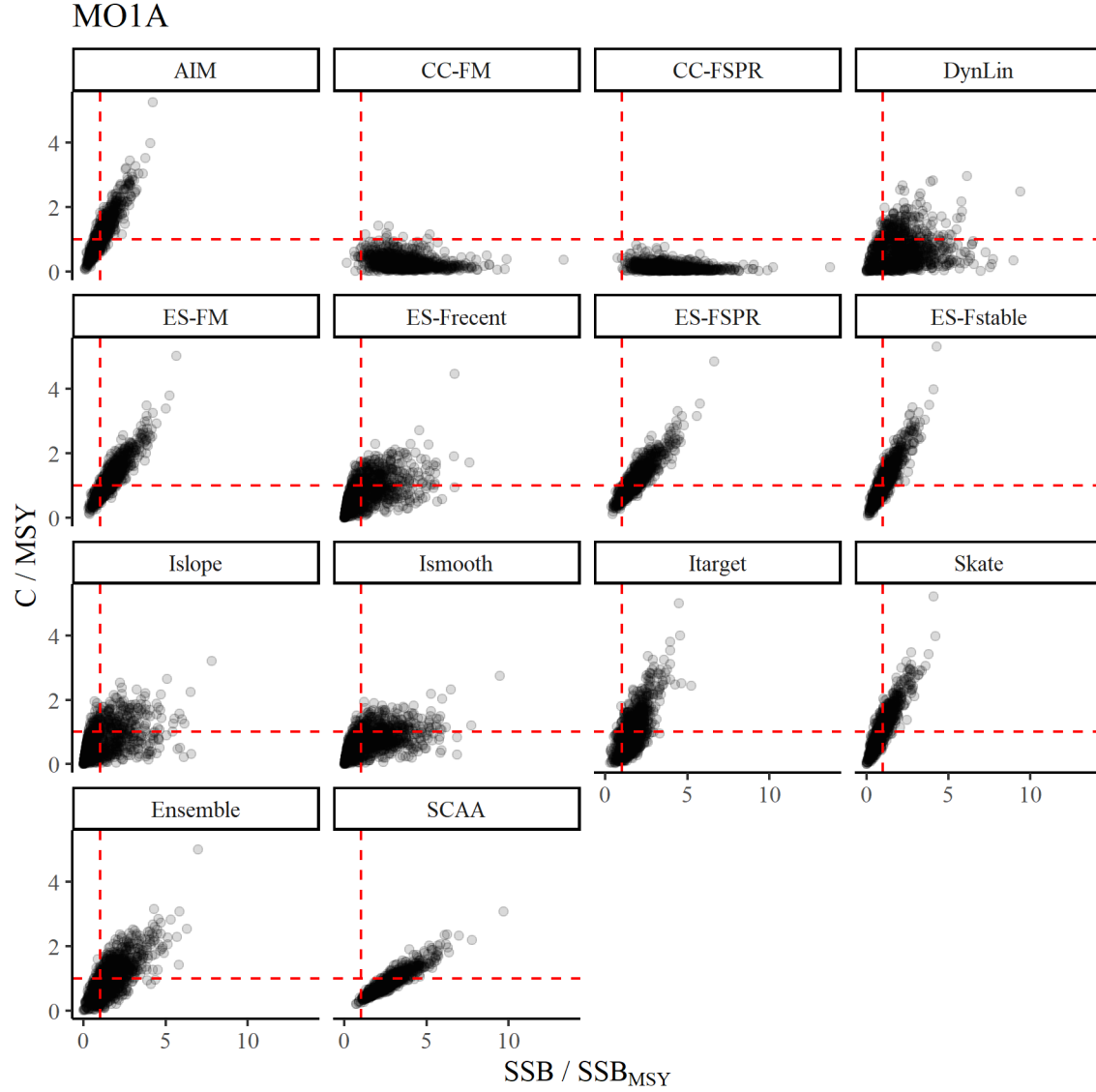


Figure S18. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

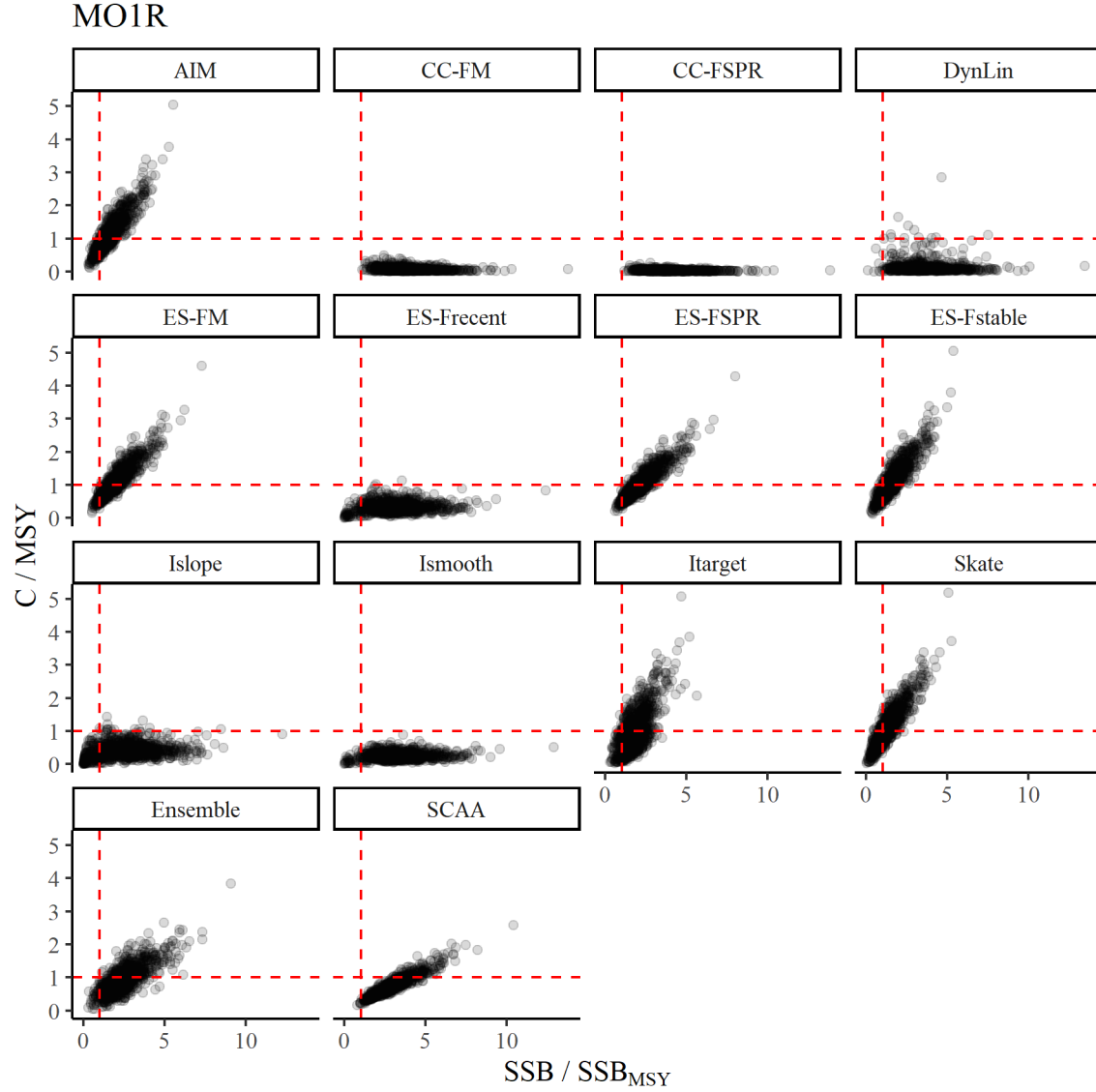


Figure S19. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

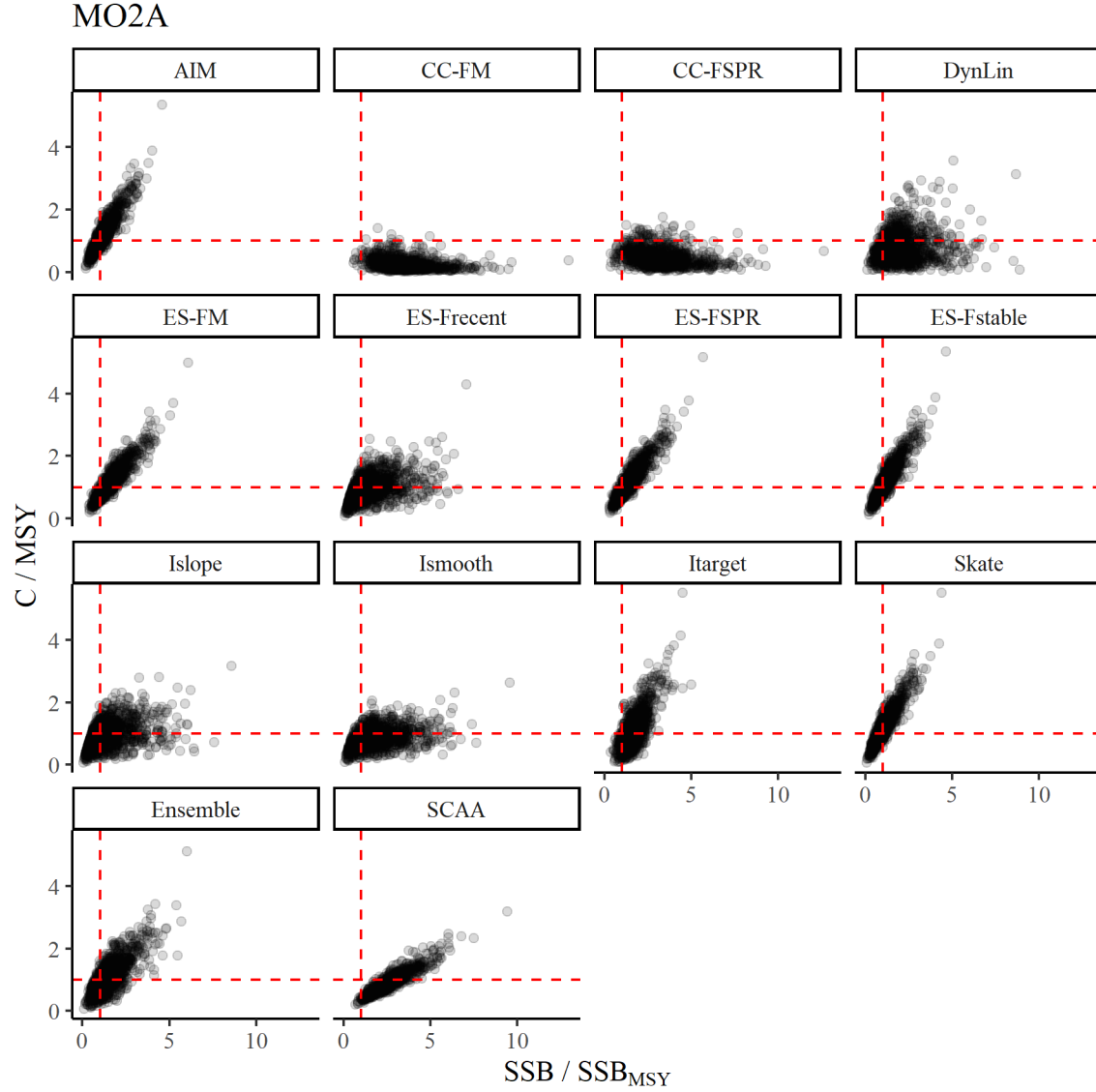


Figure S20. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

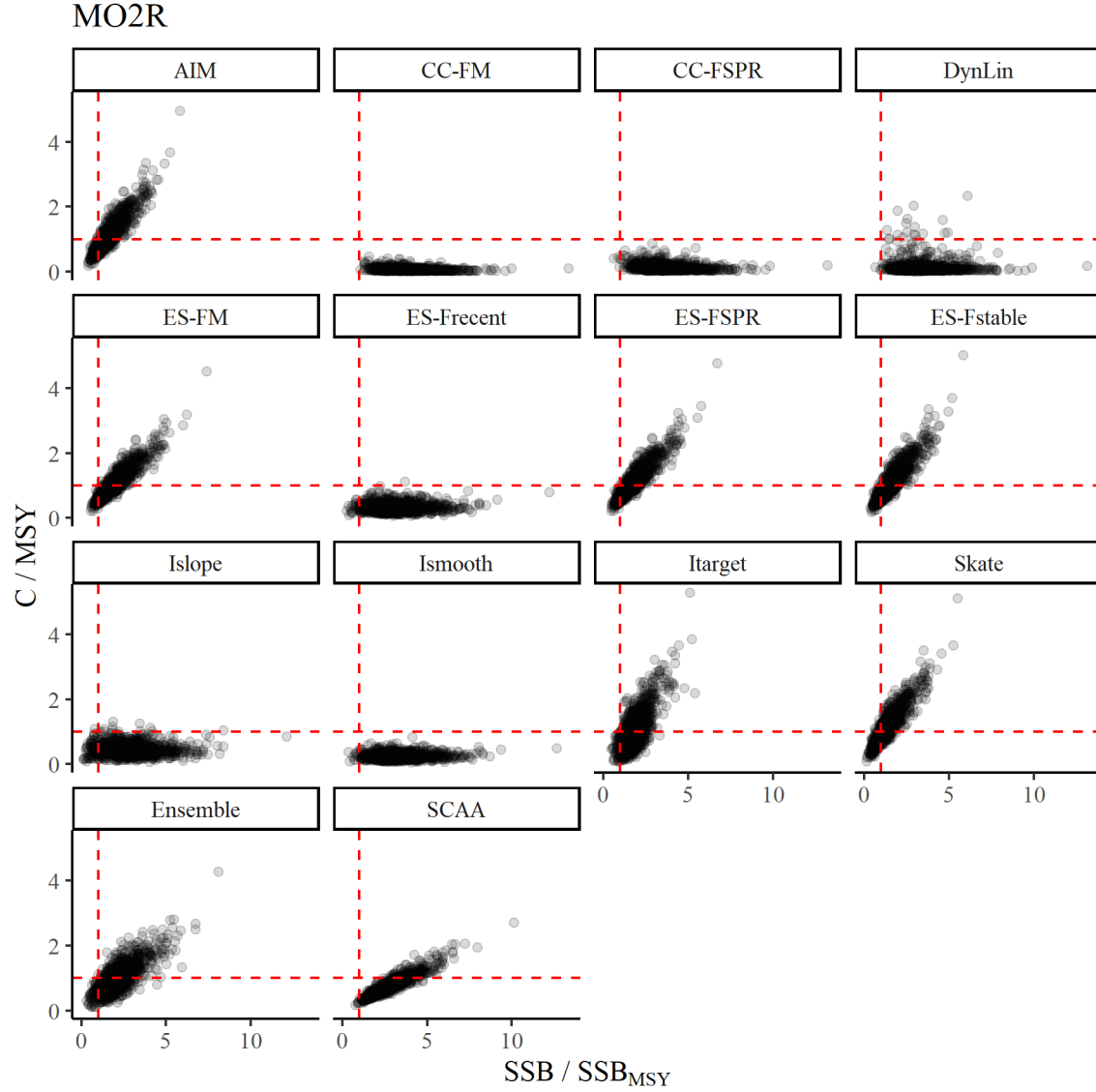


Figure S21. Relationship between long-term average catch and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

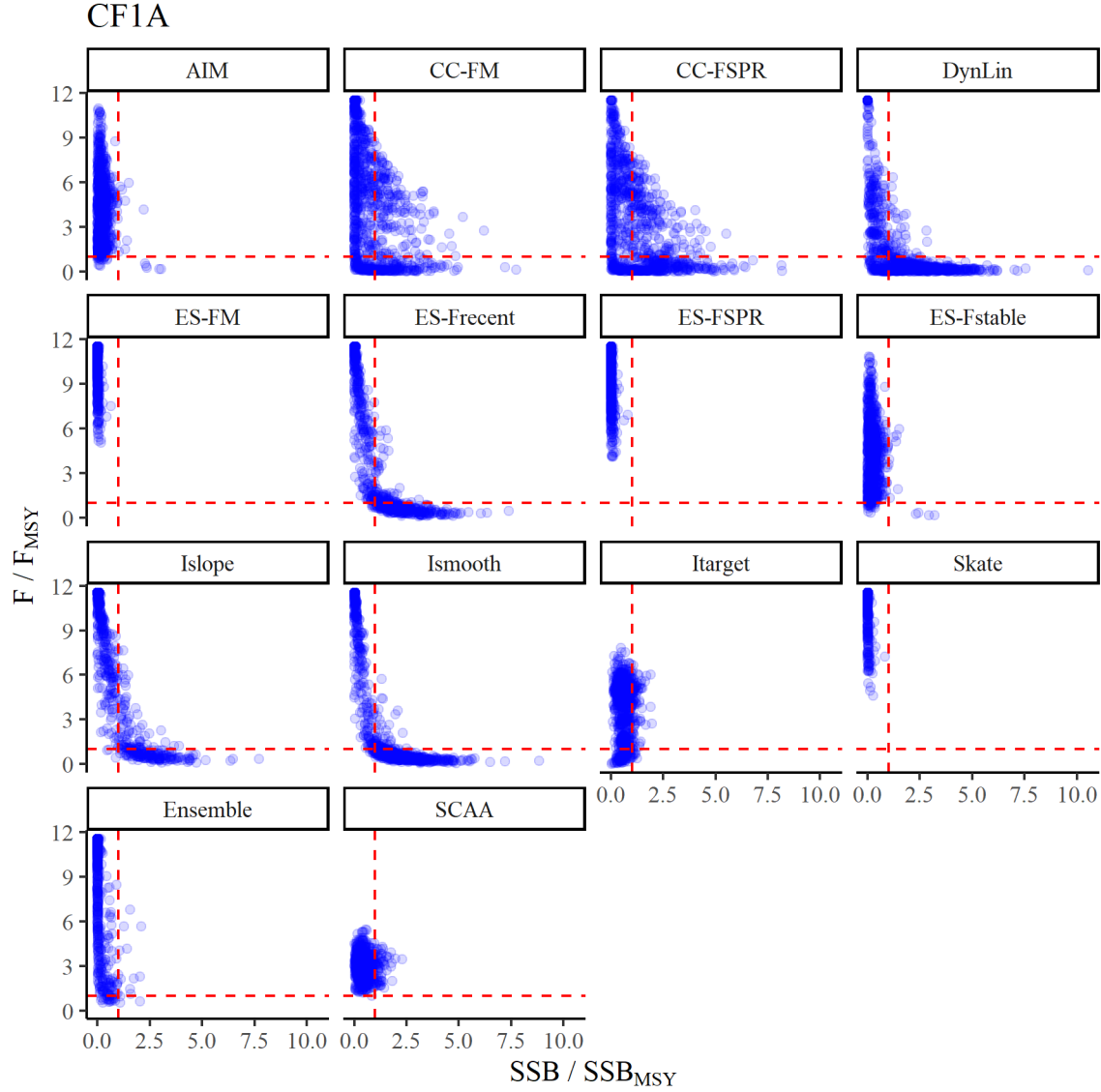


Figure S22. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

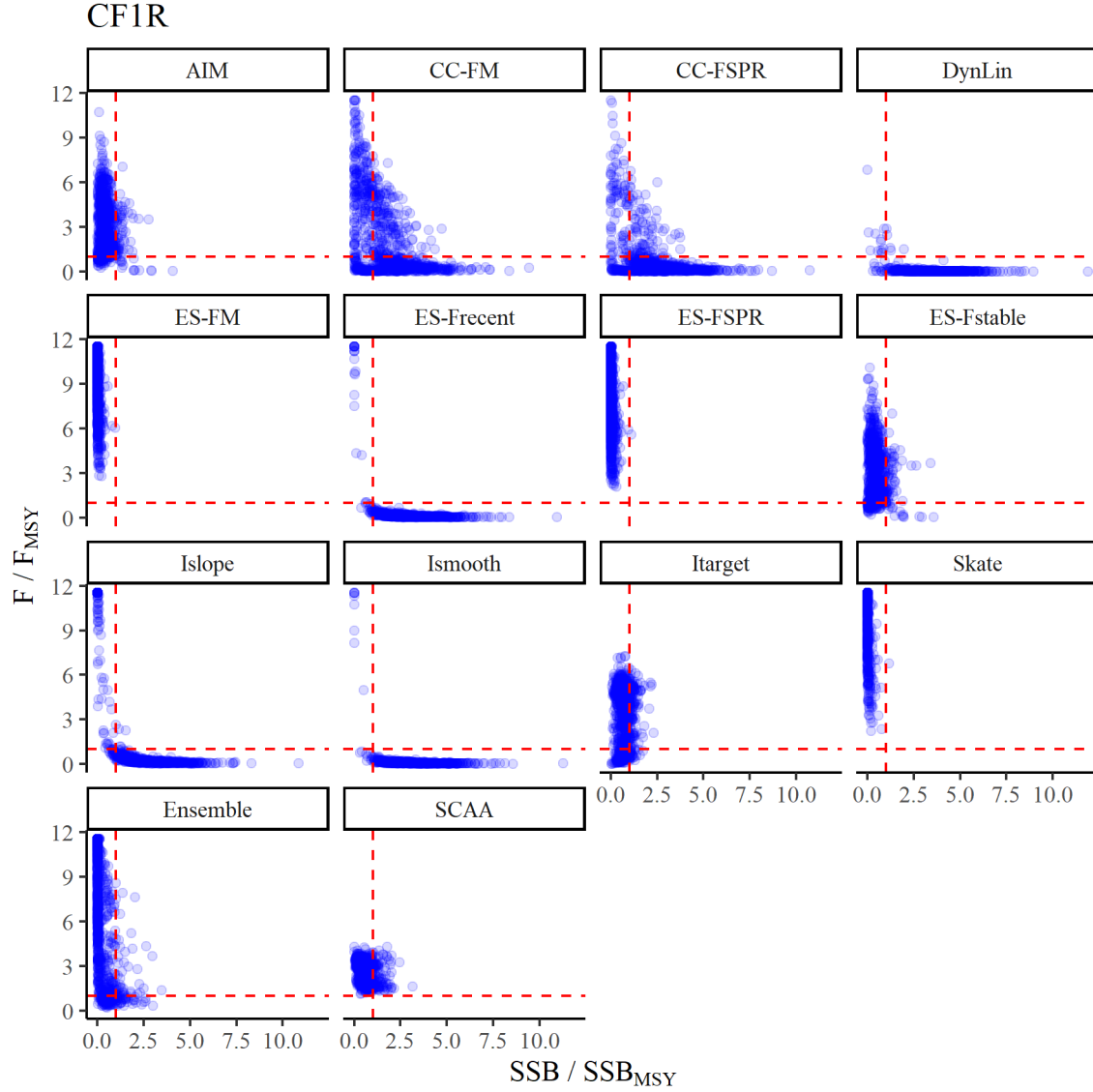


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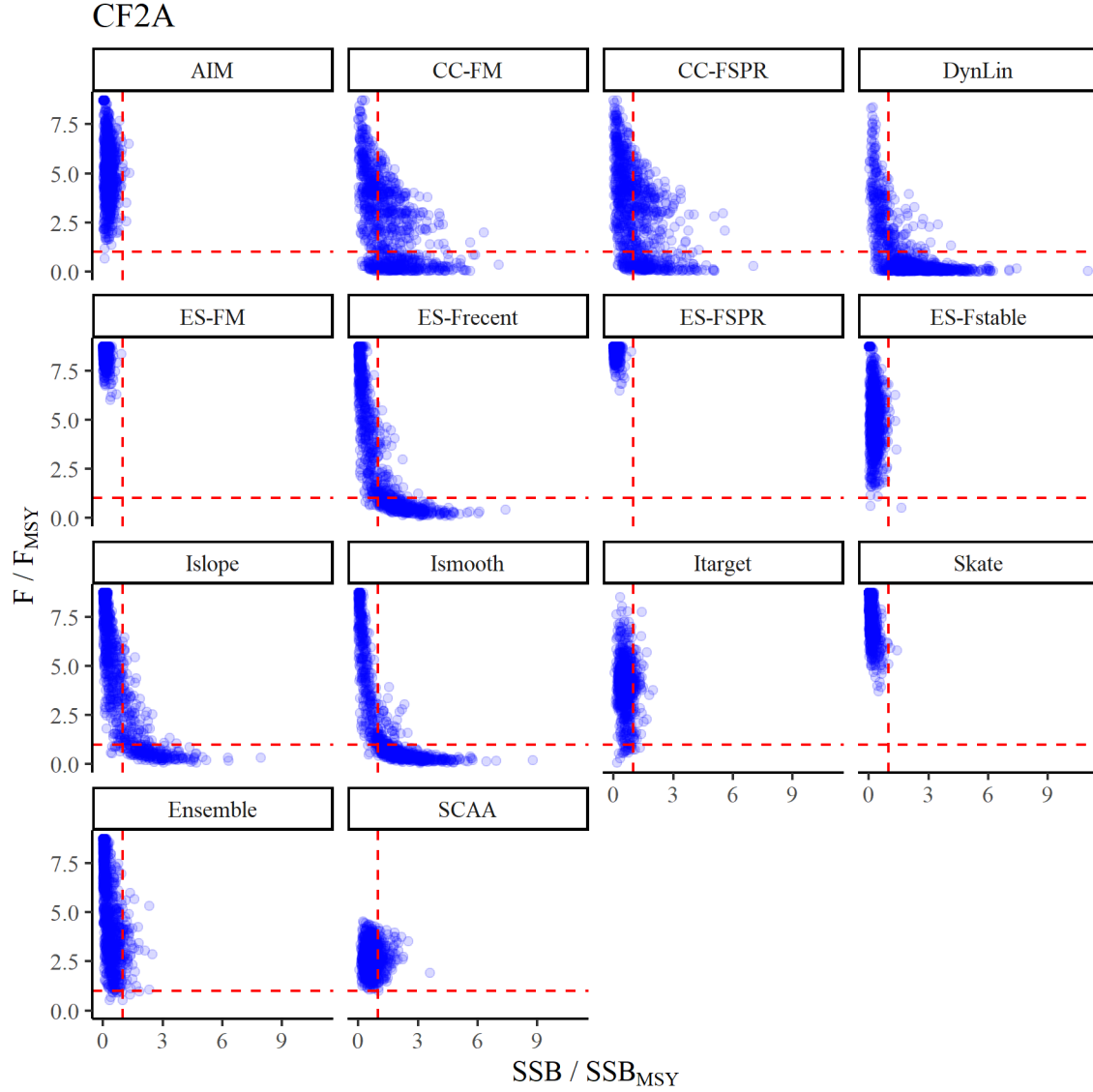


Figure S24. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

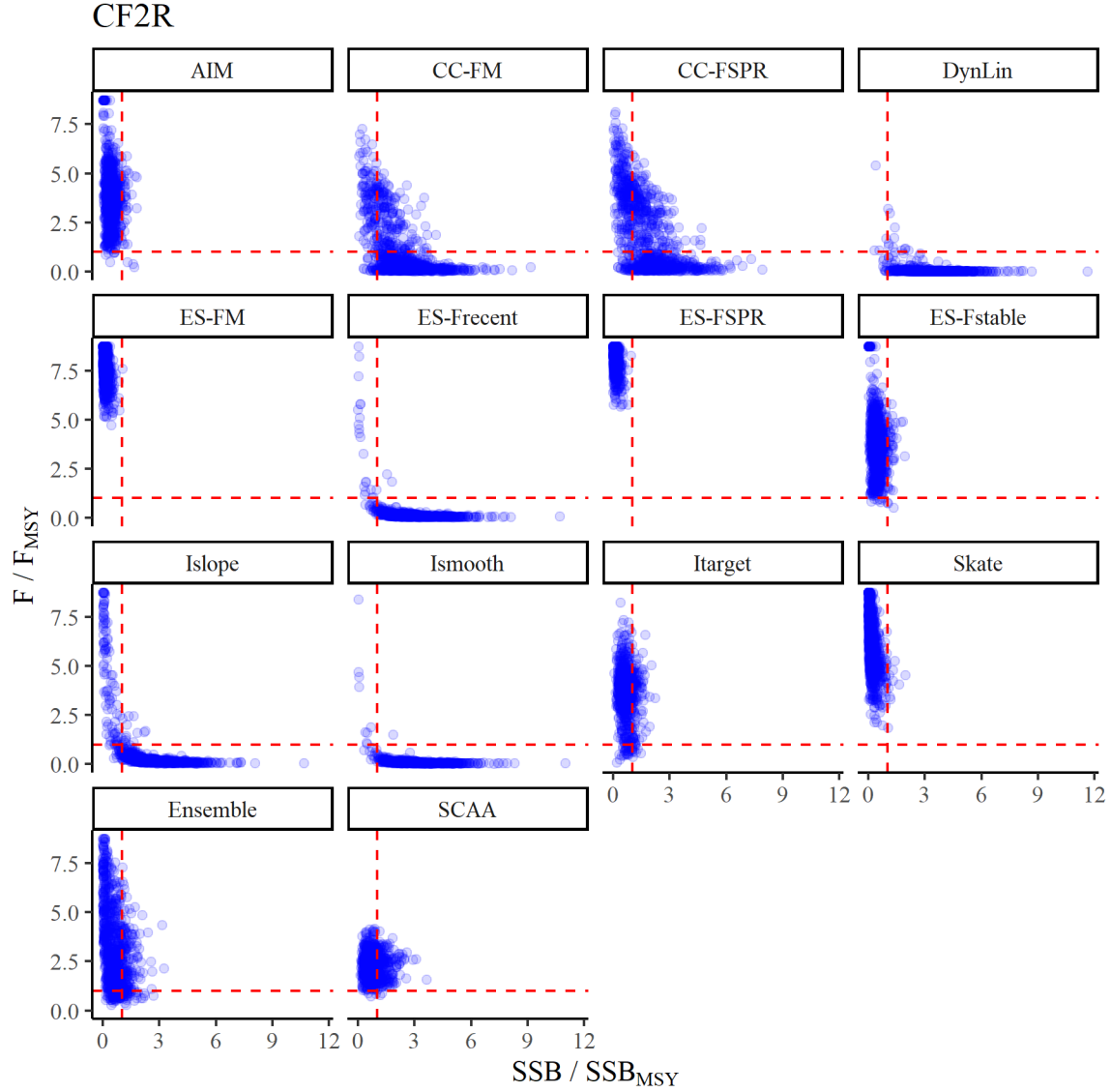


Figure S25. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

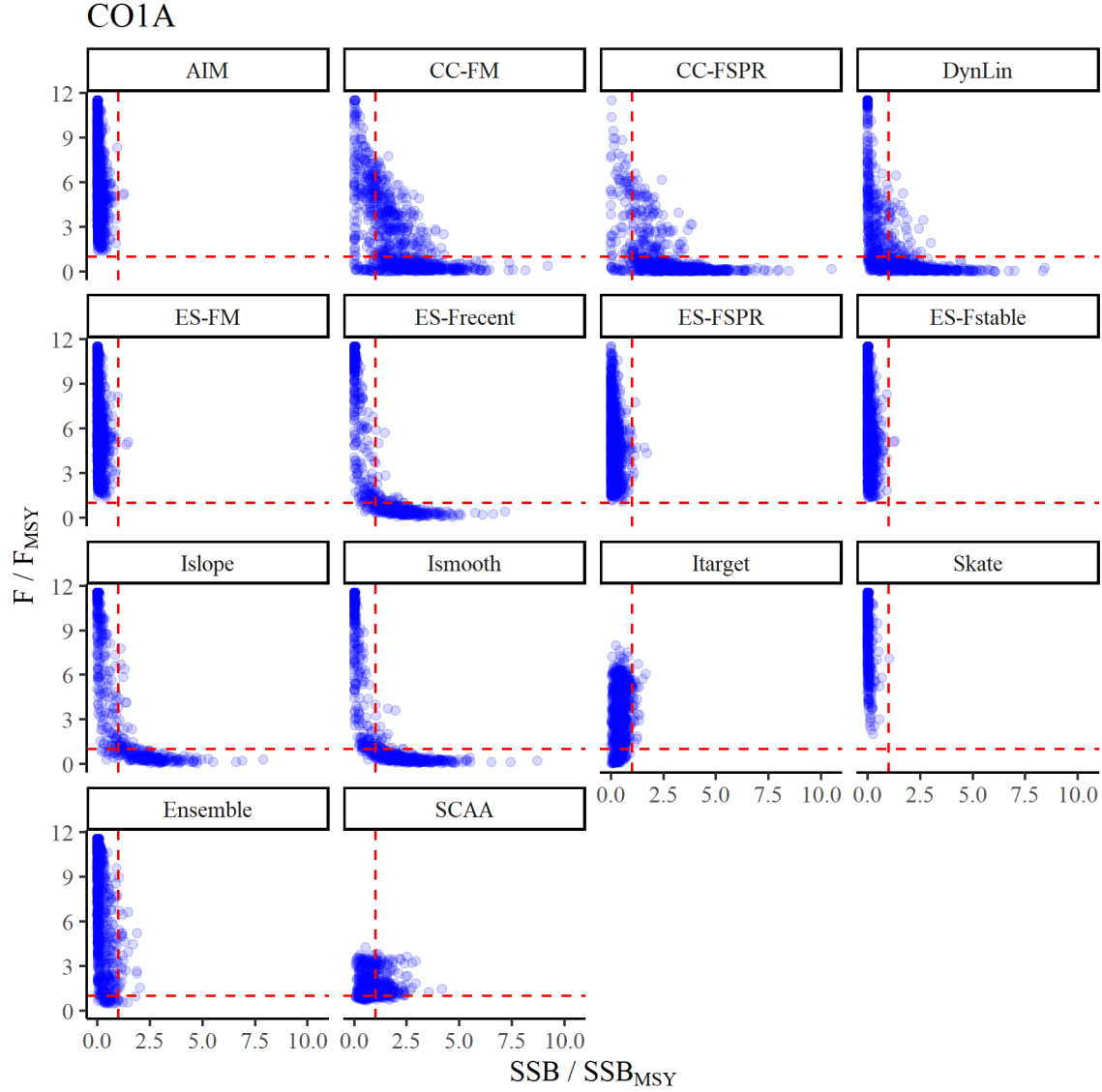


Figure S26. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

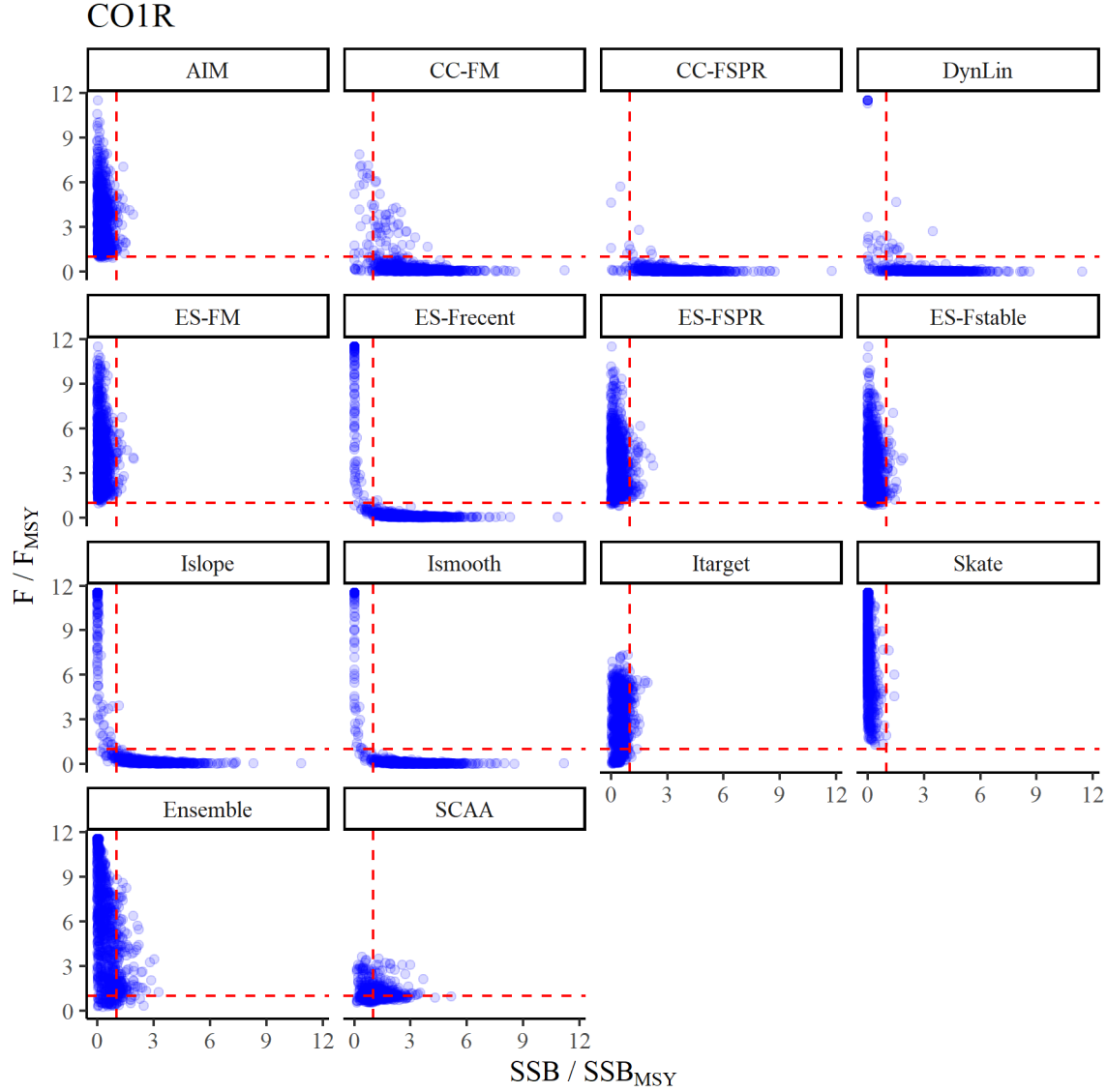


Figure S27. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

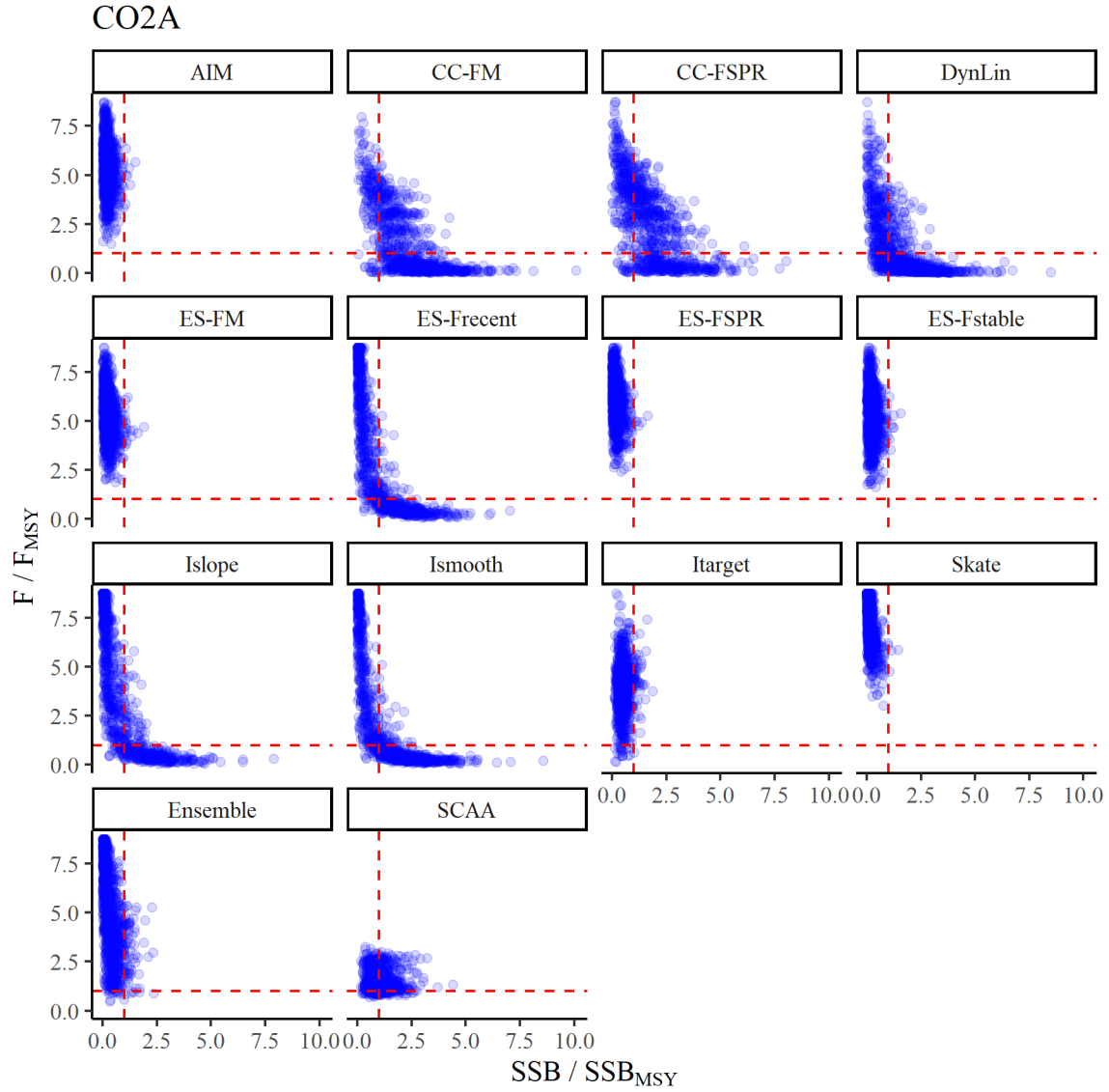


Figure S28. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

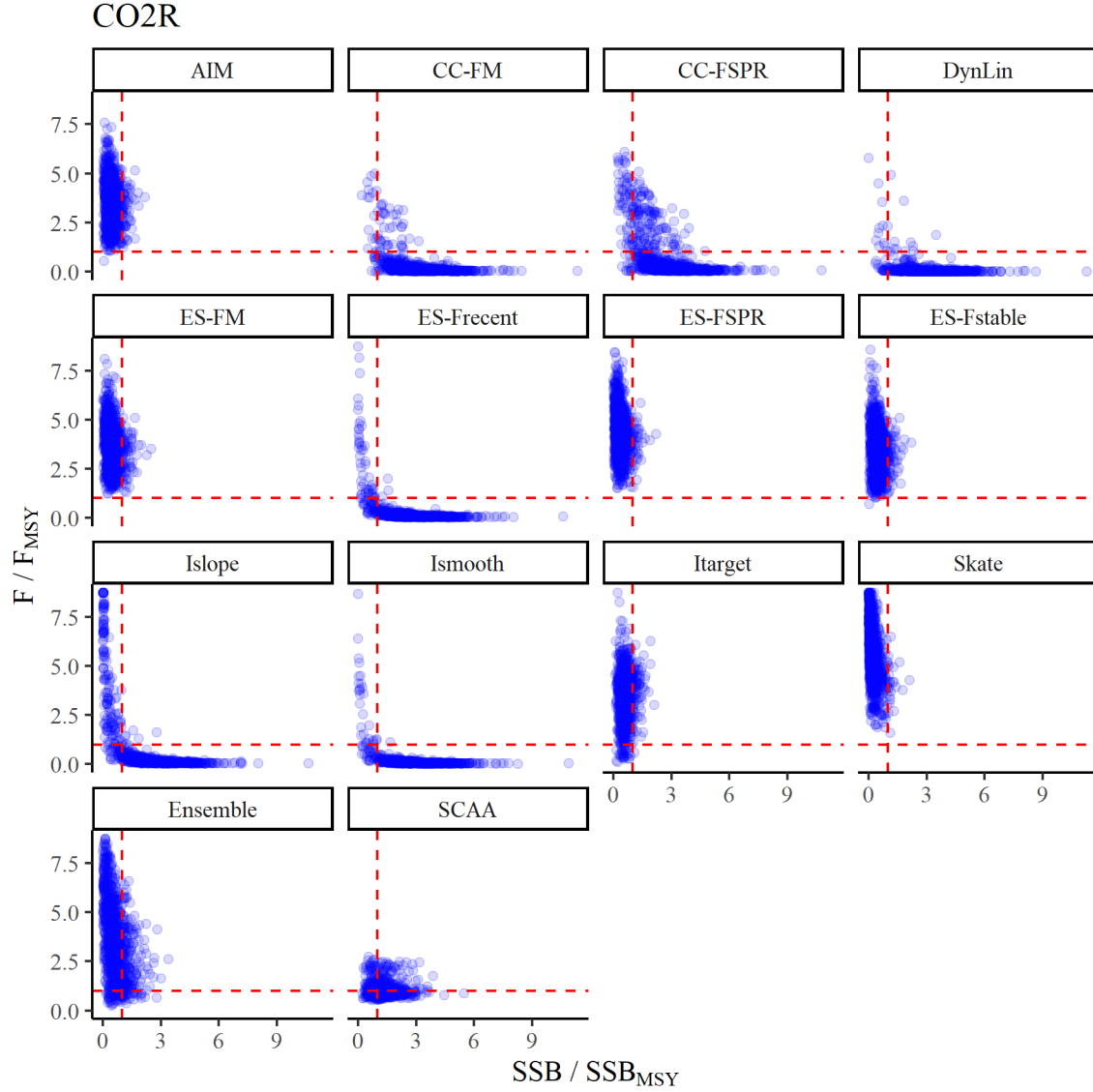


Figure S29. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where catch was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there were two selectivity blocks, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

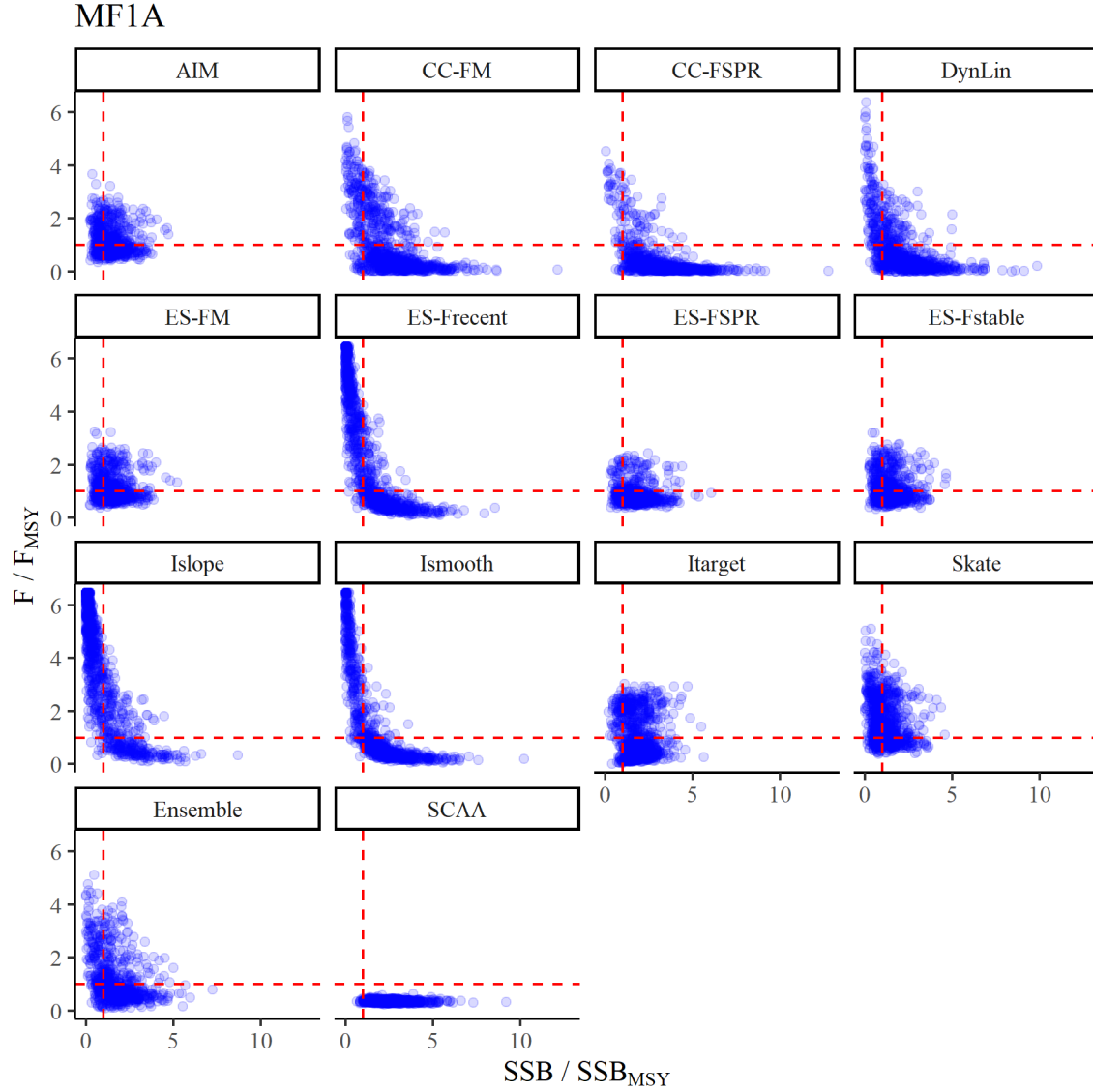


Figure S30. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

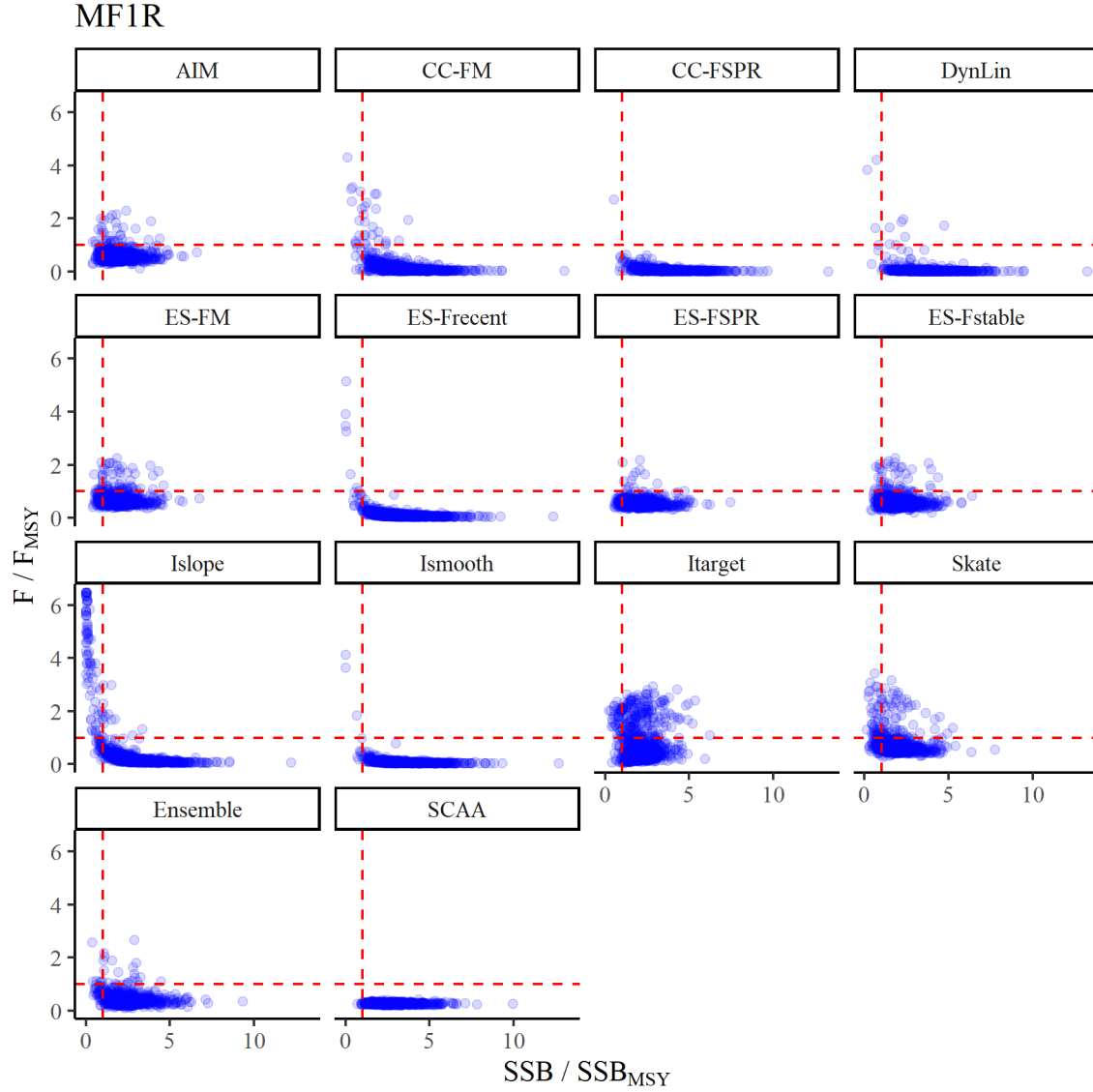


Figure S31. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

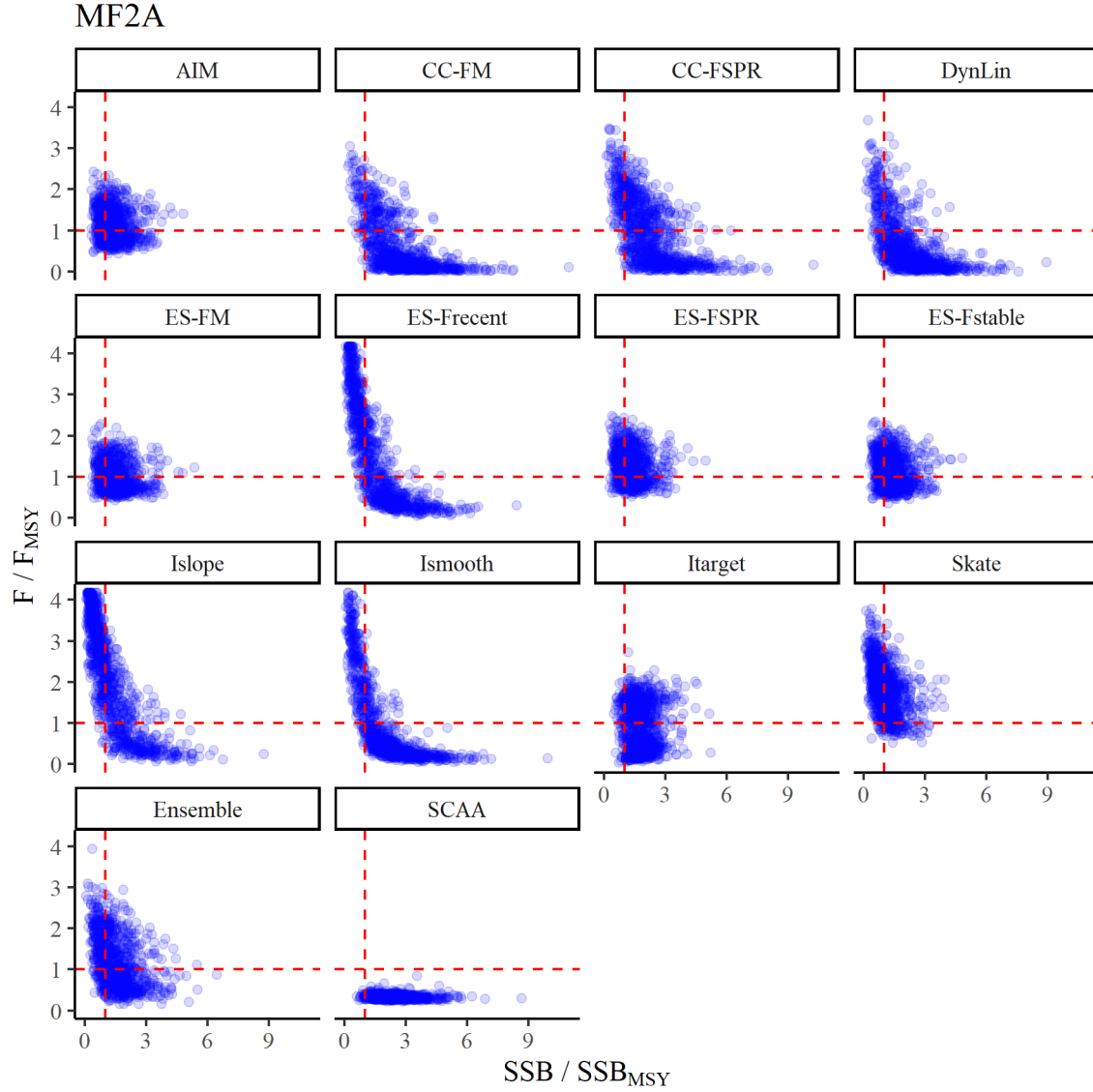


Figure S32. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F reduced to F_{MSY} in the second half of the base period, there were two selectivity blocks, and where no buffer was applied to the catch advice (catch multiplier = 1).

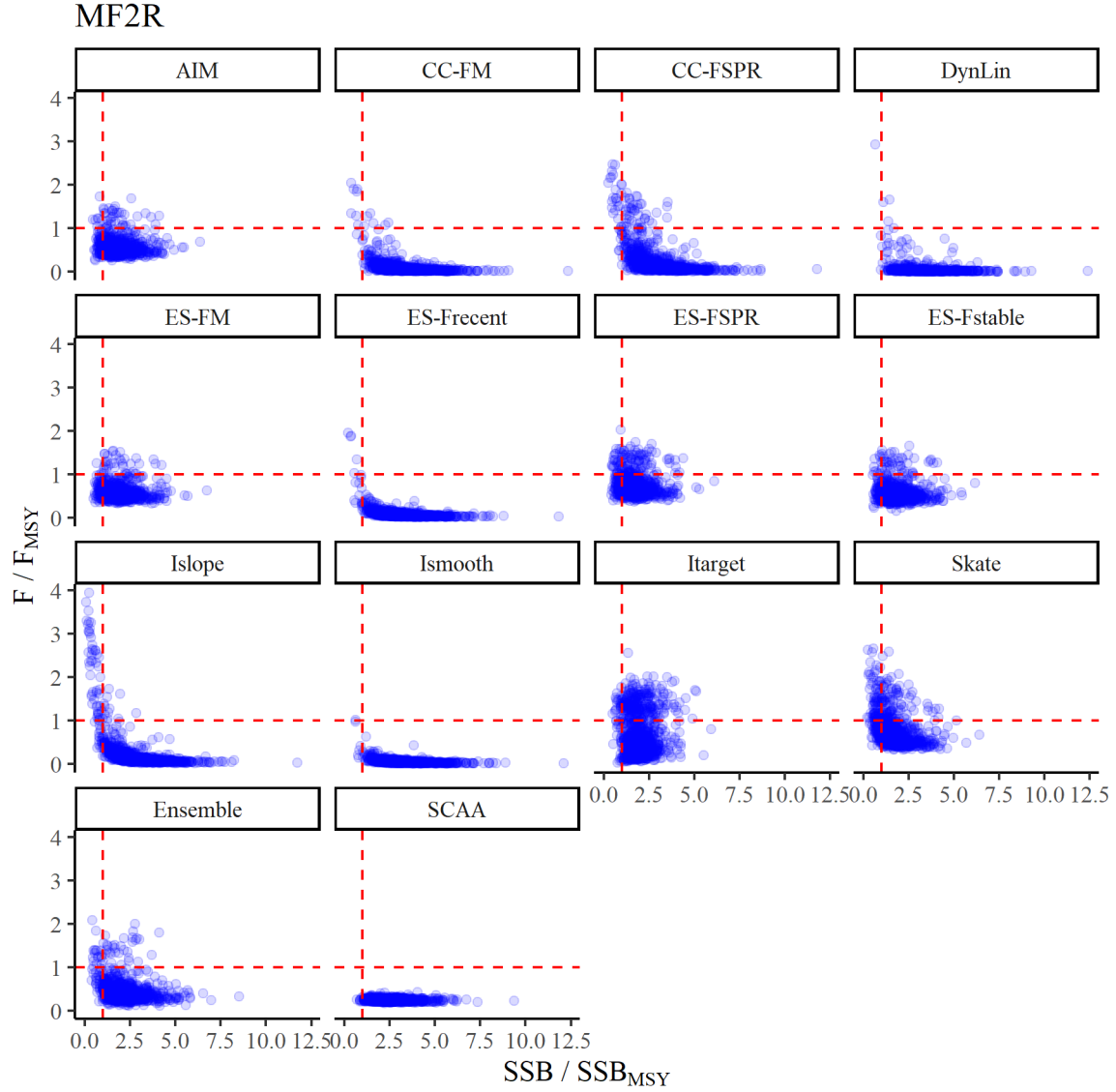


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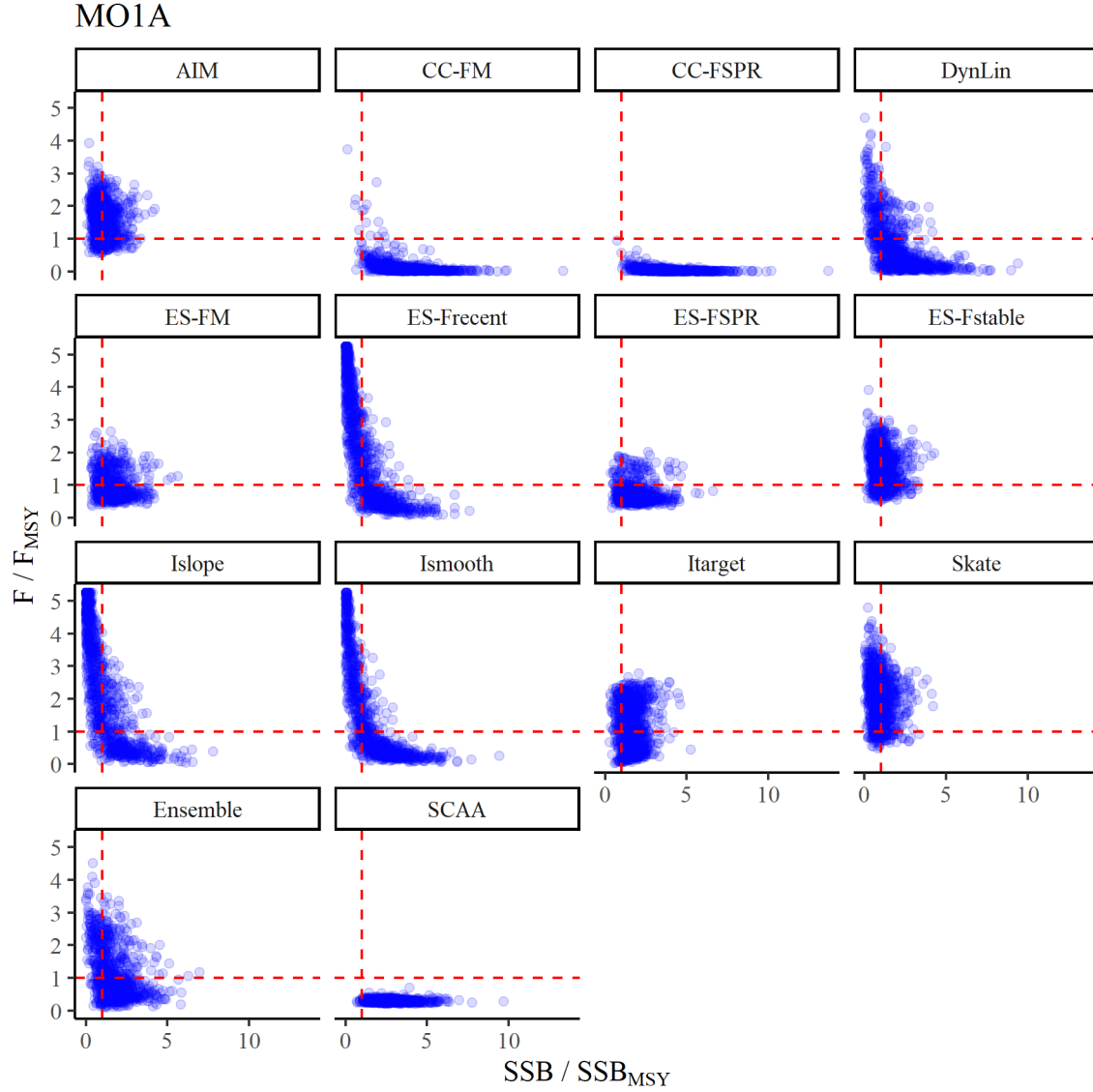


Figure S34. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where no buffer was applied to the catch advice (catch multiplier = 1).

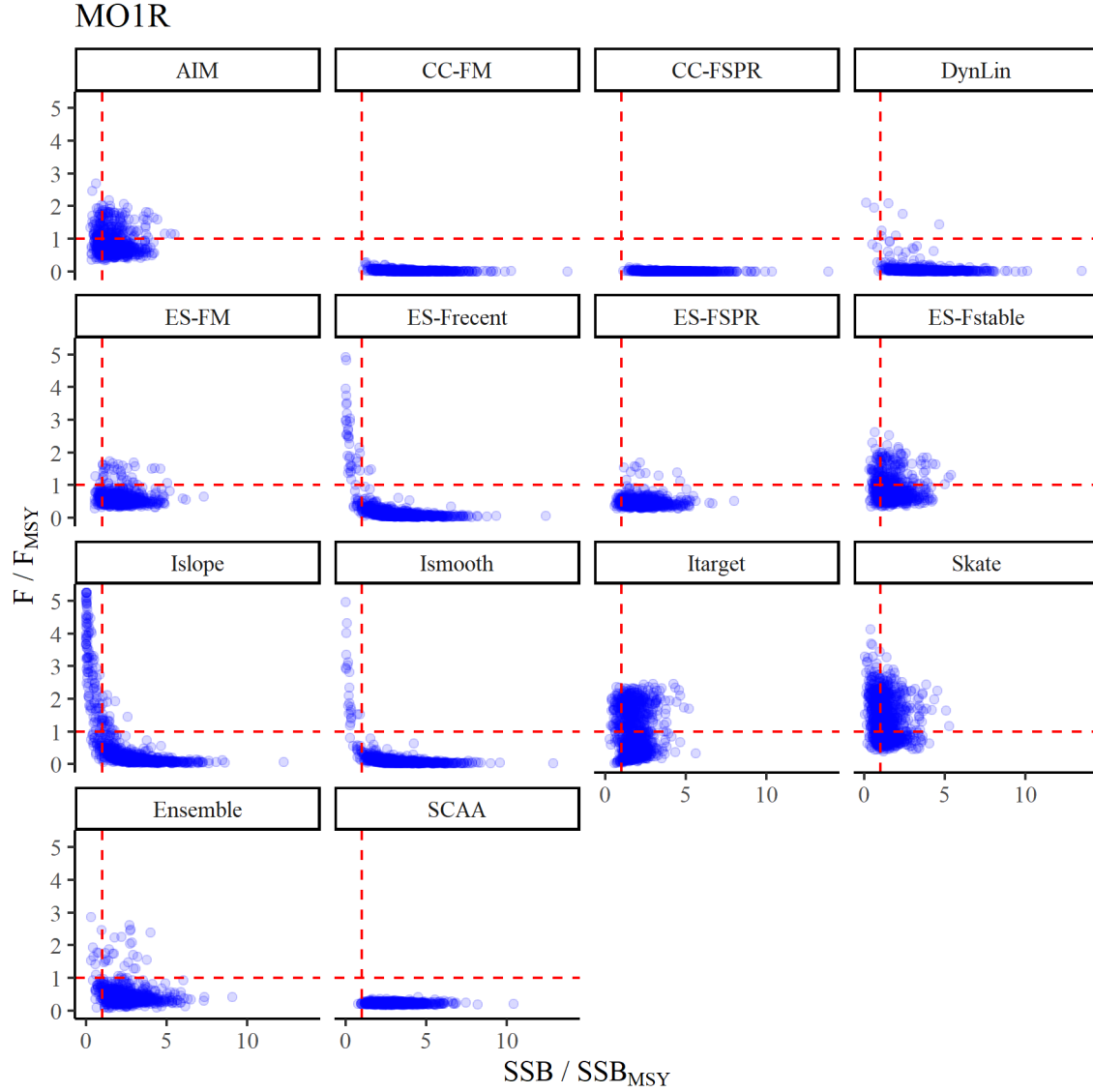


Figure S35. Relationship between long-term average fishing mortality rate and spawning stock biomass relative to their reference points by method. Each point represents the average for years 21-40 in the feedback period for a single iteration of a scenario. The scenario shown is where natural mortality was the source of the retrospective pattern with F remaining at 2.5 times F_{MSY} in the second half of the base period, there was a single selectivity block, and where a buffer was applied to the catch advice (catch multiplier = 0.75).

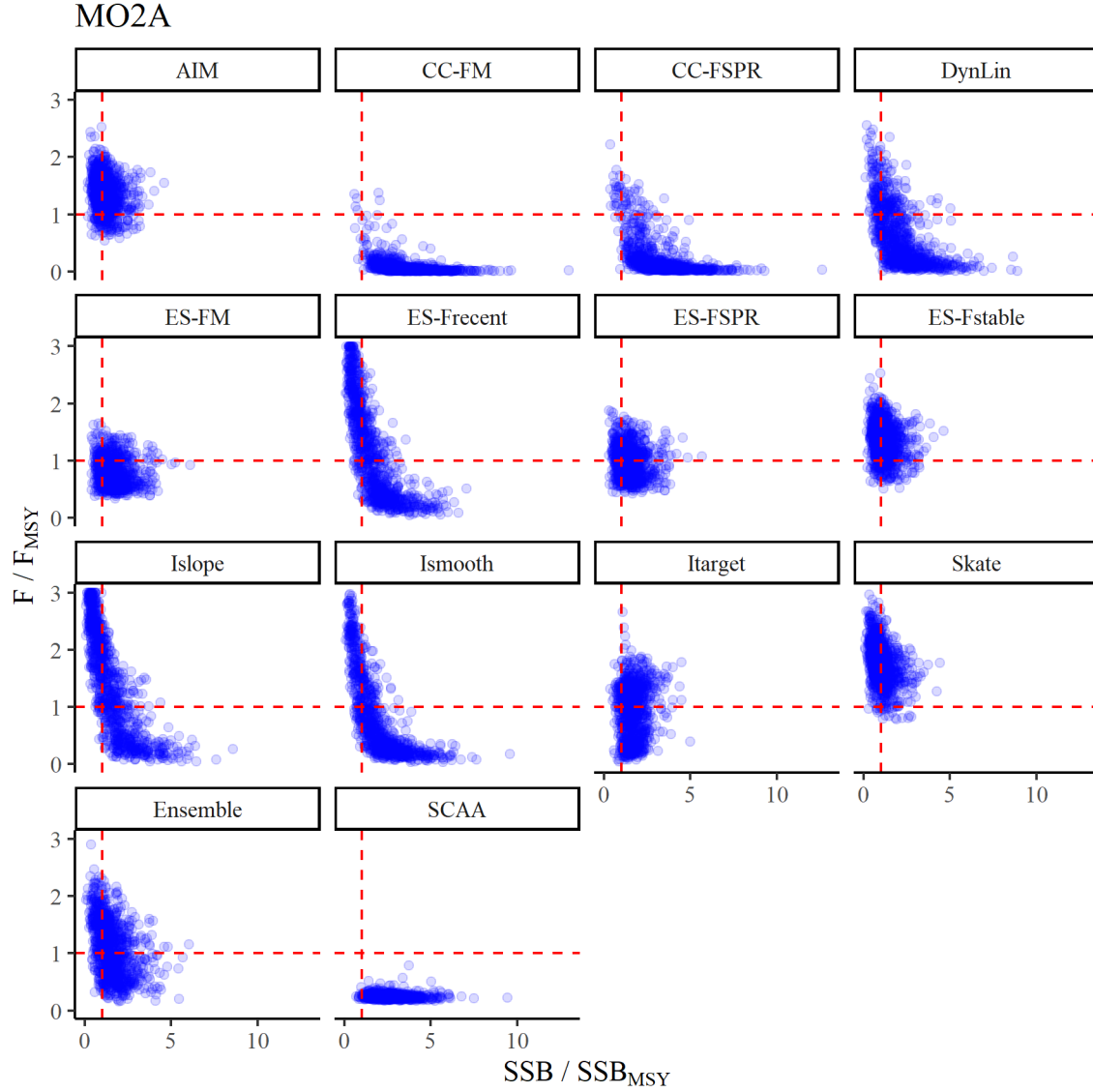


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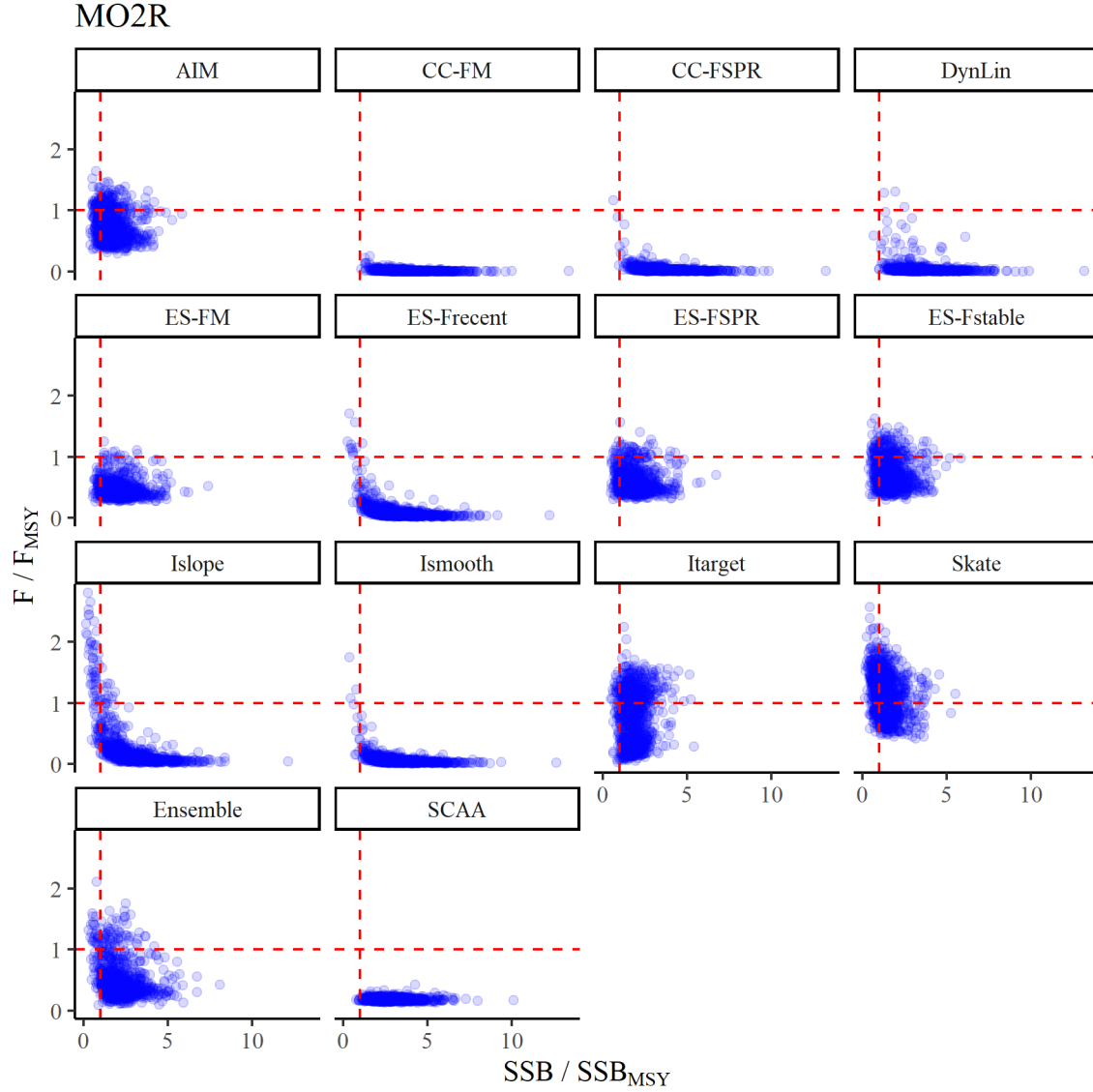


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