IPHC Secretariat MSE Program of Work (2021–2023) and an update on progress

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PURPOSE

To provide the SRB with a description of the Management Strategy Evaluation program of work for 2021–2023 and update the SRB on recent MSE progress.

1 INTRODUCTION

The current interim management procedure (MP) at the International Pacific Halibut Commission (IPHC) is shown in Figure 1.

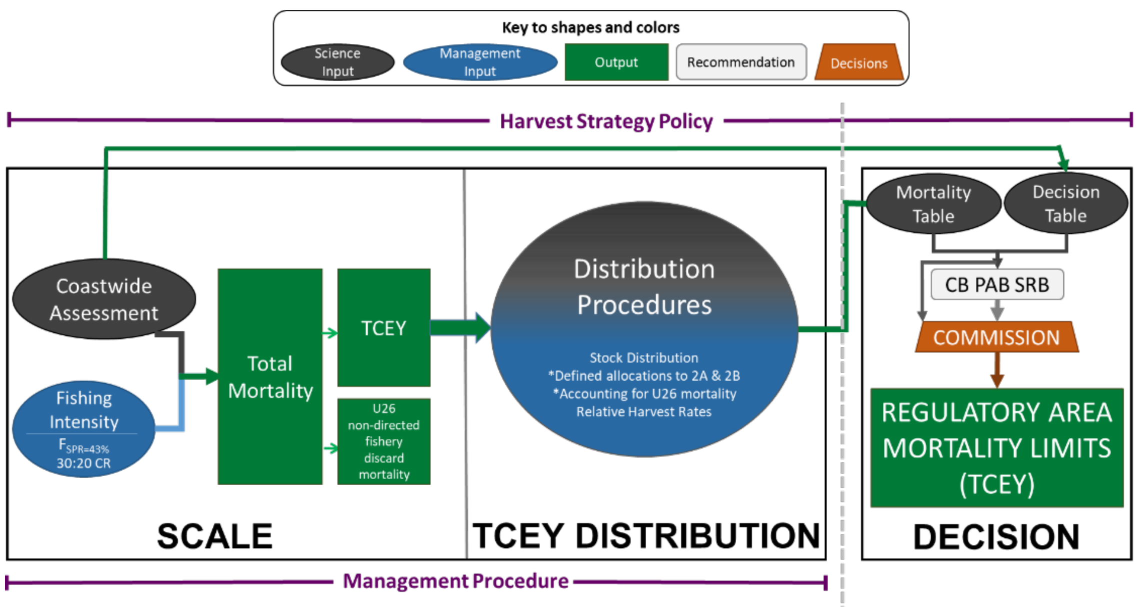

Figure 1. Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC CIRCULAR 2020-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. Items with an asterisk are interim agreements to 2022. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

The Management Strategy Evaluation (MSE) at the IPHC completed an evaluation in 2021 of management procedures (MPs) relative to the coastwide scale and distribution of the Total Constant Exploitation Yield (TCEY) to IPHC Regulatory Areas for the Pacific halibut fishery using a recently developed framework. The development of this MSE framework aimed to support the scientific, forecast-driven evaluation of the trade-offs between fisheries management scenarios. The MSE framework with a multi-area operating model (OM) and three options for examining estimation error is described in Hicks et al. (2020) with technical details available in IPHC-2021-MSE-01. Descriptions of the MPs evaluated and simulation results are presented in Hicks et al. (2021). Additional tasks were identified at the 11th Special Session of the IPHC (IPHC-2021-SS011-R) to supplement and extend this analysis for future evaluation (Table 1).

Table 1. Tasks recommended by the Commission at SS011 (IPHC-2021-SS011-R para 7) for inclusion in the IPHC Secretariat MSE Program of Work for 2021–2023.

ID	Category	Task	Deliverable
F.1	Framework	Develop migration scenarios	Develop OMs with alternative migration scenarios
F.2	Framework	Implementation variability	Incorporate additional sources of implementation variability in the framework
F.3	Framework	Develop more realistic simulations of estimation error	Improve the estimation model to more adequately mimic the ensemble stock assessment
F.5	Framework	Develop alternative OMs	Code alternative OMs in addition to the one already under evaluation.
M.1	MPs	Size limits	Identification, evaluation of size limits
M.3	MPs	Multi-year assessments	Evaluation of multi-year assessments
E.3	Evaluation	Presentation of results	Develop methods and outputs that are useful for presenting outcomes to stakeholders and Commissioners

2 VARIABILITY IN THE MSE FRAMEWORK

The IPHC MSE closed-loop simulation framework consists of an operating model written in C++ that incorporates management procedures that are written in R. Figure 2 shows the elements of the closed-loop simulation and the annual process of an MP feeding back into the simulated population (OM).

At SRB018, the SRB requested an improved explanation of variation included in the MSE.

> IPHC-2021-SRB018-R, para. 30: *The SRB* ***REQUESTED*** *that the IPHC Secretariat present a revised system diagram of the MSE, showing components of variability and their implementation within MSE.*

Leach et al. (2014) identified eight categories of uncertainty from the initial MSE of North Atlantic swordfish (*Xiphias gladius*) (see Sharma et al. 2020). These eight categories each contained multiple sources of uncertainty which provide a convenient framework for considering the components in the Pacific halibut MSE framework. We subsumed the “Recruitment” category into the “Population” category and list important sources of variability for the remaining seven categories in Table 2.

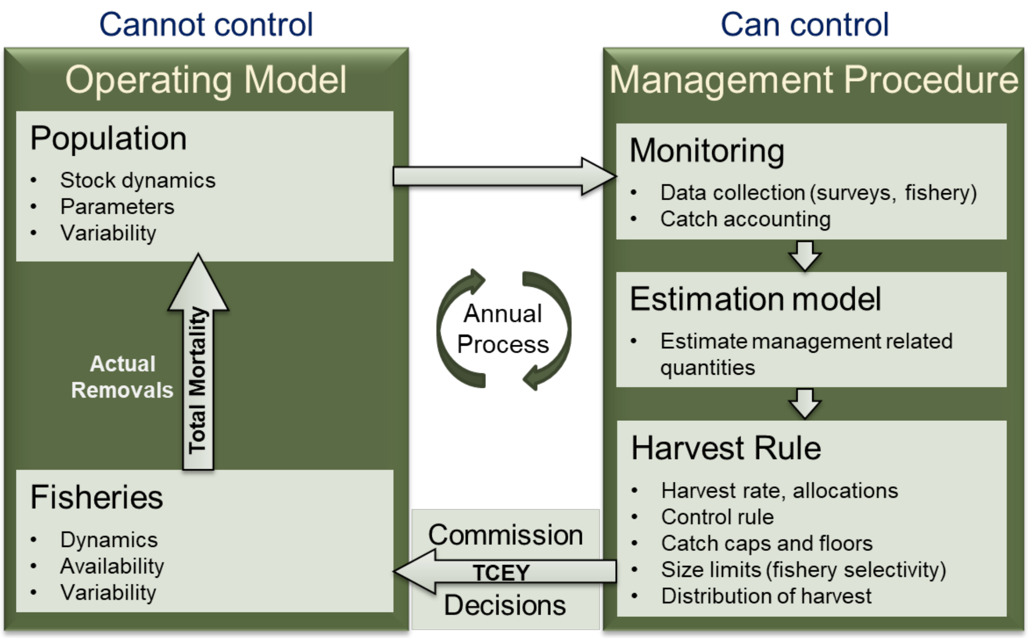

Figure 2. Illustration of the closed-loop simulation framework with the operating model (OM) and the management procedure (MP). This is the annual process on a yearly timescale.

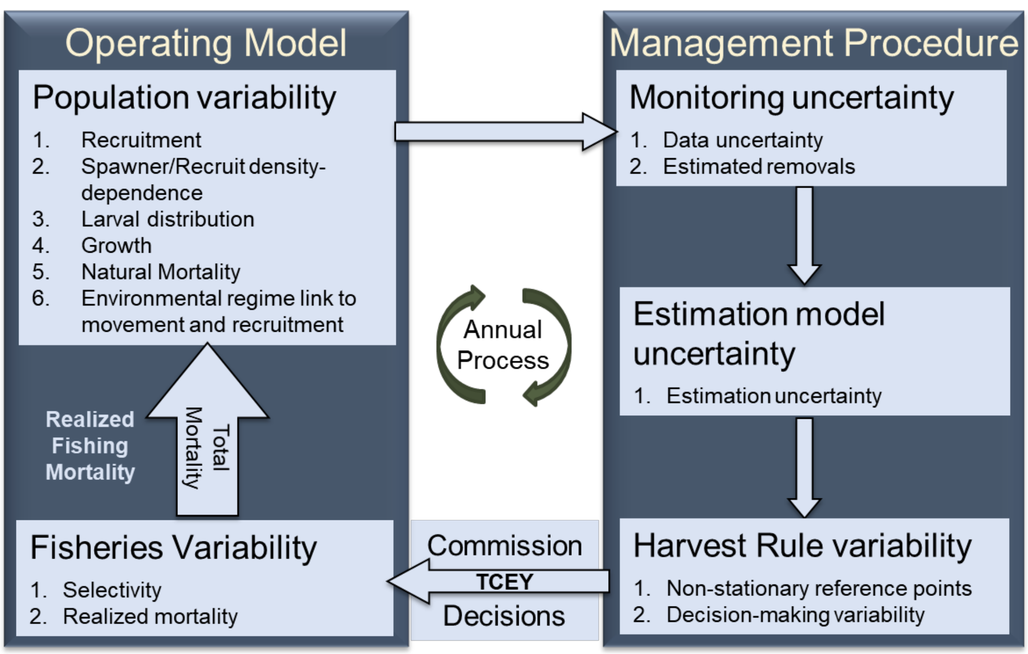

Figure 3. Sources of variability incorporated into the IPHC MSE closed-loop simulation framework. Additional sources of variability not currently included in this framework are listed in Table 2.

Figure 3 shows the sources of variability that are currently included in the IPHC MSE closed-loop simulation framework and under which elements they occur within the framework. Many sources of variability occur within the operating model because it contains many unknowns, and the goal of MSE is to identify management strategies that are robust to the unknowns. The management procedure inherently contains uncertainty because of the sampling process and the use of an estimation model. The harvest rule uses dynamic reference points and the Commission may depart from the specific harvest rule outcome, which is called decision-making variability. Future additions of variability sources are indicated with italic script in Table 2.

Table 2. Sources of variability for seven categories (based on Leach et al. (2014)) for the Pacific halibut MSE. Items not currently included in the IPHC MSE framework are shown with bullets and in italics. Shaded cells indicate combinations of categories and elements that do not have sources of variability identified.

	MSE Framework Element (Figure 2)				
Leach et al. (2014) Categories	**Population**	**Fisheries**	**Monitoring**	**Estimation Model**	**Harvest Rule**
Reference points					1. Non-stationary
Population structure	1. Recruitment 2. Spawner/Recruit density-dependence 3. Larval distribution • *Stock structure* • *Annual movement*				
Model	• *Number of bio-regions* • *Density-dependent processes (other than recruitment)*	1. Selectivity • *Number of fisheries/sectors* • *Catchability*	• *Data generation processes*	• *Estimation model structure*	
Management		• *Response of fisheries*	1. Uncertain data	1. Estimation uncertainty	2. Decision-making variability
Life History Traits	4. Growth 5. Natural mortality • *Maturation, fecundity, spawning*				
Environmental	6. Regimes 6.1. Movement 6.2. Recruitment • *Growth* • *Mortality* • *Climate change*	• *Effects on fisheries*	• *Effects on data collection*		• *Response of harvest rule*
Fishing mortality (catch)		2. Realized removals	2. Estimated removals		

3 MSE RESULTS FOR BIENNIAL STOCK ASSESSMENTS

One of the tasks recommended by the Commission at SS011 (Table 1, IPHC-2021-SS011-R para 7) for inclusion in the IPHC Secretariat MSE Program of Work for 2021–2023 was to investigate multi-year assessments. This would be an MP that incorporates a process where the stock assessment occurs at intervals longer than annually. The mortality limits in a year with the stock assessment can be determined as in previously defined MPs, but in years without a stock assessment, the mortality limits would need an alternative approach. This may be as simple as maintaining the same mortality limits for each IPHC Regulatory Area in years with no stock assessment, or as complicated as invoking an alternative MP that does not require a stock assessment (such as an empirical-based MP relying only on data/observations).

Simulations using a MP where the stock assessment occurs biennially and the mortality limits remain unchanged from the previous year were performed using the MSE framework. The specifications of the simulation model are the same as reported in Hicks et al. (2020), Hicks et al. (2021), and IPHC-2021-MSE-01. The MP specified as A was used with the addition of a biennially assessment (Table 3). Coastwide performance metrics for MP-A with and without the biennial mortality limit specification are shown in Table 4 along with MP-D and MP-J which were the best performing MPs from the previous MSE simulations.

Table 3. Specifications of MPs with an annual stock assessment and management advice (MP-A, MP-D, and MP-J), and with a biennial stock assessment and mortality limit specification (MP-A2).

Element	MP-A	MP-A2	MP-D	MP-J
Maximum coastwide TCEY change of 15%				
Maximum Fishing Intensity buffer (SPR=36%)				
O32 stock distribution				
O32 stock distribution (5-year moving average)				
All sizes stock distribution				
Fixed shares updated in 5th year from O32 stock distribution				
Relative harvest rates of 1.0 for 2-3A, and 0.75 for 3B-4				
Relative harvest rates of 1.0 for 2-3, 4A, 4CDE, and 0.75 for 4B				
Relative harvest rates by Region: 1.0 for R2-R3, 0.75 for R4-R4B				
1.65 Mlbs fixed TCEY in 2A				
Formula percentage for 2B				
National Shares (2B=20%)				
Frequency of stock assessment & mortality limits				

Table 4. Coastwide long-term performance metrics for the biological sustainability objective and P(all RSB<36%) and short-term performance metrics for the remaining fishery sustainability objectives for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit setting process (A2). All results use an SPR value of 43% with simulated estimation error.

Input SPR/TM	**43**	**43**	**43**	**43**
Management Procedure	**A**	**A2**	**D**	**J**
Number of Simulations	500	480	500	500
Biological Sustainability				
P(any RSB_y<20%)	<0.01	<0.01	0.01	<0.01
Fishery Sustainability				
P(all RSB<36%)	0.25	0.28	0.44	0.28
Median average TCEY (Mlbs)	39.92	38.31	40.22	37.90
P(any3 change TCEY > 15%)	0.44	0.36	0.10	0.00
Median AAV TCEY	12.1%	9.0%	5.9%	9.5%

The biennial mortality limit specification improved the coastwide performance metrics related to variability in the TCEY compared to MP-A with an annual mortality limit specification. The median average TCEY was less than MP-A and MP-D, but slightly higher than MP-J. The median relative spawning biomass was above the 36% target, but slightly closer than MP-A.

MP-A2 shows a different pattern of variability that is not completely captured with the performance metrics presented in Table 4. The variability performance metrics with the biennial mortality limit specification show improvements because half of the years in a ten-year period have no change in the TCEY compared to an MP with an annual mortality limit specification while the other half may show a slightly larger change. Trajectories of the projected TCEY for a 60-year period show the biennial specification process in MP-A2 (Figure 4). Comparing the trajectories for MP-A and MP-A2 shows that the biennial process generally follows the annual process but with steps. However, there are cases where the biennial process takes longer to catch up (e.g. the start of the trajectory) and where the biennial process does not unnecessarily change the TCEY (e.g. near the year 2065 for some simulations).

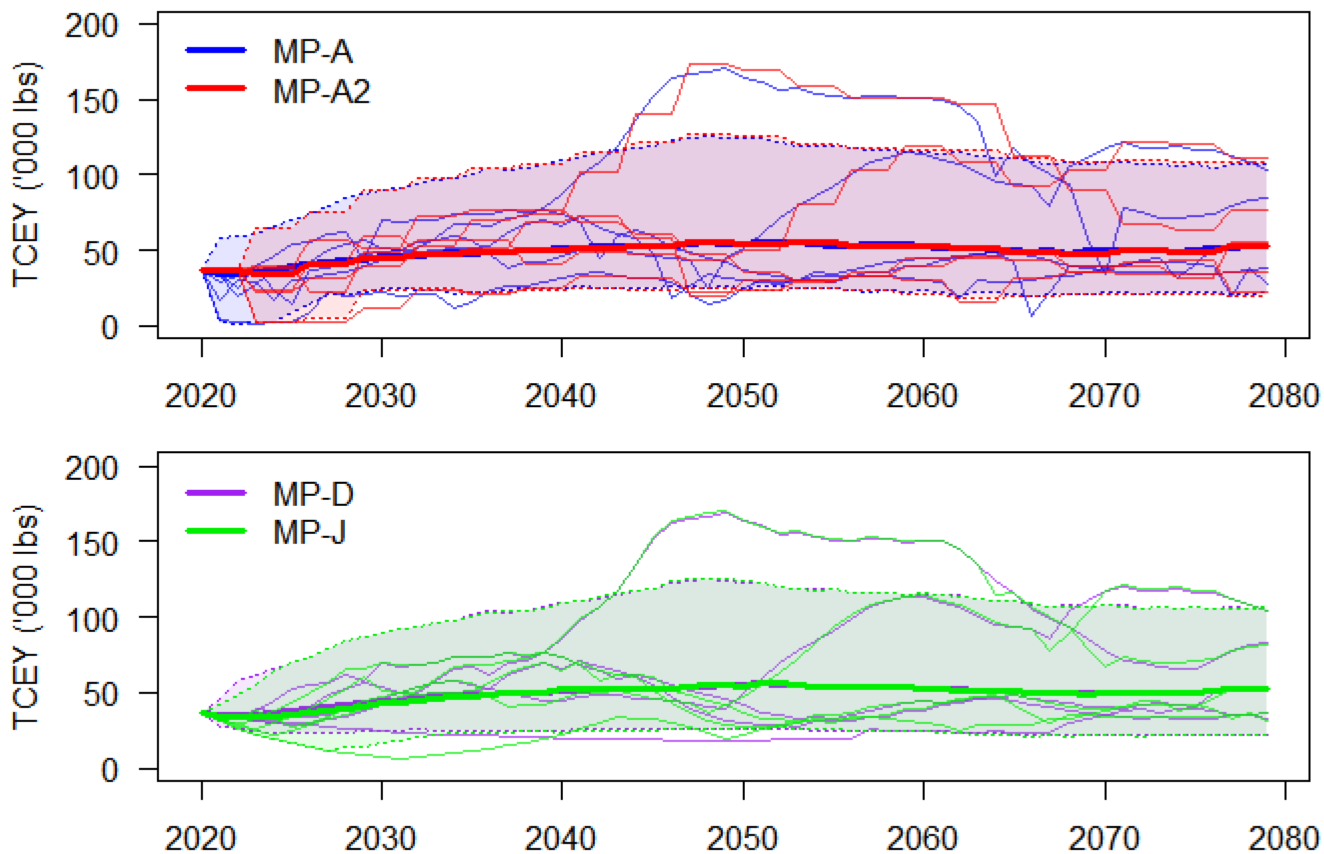

Figure 4. Trajectories of TCEY for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit specification process (A2). All results use an SPR value of 43% with simulated estimation error. The 5th and 95th quantiles are shown as a shaded polygon. Five individual trajectories are shown as thin lines and the median of all simulations is shown as a thick line.

Therefore, three new performance metrics are reported to provide a better indication of how the TCEY may change in a given year. Over a ten-year period these are, the probability that the TCEY exceeds a change greater than 15% in any one year [P(any1 change TCEY > 15%)], the probability that the TCEY exceeds a change greater than 15% in any two years [P(any2 change TCEY > 15%)], and the median maximum absolute percentage change (up or down) in the TCEY over a 10-year period (Median max abs % change TCEY). Table 5 shows that all of these performance metrics are highest for MP-A2, indicating that the change in the TCEY is typically higher in years when it changes compared to an annual mortality limit specification process. Although the maximum absolute percent change in the TCEY is on average higher for MP-A2 compared to MP-A, the inter-quartile range (middle 50% of the distribution) is diminished for MP-A2 compared to MP-A (Figure 5).

Overall, there is a clear trade-off between slightly higher biennial change and consistency within each two-year period. The benefits to a biennial mortality limit specification include stability for a two-year period and resources needed for conducting a stock assessment can be directed towards other research such as improving the stock assessment or MSE. However, it is likely that the change in the mortality limit every other year may be larger than desired for an annual process. These trade-offs must be considered when analysing any MP with a biennial mortality limit specification.

Table 5. Additional coastwide short-term and long-term performance metrics for the fishery sustainability objectives related to TCEY variability for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit specification process (A2). All results use an SPR value of 43% with simulated estimation error.

	Short-term				**Long-term**			
Input SPR/TM	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**43**
Management Procedure	**A**	**A2**	**D**	**J**	**A**	**A2**	**D**	**J**
Fishery Sustainability								
P(any1 change TCEY > 15%)	0.75	0.93	0.56	0.00	0.46	0.67	0.17	0.00
P(any2 change TCEY > 15%)	0.63	0.74	0.26	0.00	0.31	0.32	0.02	0.00
Median max absolute % change TCEY	18%	23%	11%	15%	13%	21%	9%	14%

The mortality limit does not need to be held constant in years when there is no stock assessment, but may instead use other methods to determine a mortality limit. The projection from the stock assessment may be used, or an empirical, data-driven approach can inform changes to the mortality limit. This may reduce the potential for large changes in years when a stock assessment is used for setting the mortality limit and could be extended to periods of longer than 2 years between stock assessments.

An alternative approach that would not require a stock assessment would be to adopt an empirical-based MP as the method for setting annual mortality limits. The stock assessment would not be used specifically to set mortality limits but would be used at a defined interval to verify that management is effective and to potentially tune the MSE and existing MP (Cox and Kronlund 2008). Any of the MPs mentioned in this section, empirical- or model-based or a hybrid of the two, can be evaluated using the current MSE framework.

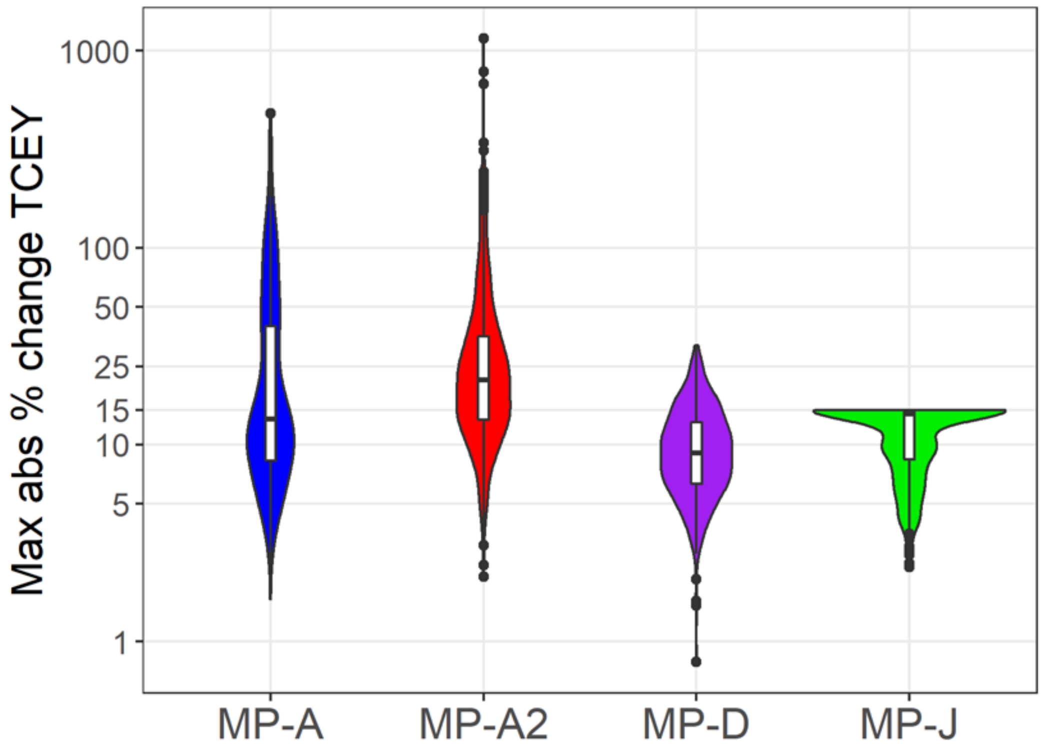

Figure 5. Boxplots (white) within violin plots (colors) of short-term maximum percent absolute change in the TCEY for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit specification process (MP-A2). All results use an SPR value of 43% with simulated estimation error. A value of 15% is shown as a horizontal grey line. White boxes represent the interquartile (50%) range with the median (dark solid line).

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2021-SRB019-07 describing the MSE Program or Work for 2021–2023, sources of variability in the MSE framework, and results from simulations with a biennial mortality limit specification.

b) **RECOMMEND** MP specifications to investigate multi-year stock assessments as part of the MSE program of work for 2021-2023.

c) **REQUEST** any further analyses to be provided at SRB020, June 2021.

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APPENDICES

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