Results investigating fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries

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PURPOSE

To provide results from the International Pacific Halibut Commission (IPHC) Management Strategy Evaluation (MSE) for the evaluation of management procedures (MPs) for distributing the TCEY.

1 INTRODUCTION

The Management Strategy Evaluation (MSE) at the International Pacific Halibut Commission (IPHC) has now completed initial development of a framework (IPHC-2020-MSAB016-08) to investigate MPs related to distributing the Total Constant Exploitation Yield (TCEY) to IPHC Regulatory Areas. The TCEY is the mortality limit composed of mortality from all sources except under-26-inch (66.0 cm, U26) non-directed commercial discard mortality, and is determined by the Commission at each Annual Meeting for each IPHC Regulatory Area. These results will be evaluated by the MSAB to provide guidance to the IPHC Secretariat and to Commissioners for future MSE work and on identifying best performing MPs relative to the objectives defined by the Commission (Appendix I).

This document presents results available at the time of publication and it is expected that additional results will be available at MSAB016. MPs presented here will likely have additional simulations completed to increase precision of the performance metrics and additional MPs will likely be added. Primary and secondary priority MPs are identified in IPHC-2020-MSAB016-07, which is repeated in Appendix II for convenience.

This document provides a static view of results and a presentation of important outcomes. For additional insights and the most up to date set of results, readers are referred to the MSE Explorer online.

http://shiny.westus.cloudapp.azure.com/shiny/sample-apps/MSE-Explorer/

2 SPECIFICS OF THE MANAGEMENT PROCEDURES

The full set of management procedures presented in Appendix II will be presented at MSAB016. In this document, only the priority 1 MPs are presented (MP-A, MP-B, MP-F, MP-G, MP-H, and MP-J) with SPR values of 40%, 43%, and 46%. A wider range of SPR values will also be presented at MSAB016.

Estimation error is important to include in MSE simulations, but it is also useful to present results without estimation error to understand the effect of estimation error. Three different types of estimation error are presented.

1. **No Estimation Error (noEE)**: The stock status, total mortality given the input SPR, the stock distribution, and any other quantities needed for the MP are known exactly.

2. **Simulated Estimation Error (EE)**: Error is added to the stock status and total mortality given the input SPR that are used in the MP by adding deviates to each that are sampled from a bivariate normal distribution with a 15% coefficient of variation on each and a correlation of 0.5. Additionally, an autocorrelation of 0.4 is used with the deviate from the previous year. This is the same method that was used in the coastwide MSE as described in IPHC-2018-MSAB012-07_Rev_1. Stock distribution is determined from survey data generated with random error similar to error estimates from the current survey time-series.

3. **Simulated assessment (SS)**: This method simulates the long coastwide stock assessment model that is included in the stock assessment ensemble and uses stock synthesis (SS). Data needed for the assessment model are generated with random error. These data are included in the assessment model which estimates the population parameters needed for the management procedure. This method is useful because it is likely a closer approximation of the stock assessment and includes bias, autocorrelation, and variability that the stock assessment may produce over time. This method can be expanded to include additional models (e.g., short coastwide model) but further testing is needed with those models to ensure that they perform adequately in the simulated projections.

3 RESULTS

The results below provide insights into the performance of the operating model as well as the performance of management procedures.

3.1 Projections without fishing mortality

Projections with parameter variability (e.g., natural morality, movement, etc.) and projection variability (e.g. simulated weight-at-age) produced a wide range of trajectories. Figure 1 shows the median of one-hundred simulations to 2099 without mortality due to fishing along with the interval between the 5th and 95th percentiles. Individual trajectories show that a single trajectory may cover a wide range of that interval in this 80-year period. The variability looks like it has reached its full range after 30 years, although there is an increasing trend near year 2090. This could be due to the small number of simulations and the expected high variability without fishing mortality. The inclusion of fishing mortality reduces this variability because SPR-based MPs are adjusting the harvest rate to remove an appropriate amount of biomass.

Overall, the population is highly variable and shows a wide range of potential unfished spawning biomass. This is largely due to changes in weight-at-age, but in these simulations is also due to the parameter variability. With fishing, the high variability will influence the variability in mortality limits.
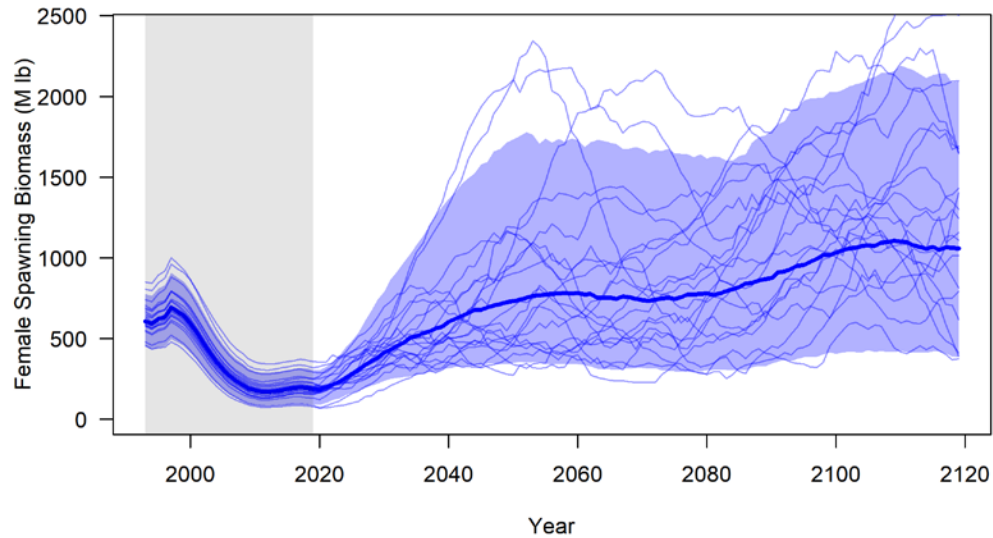
Figure 1. Six-hundred simulations for 100 years without fishing mortality. The blue line is the median and the blue shaded area shows the interval between the 5th and 95th percentiles. The light shaded grey area between 1993 and 2019 is the historical period, and 2020 has fixed fishing mortality based on the already defined catch limits for 2020. The thin blue lines are the first 20 individual trajectories.

3.2   Closed-loop simulation results

For brevity, only the simulated estimation error (EE) is used to compare across SPR values and tables with only an SPR of 43% are presented. Simulations with alternative estimation error modelling are available on the MSE Explorer.

Figure 2 shows coastwide performance metrics linked to the primary coastwide objectives. The relative spawning biomass (RSB) is similar across all management procedures, but varies with SPR. No MP exceeds the 10% tolerance for RSB dropping below 20% SPR, and the median RSB resulting from an SPR of 40% is slightly less than 36%. Table 1 shows that the probability of being below 36% is slightly less for MP-A compared to all other MPs. The AAV was higher for MP-A as well, especially at lower SPR values, because MP-A was the only MP without an annual constraint of 15% on the TCEY. For the same reason, the probability that the annual change (AC) was greater than 15% was greater than zero for MP-A and zero for all other MPs. Median TCEY was slightly greater than 40 Mlbs for all MPs and SPR values, and showed slight variations between MPs. The difference in the median TCEY was less than 1 Mlbs between MPs for an SPR of 43% (Table 1).

Performance metrics for the TCEY in each IPHC Regulatory Area are shown in Figure 3 and Tables 2 & 3. These are the median minimum and median average TCEY over a ten-year period (long term) and the median minimum and median average percentage of TCEY in each IPHC Regulatory Area over a ten-year period (medium term). MPs F–K show decreased TCEY in 2A and MPS E–K show decreased TCYE in 2B along with increased TCEY in all other IPHC

Regulatory Areas because the current agreements from 2A and 2B, or national shares for 2B, are not included in those MPs. The TCEY increases in 3B, 4A, and 4B with the increased relative harvest rate included in MP-H and MP-K, with decreases in other IPHC Regulatory Areas. MP-J, which uses a 5-year average of stock distribution, shows similar TCEY values as MP-G, but with lower AAV for most IPHC Regulatory Areas (Table 4). Stability related performance metrics differences are evident at the IPHC Regulatory Area with MP-J, even though stability was not much different than MP-G at the coastwide level (e.g., median AAV). Additional performance metrics presented in the MSE Explorer may assist in the evaluation of the MPs.

Overall, the eleven MPs show minor differences at the coastwide level but showed some important differences at the IPHC Regulatory Area level. Trade-offs between IPHC Regulatory Areas are an important consideration when evaluating the MSE results. Ranking the performance metrics across management procedures and then averaging group of ranks (e.g., over IPHC Regulatory Areas) can assist in identify MPs that perform best overall.

The Biological Sustainability objectives have a tolerance defined, thus it can be determined if the objective is met by a management procedure. All management procedures met the Biological Sustainability objectives, except for the objective to maintain a minimum percentage of female spawning biomass above 2% in IPHC Regulatory Area 4B with a tolerance of 0.05 (Table 5). This distribution of the projected percentage of spawning biomass in Biological Region 4B has a probability of 0.19 to be less than 2% with no fishing mortality (Figure 4). This probability is slightly less with fishing mortality (Table 5) because the spawning biomass is less variable with fishing. The fact that this objective is not met without fishing or with any of the management procedures suggests two things: 1) the objective should be revisited and/or 2) the operating model is not adequately representing the population across Biological Regions.

The operating model was conditioned to the observed stock distribution and the predicted range of historical stock distribution from the operating model for Biological Region 4B is wider than the confidence intervals for the observed stock distribution (Figure 8 in IPHC-2020-MSAB016-08). Biological Region 4B is a unique region in the IPHC convention area, possibly with a separate stock, and the operating model may not be completely capturing the stock dynamics in that area. Additionally, with mostly out-migration from 4B and little recruitment distributed to that area, large increases in spawning biomass in the other Biological Regions may results in Biological Region containing a small percentage of the spawning biomass even though the absolute spawning biomass is at a high level. Regardless, the spawning biomass persists in that Biological Region and in addition to revisiting the assumptions in the operating model, it would be prudent to revisit the regional spawning biomass objective.

The ranking of performance metrics for the Fishery Sustainability objectives are shown in Tables 6–9. Higher ranks generally occurred for MPs I, J, and K, although not necessarily for IPHC Regulatory Areas 2A and 2B when agreements were in place for those areas. The general objectives were averaged over IPHC Regulatory Areas to produce a summary of ranks as shown in Table 10. This summary shows that MPs J and K generally have higher ranks for stability and yield objectives specific to IPHC Regulatory Areas. However, the coastwide median average

TCEY is the lowest for MP J, although it varies by less than one million pounds across all MPs (Table 2).
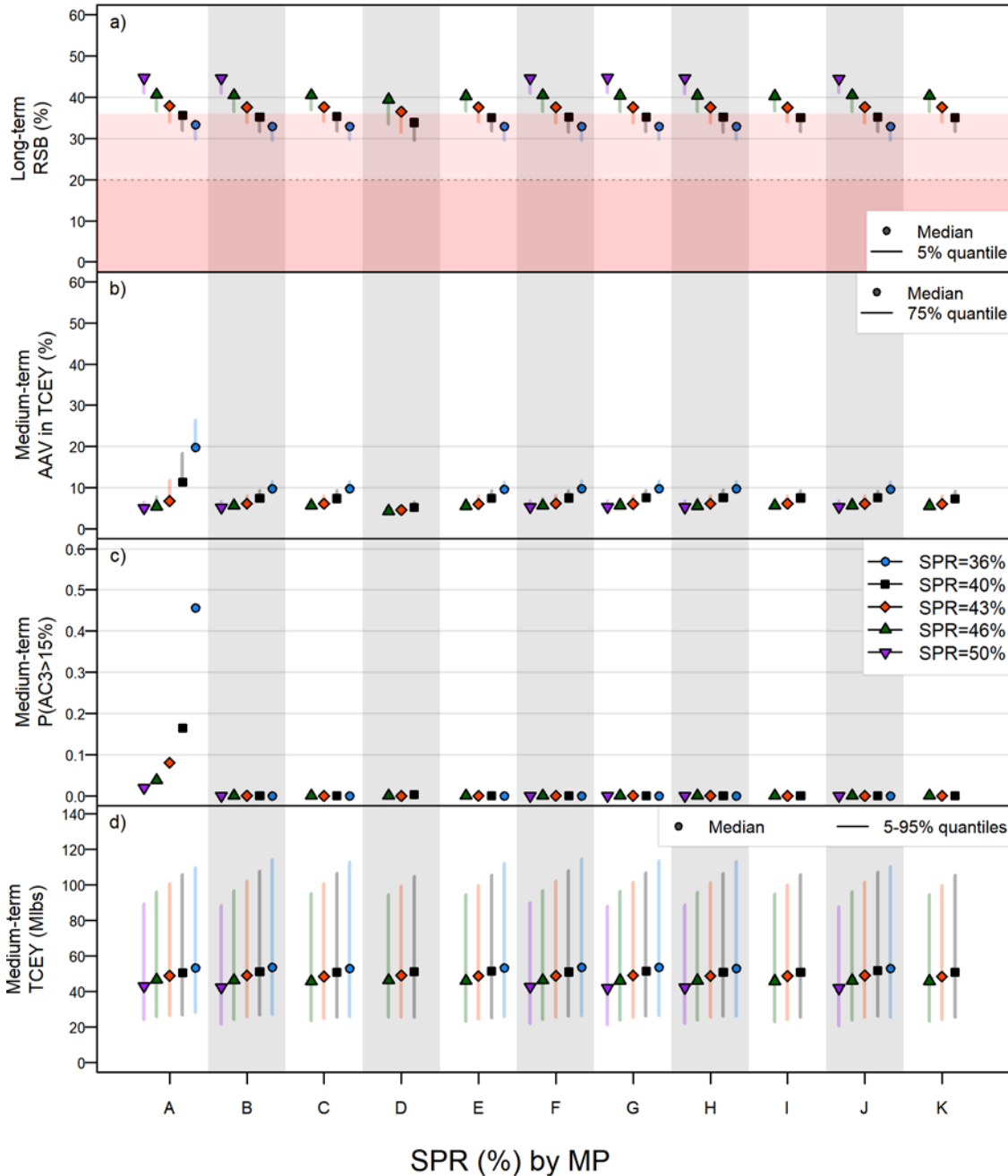
Figure 2. Coastwide performance metrics for MPs A through K using simulated estimation error with SPR values of 40%, 43%, and 46% for all and 36% and 50% for some. The relative spawning biomass and the thresholds of 20% and 36% are shown in a). The AAV for TCEY is shown in b). The probability that the annual change exceeds 15% in 3 or more years is shown in c). The median TCEY with 5th and 95th quantiles is shown in d).

Table 1. Coastwide long-term performance metrics for the biological sustainability objective and P(all RSB<36%) and medium-term performance metrics for the remaining fishery sustainability objectives for MPs A through K for an SPR value of 43% using simulated estimation error.

Input SPR/TM	43	43	43	43	43	43	43	43	43	43	43
Management Procedure	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Number of Simulations	500	500	400	300	300	500	500	500	300	500	300
Biological Sustainability											
P(any RSB_y<20%)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fishery Sustainability											
P(all RSB<36%)	0.25	0.28	0.28	0.45	0.29	0.28	0.28	0.29	0.29	0.28	0.29
Median average TCEY	48.89	49.10	48.56	49.14	48.82	48.90	49.08	48.73	48.65	49.01	48.43
P(any3 change TCEY > 15%)	0.18	<0.01	<0.01	0.01	<0.01	0.0000	0.0000	0.0000	0.0000	0.0000	<0.01
Median AAV TCEY	6.8%	6.1%	6.1%	4.6%	6.0%	6.2%	6.1%	6.1%	6.1%	6.1%	6.0%
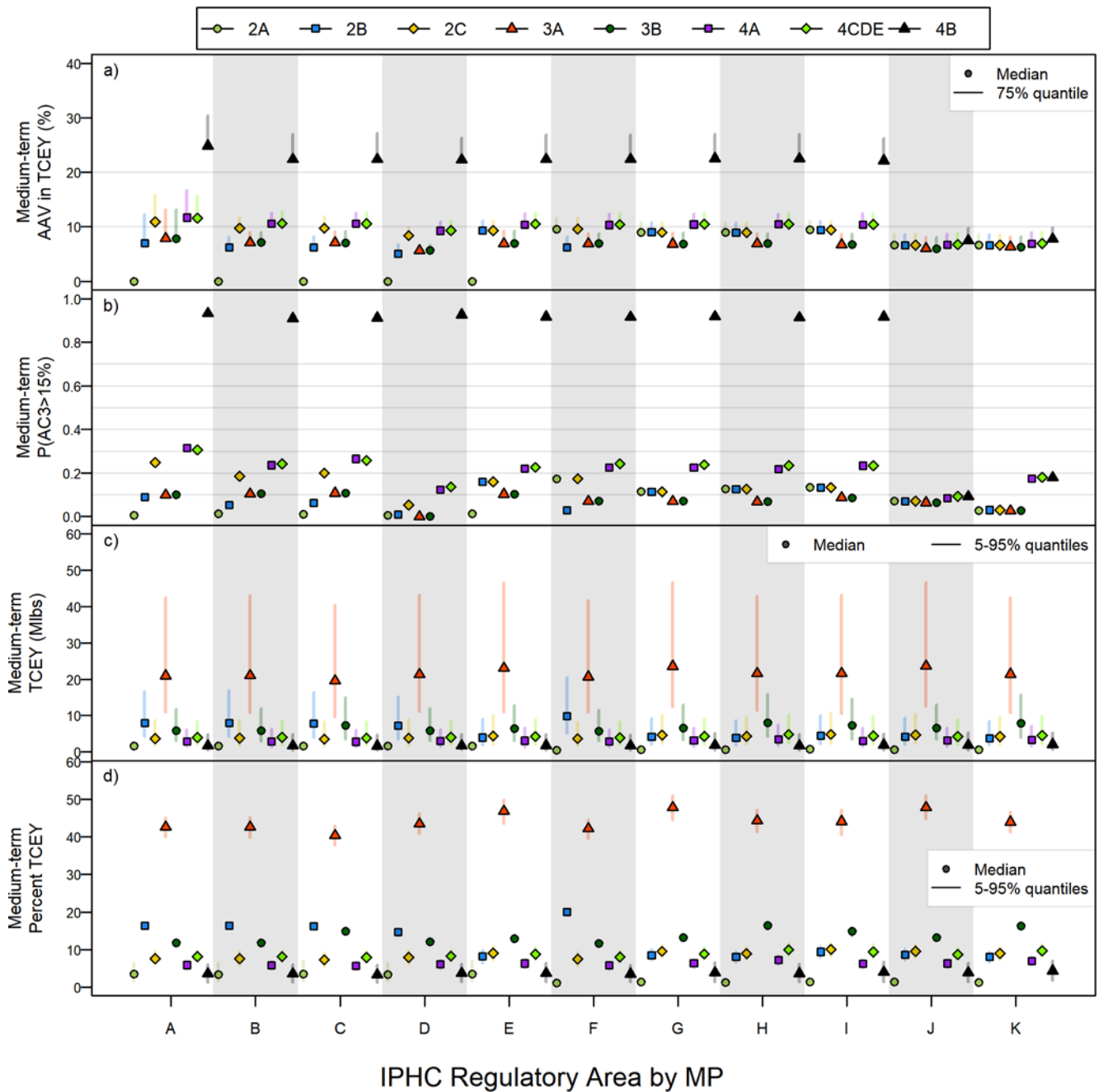
Figure 3. Performance metrics by IPHC Regulatory Areas for MPs A through K using simulated estimation error with an SPR value of 43%. The AAV for TCEY is shown in a). The probability that the annual change exceeds 15% in 3 or more years is shown in b). The median TCEY with 5th and 95th quantiles is shown in c). The median percentage of the TCEY in each IPHC Regulatory Area is shown in d).

Table 2. Long-term spawning biomass performance metrics by Biological Region and TCEY medium-term performance metrics by IPHC Regulatory Areas for MPs A through K with an SPR value of 43% using simulated estimation error.

| Input SPR/TM | 43% | 43% | 43% | 43% | 43% | 43% | 43% | 43% | 43% | 43% | 43% |
Distribution Procedure	A	B	C	D	E	F	G	H	I	J	K
Number of Simulations	500	500	400	300	300	500	500	500	300	500	300
Biological Sustainability											
$P(\%SB_{R=2} < 5\%)$	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$P(\%SB_{R=3} < 33\%)$	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$P(\%SB_{R=4} < 10\%)$	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$P(\%SB_{R=4B} < 2\%)$	0.15	0.15	0.16	0.14	0.15	0.15	0.16	0.15	0.15	0.16	0.17
Fishery Sustainability											
Median Minimum TCEY 2A	1.65	1.65	1.65	1.65	1.65	0.40	0.51	0.48	0.55	0.52	0.48
Median Minimum TCEY 2B	6.06	6.40	6.29	5.94	3.06	7.81	3.22	2.99	3.52	3.26	3.01
Median Minimum TCEY 2C	2.65	2.82	2.66	3.05	3.40	2.78	3.59	3.33	3.75	3.63	3.35
Median Minimum TCEY 3A	15.83	16.54	15.66	17.73	18.03	16.40	18.53	17.14	17.24	18.69	17.07
Median Minimum TCEY 3B	4.39	4.59	5.79	4.92	5.00	4.55	5.14	6.34	5.81	5.18	6.31
Median Minimum TCEY 4A	2.04	2.18	2.07	2.31	2.33	2.15	2.37	2.66	2.27	2.42	2.71
Median Minimum TCEY 4CDE	2.79	2.98	2.83	3.16	3.19	2.95	3.24	3.64	3.38	3.31	3.71
Median Minimum TCEY 4B	1.02	1.14	1.07	1.22	1.22	1.12	1.24	1.16	1.23	1.44	1.64
Median average TCEY-2A	1.65	1.65	1.65	1.65	1.65	0.52	0.66	0.62	0.70	0.67	0.60
Median average TCEY-2B	7.99	8.00	7.85	7.20	3.94	9.78	4.17	3.87	4.52	4.20	3.78
Median average TCEY-2C	3.70	3.76	3.53	3.83	4.39	3.64	4.64	4.31	4.82	4.68	4.21
Median average TCEY-3A	20.95	21.07	19.55	21.31	23.06	20.70	23.58	21.66	21.61	23.71	21.39
Median average TCEY-3B	5.81	5.84	7.23	5.91	6.40	5.74	6.54	8.01	7.28	6.58	7.91
Median average TCEY-4A	2.92	2.91	2.78	2.95	3.08	2.86	3.14	3.50	2.99	3.09	3.30
Median average TCEY-4CDE	4.00	3.99	3.81	4.04	4.23	3.91	4.31	4.80	4.46	4.24	4.53
Median average TCEY-4B	1.71	1.70	1.62	1.72	1.80	1.67	1.84	1.73	1.94	1.83	2.06

Table 3. Percentage of TCEY medium-term performance metrics by IPHC Regulatory Areas for MPs A through K with an SPR value of 43% using simulated estimation error.

Input SPR/TM	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
Distribution Procedure	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Number of Simulations	500	500	400	300	300	500	500	500	300	500	300
Fishery Sustainability											
Median Minimum % TCEY 2A	2.7%	2.8%	2.9%	2.8%	2.8%	0.9%	1.2%	1.1%	1.3%	1.3%	1.2%
Median Minimum % TCEY 2B	16.1%	16.1%	16.0%	14.3%	7.4%	20.0%	7.7%	7.2%	8.5%	8.2%	7.7%
Median Minimum % TCEY 2C	6.7%	6.8%	6.4%	7.0%	8.2%	6.6%	8.6%	8.0%	9.1%	9.2%	8.5%
Median Minimum % TCEY 3A	40.4%	40.6%	38.6%	41.4%	44.5%	40.2%	45.4%	42.0%	41.8%	46.7%	43.1%
Median Minimum % TCEY 3B	11.2%	11.3%	14.3%	11.5%	12.3%	11.1%	12.6%	15.5%	14.1%	13.0%	15.9%
Median Minimum % TCEY 4A	5.1%	5.1%	5.0%	5.3%	5.5%	5.1%	5.6%	6.3%	5.5%	6.0%	6.7%
Median Minimum % TCEY 4CDE	7.1%	7.1%	6.9%	7.2%	7.6%	7.0%	7.7%	8.7%	8.2%	8.2%	9.3%
Median Minimum % TCEY 4B	2.6%	2.6%	2.4%	2.7%	2.7%	2.5%	2.8%	2.6%	2.8%	3.5%	3.9%
Median average % TCEY 2A	3.5%	3.4%	3.5%	3.4%	3.5%	1.1%	1.4%	1.3%	1.5%	1.4%	1.3%
Median average % TCEY 2B	16.3%	16.3%	16.3%	14.7%	8.2%	20.0%	8.6%	8.0%	9.4%	8.6%	8.1%
Median average % TCEY 2C	7.6%	7.6%	7.3%	7.9%	9.1%	7.5%	9.5%	8.9%	10.0%	9.6%	9.0%
Median average % TCEY 3A	42.6%	42.7%	40.5%	43.5%	46.8%	42.2%	47.9%	44.3%	44.1%	47.9%	44.0%
Median average % TCEY 3B	11.8%	11.8%	15.0%	12.1%	13.0%	11.7%	13.3%	16.4%	14.9%	13.3%	16.3%
Median average % TCEY 4A	5.9%	5.9%	5.7%	6.1%	6.3%	5.8%	6.4%	7.2%	6.2%	6.3%	7.0%
Median average % TCEY 4CDE	8.2%	8.1%	7.9%	8.3%	8.8%	8.0%	8.8%	10.0%	9.4%	8.7%	9.7%
Median average % TCEY 4B	3.6%	3.6%	3.3%	3.7%	3.7%	3.5%	3.9%	3.7%	4.0%	3.9%	4.4

Table 4. Medium-term fishery stability performance metrics by IPHC Regulatory Areas for MPs A through K with an SPR value of 43% using simulated estimation error.

Input SPR/TM	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
Distribution Procedure	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Number of Simulations	500	500	400	300	300	500	500	500	300	500	300
Fishery Sustainability											
P(any3 change TCEY 2A > 15%)	0.006	0.014	0.010	0.007	0.013	0.172	0.114	0.126	0.133	0.070	0.027
P(any3 change TCEY 2B > 15%)	0.090	0.054	0.063	0.010	0.160	0.028	0.114	0.126	0.133	0.070	0.030
P(any3 change TCEY 2C > 15%)	0.248	0.186	0.200	0.053	0.160	0.174	0.114	0.126	0.133	0.070	0.030
P(any3 change TCEY 3A > 15%)	0.100	0.104	0.108	0.000	0.103	0.070	0.070	0.068	0.087	0.064	0.027
P(any3 change TCEY 3B > 15%)	0.100	0.104	0.108	0.000	0.103	0.070	0.070	0.068	0.087	0.064	0.027
P(any3 change TCEY 4A > 15%)	0.314	0.236	0.265	0.123	0.220	0.226	0.226	0.218	0.233	0.084	0.173
P(any3 change TCEY 4CDE > 15%)	0.306	0.242	0.258	0.137	0.227	0.242	0.238	0.234	0.233	0.092	0.180
P(any3 change TCEY 4B > 15%)	0.932	0.910	0.913	0.927	0.917	0.916	0.918	0.914	0.917	0.092	0.180
Median AAV TCEY 2A	0.0%	0.0%	0.0%	0.0%	0.0%	9.6%	9.0%	8.9%	9.4%	6.6%	6.6%
Median AAV TCEY 2B	7.0%	6.2%	6.2%	5.1%	9.3%	6.2%	9.0%	8.9%	9.4%	6.6%	6.6%
Median AAV TCEY 2C	10.9%	9.8%	9.8%	8.4%	9.3%	9.6%	9.0%	8.9%	9.4%	6.6%	6.6%
Median AAV TCEY 3A	7.8%	7.1%	7.1%	5.7%	6.9%	6.9%	6.9%	6.9%	6.7%	6.0%	6.3%
Median AAV TCEY 3B	7.8%	7.1%	7.1%	5.7%	6.9%	6.9%	6.9%	6.9%	6.7%	6.0%	6.3%
Median AAV TCEY 4A	11.7%	10.6%	10.5%	9.3%	10.4%	10.3%	10.4%	10.4%	10.4%	6.7%	6.9%
Median AAV TCEY 4CDE	11.6%	10.6%	10.6%	9.3%	10.5%	10.4%	10.5%	10.5%	10.5%	6.8%	6.9%
Median AAV TCEY 4B	24.9%	22.4%	22.4%	22.3%	22.4%	22.4%	22.6%	22.5%	22.2%	7.5%	7.7%

Table 5. Long-term performance metrics for biological sustainability objectives for MPs A through K with an SPR value of 43% using simulated estimation error. Red shading indicates that the currently defined objective is not met, and green shading indicates that the objective is met. Values in the cells are the calculated probability.

Objective	PM	A	B	C	D	E	F	G	H	I	J	K
Maintain a coastwide female SB above a biomass limit reference point 95% of the time	$P(SB < SB_{Lim})$	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintain a minimum proportion of female SB	$P(\%SB_{R=2} < 5\%)$	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintain a minimum proportion of female SB	$P(\%SB_{R=3} < 33\%)$	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintain a minimum proportion of female SB	$P(\%SB_{R=4} < 10\%)$	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintain a minimum proportion of female SB	$P(\%SB_{R=4B} < 2\%)$	0.15	0.15	0.16	0.14	0.15	0.15	0.16	0.15	0.15	0.16	0.17

Table 6. Long-term performance metrics for fishery objective 2.1 for MPs A through K with an SPR value of 43% using simulated estimation error. The ranks are determined by how close the long-term probability is to 0.5. Blue shading represents the ranking with light coloring indicating the objective is better met compared to other management procedures.

Objectives	PMs	A	B	C	D	E	F	G	H	I	J	K
Maintain the coastwide female SB above a target at least 50% of the time	$P(SB < SB_{36\%})$		6	6	1	2	6	6	2	2	6	2
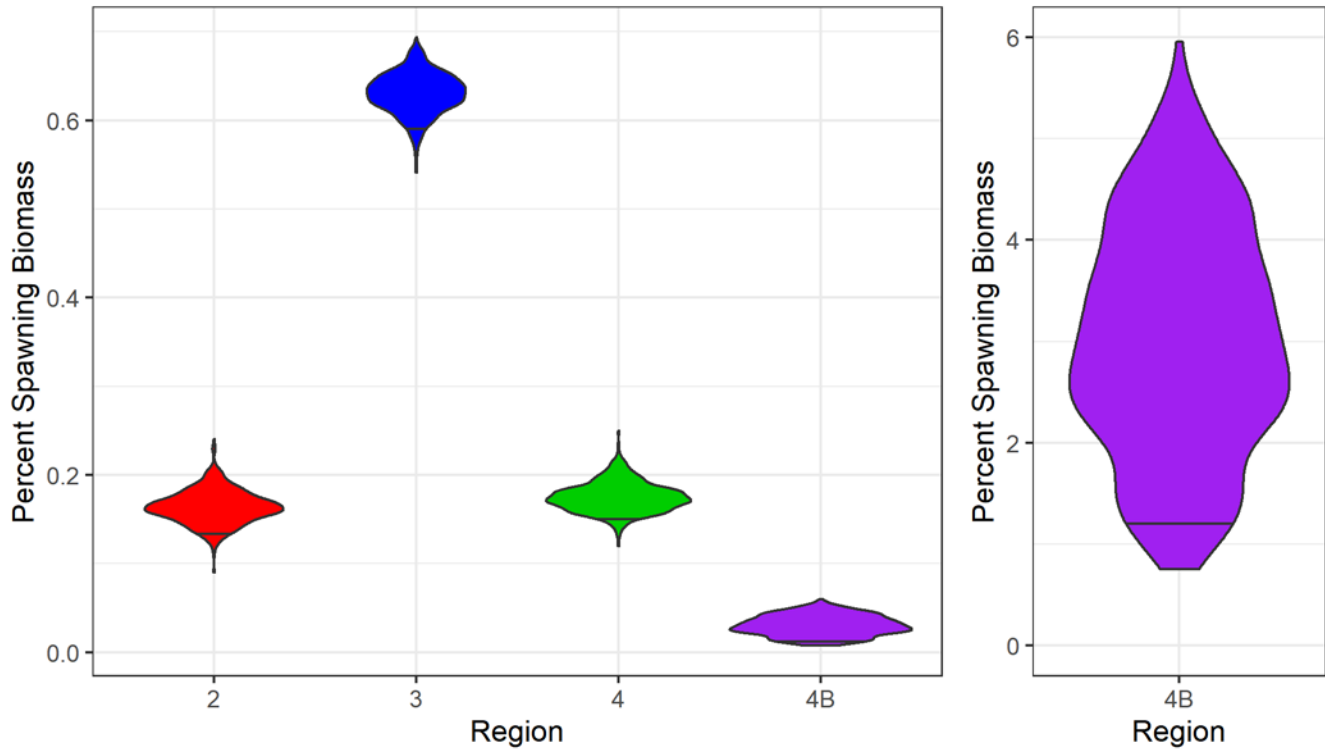
Figure 4. Distribution of the percentage of spawning biomass in each Biological Region after 60 years of projections with no fishing mortality. The right panel is zoomed in on Biological Region 4B. A horizontal line shows the 5% quantile in each plot.

Table 7. Medium-term performance metrics for fishery stability objectives for MPs A through K with an SPR value of 43% using simulated estimation error. Blue shading represents the ranking with light coloring indicating the objective is better met compared to other management procedures.

Objectives	PMs	A	B	C	D	E	F	G	H	I	J	K
Limit TCEY AC	P(AC₃ > 15%)	11	1	1	10	1	1	1	1	1	1	1
Limit TCEY AAV	Median AAV TCEY	11	4	4	1	2	10	4	4	4	4	2
Limit AC in Reg Areas TCEY	P(AC₃ 2A > 15%)	1	1	1	1	1	11	8	9	9	7	6
	P(AC₃ 2B > 15%)	7	4	5	1	11	2	8	9	9	6	2
	P(AC₃ 2C > 15%)	11	9	10	2	7	8	4	5	5	3	1
	P(AC₃ 3A > 15%)	8	8	11	1	8	4	4	4	7	3	2
	P(AC₃ 3B > 15%)	8	8	11	1	8	4	4	4	7	3	2
	P(AC₃ 4A > 15%)	11	9	10	2	4	6	6	4	6	1	3
	P(AC₃ 4CDE > 15%)	11	7	10	2	4	7	7	4	4	1	3
	P(AC₃ 4B > 15%)	10	3	3	10	6	6	6	3	6	1	2
Limit AAV in Reg Areas TCEY	Median AAV 2A	1	1	1	1	1	11	9	8	10	6	6
	Median AAV 2B	7	2	2	1	10	2	9	8	11	5	5
	Median AAV 2C	11	9	9	3	6	8	5	4	7	1	1
	Median AAV 3A	11	9	9	1	5	5	5	5	4	2	3
	Median AAV 3B	11	9	9	1	5	5	5	5	4	2	3
	Median AAV 4A	11	10	9	3	5	4	5	5	5	1	2
	Median AAV 4CDE	11	9	9	3	5	4	5	5	5	1	2
	Median AAV 4B	11	5	5	4	5	5	10	9	3	1	2

Table 8. Medium-term performance metrics for fishery yield objectives related to the TCEY for MPs A through K with an SPR value of 43% using simulated estimation error. Blue shading represents the ranking with light coloring indicating the objective is better met compared to other management procedures.

Objectives	PMs	A	B	C	D	E	F	G	H	I	J	K
Optimize TCEY	Median TCEY	5	1	9	1	7	5	1	8	9	4	10
Maintain minimum TCEY by Reg Areas	Median Min 2A	1	1	1	1	1	1	7	7	6	7	7
	Median Min 2B	4	2	3	5	9	1	8	10	6	7	10
	Median Min 2C	1	8	10	7	4	8	2	6	1	2	4
	Median Min 3A	10	8	11	4	3	9	2	6	5	1	6
	Median Min 3B	11	9	3	8	7	10	6	1	3	5	1
	Median Min 4A	11	8	9	5	5	9	3	1	5	3	1
	Median Min 4CDE	10	8	10	5	5	8	5	2	3	4	1
	Median Min 4B	1	8	8	3	3	8	3	3	3	2	1
Optimize Reg Areas TCEY	Median TCEY2A	1	1	1	1	1	1	6	9	6	6	9
	Median TCEY2B	2	2	4	5	9	1	7	9	6	7	10
	Median TCEY2C	9	7	11	7	4	10	3	5	1	2	6
	Median TCEY3A	9	8	11	7	3	10	2	4	5	1	6
	Median TCEY3B	9	9	4	8	7	10	6	1	3	5	2
	Median TCEY4A	8	8	11	6	3	8	3	1	6	3	2
	Median TCEY4CDE	7	7	11	7	5	10	4	1	2	5	2
	Median TCEY4B	6	6	11	6	3	6	3	6	2	3	1

Table 9. Medium-term performance metrics for fishery yield objectives related to the percentage of TCEY in each IPHC Regulatory Area for MPs A through K with an SPR value of 43% using simulated estimation error. Blue shading represents the ranking with light coloring indicating the objective is better met compared to other management procedures

Objectives	PMs	A	B	C	D	E	F	G	H	I	J	K
Maintain minimum % TCEY by Reg Areas	Median Min % 2A	5	2	1	2	2	11	8	10	6	6	8
	Median Min % 2B	2	2	4	5	10	1	8	11	6	7	8
	Median Min % 2C	9	8	11	7	5	10	3	6	2	1	4
	Median Min % 3A	9	8	11	7	3	10	2	5	6	1	4
	Median Min % 3B	10	9	3	8	7	11	6	2	4	5	1
	Median Min % 4A	8	8	11	7	5	8	4	2	5	3	1
	Median Min % 4CDE	8	8	11	7	6	10	5	2	3	3	1
	Median Min % 4B	7	7	11	5	5	10	3	7	3	2	1
Optimize TCEY percentage among Reg Areas	Median % TCEY2A	1	4	1	4	1	11	7	9	6	7	9
	Median % TCEY2B	2	2	2	5	9	1	7	11	6	7	10
	Median % TCEY2C	8	8	11	7	4	10	3	6	1	2	5
	Median % TCEY3A	9	8	11	7	3	10	1	4	5	1	6
	Median % TCEY3B	9	9	3	8	7	11	5	1	4	5	2
	Median % TCEY4A	8	8	11	7	4	10	3	1	6	4	2
	Median % TCEY4CDE	8	9	11	7	4	10	4	1	3	6	2
	Median % TCEY4B	8	8	11	5	5	10	3	5	2	3	1

Table 10. Ranks for fishery yield and stability performance metrics averaged with equal weighting over IPHC Regulatory Areas for those that are reported by IPHC Regulatory Areas. Medium-term performance metrics for fishery yield objectives related to the percentage of TCEY in each IPHC Regulatory Area for MPs A through K with an SPR value of 43% using simulated estimation error. Blue shading represents the ranking with light coloring indicating the objective is better met compared to other management procedures.

Objectives	PMs	A	B	C	D	E	F	G	H	I	J	K
Maintain the coastwide female SB above a target at least 50% of the time	$P(SB < SB_{36\%})$	2	4	4	1	4	11	4	4	3	4	4
Limit AC in coastwide TCEY	$P(AC_3 > 15\%)$	11	1	1	10	1	1	1	1	1	1	1
Limit AC in coastwide TCEY	Median AAV TCEY	11	4	4	1	2	10	4	4	4	4	2
Optimize average coastwide TCEY	Median TCEY	5	1	9	1	7	5	1	8	9	4	11
Limit AC in Reg Areas TCEY	$P(AC_3 > 15\%)$ RegAreas	9.25	6.75	6.62	2.12	5.25	5.5	6.62	6.12	6.12	2.38	3
Limit AAV in Reg Areas TCEY	Median AAV TCEY RegAreas	8.38	6.12	7.62	2.5	6.12	6	5.88	5.25	6.62	3.12	2.62
Optimize Reg Areas TCEY	Median TCEY RegAreas	7.25	6.5	7.88	6	5.38	8.88	4.88	5.62	4.38	3.5	3.5
Optimize TCEY percentage among Reg Areas	Median % TCEY RegAreas	8.62	6.5	6.88	4.75	4.62	8	4.5	4.5	4	3.88	3.88
Maintain minimum TCEY by Reg Areas	Median Min(TCEY) RegAreas	6.38	6	8	5.88	4.38	8.38	4.25	4.5	3.88	4	4.88
Maintain minimum % TCEY by Reg Areas	Median Min(% TCEY) RegAreas	6.62	7	7.62	6.25	4.62	9.12	4.12	4.75	4.12	4.38	4.62

4   RECOMMENDATIONS

That the MSAB:

a) **NOTE** paper IPHC-2020-MSAB016-09 Rev_1 which provides performance metrics for primary objectives for MSE simulations using six priority 1 management procedures.

b) **RECOMMEND** management procedures that meet primary objectives and perform best given consideration of trade-offs and possibly additional performance metrics.

c) **RECOMMEND** additional performance metrics that would be useful for the evaluation of management procedures.

d) **RECOMMEND** alternative ways to display and communicate results to assist in the evaluation of management procedures.

5   REFERENCES

IPHC-2018-MSAB012-07 Rev_1. Hicks A; Stewart I. 2018. IPHC Management Strategy Evaluation to investigate fishing intensity. 33 p. https://iphc.int/uploads/pdf/msab/msab12/iphc-2018-msab012-07.pdf

IPHC-2020-MSAB016-07. Potential management procedures to determine the total constant exploitation yield (TCEY) by IPHC Regulatory Area for Pacific halibut fisheries.

6   APPENDICES

Appendix I: Primary objectives defined by the Commission for the MSE

Appendix II: Proposed and Recommended Management Procedures from MSAB015

APPENDIX I
PRIMARY OBJECTIVES DEFINED BY THE COMMISSION FOR THE MSE

Table 11. Primary measurable objectives, evaluated over a simulated ten-year period, accepted by the Commission at the 7th Special Session of the Commission (SS07). Objective 1.1 is a biological sustainability (conservation) objective and objectives 2.1, 2.2, and 2.3 are fishery objectives.

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE	MEASURABLE OUTCOME	TIME-FRAME	TOLERANCE	PERFORMANCE METRIC
1.1. KEEP FEMALE SPAWNING BIOMASS ABOVE A LIMIT TO AVOID CRITICAL STOCK SIZES AND CONSERVE SPATIAL POPULATION STRUCTURE	Maintain a female spawning stock biomass above a biomass limit reference point at least 95% of the time	SB < Spawning Biomass Limit (SB_{Lim}) SB_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(SB < SB_{Lim})$
	Maintain a defined minimum proportion of female spawning biomass in each Biological Region	$p_{SB,2} > 5\%$ $p_{SB,3} > 33\%$ $p_{SB,2} > 10\%$ $p_{SB,2} > 2\%$	Long-term	0.05	$P(p_{SB,R} < p_{SB,R,min})$
2.1 MAINTAIN SPAWNING BIOMASS AROUND A LEVEL THAT OPTIMIZES FISHING ACTIVITIES	Maintain the coastwide female spawning biomass above a biomass target reference point at least 50% of the time	SB<Spawning Biomass Target (SB_{Targ}) SB_{Targ}=$SB_{36\%}$ unfished spawning biomass	Long-term	0.50	$P(SB < SB_{Targ})$
2.2. LIMIT CATCH VARIABILITY	Limit annual changes in the coastwide TCEY	Annual Change (AC) > 15% in any 3 years	Short-term		$P(AC_3 > 15\%)$
		Median coastwide Average Annual Variability (AAV)	Short-term		*Median AAV*
	Limit annual changes in the Regulatory Area TCEY	Annual Change (AC) > 15% in any 3 years by Regulatory Area	Short-term		$P(AC_{3,A} > 15\%)$
		Average AAV by Regulatory Area (AAV$_A$)	Short-term		*Median AAV$_A$*
2.3. PROVIDE DIRECTED FISHING YIELD	Optimize average coastwide TCEY	Median coastwide TCEY	Short-term		*Median $\overline{TCEY}$*
	Optimize TCEY among Regulatory Areas	Median TCEY$_A$	Short-term		*Median $\overline{TCEY_A}$*
	Optimize the percentage of the coastwide TCEY among Regulatory Areas	Median %TCEY$_A$	Short-term		*Median $\overline{\left(\frac{TCEY_A}{TCEY}\right)}$*
	Maintain a minimum TCEY for each Regulatory Area	Minimum TCEY$_A$	Short-term		*Median Min(TCEY)*
	Maintain a percentage of the coastwide TCEY for each Regulatory Area	Minimum %TCEY$_A$	Short-term		*Median Min(%TCEY)*

APPENDIX II
PROPOSED AND RECOMMENDED MANAGEMENT PROCEDURES FROM MSAB015

Recommended management procedures to be evaluated by the MSAB in 2020 and the priority of investigation. A priority of 1 denotes a focus on producing precise performance metrics. Reproduced from IPHC-2020-MSAB015-R.

Table II.1. Recommended management procedures to be evaluated by the MSAB in 2020 and the priority of investigation. A priority of 1 denotes a focus on producing precise performance metrics. A priority of 2 denotes potentially fewer simulations are desired, if time is constrained.

MP	Coastwide	Regional	IPHC Regulatory Area	Priority
MP 15-A	SPR 30:20		• O32 stock distribution • Proportional relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4) • 1.65 Mlbs floor in 2A[1] • Formula percentage for 2B[2]	1
MP 15-B	SPR 30:20 MaxChange15%		• O32 stock distribution • Proportional relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4) • 1.65 Mlbs floor in 2A[1] • Formula percentage for 2B[2]	1
MP 15-C	SPR 30:20 MaxChange15%	Biological Regions, O32 stock distribution Rel HRs[3]: R2=1, R3=1, R4=0.75, R4B=0.75	• O32 stock distribution • Relative harvest rates not applied • 1.65 Mlbs floor in 2A[1] • Formula percentage for 2B[2]	2
MP 15-D	SPR 30:20 MaxChange15% Max FI (36%)		First • O32 stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4) Second within buffer (pro-rated if exceeds buffer) • 1.65 Mlbs floor in 2A[1] • Formula percentage for 2B[2]	2
MP 15-E	SPR 30:20 MaxChange15%		• O32 stock distribution • Proportional relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4) • 1.65 Mlbs floor in 2A[1]	2
MP 15-F	SPR 30:20 MaxChange15%	National Shares: 20% to 2B, 80% to other	• O32 stock distribution to areas other than 2B • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)	1
MP 15-G	SPR 30:20 MaxChange15%		• O32 stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)	1

MP	Coastwide	Regional	IPHC Regulatory Area	Priority
MP 15-H	SPR 30:20 MaxChange15%		• O32 stock distribution • Relative harvest rates (1 for 2-3, 4A, 4CDE, 0.75 for 4B)	1
MP 15-I	SPR 30:20 MaxChange15%		• All sizes stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)	2
MP 15-J	SPR 30:20 MaxChange15%		• O32 stock distribution (5-year moving average) • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)	1
MP 15-K	SPR 30:20 MaxChange15%		• 5-year shares determined from 5-year O32 stock distribution (vary over time but change only every 5th year)	2

[1] paragraph 97b IPHC-2020-AM096-R
[2] paragraph 97c of IPHC-2020-AM096-R
[3] R2 refers to Biological Region 2 (2A, 2B, 2C); R3 refers to Biological Region 3 (3A, 3B); R4 refers to Biological Region 4 (4A, 4CDE), and R4B refers to Biological Region 4B

APPENDIX III
PERFORMANCE METRICS FOR PRIORITY MPS AND SELECT SPR VALUES

Table 12. Coastwide long-term performance metrics for the biological sustainability objective and P(all RSB<36%) and medium-term performance metrics for the remaining fishery sustainability objectives for MPs A, B, F, G, H, and J for SPR values of 40%, 43%, and 46% using simulated estimation error.

Input SPR/TM	40	40	40	40	40	40
Distn Proc	**A**	**B**	**F**	**G**	**H**	**J**
nSims	500	500	500	500	500	500
Biological Sustainability						
P(any RSB_y<20%)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fishery Sustainability						
P(all RSB<36%)	0.565	0.617	0.617	0.616	0.618	0.610
Median average TCEY	50.67	51.12	51.02	51.56	50.94	51.75
P(any3 change TCEY > 15%)	0.37	0	0	0	0	0
Median AAV TCEY	11.3%	7.4%	7.5%	7.6%	7.6%	7.6%

Input SPR/TM	43	43	43	43	43	43
Distn Proc	**A**	**B**	**F**	**G**	**H**	**J**
nSims	500	500	500	500	500	500
Biological Sustainability						
P(any RSB_y<20%)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fishery Sustainability						
P(all RSB<36%)	0.251	0.279	0.278	0.284	0.289	0.283
Median average TCEY	48.89	49.10	48.90	49.08	48.73	49.01
P(any3 change TCEY > 15%)	0.178	<0.01	<0.01	<0.01	<0.01	<0.01
Median AAV TCEY	6.8%	6.1%	6.2%	6.1%	6.1%	6.1%

Input SPR/TM	46	46	46	46	46	46
Distn Proc	**A**	**B**	**F**	**G**	**H**	**J**
nSims	500	500	500	500	500	500
Biological Sustainability						
P(any RSB_y<20%)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fishery Sustainability						
P(all RSB<36%)	0.043	0.044	0.044	0.049	0.050	0.048
Median average TCEY	46.67	46.42	46.36	46.24	46.18	46.21
P(any3 change TCEY > 15%)	0.092	<0.01	<0.01	<0.01	<0.01	<0.01
Median AAV TCEY	5.5%	5.6%	5.6%	5.7%	5.6%	5.7%

Table 13. TCEY medium-term performance metrics by IPHC Regulatory Areas for MPs A, B, F, G, H, and J with an SPR value of 40% using simulated estimation error.

Input SPR/TM	40%	40%	40%	40%	40%	40%
Distribution Procedure	**A**	**B**	**F**	**G**	**H**	**J**
Number of Simulations	500	500	500	500	500	500
Fishery Sustainability						
Median average TCEY-2A	1.65	1.65	0.54	0.70	0.65	0.71
Median average TCEY-2B	8.37	8.42	10.20	4.38	4.09	4.43
Median average TCEY-2C	3.84	3.94	3.80	4.88	4.56	4.94
Median average TCEY-3A	21.58	21.84	21.33	24.66	22.74	24.85
Median average TCEY-3B	5.99	6.06	5.92	6.84	8.41	6.89
Median average TCEY-4A	3.06	3.10	3.04	3.33	3.71	3.29
Median average TCEY-4CDE	4.20	4.24	4.17	4.57	5.09	4.51
Median average TCEY-4B	1.80	1.80	1.78	1.96	1.84	1.93
Median AAV TCEY 2A	0.0%	0.0%	10.3%	9.6%	9.6%	7.9%
Median AAV TCEY 2B	11.5%	7.5%	7.5%	9.6%	9.6%	7.9%
Median AAV TCEY 2C	14.5%	10.4%	10.3%	9.6%	9.6%	7.9%
Median AAV TCEY 3A	12.4%	8.2%	8.0%	8.1%	8.1%	7.5%
Median AAV TCEY 3B	12.4%	8.2%	8.0%	8.1%	8.1%	7.5%
Median AAV TCEY 4A	15.2%	11.2%	11.0%	11.2%	11.2%	7.9%
Median AAV TCEY 4CDE	14.7%	11.2%	11.1%	11.2%	11.2%	8.0%
Median AAV TCEY 4B	28.1%	23.0%	22.8%	23.2%	23.2%	8.6%
P(any3 change TCEY 2A > 15%)	0.0040	0.0100	0.2320	0.1900	0.1920	0.1000
P(any3 change TCEY 2B > 15%)	0.1720	0.0820	0.0260	0.1900	0.1920	0.1000
P(any3 change TCEY 2C > 15%)	0.3960	0.2480	0.2340	0.1900	0.1920	0.1000
P(any3 change TCEY 3A > 15%)	0.1980	0.1520	0.0900	0.1000	0.1020	0.0820
P(any3 change TCEY 3B > 15%)	0.1980	0.1520	0.0900	0.1000	0.1020	0.0820
P(any3 change TCEY 4A > 15%)	0.4380	0.3300	0.2960	0.2980	0.3040	0.1200
P(any3 change TCEY 4CDE > 15%)	0.4360	0.3120	0.3020	0.3100	0.3080	0.1300
P(any3 change TCEY 4B > 15%)	0.9440	0.9160	0.9160	0.9200	0.9240	0.1340
Median average TCEY percentage 2A	3.5%	3.3%	1.1%	1.4%	1.3%	1.4%
Median average TCEY percentage 2B	16.3%	16.3%	20.0%	8.6%	8.0%	8.6%
Median average TCEY percentage 2C	7.6%	7.6%	7.4%	9.6%	9.0%	9.6%
Median average TCEY percentage 3A	42.5%	42.7%	42.1%	47.8%	44.3%	47.8%
Median average TCEY percentage 3B	11.8%	11.8%	11.7%	13.3%	16.4%	13.3%
Median average TCEY percentage 4A	5.9%	5.9%	5.9%	6.4%	7.2%	6.3%
Median average TCEY percentage 4CDE	8.3%	8.2%	8.1%	8.9%	10.0%	8.7%
Median average TCEY percentage 4B	3.6%	3.6%	3.5%	3.9%	3.7%	3.9%

Table 14. TCEY medium-term performance metrics by IPHC Regulatory Areas for MPs A, B, F, G, H, and J with an SPR value of 43% using simulated estimation error.

Input SPR/TM	43%	43%	43%	43%	43%	43%
Distribution Procedure	**A**	**B**	**F**	**G**	**H**	**J**
Number of Simulations	500	500	500	500	500	500
Fishery Sustainability						
Median average TCEY-2A	1.65	1.65	0.52	0.66	0.62	0.67
Median average TCEY-2B	7.99	8.00	9.78	4.17	3.87	4.20
Median average TCEY-2C	3.70	3.76	3.64	4.64	4.31	4.68
Median average TCEY-3A	20.95	21.07	20.70	23.58	21.66	23.71
Median average TCEY-3B	5.81	5.84	5.74	6.54	8.01	6.58
Median average TCEY-4A	2.92	2.91	2.86	3.14	3.50	3.09
Median average TCEY-4CDE	4.00	3.99	3.91	4.31	4.80	4.24
Median average TCEY-4B	1.71	1.70	1.67	1.84	1.73	1.83
Median AAV TCEY 2A	0.0%	0.0%	9.6%	9.0%	8.9%	6.6%
Median AAV TCEY 2B	7.0%	6.2%	6.2%	9.0%	8.9%	6.6%
Median AAV TCEY 2C	10.9%	9.8%	9.6%	9.0%	8.9%	6.6%
Median AAV TCEY 3A	7.8%	7.1%	6.9%	6.9%	6.9%	6.0%
Median AAV TCEY 3B	7.8%	7.1%	6.9%	6.9%	6.9%	6.0%
Median AAV TCEY 4A	11.7%	10.6%	10.3%	10.4%	10.4%	6.7%
Median AAV TCEY 4CDE	11.6%	10.6%	10.4%	10.5%	10.5%	6.8%
Median AAV TCEY 4B	24.9%	22.4%	22.4%	22.6%	22.5%	7.5%
P(any3 change TCEY 2A > 15%)	0.0060	0.0140	0.1720	0.1140	0.1260	0.0700
P(any3 change TCEY 2B > 15%)	0.0900	0.0540	0.0280	0.1140	0.1260	0.0700
P(any3 change TCEY 2C > 15%)	0.2480	0.1860	0.1740	0.1140	0.1260	0.0700
P(any3 change TCEY 3A > 15%)	0.1000	0.1040	0.0700	0.0700	0.0680	0.0640
P(any3 change TCEY 3B > 15%)	0.1000	0.1040	0.0700	0.0700	0.0680	0.0640
P(any3 change TCEY 4A > 15%)	0.3140	0.2360	0.2260	0.2260	0.2180	0.0840
P(any3 change TCEY 4CDE > 15%)	0.3060	0.2420	0.2420	0.2380	0.2340	0.0920
P(any3 change TCEY 4B > 15%)	0.9320	0.9100	0.9160	0.9180	0.9140	0.0920
Median average TCEY percentage 2A	3.5%	3.4%	1.1%	1.4%	1.3%	1.4%
Median average TCEY percentage 2B	16.3%	16.3%	20.0%	8.6%	8.0%	8.6%
Median average TCEY percentage 2C	7.6%	7.6%	7.5%	9.5%	8.9%	9.6%
Median average TCEY percentage 3A	42.6%	42.7%	42.2%	47.9%	44.3%	47.9%
Median average TCEY percentage 3B	11.8%	11.8%	11.7%	13.3%	16.4%	13.3%
Median average TCEY percentage 4A	5.9%	5.9%	5.8%	6.4%	7.2%	6.3%
Median average TCEY percentage 4CDE	8.2%	8.1%	8.0%	8.8%	10.0%	8.7%
Median average TCEY percentage 4B	3.6%	3.6%	3.5%	3.9%	3.7%	3.9%

Table 15. TCEY performance metrics by IPHC Regulatory Areas for MPs A, B, F, G, H, and J with an SPR value of 46% using simulated estimation error.

Input SPR/TM	46%	46%	46%	46%	46%	46%
Distribution Procedure	**A**	**B**	**F**	**G**	**H**	**J**
Number of Simulations	500	500	500	500	500	500
Fishery Sustainability						
Median average TCEY-2A	1.65	1.65	0.50	0.63	0.58	0.63
Median average TCEY-2B	7.61	7.58	9.27	3.93	3.66	3.96
Median average TCEY-2C	3.56	3.57	3.48	4.38	4.07	4.42
Median average TCEY-3A	20.12	19.86	19.54	22.38	20.56	22.43
Median average TCEY-3B	5.58	5.51	5.42	6.21	7.60	6.22
Median average TCEY-4A	2.75	2.74	2.69	2.96	3.34	2.91
Median average TCEY-4CDE	3.77	3.75	3.69	4.06	4.58	4.00
Median average TCEY-4B	1.60	1.59	1.57	1.72	1.61	1.73
Median AAV TCEY 2A	0.0%	0.0%	9.4%	8.6%	8.6%	6.1%
Median AAV TCEY 2B	5.6%	5.7%	5.6%	8.6%	8.6%	6.1%
Median AAV TCEY 2C	9.5%	9.3%	9.4%	8.6%	8.6%	6.1%
Median AAV TCEY 3A	6.5%	6.5%	6.3%	6.6%	6.5%	5.6%
Median AAV TCEY 3B	6.5%	6.5%	6.3%	6.6%	6.5%	5.6%
Median AAV TCEY 4A	10.3%	10.0%	9.9%	10.0%	10.1%	6.3%
Median AAV TCEY 4CDE	10.3%	10.1%	10.0%	10.1%	10.1%	6.4%
Median AAV TCEY 4B	23.4%	22.4%	22.3%	22.5%	22.4%	7.0%
P(any3 change TCEY 2A > 15%)	0.0040	0.0120	0.1380	0.0940	0.1040	0.0580
P(any3 change TCEY 2B > 15%)	0.0460	0.0460	0.0240	0.0940	0.1040	0.0580
P(any3 change TCEY 2C > 15%)	0.1540	0.1520	0.1400	0.0940	0.1040	0.0580
P(any3 change TCEY 3A > 15%)	0.0540	0.0760	0.0500	0.0560	0.0540	0.0540
P(any3 change TCEY 3B > 15%)	0.0540	0.0760	0.0500	0.0560	0.0540	0.0540
P(any3 change TCEY 4A > 15%)	0.2400	0.2180	0.1920	0.1780	0.1740	0.0620
P(any3 change TCEY 4CDE > 15%)	0.2480	0.2140	0.2140	0.1940	0.1820	0.0700
P(any3 change TCEY 4B > 15%)	0.9180	0.9060	0.9060	0.9060	0.9020	0.0680
Median average TCEY percentage 2A	3.6%	3.6%	1.1%	1.4%	1.3%	1.4%
Median average TCEY percentage 2B	16.4%	16.4%	20.0%	8.6%	8.0%	8.6%
Median average TCEY percentage 2C	7.7%	7.6%	7.6%	9.5%	8.9%	9.6%
Median average TCEY percentage 3A	42.6%	42.6%	42.3%	48.0%	44.4%	48.0%
Median average TCEY percentage 3B	11.8%	11.8%	11.7%	13.3%	16.4%	13.3%
Median average TCEY percentage 4A	5.8%	5.8%	5.8%	6.4%	7.2%	6.3%
Median average TCEY percentage 4CDE	8.1%	8.1%	8.0%	8.8%	10.0%	8.7%
Median average TCEY percentage 4B	3.6%	3.5%	3.5%	3.9%	3.7%	3.9%