Management Strategy Evaluation: Update for 2018

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1 PURPOSE

To provide the SRB with an update on the MSE-related activities of the IPHC Secretariat in 2018 (as of 26 August 2018).

2 INTRODUCTION

At the 2017 Annual Meeting (AM093) Commissioners supported a revised harvest policy that separates the scale and distribution of fishing mortality (Figure 1). Furthermore, the Commission identified an interim “hand-rail” or reference for harvest advice based on a status-quo SPR, which uses the average estimated coastwide SPR for the years 2014–2016 from the 2016 stock assessment, resulting in an SPR of 46%. The justification for using an average SPR from recent years is that this corresponds to fishing intensities that have resulted in a stable or slightly increasing stock, indicating that, in the short-term, this may provide an appropriate fishing intensity that will result in a stable or increasing female spawning biomass.

The 2017 stock assessment updated the population estimates and determined that the SPR resulting from actual total mortality from all sources in 2017 was 40%, instead of the 45% adopted by Commissioners at AM093. This was an example of estimation error and something that is inherent in the process due to uncertainty in the data. The SPR of 40% was well within the confidence bounds for SPR reported in the 2017 stock assessment (30-59%), and was most likely less than the adopted SPR because of the updated estimation of recent below average recruitment. The estimation may easily go either way (above or below the adopted value).

This document (IPHC-2018-SRB013-06 focuses on five topics:

1. goals and objectives,
2. simulation framework
3. simulation results,
4. a brief description of topics related to distributing the TCEY, and
5. a review of the five-year work plan.

Appropriate background or reference to documents is provided, when needed. Useful documents to reference are IPHC-2018-MSAB011-07 for a description of objectives (with an update in Appendix Va in IPHC-2018-MSAB011-R, and reproduced here in Appendix I), IPHC-2018-MSAB011-08 for a description of the simulation framework, and IPHC-2018-MSAB011-09 for a discussion of the TCEY distribution framework. The 5-year program of work is described in document IPHC-2018-MSAB011-10, with a detailed description of deliverables up to and including the Annual Meeting in 2021 (AM097). The MSAB011 report (IPHC-2018-MSAB011-R) provides a summary of the outcomes of that meeting. Additionally, documents IPHC-2018-SRB012-08 and IPHC-2018-SRB012-R provide background to SRB discussions in June 2018.

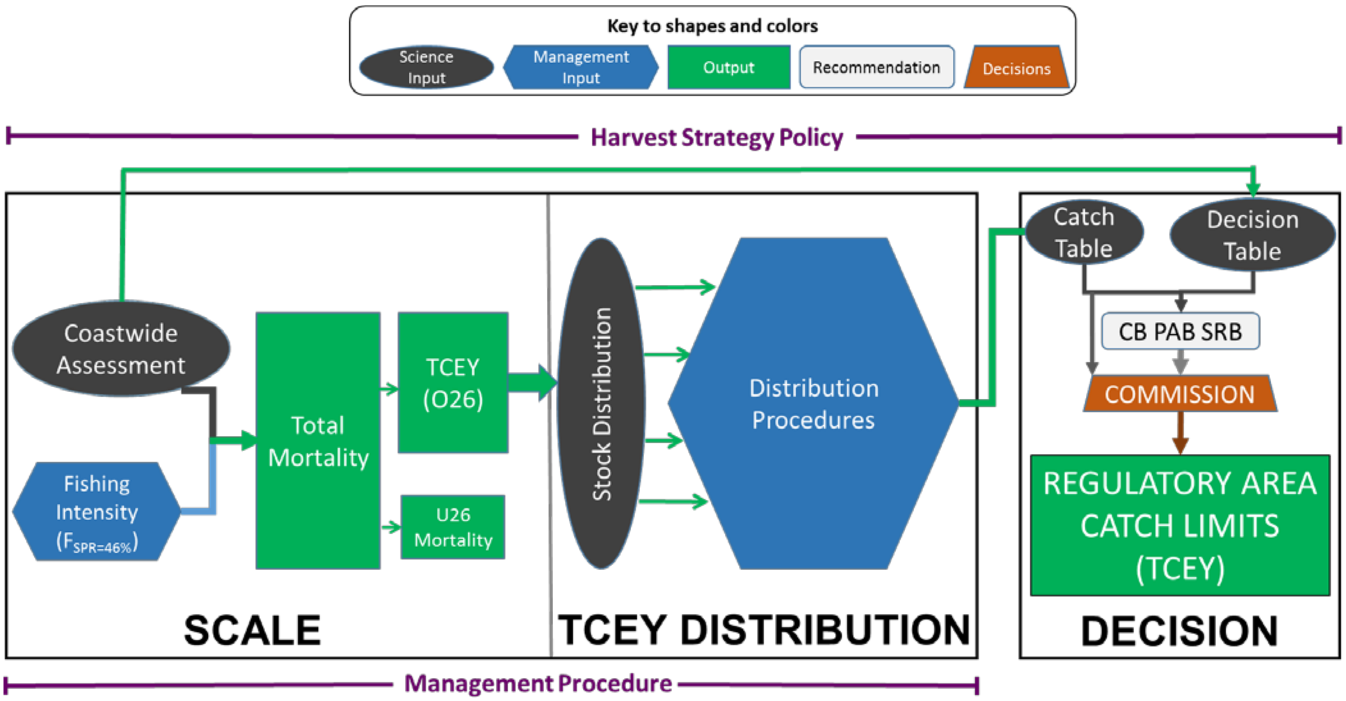

Figure 1: A pictorial description of the interim IPHC harvest strategy policy showing the separation of scale and distribution of fishing mortality. The "decision step" is when policy and decision making (not a procedure) influences the final mortality limits.

3 Goals and Objectives

Defining goals and objectives is a necessary part of a management strategy evaluation (MSE) which should be revisited often to make sure that they are inclusive and relevant. The MSAB originally developed five goals with multiple objectives for each (Tables A1–A5 in Appendix A). Performance metrics have also been developed from the goals and objectives by defining a measurable outcome, a probability (i.e. level of risk), and time-frame over which it is desired to achieve that outcome. Management procedures will be evaluated by determining which ones meet the objective (via the performance metric).

At MSAB011, the goals and objectives in Appendix A were discussed. It was determined that the goal "serve consumer needs" was not necessary at this time as it would be captured under the goal of "fishery sustainability and stability," and MSAB members appointed an *ad hoc* working group to refine the objectives presented in Appendix A (IPHC-2018-MSAB011-R, paragraph 20). This *ad hoc* working group is currently refining the objectives to reflect the current objectives of the MSAB and Commission, reduce redundant objectives, and clarify and simply the objectives for evaluation. There is also an ongoing discussion of objectives related to distributing the stock, and these will be reflected in the refined objectives. Further refinements will occur after discussion at MSAB012, and as results are evaluated. Final objectives used to evaluate the harvest control rule will be presented to the Commission at AM095.

The concept of biological regions (Figure 2) was also discussed at MSAB011 and followed up at SRB012. The SRB agreed that the "defined bioregions (i.e., 2, 3, 4, and 4b described in paper IPHC-2018-SRB012-08) are presently the best option for implementing a precautionary approach given uncertainty about spatial population structure and dynamic of Pacific halibut" (IPHC-2018-SRB012-R, paragraph 31). Additional data collected and analyzed in the future may provide guidance on redefining biological regions that best represent spatial diversity and meet management needs.

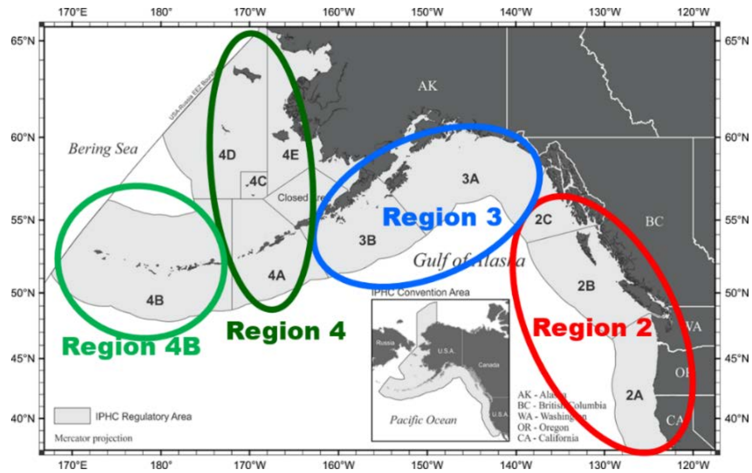

Figure 2:. Four biological Regions. They are overlayed on IPHC Regulatory Areas with Region 2 comprised of 2A, 2B, and 2C, Region 3 comprised of 3A and 3B, Region 4 comprised of 4A and 4CDE, and Region 4B comprised solely of 4B.

From this discussion on biological regions, the goal of preserving biocomplexity was considered. The SRB noted that biocomplexity is "poorly defined and not understood for Pacific halibut" (IPHC-2018-SRB012-R, paragraph 30). Additionally, "preserve" is not the appropriate term, because conservation is typically the goal of fisheries management. It was determined that conserving Pacific halibut stock structure across the entire range would be easily incorporated as objectives within the Biological Sustainability goal.

The MSAB agreed that the Commission should review and provide guidance on the revised goals to be presented at AM095 (IPHC-2018-MSAB011-R, paragraph 34).

4 SIMULATIONS

The framework of the closed-loop simulations is a map to how the simulations will be performed (Figure 3). There are four main modules to the framework:

1. The **Operating Model (OM)** is a representation of the population and the fishery. It produces the numbers-at-age, accounting for mortality and any other important processes. It also incorporates uncertainty in the processes and may be composed of multiple models to account for structural uncertainty.

2. **Management Procedure**

    a. **Monitoring (data generation)** is the code that simulates the data from the operating model that is used by the estimation model. It can introduce variability, bias, and any other properties that are desired.

    b. The **Estimation Model (EM)** is analogous to the stock assessment and simulates estimation error in the process. Using the data generated, it produces an annual estimate of stock size and status and provides the advice for setting the catch levels for the next time step. However, simplifications may be necessary to keep simulation times within a reasonable time.

    c. **Harvest Rule** is the application of the estimation model output along with the scale and distribution management procedures (Figure 1) to produce the catch limit for that year.

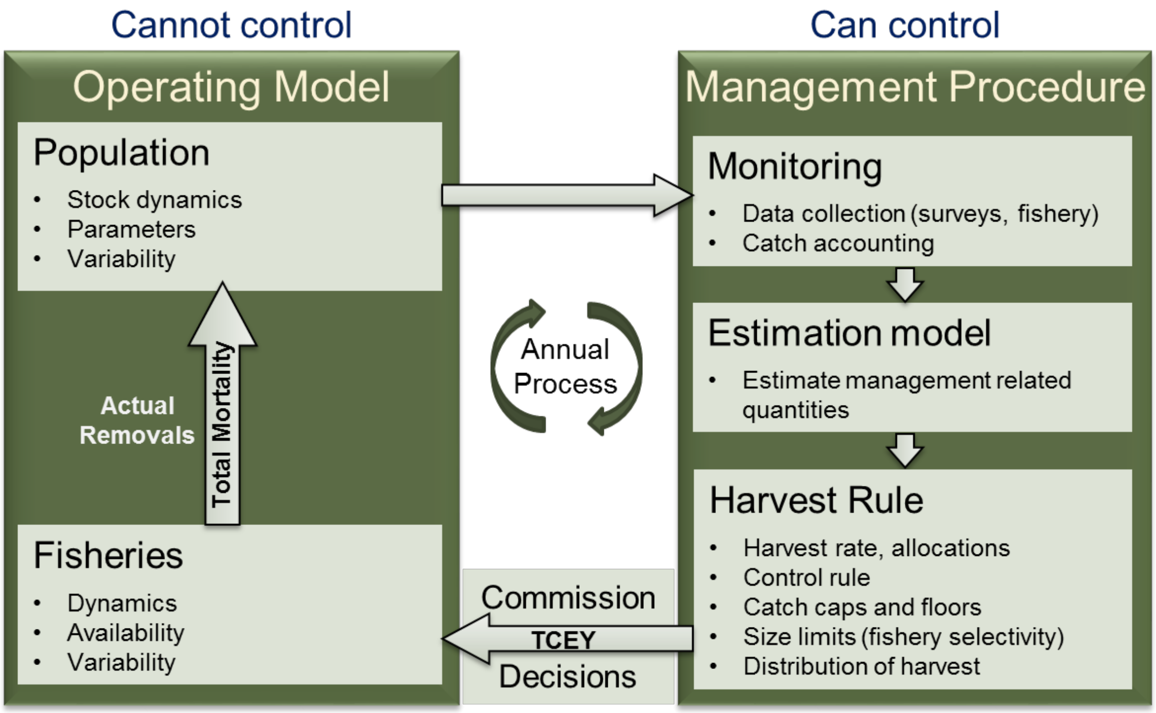

Figure 3: Diagram of the relationship between the four modules in the framework. The simulations run each module on an annual time-step, producing output that is used in the next time-step. See text for a description of operating model, monitoring, estimation model, and harvest rule.

4.1 Operating Model

For the simulations to investigate a coastwide fishing intensity, the stock synthesis (Methot and Wetzel 2013) assessment software was used as an operating model. This platform is currently used for the stock assessment, and the operating model was comprised of the two coastwide assessment models (short and long time-series) currently used in the ensemble. For future MSE evaluations (in particular, investigating the Distribution component of the harvest policy) a more complex operating model will be developed that can provide outputs by defined areas or regions and can account for migration between these areas. This model has been referred to as a multi-area model.

The current stock assessment ensemble, composed of four different assessment models, includes a cross between coastwide or fleets-as-areas structuring of the data, and the length of the time series. Using an areas-as-fleets model would require generating data and distributing catch to four areas of the coast, which would involve many assumptions. In addition, without a multi-area model, there would not be feedback from migration and productivity of harvesting in different areas. Therefore, only the two coastwide models were used, but with additional variability. These models are structured to use five general sources of removals (these are aggregated for modelling purposes and do not necessarily correspond to specific fisheries or sectors): the directed commercial halibut fishery (including research landings), commercial discard mortality (previously known as wastage), bycatch (from non-halibut-target fisheries), recreational, and subsistence. The TCEY was distributed to each source in an ad hoc manner using current available information (see below).

4.1.1 Conditioning the Operating Model

The operating model (OM) should be a reasonable depiction of reality with an appropriate level of uncertainty, which is accomplished through a process called conditioning. The operating model (OM) consists of two Stock Synthesis, or SS (Methot and Wetzel 2013), models parameterized similarly to the short and long coastwide assessment models for Pacific halibut (Stewart 2015 appendix of RARA). Each SS model is conditioned by fitting to the same data used in the 2017 stock assessment (Stewart & Hicks 2018, documents 08-10). In order to evaluate and choose management procedures that are robust to uncertainty in the population, many assumptions in the assessment model were freed up to characterize a wider range of possibilities in the future. Table 1 shows the parameters that were different from the assessment models. Estimating natural mortality in both models and estimating steepness were the only processes changed from the assessment model when conditioning.

Table 1: Parameter estimation in the assessment and operating model.

Parameter	Assessment	OM
Natural Mortality (*M*)	Some estimated	All estimated without priors
Recruitment (lognormal devs)	Variability 0.6 (long) and 0.9 (short)	Same as assessment
Steepness (*h*)	Fixed at 0.75 (long) 0.9 (short)	Estimated variability introduced around assessment value

4.1.1.1 Characterizing Variability in Stock and Fishery Dynamics

Variability was characterized by the estimated variance-covariance matrix estimated automatically by inverting the Hessian within ADMB (http://www.admb-project.org/), which is the optimization software that SS uses. This provides the uncertainty for each estimated parameter, and its correlation with other parameters, given the data and assumptions. Using this variance-covariance matrix, sets of parameters were randomly generated from a truncated multivariate normal distribution. The truncation of parameter bounds was determined from the bounds entered in the SS model files. Some bounds (e.g., dev parameters) were infinite.

An alternative approach for characterizing variability is to design a grid over which different parameter values and assumptions are used. For example, different values of steepness could be chosen and simulations use those fixed values of steepness. Then, the simulations are combined across grid points. We are using the Hessian approach to integrate over a range of parameter values and account for correlation between parameters.

To ensure that parametrically sampling from using a multivariate normal distribution and the inverted Hessian produced similar results as the assessment SS models (the current best information for the historical trajectory), 1000 samples of the parameters estimated in the assessment models were generated from a multivariate normal distribution. Estimated recruitment deviations were bias-corrected by their corresponding estimated variances before sampling from the multivariate normal distribution. The mean spawning biomass trajectory and 95% confidence interval around that trajectory were compared to the assessment results and the long coastwide model showed an increased density of low spawning biomass compared to the assessment model (Figure 4). Trajectories with a maximum F greater than 0.4 were not within the 95% confidence interval determined from the inverted Hessian in assessment model, thus the sampling from the multivariate normal was limited to trajectories that had a maximum fishing mortality rate less than 0.4.

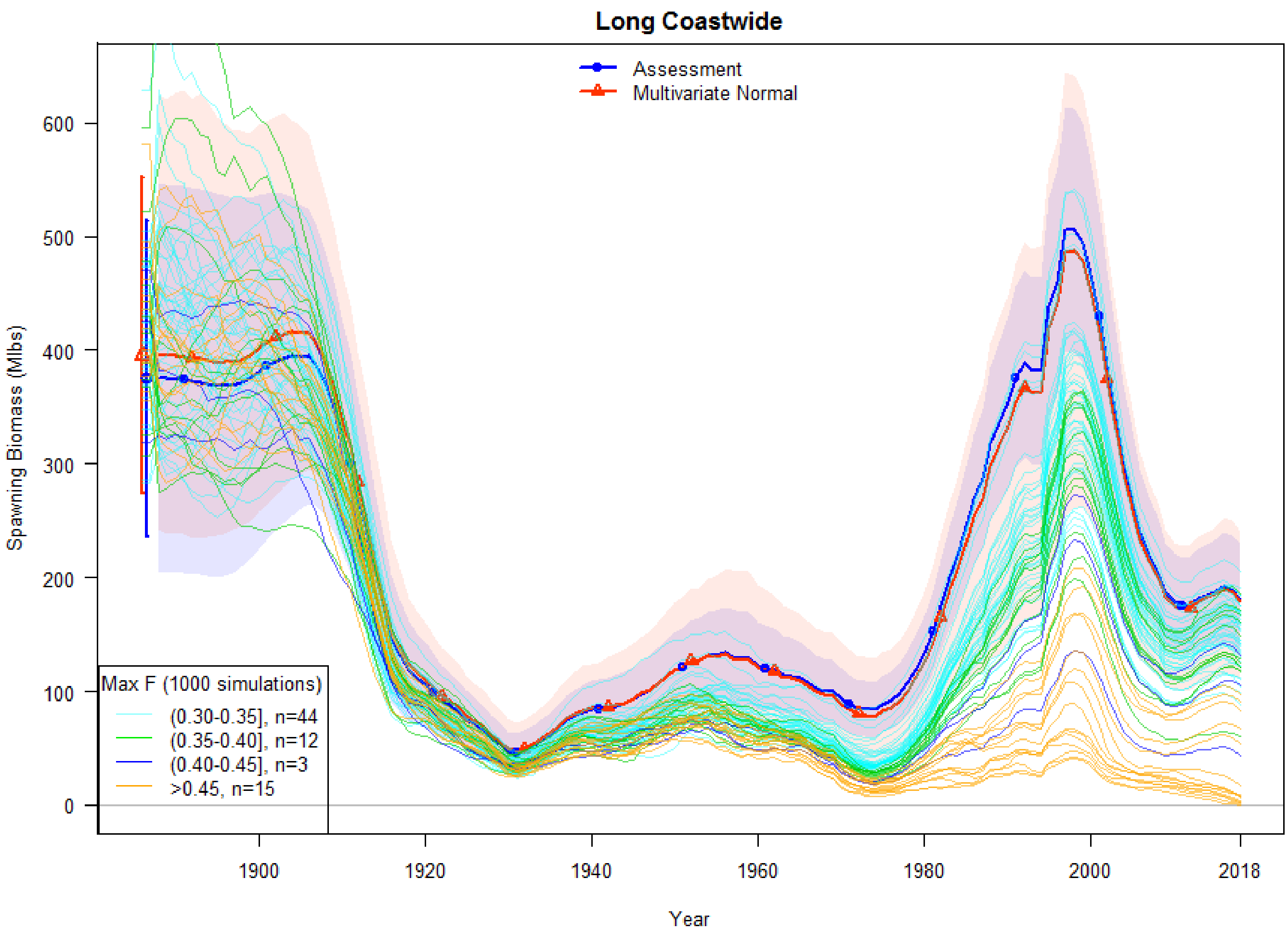

Figure 4: Mean spawning biomass trajectories from the long coastwide assessment model with 95% confidence range (blue) and the mean and 95% confidence range of 1000 samples from a multivariate normal using the parameter estimates and inverted Hessian from the long coastwide assessment model (red). Individual trajectories from specific samples that produced large maximum F values are also plotted with the number of trajectories for various ranges of F listed in the legend.

Implementing a maximum F of 0.4 when sampling from the multivariate normal distribution (only the long coastwide was limited as short coastwide showed fishing mortality rates lower than 0.2), the assessment was mimicked reasonably well by the sampled trajectories for the long and short coastwide models (Figure 2).

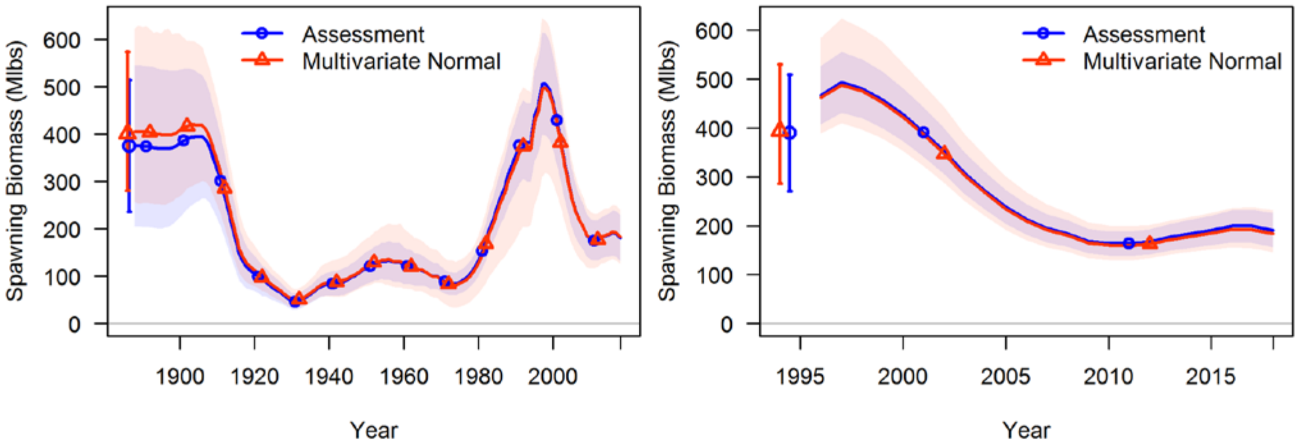

Figure 5: Median spawning biomass trajectories from the long coastwide (left) and short coastwide (right) assessment models with a 95% confidence range (blue) and the median and 95% confidence range of 1000 samples from a multivariate normal using the parameter estimates and inverted Hessian from each assessment model (red).

Estimating parameters that were fixed in the assessment may produce stock dynamics that are not consistent with the assessment. To condition the OM to match the assessment, but introduce additional variability, the following steps were performed.

1. Allow for the estimation of the additional parameters in the assessment models. For the long coastwide model, steepness was estimated without a prior. For the short coastwide model, female M was estimated without a prior (and the upper bounds on female and male M's were increased to 0.45) and steepness was estimated with a prior created from the results of the long coastwide model and assuming a normal distribution. A prior on steepness was used to keep steepness within a reasonable range and force the estimated standard deviation for the short coastwide OM to be similar to the standard deviation in the long coastwide OM (i.e., both operating models are sampling from the same steepness distribution). Without a prior, the estimated variability in steepness resulted in a nearly uniform distribution between 0.2 and 1.0. The prior is centered around 0.75 with a standard deviation of 0.084 (2.5th and 97.5th percentiles equal to 0.59 and 0.91, respectively). See Figure 6 and the following steps.
2. Use the estimated covariance from the models with the extra parameters estimated (full model), the variances from the assessment model, and the variance of the additional estimated parameters from the full model to build a covariance matrix. Use the point estimates from the assessment model with that covariance matrix to sample from a multivariate normal distribution. This keeps the full model's predictions near the assessment model, but introduces extra variability accounting for correlation between estimated parameters.
3. Run the SS model using the sampled parameters, but without estimation to predict the historical population dynamics.
4. Eliminate the simulation if the maximum exploitation rate is greater than 0.4 in any year, or if the spawning biomass drops below 100 pounds in any year.
5. Repeat 2 through 4 as many times as necessary to create 1000 simulated trajectories.

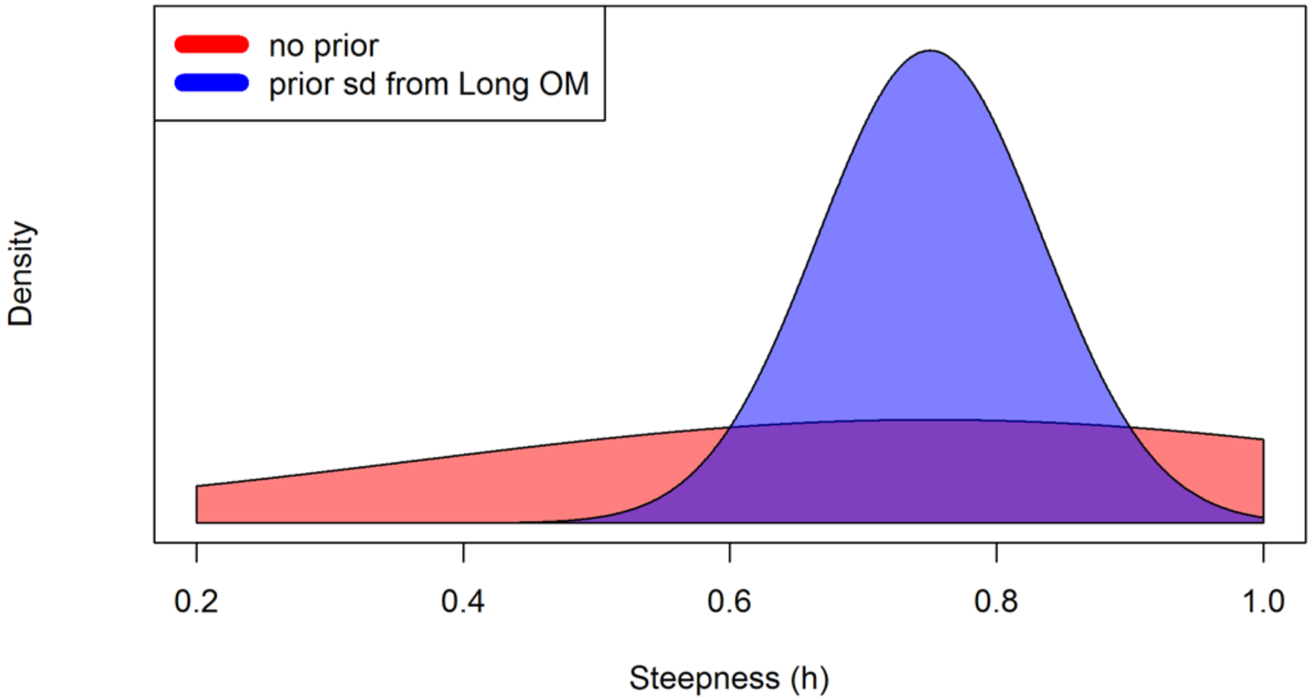

Figure 6: Steepness Normal distributions centered around 0.75 using the standard deviations estimated without a prior in the short coastwide model (red) and with a prior determined from the long coastwide operating model (blue).

4.1.1.2 Long coastwide operating model

Steepness was the only additional parameter in the long coastwide operating model, compared to the assessment, that had variability. Steepness was centered on 0.75, as in the assessment, even though the estimated value of steepness was 0.9463, but the estimated variance (standard deviation = 0.08376) and covariances were used. The normal distribution of steepness, from which values were sampled, can be seen as the blue curve in Figure 6, and the estimated value (0.9463) is the 88th percentile in this distribution.

The parameters, including steepness centered around 0.75, were sampled from a multivariate normal distribution to create 1000 parameter vectors, each used to create a population trajectory. Trajectories that showed a maximum exploitation rate greater than 0.4 at any point in the time series were eliminated and parameters were re-sampled until 1000 acceptable parameter vectors were found. In total, 399 parameter draws were eliminated in the process. The final 1000 trajectories of historical spawning biomass from the operating model are compared to the assessment in Figure 7.

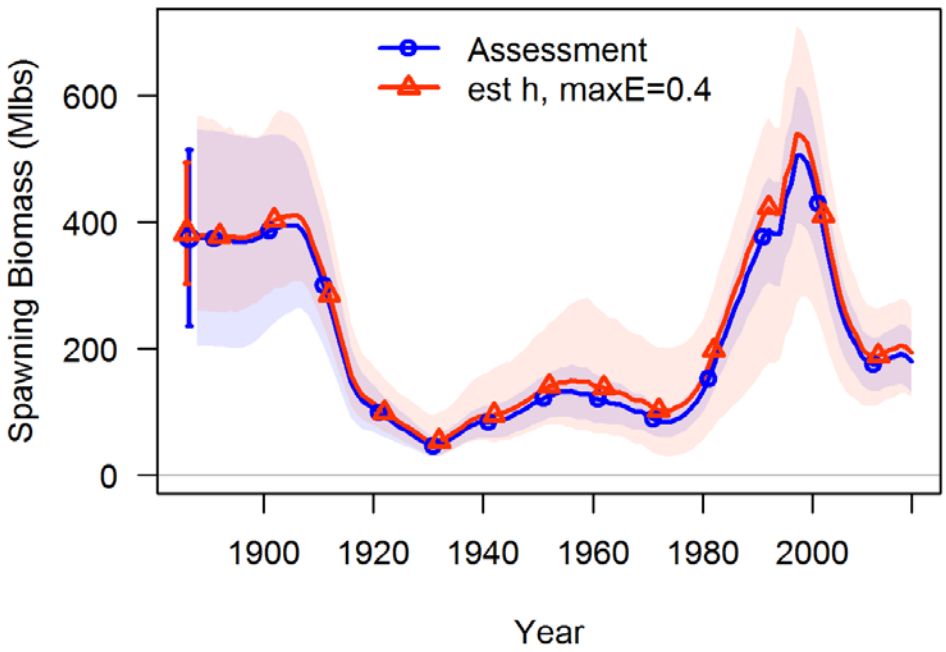

Figure 7: Predicted median biomass trajectories with 95% confidence intervals for the long coastwide assessment model (blue) and the long coastwide operating model (red).

The median spawning biomass in the operating model is slightly greater than the assessment model. This is an effect of using a parametric bootstrap and adding the variability on steepness, even though the distribution of steepness was centered on the assessment value of 0.75. There are a number of reasons that the median of the operating model is slightly greater than the assessment model.

1. The distribution of spawning biomass from the operating model is broader and not necessarily symmetric, whereas the assessment model uses a point estimate (maximum likelihood) and an assumption that the variability in spawning biomass is characterized by a normal distribution.
2. The threshold maximum exploitation rate of 0.4 eliminates some low trajectories.
3. The covariances in the variance-covariance matrix used to characterize the normal distribution are from the full model (with steepness estimated) and are different than the covariances estimated in the assessment model. The variances of the parameters estimated in the assessment model are from the assessment model in the variance-covariance matrix used for sampling. Even setting the variance and covariances of the steepness parameter to zero in the variance-covariance matrix for sampling resulted in a median spawning biomass trajectory slightly above the assessment for most of the time-series, although it was similar to the assessment in recent years.

The 2018 point-estimate of spawning biomass from the assessment is the 36th percentile of the distribution of 2018 spawning biomass in the operating model (see Figure 8).

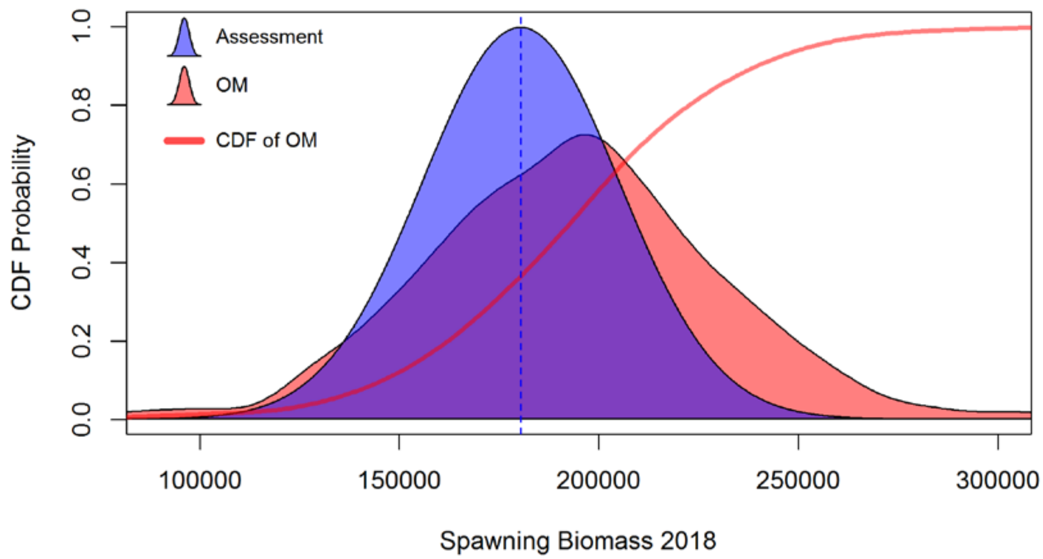

Figure 8: Predicted distributions of 2018 spawning biomass for the long coastwide assessment model (blue) and the long coastwide operating model (OM, red). The cumulative distribution function (CDF) of the OM distribution and the median of the assessment 2018 spawning biomass (dashed blue line) are also shown.

4.1.1.3 Short coastwide operating model

Steepness and female natural mortality were the additional parameters in the full short coastwide model, compared to the assessment, that had variability. Steepness was centered on 0.75, as in the assessment, even though the estimated value of steepness (without a prior distribution) was 0.43. A prior was put on the steepness parameter (normal with a mean of 0.75 and a standard deviation of 0.08376, from the long coastwide model estimate of steepness), as discussed above, to make it have a similar distribution as the long coastwide model (see Figure 6). Female natural mortality was estimated without a prior, but the upper bound was extended to 0.45 because the estimate was 0.35. The upper bound on male natural mortality was also extended to 0.45 and its estimate was 0.26.

The estimated variances and covariances of steepness and female natural mortality were used, along with estimated variances and covariances from the assessment model for other parameters, to characterize the variance-covariance matrix used in the multivariate normal distribution from which parameters were sampled. The estimated standard deviations for steepness and female natural mortality were 0.08399 and 0.00864, respectively. The means for the multivariate normal distribution were the estimated or fixed values from the assessment (i.e., h = 0.75 and female M = 0.15).

The parameters, including steepness, were sampled from a multivariate normal distribution to create 1000 parameter vectors, each used to create a population trajectory. Trajectories that showed a maximum exploitation rate greater than 0.4 at any point in the time series were eliminated until 1000 parameter vectors were obtained. In total, 68 parameter draws were eliminated. The final 1000 trajectories of historical spawning biomass from the operating model are compared to the assessment in Figure 9.

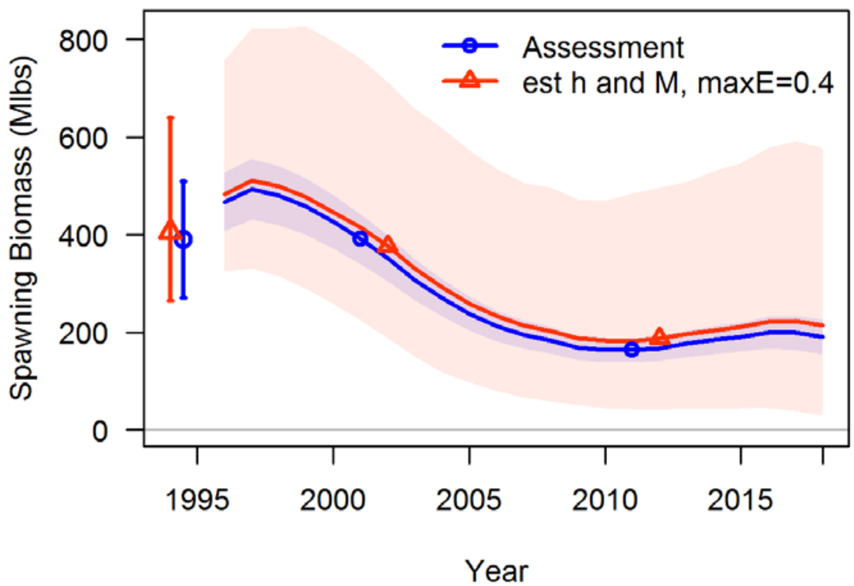

Figure 9: Predicted median biomass trajectories with 95% confidence intervals for the short coastwide assessment model (blue) and the short coastwide operating model (red).

The median spawning biomass in the operating model is slightly greater than the assessment model. This is an effect of using a parametric bootstrap and adding the variability on steepness and female natural mortality, even though the distributions of these parameters were centered on the assessment values. This occurs for a number of reasons, as outlined above when discussing the long coastwide model.

The 2018 point estimate of spawning biomass from the assessment is the 44th percentile of the distribution of 2018 spawning biomass in the operating model (see Figure 10).

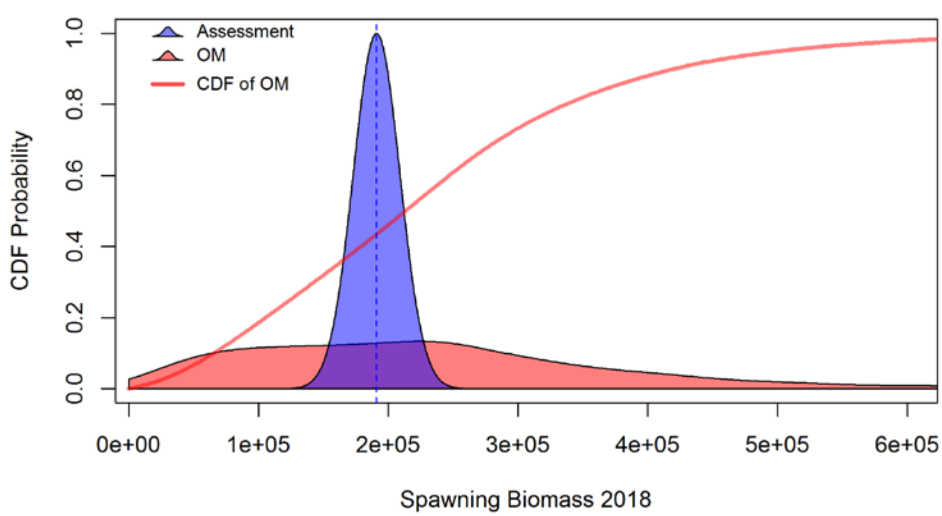

Figure 10: Predicted distributions of 2018 spawning biomass for the short coastwide assessment (blue) and the short coastwide operating model (OM, red). The cumulative distribution function (CDF) of the OM distribution and the median of the assessment 2018 spawning biomass are also shown.

4.1.1.4 Summary of conditioned operating models

Overall, the individual operating models mimic the assessment well, but with additional uncertainty. The presence of a slightly higher median spawning biomass in the individual operating models is not a concern because the MSE is focused on ranking procedures and is not meant to predict the exact quantities. The most important aspect is to characterize variability and the dynamics of the stock. The variability in the short coastwide model is much greater than in the long coastwide model, and is a large contributor to the overall variability, in recent years, of the operating model consisting of the combination of the two individual models (Figure 11). When comparing the combined operating model to the ensemble assessment, the median spawning biomass trajectories are similar, but the variability in the operating model is much greater than the ensemble assessment (Figure 11).

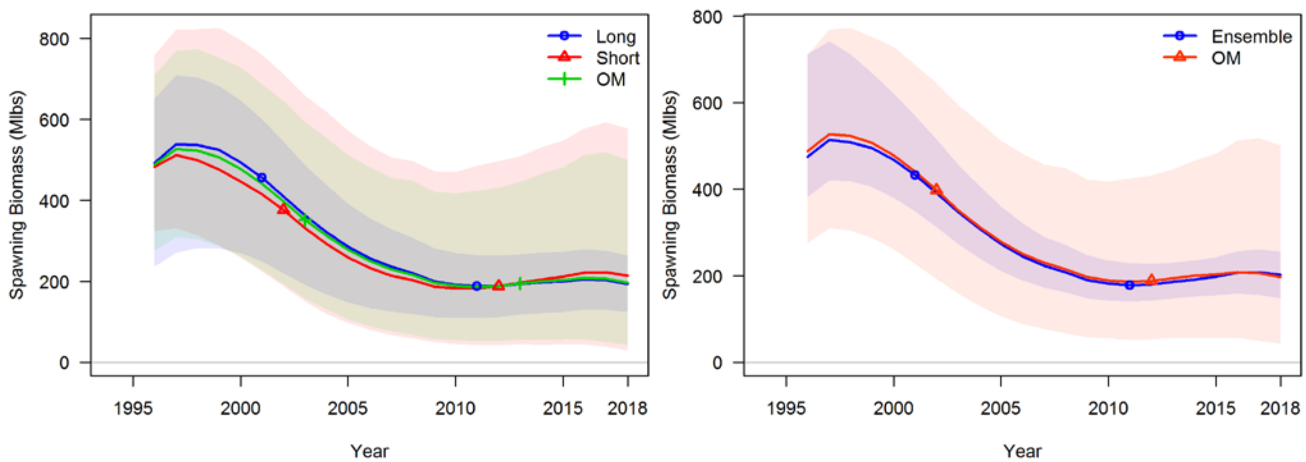

Figure 11: The conditioned operating model (red) compared to the stock assessment ensemble (blue) with 95% confidence intervals on each.

The historical simulated trajectories were examined for evidence of “quasi-extinction”, which can be defined as a trajectory that reaches a value low enough that it would unlikely recover (in reality). That low value is not defined, so we compared simulated trajectories of spawning biomass to observed total mortality from all fisheries (Figure 12). The spawning biomass was generally low from around 1920 to 1980, and again in recent years. Especially low spawning biomass occurred near 1930 and 1975, and in recent years in the short coastwide model. The observed total mortality from fishing overlaps the lower trajectories around these low points, even with a maximum exploitation rate of 0.4. This can occur because the fishing mortality is partially composed of immature, young fish. Overall, some spawning biomass trajectories are surprisingly low, but it does not appear that quasi-extinction is apparent.

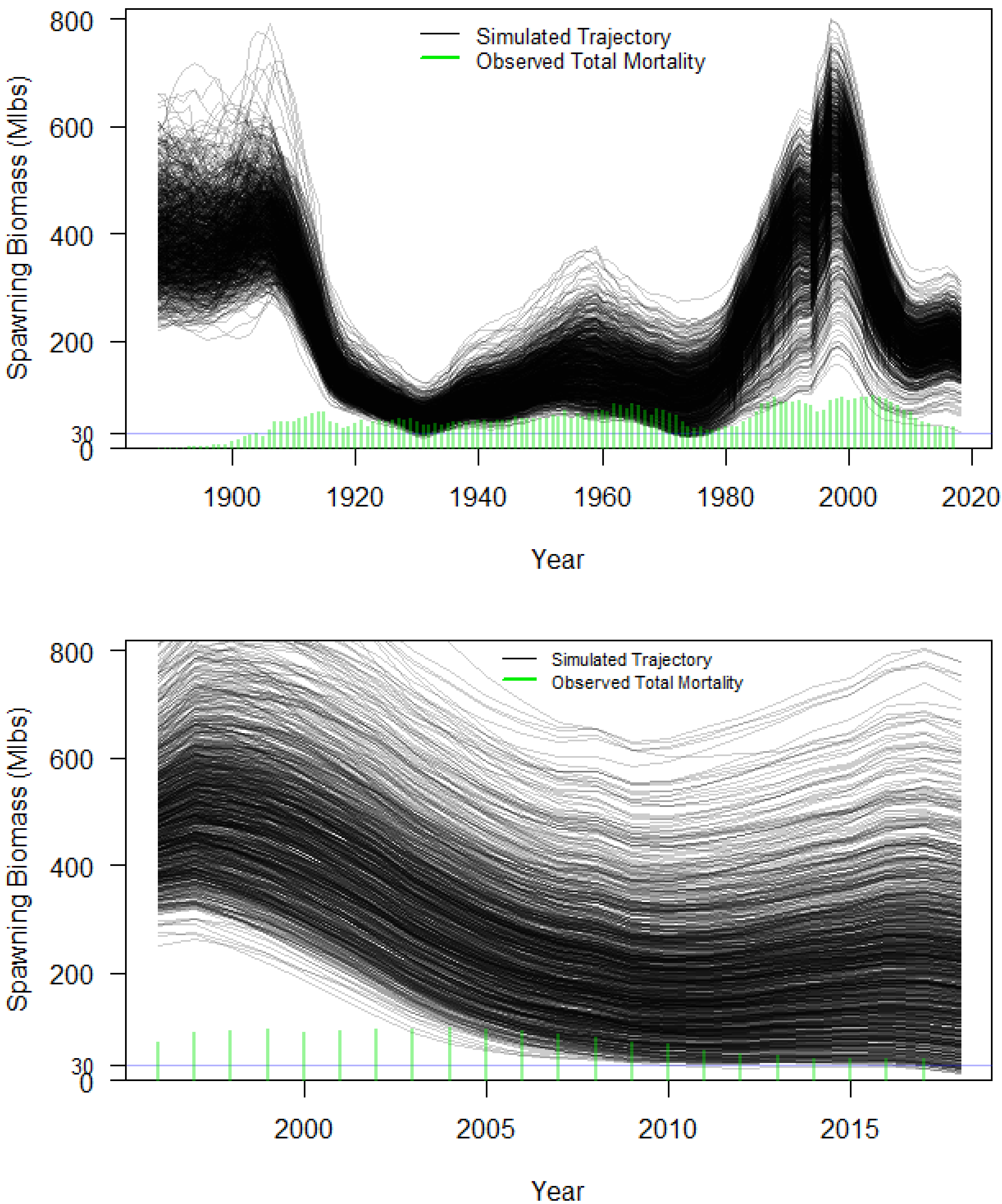

Figure 12: Historical simulated trajectories of spawning biomass (M lbs) from the long coastwide operating model (top) and the short coastwide operating model (bottom). Observed total mortality (M lbs) from all fisheries is shown by the green histogram bars. A horizontal line at 30 million pounds is drawn for reference.

4.1.2 Simulating Forward with the Operating Model

The short and long coastwide models make up the operating model and incorporate variability associated with estimated parameters describing stock and fishery dynamics. Variability from other sources (e.g., weight-at-age, recruitment regimes, and allocation to fishery sectors) was introduced when projecting into the future. Descriptions of these procedures are provided in IPHC-2017-MSAB010-09 Rev1, and updates to the procedures are described here.

4.1.2.1 Allocating the Total Mortality to Fishery Sectors

There are five fishing sectors in simulations, as is defined in the coastwide assessment models. These are a commercial fishery, a discard mortality from the commercial fishery, a recreational fishery, bycatch mortality, and a subsistence fishery. The changes to the methods used to allocate total mortality to these five sectors are described below.

Bycatch Mortality

Bycatch mortality across all IPHC Regulatory Areas (Figure 13) has been declining since a peak in 1992 of 20 million pounds (~9,000 t). In 2017, bycatch mortality was estimated to be 6.0 million pounds (~2,700 t), which is due to industry measures to reduce bycatch as well as reductions in the Pacific halibut stock.

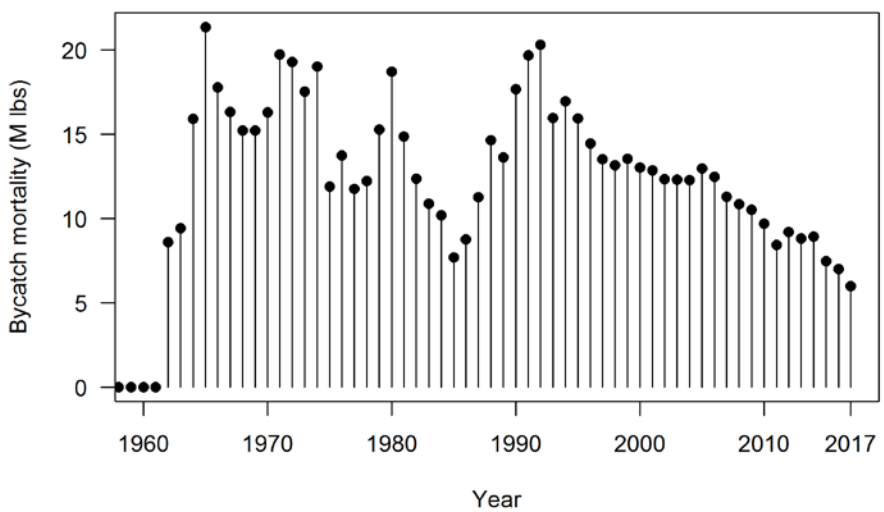

Figure 13: Observed bycatch mortality.

A look at the historical relationship between bycatch mortality and total biomass was done to predict how bycatch may change with changes in Pacific halibut biomass. Before 1997 bycatch increased greatly with little change to total biomass (Figure 14) and after 2014 the bycatch dropped substantially with little change in total biomass (likely due to the industry specified protocols to reduce bycatch, such as deck sorting in the Amendment 80 trawl fleet). Therefore, using bycatch mortality from 1997 to 2014 and estimating the relationship with total biomass, the predicted slope of the line is 0.004. This is interpreted as each pound increase in total biomass results in a 0.4% increase in bycatch mortality. However, in the past three years, the bycatch mortality has declined from approximately 9 million pounds (4,000 t) to 6 million pounds (2,700 t) with little change in total biomass, thus the prediction line should reflect the efforts to reduce bycatch mortality, and the intercept was shifted to match the 2017 observations of bycatch mortality and total biomass (Figure 14). The predicted total biomass in 2017 was 848 million pounds (385 thousand t) which shifts the line downward by 3.4 million pounds to current bycatch levels but retains the relationship (change in bycatch) with total biomass.

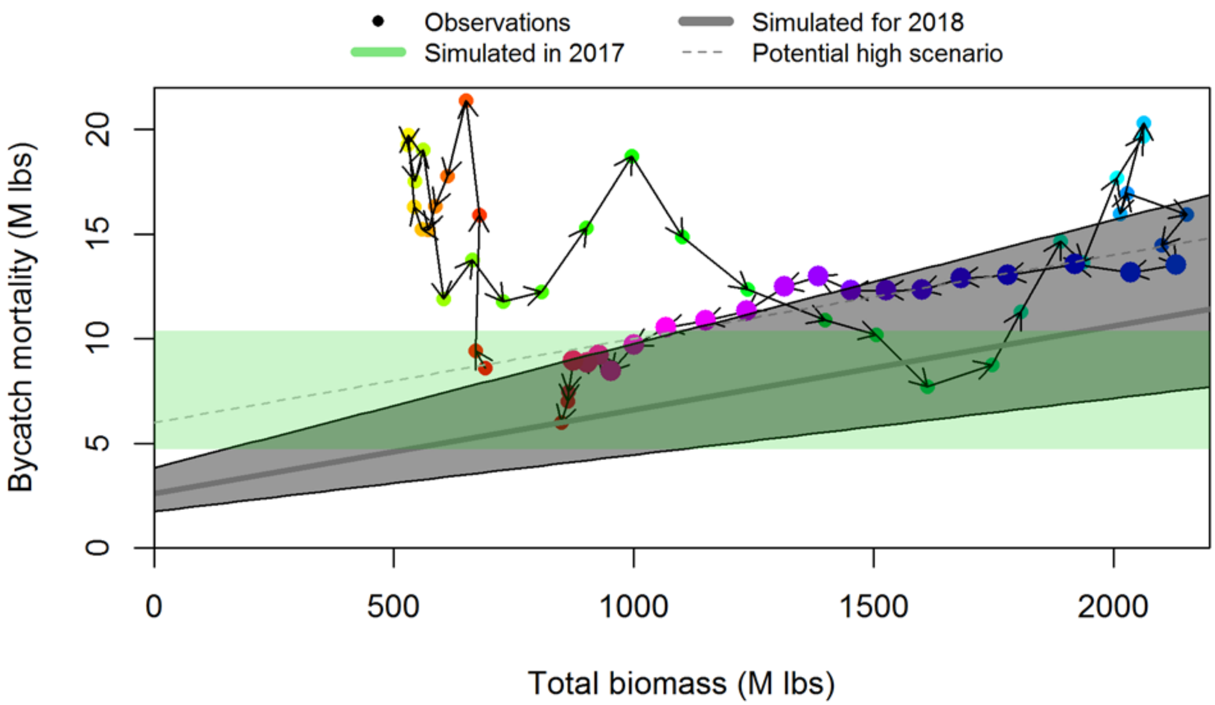

Figure 14: Bycatch mortality (colored dots) plotted against estimated total biomass from the 2017 stock assessment. Arrows and colors show the sequence of time. The years 1997 to 2014 are shown by larger dots. The light green area shows the range of bycatch that was simulated from a lognormal distribution for 2017 MSE results, and did not change with total biomass. The grey areas shows the updated lognormal distribution for simulated bycatch that is a function of total biomass. The dashed line shows the mean of a potential high scenario for simulating bycatch.

A potential high bycatch scenario would be to use the original intercept of 6, which creates a line passing through the 1997-2014 observations (Figure 2, dashed line).

The previous CV on bycatch was 0.2 with a constant mean bycatch regardless of total biomass. This CV was kept to maintain the unpredictability of bycatch in the future.

Recreational mortality

A recommendation from MSAB012 was to modify the recreational allocation so that it kept increasing as the biomass (or TCEY) increased (REF to paragraph). Therefore, recreational mortality was investigated, and a constant proportion of the total mortality was used for allocation. To determine the proportion, the last five years (2013-2017) were used to determine the mean proportion, which was 0.18. The error on the proportion was set to capture the range of proportions observed over the past five years, resulting in a CV of 0.01. Figure 15 shows the recreational mortality and the proportion of recreational mortality plotted against the total mortality, as well as the simulated mean and range.

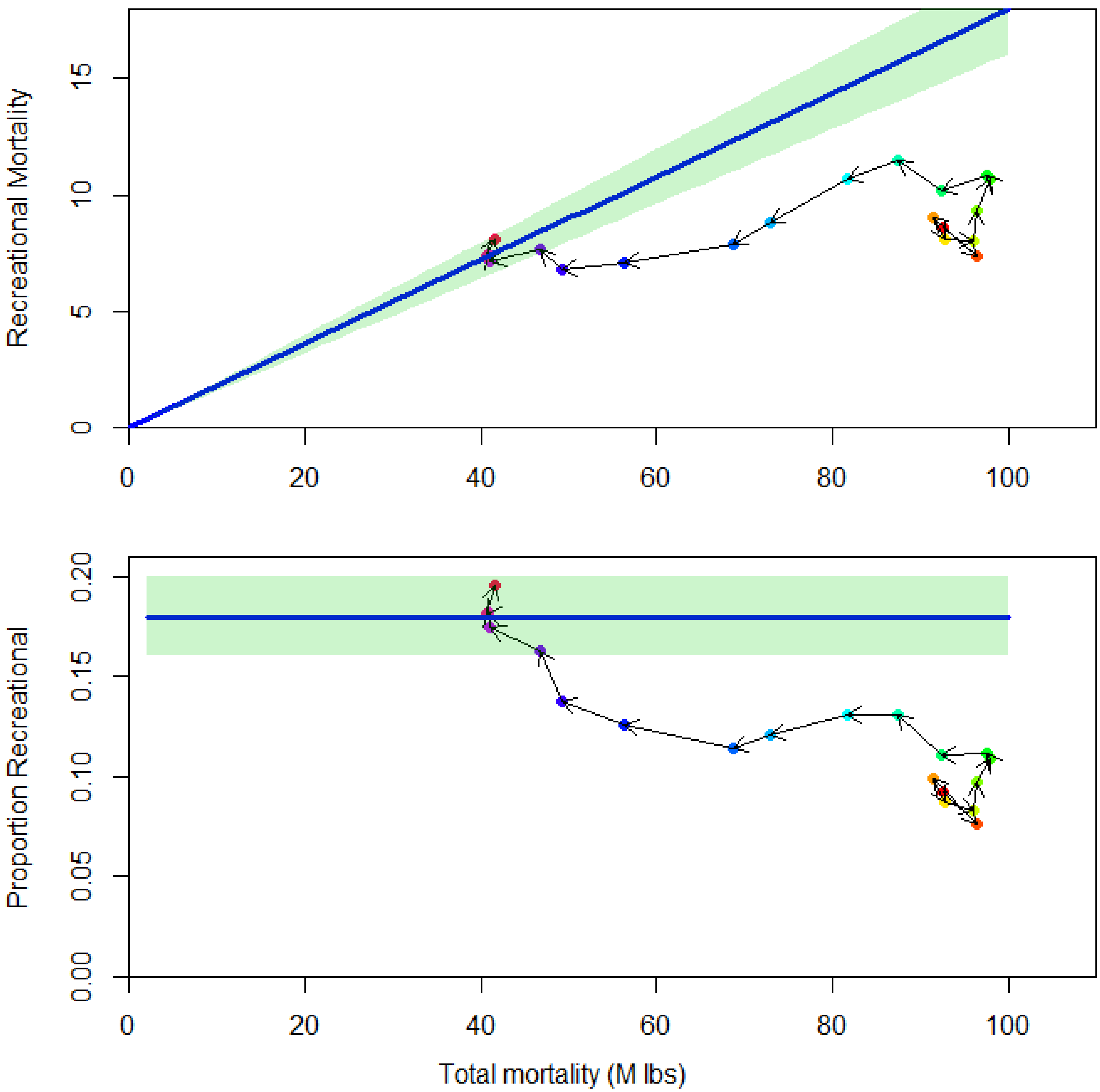

Figure 15: Recreational mortality (top) and the proportion of recreational mortality (bottom) plotted against the total mortality, as well as the simulated mean (blue line) and range (green area). Arrows show the sequence of time.

The resulting average allocations are shown in Figure 16.

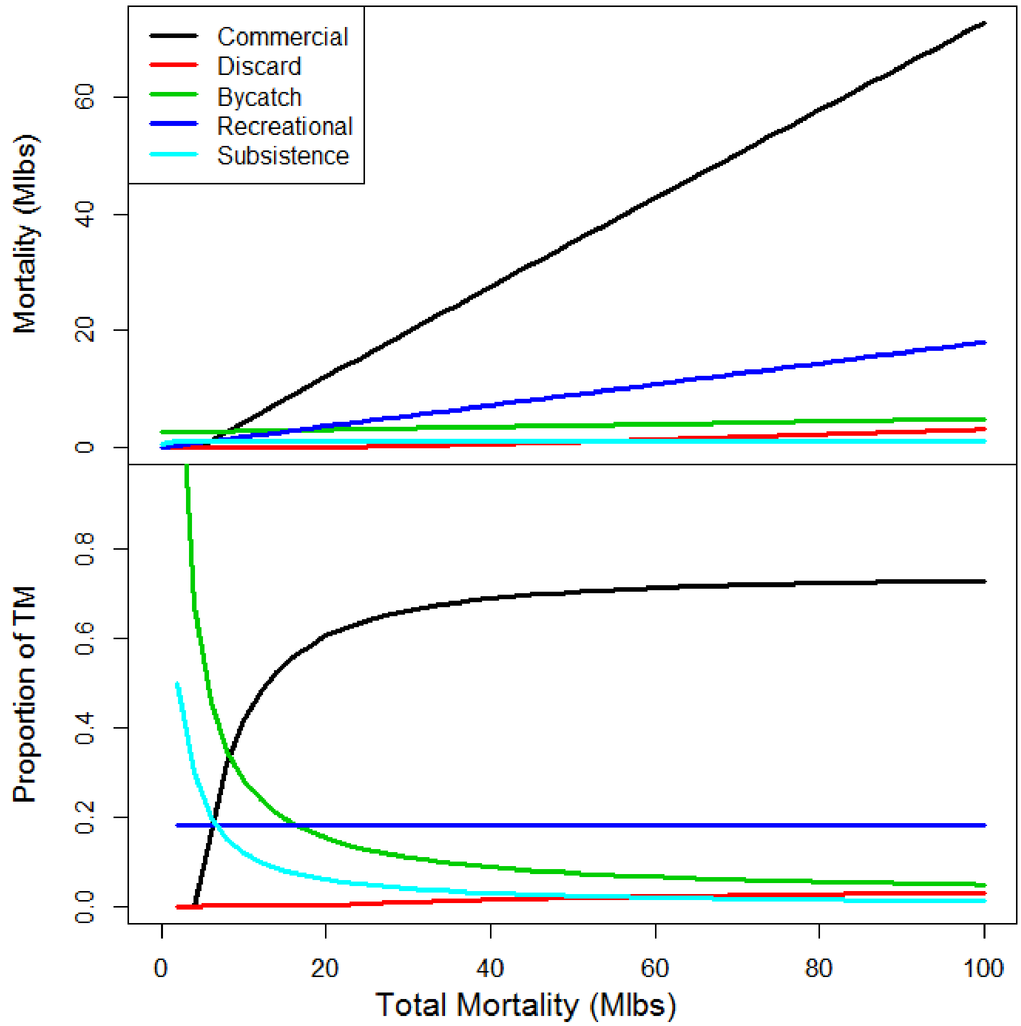

Figure 16: Average allocations in terms of mortality (top) and proportion (bottom) for the five fishing sectors. Bycatch allocation is a function of total biomass, and it was assumed that total mortality is 17.5% of total biomass (based on estimates from 1998–2017).

4.1.2.2 Variability in Commercial Selectivity

Commercial selectivity varies annually in the stock assessment model through estimated deviations on the ascending width and peak parameters of the double normal paramterization. This time-varying concept is retained in the operating model and it is easy to simply generate random deviates for the selectivity parameters. However, it is likely that selectivity varies because of the behavior of another process, such as weight-at-age. It is proposed to make selectivity vary with changes to weight-at-age.

Random walk deviates are estimated for the ascending width and peak parameters of the double normal parameterization for female selectivity. Male selectivity is tied parametrically to the female selectivity, thus it also varies in time without any additional estimated deviates. Therefore, the relationship between the deviates and the weight for a specific age was investigated. Using female weight at age 17 showed a positive relationship with the deviates (Figure 17) and some of the highest R^2 values for the relationship using different ages (22.6% for the peak deviations and 44.5% for the ascending limb deviations)

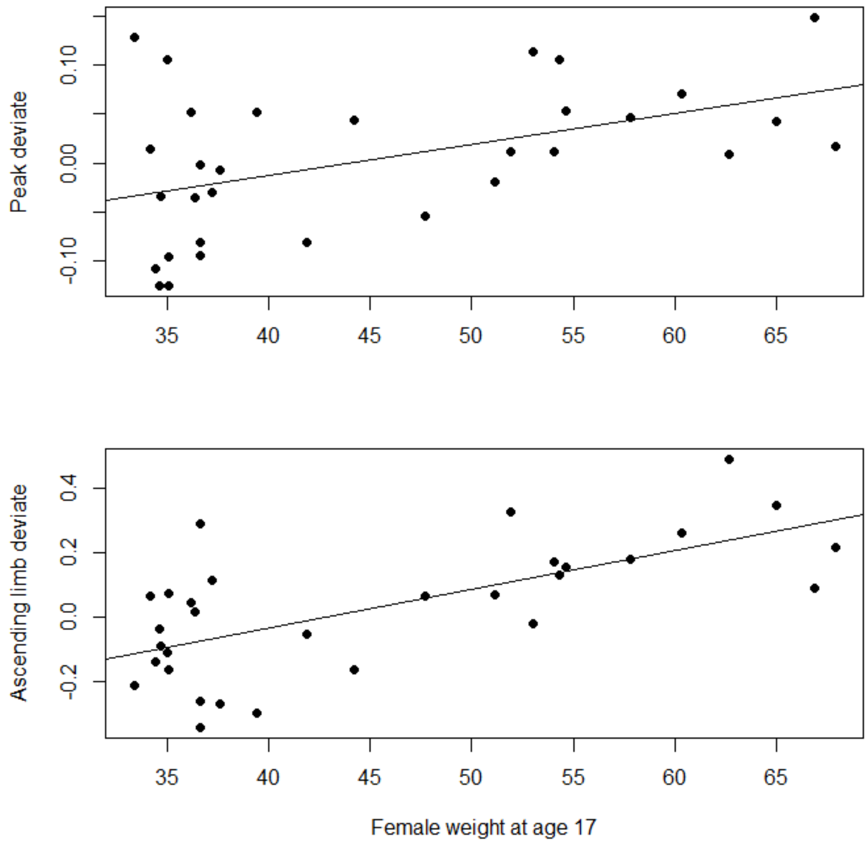

Figure 17: Selectivity deviates plotted against female weight at age 17.

It is proposed to randomly draw the selectivity deviates from a normal distribution with a mean that is a function of the female weight at age 17.

4.2 MANAGEMENT PROCEDURE

The elements of the management procedure are described in reverse order because it is easier to understand the decisions made for modelling them since they are dependent on each other. Therefore, the harvest rule is presented first, followed by the estimation model, and finishing with monitoring.

4.2.1 Harvest Rule

The generalized management procedure to evaluate is shown in Figure 1, but the focus will be on the Scale portion to produce results for the MSAB to evaluate before AM095 in 2019. Specifically, the portion of the management procedure being evaluated is a harvest control rule (Figure 18) that is responsive to stock status and consists of a procedural SPR determining fishing intensity, a fishery trigger based on stock status that determines when the fishing intensity begins to be linearly reduced (note that this may differ from the biological threshold), and a fishery limit that determines when there is theoretically no fishing intensity (this may differ from the biological limit). For these simulations, the two coastwide models were used, thus mortality only needed to be distributed to the five coastwide sources of mortality (directed commercial, discard mortality, bycatch mortality, recreational, and subsistence).

Simulations have been used in the past to evaluate a range of SPR values from 25% to 60% and trigger values of 30% and 40% (IPHC-2017-MSAB10-09 Rev 1). Those simulations provided insight into how those different levels of SPR would meet the objectives defined by the MSAB, but few values of SPR below 40% were tested. Future simulations will use a finer resolution of SPR values ranging from 30% to 56% and fishery trigger points of 30% and 40% (with the addition of 45% if time allows).

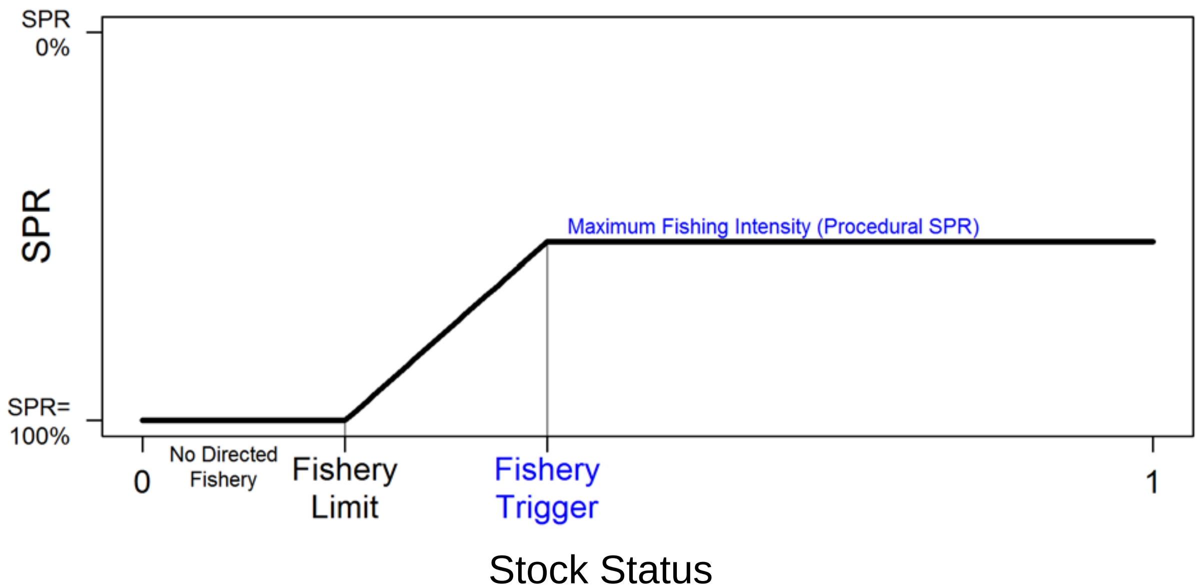

Figure 18: A harvest control rule responsive to stock status that is based on Spawning Potential Ratio (SPR) to determine fishing intensity, a fishery trigger level of stock status that determines when the fishing intensity begins to be linearly reduced, and a fishery limit based on stock status that determines when there is theoretically no fishing intensity (SPR=100%). In reality, it is likely that only the directed fishery would cease. The Procedural SPR and the Fishery Trigger (in blue) are the two values to be evaluated.

4.2.2 Estimation Model

Two options to simulate an estimation model will be used: the No Estimation Model (previously called Perfect Information) option, as was used in past simulations, and the Simulate Error option. The No Estimation Model method assumes that the population values needed to apply the management procedure are exactly known (e.g., spawning biomass). This option is useful as a reference to better understand the performance with and without uncertainty in an estimation model. Due to time constraints, the only other option to be considered for simulations in 2018 is the Simulate Error option, which will be suitable to understand the effects of estimation error. This method is described below.

The harvest control rule contains two components that have estimation error. The first component is the estimated total mortality determined from the specified SPR. The second component is the estimated stock status that is used to reduce the fishing intensity when stock status is low (fishery trigger and fishery limit). These components are dependent on the estimated biomass, but it is more straightforward and computationally efficient to introduce error into these two components, rather than introducing error on the estimated biomass and then determining the resulting estimates of total mortality and stock status.

The 2017 stock assessment (Hicks & Stewart 2018) was used to determine a reasonable amount of variability in these two components and the correlation between them. Autocorrelation is currently being investigated and will also be implemented in the MSE simulation framework through a procedure that will introduce persistent time periods of negative or positive errors. At this time, bias will not be introduced, unless time allows for some sensitivities.

Overall, there are many assumptions in this incorporation of estimation error, but we are only trying to determine a reasonable amount of error for the simulations. Other levels of error will likely be simulated to determine how sensitive the results are to the estimation error.

4.2.3 Monitoring (Data Generation)

The simplified incorporation of estimation error will be used due to time constraints; thus no data are required to be generated. However, if a stock assessment were simulated, there would be many sources of data to generate.

4.3 Summary of the Framework

A summary of the major specifications for each component is provided below, with the components listed in a specific order where the next component is dependent on the decisions for the previous components.

1) Operating Model
    a) Stock synthesis, based on coastwide assessment models (short and long models).
    b) Five fleets, as in the assessment models (commercial, discards, bycatch, sport, personal use).
    c) Uncertainty incorporated through parameter uncertainty and model uncertainty. See Scenarios.
2) Management Procedure
    a) Estimation Models
        i) Perfect Information (as a reference if we knew population values exactly when applying the harvest rule).
        ii) Simulate error in total mortality and spawning biomass, with autocorrelation, from the simulated time-series to mimic an unbiased stock assessment.
    b) Data Generation
        i) Not needed at this time.
    c) Harvest Rule
        i) Coastwide fishing intensity (F_{SPR}) using a procedural SPR.
        ii) A fishing trigger to reduce the fishing intensity (increase SPR) when stock status is below a specified level.
        iii) A fishing limit to cease directed fishing when the stock status is less than a specified value (20%).
        iv) Catch assigned to sectors based on historical information (with variability).

5 SIMULATION RESULTS

Using the simulation framework described above and in previous documents, test cases were first investigated to better understand the dynamics of the simulations. The simulations were done with no directed fishing, but with bycatch and subsistence fishing (approximately ranging from 4.5 million pounds to 12 million pounds), to investigate the nature of the projections and the presence, if any, of quasi-extinction. Additionally, projections with constant levels of weight-at-age and recruitment (low/high combinations) were done.

Figure 19 shows forward simulation results for the no fishing case with simulated variability in weight-at-age and simulated recruitment regimes. Only one-hundred trajectories were simulated, but it is clear that the entire range of variability is not captured until at least after 60 years. As also shown in the conditioning results, the short coastwide model had a wider range of variability. No simulated trajectory for the long coastwide model produced a spawning biomass less than 30 million pounds, and the minimum spawning biomass from all long coastwide model trajectories was near 60 million pounds, which occurred at time step 2. The short coastwide model produced four (out of 100) trajectories that had a spawning biomass less than 30 million pounds. Of these four, three of them started at a spawning biomass less than 30 million pounds, and all three recovered to levels above that. One trajectory started above 30 million pounds, but eventually crashed to zero.

Specific states of weight-at-age and the recruitment regime were simulated to investigate how these factors, and the combination of them, affect the simulated population trajectories. Low and high recruitment regimes were simulated by fixing the regime in the model at its low or high value since it is modeled as discrete low or high. Changes in weight-at-age are continuous, thus specific states had to be determined. Low, medium, and high states are determined by calculating the 15th, 50th, and 85th percentiles of the historical weight-at-age (1935-2017) for each age, running a loess smoother through the specific quantile-at-ages, and then making sure it increases monotonically over age by predicting weight (from the loess model) for any ages that had a weight less than the weight at a younger age (Figure 20).

Using the low and high states of weight-at-age, crossed with the low and high recruitment regimes, and keeping them static for the entire simulation allowed for the investigation of these different factors as well as testing to make sure that they produced reasonable results. Figure 19 shows the simulated trajectories using the long coastwide model and the short coastwide model for the four different combinations. The long coastwide model was most influenced by weight-at-age, and each combination produced a well-defined band of trajectories. The short coastwide model showed more influence from recruitment with the high weight low recruitment scenario showing similar trajectories as the low weight high recruitment scenario. Some trajectories in the low weight low recruitment scenario showed quasi-extinction. In both models, the high recruitment regime resulted in more variability.

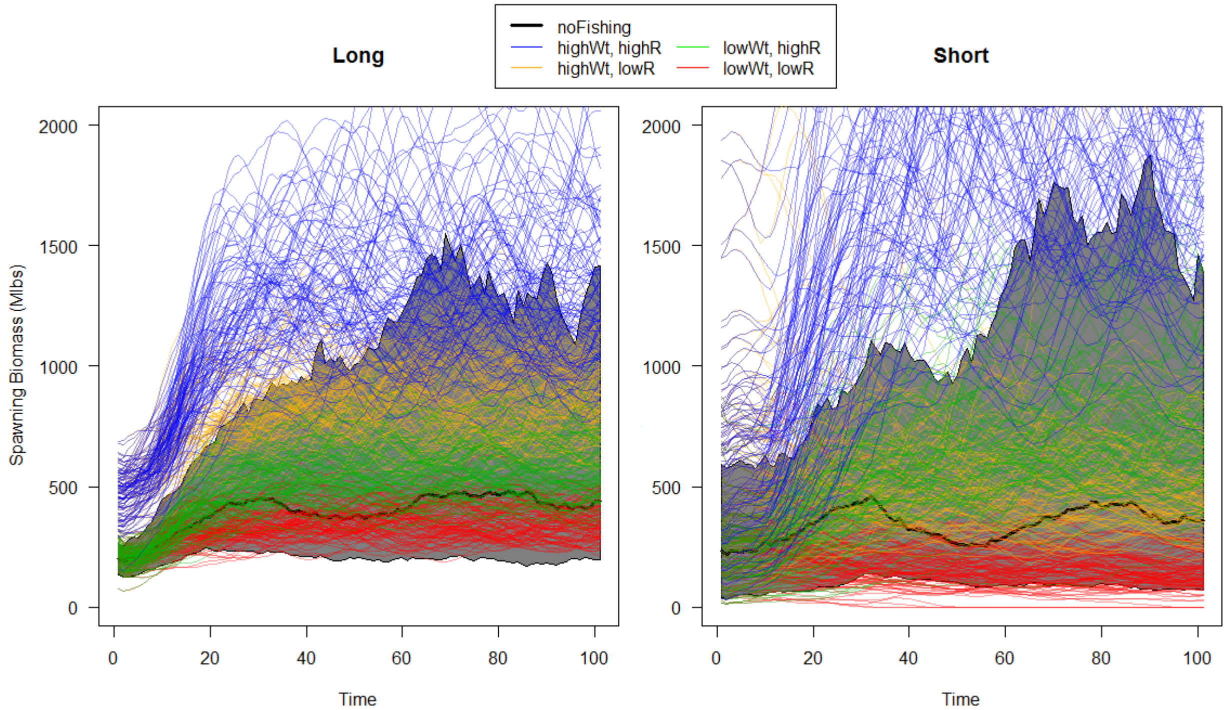

Figure 19: One-hundred forward simulated trajectories of spawning biomass without directed fishing. Bycatch mortality and subsistence mortality occurred (note, bycatch is simulated as a constant level with error for these trajectories). The gray area shows the range of simulations between the 2.5th and 97.5th percentiles with no fishing, but with simulated weight-at-age and simulated recruitment regimes. The individual lines of different colors show individual simulated trajectories with specific constant levels of weight-at-age and recruitment.

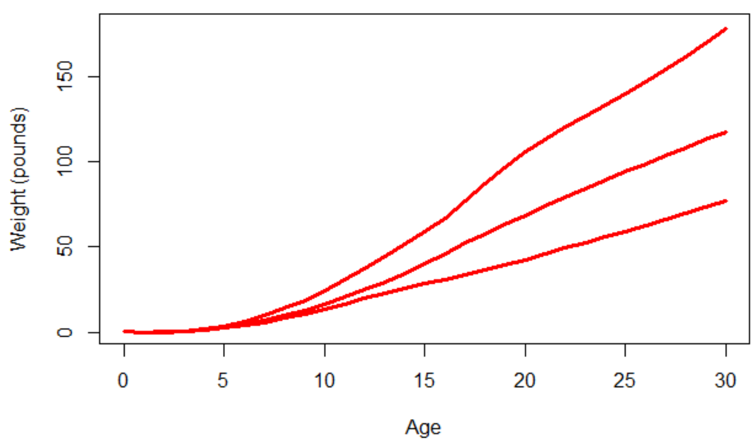

Figure 20: Plot of the low, medium, and high states of weight-at-age for testing.

Additional results will be presented at SRB013.

6 DISTRIBUTING THE TCEY

A considerable amount of discussion related to a description of the harvest strategy policy occurred at previous MSAB meetings. Figure 1 shows an updated depiction of the harvest strategy policy with terms describing the various components. These terms are defined in the IPHC glossary[1], but of note for this paper are TCEY distribution, stock distribution, and distribution procedures. The management procedure is the sequence of elements including the assessment, fishing intensity, stock distribution, and distribution procedures. The goal of the MSAB is to define a management procedure that will be used to output O26 mortality limits (TCEY) for each Regulatory Area that meet the long-term objectives of managers and stakeholders. The "decision" step on the right of Figure 1 is where a deviation from the management procedure may occur due to input from other sources and decisions of the Commissioners that may reflect current biological, environmental, social, and economic conditions.

In 2017, the Commission agreed to move to an SPR-based management procedure to account for the mortality of all sizes and from all fisheries. The procedure uses a coastwide fishing intensity based on spawning potential ratio (SPR), which defines the "scale" of the coastwide catch. This eliminates the use of EBio and area-specific absolute harvest rates. Therefore, there are currently two inputs to the current management procedure for distributing the TCEY among IPHC Regulatory Areas: 1) the current estimated stock distribution and 2) relative target harvest rates.

6.1 STOCK DISTRIBUTION

The IPHC uses a space-time model to estimate annual Weight-Per-Unit-Effort (WPUE) for use in estimating the annual stock distribution of Pacific halibut (Webster 2018). Briefly, observed WPUE is fitted with a model that accounts for correlation between setline survey stations over time (years) and space (within Regulatory Areas). Competition for hooks by Pacific halibut and other species, the timing of the setline survey relative to annual fishery mortality, and observations from other fishery-independent surveys are also accounted for in the approach. This fitted model is then used to predict WPUE (relative density) of Pacific halibut for every setline survey station in the design (including all setline survey expansion stations), regardless of whether it was fished in a particular year. These predictions are then averaged within each IPHC Regulatory Area, and combined among IPHC Regulatory Areas, weighting by the "geographic extent" (calculated area within the survey design depth range) of each IPHC Regulatory Area. It is important to note that this produces relative indices of abundance and biomass, but does not produce an absolute measure of abundance or biomass because it is weight-per-unit-effort scaled by the geographic extent of each IPHC Regulatory Area. These indices are useful for determining trends in stock numbers and biomass, and are also useful to estimate the geographic distribution of the stock.

6.2 USING RELATIVE HARVEST RATES

The distribution of the TCEY for 2018 was shifted from the estimated stock distribution to account for additional factors related to productivity and paucity of data in each IPHC Regulatory Area. Previously, this was accomplished by applying different harvest rates in western areas (16.125% in IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE)) and eastern areas (21.5% in IPHC Regulatory Areas 2A, 2B, 2C, and 3A). However, with the elimination of EBio and the use of SPR-based fishing intensity to determine the coastwide scale, the TCEY, rather than the esoteric concept of exploitable biomass, was distributed. Therefore, an absolute measure of harvest rate is not necessary, but it may still be desired to shift the distribution of the TCEY away from the estimated stock distribution to account for other factors. Consistent with the previous approach, relative harvest rates were used with a ratio of 1.00:0.75, being equal to the ratio between 21.5% and 16.125%. This application shifted the target TCEY distribution away from the stock distribution by moving TCEY into IPHC Regulatory Areas 2A, 2B, 2C, and 3A and removing TCEY from IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE (Table 1), thus harvesting at a higher rate in eastern IPHC Regulatory Areas.

[1] https://iphc.int/the-commission/glossary-of-terms-and-abbreviations

Table 1: IPHC Regulatory Area stock distribution estimated from the 2017 space-time model O32 WPUE, IPHC Regulatory Area-specific relative target harvest rates, and resulting 2018 target TCEY distribution based on the IPHC's 2018 interim management procedure (reproduced from Table 1 in IPHC-2018-AM094-11 Rev_1).

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
O32 stock distribution	1.7%	11.3%	16.6%	35.6%	10.0%	6.6%	4.8%	13.3%	100.0%
Relative harvest rates	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	--
Target TCEY Distribution	1.9%	12.4%	18.2%	38.9%	8.2%	5.4%	3.9%	10.9%	100.0%

6.3 Redefining the Distribution of the TCEY

TCEY distribution is the part of the management procedure for distributing the TCEY among Regulatory Areas and is composed of a purely scientific component to distribute the TCEY in proportion to its estimated biomass in each area (stock distribution) and steps to further modify the distribution of the TCEY based on additional considerations (distribution procedures). Those two components are described below.

6.3.1 Stock Distribution

Emerging understanding of Pacific halibut diversity across the geographic range of the Pacific halibut stock indicates that IPHC Regulatory Areas should only be considered as management units and do not represent relevant sub-populations (Seitz et al. 2017). Balancing the removals against the current stock distribution is likely to protect against localized depletion of spatial and demographic components of the stock that may produce differential recruitment success under changing environmental and ecological conditions. Biological Regions, defined earlier and shown in Figure 2, are considered by the IPHC Secretariat, and supported by the SRB, to be the best current option for biologically-based areas to meet management needs.

The overarching conservation goal for Pacific halibut is to maintain a healthy coastwide stock. However, given the wide geographic range of the Pacific halibut stock, there likely is stock structure that we do not fully understand, and this stock structure may be important to coastwide stock health. Therefore, conservation objectives relate to where harvesting occurs, with an objective to retain viable spawning activity in all portions of the stock. One method for addressing this objective is to distribute the fishing mortality relative to the distribution of observed stock biomass. This requires defining appropriate areas for which the distribution is to be conserved. Splitting the coast into many small areas for conservation objectives can result in complications including being cumbersome to determine if conservation objectives are met, being difficult to accurately determine the proportion of the stock in that area, being subject to inter-annual variability in estimates of the proportion, forcing arbitrary delineation among areas with evidence of strong stock mixing, and not being representative of biological importance. Therefore, Biological Regions represent the most logical scale over which to consider conservation objectives related to distribution of the fishing mortality. Adjusting the distribution of the TCEY among Biological Regions to account for additional considerations, and further distributing the TCEY to IPHC Regulatory Areas would be done through steps defined in the Distribution Procedures component (Figure 1).

In addition to using Biological Regions for stock distribution, the "all sizes" WPUE from the space-time model (Figure 21), which is largely composed of O26 Pacific halibut (due to selectivity of the setline gear), is more congruent with the TCEY (O26 catch levels) than O32 WPUE. Therefore, when distributing the TCEY to Biological Regions, the estimated proportion of "all sizes" WPUE from the space-time model should be used for consistency.

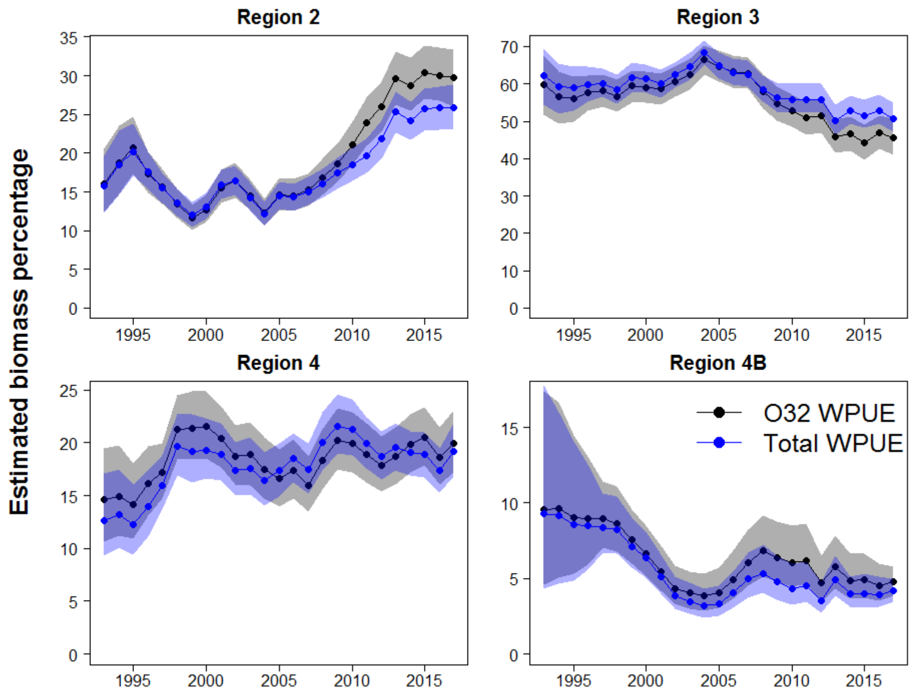

Figure 21: Estimated stock distribution (1993-2017) based on estimate WPUE from the space-time model of O32 (black series) and all sizes (blue series) of Pacific halibut. Shaded zones indicate 95% credible intervals.

6.3.2 Distribution Procedures

Distribution Procedures contains the steps of further modifying the distribution of the TCEY among Biological Regions and then distributing the TCEY among IPHC Regulatory Areas within Biological Regions (Figure 22). Modifications at the Biological Region or IPHC Regulatory Area level may be based on differences in production between areas, observations in each area relative to other areas (e.g., WPUE), uncertainty of data or mortality in each area, defined allocations, or national shares. Data may be used as indicators of stock trends in each Region or IPHC Regulatory Area and are included in the Distribution Procedures component because they may be subject to certain biases and include factors that may be unrelated to biomass in that Biological Region or IPHC Regulatory Area. For example, commercial WPUE is a popular source of data used to indicate trends in a population, but may not always be proportional to biomass. Types of data to be used may include fishery WPUE, survey observations (not necessarily the IPHC fishery-independent setline survey), age-compositions, size-at-age, and environmental observations.

The steps in the Distribution Procedures may consider conservation objectives, but they will mainly be developed with respect to fishery objectives. Yield and stability in catch levels are two important fishery objectives that often contradict each other (i.e. higher yield often results in less stability). Additionally, area-specific fishery objectives may be in conflict across IPHC Regulatory Areas. Pacific halibut catch levels are defined for each IPHC Regulatory Area and quota is accounted for by those Regulatory Areas. Therefore, IPHC Regulatory Areas are the appropriate scale to consider fishery objectives.

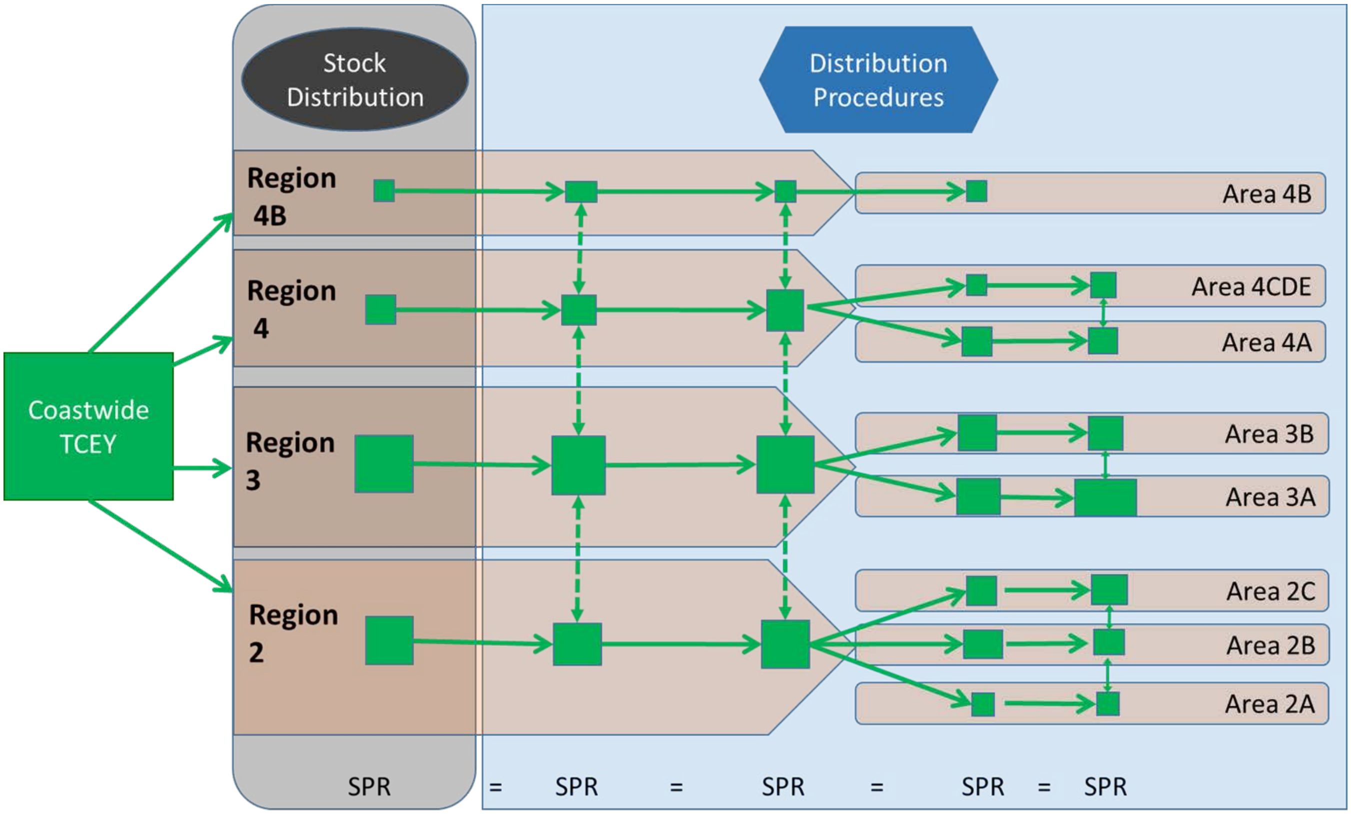

Figure 22: The process of distributing the TCEY to Regulatory Areas from the coastwide TCEY. The first step is to distribute the TCEY to Biological Regions based on the estimate of stock distribution. Following this, a series of adjustments may be made based on observations or social, economic, and other considerations. Finally, the adjusted regional TCEY's are allocated to IPHC Regulatory Areas. The allocation to IPHC Regulatory Areas may occur at any point after regional stock distribution. The dashed arrows represent balancing that is required to maintain a constant coastwide SPR.

6.4 A Summary of the Management Procedure for Distributing TCEY Across the Coast

The harvest strategy policy begins with the coastwide TCEY determined from the stock assessment and fishing intensity determined from a target SPR (Figure 1). When distributing the TCEY among regions, stock distribution occurs first to distribute the harvest in proportion to biomass and satisfy conservation objectives, and then is followed by adjustments across Regions and Regulatory Area based on distribution procedures to further encompass conservation objectives and consider fishery objectives. The key to these adjustments is that they are relative adjustments such that the overall fishing intensity (target SPR) is maintained (i.e., a zero sum game relative to fishing intensity). Otherwise, the procedure is broken, and it is uncertain if the defined objectives will be met.

A framework for a management procedure that ends with the TCEY distributed among IPHC Regulatory Areas and would encompass conservation and fishery objectives is described below.

1. **Coastwide Target Fishing Intensity:** Determine the coastwide total mortality using a target SPR that is most consistent with IPHC objectives defined by the Commission. Separate the total mortality in ≥26 inches (O26) and under 26 inches (U26) components. The O26 component is the coastwide TCEY.
   1.1. Target SPR is scheduled for evaluation at the 2019 Annual Meeting. The current interim target SPR is 46%.
2. **Regional Stock Distribution:** Distribute the coastwide TCEY to four (4) biologically-based Regions using the proportion of the stock estimated in each Biological Region for all sizes of Pacific halibut using information from the IPHC setline survey and the IPHC space-time model.
   2.1. Four Regions (2, 3, 4, and 4B) are defined above (Figure 2).
3. **Regional Allocation Adjustment:** Adjust the distribution of the TCEY among Biological Regions to account for other factors.
   3.1. For example, relative target harvest rates are part of a management/policy decision that may be informed by data and observations. This may include evaluation of recent trends in estimated quantities (such as fishery-independent WPUE), inspection of historical trends in fishing intensity, recent or historical fishery performance, and biological characteristics of the Pacific halibut observed in each Biological Region. The IPHC Secretariat may be able to provide Yield-Per-Recruit (YPR) and/or surplus production calculations as further supplementary information for this discussion. The regional relative harvest rates may also be determined through negotiation, which is simply an allocation agreement for further Regional adjustment of the TCEY.
4. **Regulatory Area Allocation:** Apply IPHC Regulatory Area allocation percentages within each Biological Region to distribute the Region-specific TCEY’s to Regulatory Areas.
   4.1. This part represents a management/policy decision, and may be informed by data, based on past or current observations, or defined by an allocation agreement. For example, recent trends in estimated all sizes WPUE from the setline survey or fishery, age composition, or size composition may be used to distribute the TCEY to IPHC Regulatory Areas. Inspection of historical trends in fishing intensity or catches by IPHC Regulatory Area may also be used. Finally, agreed upon percentages are also an option. This allocation to IPHC Regulatory Areas may be a procedure with multiple adjustments using different data, observations, or agreements

The four steps described above would be contained within the IPHC Harvest Strategy Policy as part of the Management Procedure and are pre-determined steps that have a predictable outcome. The decision-making process would then occur (Figure 1).

5. **Seasonal Regulatory Area Adjustment**: Adjust individual Regulatory Area TCEY limits to account for other factors as needed. This is the policy part of the harvest strategy policy and occurs as a final step where other objectives are considered (e.g. economic, social, etc.).
   5.1. Departing from the target SPR may be a desired outcome for a particular year (short-term, tactical decision making based on current trends estimated in the stock assessment) but would deviate from the management procedure and the long-term management objectives. Departures from the management procedure may result in unpredictable outcomes but could also take advantage of current situations.

7 WORK PLAN

This Program of Work (IPHC-2018-MSAB011-10) is a description of activities related to the MSE and the Management Strategy Advisory Board (MSAB) that the IPHC Secretariat will engage in for the next five years. It describes each of the priority tasks, lists some of the resources needed for each task, and provides a timeline for each task. However, this work plan is flexible and may be changed throughout this period with the guidance of the MSAB, Science Review Board (SRB) members, and Commission. The order of the tasks in this work plan represents the sequential development of each task, and many subsequent tasks are dependent on the previous tasks.

7.1 MANAGEMENT STRATEGY EVALUATION (MSE)

Management Strategy Evaluation (MSE) is a process to evaluate alternative management strategies. This process involves the following

1. defining fishery goals and objectives with the involvement of stakeholders and managers,
2. identifying management procedures to evaluate,
3. simulating a halibut population with those management procedures,
4. evaluating and presenting the results in a way that examines trade-offs,
5. applying a chosen management procedure, and
6. repeating this process in the future in case of changes in objectives, assumptions, or expectations.

Figure 23 shows these different components and that the process is not necessarily a sequential process, but there may be movement back and forth between components as learning progresses. The involvement of stakeholders and managers in every component of the process is extremely important to guide the MSE and evaluate the outcomes.

7.2 BACKGROUND

Many important tasks have been completed or started and much of the work proposed will use past accomplishments to further the Management Strategy Evaluation (MSE) process. The past accomplishments include:

1. Familiarization with the MSE process.
2. Defining goals for the halibut fishery and management.
3. Developing objectives and performance metrics from those goals.
4. Development of an interactive tool (the Shiny application).
5. Discussions about coast-wide (single-area) and spatial (multiple-area) models.
6. Presentation of preliminary results investigating fishing intensity.
7. Discussions of ideas for distributing the TCEY to Regulatory Areas.

Management Strategy Evaluation is a process that can develop over many years with many iterations. It is also a process that needs monitoring and adjustments to make sure that management procedures are performing adequately. Therefore, the MSE work for Pacific halibut fisheries will be ongoing as new objectives are addressed, more complex models are built, and results are updated. This time will include continued consultation with stakeholders and managers via the MSAB meetings, defining and refining goals and objectives, developing and coding models, running simulations, reporting results, and making decisions. Along the way, there will be useful outcomes that may be used to improve existing management and will influence recommendations for future work.

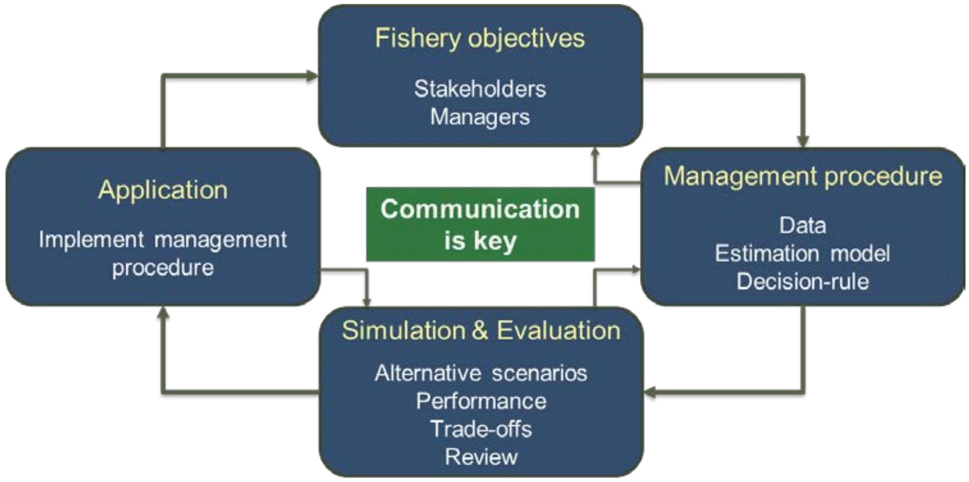

Figure 23: A depiction of the Management Strategy Evaluation (MSE) process showing the iterative nature of the process with the possibility of moving either direction between most components.

A detailed program of work has been developed for the next two years, with results for decision-making being presented to the Commission at the Annual Meetings in 2019 and 2021 (Table 2). More specifically, an evaluation of "Scale" (coastwide fishing intensity and the harvest control rule) will be presented at AM095 in January 2019. An evaluation of the entire harvest strategy depicted in Figure 1 (Scale and Distribution) will be completed in late 2020 and presented to the Commission for decision-making at AM097 in January 2021.

The evaluations delivered at AM097 will shape the IPHC harvest policy, but other aspects will become of interest and MSE work will continue afterwards.

Table 2: Timeline for MSE work in 2018–21.

May 2018 MSAB Meeting
Review Goals
Look at results of SPR
Review Performance Metrics
Identify Scale MP's
Review Framework
Identify Preliminary Distribution MP's
October 2018 MSAB Meeting
Review Goals
Complete results of SPR
Review Performance Metrics
Identify Scale MP'S
Verify Framework
Identify Distribution MP's
Annual Meeting 2019
Recommendation on Scale Present possible distribution MP’s
May 2019 MSAB Meeting
Review Goals
Spatial Model Complexity
Identify MP's (Distn Scale)
Review Framework
October 2019 MSAB Meeting
Review Goals
Spatial Model Complexity
Identify MP's (Distn Scale)
Review Framework
Review multi-area model development
Annual Meeting 2020
Update on progress
May 2020 MSAB Meeting
Review Goals
Review multi-area model
Review preliminary results
October 2020 MSAB Meeting
Review Goals
Review preliminary results
Annual Meeting 2021
Presentation of first complete MSE product to the Commission Recommendations on Scale and Distribution MP

MSE TASKS FOR THE NEXT 5 YEARS

Task 1. Verify that goals are still relevant and further define objectives.

Task 2. Develop performance metrics to evaluate objectives.

Task 3. Identify realistic management procedures of interest to evaluate with a closed-loop simulation framework. This includes management procedures related to coastwide scale (e.g., SPR) and to distributing the TCEY.

Task 4. Design a closed-loop simulation framework and code a computer program to extend the current simulation framework.

Task 5. Develop educational and visualization tools that will engage stakeholders and Commissioners, as well as facilitate communication and evaluation.

Task 6. Further the development of operating models to include multiple areas and structural uncertainty.

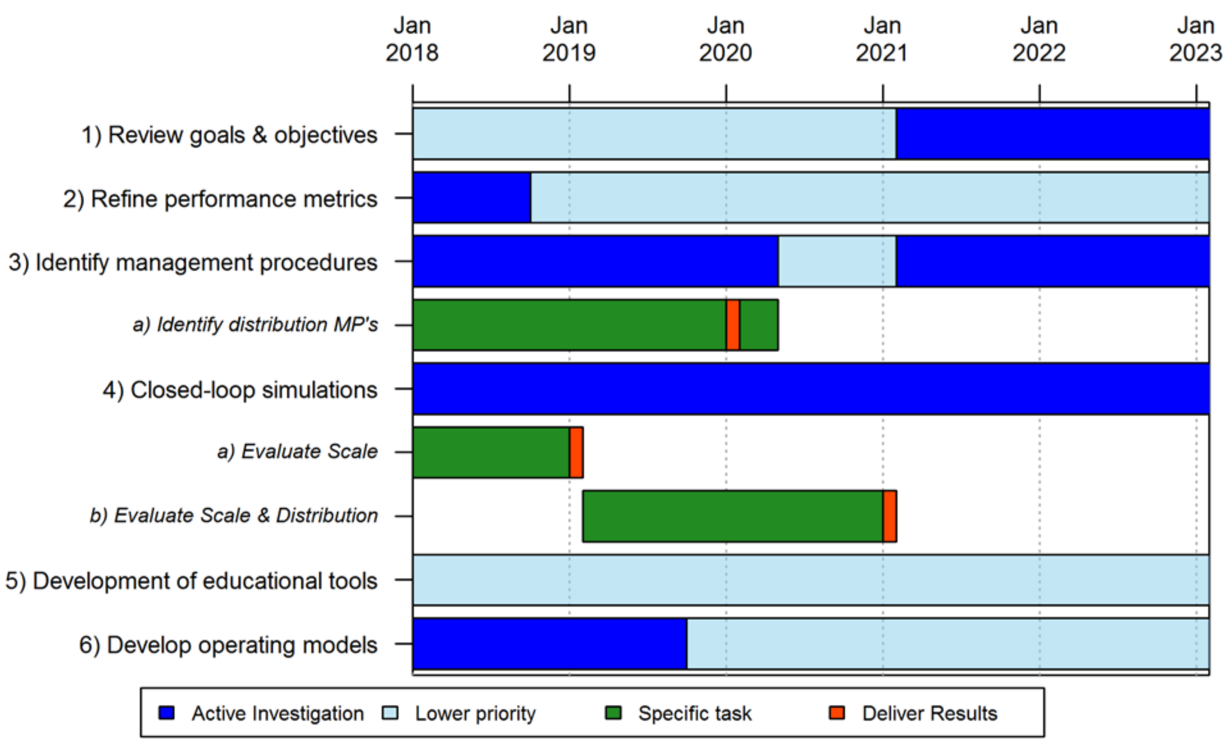

Figure 24: Gantt chart for the five-year work plan. Tasks are listed as rows. Dark blue indicates when the major portion of the main tasks work will be done. Light blue indicates when preliminary or continuing work on the main tasks will be done. Dark green indicates when the work on specific sub-topics will be done. The orange color shows when results will be presented at an Annual Meeting.

8 RECOMMENDATION

That the SRB:

1) **NOTE** paper IPHC-2018-SRB013-06 which provides the SRB with a preliminary update on MSE-related activities of the IPHC Secretariat in 2018.
2) **NOTE** the goal and objectives currently being refined by the MSAB.
3) **NOTE** the simulation framework and improvements to the simulation framework
4) **RECOMMEND** any additional improvements to the simulation framework. Improvements explained in this document included the following.
    a. A prior on steepness developed from the long coastwide model, that was used when conditioning the short coastwide model.
    b. Rejecting simulations with a maximum exploitation rate greater than 0.4 to avoid cases of quasi-extinction.
    c. Modifying the allocation of total mortality procedure to make bycatch mortality increase with increasing total biomass.
    d. Modifying the allocation of total mortality procedure to make recreational mortality a constant proportion with variability on the proportion.
    e. Future improvements that will be described at SRB013, including autocorrelation in estimation error and commercial selectivity a function of weight-at-age.
5) **NOTE** the results of simulating forward in time with no fishing and the influence of weight-at-age and recruitment regimes.
6) **NOTE** the distribution frame-work and the separation of scientific and management elements of distribution procedures.
7) **RECOMMEND** modifications that may improve the TCEY distribution framework and which components the MSAB should consider when developing management procedures to evaluate.
8) **NOTE** the five-year workplan and the timeline for deliverables in 2019 and 2021.

9 APPENDICES

I. Goals, measurable objectives, and intent (From IPHC-2018-MSAB011-07)

APPENDIX I: GOALS, MEASURABLE OBJECTIVES, AND INTENT (FROM IPHC-2018-MSAB011-07)

Table A1: Objectives for the biological sustainability goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Biological Sustainability	1.1. Keep biomass above a **limit** below which no fishing can occur	a) Maintain a minimum number ***[spawning potential ratio]*** of mature female Pacific halibut coast-wide	0.99	Each year	• Ensure that conservation needs of the stock are met for long-term sustainability with a high degree of certainty • Regularly monitor stock biomass (i.e. continuation and improvement of survey and stock assessment efforts) to detect changes in status and abundance • **Define reference points and harvest targets (e.g. MSY)** • Take a risk-averse approach when the stock is below the threshold
		b) 2) Maintain a minimum spawning stock biomass of 20% of the unfished biomass	0.95	Each year	
	1.2. Account for all sizes in the population?	*c)*			
	1.3. Reduce harvest rate when abundance is below a threshold	d) Maintain a minimum spawning stock biomass of 30% of the unfished biomass	0.75	Each year	
	1.4. Risk tolerance and assessment uncertainty	e) When Limit < estimate biomass < Threshold, limit the probability of declines	0.05 – 0.5, depending on est. stock status	10 years	

Table A2: Objectives for the fishery sustainability goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Fishery Sustainability and Stability and Assurance of Access – Minimize Probability of Fishery Closures	2.1. Maintain an economically sufficient level of catch (i.e., target) across regulatory areas	a) Maintain directed fishing opportunity	0.95	Each year	• Ensure that the directed fishery has viable fishing opportunities every year • Provide directed fisheries that are economically beneficial to individual participants, local businesses, and broader communities • Support efforts to allow continued access to the halibut resource within acceptable conservation limits
		b) Maximize [Optimize?] yield in each regulatory area	0.5	Each year	
		c) Maintain median catch within ±10% of 1993-2012 average	?	Within 5 yrs	
		d) Maintain average catch at > 70% of historical 1993-2012 average	0.9	Each year	
	2.2. Limit catch variability	e) Limit annual changes in TAC, coast-wide and/or by Regulatory Area, to < 15%		Each year	

Table A3: Objectives for the minimize wastage goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Minimize Discard Mortality	3.1. Harvest efficiency	a) Discard mortality in the longline fishery < 10% of annual catch limit	0.75	Over 5 years	• Support fishing practices that reduce discard mortality • Regulatory revisions that promote efficiency

Table A4: Objectives for the minimize bycatch goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Minimize Bycatch and Bycatch Mortality	4.1.	a)		Over 5 years	• Support fishing practices that reduce bycatch and bycatch mortality