Pacific halibut stock assessment development for 2017

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PURPOSE

To provide the Scientific Review Board (SRB) an overview of proposed improvements related to the stock assessment data and reporting of results for the 2017-2018 annual process.

TCEY-BASED MANAGEMENT

At the 2017 Annual Meeting (AM093), the Commission requested the Secretariat provide a framework for making management decisions (i.e., setting catch limits) based on the Total Constant Exploitation Yield (TCEY; all removals over 26" (66 cm) in length) rather than the Fishery Constant Exploitation Yield (FCEY) as has been recent practice.

Although this request represents a substantial conceptual challenge for those accustomed to historical processes, it will not change the contents or calculation of catch tables. Since 2014, the catch tables providing the breakout of Regulatory Area-specific removals by source have included all individual components in the TCEY, as well as projected U26 mortality (e.g. Table 1). Relative harvest rates among Regulatory Areas (for use in harvest policy calculations) have always been calculated based on the TCEY (Stewart 2017b); therefore, this change in focus should make interpretation of those rates much simpler, as the rates will be calculated directly from the catch limit, not as a complicated function of the catch limit (including wastage rates and non-FCEY components).

It will be important during the decision-making process (Annual Meeting, AM) to make the detailed results of alternative TCEYs available for consideration. This has already been standard practice for FCEY-based catch limits, with many alternatives produced during the AM for the Conference Board, Processors Advisory Board and Commissioners. In the future, a web-based tool could be constructed that would allow real-time evaluation of catch table alternatives by any and all stakeholders.

A TCEY-based approach is likely to particularly emphasize potential instances where insufficient TCEY is available to cover all projected removals. If there is insufficient TCEY available in a particular Regulatory Area (or Region; see paper IPHC-2017-SRB-10-10) to cover all projected removals (after the FCEY has been reduced to 0), the remaining reduction would be spread among other regions in proportion to the stock distribution in order to meet match the total target TCEY, as has been done for alternative rows in previous year's decision table results.

TABLE 1. Projected mortality associated with adopted FCEY catch limits for 2017. Table was produced during AM093, 27 January 2017.

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
O26 Non-FCEY									
Comm. wastage	0.05	0.23	NA	NA	0.23	0.05	0.06	0.08	0.69
Bycatch	0.10	0.24	0.03	1.17	0.58	0.34	0.14	1.98	4.57
Sport (+ wastage)	NA	NA	1.33	1.56	0.01	0.01	0.00	0.00	2.91
Pers./Subs.	NA	0.41	0.43	0.23	0.02	0.01	0.00	0.08	1.17
Total Non-FCEY	0.14	0.87	1.79	2.96	0.84	0.41	0.20	2.14	9.34
O26 FCEY									
Comm. wastage	NA	NA	0.12	0.37	NA	NA	NA	NA	0.49
CSP Sport (+wastage)	0.53	1.15	0.92	1.89	NA	NA	NA	NA	4.49
Pers./Subs.	0.03	NA	NA	NA	NA	NA	NA	NA	0.03
Comm. Landings	0.77	6.30	4.21	7.74	3.14	1.39	1.14	1.70	26.39
Total FCEY	1.33	7.45	5.25	10.00	3.14	1.39	1.14	1.70	31.40
TCEY	1.47	8.32	7.04	12.96	3.98	1.80	1.34	3.84	40.74
U26									
Comm. wastage	0.00	0.00	0.00	0.01	0.03	0.01	0.00	0.00	0.07
Bycatch	0.00	0.02	0.00	0.62	0.29	0.23	0.01	1.27	2.44
Total U26	0.00	0.02	0.00	0.63	0.33	0.24	0.01	1.27	2.51
Total Mortality	1.48	8.35	7.04	13.60	4.30	2.04	1.35	5.11	43.25

DATA SOURCE DEVELOPMENT

Measured individual fish weights

The IPHC has relied on a standard length-weight relationship for decades to infer individual fish weight from length measurements (Clark 1991). Recent data collection from the landed catch and sampling at-sea has revealed some systematic differences between observed individual weights and weights predicted from the length-weight relationship (Webster and Erikson 2017, Webster et al. 2016). During 2016, all fish sampled for length and age during IPHC port sampling were also weighed (Erikson and Kong 2017). To improve estimates of average individual weight reported for use in the stock assessment and for catch-weighting of age-frequency data (Stewart 2017a), it is proposed that the 2017 stock assessment and supporting analyses use the measured weight for all samples where it is available instead of the predicted weight.

A similar approach may be possible for fish caught by the IPHC's fishery-independent setline survey if/when weights are collected on a routine basis. A pilot project in ongoing to better understand the quality of and variability in at-sea weights as well as to measure the effects of shrinkage in the hold during the fishing trip through longitudinal sampling of individual fish (Planas 2017).

Fishery independent setline survey time-series extension to include 1995-1997.

The extension of the space-time (geospatial) model for setline survey analysis to include 1995-1997 is anticipated to be available for the 2017 stock assessment and stock distribution analyses. Further extension to include additional historical years could be considered, but because of differences in survey standardization (i.e. the bait used) this may require a separate modelling exercise. Therefore, it may be most pragmatic to retain the older historical series in their current form (naïve average catch-rates) and allow variability in survey catchability and selectivity (already included in the assessment models) to capture this source of variability. Focus of modelling efforts could then be placed on including covariates and other improvements to the recent time-series (see paper IPHC-2017-SRB10-05).

Continued investigation of historical bycatch estimates and length-frequency data

It has been IPHC practice to correct previous years bycatch mortality estimates, once observed fishery data become available (generally 3-6 months after the end of the year). This process is similar to the calculation of Discard Mortality Rates (DMRs) by the National Marine Fisheries Service (NMFS) for use in the catch-accounting system; however, it uses observed viabilities by fishery from the year being estimated, rather than values predicted for use in in-season management based on previous data. Although the differences in final bycatch estimates are generally small, they can be systematic, as was the case for decreasing DMRs in the freezer-longliner fishery for Pacific cod over the last decade (e.g., Williams 2014, Williams 2016).

A database table has been created at the IPHC to store the catch and biological data obtained annually from the NMFS Observer Program. Use of this table will allow re-evaluation and documentation of the aggregation methods for these analyses as well as automation of the process in the future. It will also allow estimates to be re-created as needed, rather than estimated once and stored only as derived information in perpetuity.

Length-frequency data by Regulatory Area has historically been summarized by the IPHC on an *ad hoc* basis. We currently use a time-series consisting of aggregate estimates with little to no meta-data and likely differing methods of aggregation in different years (e.g., catch weighted, raw length-frequencies, projected values from incomplete data, etc.). These data are currently used in the stock assessment model to inform the selectivity curve describing bycatch removals, but are down-weighted due to these concerns over standardization (Stewart and Martell 2016). Ongoing efforts in 2017 and moving forward will include: 1) identifying raw data sets suitable for inclusion, 2) re-estimating length-frequency distributions using standardized methods for all available years, 3) recording meta-data and results such that they can be recreated if changes to the analysis approach are desired in the future, and 4) updating the stock assessment model inputs to reflect the best available series, potentially increasing the weight on these data, while allowing for an appropriate degree of temporal variability in selectivity to reflect differences among areas, fishing fleets and other factors.

Biological data from setline survey expansion stations

It became evident during 2017 that the biological data (ages and lengths) from expansion stations sampled by the IPHC's fishery independent setline survey had not been included in the summaries produced for the annual stock assessment. This was due to the use of alternative values in the database table indicating the purpose of each set as part of the standardized grid, or alternative projects. Although these data represent a relatively small fraction of the total available (approximately 10% over the first few years of expansion), their omission is inconsistent with the use of a trend index from the space-time (geospatial) model that includes predictions at all of the expansion stations.

For the 2017 stock assessment analyses, these data will be added, and the results evaluated at the October SRB meeting. Since the setline survey selectivity is already parameterized to include a modest amount of temporal variability (Stewart and Martell 2016), no change will be necessary to the model structure to accommodate these additional data.

Future efforts could include application of an approach to standardize the age-compositions in a space-time (geospatial) model, such that abundance weighting would be fully logically consistent with the spatial trend information. This is an avenue of ongoing inquiry that will be addressed in the planned Center for Advancement of Population Assessment Modelling (CAPAM) meeting in February 2018. IPHC collaboration on supporting research for this conference is underway.

Effective skate calculations

Recent research comprising a portion of Cole Monnahan’s PhD thesis (University of Washington, defense scheduled for 9 June 2017) has re-evaluated the hook-spacing/power relationship used to standardize commercial Pacific halibut fishery logbook records (Monnahan and Stewart 2015). Pending scientific review, a published hook-spacing correction derived from logbook records and compared with original experimental observations (Hamley and Skud 1978) may soon be available. The IPHC may consider updating the formula used in its databases for calculating the number of effective skates for the commercial fishery data (Stewart 2017a).

Although this improved estimate is not identical to the *status quo* relationship, the likely effect on current analysis methods is small. Future evaluation, once the approach has been published, will determine exactly how this change could be applied.

Consideration of model-based Catch-Per-Unit-Effort (CPUE) indices

As has been discussed for several years, the calculation of commercial Pacific halibut fishery CPUE is currently very simple, treating each set with a logbook record as an independent replicate within a Regulatory Area (Stewart 2017a). Further, because fishing power is estimated to differ among fixed snap and autoline gear, only fixed gear is included in the standardization for areas 2C-4CDE. Recently completed work by Cole Monnahan (University of Washington, defense scheduled for 9 June 2017), following on an initial analysis in 2015 (Monnahan and Stewart 2015), suggests that after accounting for spatial processes, it may be possible to include all gear types in a model-base standardization. This would allow for the inclusion of approximately 22% of the data that is currently unused in the fixed-gear only calculations. Although preliminary work did not suggest large differences in trends among areas based on the larger data set (Monnahan and Stewart 2015), it would be very desirable from the fishery’s perspective to include all possible logbook records in stock assessment analyses. Further, if the Management Strategy Evaluation (MSE) compares the use of commercial CPUE-based harvest control rule or distribution approaches, standardization of these data could be particularly important.

A space-time (geospatial) model could be developed for use in standardizing these data similar to that used for the setline survey. However, an important difference between the datasets is the spatial distribution of the observations, particularly the nonrandom nature of fishery data. Recent work has explored methods to extend space-time (geospatial) models to account for fishery targeting of increased CPUE (Diggle 2010, Thorson et al. 2016).

Another alternative to a fully model-based standardization is to use the coefficients estimated for snap, fixed, and autoline gear to 'calibrate' the data prior to standardization, but retain a simple mean and variance approach within each area. The benefit of this method would be increased simplicity and transparency for the commercial fishery, while still including more of the information. However, the spatial effects would be unaccounted for and could contribute to bias in the time series, and an underestimate of the variance (Cole Monnahan, pending PhD thesis). This topic remains an open discussion.

Reporting of 2A CPUE

During the 2016-2017 annual process there was a considerable interest in better understanding the CPUE trend information and estimation approach for Regulatory Area 2A. The IPHC responded with a delineation of tribal and non-tribal catch rates, identifying significantly differing recent trends in each. This exploration revealed the potential importance of how these two pieces of information are weighted, both for presentation and use is assessment-related analyses (See Appendix A for comparisons). Currently, there is no explicit weighting, as the CPUE is calculated via the sum of catch and sum of effort in reported logbooks (Stewart 2017a), so if reporting rates differ between the tribal and non-tribal fisheries the trend may be affected.

There are several potential avenues for improving the use and reporting of these data:

1) Continue using the *status quo* approach, but acknowledge the differing sources of trend information (example figure in Appendix A).
2) Revise the CPUE approach to be catch-weighted rather than area-weighted, which would allow for easy stratification of these (tribal and non-tribal) components (and potentially others in other Regulatory Areas).
3) Move toward a spatial model for CPUE (similar to that used for survey data) and following the methods of Monnahan et al. (In review).

MODEL CODE UPDATE

Recent Pacific halibut stock assessment models have used stock synthesis (Methot Jr and Wetzel 2013) version 3.24u. For the features that are currently included in these models there are no identified bugs that have required updating the IPHC's application to a newer version. However, a more recent release of Stock Synthesis is now available (3.30.03.07 as of 22 May, 2017). This version is just recently ungraded from a Beta version, and has been subject to a considerable amount of updating during the last year. The first bug-fixes to the non-Beta version were released within the first week. It is anticipated that several NMFS stock assessments will be based on this new version later in 2017. For efficiency, both the MSE and stock assessment development for the 2017-2018 IPHC annual process will be conducted in version 3.24u, with the expectation that version 3.3 will be stable enough to allow both efforts to use the newer code for the 2018-2019 process.

This change will allow exploration of some newer features that may be of particular interest to the Pacific halibut assessment, specifically: alternative error distributions for age-composition data, more flexibility in the treatment of constraints on time-varying processes, age-based discard and retention schedules, as well as others. These changes are likely to be evaluated for the June 2018 SRB meeting.

ADDITIONAL DEVELOPMENT AVENUES

Model weighting methods

Following on several years of analysis of alternative methods for weighting the component models included in the IPHC's stock assessment ensemble, three primary approaches have been identified: 1) weighting based on relative fit to the coastwide setline survey index of abundance, 2) weighting based on the predictive skill of each model relative to the terminal survey index observation, and 3) weighting based on retrospective performance over recent terminal spawning biomass estimates (these were last discussed in detail at the June 2016 SRB-8). Weights based on both of these approaches were compared in June 2016, with neither suggesting appreciably different weighting than the *status quo* approach of equal weighting of each of the four models. At that time, no formal change was made to the weighting approach, but it was recognized that these alternative weights should be routinely compared.

A manuscript reporting the approach for both types of weighting is in preparation. These alternative weights will be produced again for evaluation at the September 2017 SRB meeting. As long as the results continue to be generally consistent with equal weighting, there is no pressing need for a change in methodology; however, if/when additional models are added to the ensemble and/or performance-based approaches suggest differing model weights this topic may need to be revisited.

Bayesian integration

There have been several recent developments toward alternative Markov Chain Monte-Carlo (MCMC) search algorithms implemented in Automatic Differentiation Model Builder (ADMB; Monnahan et al. 2016), which is the underlying code for the stock synthesis model. In addition to these new tools, research into approaches for regularization, adding informative priors and/or reducing complexity to improve performance, has also moved forward, using the short coastwide model as one of a set of examples (Cole Monnahan, pending PhD Thesis). This work, in concert with some of the options available in the new stock synthesis version (see section above) may provide avenues for improved efficiency in implementing Pacific halibut models in a fully Bayesian framework. Preliminary results suggested similar stock size estimates even after regularizing for more efficient Bayesian integration. This continues to be an avenue for future work, as true probability distributions (rather than asymptotic approximations) would be desirable for calculating probabilistic management results.

Spatial model development

During 2016 there was a substantial amount of review during SRB08 and SRB09 of the initial work toward creating a spatially explicit Pacific halibut model. That effort focused on fitting to various disaggregated datasets at the regional level, including the NMFS trawl survey data from Alaska which has not been included in coastwide models to date. Based on model performance and SRB guidance on those efforts, spatial model development has been refocused toward creating a spatial framework for MSE development that emphasizes hypothesis testing over statistical fitting for tactical management use. Based on the priorities identified by the Management Strategy Advisory Board for 2017 and 2018, further development of the spatially explicit model has been put on hold until coastwide objectives have been addressed by that process.

SUMMARY

Much of the assessment focus during 2017 has been on harvest strategy policy related analyses. However, continued refinement of the data sources feeding in to the stock assessment models, the harvest strategy policy analyses, and the management structure remains a priority. A number of improvements have been evaluated, with progress on most and several likely to be completed during the 2017-18 management cycle (Table 2).

TABLE 2. Summary of improvements.

Improvement	Rationale	Timeline
TCEY-based management	Requested by commissioners; more transparent comparison of catch limits among Regulatory Areas.	To be discussed at the 2017 September Work Meeting, IM, and 2018 AM.
Measured individual fish weights	Data suggest systematic differences in observed vs. predicted weights from the standard length-weight relationship. Port data now include individual weights for all biological samples.	Data to be included in the 2017 stock assessment analyses.
Setline survey model-based time-series extension	Data from 1995-1997 are available for several Regulatory Areas for use in the space-time model	These data will be included in 2017 stock assessment analyses
Historical bycatch data	Re-analysis of historical data needed to reconcile observed DMRs and ensure length-frequency data have been summarized consistently.	As much of this time-series will be updated for the 2017 stock assessment analyses as is possible.
Biological data from setline survey expansion stations	Additional data from expansion stations are available for use in stock assessment analyses.	Data and effects on model results will be evaluated at the October 2017 SRB meeting
Effective skate calculations	A revised hook-power relationship may be published in 2017.	Pending final review of these results, the revised relationship may be included in the IPHC's standard database calculations
Model-based CPUE estimates	Spatial models offer a reasonable approach to improve existing standardization methods and include a greater proportion of logbook data available.	Continued evaluation of revised methods is planned for 2018.
Reporting of 2A CPUE	Important differences between trends in tribal and non-tribal catch-rates in Regulatory Area 2A have been identified	Clearer delineation of this information is planned for the 2017 process. CPUE standardization methods development may improve this inconsistency.
Model code update	Current stock synthesis version still being tested.	Anticipated update in 2018.
Model weighting methods	Weighting approaches are important in determining ensemble results.	Evaluation of alternative methods will be continued; publication of these approaches is planned.
Bayesian integration	Better represents probability distributions for management use.	Ongoing.
Spatial model development	This level of model complexity will be required in order to evaluate some MSE objectives.	Continued development is planned for 2018.

RECOMMENDATION/S

That the SRB:

1) **NOTE** paper IPHC-2017-SRB10-07 which provided an overview of proposed improvements related to the stock assessment data and reporting of results for the 2017-2018 annual process.
2) **RECOMMEND** any modifications or additions to this proposal for the 2017-18 annual management process, and any extensions for future processes.

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APPENDICES

<u>Appendix A</u>: Comparison of tribal and non-tribal CPUE trends.

APPENDIX A

Figures illustrating differing trends for tribal and non-tribal data in Area 2A.

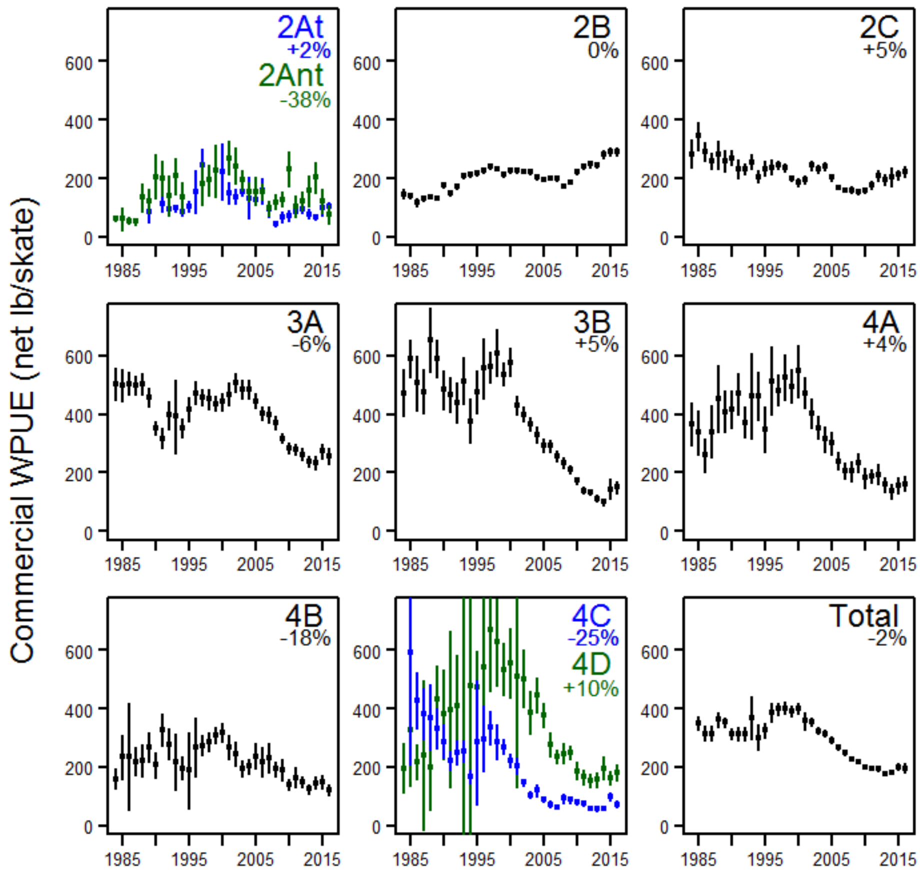

Figure A1. Commercial WPUE including separated tribal (2At, blue) and non-tribal (2Ant, green) time series in Area 2A. Percentages indicate the change from 2015-2016; vertical bars an approximate 95% confidence interval based only on between-set variability. Other Areas are presented for comparison of the level of variability.

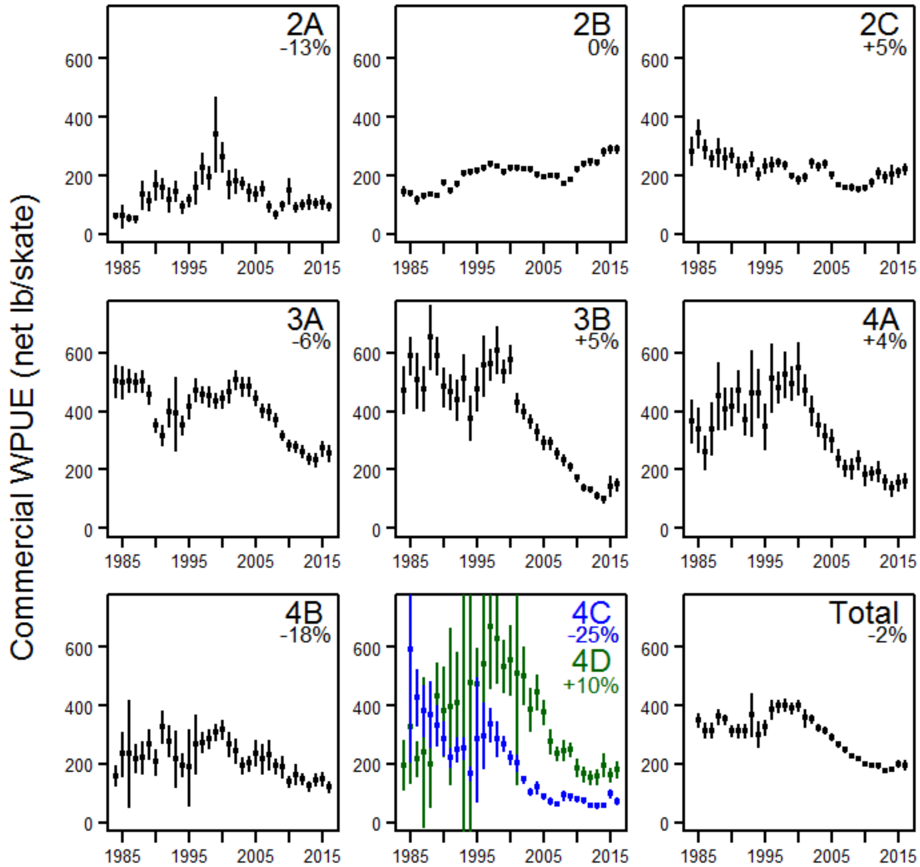

Figure A2. Commercial WPUE including aggregated tribal and non-tribal time series in Area 2A. Percentages indicate the change from 2015-2016; vertical bars an approximate 95% confidence interval based only on between-set variability. Other Areas are presented for comparison of the level of variability.