SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON
STOCK ASSESSMENT PLAN AND TERMS OF REFERENCE (TOR) – FINAL ACTION

The Scientific and Statistical Committee (SSC) discussed Agenda Item F.2, Stock Assessment Plan and Terms of Reference (TOR) – Final Action.  Dr. James Hastie (National Marine Fisheries Service - Northwest Fisheries Science Center) presented the Northwest Fisheries Science Center groundfish stock assessment priorities, including data availability for species under consideration for 2021 and 2023 stock assessments, and a proposed schedule of 2021 Stock Assessment Review (STAR) panels.  Dr. John Budrick provided an overview of the implications of endorsement of the length-based data-moderate stock assessment methodology by the review panel as well as other considerations for stock assessment prioritization and review of the TOR.

Should the Council adopt the length-based methods for use in management at the September Council meeting, they would be applicable to 2021 assessments allowing assessment of an additional two to four species.  The SSC discussed making revisions and finalizing the data-moderate stock assessment section of the TOR (see the appended SSC Groundfish Subcommittee report) prior to the September Council meeting where review of the methods by the SSC and potential adoption is anticipated to take place.  These assessments would be subject to more streamlined documentation requirements than full assessments and would be reviewed by the SSC's Groundfish Subcommittee.  While these data-moderate assessments may conserve STAR capacity for review, these assessments will require additional effort from stock assessors and reviewers, especially in the first application of these methods.

The SSC is concerned with the capacity for stock assessment modeling and ageing capacity, as well as the capacity to review stock assessments, given the ongoing productivity impacts due to continuing dispersed work environments and the COVID-19 pandemic.  While the Northwest and Southwest Fisheries Science Centers and state agencies work together to produce as many stock assessments as possible, the SSC requests that the Council prioritize stock assessments within each stock assessment category (full, data-moderate, and update).  Prioritization is further necessary because many nearshore species have high levels of geographic population structure, thus requiring independent stock assessment models for each region with additional workload for authors and reviewers.

The SSC recommends holding three STAR panels, and one SSC Groundfish Subcommittee review of data-moderate stock assessments during the 2021 assessment cycle.  A STAR panel held in May 2021 could be reviewed during the June 2021 Council meeting.  The remaining two STAR panels could be held during June to July 2021 and reviewed during the September 2021 Council meeting.  Holding more than three STAR Panels is not feasible given the increased workload associated with region-specific models for more demographically complex species (i.e., lingcod, vermilion rockfish, brown rockfish, and copper rockfish), competing workload from new data-moderate assessments, and the productivity impacts of the pandemic.  The mop-up panel will be scheduled during the end of September 2021.

The SSC recommends full stock assessments for vermilion/sunset rockfish, Dover sole, and lingcod. Vermilion/sunset rockfish will have three to four modeled areas and lingcod will have two to three modeled areas, thus requiring increased stock assessment modeling capacity compared to single area assessments like Dover sole. The SSC recommends data-moderate assessments in the following priority order: spiny dogfish, copper rockfish, brown rockfish, and, if stock assessment modeling capacity allows, squarespot rockfish. Copper rockfish will have two to three modeled areas, and brown rockfish may have multiple modeled areas. The SSC recommends conducting an update stock assessment for sablefish during 2021.

In addition to the species presented by Dr. Hastie as the subject of prospective assessments in 2023, the SSC identified additional stocks for consideration to facilitate prioritization of data collection before reconsideration of priorities in 2022. Redbanded rockfish was identified as a potential candidate for a full assessment. Cowcod, canary rockfish, and greenspotted rockfish were identified as potential candidates for update assessments. Treefish, olive rockfish, and speckled rockfish were identified as additional potential candidates for length-based data-moderate stock assessments.

The SSC endorses the final draft of the TOR for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process for 2021-2022, with a correction to Appendix A that changes the current text that reads a "CPS catch-only projection review for the central subpopulation of northern anchovy" to a "CPS STAR Panel review of a full assessment for the central subpopulation of northern anchovy". Additionally, the SSC will review and finalize the revised data-moderate stock assessment TOR language prior to the September Council meeting.

The SSC endorses the final draft of the terms of reference for the Methodology Review Process for Groundfish and Coastal Pelagic Species for 2021-2022, and final recommendations on TOR for the Groundfish Rebuilding Analysis for 2021-2022.


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A stock assessment methodology review for length-based data-moderate stock assessments was held via webinar on May 12 to 14. The review focused on the application of Stock Synthesis incorporating catch and length data (SS-CL) as well as incorporating indices from research surveys (SS-CL-Index), which were both endorsed by the panel. The draft proposed language for the Terms of Reference (TOR) for length-based methods reflects the findings of the methodology review and suggestions from the panel. This language should be amended given feedback at the June Council meeting. If the Council adopts them for use in management after the full SSC and Council review under the Methodology Review agenda item at the September 2020 Council meeting, the proposed language should be incorporated into the TOR for 2021 stock assessments to facilitate application of the proposed methods. Adoption of length-based assessment methods will have implications for the species selected for assessment, the assessment methods applied to a given stock and the review process for 2021.

The panel review identified the following research to inform guidance in the TOR.
- The time lag between reproduction and recruitment of fish to the survey or fishery from which lengths are obtained may affect the ability to resolve recent recruitment and the potential for bias or increased uncertainty as is the case for any model estimating recruitment. Additional research would help inform which data sources might be most amenable to analysis.
- A formalized ensemble process is needed to integrate results from multiple model runs, and, once developed, the process should be included in the TOR.
- Length-based selectivity curves are constrained to being asymptotic for at least one fleet to allow estimation of natural mortality, despite a lack of evidence from the data that the selectivity is in fact asymptotic, which is also the case for full assessments. Evaluation of dome-shaped curves for one or more of fleets should be the subject of future research that provides guidance on modeling selectivity.
- Considerations around modeling of discards should be identified. The question remains whether discards should be added to catches, as well as whether to add discarded lengths to retained compositions and adjust selectivity.

The following sections of the TOR for Stock Assessments (Agenda Item F.2, Attachment 3, June 2020) would be amended as noted in track changes below to incorporate length-based assessment methods:

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**4. Data-moderate assessment**: A continuum of **"data-moderate assessment"** methods exist between data-poor methods relying on catch data alone to fully integrated stock assessments incorporating all available data including up to date age data. Council-approved methods for data-moderate assessments are limited in that they do not use age data, even if available, and have simplified population dynamics (deterministic recruitment), which makes such assessments less complicated and enables more expeditious review. Two methods have been developed to conduct data-moderate assessment with historical catch data and one or more indices of abundance (or biomass) (e.g., survey data or fishery catch per unit effort (CPUE) indices) referred to as extended DB-SRA (XDB-SRA) using stand-alone programming and extended Simple Stock

Synthesis (XSSS) using Stock Synthesis. In addition, length-based data-moderate stock assessment methods have been developed that incorporate only catch and length data in Stock Synthesis (SS-CL). Methods incorporating catches, lengths, and indices of relative abundance from fishery-independent surveys in Stock Synthesis have also been adopted by the Council for use in management (SS-CL+Index). Methods using length data do have the potential to estimate recruitment, thus adding more dynamics and complexity to the assessment and the review. Data-moderate assessments are reviewed by the relevant SSC Subcommittee (Groundfish or CPS) if an approved standard methodology is proposed to be used. They are reviewed by a STAR panel if a new or non-standard assessment methodology is proposed to be used.

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## 9. Data-Moderate Assessments for Groundfish Species

Data-moderate assessments for groundfish species are a refinement over data-poor methods that result in category 3 assessments (described below) in that a data-moderate assessment includes length and/or abundance trend information in addition to the data informing a data-poor form of the assessment (catch series plus prior information on productivity and status). Data-moderate assessments can result in category 2 (catch and length or catch and index) or category 1 designations (possible when catches, lengths, and index data are incorporated). One defining distinction between category 2 and category 3 assessments is that the length and/or abundance trend information is incorporated in a category 2 assessment enabling an estimate of stock status (Appendix F).

Two index-based data-moderate assessment methods have been endorsed since the 2013-14 assessment cycle, XDB-SRA and XSSS. In both cases, abundance trend information (e.g., survey or fishery CPUE indices) is included in the assessment. The length-based data-moderate assessment method using only catches and lengths is SS-CL, while SS-CL+Index uses catches, lengths, and indices of abundance from fishery-independent surveys for which index derivation is well established. A flowchart describing the specific steps to take in conducting these assessments is provided in Appendix J. These specific applications provide assessments that are well understood enough to require only review by the SSC Groundfish Subcommittee. More complex data-moderate assessments within the SS framework incorporating fishery-dependent indices of abundance or use of age data are also possible and require review by a STAR panel review to address the added complexities of model fitting and index development.

The continuum of models should be accommodated to allow combinations of catch, lengths, ages and, indices to be applied to both new assessments and length-based extensions of existing benchmark assessments, though review processes may differ. A categorization of each assessment method is provided in Table 2, which defines the scope of each method in terms of data source and assessment type. The flow chart in Appendix J includes how to prepare catch estimates, length data, parameter estimation, model weighting, model convergence, and characterize uncertainty. The SS-CL+Index assessment method includes fishery-independent indices of abundance for which index development methods are well established. Implementation of assessments within the provided specifications allows for standardization and more streamlined review by the SSC Groundfish Subcommittee in May or June of odd years along with update assessments. The depth of potential reviews should increase with the estimation of more parameters. Review of one or more of length-based models that use an approved standard methodology can still be reviewed

within a STAR Panel setting, though Groundfish Subcommittee review is generally sufficient. Intermediate methods using fishery-dependent indices or age data are subject to review at a STAR panel to allow further evaluation of model fitting and tensions between data sources (see Table 2 for categorization of assessment types). Assessments conducted with data-moderate methods may be category 2 or category 1 depending on whether only catch and length or catch and index data were used resulting in a category 2 assessment or if catch, length and index data were used, which can result in a category 1 assessment.

Intermediate assessments picking up where past full stock assessments left off, that exclude new age and/or index data, but maintain index or age data included in the previous assessment while adding length and catch data are subject to STAR panel review. These types of intermediate methods may be applied to stocks that were formerly assessed with a full benchmark assessment, but for which attainment has been low or conducting a full or update assessment is not a priority despite the assessment becoming dated. Addition of new age data to either type of length-based Stock Synthesis assessment is discouraged to avoid confounding the nature of the assessment, reducing model tension arising from potential conflicts in age and length data, and increasing clarity in the related review process. Due to the complexities and potential data conflicts that can occur from fitting to age data in combination with indices and lengths, assessments that include current age data should be considered full benchmark assessments and reviewed in STAR panels.

Table 2. Model types, their data types and assessment type. All assume a known catch history.

| Model | Lengths | Ages | Index | Assessment Type |
|---|---|---|---|---|
| DB-SRA/SSS | Ignore | Ignore | Ignore | Data-limited |
| XDB-SRA/XSS | Ignore | Ignore | Use | Data-moderate |
| SS-CL[1] | Use | Ignore | Ignore | Data-moderate |
| SS-CL+Index | Use | Ignore | Fishery-independent indices only (e.g., WCGBTS, H&L) | Data-moderate |
| SS (new config[2])-lite | Use | Ignore | Use | Likely Benchmark |
| SS (old config[3]) | Use / update? | Use new / Ignore unread | Use / update? | Update |
| SS (new config[2])-heavy | Perhaps new data sources | Perhaps new data sources / Ignore unread | Perhaps new data sources | Benchmark |

1: Flow chart for specifications related to fleets, life history parameters, selectivity etc.
2: New specifications for how the assessment is configured
3: Model specifications the same as the last assessment

*Index-based Methods*
The index-based method XSSS assumes that recruitment is related deterministically to the stock-recruitment relationship and allows index data to be used within a Bayesian framework. The Markov chain Monte Carlo (MCMC) or Sample Importance Resample (SIR) algorithm (perhaps implemented using Adaptive Importance Sampling) is used to quantify uncertainty for XSSS-based assessments. The XDB-SRA method is implemented within a Bayesian framework, with the priors for the parameters updated based on index data. The additional parameters in XDB-

SRA compared with DB-SRA include the catchability coefficient ($q$), and the extent of observation variance additional to that inferred from sampling error ($a$). The priors for these parameters are a weakly informative log-normal and a uniform distribution, respectively.

Comparison of alternative methods (XDB-SRA and XSSS) is encouraged, but it is acceptable to present an assessment using a single modeling approach. The SSC Groundfish Subcommittee can make requests of the STATs for additional runs but should not impose an alternative method if STATs consider this is not appropriate for the stock concerned. If more than one model is presented, the SSC Groundfish Subcommittee should recommend adoption of a preferred model, if one can be identified, for use in management.

*Length-based Methods*
Applying SS-CL and SS-CL-Index is very similar to conducting a standard Stock Synthesis (SS) assessment since SS-CL is conducted in Stock Synthesis, and all equations for the model can be found in the SS documentation (Appendix A of Methot and Wetzel, 2013). Like SS, the data for these methods can include many fleets, sexes, etc. as desired, catches are a full time series and assumed known and length compositions are assumed to be representative, with effective sample size treated in standard ways. Life history values (i.e., steepness, growth parameters ($k$, $L_\infty$, $t_0$), natural mortality, fecundity, maturity) are initially pre-specified (some degree of this does happen in many standard SS models), but estimation of some values may be possible. Recruitment can be estimated, and standard bias correction procedures are applied. Selectivity can is also typically estimated and can be fixed. If multiple fleets have length composition data, data weighting approaches would follow standard procedures as outlined in Appendix B Section H. The starter and forecast files are specified as in traditional SS assessments. The performance and stability of SS-CL was better with smaller model dimensions (e.g., fewer fleets) and is sensitive to errors in the fixed values for $L_\infty$ and the coefficient of variation (CV) of length-at-age, which, if fixed, should be explored in sensitivity analyses.

The limited scope of SS-CL and SS-CL+Index allow for more limited documentation requirements, described in Appendix E. For more complex intermediate models beyond the scope of these focused methods, reporting requirements should be developed in an assessment-specific TOR developed by the Chair of the STAR panel to provide flexibility to cover the range of possible applications, while still providing appropriate specificity and thorough evaluation. The reviews are expected to take between a half day and two days depending on the number, type, and novelty of the assessments. It may be beneficial to hold a half day preliminary review during a virtual meeting prior the Groundfish Subcommittee at which the review will be conducted. The number of SS-CL or SS-CL+Index assessments that can be conducted at a given STAR panel or the Groundfish Subcommittee of the SSC in combination with update assessments, depends on the complexity of the models, spatial areas, and novelty of the methods. Between two and four assessments in a review may be reasonable, and flexibility should be provided to the SSC in determining how many assessments should be reviewed and the process for each review.

The critical modeling steps for SS-CL and SS-CL+Index are included in the methodology step flow chart in Appendix J in addition to the following guidance. Jittering and alternative phasing should be used given the difficulties encountered by the analysts during this review finding the global minimum of the objective function. If there is dimorphic growth, then sex-specific

information should be included. Fleet consolidation is recommended if selectivity is similar among sectors or surveys to reduce model conflict and confounding affects. If a survey is included in an SS-CL+Index assessment, the length-composition from that survey should also be included, as well as length-composition from other fishery-independent or fishery-dependent data sources. Application of dome-shaped selectivity should be investigated when plausible, in addition to asymptotic selectivity. It is recommended that the model be run with asymptotic selectivity for at least one fleet if natural mortality is being estimated. Simplifying model structure and spatial areas will reduce complexity in the assessments and workload in both the analysis and review.

References
Methot, R.D. and C.R. Wetzel. 2013. Stock Synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research* 142: 86-99.

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**Appendix E: Template for a Data-Moderate or Data-Poor Assessment Document**

1. Title page and list of preparers – the names and affiliations of the stock assessment team (STAT).
2. Introduction: Scientific name, distribution, basic biology (growth, longevity, ecology), the basis for the choice of stock unit(s) (no more than 1-2 paragraphs).
3. Development of indices (used and rejected). Novel approaches should be fully documented.
4. Treatment of length composition data (weighting, addressing discards, etc.).
5. Survey of other data available for assessment: data available to inform indices of abundance, sample sizes by year and source of lengths, and ages (read and unread)--in case there is interest in conducting a full assessment in the future.
6. Selection of method: length-based (SS-CL), index-based (XSSS or XDB-SRA; authors are "encouraged" to do both) or hybrid method (SS-CL+Index).
7. Assessment model
   a. Specification of priors / production function (defaults are acceptable)
   b. Initial runs using catch-only methods (DB-SRA or SSS (or both))
   c. Diagnostics
      i. Evaluation of convergence
      ii. Residual plots
      iii. Posterior predictive intervals (if Bayesian)
      iv. Time-trajectories of biomass, depletion, etc.
      v. Sensitivity analyses using alternative catch streams, alternative priors for depletion, etc.
7. Estimates of OFL (median of the distribution), and
8. Estimates of stock status where applicable.

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**Appendix J: Flow chart for SS-CL**
- **Take the following steps in completing an SS-CL assessment: Prepare catch data**
- Catch treated as known. Use total mortality (landings + dead discards).
  - **Prepare length composition**

o Determine length bins and frequency within bins across years. More than 10 years of data (with reasonable sample sizes) is recommended. Otherwise it is a category 3 assessment.
o This can be done for as many fleets as needed, but use the parsimony principle to define fleets, as model convergence may be more difficult with more fleets.
o Female, male, and unknown data can be used.
o Determine effective sample sizes following standard protocol.
o Combine length data from landings and discards (or reasonable assumptions for the latter if no data) appropriately.

- **Define life history parameters**
o Natural Mortality: define using estimators (e.g., Hamel method (must include as a sensitivity at least, if an estimate of longevity/maximum age is available), Natural Mortality Tool (which includes the Hamel method)). Fix to central tendency (median value) and retain uncertainty for sensitivity analyses.
o Growth parameters. Externally fit the von Bertalanffy growth function and use point estimates to fix in model. Choose a fixed valued for CV at length. Retain uncertainty for sensitivity analyses.
o Steepness defined either through meta-analysis or expert opinion. Retain uncertainty for sensitivity analyses.
o Recruitment variability also defined through meta-analysis or expert opinion. Retain uncertainty for sensitivity analyses.
o Life history parameters will generally be pre-specified, but consideration could be given to estimating these parameters (see Section 1.5.3).

- **Parameter estimation**
o Estimate $R_0$, recruitment deviations and selectivity parameters.
o Life history parameters if likelihood profiles show information.
o Selectivity can be logistic, dome-shaped, or whatever form in chosen in SS.
o Bias correction to recruitment deviations can subsequently be applied.

- **Model weighting**
o Consider weighting the length compositions if multiple fleets.

- **Model convergence**
o Length-only models may take additional jittering to find convergence and avoid local likelihood minima.
o Check model fits to length compositions.
o Determine whether selectivity shapes make sense.
o Review other parameters estimates for bounds and poor estimation (and whether they are reasonable).

- **Characterize uncertainty**
o Likelihood profile over, at minimum, $M$, $L_2$ (preferably parameterized as $L_\infty$, though can also make the transformation for reporting) and $k$ (retain correlation structure if possible), CV at length, and $h$.
o Sensitivity analysis should be conducted, either based on likelihood profile information or identified model specification.
o Ensemble modeling to quantify model specification error would be useful. This would need further discussion on how best to approach it.