CCIEA Team Report on FEP Initiative 4

July 22, 2024

1. Introduction

The development of catch advice should be based on best scientific information available, which includes climate and ecosystem science. Stock assessment models can be developed in a way that implicitly or explicitly incorporates environmental conditions as they relate to the stock, but this is not always possible due to limits in data availability, constraints on the structure of stock assessment models, and staff capacity. Therefore, an alternative framework to incorporate climate and ecosystem conditions into catch advice is needed to include pertinent conditions affecting stock productivity, which are not incorporated directly into the assessment, in the setting of acceptable biological catch (ABC) buffers. The North Pacific Fishery Management Council (NPFMC) has developed and implemented a process for their Council to address this gap. Specifically, the NPFMC uses "risk tables" that provide a standardized framework to document ecosystem and climate factors potentially affecting stock productivity and uncertainty or other concerns arising from the stock assessment (Dorn and Zador 2020). The risk tables are developed for individual stocks and provide a tool for determining whether additional catch buffers (i.e., reduction below the maximum ABC) may be needed based on potential risk of exceeding the overfishing limit (OFL; Dorn and Zador 2020). Because the process for setting the ABC differs in the Pacific Fishery Management Council (PFMC) region, an alternative framework is needed. Here, we describe the development of risk tables that share a similar function as the NPFMC's risk tables, but are tailored for the PFMC's groundfish harvest specification process.

1.1 Timeline of risk table development

In September 2023, the SSC Ecosystem Subcommittee (SSC-ES) and SSC Groundfish Subcommittee (SSC-GS) reviewed the Ecosystem Workgroup's (EWG) approach for developing an ecosystem evaluation rubric and pilot risk tables for two groundfish species, sablefish

(*Anoplopoma fimbria*) and petrale sole (*Eopsetta jordani*), in support of the Fishery Ecosystem Plan's Initiative 4: Ecosystem and Climate Information for Species, Fisheries, and Fishery Management Plans (Agenda Item F.1.a EWG Report 1 September 2023). The SSC subcommittees were supportive of the risk table approach proposed by the EWG and made a number of useful recommendations for improving the risk table methodology and connecting them to management decisions (SSC-ES/GS November 2023 report on FEP Initiative 4).

At the March 2024 Council meeting, the California Current Integrated Ecosystem Assessment (CCIEA) team, with support from the EWG, proposed that Science Center ecosystem and stock assessment scientists (1) refine the risk table approach and pilot sablefish and petrale sole tables based on the SSC-ES and SSC-GS feedback, (2) generate examples of how the risk tables could inform groundfish management through the multiple pathways identified by the subcommittees, and (3) present new developments to the SSC-ES for review prior to the September 2024 Council meeting (Agenda Item H.1.a Supplemental CCIEA Team Report 3). The SSC identified this topic as a priority to review in the summer of 2024 (Agenda Item H.1.b Supplemental SSC Report 1 March 2024).

In addition, in its March 2024 Decision Summary, the Council directed the EWG to work with National Marine Fisheries Service Science Center staff to further develop the methodological framework for risk tables and apply it to groundfish, and to broaden the development of risk table methodology to include Sacramento River and Klamath River salmon stocks, as described in Agenda Item H.2.a, Supplemental HC Report 1. The Council also endorsed SSC review of this topic in summer 2024 and a report back to the Council at the September 2024 PFMC meeting.

In this document, the CCIEA team presents: (1) potential pathways for translating risk tables into management advice, (2) a revised evaluation rubric, (3) a process for filling out stock-specific risk tables, (4) a retrospective analysis of sensitivity of harvest specifications to redeveloped sablefish and petrale risk tables, and (5) future steps.

2. Potential pathways for translating risk tables into management advice

In September 2023, the SSC-ES recommended four potential pathways for incorporating risk tables into the setting of groundfish ABCs within the PFMC. They were to incorporate the information into: (1) the selection of scientific uncertainty (sigma) by the SSC when an assessment is conducted, (2) the selection of the risk policy (P*) set by the Council, (3) the setting of either/both sigma or P* in between new stock assessments (e.g., the time-varying penalty on sigma), or (4) developing a different process for the SSC to set the ABC directly and using the risk table to inform that decision. Sigma is defined as the width of the uncertainty bounds around the OFL distribution (representing the ratio of the difference between "true" OFL and the model-derived OFL relative to the “true” OFL). For this iteration of risk table development we focused on the three potential pathways that are possible in the current PFMC harvest specifications process (options 1-3). The CCIEA team recommends moving forward with the sigma pathway (option 1) but is also open to discussing and pursuing the other pathways.

2.1 Option 1: Informing scientific uncertainty (sigma) when an assessment is conducted

Scientific uncertainty is incorporated into the PFMC catch-level setting process through the setting of the value of sigma by the SSC. The current approach is for the SSC to assign one of three categories to each stock assessment. As described in the Groundfish Stock Assessment Terms of Reference (Appendix D), Category 1 is used for the most robust assessments and corresponds to a sigma value of 0.5. Category 2 is generally used for assessments that use data-moderate approaches and corresponds to a sigma value of 1.0, and Category 3 is used for data-limited assessments and corresponds to a sigma value of 2.0. Note that while there are subcategories in Appendix D (e.g., category 1c), only the major categories are currently used for setting sigma. The sigma value of 0.5 for Category 1 stocks was informed by a meta-analysis of between-assessment uncertainty in OFL projections from 18 assessments of seven groundfish species (Privitera-Johnson and Punt 2020). Sigma also has a time-varying component such that the value of sigma increases with the number of years since the last assessment was conducted. The rate at which sigma increases is based on an analysis of the performance of advice from past stock assessments (Wetzel and Hamel 2023) and is incorporated into forecasts as the staleness penalty *r*.

Using a risk table approach to inform sigma would build on the existing framework used by the SSC. We propose that risk tables could modify the table in Appendix D from the Groundfish Stock Assessment Terms of Reference, and provide an extended set of criteria for the SSC to select from a wider array of potential values for sigma when an assessment is adopted. Greater uncertainty leads to larger values for sigma and less uncertainty leads to smaller values. This ability to incorporate positive, neutral, and negative adjustments makes sigma a flexible target in the PFMC harvest specification process.

2.2 Option 2: Informing the Council’s risk policy (P*)

In contrast to the sigma pathway, using a risk table to inform P* in the current system may be more challenging because the upper limit on P* of 0.45 is specified in the groundfish FMP, and is already a commonly chosen value. Therefore, though risk table information could be incorporated via P* to reflect both favorable and unfavorable conditions, the ability to reflect favorable conditions is constrained. If PFMC wanted to develop a P* pathway in the future, only the environmental and ecosystem categories in a risk table would be applied (if they were not used to set sigma), to avoid double-counting of risk or uncertainty. The assessment-related columns should not be used because they would have already been used in the SSC’s selection of sigma. In a P* pathway, a column on fishery performance could be added to more explicitly translate conditions in the fishery that may influence the Council’s selection of its risk tolerance (P*) as proposed in Chan et al. (2022). For example, the NPFMC includes a fishery performance column in their risk tables that include considerations such as market conditions or CPUE trends that were not well captured by the assessment model. However, social scientists at the Science Centers have advised caution in considering the addition of a fishery performance, because it is not clear in what direction fishery considerations should affect catch advice. Specifically, identifying high community reliance on and/or engagement with a fishery could be treated as an argument for either taking a more risk-averse approach, because the consequences of overfishing would be high, or for taking a more risk-tolerant approach, because greater catch reductions will adversely impact communities in the short term. Note that fishery considerations are likely not relevant for specifying uncertainty in the biological capacity of the population to sustain exploitation, which makes them less applicable to the sigma pathway.

2.3 Option 3: Informing the time-varying penalty on sigma

We also discussed the potential to use a risk table approach to influence sigma levels set in between assessments or as part of the time-varying penalty on sigma. This could be done by adopting a different rate of increase in sigma based on the information in the table, or by adjusting the penalty with step-changes every biennium if new information becomes available. After discussing the options we do not recommend adjusting the rates due to the extra complexity and potential confusion this could create with category 2 buffers becoming smaller than category 1 buffers through time in some cases (Figure 1). If capacity existed to update the environmental and ecosystem column of a risk table in between assessments, it would be more straightforward to adjust the base sigma level used for the projections based on environmental and ecosystem conditions. This may require doing a catch-only or catch-climate projection.

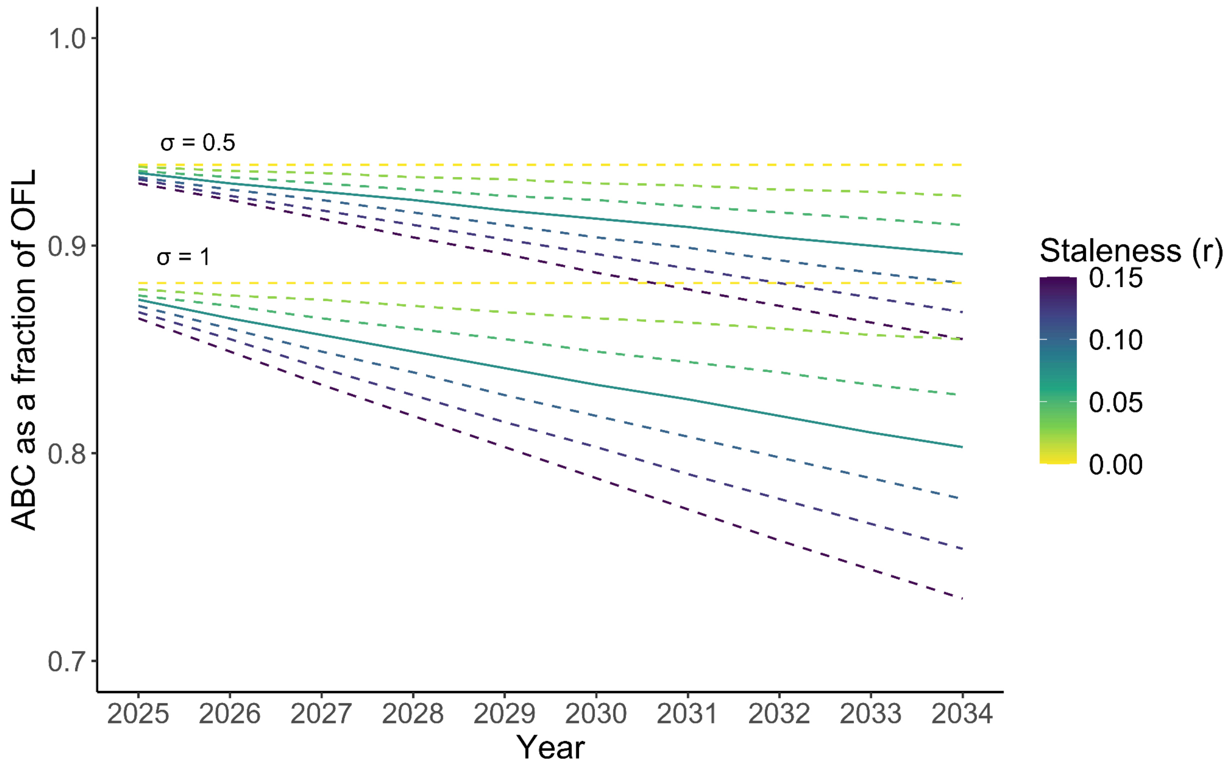

Figure 1. Changes in the size of the buffer between ABC and OFL, measured as a fraction of OFL, for Category 1 stocks (sigma = 0.5) and Category 2 stocks (sigma = 1) over time for a range of values of stock assessment time-varying adjustment to sigma via a rate of change parameter *r*. The current default value of *r*, 0.075, is indicated with a solid line. Possible alternative values are indicated with a dashed line. Yellow indicates the smallest values of *r* shown here (least precautionary), while purple indicates the largest values of *r* (most precautionary).

2.4 Other potential pathways

The EWG previously explored the possibility of using a risk table approach within the stock assessment prioritization. This pathway is also still plausible but it would only affect the species rankings in the assessment prioritization, and would not influence the ABC buffers. The existing framework for assessment prioritization could be expanded to include more indicators of ecosystem conditions relevant to particular stocks. This would not necessarily require a full risk table to be developed, but rather would involve including some factors from the ecosystem and environmental considerations column of the table into the stock assessment prioritization algorithm. However, one limitation of this approach is that many of the ecological indicators available to us (e.g., in the annual Ecosystem Status Reports) are best viewed as pointing at overall ecosystem productivity that impacts multiple species simultaneously, for instance as influenced via a heat wave, El Niño, or productive phase of the Pacific Decadal Oscillation. In such cases, the relative ranking (prioritization) of individual stocks may not change, even if there is an indication of absolute changes (good or bad) in ocean conditions that affect a large suite of species. Moreover, the influence of additional indicators to the prioritization algorithm ultimately depends on the weights assigned to those indicators, so the potential for the algorithm to be adaptive to climate and ecosystem conditions may be limited unless those components are assigned higher weights.

3. Sensitivity of ABC buffers to sigma and P*

Although we recommend using risk tables to adjust sigma rather than P*, both sigma and P* interact to determine the overall size of the buffer between the OFL and the ABC. We therefore explored how the size of the buffer between the OFL and the ABC responded to plausible ranges of P* and sigma over the 10-year projection period from 2025 to 2034. We explored a range of sigmas from 0.25 to 0.75 for category 1 stocks (default sigma = 0.5). The lower limit for this range was chosen because it is halfway between the default sigma for category 1 stocks and category 2 stocks, and the upper limit was chosen because it is halfway between the default sigma for category 2 stocks and category 3 stocks (default sigma = 2). We explored a P* range from 0.5 (50% chance of overfishing) to 0.25 (the lowest value used by other regional Councils; Free et al. 2022) (Table 1). Note that values of P* above 0.45 are not currently allowed under the groundfish FMP; these values are indicated with dashed line in line graphs and with transparent overlays in heatmaps. Figures throughout the rest of this report use a color scale from yellow to purple in which yellows indicate more risk-tolerant values (lower sigmas, higher P*s, smaller buffers, and larger ABCs) and purples indicate more risk-averse values (higher sigmas, lower P*s, larger buffers, and smaller ABCs).

Generally, the range of P* values we explored in this analysis produced greater differences in ACL than did the range of sigma values we explored. This is because the default choice of P* (0.45) limits the impact of changes in sigma, as noted in the SSC-ES/GS November 2023 report on FEP Initiative 4. At the default P* value of 0.45, selecting the lowest value of sigma we evaluated here (sigma = 0.25) resulted in an ABC that was 96.7% of the OFL in the first projection year and 94.7% of the OFL in the final projection year. At the highest sigma value we used (sigma = 1.5), with default P*, the buffer resulted in an ABC of 81.7% of the OFL in the first projection year and 71.9% in the final year (Figure 2A). Since this final year buffer size is larger than the buffer for category 3 stocks under a P* of 0.45, and the buffer for a category 2 stock cannot exceed the default category 3 buffer, the 2034 would be capped at 77.8% of OFL. At the default sigma value of 0.5 for category 1 stocks, selecting a P* of 0.45 resulted in an ABC that was 93.5% of the OFL in the first projection year and 89.6% of the OFL in the final year. At this default sigma value, selecting a P* of 0.25 (the lowest evaluated here) resulted in an ABC that was 69.6% of the OFL in the first projection year and 55.4% of the OFL in the final year (Figure 2B). Panels C and D of Figure 2 indicate projected ABC as a fraction of OFL for all combinations of sigma and P* in 2025 and 2034, respectively.

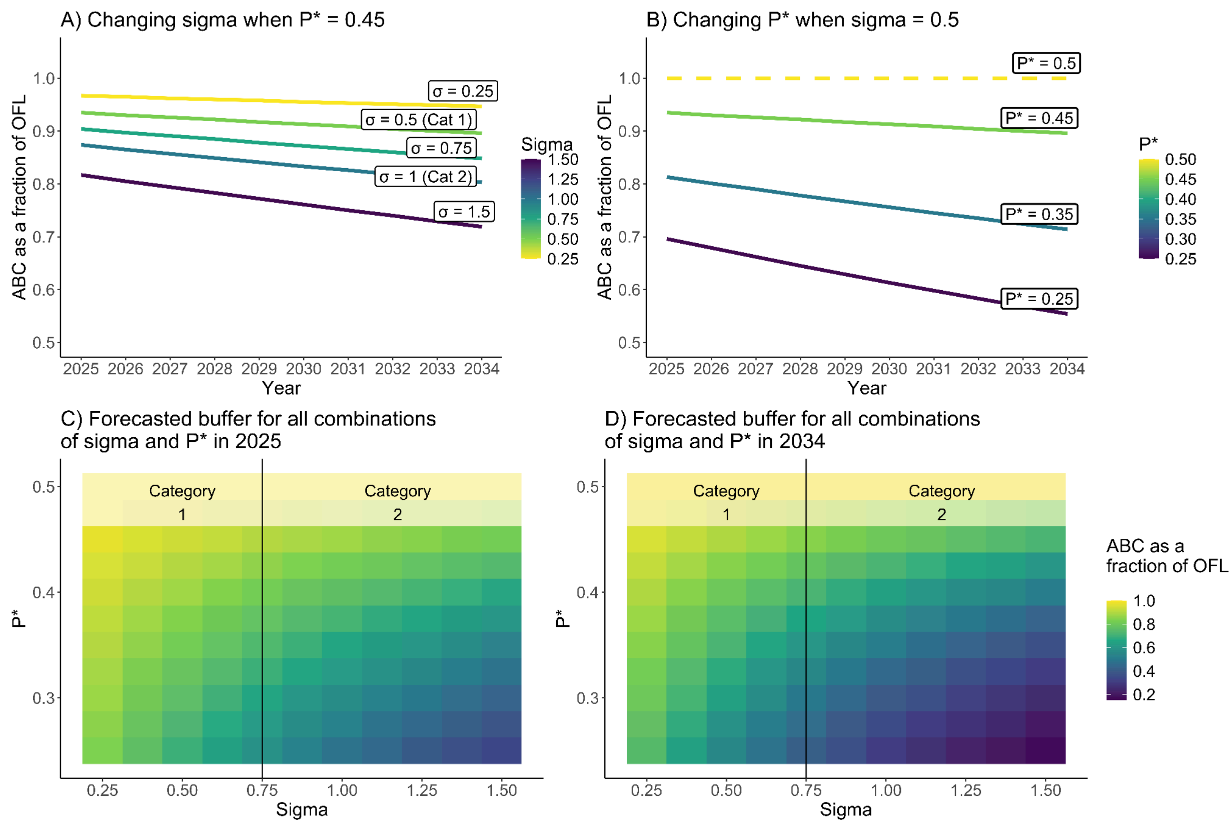

Figure 2. Changes in Acceptable Biological Catch (ABC) calculated as a fraction of the overfishing limit (OFL) across a range of reasonable values of sigma and P*. Panel A varies sigma with the PFMC's default P* value of 0.45. Panel B varies P* with the default sigma value of 0.5 for category 1 stocks. Panels C and D show the ABC for all combinations of P* and sigma in 2025 (the beginning of the projection period) and 2034 (the end of the 10-year projection period), respectively (note that the *y*-axes do not begin at zero in order to better communicate differences across the feasible range of P*s and sigmas). Yellows indicate more risk-tolerant values (lower sigmas, higher P*s, smaller buffers, and larger ABCs) and purples indicate more risk-averse values (higher sigmas, lower P*s, larger buffers, and smaller ABCs). Values of P* that are not currently legal under the groundfish FMP are indicated with dashed lines and transparent overlays in heatmaps.

Table 1. ABC as a fraction of OFL for values of sigma ranging from 0.25 to 1.5 and values of P* ranging from 0.25 to 0.5 for the 10-year projection period. Note that P*s above 0.45 are not permissible under the current groundfish FMP and a P* value of 0.5 is not legal under the Magnuson-Stevens Act.

		Sigma					
P*	**Year**	**0.25**	**0.5**	**0.75**	**1**	**1.25**	**1.5**
0.25	**2025**	0.834	0.696	0.581	0.484	0.404	0.337
	2026	0.824	0.679	0.559	0.46	0.379	0.312

	2027	0.813	0.662	0.538	0.438	0.356	0.29
	2028	0.803	0.645	0.518	0.416	0.334	0.268
	2029	0.793	0.629	0.499	0.396	0.314	0.249
	2030	0.783	0.613	0.48	0.376	0.294	0.231
	2031	0.773	0.598	0.462	0.358	0.276	0.214
	2032	0.764	0.583	0.445	0.34	0.26	0.198
	2033	0.754	0.568	0.429	0.323	0.244	0.184
	2034	0.744	0.554	0.413	0.307	0.229	0.17
0.3	**2025**	0.869	0.754	0.655	0.569	0.494	0.429
	2026	0.86	0.74	0.636	0.547	0.471	0.405
	2027	0.852	0.725	0.618	0.526	0.448	0.382
	2028	0.843	0.711	0.6	0.506	0.426	0.36
	2029	0.835	0.697	0.582	0.486	0.406	0.339
	2030	0.827	0.684	0.565	0.467	0.387	0.32
	2031	0.819	0.67	0.549	0.449	0.368	0.301
	2032	0.811	0.657	0.533	0.432	0.35	0.284
	2033	0.803	0.645	0.517	0.415	0.334	0.268
	2034	0.795	0.632	0.502	0.399	0.318	0.252
0.35	**2025**	0.902	0.813	0.733	0.661	0.596	0.537
	2026	0.895	0.801	0.717	0.642	0.575	0.514
	2027	0.889	0.79	0.702	0.624	0.554	0.493
	2028	0.882	0.778	0.687	0.606	0.535	0.472
	2029	0.876	0.767	0.672	0.589	0.516	0.452
	2030	0.87	0.756	0.658	0.572	0.497	0.433
	2031	0.863	0.745	0.644	0.556	0.48	0.414
	2032	0.857	0.735	0.63	0.54	0.463	0.397
	2033	0.851	0.724	0.616	0.524	0.446	0.38
	2034	0.845	0.714	0.603	0.51	0.43	0.364
0.4	**2025**	0.934	0.873	0.815	0.762	0.711	0.665
	2026	0.93	0.864	0.804	0.747	0.695	0.646
	2027	0.925	0.856	0.792	0.733	0.678	0.628
	2028	0.921	0.848	0.781	0.719	0.663	0.61
	2029	0.917	0.84	0.77	0.706	0.647	0.593
	2030	0.912	0.832	0.759	0.693	0.632	0.576
	2031	0.908	0.824	0.748	0.68	0.617	0.56
	2032	0.904	0.817	0.738	0.667	0.602	0.544
	2033	0.899	0.809	0.727	0.654	0.588	0.529
	2034	0.895	0.801	0.717	0.642	0.575	0.514
0.45	**2025**	0.967	0.935	0.904	0.874	0.845	0.817

	2026	0.965	0.93	0.897	0.865	0.835	0.805
	2027	0.962	0.926	0.891	0.857	0.825	0.794
	2028	0.96	0.922	0.885	0.849	0.815	0.783
	2029	0.958	0.917	0.878	0.841	0.806	0.772
	2030	0.955	0.913	0.872	0.833	0.796	0.761
	2031	0.953	0.909	0.866	0.826	0.787	0.75
	2032	0.951	0.904	0.86	0.818	0.778	0.74
	2033	0.949	0.9	0.854	0.81	0.769	0.729
	2034	0.947	0.896	0.848	0.803	0.76	0.719
0.5	**2025**	1	1	1	1	1	1
	2026	1	1	1	1	1	1
	2027	1	1	1	1	1	1
	2028	1	1	1	1	1	1
	2029	1	1	1	1	1	1
	2030	1	1	1	1	1	1
	2031	1	1	1	1	1	1
	2032	1	1	1	1	1	1
	2033	1	1	1	1	1	1
	2034	1	1	1	1	1	1

4. Revised evaluation rubric

A pilot risk table framework was developed by the EWG and applied to sablefish and petrale sole prior to the 2023 September Council meeting and reviewed by the SSC on September 21, 2024. As a result of feedback from Council advisory bodies and the SSC and discussion with Alaska Fisheries Science Center (AFSC) researchers familiar with the NPFMC risk tables, the CCIEA team recommends several revisions to the structure and content of the framework for this iteration as it applies to groundfish. First, given our recommendation to focus a risk table approach on the specification of scientific uncertainty, the first change we recommend is a change in name to reflect this focus. For example, revising the name to Climate and Ecosystem Adaptive Scientific Uncertainty Buffers (CEASUB) captures the application of the table for specifying scientific uncertainty. The CCIEA team is not wedded to this name but merely proposes it as an example to illustrate that the name of the table should reflect its application.

We also redefined the columns of the table, reduced the number of levels, and applied Intergovernmental Panel on Climate Change (IPCC) language (Mastrandrea et al. 2010, Field et al. 2014) in our evaluation of information within the tables to aid in more transparently communicating the strength of evidence supporting the level designation (Table 2). We further describe and justify each of these changes below. The development of CEASUB tables will be an ongoing process and will likely require further iteration as they are applied to more groundfish stocks and considered for other FMPs.

Table 2. Updated definitions of CEASUB table categories and levels.

	Ecosystem and environmental conditions	**Assessment data inputs**	**Assessment model fits and structural uncertainty**
Level 1: favorable	Indicators not used in the stock assessment show medium to high level of agreement and moderate to strong evidence supporting high species productivity	Reliable catch reconstruction, informative fishery-independent survey, age and length composition data for landed fish and bycatch for key fleets across a range of years, solid fits to data (with minimal conflicts between data sources), maturity data from samples collected across time and the model area, species-specific fecundity in the California Current Ecosystem	Most productivity parameters across multiple processes (recruitment, natural mortality, growth) are estimated internally, minimal evidence for temporally and/or spatially varying biology (or non-stationarity is accounted for in the model), sensitivity model runs are within the estimated parametric uncertainty, sensitivities are symmetric around the base model, no long-term trends in recruitment (or these trends are captured in the forecast), steep likelihood profiles and stable jitters indicating parameters are well-estimated, minimal evidence of retrospective bias
Level 2: neutral	Majority of indicators show no notable trends and/or no apparent environmental and ecosystem concerns	Historical catches with moderate uncertainty, but reliable catches over the last 4+ decades; age and length composition data covering landed catch for fleets that account for the	Moderate fits to data, multiple productivity parameters (recruitment, natural mortality, growth) are estimated internally, possible weak-moderate evidence for temporally and/or

		majority of removals, may be some gaps in time and/or for bycatch; species-specific maturity; fecundity may be based across species or regions	spatially varying biology not captured by model, weak-moderate long-term trends in recruitment not captured in the forecast, likelihood profiles and stable jitters indicate most parameters are well-estimated, some possible evidence of retrospective bias
Level 3: unfavorable	Majority of indicators show medium to high level of agreement and moderate to strong evidence supporting low species productivity	Uncertain catch reconstructions both historically and more recently; limited age composition data; maturity and fecundity based on other species and/or regions	Some problematic fits to data, most productivity parameters (recruitment, natural mortality, growth) are fixed or estimated externally, although recruitment deviations are estimable for some portion of the time series, they are only weakly informed by composition data; evidence for temporally and/or spatially varying biology not captured by model, long-term trends in recruitment not captured in the forecast, likelihood profiles and stable jitters indicate difficulty estimating parameters and a generally flat likelihood surface, evidence of retrospective bias

4.1 Redefining the table categories/columns

In the pilot version of the risk tables we recognized challenges in discerning the two columns for "assessment considerations" and "population dynamics considerations." We therefore redefined and clarified the columns in the new CEASUB tables to focus on (1) uncertainties in the data going into a stock assessment ('Assessment data inputs'), and (2) descriptive information about assessment model fits and structural uncertainties ('Assessment model fits and structural uncertainty'). 'Assessment data inputs' might include new or uncertain catch histories, or the quality and quantity of fishery independent or fishery dependent data used in the assessment. 'Assessment model fits and structural uncertainty' includes considerations like how well the model fits the data, concerns about patterns in residuals or retrospective bias, and the degree to which the assessment model structure can capture the understood biology and ecology of the stock. In all three columns, multiple lines of evidence are developed for each evaluation and each consideration is generally weighted equally, unless otherwise specified. We note that the content of these columns are reflective of Category 1 groundfish stock assessments, and modifications would be needed if the approach is applied to Category 2 or Category 3 assessments.

4.2 Using IPCC language to communicate degree of confidence for the ecosystem and environmental conditions

Several types of information can be used within the ecosystem and environmental conditions column of the CEASUB table. Summarizing these different types and sources of information into a single designation of favorable, neutral, or unfavorable conditions can be challenging. We borrowed from the IPCC's framework (Mastrandrea et al. 2010, Field et al. 2014) for assigning the degree of confidence in designating this level for ecosystem and environmental conditions only (Figure 3). We summarized the level of agreement across multiple data sources or models (e.g., related to environmental drivers of recruitment) and the strength of evidence linking environment, trophic dynamics, and habitat with population dynamics. This approach allowed us to synthesize and communicate many types of information in a repeatable, transparent way. For example, if multiple lines of evidence suggest ocean conditions are positive for recruitment of a given stock, we can be more confident in the predicted recruitment than if some indicators of recruitment are positive and others are negative. We did not use this approach for the assessment data inputs or model fits and structural uncertainty considerations columns because the strength of evidence was part of the definition of a particular level in many cases (e.g., robust evidence of age composition in the assessment data inputs column would automatically imply a Level 1 designation, and limited age composition data would lead to a Level 3).

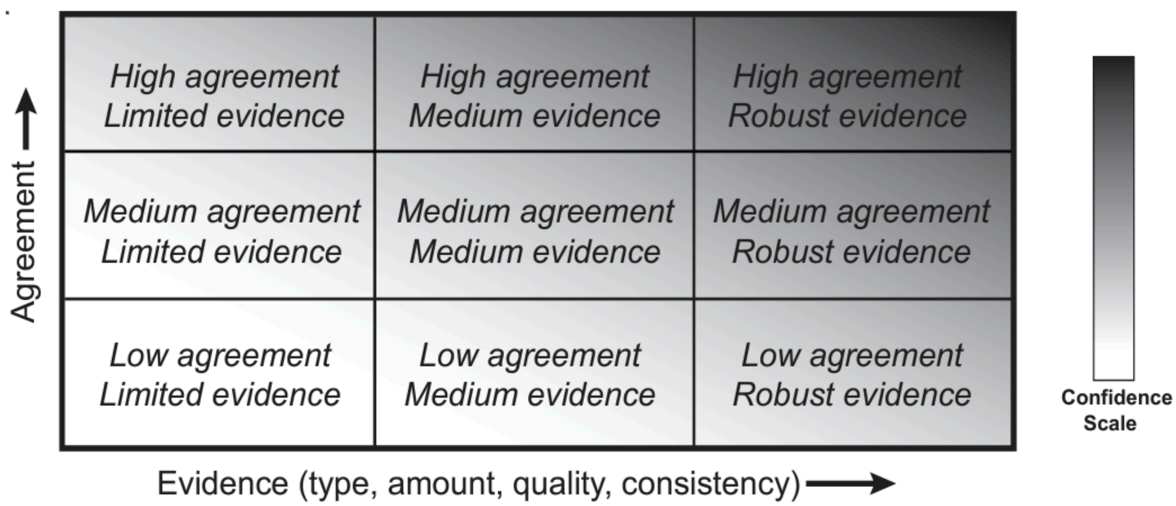

Figure 3. A depiction of evidence and agreement statements and their relationship to confidence in the data or statistical relationship. Confidence increases towards the top right corner (indicated by the shading). Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence. Figure from IPCC (Mastrandrea et al. 2010, Figure 1).

4.3 Reducing the number of levels

The goal of assigning a “Level” is to summarize and communicate two components of the scientific uncertainty buffer. The first is whether assessment data inputs, model structure, and model uncertainty are generally positive, neutral, or negative. The second is whether environmental and ecosystem conditions not included in the assessment model indicate favorable, neutral, or unfavorable productivity of a stock. Recognizing previous advice from the PFMC, and in contrast to the approach adopted by the NPFMC, we retained levels that could allow for positive conditions to reduce the default scientific uncertainty buffer. Compared to the pilot tables from 2023, we recommend reducing the total number of levels from four to three. Level 1 is favorable, Level 2 is neutral, and Level 3 is unfavorable. Using three levels keeps a balanced number of “positive” and “negative” levels, and reduces complexity in synthesizing the qualitative ratings of agreement and evidence.

5. Process for filling out CEASUB tables

5.1 Proposed timing of future CEASUB table development, review process, and frequency of updating

At the September 2023 Council meeting, the EWG outlined a schedule (EWG report 1, Agenda Item F.1.a, “the wheel of time”) for development of risk tables to support harvest setting processes for groundfish, coastal pelagic species, and salmon. On the groundfish schedule, between June and September in *even* years, the EWG would work with the Groundfish Advisory Panel (GAP) / Groundfish Management Team (GMT) to identify which groundfish assessments prioritized by the Council at the June meeting would be candidates for CEASUB tables (Table 3). Between September of *even years* and March of *odd* years, the CCIEA team recommends Science Center ecosystem scientists work with the stock assessment teams (STATs) to acquire data for CEASUB table evaluations for this subset of assessments. We then recommend that ecosystem scientists and stock assessors participate in a structured conversation to ensure that all relevant information is captured in the CEASUB table (see section 5.3 and Appendix A). The environment and ecosystem column of the CEASUB table could be completed prior to the stock assessment review (STAR) panel deadline for submission with the draft assessment, and could be included in the STAR panel review. However, because the assessment scientists will be focused entirely on development of the assessment, it may be more pragmatic to develop the assessment-related columns of the CEASUB table after the pre-STAR panel document deadline. Review of CEASUB tables could occur during STAR panels (usually in between May and July of odd years) or during later Groundfish Subcommittee (GFSC) review of the STAR panel review (usually June or August of odd years). If a pathway for applying the CEASUB tables to P* is developed (see section 2.2), additional review by the GAP and GMT would be warranted. The EWG, ecosystem scientists, and stock assessors can provide a final draft of the CEASUB tables as part of the Briefing Book deadline for the September Council meeting of the odd year. This process will allow the SSC to review and potentially revise a final CEASUB table, in time for it to be adopted by the Council at the same time as the assessment.

Table 3. Proposed biannual timeline for CEASUB table development for groundfish stocks.

	Jul-Sep (even year)	Oct-Dec (even year)	Jan-Mar (odd year)	Apr-Jun (odd year)	Jul-Sep (odd year)
Identify candidate stocks for risk tables	X				
Acquire data		X	X		
Complete ecosystem column; Discussion between ecosystem and assessment scientists				X	
STAR panel or SSC-GFSC review; Discuss draft table and SSC review of levels; Finalize at Sept Council meeting					X

We recommend development of a full update of the CEASUB table in the years in which benchmark or update assessments are conducted. Due to workload concerns for Council advisory bodies, assessment scientists, and ecosystem scientists, we do not recommend full updates of CEASUB tables more frequently than that. However, it may be possible and desirable to update the ecosystem and environmental conditions category of the table on a more regular basis (e.g., in odd years), especially if there are major changes in the ecosystem (e.g., an El Niño). In these cases, the levels assigned to the other two assessment-related categories in the CEASUB table could remain unchanged.

5.2 Prioritizing species for CEASUB table development

The process of identifying which assessments are candidates for CEASUB tables will likely consider a variety of factors, including capacity at the Science Centers. With capacity concerns in mind, we recommend *not* considering species that are typically far from attainment of the Annual Catch Limit (ACL) and that have not shown an anomalous recent change in attainment of the ACL. The rationale is that if the realized catch of a species does not approach the ACL, then there would be very little or no influence of a CEASUB table evaluation on harvest. Therefore, it is worth dedicating Council and Science Center resources toward development of CEASUB tables for other species. In contrast, an anomalous recent change in attainment of the ACL for a species could reflect changing population, environmental, or ecosystem conditions and warrants closer scrutiny. Indicators synthesized as part of the stock assessment prioritization process could shed additional light on factors responsible for attainment anomalies. If a new benchmark assessment suggests that attainment may increase in future years due to new best scientific information available, expected declines in the ACL, or other anticipated changes in the fishery, a CEASUB table could be developed after the STAR panel for the SSC to review.

5.3 Structured conversation between ecosystem scientists and stock assessors

Following the successful example of colleagues at the AFSC, we recommend that ecosystem scientists and stock assessors participate in a structured conversation about assessment and ecosystem considerations for each species for which a CEASUB table will be evaluated. We recommend designating a dedicated facilitator of the conversation to keep the conversation on-topic and probe for additional information as needed. This facilitator role should be held by someone who has training and experience in meeting facilitation best practices (e.g., OCM 2018) and is broadly familiar with the assessment process. This conversation will also benefit from participation of Science Center staff who can serve as a bridge to the ecosystem scientists and stock assessors, translating information for application to the CEASUB tables and provoking dialogue. In June 2024, we piloted this approach by having a postdoctoral researcher with experience in facilitation lead the discussions, in collaboration with Science Center EWG and SSC-ES members who played the bridging role in the structured discussions (see Appendix A). Because this process requires a fair number of Science Center staff, we anticipate it could be a limiting factor in the number of tables that can be completed in a given year and the frequency of updating existing tables. Because of this limitation we anticipate that it will be reasonable to develop CEASUB tables in the year a species is being assessed, but updating tables between assessments will not be feasible in most years.

The goal of the structured conversation is to identify major sources of uncertainty in the stock assessment due to data, model, and ecosystem factors and to explore potential ocean conditions and ecosystem drivers that may influence population dynamics for a given species and are not currently included in the stock assessment. This uncertainty may include alternative plausible parameterizations of the stock assessment model or treatments of input data that could lead to notably different outlooks on the stock's current status and/or scale, how well the assessment model fits the input data, and whether the species is experiencing favorable or unfavorable climate and ecosystem conditions.

5.4 Designating overall levels of uncertainty

Once the CEASUB table is fully developed, there will be three categories of information (ecosystem and environmental conditions, assessment data inputs, assessment model fits and structural uncertainty), each of which is assigned to one of three levels (favorable, neutral, unfavorable) based on the level of agreement of multiple data sources or models and the amount of evidence. To be applied in the harvest setting process, this panoply of information needs to be distilled into an overall level of uncertainty. One option (equal-weighting) for designating an overall level is to weigh each category of information equally. Another (dominant risk) option is to rely on the category of information with the least favorable level. Rather than prescribing an algorithm for making this determination, we recommend passing the three individual levels from each category to the SSC for their review in September of the odd year (Table 3). Based on SSC discussion of the CEASUB table, they can recommend to the Council how to use the information in the next step of the harvest specification process.

6. Retrospective analysis of sensitivity of harvest specifications to CEASUB tables

The Council requested a retrospective analysis showing how risk tables would have affected harvest specifications from the 2023 assessments for sablefish and petrale sole. To address this request, we first show redeveloped CEASUB tables based on structured conversations held in spring 2024 between ecosystem scientists and stock assessors who worked on the 2023 assessments for sablefish and petrale sole. These tables are updates to those presented in F.1.a, Supplemental EWG Report 2 from September, 2023 for sablefish (Table 4) and petrale sole (Table 5), but use only the information that was available about the populations and the ecosystem as of spring/summer 2023. For example, at that time there was knowledge of a rapidly building El Niño event, but we did not yet know the impacts it would have on the ecosystem or its duration. We also do not include data collected during the spring and summer of 2023, as that would not have been complete for use at the time. We then show how the range of potential adjustments to sigma or P* from section 3 would have impacted the ACL advice from the 2023 stock assessments for sablefish and petrale sole. Finally, we synthesize the new CEASUB tables with this sensitivity analysis to provide possible updated ACLs that could have resulted.

6.1 Sablefish

6.1.1 Updated CEASUB table

Table 4. Redeveloped sablefish CEASUB table for 2023. CVA refers to the Climate Vulnerability Assessment (McClure et al. 2023).

Ecosystem and environmental conditions	**Assessment data inputs**	**Assessment model fits and structural uncertainty**
• Recruitment: 2020-2021 recruitment indicators were positive (environmental conditions, abundance of age-0 sablefish), but have returned to neutral and forecast of El Niño suggests potential downturn • Prey: increasing (krill, juvenile hake) • Predators: no trend • CVA rank: moderate	• Most important: no fishery-dependent ages in final two years of model. These greatly increase the uncertainty in the unprecedented recruitment event. • Informative fishery-independent survey index • Reliable catch reconstruction • Includes sea-level height index of recruitment • Generally well-sampled fishery-dependent age compositions	• Potential for density-dependent decreases in growth from large recruitment event • Evidence of changing length-at-age not captured by model. • Transboundary MSE indicates southern portion of stock may be at risk of overexploitation • Age compositions of older fish not captured well. • Many biological parameters estimated internally
Level 2 (medium agreement, robust evidence)	Level 3	Level 3

6.1.1.1 Ecosystem and Environmental Conditions

We evaluated recent trends in environmental drivers of sablefish recruitment and growth, predators, and prey, along with the climate vulnerability assessment (CVA) rank assigned to sablefish by McClure et al. (2023). We did not consider competitors, habitat, or non-fisheries human activities (such as offshore wind development) during this evaluation. Overall, we consider ecosystem and environmental conditions to be neutral (Level 2) for sablefish, with medium to high confidence, based on medium agreement among indicators and robust evidence. Recent trends in prey abundance have been positive and the evidence for this trend is robust. However, other indices (potential negative impacts of El Niño and a moderate CVA rank) do not portend favorable conditions for sablefish productivity, though the evidence for these indicators is not as strong.

6.1.1.1.1 Environmental drivers

Over the past three years, environmental conditions in the California Current Ecosystem have been largely warmer than average even with the backdrop of a prolonged La Niña event, which provided favorable recruitment conditions. These conditions likely contributed to the high abundance of age-0 sablefish in pelagic surveys of the northern California Current ecosystem observed in 2020 (Leising et al. 2024). However, the abundance of age-0 sablefish in pelagic surveys of the northern California Current ecosystem returned to average in 2021 and below-average in 2022 (2023 Ecosystem Status Report). The dramatic increase in young sablefish was also seen in the West Coast Groundfish Bottom Trawl (WCGBT) survey during 2021 (there was no WCGBT survey in 2020). Overall, these data suggest a potential improvement in stock productivity in coming years due to strong year classes, consistent with the assessment model which suggests recruitment was high in both 2020 and 2021 (Johnson et al. 2023). However, forecasts suggest an intensifying El Niño during fall 2023/winter 2024. During El Niño events that impact the California Current Ecosystem, upwelling is generally weaker (Jacox et al. 2015), and northern copepod populations are generally lower. These changes have the potential to negatively impact sablefish recruitment (Tolimieri et al. 2018). Furthermore, historical tagging data from adult sablefish showed that El Niño conditions have a significant negative effect on sablefish growth off the U.S. West Coast (Kimura et al. 1998).

6.1.1.1.2 Predators and prey

There are no notable recent trends (i.e. over the last 5 years) in the populations of sablefish predators (e.g., sea lions, sperm whales, skates, fur seals). We assume that long term trends, in particular those related to recovery of marine mammals over several decades, are implicitly represented in the stock assessment and do not represent notable changes that warrant inclusion in the CEASUB. However, recent indices of prey abundance are favorable. Krill is a dominant diet item for juveniles and adult sablefish (Wippel et al. 2017, Tolimieri et al. 2018, Bizzarro et al. 2023). The CCIEA krill indicator shows an increasing trend over the last five years. Juvenile hake are also a major diet item for adult sablefish and show an increasing trend in recent years.

6.1.1.1.3 CVA results

Sablefish are highly exposed and moderately sensitive to climate change, with an overall rank of moderate (McClure et al. 2023).

6.1.1.2 Data inputs

The assessment of U.S. West Coast sablefish is fit to length data from the discarded fish in the commercial fishery, rates of annual discards and mean weight of discarded fish, indices of relative abundance from the fishery-independent NWFSC WCGBT survey, as well as age data from all available sources. Fishery-independent data and catch histories are included through 2022. Fishery-dependent length data are excluded from the assessment because they, sometimes, provide conflicting information about growth given that sablefish are relatively fast growing but can live to over 100 years of age. The assessment contains a reliable catch reconstruction relative to other west coast groundfish.

The population is well-sampled by the WCGBT survey with a high proportion of positive survey tows, but the survey does not go out to the deepest extent of the population (only samples depths between 55 - 1,280 meters). This could be especially problematic in the future if the stock moves farther offshore due to ocean warming (Liu et al. 2023).

Most notably, age compositions from the fishery are only included through 2020, so cannot be used to inform estimation of the large recruitment event in 2020-2021; only the survey index of abundance and its more limited age data inform the estimate of recruitment for those years, which is estimated to be beyond the bounds of any recruitment observed historically. Although the event was likely quite large, it is difficult to know its precise size given the lack of multiple observations from the fishery and survey across subsequent years. This lack of age composition data in the final two years is weighted most heavily for the “data inputs” category. The large recruitment event has a major impact on the OFL during the projection period, and the lack of age composition data generates considerable uncertainty as to the appropriate magnitude of increase.

The model is also fit to an environmental index of sea-level starting in 1925 to help inform recruitment. This index improved model predictions as compared to catch-only models (Tolimieri and Haltuch 2023). However, the index does not provide much additional information in the full assessment relative to the age data because the WCBT survey catches age-0 fish.

6.1.1.3 Model fits and structural uncertainty

There is evidence that length-at-age of sablefish has varied substantially over time, but this is not accounted for in the assessment for a variety of reasons. Initial data on length-at-age of the recent large year class indicate they may be growing more slowly, possibly due to density-dependence. The projections assume this year class has grown and will continue to grow at an average rate. In general, because recruitment in 2020 and 2021 is estimated at unprecedented levels, there is no historical analog for how the population will respond to these anomalously high densities, and whether compensatory mechanisms (i.e., density-dependence) might dampen the overall impact of the event on future spawning output.

The assessment estimates all three growth parameters and the coefficient of variation around the size-at-age for young and old, as well as sex-specific natural mortality. Steepness of the stock-recruit relationship is fixed. This leads to a fairly flexible productivity of the population. Age compositions of fish older than ~50 are not fit well by the model. While this is partially due to high sampling variance, it is likely in part a model misspecification, and impacts estimation of natural mortality. There is no evidence of retrospective bias. The model is particularly sensitive to the data weighting method, whether survey selectivity is dome-shaped, and whether natural mortality is estimated to be sex-specific.

Sablefish display high genetic connectivity across their entire range (Jasonowicz et al. 2016), but this assessment is limited to the portion of the population along the U.S. West Coast. A transboundary management strategy evaluation indicated that the southernmost portion of the population in the model area may be more prone to overexploitation, because it does not benefit as much from immigration from north of the model area (Kapur et al. 2024). While management does specify area-specific ACLs north and south of 36° north latitude, the relative apportionment is based on the recent five-year average of estimated biomass by area from the WCGBT survey data, not productivity.

6.1.2 Projections under different sigma and P*

We converted the buffers described in Section 3 into projections of ACLs in metric tons (mt) for sablefish. For sablefish, the projected ACL was 36,545 mt in 2025 and 14,587 mt in 2034 with a default P* of 0.45 and default category 1 sigma of 0.5. This halving of the projected ACL from the beginning to the end of the projection period results from the assumption in the projections of full ACL removals, and the application of a harvest control rule that recommends fishing down the population at the target fishing mortality rate until the population reaches the biomass target. To understand the impact of P* and sigma on sablefish ACL, it is therefore more informative to explore the range in metric tons of the ACL in a given projection year rather than across years. In 2025, varying sigma across the range proposed here for category 1 stocks (0.25 - 0.75) with default P* resulted in a 2,462 mt range in potential sablefish ACLs (Figure 4A,B). Varying P* across the legal range explored here (0.25-0.45) with default sigma resulted in a 9,341 mt range of sablefish ACLs in the same year. For 2034, varying sigma at default P* resulted in a 1,203 mt range of potential ACLs, and varying P* at default sigma resulted in a 4,602 mt range in ACL (Figure 4A,B).

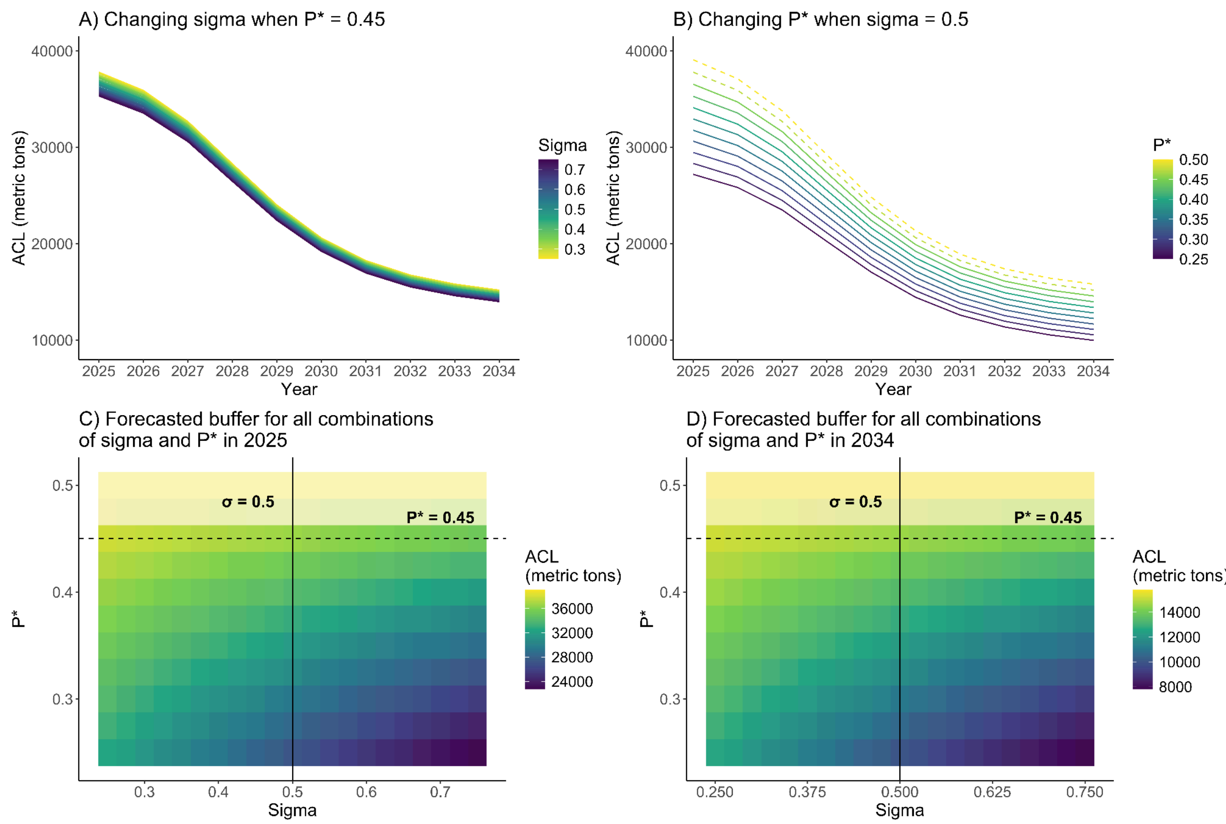

Figure 4. Changes in the projected sablefish ACL in metric tons across the range of values of sigma and P* explored here. Panel A varies sigma with the PFMC's default P* value of 0.45. Panel B varies P* with the default sigma value of 0.5 for category 1 stocks. Panels C and D show the ACL for all combinations of P* and sigma in 2025 (the beginning of the projection period) and 2034 (the end of the 10-year projection period), respectively. In Panels C and D, the solid vertical line indicates the current sigma value for sablefish as a category 1 stock, and the dashed horizontal line indicates the P* value chosen for sablefish in 2023. All other color scales and line types are as in Figure 2.

6.1.3 Application, uncertainty level and ACL recommendations

The sablefish CEASUB table based on the 2023 update suggests average environmental conditions moving forward. While environmental conditions were quite favorable around 2020-2021, those are included in the environmental index in the stock assessment, and are evident in the composition data and index of abundance from the bottom trawl survey, so are not included in the environment and ecosystem conditions column of the CEASUB table. The assessment categories indicate more cause for concern. The assessment lacks fishery-dependent ages in the final two model years. These are the only two years that would reflect the major recruitment event that is evident in the survey data. The model recommends more than a threefold increase in the 2025 OFL relative to adopted 2024 OFL based on the previous assessment conducted in 2021, as a result of this recruitment event, but given the limited data available to inform the recruitment event, the recruitment event's absolute magnitude is highly uncertain. In addition, there is potential for an unprecedented recruitment event of this magnitude to lead to density-dependent impacts on other population processes such as growth, condition, survival, and reproduction. Therefore, the sablefish table suggests it may be prudent to increase the default sigma for category 1 stock assessments (0.5). For example, a sigma of 0.75 with the selected P* of 0.45 would lead to an ACL in 2025 of 35,333 mt, as compared to the 36,545 mt that was approved (Figure 4A,C).

6.2 Petrale sole

6.2.1 Updated CEASUB table

Table 5. Redeveloped petrale sole CEASUB table for 2023. CVA refers to the Climate Vulnerability Assessment (McClure et al. 2023).

Ecosystem and environmental conditions	**Assessment data inputs**	**Assessment model fits and structural uncertainty**
● Recruitment: recent recruitment indicators suggest positive conditions ● Prey: unknown ● Predators: no trend ● CVA rank: moderate	● Reliable catch reconstruction, with some uncertainty about apportioning historical landings caught off U.S. and Canada ● Informative fishery-independent survey index ● Well-sampled fishery-dependent age compositions, particularly in the North.	● Many biological parameters estimated internally ● Minimal data conflicts ● Model very stable to alternative structural assumptions
Level 1 (medium agreement, medium evidence)	Level 1	Level 1

6.2.1.1 Ecosystem and Environmental Conditions

We evaluated recent trends in environmental drivers of petrale sole recruitment and growth, predators, and prey, along with the CVA rank assigned to petrale sole by McClure et al. (2023). We did not consider competitors, habitat, or non-fisheries human activities (such as offshore wind development) during this evaluation. Overall, we consider ecosystem and environmental conditions to be favorable (Level 1) for petrale sole, with medium confidence, based on medium agreement among indicators and moderately robust evidence. An environmental index for petrale sole recruitment indicated that 2023 petrale sole recruitment was high (Appendix of Taylor et al. 2023), and year class strength is an influential component of petrale sole dynamics. The evidence for trends in prey of petrale sole is weak, and there are no recent trends in predators of petrale sole. A moderate CVA rank gives reason for caution about future productivity of petrale sole (McClure et al. 2023), though the evidence for this indicator is not as strong as those for recruitment.

6.2.1.1.1 Environmental drivers

An environmental index found that degree days during the pelagic juvenile phase and long-shore transport during the larval stage were the best predictors of recruitment variability (Appendix of Taylor et al. 2023). The index predicts near-average recruitment in 2019-2022, but a very strong year class in 2023, on par with the peak recruitment observed from 2006-2008 that led to the stock's rebuilding. This environmental index, developed using data from Copernicus Marine Environment Monitoring Service (CMEMS) (https://marine.copernicus.eu/) and Mercator Ocean International (MOI) (https://www.mercator-ocean.eu/), is new but appears robust. Because the assessment model data ends in 2022, this positive indicator for 2023 recruitment is not in the sensitivity model that includes the environmental index. Forecasts suggest an intensifying El Niño during fall 2023/winter 2024. It is not certain what impacts this event will have on petrale sole populations.

6.2.1.1.2 Predators and prey

There are no notable recent trends (i.e. over the last 5 years) in major predators of petrale sole (e.g., harbor seals, skates, lingcod, arrowtooth, dogfish). We assume that long term trends, in particular related to recovery of marine mammals over several decades, are implicitly represented in the stock assessment and do not represent notable changes that warrant inclusion in the CEASUB table. Limited diet data indicate petrale sole are benthic generalists that feed on shrimp and small flatfish. There is no current indicator for this forage complex; a small flatfish index could be developed from the WCGBT survey in the future.

6.2.1.1.3 CVA results

The CVA suggests petrale sole are highly exposed and moderately sensitive to climate change, with an overall CVA rank of moderate (McClure et al. 2023).

6.2.1.2 Data inputs

Because petrale sole was historically sorted to the species-level, the historical catch reconstruction is considered reliable, though there is some uncertainty about what fraction of historical landings in Washington were caught in Washington versus Canadian waters. While historical discards are more uncertain, the high commercial value makes discarding relatively uncommon. The fishery is also well-sampled for age composition data, particularly in the north (Oregon and Washington).

Flatfish, including petrale sole, are well-sampled by the WCGBT survey since they mainly occupy trawlable habitat. This provides an informative fishery-independent index of relative abundance. However, fish are not well-selected until age 3, making it difficult to estimate recruitment in the most recent years.

6.2.1.3 Model fits and structural uncertainty

The major sources of structural uncertainty are in natural mortality by sex (estimated within the model using a meta-analytic prior) and the steepness of the stock-recruit curve, which is fixed at 0.8, a meta-analytical steepness prior for Pleuronectidae. The steepness likelihood profile illustrated that key model estimates (starting and ending spawning output and associated fraction unfished) are robust to assumptions regarding steepness. The likelihood profile for natural mortality showed that the same parameters are more sensitive to the changes in natural mortality than in steepness. All growth parameters are estimated within the model. In general, the model has a lot of flexibility to estimate parameters. Conflicts among data sources were generally low. There is some evidence that the southern ages are not well fit, but because the southern fleet has limited age data, further explorations were limited, and a model with spatially explicit growth (north versus south) was not feasible. Model sensitivities generally fell within the asymptotic confidence intervals estimated within the model. There is no evidence of retrospective bias.

6.2.2. Projections under different sigma and P*

Overall, projected ACLs for petrale sole were lower than for sablefish, reflecting the lower stock size for this species. The projected petrale sole ACL was 2,403 mt in 2025 and 2,396 mt in 2034 with default sigma and P* values. Varying sigma with default P* resulted in a 162 mt range in potential petrale ACL in 2025 and a 99 mt range in 2034 (Figure 5A). Varying P* with default sigma varied petrale sole by 614 mt in 2025 and 465 mt in 2034 (Figure 5B).

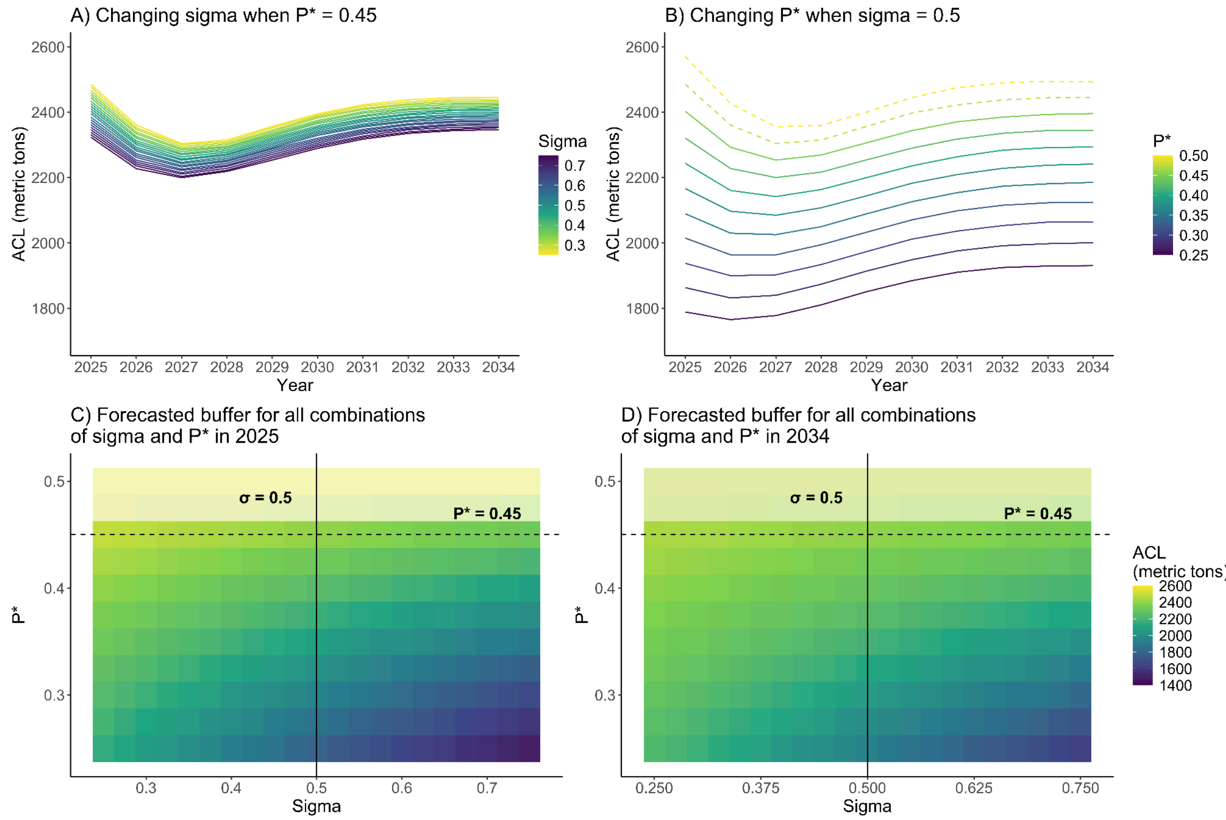

Figure 5. Changes in forecasted petrale sole ACL in metric tons across a range of reasonable values of sigma and P*. Panel A varies sigma with the PFMC's default P* value of 0.45. Panel B varies P* with the default sigma value of 0.5 for category 1 stocks. Panels C and D show the ACL for all combinations of P* and sigma in 2025 (the beginning of the projection period) and 2034 (the end of the 10-year projection period), respectively. In Panels C and D, the solid vertical line indicates the current sigma value for petrale sole as a category 1 stock, and the dashed horizontal line indicates the P* value chosen for petrale in 2023. All other color scales and line types are as in Figure 2. Note that in some of the scenarios with buffers resulting in larger reductions in the ABC, spawning output briefly falls below the management target, and the harvest control rule is applied. This further reduces the ACL beyond the application of the scientific uncertainty buffer.

6.2.3 Application, uncertainty level and ACL recommendations

The petrale sole CEASUB table based on the 2023 benchmark assessment suggests positive environmental conditions. It is also one of the most data-rich groundfish assessments on the U.S. west coast. The data fit the model well, and the model is unusually robust to a number of different assumptions on how to parameterize the model. Therefore, it may be acceptable to use a sigma value less than 0.5 for petrale sole. From our sensitivity analysis, a sigma of 0.25 (50%

of the standard sigma value for Category 1 stocks) with the selected P* of 0.45 would lead to an ACL of 2,485 mt, as compared to the 2,403 mt used in 2025.

6.3 Category 2 projections: shortspine thornyhead

The two example stocks, sablefish and petrale sole, both have category 1 assessments. Our sensitivity analysis (Figure 2) suggests that category 2 stocks (default sigma = 1) may yield more scope for adjustments in sigma to influence overall ACL. We therefore use the 2023 assessment of shortspine thornyhead to illustrate how CEASUB tables might impact harvest specifications for category 2 assessments. We show the projections from the assessment under a range of sigma and P*. We varied P* across the same range as for sablefish and petrale sole (0.25 - 0.5), and varied sigma from 0.75 to 1.5, reflecting the status of shortspine thornyhead as a category 2 stock. Because we did not develop a CEASUB rubric for category 2 assessments, we do not include a full worked example evaluating the ecosystem conditions and the assessment data and model structure. With a default P* of 0.45 and default category 2 sigma of 1, projected shortspine thornyhead ACL was 815 mt in 2025 and 883 mt in 2034. Varying sigma with default P* resulted in a 81 mt range in potential shortspine thornyhead ACLs in 2025 and a 129 mt range in 2034 (Figure 6A). Varying P* with default sigma varied shortspine thornyhead ACLs by 364 mt in 2025 and 527 mt in 2034 (Figure 6B).

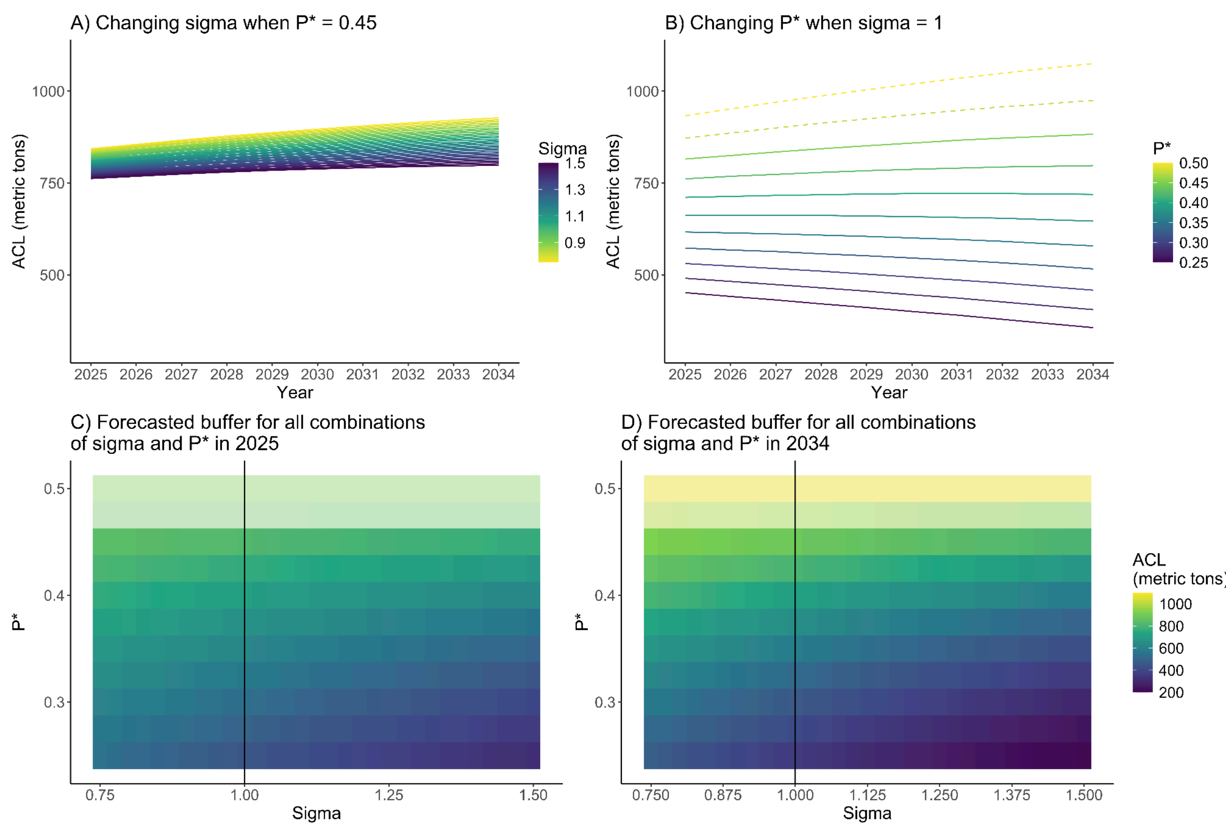

Figure 6. Changes in projected shortspine thornyhead ACL in metric tons across a range of reasonable values of sigma and P*. Panel A varies sigma with the PFMC's default P* value of 0.45. Panel B varies P* with the default sigma value of 0.5 for category 1 stocks. Panels C and D show the ACL for all combinations of P* and sigma in 2025 (the beginning of the projection period) and 2034 (the end of the 10-year projection period), respectively. Color scale and line type are as in Figure 2. Note that because shortspine thornyhead spawning output is estimated to be slightly below the management target in 2023, the harvest control rule has been applied. This further reduces the ACL beyond the application of the scientific uncertainty buffer.

7. Future Steps

During the May 24, 2024 EWG meeting where the CCIEA team updated the EWG on progress towards this report, several EWG members commented that the approach where we repeated assessment projections under different values of sigma and P* did not account for the fact that being more precautionary (lower P*, higher sigma) ultimately results in fewer removals, which would leave the stock at a more favorable and less constraining status if a subsequent benchmark assessment finds evidence that the stock is less productive or abundant than assumed in previous assessments. We acknowledge that our exploration here of the impact of changing buffers on harvest specifications does not account for structural uncertainty across benchmark assessments and how that uncertainty propagates through the management process. Unfortunately, accounting for such uncertainty would require a closed-loop management strategy evaluation, which was beyond the scope of this report, but could be a useful endeavor in the future. We also did not explicitly include the pathway where the SSC directly specifies the ABC after the assessment process, but Figures 4-6 provide an idea of how harvest values could be directly adjusted.

Lastly, due to challenges with scheduling meetings with salmon advisory bodies, the CCIEA team and EWG have not been able to move forward with the development of risk tables for Sacramento River and Klamath River Chinook salmon. A potential next step includes a methodology review of Satterthwaite & Shelton (2023) by the Salmon Technical Team and the Salmon Advisory Subcommittee (SRCTC) in October 2024. This possibility was raised at the June 2024 joint meeting between the EWG and Sacramento River Fall Chinook Working Group.

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Appendices

Appendix A - Template for structured conversation between ecosystem scientists and stock assessors template, using sablefish as an example

CEASUB table background [to be shared via email and at the beginning of the meeting]

The goal of this conversation is to identify major sources of uncertainty in the sablefish stock assessment due to population, structural, and ecosystem factors. Broadly, we are interested in identifying

1) Where alternative plausible parameterizations of the stock assessment model or treatments of input data lead to notably different outlooks on the stock's current status and/or scale
2) How well the assessment model fits the input data
3) Whether sablefish are experiencing favorable or unfavorable climate and ecosystem conditions

Considerations like these are candidates for inclusion in the **draft CEASUB tables** being developed for sablefish that will be used to inform scientific uncertainty (σ) and/or Council risk tolerance (P*). These tables include three sets of factors: ecosystem considerations (Column 1), model structure/uncertainty (Column 2), and population dynamics (Column 3).

In this conversation, we want to groundtruth which indicators should go in Column 1 (ecosystem) and/or Column 3 (population dynamics) of the tables. We'll ask questions of each of you directly, but we encourage you both to jump in and add or respond to each other's answers. We expect this conversation to last about an hour.

We're also still in the process of refining this structured conversation approach. If any of the questions we're asking aren't clear or aren't relevant, or there are other important questions we're not asking, please let us know

Ecosystem Processes [to be shared via email]

To kick off our conversation, we've built a list of potential population dynamics and ecosystem processes to be considered for inclusion in the tables. This isn't supposed to be a comprehensive list: there may be important processes we're missing, and some of the indicators on this list may not make sense to include in a CEASUB table for sablefish. That's what we're going to try to figure out in this conversation.

[For stock assessors] To facilitate our conversation, we ask that you think about how you would characterize uncertainty in your assessment.

[For ecosystem scientists] To facilitate our conversation, we ask that you think about these concepts and processes in advance of our meeting and review any relevant literature you're aware of about how they may be influenced by ocean and ecosystem conditions.

Here is our initial list of potential processes:

- **Food webs** (e.g., predator abundance or productivity, competitor abundance or productivity, spatial overlap with predators/competitors, prey abundance)
- **Habitat availability** (e.g., do current or near-term predictions of ocean temperatures and oxygen match known optimal ranges for sablefish life history stages, closed area regulations)
- **Changes in ecosystem productivity** (e.g., upwelling indices, chlorophyll *a*, abundance of low trophic level organisms)
- **Physiological indices** (e.g., growth, condition, pathogens/parasites, stomach weight/fullness)
- **Reproductive indices** (e.g., maturity, fecundity, spawn timing and duration)

Questions

1. This question is for [stock assessor]. **Based on your work on the assessment, what do you think are the greatest sources of uncertainty in the most recent sablefish assessment? Are any of these sources of uncertainty outside the norm you typically expect for this assessment?**

   <u>Probes:</u>

   - Which key parameters in the model are fixed versus estimated? (e.g., mortality, growth, steepness, recruitment deviations). Did you explore any potential for time-varying [parameter]?
   - Were sensitivities symmetric about the stock's status in the reference model, or did they generally tend to indicate more/less favorable conditions than the reference model?
   - Are there dynamics that you think are not being captured by the model structure?

- For the dynamics/asymmetric sensitivities that are mentioned, what do you think the implications are for uncertainty in the estimated OFL?

2. This question is for [stock assessor]. **In the assessment, how were the fits to the data overall? Were there any patterns in residuals or other indicators of especially poor fits or concerning diagnostics?**

   Probes:

   - Were there any conflicts among data sources that were challenging to resolve?
   - How informative were the data – were likelihood profiles flat or were parameter estimates well-informed?
   - Are there retrospective biases?
   - What do you think caused the poor data fit for [indicator]?
   - Do you think that this conflict/pattern/issue has a significant effect on projected stock status/scale, and if so, in which direction?
   - How reliable are the data sources?
     - Is this a well sampled population with robust composition data?
     - Is there an informative fishery independent survey?
     - How reliable are the catch reconstructions?
   - For the issues that are mentioned, what do you think the implications are for uncertainty in the estimated OFL?

3. This question is for [ecosystem scientist]. **What are the important oceanographic or ecosystem drivers in this ecosystem for [species]?**

   Probes, to repeat for each driver:

   - What is that link? What is the magnitude and direction of the relationship?
   - How has that driver changed through time, especially in the recent past? Please describe the strength and direction of that trend.
   - How confident are you in the evidence supporting that relationship and that trend?
   - For the links that are mentioned, what do you think the implications are for uncertainty in the estimated biomass of [species]?

4. This question is for [stock assessor]. **Are there any ecosystem processes that are currently included in the stock assessment model for [species]? Are there any ecosystem processes that are not included in the assessment model but that you think could have a potential link to [species] recruitment, growth, fecundity, mortality, or distribution?**

   Probes:

- Do you know of any temporal trends in these ecosystem conditions? Please describe the strength and direction of that trend and how confident you are in the data.
- For the links that are mentioned, what do you think the implications are for uncertainty in the estimated OFL?

5. This question is for everyone. **Are there any ecosystem processes that we didn't already cover in this conversation that could have a potential link to [species] recruitment, growth, fecundity, or migration?**

   Probes:

   - What is the potential mechanism for that link?
   - What evidence exists for that link, and how confident are you in the data supporting it?
   - For the links that are mentioned, what do you think the implications are for uncertainty in the estimated OFL?

Appendix B - Contributors to the report.

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