RISK EVALUATION TABLES FOR PETRALE SOLE AND SABLEFISH

This supplemental report contains the draft risk assessment tables for petrale sole (Table C-2) and sablefish (Table C-3). As discussed in Agenda Item F.1.a, EWG Report 1, these tables represent a pilot application of a risk assessment methodology adapted from the methods in use by the North Pacific Fishery Management Council. The purpose of these risk assessment tables is to provide climate and ecosystem information to the Pacific Fishery Management Council (Council) to supplement results of stock assessments (or if a stock assessment is not available) to help establish harvest reference points or other management measures.

The application of this risk assessment methodology revealed a variety of considerations that need to be further explored to develop a robust tool that can be effectively used in management decision making. Overall, the methodology should contribute to an understanding of how stock dynamics, not explicitly considered in a stock assessment, may inform various management related considerations. The Ad Hoc Ecosystem Workgroup (EWG) expects that these risk assessments would encompass a time frame tied to the fishery management decision processes (which can occur as often as every year) with longer term considerations (e.g., tied to stock management boundaries) taken up elsewhere. In such a risk assessment a wide variety of ecological factors could be considered including oceanographic drivers, changes in physical habitat, predators/prey/competitor dynamics, direct and indirect non-fishing effects (e.g., offshore wind facility development, construction-related habitat modification), and range shifts. These current risk tables only include environmental drivers, but future risk tables could consider incorporating other ecosystem drivers like those listed above as they become available and as methods for determining risk associated with such factors are developed. Furthermore, an overall risk level assignment requires a weighting scheme to account for the relative magnitude of the effect of these factors on stock characteristics of concern. This weighting scheme is likely to be stock-specific and could be qualitative or quantitative. In addition, we are seeking guidance on what additional information should be included in the population dynamics and stock assessment columns.

While developing the risk assessment tables for petrale sole and sablefish, the EWG noted the need for dedicated time and effort and a structured process to complete a risk assessment that provides actionable information for decision making. Such a process should entail convening multi-disciplinary teams — composed of ecologists, survey scientists, ecosystem modelers, stock assessors, and physiologists, among others — to populate the risk assessment table and complete the risk assessment process. Such teams are needed because of the diversity of ecosystem and climate-related factors enumerated above, which demand the provision of comprehensive information relevant to the species being evaluated. These teams would be responsible for weighting the different types of information within and across the four categories delineated in the risk evaluation framework (see Table C-1 in EWG Report 1) and achieving consensus on risk classification for each category as well as the overall risk classification for the particular species/stock/fishery management plan. As part of such a process, the teams would document how a particular conclusion was reached (e.g., scoring according to the risk classification scheme), the underlying rationale, and other considerations related to their consensus (or lack thereof) on risk classifications. Terms of reference could be developed to guide such an effort and could build from

analogous processes conducted to evaluate risk to populations within National Marine Fisheries Service (e.g., for Biological Opinions).

Should the Council decide to further explore the application of this methodology, the EWG is prepared to present a detailed proposal in March 2024 covering process, personnel, and methodological considerations. The EWG expects that discussions with other Council advisory bodies, including the Scientific and Statistical Committee, in the interim between this meeting and March 2024, as well as the proposed TNC workshops, will greatly benefit the development of such a proposal. If the Council were to adopt the proposal in March it could be applied as part of the 2027-2029 groundfish harvest specifications process (which notionally begins with stock assessment prioritization in March 2024) and/or another stock/fishery management plan that may be chosen through the species selection process described in EWG Report 1.

Table C-2: Risk evaluation table for petrale sole in 2023.

Environmental/ecosystem considerations	Assessment-related considerations	Population dynamics considerations
We evaluated the influence of oceanographic drivers of petrale sole recruitment exclusively for this draft risk table. While potentially important to petrale sole population dynamics, the influence of predators, prey, competitors, habitat, and non-fisheries human activities, (such as offshore wind development) were not assessed during this evaluation. 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. An index of juvenile petrale sole from the West Coast Groundfish Bottom Trawl Survey did not identify a strong 2022 year class, which is consistent with the environmental index. A sensitivity of the 2023 assessment model to inclusion of the environmental index indicated higher recruitment estimates in the most recent few years, which translated into slightly higher estimates of spawning depletion (0.415 vs 0.336 in the base model) and the OFL. A three-year La Niña ended in the spring of 2023 and an El Niño began impacting the CCE in the summer 2023. Over the past several years large MHWs have also occurred during the summer, making for warm conditions despite being in a La Niña. These types of environmental conditions have not been	Petrale sole is a data-rich stock with a variety of data sources providing consistent information on stock trajectories over the years and no major conflicts among data sources. The 2023 model estimates are similar to those from previous assessments (even after the model structure was substantially simplified within the 2023 assessment). All sensitivity model runs explored as a part of the 2023 assessment also resulted in very similar trajectories. Studies on stock structure and movement of petrale sole indicate transboundary movement of petrale sole (adults and pelagic juveniles, Cruz et al. 2023) between U.S. and Canadian waters. However, the 2023 assessment results apply only to the area off the U.S. West Coast.	The stock dynamics are driven by infrequent above average recruitment events, generally followed by several years of low recruitment that together drive fluctuations in the spawning biomass. The fishery for petrale sole is sustained by the large, infrequent year classes. Recruitment estimates in the most recent few years, during which the youngest cohorts are not well-selected by surveys or fisheries, are uncertain. The status of the stock is estimated to be above the target reference point of 0.25. However, the biomass is estimated to be declining due to below-average and then

Environmental/ecosystem considerations	Assessment-related considerations	Population dynamics considerations
observed in past years and thus at present it is not certain what impacts this will have on petrale sole populations but may facilitate stronger recruitment. Additionally, it is important to monitor local environmental conditions such as hypoxia because coastal environmental conditions may be different in the future during La Niña/El Niño. Further, climate-induced changes in growth are important to consider and monitor over time, as growth alterations can affect various ecological processes, including reproduction and recruitment, as well as management reference points (Stawitz et al. 2019) The Climate Vulnerability Assessment (McClure et al. 2023) suggests petrale sole are highly exposed and moderately sensitive to climate change, with an overall CVA rank of moderate. **EWG Recommendation: Level 1**	**STAT Recommendation: Level 1**	uncertain recruitment in recent years. **STAT Recommendation: Level 2**

Table C-3: Risk evaluation table for sablefish in 2023.

Environmental/ecosystem considerations	Assessment-related considerations	Population dynamics considerations
We evaluated the influence of oceanographic drivers of sablefish recruitment exclusively for this draft risk table. While potentially important to sablefish population dynamics, the influence of predators, prey, competitors, habitat, and non-fisheries human activities (such as offshore wind development) were not assessed during this evaluation. The 2023 Ecosystem Status Report indicates that the abundance of age-0 sablefish in pelagic surveys of the northern California Current ecosystem returned to average in 2021 and 2022, following anomalously high abundance in 2020. This dramatic increase in young fish was also seen in the bottom trawl survey used in the stock assessment. Overall, these data suggest potential improvement in stock status in coming years due to this strong year class. Over the past three years, environmental conditions in the California Current have been largely warmer than average even with the backdrop of a prolonged La Niña event, which provided favorable recruitment conditions and likely contributed to the strong year classes we are currently seeing. However, we are currently transitioning to an El Niño that is forecast to intensify this fall/winter. 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. This has the potential to	The assessment of U.S. West Coast sablefish is fit to length data from the discarded fish in the commercial fishery and whole catch in the West Coast Groundfish Bottom Trawl Survey, as well as age data from all available sources. Additional 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 productivity of the stock and how it responds to fishing is uncertain due to confounding of natural mortality, absolute stock size, and stock-recruit steepness. The model is also fit to an environmental index of sea-level height to help inform recruitment starting in 1925. The index improved model	Recruitment is estimated to be highly variable with estimates of above average year classes approximately every 5-10 years. The most recent large recruitment event in 2020 also carried forward to 2021 and leads to all explorations of the assessment model indicating that the population is above the management target and currently increasing. These recruitment events are estimated to be greater than any other recruitment across the modeled period. However, the scale of the population is highly uncertain and will not be better informed until there is a larger contrast in the time series of biomass since 2003, the start year of the most recent survey.

Environmental/ecosystem considerations	Assessment-related considerations	Population dynamics considerations
negatively impact sablefish recruitment. 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). The Climate Vulnerability Assessment (McClure et al. 2023) suggests sablefish are highly exposed and moderately sensitive to climate change, with an overall rank of moderate. **EWG Recommendation**: **Level 2**	predictions as compared to catch-only models (Tolimieri and Haltuch 2023). However, the index does not provide a lot of additional information in the full assessment relative to the age data because the survey catches age-0 fish. The index is particularly valuable when empirical data cannot be collected via surveys. **STAT Recommendation: Level 2**	**STAT Recommendation: Level 1**

Literature Cited

Cruz, F.S., Parada, C., Haltuch, M., Wallace, J., Cornejo-Guzman, S., and Curchitser, E. (2023) Petrale sole transboundary connectivity and settlement success: a biophysical approach, Front. Mar. Sci., doi.org/10.3389/fmars.2023.1155227

Jacox, M.G., Fiechter, J., Moore, A.M., and Edwards, C. A. (2015) ENSO and the California Current coastal upwelling response, J. Geophys. Res. Oceans, 120, 1691–1702, doi:10.1002/2014JC010650

Kimura, D.K., Shimada, A.M., and Shaw, F.R. (1998) Stock structure and movement of tagged sablefish, *Anoplopoma fimbria*, in offshore northeast Pacific waters and the effects of El Niño-Southern Oscillation on migration and growth. Fishery Bulletin, 96, 462-481.

McClure MM, Haltuch MA, Willis-Norton E, Huff DD, Hazen EL, Crozier LG, Jacox MG, Nelson MW, Andrews KS, Barnett LAK, Berger AM, Beyer S, Bizzarro J, Boughton D, Cope JM, Carr M, Dewar H, Dick E, Dorval E, Dunham J, Gertseva V, Greene CM, Gustafson RG, Hamel OS, Harvey CJ, Henderson MJ, Jordan CE, Kaplan IC, Lindley ST, Mantua NJ, Matson SE, Monk MH, Moyle P, Nicol C, Pohl J, Rykaczewski RR, Samhouri JF, Sogard S, Tolimieri N, Wallace J, Wetzel C and Bograd SJ. (2023) Vulnerability to climate change of managed stocks in the California Current large marine ecosystem. Front. Mar. Sci. 10:1103767. doi: 10.3389/fmars.2023.1103767.

Stawitz, C.C., Haltuch, M.A., and K.F. Johnson. How does growth misspecification affect management advice derived from an integrated fisheries stock assessment model? Fisheries Research. 213: 12-21.

Taylor, I.G., Gertseva, V., and Tolimieri, N. (2023) Draft assessment of "Status of petrale sole (*Eopsetta jordani*) along the U.S. West Coast in 2023." Agenda Item G.2, Attachment 11. PFMC September 2023 Briefing Book.

Tolimieri, N. and M.A. Haltuch. (2023). Sea-level index of recruitment variability improves assessment model performance for sablefish Anoplopoma fimbria. Canadian Journal of Fisheries and Aquatic Sciences. 80(6): 1006-1016. https://doi.org/10.1139/cjfas-2022-0238