Summary of the Preliminary 2023 Recommended Model Changes for Gulf of Alaska Pacific cod

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# Executive Summary

In this summary of recommended model changes for the 2023 assessment of Gulf of Alaska (GOA) Pacific cod we explore and recommend two model changes:

1. Correct the minimum sample size in the Stock Synthesis data file so that all the Conditional Age-at-Length data is included in model fitting
2. Change the environmental index used for the link to the AFSC longline survey catchability

Both of these model changes result in improvements to the model as compared to the accepted model in 2022 (model 2019.1a) and result in comparable estimates of model quantities, including Spawning Biomass.

# Data

The data used for these analyses were the final data used in the accepted 2022 assessment model. The following table summarizes the data fit by the GOA cod assessment for 2022:

|  |  |  |  |
| --- | --- | --- | --- |
| **Data** | **Source** | **Type** | **Years** |
| Federal and state fishery catch, by gear type | AKFIN | metric tons | 1977 – 2022 |
| Federal and state fishery catch-at-length, by gear type | AKFIN / FMA / ADF&G | number, by cm bin | 1977 – 2022 |
| GOA NMFS bottom trawl survey biomass | AFSC | metric tons | 1990 – 2021 |
| AFSC Sablefish Longline survey Pacific cod Relative Population Numbers | AFSC | RPN | 1990 – 2022 |
| GOA NMFS bottom trawl survey length composition | AFSC | number, by cm bin | 1990 – 2021 |
| GOA NMFS bottom trawl survey conditional age-at-length | AFSC | mean value and number | 1990 – 2021 |
| AFSC Sablefish Longline survey Pacific Cod length composition | AFSC | number, by cm bin | 1990 – 2022 |
| Federal fishery conditional age-at-length | AFSC | proportion age at length | 2007 – 2021 |

Additional analyses focused on evaluation of the environmental index used in the GOA cod assessment, which is described in more detail in the following section.

## Environmental indices

The Climate Forecast System Reanalysis (CFSR) is the latest version of the National Centers for Environmental Prediction (NCEP) climate reanalysis. The oceanic component of CFSR includes the Geophysical Fluid Dynamics Laboratory Modular Ocean Model version 4 (MOM4) with iterative sea-ice (Saha *et al.* 2010). It uses 40 levels in the vertical with a 10-meter resolution from surface down to about 262 meters. The zonal resolution is 0.5**°** and a meridional resolution of 0.25° between 10°S and 10°N, gradually increasing through the tropics until becoming fixed at 0.5° poleward of 30°S and 30°N.

To make the index, the CFSR reanalysis grid points were co-located with the AFSC bottom trawl survey stations. The co-located CFSR oceanic temperature profiles were then linearly interpolated to obtain the temperatures at the depths centers of gravity for 10 cm and 40 cm Pacific cod as determined from the AFSC bottom trawl survey. All co-located grid points were then averaged to get the time series of CFSR temperatures over the period of 1979-2020 (Table 2.14 and Fig. 2.26).

The mean depth of Pacific cod at 0-20 cm and 40-60 cm was found to be 47.9 m and 103.4 m in the Central GOA and 41.9 m and 64.07 m in the Western GOA. The temperatures of the 0-20 cm and 40-60 cm Pacific cod in the CFSR indices are highly correlated (R2 = 0.89). The shallower index is more variable (CV0-20 cm = 12% vs. CV40-60cm= 8%). There are high peaks in water temperature in 1981, 1987, 1998, 2015, 2016 and 2019 with 2019 being the highest in both the 0-10 cm and 40-60 cm indices. There are low valleys in temperature in 1982, 1989, 1995, 2002, 2009, 2012, and 2013. The coldest temperature in the 0-20 cm index was in 2009 and in the 40-60 cm index in 2012. The trend is insignificant for both indices. In 2020 and 2021 the temperatures at both the 0-20 and 40-60 are below the time series mean with 2021 being within 1% of the 2020 temperatures. In 2022 for both 0-20 and 40-60 the temperatures were above the time series mean.

Pacific cod in the Gulf of Alaska are assessed on an annual stock assessment schedule to coincide with the availability of new survey data. We use a statistical age-structured model as the primary assessment tool for Gulf of Alaska Pacific cod which qualifies as a Tier 3 stock.

The Center for Independent Expert (CIE) review for Gulf of Alaska Pacific ocean perch was conducted virtually from March 30 to April 1, 2021. The panel of experts consisted of Drs Noel Cadigan, Saang-Yoon Hyun, and Geoff Tingley. Overall, the review was productive, resulting in a number of recommendations for future development and research into the assessment for GOA POP. By the conclusion of the review the experts found the assessment to be of high quality, and the reviews contained statements like, “The overall outcome of this assessment, as reviewed, is that it meets the description of best available science and exceeds the acceptability quality threshold to be used to inform management.” (Tingley).

Each of the reviewers provided research recommendations that should serve to improve the assessment model for GOA POP. A number of the recommendations focused on a variety of sensitivity analyses, while others involved more in-depth model development. Distilling these comments, the more in-depth recommendations included:

* Investigate data weighting of compositional data
* Develop a state-space model to be run in parallel to the current assessment
* Continue to investigate use of VAST estimates of survey biomass, in particular investigate reasons behind the divergence between design-based and model-based estimates of abundance

As it pertains to the use of VAST estimates of survey biomass, the consensus among the reviewers was that it is still premature to use this index in the assessment until it can be more thoroughly investigated. This was also the consensus with the use of acoustic survey biomass estimates as an additional index to the model. Due to the recommendations that further work be conducted before implementation into the assessment, and in conjunction with the work that the AFSC internal review team performed through 2020 and 2021 (which additionally identified different methods to estimate fishery selectivity as a topic to be considered in the assessment model development), the GOA POP assessment will not incorporate any substantial model changes for the 2021 assessment cycle, but will investigate and continue to develop these various recommendations to be potentially implemented in the next full assessment that will be conducted in 2023.

The following tables compile the main recommendations suggested by the reviewers and are organized by the terms of reference of the review.