Scientific and Statistical Committee's Economics and Groundfish Subcommittees Report on Sablefish Daily Trip Limit Model

Pacific Fishery Management Council
Online Meeting

October 12, 2023

The Scientific and Statistical Committee's (SSC) Economics and Groundfish Subcommittees met virtually on October 12, 2023 to review a revised version of Updates to the Sablefish Trip Limit Model proposed by the Groundfish Management Team (GMT). Whitney Roberts presented the model and results of model performance evaluations. The subcommittees appreciate the considerable amount of work done by the analysts over the past several months in order to complete the analysis.

The Subcommittees find that the model as presented can be used in the groundfish harvest specification process and inseason actions.

Model Summary

The Sablefish Trip Limit Model, as proposed by the GMT, projects catch in two segments of the sablefish fixed gear fishery: Limited Entry North of 36° N. lat. (LEN) and Open Access North of 36° N. lat. (OAN). The catch projection models consist of two sub-models for each segment: a vessel participation model that forecasts the number of active vessels per two-month period and a catch-per-vessel model that forecasts the average, segment-wide catch per vessel in each two-month period. In both sub-models, the forecasted variable is assumed to be a linear function of covariates. Each model's parameters were estimated from data for 2012-2022. A number of candidate models were evaluated and compared in terms of out-of-sample prediction performance using cross-validation methods. The models selected for use are the same for each fishery segment (LEN and OAN):

Catch per vessel: $Average\ lbs.\ per\ vessel \sim bimonthly\ trip\ limit + PERIOD + COVID$

Vessel participation: $Number\ of\ vessels \sim avg.\ sablefish\ price\ per\ lb. + PERIOD + COVID$

The variable PERIOD is a collection of 6 period fixed effects, which are set equal to 1 depending on which two-month interval the observation occurs in. The variable COVID is a fixed effect that adjusts for the impact of the COVID-19 pandemic of 2020 and 2021. It is set equal to 1 for observations occurring in either of those two years.

Catch projection models in the two smaller segments of the sablefish fixed gear fishery, Limited Entry South of 36° N. lat. (LES) and Open Access South of 36° N. lat. (OAS), were not considered. Catch projections for these will be made using the same models.

Subcommittees' Recommended Changes

The subcommittees suggested a number of changes that can be considered for future work. Most of these are minor changes that could be made in a reasonably short period of time and would not require any additional review by the subcommittees:

- A minor change that could be implemented prior to the November 2023 Council meeting is to ensure that the COVID period fixed effect does not apply to the first period of 2020. The models presented to the subcommittees were estimated with COVID fixed effects for all periods in 2020. However, since the effects of the pandemic were first felt in March 2020, it would be better to estimate the model parameters with no COVID effect for the first period of 2020.
- Adding sablefish ex-vessel price to the catch-per-vessel model should be considered. Catch-per-vessel is determined by catch-per-trip and the number of trips a vessel takes. The number of trips may be influenced by price, so including this variable may improve predictive accuracy.
- Evaluate model performance using forecast price rather than observed price. The current version of the vessel participation model uses the sablefish ex-vessel price observed in the period as an explanatory variable. However, forecasts will be made with a predicted sablefish price (since future prices cannot be observed). Model evaluation should be performed using prices which were forecasted prior to the predicted periods.
- Develop and document methods for generating price forecasts for sablefish. The current methods involve some judgment in selecting recent observed years on which to base forecasts. Price forecast performance could improve by developing methods that are reproducible.

Additional, more significant possible future that might require further review include:

- Consider selecting the best performing catch-per-vessel and participation models jointly. The current model selection procedure compares predicted average catch per vessel and vessel participation to observed levels separately. An alternative would be to select the pair of models that best predicts total catch. This would better evaluate the overall goal of the modeling exercise.
- Individual rather than aggregated models could be considered. The current model estimates total number of vessels and average catch per vessel across the entire fleet. An alternative would be to model participation and catch outcomes for individual vessels. Such a model requires a set of vessels to include in the model, which is straightforward in the limited entry fleets because all vessels with permits could be included. If a system of open access registration or permitting is adopted, then this approach may become more feasible in the open access sector. Individual-based models could be estimated using a hurdle model such as the Cragg-hurdle model, which jointly estimates the probability of fishing and the expected revenue conditional on fishing (see Holland et al. 2020 for an example).
- Adding additional variables that might require forecasts. The model evaluation process considered several variables, including fuel prices and the Japanese Yen – US Dollar exchange rate. These variables would require forecasted values in order to be useful in predicting sablefish catch. There may be publicly available values for use (e.g. from Yen futures markets). If these variables are included, analysts should consider whether their

inclusion is necessary. For example, the Japan-US exchange rate is correlated with sablefish price and likely affects catch through its effect on sablefish price.

References

Holland, D.S. and J. Leonard 2020. Is a Delay a Disaster: Evaluation the Economic Impacts of the Delay of the California Dungeness Crab Fishery due to a Harmful Algal Bloom. Harmful Algae 98 (September 2020) 101904.

Appendix 1

SSC Economics Subcommittee Members Present

Dr. Cameron Speir (SSC Economics Subcommittee Chair), National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, CA
Dr. Michael Hinton, San Diego, CA
Dr. Dan Holland (SSC Chair), National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Dr. Matthew Reimer, University of California Davis, Davis, CA

SSC Groundfish Subcommittee Members Present

Dr. John Budrick, (SSC Groundfish Subcommittee Chair), California Department of Fish and Wildlife, San Carlos, CA
Dr. Kristin Marshall, National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, WA
Dr. Tommy Moore, Northwest Indian Fisheries Commission, Olympia, WA
Dr. Jason Schaffler (SSC Vice-Chair), Muckleshoot Indian Tribe, Auburn, WA
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Scientific and Statistical Committee's Economics and Groundfish Subcommittees Report on Sablefish Daily Trip Limit Model

Pacific Fishery Management Council
Online Meeting

May 9, 2023

The Scientific and Statistical Committee's (SSC) Economics and Groundfish Subcommittees met virtually on May 9, 2023 to review the updates to the Sablefish Daily Trip Limit Model proposed by the Groundfish Management Team (GMT). The review document can be found here: https://rpubs.com/robwm477/1030260.

The Subcommittees have three major recommendations for changes to the model and model evaluation process. This report also contains other recommendations.

The SSC also notes that accurately modeling participation, particularly in the open access sector, may be extremely difficult as it is likely impacted by outside opportunities (or loss of them) for a large group of potential participants as well as conditions and trip limits in the sablefish fishery. Focusing effort on predicting participation is likely to improve overall model performance more than improvements in the vessel catch model, but with no real limits on participation in the open access sector it is unclear how well participation and thus overall catch can be predicted.

1. Alternative models should be evaluated using different metrics based on out-of-sample prediction performance.

The current analysis uses R^2 as the measure of predictive performance. The subcommittees recommend that the models be evaluated based on out-of-sample performance. Cross-validation procedures that use part of the data to estimate a model and then compare it to the unused observations (e.g., leave-one-out, one-step-ahead) are potential methods.

In addition, the analysts should consider the consequences of poor prediction performance and evaluate model performance in terms of the risk of exceeding the ACL. Measures such as Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) measure the magnitude of expected prediction error. In addition, it is possible to quantify prediction bias, the tendency to over-predict versus under-predict. Measures such as Mean Forecast Error and Mean Percent Error will assess a model's tendency to over-or under-predict. Methods such as lasso regression and ridge regression can also be used to assess prediction bias versus efficiency tradeoffs.

2. Forecast methods should incorporate period-specific outcomes in a transparent and systematic way.

The current version of the model evaluation presents the vessel participation and catch per vessel models as single equations. Model selection is based on R^2 values of single equations estimated with pooled data (i.e., data containing all six intra-annual periods). However, forecasting is performed by estimating six separate equations, one for each two-month period, and generating predicted values from period specific equations.

Both models (vessel participation and catch per vessel) should incorporate period specific effects. Estimating separate equations for each period accomplishes this and allows the coefficients to vary across periods. If this approach is evaluated, then model performance should be evaluated for each period individually. That is, the set of predictor variables should not be constrained to be the same across all periods (the best performing models may have different combinations of variables). The drawback of this approach is that the data set for each model would be substantially smaller, containing only one observation per year. An alternative would be to estimate a pooled model (a single equation with all periods included in the data) with period specific fixed effects. This would allow for seasonality in the outcomes and provide more degrees of freedom. Estimating these fixed effects from the data is alternative to the "period 4 peak adjuster" described in Section 3.1.2. The peak adjustor is arbitrary in its scaling and simply using period fixed effects would be preferable. The analysts could also allow slope coefficients to vary by period by including an interaction between the slopes and period-specific dummy variables. This would leave few degrees of freedom and may lead to overfitting, however, which again highlights the importance of using out-of-sample prediction in model selection. Fitting a model with pooled data and fixed effects of period and period slopes may also indicate that intercepts or slopes for some periods are not significantly different from each other. This cannot be evaluated when modeling each period separately.

3. Consider the following when choosing explanatory variables to include in the models:

- Including explanatory variables that require forecasting (such as Dungeness crab prices or fuel prices) adds complexity for a relatively small increase in model fit. While these variables may in fact influence participation, adding them to the model may not be warranted, particularly if these explanatory variables cannot be accurately forecasted. If variables that require forecasting are included in the models, then the forecast method must also be included in the model evaluation.
- The analysts should consider incorporating time components in the model. The simplest method is to include a time trend. Using lagged dependent variables to incorporate autocorrelation is another option.
- Add fixed effects for 2020 and 2021 to account for effects of the COVID-19 pandemic.
- The model selection process is limited by only including linear terms. Prediction performance could be improved by considering squared terms and interactions. The model suite, or "dredge", approach used to help select the LEN model (Section 2.2.6) could also be used to select which of these nonlinear terms might be included.
- Season structure (e.g., number of open days for salmon or crab) may be a good predictor of sablefish effort and catch. However, the analysts indicated that the timing of the regulatory cycle may make using these variables in forecasts difficult.
- The US-Japan exchange rate and Annual Catch Limit for Alaskan sablefish fisheries may be useful predictors to consider.
- Bimonthly and weekly trip limits appear to be highly correlated, so it is unclear whether including both is necessary or appropriate.

Other Recommendations

The analysts could estimate individual, rather than aggregate, models. The current model estimates total number of vessels and average catch per vessel across the entire fleet. An alternative would be to model the participation decisions and expected catch at the individual level using a hurdle model such as the Cragg-hurdle model, which jointly estimates the probability of fishing and the expected revenue conditional on fishing (see Holland et al. 2020 for an example). Effectively, the model jointly estimates a binary logit model of participation choice and a linear model of expected revenue for observations of positive revenue. This approach would have the advantage of allowing changes in fleet composition and behavior as well as incorporating the effects of outlier vessels in the data. This alternative should be a long-range development option as it would require a substantial rethinking of how catch is modeled. Further, selecting which vessels to include in the participation model would be difficult. It would be straight forward for the limited entry fleet because all vessels with permits could be included in the data set. For the open access fleet, however, it is less clear which vessels would be included in the model. As a "one-off" exercise, this type of model would not be difficult. However, maintaining the model to use for policy would be much more difficult.

The analysts should explain the "upweighting" method used and evaluate alternative weighting schemes.

The authors indicated that data prior to 2011 were not compatible with data post due to structural changes in the fishery. However, another longer-term exploration could involve modeling pre-2011 data using fixed effects or other methods to account for that structural change. The additional degrees of freedom from using a longer time series could be particularly useful to evaluate period specific impacts.

References

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