Butterfish OFL-CV Determination

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Background

An enhanced stock assessment process for butterfish was initiated in 2020 that included a research track assessment (peer reviewed, March 2022) which provided the working group (WG) with maximum flexibility to develop a new and improved stock assessment (analogous to the previous SAW assessments), and a management track assessment (compiled June 2022) which updated data inputs, the analytical model, and the reference points associated with the 2021 research track assessment.

1. Data Quality

- Landings from 1989-2021 spanned three phases of commercial fishing activity: the historic directed fishery (1989-2001), the bycatch fishery (2002-2011), and the recent directed fishery (2012-2021). Landings during the recent directed fishery showed a variable but increasing trend through time, with magnitudes in several years comparable to those during the historic directed fishery (~3500-4000 mt).
- Discard estimation was based on the standardized bycatch reporting methodology (SBRM, Wigley et al. 2007). During the historic directed and bycatch phases, the magnitude of discards often exceeded landings, however, during the recent directed fishery, discards have generally remained lower than landings (~1300-1600 mt). In the early part of the time-series, estimated precision of discards was generally poor, but since 2010, estimated precision has been good.
- Landings-at-age have been stable within each of the three phases, with most harvested fish being ages 1-3 (majority age 2). Very few age 4+ fish appear in the landings. Most discards are age 0-2 with some age 3 fish and very few age 4+ fish.
- The research track Peer Review Panel (herein, the Panel) concluded that the gap filling procedure applied by the WG to develop the age-length key and landings length composition likely leads to blending of cohorts which could introduce bias into the age composition data. Data gaps could be treated as missing years in the assessment model.
- Indices of relative abundance recommended by the WG were based on the NEFSC Albatross Fall survey, NEFSC Spring and Fall Bigelow surveys, NEAMAP Spring and Fall surveys, and a coastal YOY composite time series based on six state surveys. The NEFSC Albatross and Bigelow surveys were treated separately in the assessment model. Uncertainties associated with the survey indices were well quantified.
- The Panel suggested that the NEFSC Spring Albatross survey be included only as a sensitivity since butterfish availability during spring seems to have changed over time. The Panel also recommended that the life history data derived from different survey programs be compared to identify possible spatial variability.

2. Model appropriateness and identification during the assessment process

- Initial model development done with ASAP3. The final ASAP3 model was brought into the Woods Hole Assessment Model (WHAM) for further development.
- WHAM model preferred, years 1989-2019, ages 0-4+.
- WHAM can implement random effects on interannual transitions in numbers-at-age, M, and selectivity.
- The Panel made several comments/recommendations to the assessment modeling approach:
    - Develop a model with a shorter time step than one year to more accurately reflect the biology of butterfish (relatively short-lived species).
    - Separate catch into retained and discarded components as opposed to estimating the weight of discards and adding those quantities to landings. Age-structure of discards shows a skew toward smaller/younger fish when compared to that of the landings.
    - Presentation of a broader set of sensitivity model runs.
    - Free selectivity estimation (as opposed to estimation of a functional form) could hide or compensate for an incorrect value of M.
    - Butterfish scale cannot be reliably estimated because there is little indication that fishing has affected abundance. Therefore, choosing a value for one of the catchabilities (q's) essentially defines scale/abundance.
- WHAM model diagnostics showed generally good model fit and performance.

3. Informed by retrospective analysis

- A retrospective analysis was performed and no retrospective adjustments were made to assessment model results.

4. Informed by comparison with simpler analyses

- Presumably because of the sizable workload associated with first developing an ASAP3 model (reverting back from the ASAP4 model in recent assessments), migrating the final ASAP3 model to WHAM, and then further developing the WHAM model, no simpler analyses were presented.

5. Informed by ecosystem factors or comparisons with other species

- The assessment included consideration of stomach contents data from NEFSC trawl surveys and studies on marine mammals and birds. The estimated consumption amounted to a small fraction of the estimated losses due to natural mortality. This result is odd given that butterfish is considered a forage species.
- The Panel recommended that the WG consider alternative approaches for estimating consumptive removals of butterfish, and noted that results of the consumption study could be an indication that the estimated scale of the butterfish stock is too high.

6. Informed by measures of trend in recruitment (primarily affecting the accuracy of forecasts)

- The WG considered several potential candidate reference points and recommended $F_{50\%}$ and $B_{50\%}$. However, the Panel had significant concerns about the very high estimated value for $F_{50\%}$ (> 6.0 yr^{-1}, ~ 99.9% mortality for fully selected ages). The recent range of years for estimation of $B_{50\%}$ was viewed as appropriate. Fishing appears to have little impact on the butterfish stock.
- The Panel noted that the previously used reference point of F = 2/3M may be more appropriate than $F_{50\%}$.
- Short-term projections of catch and SSB were computed by sampling from the cumulative distribution function of WHAM recruitment estimates, 2011-2021. The most recent 5-year averages were used for the annual fishery selectivity, maturity ogive, and mean weights-at-age. The WHAM model assumes an AR(1) process for recruitment.

7. Informed by prediction error

- Predictive skill of the WHAM model was evaluated. Aggregate and age composition data for one index at a time were removed, the model was fitted to the reduced data, and the model was used to predict the removed data. Mean absolute scaled error (MASE) of the predictions over time horizons (1-3 years) was computed and appeared to be relatively low.

8. Assessment accuracy under different fishing pressures

- Accuracy of assessment results were not characterized in relation to different fishing pressures.

9. Informed by simulation analysis or full MSE

- The assessment results and subsequent management advice were not informed by simulation analysis or MSE.

Summary

Based on the 2021 management track assessment results, the butterfish stock is not overfished and overfishing is not occurring. SSB in 2021 was estimated to be 66,566 mt, which is 169% of the biomass target ($SSB_{MSY\ Proxy}$ = 39,436 mt). The fully selected fishing mortality rate was estimated to be 0.19, which is 3% of the overfishing threshold ($F_{MSY\ Proxy}$ = 5.6). The PRC accepted the stock assessment model results and affirmed that they can be used to formulate management advice. Major sources of uncertainty include:

- Scale of the population. A q of 0.2 for the Fall Albatross survey was needed to reasonably scale the population. However, a q of 0.2 implies 80% of the stock is not within the survey area, which is potentially problematic given that butterfish are frequently captured throughout the survey.

- Uncertainty in discard estimates, particularly early in the time-series.
- Gap filling procedures potentially blending cohorts and potentially leading to bias in the age composition data.
- Estimated consumption removals comprise only a small fraction of estimated M. Results seem inconsistent with butterfish being considered a forage species.
- Gap filling procedures for years with missing data potentially blending cohorts.
- Choice of reference points, especially $F_{50\%}$ since the value was estimated to be > 6.0 in the research track assessment, and 5.6 in the management track assessment.