CONSIDERATIONS FOR DECIDING THE OVERFISHING PROBABILITY (P*) WHEN SPECIFYING AN ACCEPTABLE BIOLOGICAL CATCH

Background

West coast groundfish stocks are managed under a harvest specification framework that considers scientific and management uncertainties. The first specification decided is the overfishing limit (OFL), which is the maximum sustainable yield (MSY) estimated for the stock and the legal harvest limit beyond which constitutes overfishing. The OFL is determined either by applying the harvest rate estimated to result in a biomass capable of sustaining MSY (i.e., F_{MSY}) recommended by the Council's Scientific and Statistical Committee (SSC) to an estimate of exploitable biomass in the case of assessed stocks or through an approved data-poor method (e.g., depletion-corrected average catch (DCAC) or depletion-based stock reduction analysis (DBSRA)) in the case of unassessed stocks. Regardless of the method or data informing the calculation of an OFL, there is scientific uncertainty in the estimation of an OFL. The Pacific Coast Groundfish Fishery Management Plan (FMP) mandates a precautionary buffer to address this uncertainty by prescribing an acceptable biological catch (ABC) harvest level that is less than the OFL. A further reduction from the ABC can be specified when setting an annual catch limit (ACL) that accounts for management uncertainty, socioeconomic considerations, ecological considerations, conservation objectives, and/or other considerations the Council and NMFS wish to address. Since the ACL can be set equal to the ABC, the ABC is the highest harvest level that can be considered for west coast groundfish stocks.

Under the FMP harvest specification framework, scientific advice that is relatively uncertain will result in ABCs that are relatively lower, all other things being equal (i.e., a precautionary reduction in catch will occur due purely to scientific uncertainty in estimating the OFL). The SSC has recommended a two-step approach referred to as the overfishing probability (P*) approach for determining ABCs. In the P* approach, the SSC determines the amount of scientific uncertainty associated with estimating the OFL in stock assessments, referred to as the sigma (σ) value. Since the OFL is estimated by applying the harvest rate estimated or assumed to produce MSY (i.e., F_{MSY}) to the exploitable biomass and since assumed proxy F_{MSY} harvest rates by taxa are currently used to estimate the OFL, the variance in estimating biomass is the metric used for determining sigma. The Council chooses its preferred level of risk of overfishing, which is designated as the P*. The scientists then apply the P* value to the sigma value to determine the amount by which the OFL is reduced to establish the ABC.

The SSC assigns each species in the groundfish fishery to one of three categories based on the level of information available about the species. The SSC's recommended sigma value for category 1 stocks is based on a statistical analysis of the variance within and among stock assessments. The meta-analysis used stock assessments from 17 data-rich stocks to determine the proxy sigma value for category 1 stocks. The general methodology used by the SSC subcommittees to assess among-assessment uncertainty was to compare previous stock assessments and stock assessment updates and consider the logarithms of the ratios of the

biomass estimates for each pair of assessments and their reciprocals using the last 20 years from an assessment. This provides a distribution of stock size differences in log-space and, if this variation is averaged over species, provides a general view of total biomass variation (represented as sigma - σ) that emerges among repeat assessments of stocks, while embracing a wide range of factors that affect variability in results. The SSC indicated that biomass is most likely the dominant source of uncertainty; however, it is anticipated that other factors will need to be considered in the future.

Based on this analysis, the SSC recommended using the biomass variance statistic of $\sigma = 0.36$ for category 1 stocks. In cases where the stock biomass estimated in the most recent assessment has a variance greater than the variance estimated for that stock's category, the assessment's estimated biomass variance is used instead. For instance, the stock biomass estimated in the 2011 widow rockfish assessment was judged to have a greater variance than the sigma of 0.36 used for other category 1 stocks. In this case, the SSC recommended using a sigma value of 0.41 for deciding the widow rockfish ABC. The 2013 assessment cycle produced another category 1 stock with an estimated biomass variance greater than 0.36; aurora rockfish had an estimated sigma of 0.39. Each P* is mapped to its corresponding buffer fraction. The Council then recommends an appropriate P* value. When the P* approach is used, the upper limit of P* allowed by the FMP is 0.45.

Since there is greater scientific uncertainty for category 2 and 3 stocks relative to category 1 stocks, the scientific uncertainty buffer is generally greater than that recommended for category 1 stocks. The SSC recommended sigma values for category 2 and 3 stocks of 0.72 and 1.44, respectively (i.e., two and four times the sigma for category 1 stocks). The specific values of 0.72 and 1.44 were recommended by the SSC and considered to be the best available scientific information; however, the values are not based on a formal analysis of assessment outcomes and could change substantially when the SSC reviews additional analyses in future management cycles.

Considerations for Deciding P*

The overfishing probability metric (P*) is technically defined in the National Standard 1 guidelines as the probability of overfishing a stock based on the scientific uncertainty in estimating the OFL. There is always scientific uncertainty in estimating both the exploitable biomass and the harvest rate associated with maximum sustainable yield; the product of which is the OFL. This technical definition has generated a level of confusion in the Council's harvest specification decision-making process (further, there are those that take the "overfishing probability" term literally, believing it incorporates all sources of uncertainty that affect the probability that the estimated OFL is too high). There are those that maintain the technical or literal definition of the overfishing probability. The functional definition is that P* is the Council's level of risk tolerance that the OFL will be exceeded due to error in the biomass estimate. The latter argument is more tractable in the Council process and is a more accurate representation of how the P* value is decided.

One problem with the technical definition of P* is that not all assessments are alike. The SSC recognizes this and has recommended a proxy value of sigma (0.36) for category 1 stocks, which are stocks that have assessments with estimated recruitment deviations (i.e., the strength of

individual year classes is estimated). However, the SSC acknowledges that the proxy sigma for category 1 stocks may not represent the relative uncertainty of all category 1 stocks. For this reason, sigma is estimated in new category 1 assessments. If the estimated sigma is greater than the proxy value of 0.36, then the estimated sigma is used rather than the proxy value. However, the true scientific uncertainty is not estimated well in this process. Assessments vary greatly in the amount of uncertainty that is characterized in the assessment model. It is common that one or more parameters are either estimated outside the model or assumed based on the assessment scientist's best judgment. In such cases, the uncertainty associated with that parameter is also not estimated nor characterized in any way within the assessment. For instance, the 2011 sablefish assessment (Stewart, Thorson et al. 2011) appears to estimate current biomass with significant uncertainty. However, within that assessment many of the key parameters that affect the estimated biomass such as growth and natural mortality are explicitly estimated within the model[1]. The confidence interval associated with the ending year biomass estimate appears quite large relative to other assessments since the uncertainties associated with estimated growth and natural mortality are included within the overall assessment uncertainty. This compares to many other assessments, such as splitnose rockfish in 2009 (Gertseva, Cope et al. 2009) or longspine thornyhead in 2013 (Stephens and Taylor 2013) where many parameters are assumed and fixed (e.g., natural mortality and steepness) and the estimated biomass variance appears smaller. However, this is not necessarily the case; more of the true uncertainty in estimated biomass is characterized in the sablefish assessment.

The spectrum of assessment approaches vary between fully Bayesian models with most key parameters estimated (e.g., sablefish in 2011) to deterministic models with most parameters fixed (e.g., longspine thornyhead in 2013). Within the spectrum are parameter estimations using informed or diffuse priors, where parameters are estimated within either tight bounds (informed priors) or estimated with a much wider distribution (diffuse priors). Given this variety of approaches and the degree to which uncertainty is characterized, it is hard to pursue a formulaic approach where the P* decision hinges on the scientific uncertainty associated with estimating the OFL. For the most part, the relative uncertainty in estimating the OFL is addressed with the SSC's sigma specification. The Council's P* decision is therefore most appropriately considered as a risk assessment given many sources of uncertainty regarding the true state of nature or true OFL for a stock. The risk of overfishing a stock as contemplated in a P* decision therefore needs to consider the cost of being wrong. Such costs may weigh the socioeconomic importance of the stock, the attainment rate of a stock's harvest limit, the relative vulnerability of a stock to overfishing based on its relative productivity and susceptibility of the stock to be impacted by the fishery, and a host of other factors. Many of these same considerations are made when deciding the ACL. Since the ACL is the effective total catch limit used to manage fisheries, the absolute risk of overfishing is ultimately made when deciding this limit. Therefore, it does not matter whether these considerations are made in deciding the P*/ABC or the ACL for the stock. What does matter is that these considerations are made in deciding harvest limits and having the ability through effective management measures, inseason monitoring of catches and adjustments to management measures specified for fisheries to keep harvest within prescribed limits. The Council's track record on this is quite good and the precautionary principles that underlie the

[1] Stock-recruitment steepness (h), another parameter that affects the estimate of biomass, is fixed at an assumed 0.6 in the 2011 sablefish assessment.

FMP harvest specification framework effectively address the risk of overfishing by considering scientific and management uncertainties.

Literature Cited

Gertseva, V., J. M. Cope, et al. (2009). Status of the U.S. splitnose rockfish (*Sebastes diploproa*) resource in 2009. Portland, OR, Pacific Fishery Management Council.

Stephens, A. and I. G. Taylor (2013). Stock assessment and status of longspine thornyhead (*Sebastolobus altivelis*) off California, Oregon and Washington in 2013. Portland, OR, Pacific Fishery Management Council.

Stewart, I. J., J. T. Thorson, et al. (2011). Status of the U.S. sablefish resource in 2011. Portland, OR, Pacific Fishery Management Council.

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