SSC GROUNDFISH SUBCOMMITTEE STATEMENT REGARDING A CHANGE IN TARGET SPR RATE FOR WEST COAST ELASMOBRANCH SPECIES

Background of the problem

The Pacific Fishery Management Council (the Council) uses biological reference points to determine whether a stock is in an overfished state, and whether overfishing is occurring. The former is determined from the estimated depletion level, which is the ratio of the reproductive output (number of eggs or embryos) in the fished condition, to the reproductive output in the unfished condition. The latter is determined by a fishing mortality rate (F), expressed based on spawning potential ratio (SPR). This ratio is the number of eggs (or another appropriate measure of reproductive output) produced by an average recruit over its lifetime when the stock is fished, divided by the same metric when the stock is unfished. The SPR is based on the principle that certain proportions of fish have to survive in order to spawn and replenish the stock at a sustainable level.

The spiny dogfish shark (*Squalus suckleyi*) is an elasmobranch fish species that inhabits waters of the North Pacific Ocean. In North America, spiny dogfish occur from the Gulf of Alaska to southern Baja California. The status of this species off the West Coast of the United States, in the area managed by the Council, was assessed for the first time in 2011 (Gertseva and Taylor 2011). The spiny dogfish assessment model estimated the reproductive output of the stock at the beginning of 2011 to be 63% of its unfished level, which is well above the MSY proxy reproductive output of 40% of the unfished condition of the stock.

The default proxy fishing mortality rate for spiny dogfish used by the Council has been $F_{SPR45\%}$. This value is not based on an analysis specific to spiny dogfish or other elasmobranchs, but rather on teleost species (whose life history is quite different), since information on elasmobranch species is generally limited.

The current spiny dogfish assessment model predicts that fishing at the current proxy rate of $F_{SPR45\%}$ will severely reduce the reproductive output of the stock over the long term, due to low productivity and other reproductive characteristics. The current assessment indicates that a rate no greater than $F_{SPR79\%}$ (higher SPR values equate to lower fishing mortality rates) would be required to maintain reproductive output near MSY proxy reproductive output.

The spiny dogfish Stock Assessment Review (STAR) Panel suggested that the Council's Scientific and Statistical Committee (SSC) consider the appropriateness of the current proxy fishing mortality rate for spiny dogfish. The SSC agreed that the Council's F_{MSY} proxy of $F_{SPR45\%}$ may be too aggressive for spiny dogfish. The Council tasked the SSC to evaluate the current proxy and, if needed, propose a new target SPR value for spiny dogfish, as well as other elasmobranchs (sharks, skates, and rays) managed under the Groundfish Fishery Management Plan, since they share similar life history characteristics.

The analysis

Introduction

The SSC has previous noted that proxy reference points should ideally be based on analysis and consideration of multiple species within a taxonomic group with similar life history characteristics, to avoid problems of high variability in estimates of SPR and MSY reference points within and between stock assessments, for any individual species (Haltuch et al. 2008). Exceptions to this would only be for stock assessments displaying a remarkable degree of consistency and certainty. Following the 2009 petrale sole assessment, the Council revised the reference points for flatfish, separately from other groundfish species. Then, the SSC rejected the notion of setting the target SPR rate based upon a single stock assessment and species[1], and revised the flatfish proxies only after undertaking a meta-analysis involving multiple species.[2]

Zhou et al. (2012) compiled information on fishing mortality reference points for more than 200 species and stocks worldwide that have been assessed with various methods, and conducted a meta-analysis to link fishing mortality-based reference points to natural mortality and other life history traits. Zhou et al. used Bayesian hierarchical errors-in-variables models to investigate the relationships and included the effect of taxonomic class and order.

To inform an appropriate target SPR rate for West Coast elasmobranch species managed by the Council, Dr. Martin Dorn conducted the following analysis using results reported in Zhou et al. (2012). The SSC Groundfish Subcommittee reviewed this analysis and formed its recommendation for the Council during a conference call that took place on August 16, 2013.

Methods

To obtain a target SPR value for elasmobranchs, the posterior distribution for F_{MSY}/M as reported for Chondrichthyes in the meta-analysis conducted by Zhou et al. (2012) was used. Chondrichthyes (with n=12) was used since the distributions at the lower taxonomic levels were considered unreliable, due to small sample sizes. Values of natural mortality used in Zhou et al. were highly uncertain; therefore the analysis used the mean-unbiased distribution of F_{MSY}/M ratio, in which measurement error in M was taken into account. This distribution has a mean of 0.460 and standard deviation of 0.088 (Zhou et al. 2012). A large set of random draws was taken from the F_{MSY}/M posterior distribution. Normal and lognormal distributions for the sampled F_{MSY}/M ratio were explored. These two distributions did not differ substantially (Figure 1), and the results of the analysis were not sensitive to the assumed distribution. Therefore, the normal distribution was used for the target elasmobranch SPR analysis.

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[1] PFMC Agenda Item E.6.c. Supplemental SSC Report, June 2009: "The SSC does not consider that a strong enough case has been made that the estimate of B_{MSY} is sufficiently reliable to be used for fisheries management… the SSC recommends that these analyses and model changes be reviewed by the SSC Groundfish Subcommittee at a short meeting during August. … The Groundfish Subcommittee may also consider whether a single proxy could be used for west coast flatfish stocks, since other assessed flatfish show the high productivity characteristics of petrale sole."

[2] PFMC Agenda Item E.2.c. Supplemental SSC Report, September 2009; SSC groundfish subcommittee Report on Petrale Sole: "The use of proxy estimates of F_{MSY} and B_{MSY} was adopted by the council due the inherent statistical difficulties in estimating these quantities in any single stock assessment and because of a well-developed scientific literature supporting the use of proxies."

The shark assessments used in the Zhou et al. meta-analysis were all based on aggregate biomass dynamics models and thus, values of F_{MSY} reported by Zhou et al. would not necessarily be comparable to F_{MSY} values produced by the age-structured models that were used in the spiny dogfish and longnose skate assessments, which are the only two West Coast elasmobranch species that have been assessed. To convert the Zhou et al. F_{MSY}/M ratio to dogfish and longnose skate SPR rates, we used life history parameter vectors from the most recent (and only) dogfish and longnose skate assessments, and solved for SPR rates that produce an equilibrium (Catch/Mean exploitable biomass)/M ratio, which is equal to the F_{MSY}/M ratio from Zhou et al. It was assumed that Catch/Mean exploitable biomass approximates a production model fishing mortality, (i.e., $C = F\,\bar{B}, F = C/\bar{B}$). Since both catch and exploitable biomass can be expressed on a per recruit basis, the per recruit term cancels out, so that the developed relationship does not depend on the shape of the stock-recruit curve.

Life history vectors used included natural mortality at age, mid-year weight at age, reproductive output at age, selectivity at age, and fishery weight at age. All vectors were sex-specific. For spiny dogfish, where multiple fisheries were modeled in the assessment, a weighted average selectivity was used, with weights informed by the relative fishing mortality in each fishery. Fishery weights at age for spiny dogfish were also weighted averages. The resultant transfer functions for converting the Zhou et al. F_{MSY}/M ratio to dogfish and longnose skate SPR rates are shown in Figure 2.

Results

For spiny dogfish, the mean SPR at F_{MSY} is $F_{\mathrm{SPR49\%}}$, at a full selection F of 0.026 and a catch/biomass ratio of 2.9%. For longnose skate, the mean SPR at F_{MSY} is calculated to be $F_{\mathrm{SPR45\%}}$, at a full selection F of 0.085, and a catch/biomass ratio of 9.0%. The distributions of longnose skate and spiny dogfish SPR obtained in the analysis are shown in Figure 3. An average mean SPR at F_{MSY} across both distributions is $F_{\mathrm{SPR47\%}}$.

The longnose skate assessment expresses reproductive output in spawning biomass (in common with most fish stocks), which may not accurately reflect elasmobranch reproductive biology; therefore it is reasonable to place more weight on the spiny dogfish result. Even in this case, $\mathrm{F}_{\mathrm{SPR50\%}}$ is the highest fishing mortality rate that does not exceed the F_{MSY} value with 50% probability for either longnose skate or spiny dogfish (Table 1).

SSC Groundfish Subcommittee Recommendations

The SSC's groundfish subcommittee continues to emphasize importance of using proxies as a general practice for management. It is usually very difficult to obtain reliable stock-specific estimates of F_{MSY} and B_{MSY} in any particular assessment (Haltuch et al. 2008). From a meta-analytical perspective, useful inference about management-related parameters can be drawn by comparative analysis of information drawn from studies of related species. Also, the use of proxies has a stabilizing influence on stock reference points, which is beneficial to the management process.

The SSC's groundfish subcommittee agrees that target elasmobranch SPR analysis (described above) represents the best available science and recommends that the Council adopt $F_{\mathrm{SPR50\%}}$ as the default proxy fishing mortality rate for elasmobranch species in the West Coast of the United States, managed by the Council.

The subcommittee will continue to review existing information that is relevant to the target fishing mortality rate for elasmobranches, which may influence and/or supersede this recommendation, and if so, the recommended value will be refined in the future.

References

Gertseva, V. V., Taylor, I. G. 2011. Status of the spiny dogfish shark resource off the continental U.S. Pacific Coast in 2011. In Status of the Pacific Coast Groundfish Fishery through 2011, Stock Assessment and Fishery Evaluation: Stock Assessments, STAR Panel Reports, and Rebuilding Analyses. Pacific Fishery Management Council, Portland, Oregon.

Haltuch, M.A., Punt, A.E., Dorn, M.W. 2008. Simulation testing alternative estimators of unfished stock size. Fish. Res. 94: 290-303.

Zhou, S., Yin, S., Thorson, J., Smith, T., Fuller, M 2012. Linking fishing mortality reference points to life history traits: an empirical study. Can. J. Fish. Aquat. Sci. 69: 1292–1301.

Table 1. Probability of different F values exceeding F_{MSY} for spiny dogfish and longnose skate.

	Spiny dogfish	**Longnose skate**
$Pr(F_{35\%}>F_{MSY})$	0.997	0.969
$Pr(F_{40\%}> F_{MSY})$	0.950	0.801
$Pr(F_{45\%}> F_{MSY})$	0.731	0.474
$Pr(F_{50\%}> F_{MSY})$	0.386	0.193
$Pr(F_{55\%}> F_{MSY})$	0.164	0.061
$Pr(F_{60\%}> F_{MSY})$	0.048	0.017

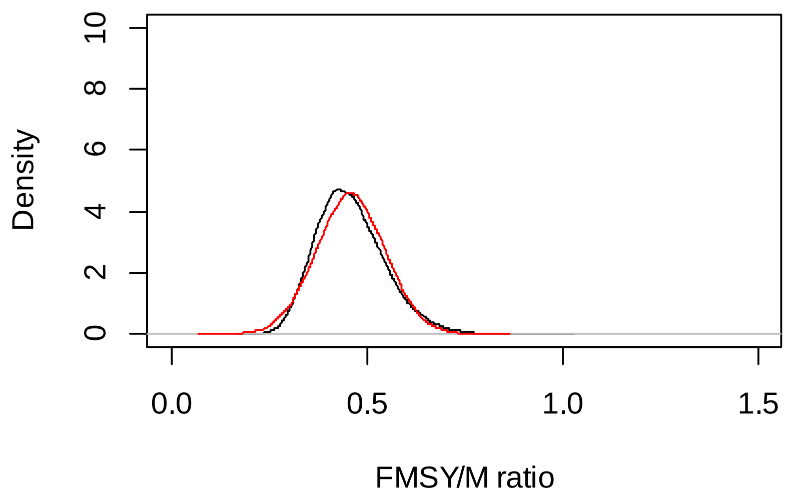

Figure 1. Comparison of normal and lognormal distributions for F_{MSY}/M developed based on results in Zhou et al. (2012). The curve on the right (red) is the normal distribution and the curve on the left (black) is the lognormal distribution. A normal distribution for F_{MSY}/M was assumed for the analysis.

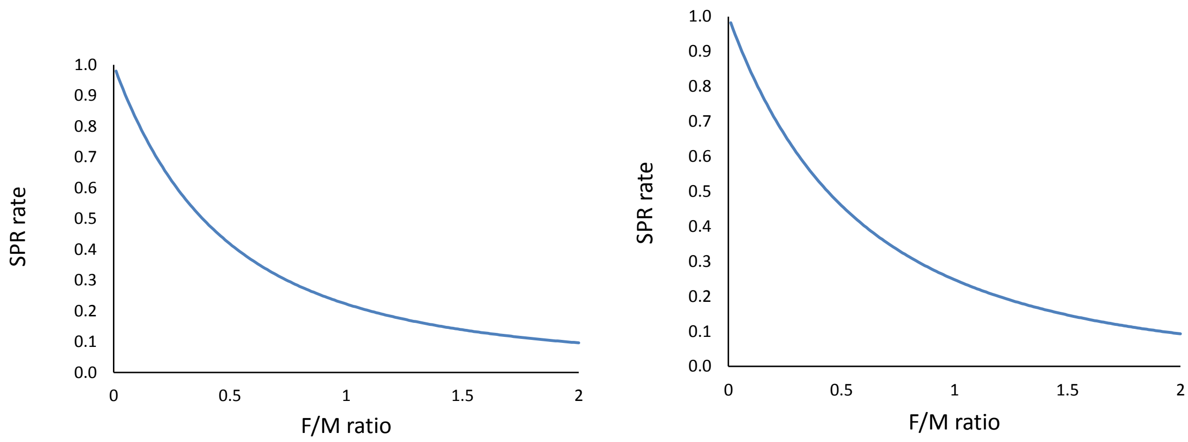

Figure 2. Transfer functions converting F_{MSY}/M to SPR for longnose skate (left panel) and spiny dogfish (right panel).

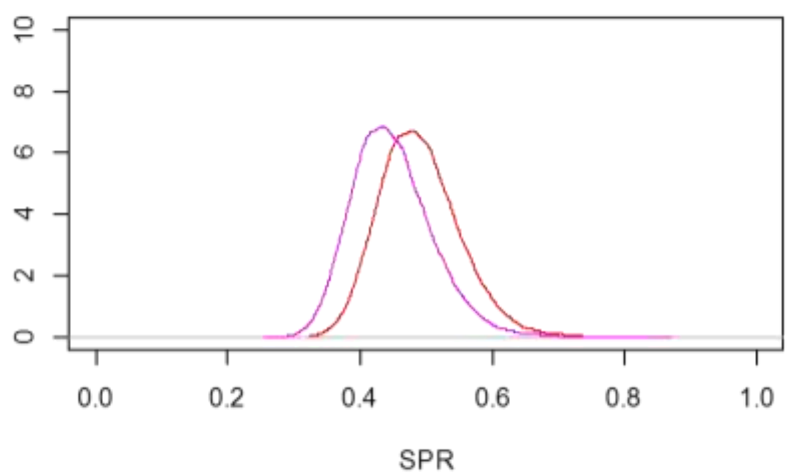

Figure 3. Distributions of spiny dogfish and longnose skate SPR obtained in the analysis. The curve on the right (red) represents spiny dogfish SPR distribution and the curve on the left (pink) represents longnose skate SPR distribution.