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Quantifying Uncertainty in Catch Forecasts… from a SSC perspective

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Annual Catch Limits (ACLs) and associated guidelines place greater demands on catch forecasts from stock assessments than previously needed. The first iteration of ACL implementation was focused on developing catch recommendations to meet the 2010-11 deadlines for federally managed marine fisheries. The Scientific and Statistical Committee (SSC) process involved a gradually increasing understanding of the many practical implications of the guidelines (Witherell and Dalzell 2009, Witherell 2010). Many catch recommendations were based on the existing technical guidance for implementing National Standard 1 (Restrepo et al. 1998), which offers several ways in which a precautionary approach can be incorporated into harvest control rules. However, the 2009 guidelines outline a management strategy that is not entirely consistent with the existing technical guidance, because precaution should now be more explicitly expressed as the difference between the overfishing limit (OFL) and Acceptable Biological Catch (ABC) to account for scientific uncertainty and optionally an Annual Catch Target to account for management uncertainty. A critical aspect of the management strategy is that a 'precautionary approach' should not be used to derive OFL. Revised technical guidance is needed to support ACLs by identifying best practices for catch forecasts, including each component of OFL and ABC: 1) the overfishing limit, 2) projected stock size and 3) their uncertainty.

As defined in the Magnuson Act, 'overfishing' means "*a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis*" (i.e., F_{MSY}). Performance of alternative approaches for estimating F_{MSY} has been evaluated. Biomass dynamics models have advanced from the early, equilibrium approaches (e.g., Schaefer 1957, Fox 1970) which are no longer used because they tend to overestimate productivity during periods of depletion (Hilborn and Walters 1992) . Non-equilibrium approaches to biomass dynamics are favored and have well-understood properties (see reviews by Polachek et al. 1993 and Prager 1994). Age-Structured models for estimating F_{MSY} also include equilibrium methods (e.g., Beverton et al. 1984, Sissenwine and Shepherd 1987) as well as non-equilibrium approaches that involve long-term stochastic projection (e.g., Mace 2001), providing a method that is entirely consistent with short-term projections of OFL. Estimation techniques include using assessment results (e.g., Jacobson et al. 2002, Sissenwine and Shepherd 1987) or estimating F_{MSY} in the assessment model (e.g., Prager 1994, Methot 2000); the later provides an integrated estimate of OFL uncertainty. Although the guidelines allow for OFL to be based on F_{MSY} proxies, Restrepo et al. (1998) limit the use of proxies to "*cases in which MSY cannot be estimated directly*." Many F_{MSY} proxies are used to define overfishing, because the yield curve may be 'flat' and F_{MSY} is not well determined, but direct estimates of F_{MSY} and the associated distribution are more appropriate for implementing the Act and guidelines (e.g., Figure 1 from NEFSC 2010). If ABC is intended to represent the Council's desired risk tolerance of overfishing, OFL should be based on F_{MSY} whenever possible rather than a proxy for F_{MSY}, because probability overfishing (as defined in the Act) is confounded by proxies.

Uncertainty in projected stock size includes both estimation error and model error. Most stock assessment models can quantify statistical uncertainty in recent and projected stock size estimates at $F=F_{MSY}$, providing an estimate of OFL and its distribution. Evaluating the magnitude of estimation error assumes that the model is correct, but historical or retrospective inconsistencies can indicate considerable model specification error. The Pacific Fishery Management Council includes 'among-assessment' variance in the evaluation of scientific uncertainty (Witherell 2010). Similarly, the magnitude of retrospective inconsistency was considered by the New England Council as a measure of scientific uncertainty, but the source of inconsistency is not understood, and its persistence during the forecast period is unknown.

If OFL forecasts are risk neutral, ABC can accurately reflect the Council's desired risk tolerance. Conversely, if OFL is itself precautionary, evaluating risk of overfishing will be confounded. Risk management can be extended so that optimum yield can be based on the probability of overfishing (P*<0.5) and other risks (e.g., the stock becoming overfished, foregone yield, etc.), so that ABC is derived from OFL "… *as reduced by any relevant economic, social, or ecological factor*", and the ABC control rule "*will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems*". New technical guidance is needed so that precaution is expressed in the desired risk of overfishing (P*) rather than precautionary overfishing proxies or stock assessment decisions.

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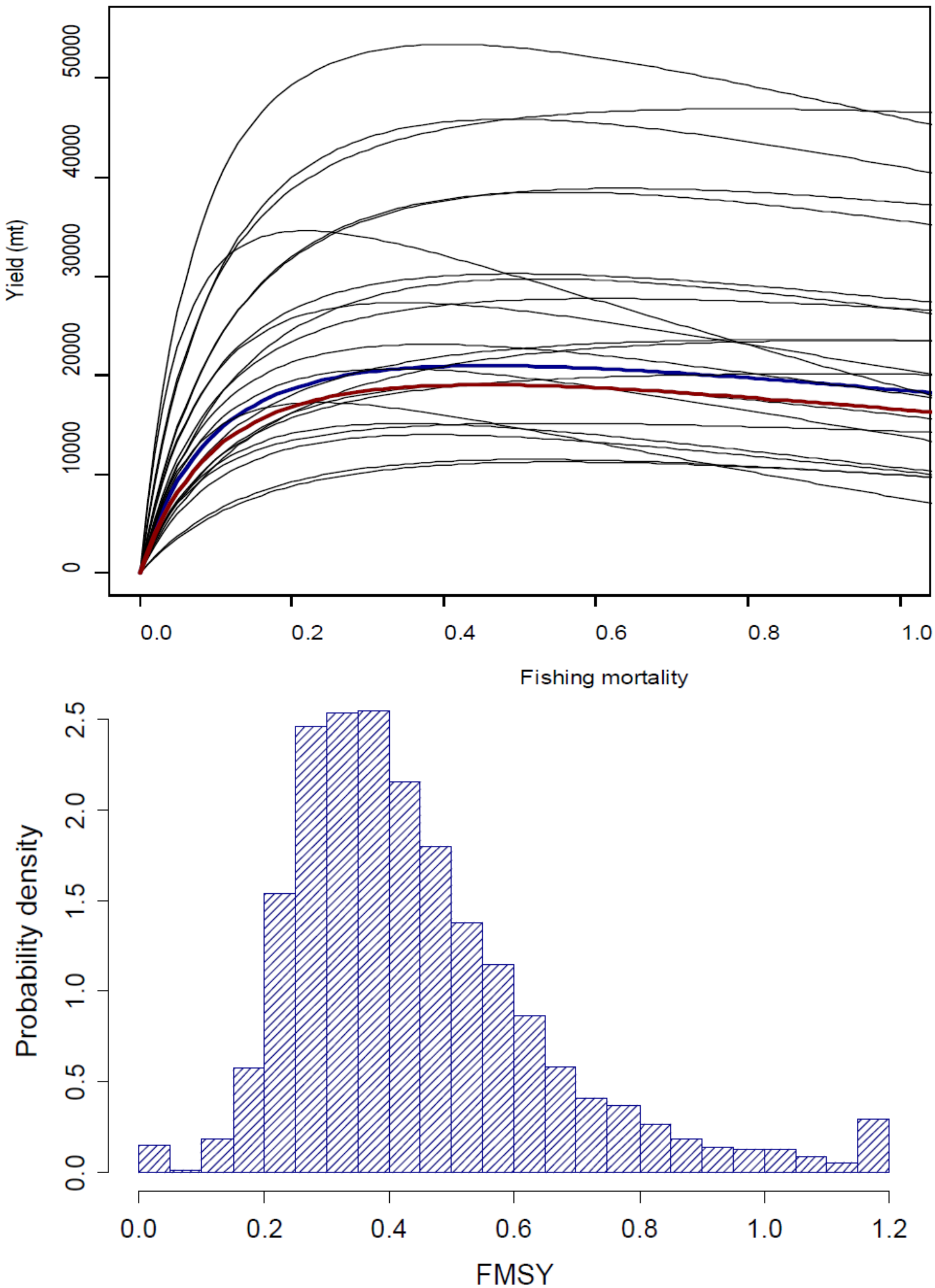

Figure 1. Yield of Mid-Atlantic sea scallops from 25 example simulations, the mean (red line) and median (blue line) of 50,000 simulations (upper panel) and probability densities for whole-stock F_{MSY} (from NEFSC 2010).