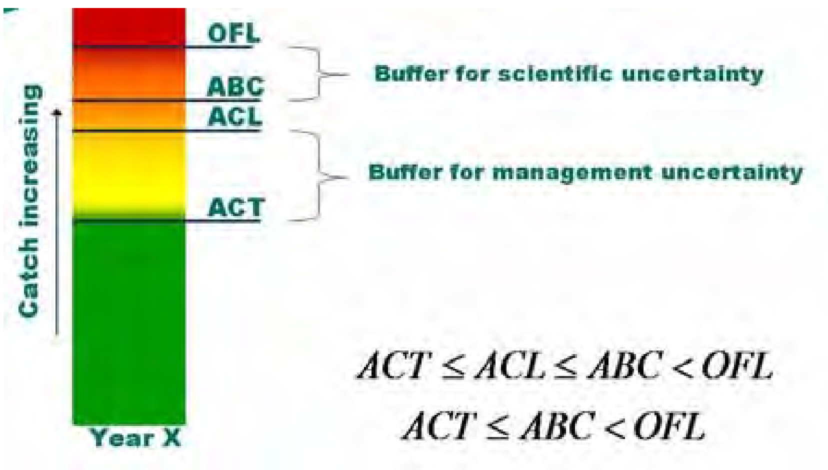
National Standard 1: ACLs and Scientific Uncertainty

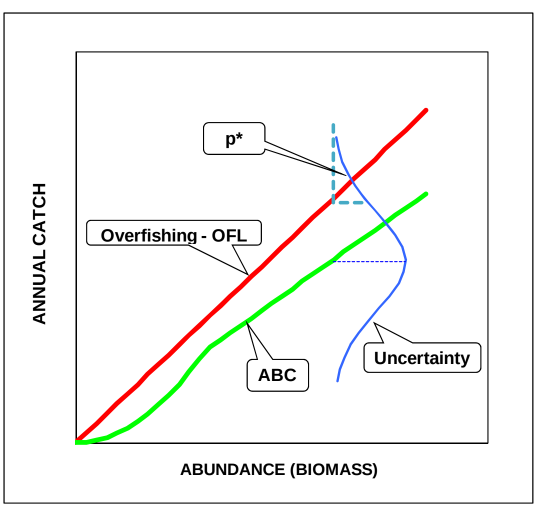
Control Rules and Scientific Uncertainty

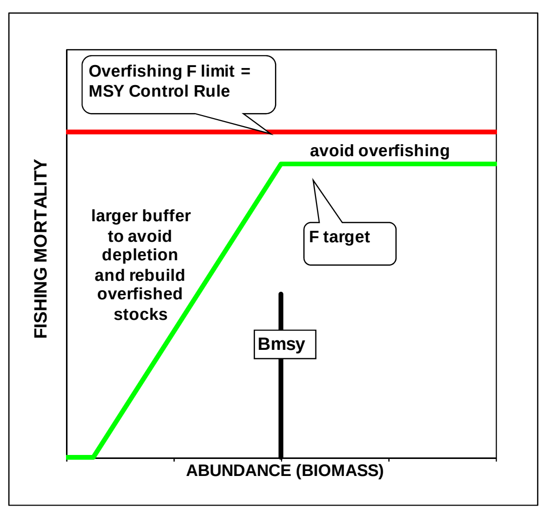
Rick Methot (NMFS) and Erik Williams (NMFS) provided a presentation on ABC Control Rules and Scientific Uncertainty. Their report is summarized below.

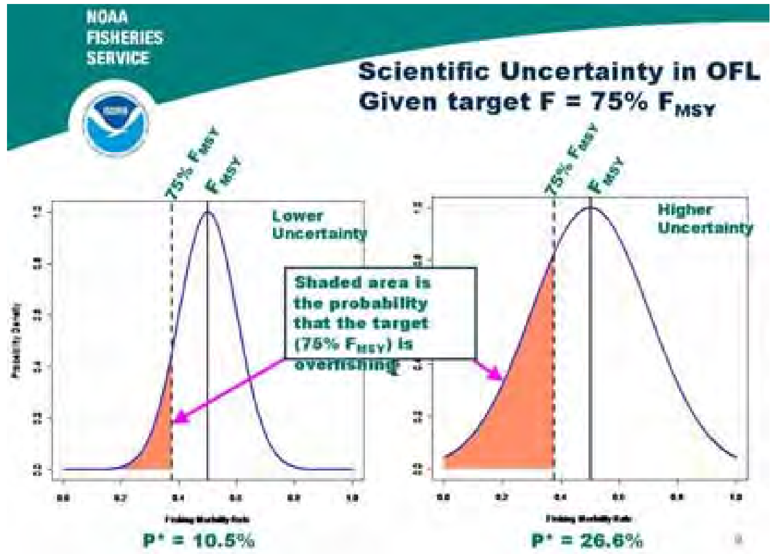


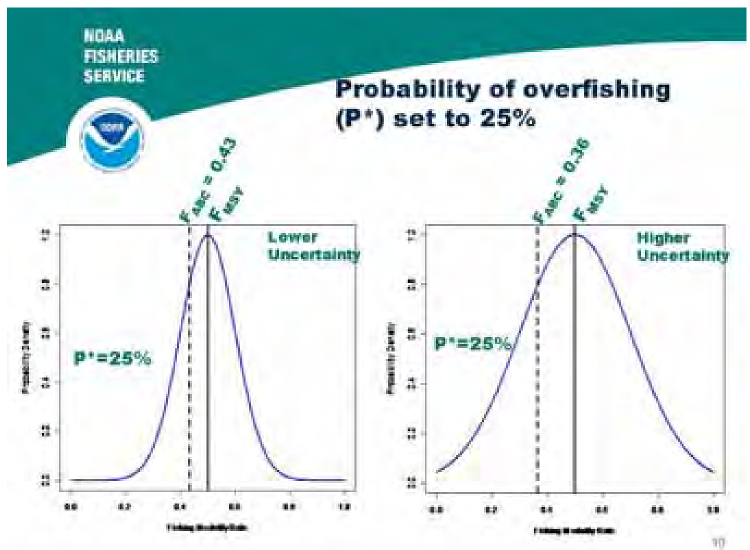
Control rules are procedures for translating information about the abundance and productivity of a fish stock into recommendations regarding future levels of fishing activity. A precautionary approach to implementation of such control rules was recommended in the 1998 version of the National Standard 1 Guidelines, and in a subsequent NMFS Technical Memorandum (Restrepo, et al., 1998). The 2009 update of the National Standard 1 Guidelines provides more explicit guidance regarding the need to account for scientific uncertainty when designing Acceptable Biological Catch (ABC) control rules to prevent overfishing.

An ABC control rule for a quantitatively assessed stock should take into account three basic factors: stock productivity, stock abundance, and uncertainty. Stock productivity is the primary factor in the calculation of the fishing mortality rate, F_{msy} or proxy, that would produce the maximum long-term yield. This fishing mortality rate is the limit for overfishing, F_{limit}. This rate, which determines the fraction of the stock caught per year, is applied to a forecast of the stock abundance for the next one or more fishing seasons to calculate the annual overfishing limit (OFL) in terms of catch. Thus the OFL, as an annual quantity, is expected to fluctuate in synchrony with fluctuations in stock abundance. It follows that long-term fishing at exactly the F_{msy}=F_{limit} would produce a time series of OFL catches, the average of which would be the maximum sustainable yield. However, it is not technically feasible to implement such a policy exactly because the OFL calculation is an estimate that has statistical and structural uncertainty. The ABC control rule is expected to take into account these uncertainties and create a buffer between the OFL and the ABC based on an acceptable probability of overfishing that cannot exceed 50% and should be lower. This probability is termed P*.









The methodology for computing P* is based on simple probability theory, by which scientific advisers can compute ABC from OFL and its statistical distribution, as estimated by a stock assessment. Several authors have demonstrated uses of probability theory to derive fishery reference points (typically denoted "targets" and "limits") that incorporate various kinds of uncertainty. Caddy and McGarvey (1996) described a procedure to set a target fishing mortality rate, given an OFL, so that the rate realized in the next period (F_{next}) would exceed OFL with only some specified probability P*. The procedure assumes that F_{next} will be centered on the target, but may not equal it, because of imperfect implementation of management controls (e.g., quota overruns) or imperfect stock assessment.

Prager et al. (2003) revised and extended the work of Caddy and McGarvey (1996) in several ways. The revised procedure, which they termed REPAST, allows uncertainty both in estimating the limit reference point (a type of scientific uncertainty) and in attaining the target (a type of management uncertainty), uses ratios to reduce possible covariance between quantities, and can be applied to reference points in biomass as well as in fishing mortality rate. Shertzer et al. (2008) described a procedure (PASCL), which extended considerably from that of Prager et al. (2003), and was intended for setting ABCs, ACLs, and annual catch targets (ACTs) over a series of several years, generally the period from one stock assessment until the next. The Shertzer et al. (2008) procedure uses a stochastic projection model, starting from estimates of OFL and terminal-year abundance; it can incorporate major forms of scientific uncertainty and management uncertainty. Most recently, Prager and Shertzer (In Press) applied approximations to the distribution of OFL, for cases when it is not known from the assessment; their conclusions suggest it is preferable to have the assessment model estimate the distribution of OFL directly. A procedure to do this is under development for the Stock Synthesis assessment model.

The general P* framework can easily extend common projection methodology by including uncertainty in the limit reference point and in management implementation, by making explicit the risk of overfishing that managers consider acceptable. Probability based methods, such as P*, provide well-defined approaches to setting ABC based on the degree of scientific uncertainty.

Factors that go into the calculation of the degree of scientific uncertainty should be reasonably inclusive and should recognize that calculation of uncertainty is itself uncertain. Factors to be considered include: statistical uncertainty associated with the fit of the assessment model to the available data, structural uncertainty due to use of particular model structures often with some constant parameters (such as natural

> *"Evaluating the consequences of different P* levels should be part of a technical contribution to the amendments that implement these procedures. Yes, it is a management decision, but it should be informed by science and neither side should work in a vacuum in that regard. The ABC control rule also needs to be a joint science/management process."*
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> Rick Methot

mortality rate), inability to directly account for climate and ecosystem factors, etc. It may be necessary to employ proxies for unmeasured components of uncertainty in data-weak simple models to assure that the addition of more information will be expected to lead to more certainty, rather than to a capability to calculate more components of uncertainty. Until the science for calculation of uncertainty matures, proxies for the overall level of uncertainty may be useful.

In some cases, little may be known other than catch and even this may be associated with uncertainty. In such cases, direct quantification of overfishing limits and other quantities may appear infeasible. Nevertheless, some evaluation of the status of current levels of fishing is a necessary first step. This first step could be a classification of stocks by scientists and locally knowledgeable people into one of four categories of fishery impact. This is essentially a stock assessment tailored to the data that is available and should be conducted with adequate transparency and an appropriate level of review. This classification should be accompanied and guided by a productivity-susceptibility analysis of the species. Possible fishery impact categories are:

- Trivial impact: e.g. potential ecosystem component species;

- Small impact: thus current catch could remain a target but not be allowed to expand unless supported by evidence of the safety of this expansion;

- Moderate impact: thus recent catches could be considered as a limit and future fishing should be more restricted until future transition to a fully assessed stock allows direct calculation of limits and targets;

- High impact: overfishing may already be occurring and immediate reductions appear necessary.

Catch Only Situations

Historical Catch	Expert Judgment	Possible Action
Nil, not targeted	Inconceivable that catch could be affecting stock	Not in fishery; Ecosystem Component; SDC not required
Small	Catch is enough to warrant including stock in the fishery and tracking, but not enough to be of concern	Set ABC and ACL above historical catch; Set ACT at historical catch level. Allow increase in ACT if accompanied by cooperative research and close monitoring.
Moderate	Possible that any increase in catch could be overfishing	ABC/ACL = f(catch, vulnerability) So caps current fishery
Moderately high	Overfishing or overfished may already be occurring, but no assessment to quantify	Set provisional OFL = f(catch, vulnerability); Set ABC/ACL below OFL to begin stock rebuilding

With the ABC defined in terms of an acceptable probability of overfishing, it shares some technical characteristics with the rebuilding analyses conducted after rebuilding requirements were put in place 10 years ago. Rebuilding analyses typically take into account uncertainty in current stock abundance and uncertainty about future fluctuations in productivity (recruitment) in order to calculate a fishing rate that would have at least a 50% chance of getting the stock to a rebuilt condition within a specified period of time. Analyses in support of ABC control rules can be, in addition to calculating an annual probability of overfishing, projected several years into the future to calculate quantities such as the probability that a stock will approach an overfished condition or will remain above B_{msy}. A simple example of such an analysis was presented at the workshop.

Evaluation of the impact associated with potential levels for P* can consider multiple factors because there is a trade-off between the degree of protection from overfishing and the degree to which fisheries can access a large fraction of the biological limit. For example, the vulnerability of a stock to the cumulative effects of overfishing could support a lower p*. High value of catch and fishing opportunities could support accepting a higher P*. The multi-year effect of a particular P* needs also to take into account the management uncertainty associated with controlling the actual catch to the level prescribed by the control rule. Thus, efforts to guide selection of an acceptable annual probability of overfishing, P*, can be guided by a broader cost/benefit/risk analysis oriented towards calculation of optimum yield.