REVIEW OF RISK OF OVERFISHING

Introduction

The reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act of 2006 (Magnuson-Stevens Act) requires setting annual catch limits for federally managed fish stocks to prevent overfishing. Overfishing occurs when total mortality (F) exceeds the mortality that supports maximum sustainable yield (F_{msy}), (i.e, $F > F_{msy}$). Fisheries managers worldwide are now employing harvest control rules to avoid fishing mortalities above targets (Smith et al 2008, 2009). Harvest control rules are used to evaluate tradeoffs of harvest strategies. Fishing levels that are too high may deplete the stock with long-term biological and socioeconomic consequences. More conservative strategies minimize the probability of stock depletion, yet costs are incurred through forgone catch and undesired social impacts. Unfortunately, precise harvest levels to achieve the management goals are often uncertain, thus probabilistic applications are being developed (and implemented) so that the probability of exceeding the overfishing limit can be estimated for various catch limits.

Prager et al. (2003) developed the P-star (P^*) method for deriving the target reference point based on the overfishing limit. Implicit in this method is a decision by fisheries managers about the probability of exceeding the overfishing limit that they are willing to accept and an estimate of uncertainty in the overfishing limit. Shertzer et al. (2008) extended this probabilistic approach (P^*) in response to requirements in the Magnuson-Stevens Act to set annual catch levels for federally managed fish stocks. It extends usual projection methodology by including uncertainty in the limit reference point and in management implementation by making explicit the overfishing risk that managers consider acceptable. This approach is intended for use when the risk of overfishing is managed by controlling catch and is widely used in some form among the regional fishery management Councils.

Despite improvement from the P^* methodology, establishing appropriate harvest levels is challenging on several fronts. For many stocks, data are insufficient to precisely estimate the

probability of overfishing for different levels of harvest. Also, National Standard Guidelines suggest that the Councils define acceptable risk levels for preventing overfishing, but the Councils do not yet know the consequences (biological, social, or economic) associated with different risk levels. An additional source of confusion is the inconsistent use of the term "risk" and how the Council identifies, assesses, and manages risk. In the Gulf Council acceptable biological catch control rule (hereafter: ABC control rule), the Council uses the terms uncertainty and risk interchangeably (GMFMC 2011). However, in terms of risk evaluation, these terms are not equivalent. Risk assessment is common practice in many fields (e.g., finance, human health, business) and consists of two parts. Risk (R) includes a determination of 1) the probability of an event occurring (p), and 2) the magnitude of the potential effect (L). In fisheries, this concept is relevant as events with low probability of occurrence may have large impact to the fish stock being considered. These trade-offs could be evaluated as part of a risk management framework.

Risk management is the identification, assessment, and prioritization of risks followed by a coordinated effort to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Risk assessment aims primarily at evaluating the consequences of various harvest strategies in terms of probabilistic statements about future trends in yields, biomass, and dangers to the stock, while risk management involves finding and implementing management policies, strategies, and tactics that reduce the risk to the communities exploiting the stock (Hilborn et al. 2001).

To date, the Gulf Council has adopted a risk strategy based only on the level of uncertainty and the probability of overfishing, not a combination of uncertainty and impacts of potential outcomes (i.e., biological, social, or economic impacts) in a risk management framework. In the current form, the acceptable biological catch (ABC) is the harvest level that reflects scientific uncertainty in estimating a stock's overfishing limit (OFL) where the OFL is the maximum catch that could be sustained given perfect information and the set catch (Punt et al. 2012). In general, the size of the buffer between the OFL and the ABC is positively correlated with the amount of uncertainty in the stock of interest and this consistent with a precautionary approach to fisheries management (FAO 1995).

The Precautionary Approach to Fishery Management

- Exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values.
- Gives due concern to long-term effects in the specification of management objectives and in the development of management frameworks, procedures, and measures. The consequences of management and fishery development are evaluated to reduce the possibilities of changes that are not potentially reversible on a 2 to 3 decade time scale.

For the stocks managed by the United States regional fishery management Councils, the acceptable biological catch (ABC) is set by each Council's Scientific and Statistical Committee (SSC) where the ABC is set at or below the stock's overfishing limit (OFL). The ABC is calculated using an ABC control rule that accounts for scientific uncertainty in the estimate of the OFL, thus the acceptable probability (as determined by the Council) that catch equal to the ABC would result in overfishing (i.e., exceeding the OFL). By law, the probability of overfishing cannot exceed 50 percent (74 FR 3178, January 9, 2011). All regional fishery management Councils operate under these guidelines, yet there is variation in the methodologies used to derive ABC. This is largely the result of varying degrees of scientific information available to inform decision makers when setting harvest levels. In response, most Councils have developed tiered ABC control rules with specific procedures based on data availability and stock status. In general, the percent reduction of the acceptable biological catch from the overfishing limit is greatest in stocks with little information (e.g., catch only). Several Councils have adopted a single framework for all Fishery Management Plans (FMPs) under which the size of the buffer between the OFL and the ABC is predetermined based on the type of assessment and quality of data used to develop biological reference points. Smaller buffers are set for assessed stocks including statistical estimates of uncertainty for biological reference points and larger buffers are set for data poor stocks. Other Councils have set ABCs using an ad-hoc approach for each fishery or stock, although the same sources of uncertainty are considered in setting ABC buffers. The essential difference between the two approaches is that the ad-hoc approach allows more flexibility while the overall framework saves the SSC time that would

need to be spent to evaluate each fishery or stock in much greater detail. A brief summary of the different regional management Council approaches is given below.

Review of Council ABC control rules

New England Fishery Management Council

The New England Council has adopted an ad-hoc approach both because of direction from the Council and because of differences in scientific knowledge about various stocks. This has enabled the SSC to weigh different uncertainties as it thinks appropriate instead of simply categorizing stocks according to the level of scientific information available. However, it has not been possible to make progress in developing a comprehensive risk policy that considers possible outcomes as well as scientific uncertainty because of the need for the SSC to complete ABC recommendations quickly and for the Council to amend its FMPs to meet deadlines for implementing annual catch limits.

Mid-Atlantic Fishery Management Council

A multi-level approach is used for setting an ABC for each Mid-Atlantic stock, based on the overall level of scientific uncertainty associated with its assessment. The stock assessment will be required to provide estimates of the maximum fishing mortality threshold (MFMT) and future biomass, the probability distributions of these estimates, the probability distribution of the overfishing limit (OFL; level of catch that would achieve MFMT given the current or future biomass), and a description of factors considered and methods used to estimate their distributions. The multi-level approach defines four levels of overall assessment uncertainty by characteristics of the stock assessment and determination by the SSC that the uncertainty in the probability distribution of OFL adequately represents best available science. Level 1 represents the highest level to which an assessment can be assigned. Assignment of a stock to Level 1 implies that all important sources of uncertainty are fully and formally captured in the stock assessment model and the probability distribution of the OFL calculated within the assessment provides an adequate description of uncertainty of OFL estimates. Under Level 1, the ABC will be determined solely on the basis of an acceptable probability of overfishing (P*), and the probability distribution of the OFL.

Level 2 indicates an assessed species with greater uncertainty of the true OFL than a Level 1 stock. In this level, ABC will be determined by using the Mid-Atlantic Council's risk policy, as with a Level 1 assessment, but with the OFL probability distribution based on the specified distribution in the stock assessment. Level 3 applies to assessed species where the assessment does not contain estimates of the probability distribution of the OFL or the probability distribution provided does not, in the opinion of the SSC, adequately reflect uncertainty in the OFL estimate. A control rule of 75 percent of F_{MSY} may be applied as a default if an OFL distribution cannot be developed. Level 4 stocks are considered to have reliable estimates of abundance and catch abundance but absolute abundance, fishing mortality rates, and reference points are suspect or absent. In this level, a simple control rule will be used based on biomass and catch history and the Council's risk policy.

Caribbean Fishery Management Council

Many differences exist among the U.S. Caribbean island platforms regarding habitat, species composition, gear choice, other fishing practices, environmental variability, and cultural preferences. As a result, ABC Control Rules are island and fishery management unit (FMU) specific, as they respond to the unique characteristics and needs of those islands and FMUs (CFMC 2011).

Setting ACLs for the U.S. Caribbean is a multi-step process. The first step in the process is to establish an overfishing limit (OFL). The OFL can be set to the average or median of annual catch for a specified period in the absence of a stock assessment and will equal an MSY proxy. The MSY proxy could equal the median or mean annual landings. Defining the ABC could entail using a buffer from the OFL that represents an acceptable level of risk due to scientific uncertainty or setting the ABC equal to OFL. The buffer is predetermined for each stock or stock complex by the Council with advice from the SSC.

After the OFL has been defined, the ABC needs to be established. The SSC decided to make the calculation of the ABC from the OFL a two-step process. The SSC determined that it would classify whether each stock is at low, moderate, or high risk of becoming overfished due to its productivity. Highly productive stocks were determined to be at low risk, while stocks

with extremely low production were determined to be at high risk. The SSC classified each stock as being at low, moderate, or high risk based on the group's cumulative knowledge of the life history of the stock (Table 4.1.6). The SSC then left it to the Council to decide on a risk-specific scalar to be applied to each risk level to arrive at the ABC. The Council can choose a scalar equal to or less than one depending on their risk assessment (Alternatives 2(h) through 2(k)). The scalar could either decrease or remain equal as risk increases (Table 1).

Table 1. Summary of Caribbean Fishery Management Council management reference points.

REFERENCE POINT	
Maximum Sustainable Yield	
Alternative 2(a)	MSY proxy = Median annual landings selected by Council in Action 2(a).
Alternative 2(b)	MSY proxy = Mean annual landings selected by Council in Action 2(a).
Alternative 2(c)	MSY proxy = Maximum of a single year of recreational landings x 3.
Overfishing Threshold	
Alternative 2(d)	OFL = MSY proxy adjusted according the ORCS scalar; overfishing occurs when annual landings exceed the OFL.
Alternative 2(e)	OFL = MSY proxy adjusted according the ORCS scalar; overfishing occurs when annual landings exceed the OFL, unless NOAA Fisheries' Southeast Fisheries Science Center (in consultation with the Caribbean Fishery Management Council and its SSC) determines the overage occurred because data collection/monitoring improved, rather than because landings actually increased.
Alternative 2(f)	OFL = MSY proxy; overfishing occurs when annual landings exceed the OFL.
Alternative 2(g)	OFL = MSY proxy; overfishing occurs when annual landings exceed the OFL, unless NOAA Fisheries' Southeast Fisheries Science Center (in consultation with the Caribbean Fishery Management Council and its SSC) determines the overage occurred because data collection/monitoring improved, rather than because landings actually increased.
Acceptable Biological Catch/ABC Control Rule	
Alternative 2(h)	ABC= OFL
Alternative 2(i)	ABC= [OFL x 0.85]
Alternative 2(j)	ABC= [OFL x 0.75]
Alternative 2(k)	ABC= [OFL x 0.50]
Optimum Yield/Annual Catch Limit	
Alternative 2(l)	OY = ACL = ABC
Alternative 2(m)	OY = ACL = [ABC x (0.85)]
Alternative 2(n)	OY = ACL = [ABC x (0.75)] (Preferred for Surgeonfish)
Alternative 2(o)	OY = ACL = [ABC x (0.50)]

Source: (CMFMC 2011).

Pacific Council

The default harvest control rule in the FMP is called the "40-10" rule and is an adjustment of the OY below the ABC for a stock in the precautionary zone (i.e., estimated biomass below the BMSY target but above the MSST). The OY is adjusted progressively lower as the stock's depletion (i.e., estimated biomass relative to its estimated unfished biomass) is progressively lower than the target of 40% of unfished biomass (denoted B40%) until at B10%, the OY is set to zero (Figure 1). The slope of the line describing the OY adjustment relative to the ABC is defined by intersecting the ABC line at B40% and the x-axis at B10%. In practice, the 40-10 adjustment is only applied to stocks in the precautionary zone that are managed using the proxy B40% BMSY target with an MSST of B25%. For overfished stocks with an estimated depletion below the MSST, OYs are decided using analyses and considerations for developing a rebuilding plan.

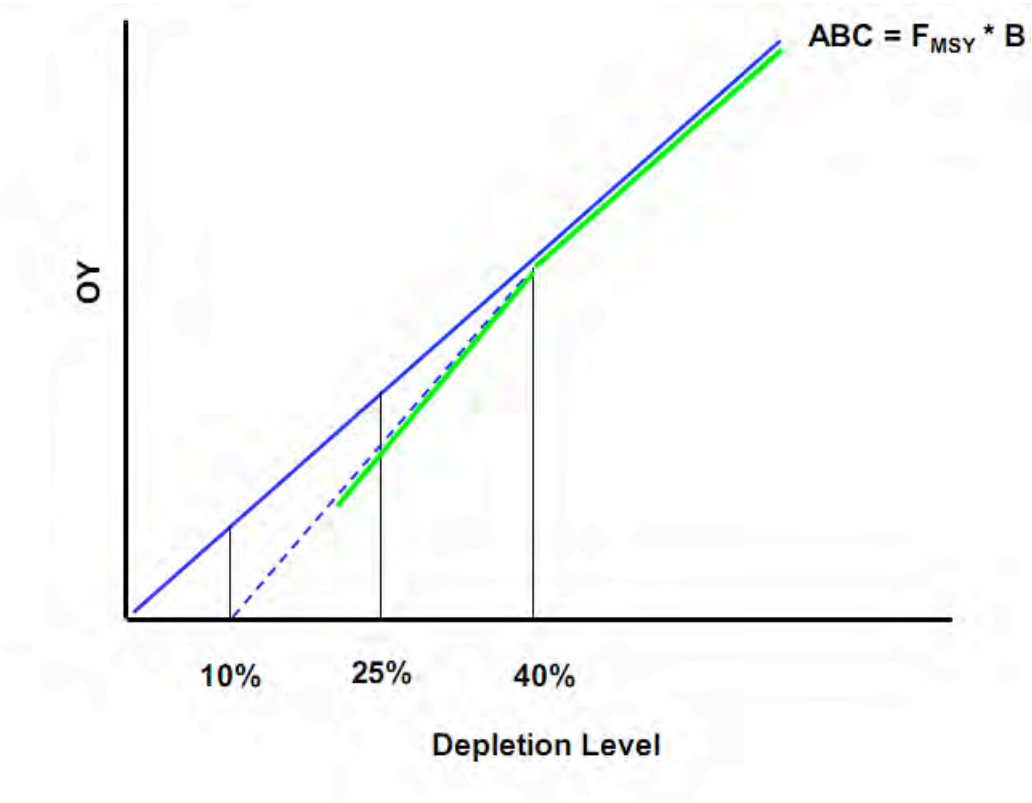

Figure 1. Diagrammatic summary of the Pacific Fishery Management Council ABC control rule.

Western Pacific Council

The Western Pacific Council developed a scoring system and established categories within each dimension. The *P** Working Group chose to use scores for each dimension as high as 10, such that the dimensions added up to a maximum of 40. The summed score is subtracted from the P^*_{MAX} of 50% OFL, or a maximum of 50% risk of overfishing, to determine the *P**. The justification was that the group thought the results of its deliberations should never result in a P* of zero, or no fishing, thus the lowest *P** is equivalent to a 10% risk of overfishing.

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