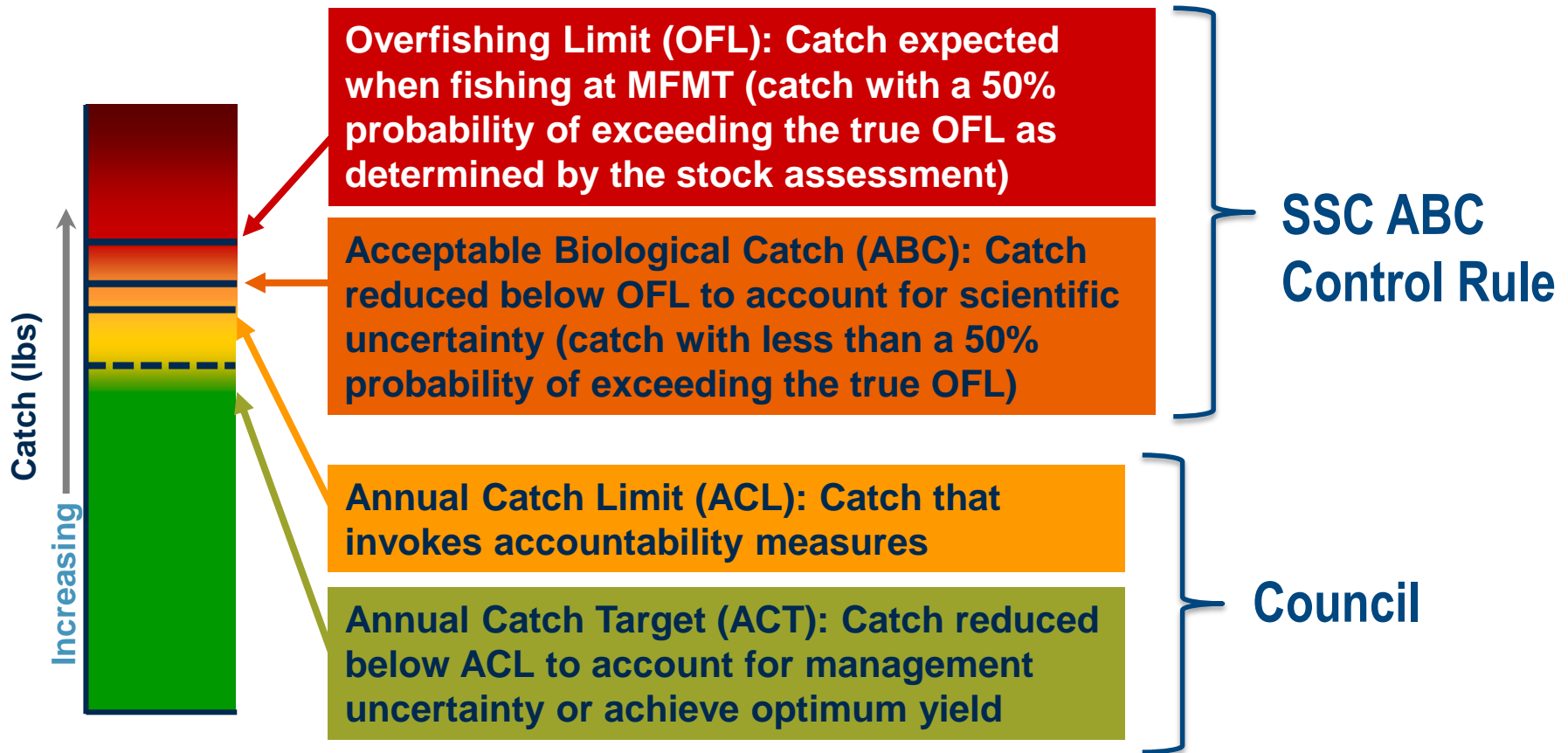# Towards Revitalizing the ABC Control rule for the Gulf of Mexico Fishery Management Council

Shannon Cass-Calay and Clay E. Porch
Gulf of Mexico Fishery Management Council SSC
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ABC in context: Sorting through the acronyms

Overfishing Limit (OFL): Catch expected when fishing at MFMT (catch with a 50% probability of exceeding the true OFL as determined by the stock assessment)

Acceptable Biological Catch (ABC): Catch reduced below OFL to account for scientific uncertainty (catch with less than a 50% probability of exceeding the true OFL)

SSC ABC Control Rule

Annual Catch Limit (ACL): Catch that invokes accountability measures

Annual Catch Target (ACT): Catch reduced below ACL to account for management uncertainty or achieve optimum yield

Council

Catch (lbs)

Increasing

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National Standard 1 Guidelines

For all stocks and stock complexes that are "in the fishery"… the Councils must evaluate and describe the following items in their FMPs and amend the FMPs, if necessary, to align their management objectives to end or prevent overfishing:

(1) Maximum sustainable yield (MSY) and status determination criteria (SDC)

(2) Optimum Yield (OY)

(3) ABC control rule

(4) Mechanisms for specifying ACLs and ACTs

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Maximum Sustainable Yield

MSY is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets.

F_{MSY} = fishing mortality rate that, if applied over the long term, would result in *MSY*.

B_{MSY} = long-term average size of the stock, measured in terms of the stock's reproductive potential that would be achieved by fishing at F_{MSY}

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Status determination criteria (SDC)

MFMT (Maximum fishing mortality threshold) = level of fishing mortality F above which overfishing is occurring (typically = F_{MSY} or proxy)

OFL (Overfishing limit OFL) = annual amount of catch that corresponds to fishing at MFMT. The OFL is an estimate of the catch level above which overfishing is occurring.

MSST (Minimum stock size threshold) = the stock size below which the stock or stock complex is considered to be overfished (typically = cB_{MSY}, where $c \geq 0.5$).

Optimum Yield (OY) in the MSRA

(28) The term "optimum", with respect to the yield from a fishery, means the amount of fish which--

(A) 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;

(B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, *as reduced* by any relevant economic, social, or ecological factor; and

(C) in the case of an overfished fishery, provides for *rebuilding to a level consistent with producing the maximum sustainable yield* in such fishery.

ABC Control Rule

- ABC control rule is an agreed procedure, adopted in the FMP, for setting the ABC for a stock or stock complex as a function of the scientific uncertainty in the estimate of OFL and any other scientific uncertainty
- Each Council must establish an ABC control rule based on scientific advice from its SSC.
- The SSC must recommend the ABC to the Council. An SSC may recommend an ABC that differs from the result of the ABC control rule, but must explain why.
- It can be data-limited in some circumstances and can involve complex drivers based on measured stock biomass, measured uncertainty, forecasts of environmental effects, etc.
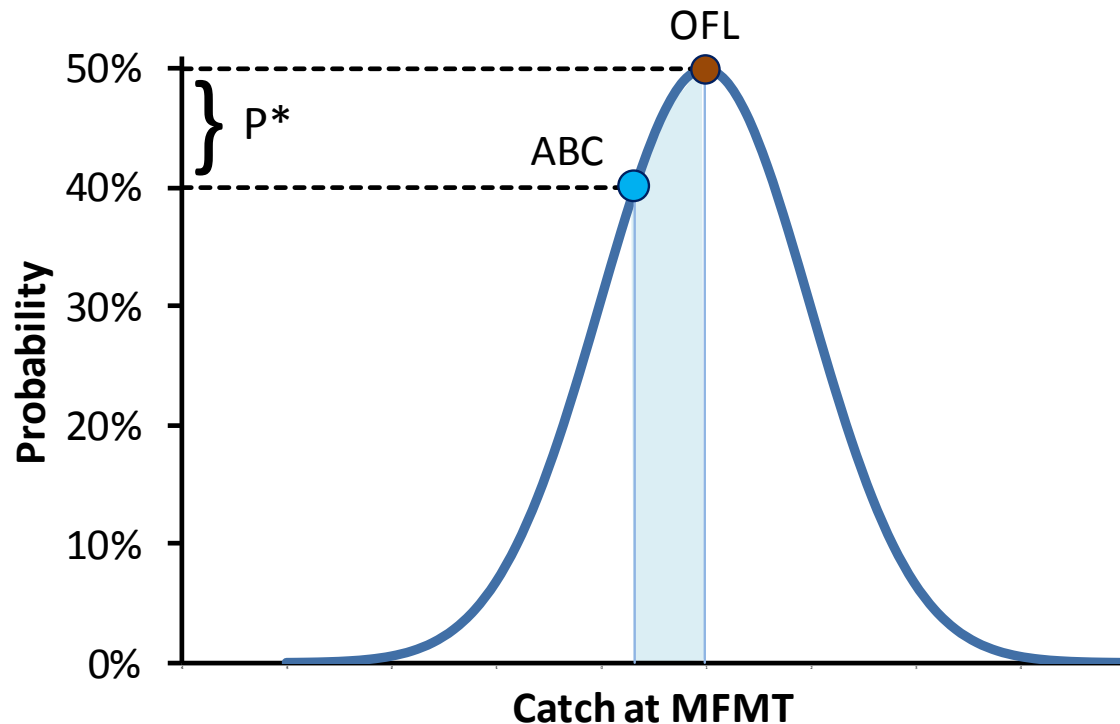
ABC Control Rule

- The ABC control rule should consider reducing fishing mortality (MFMT) as stock size declines
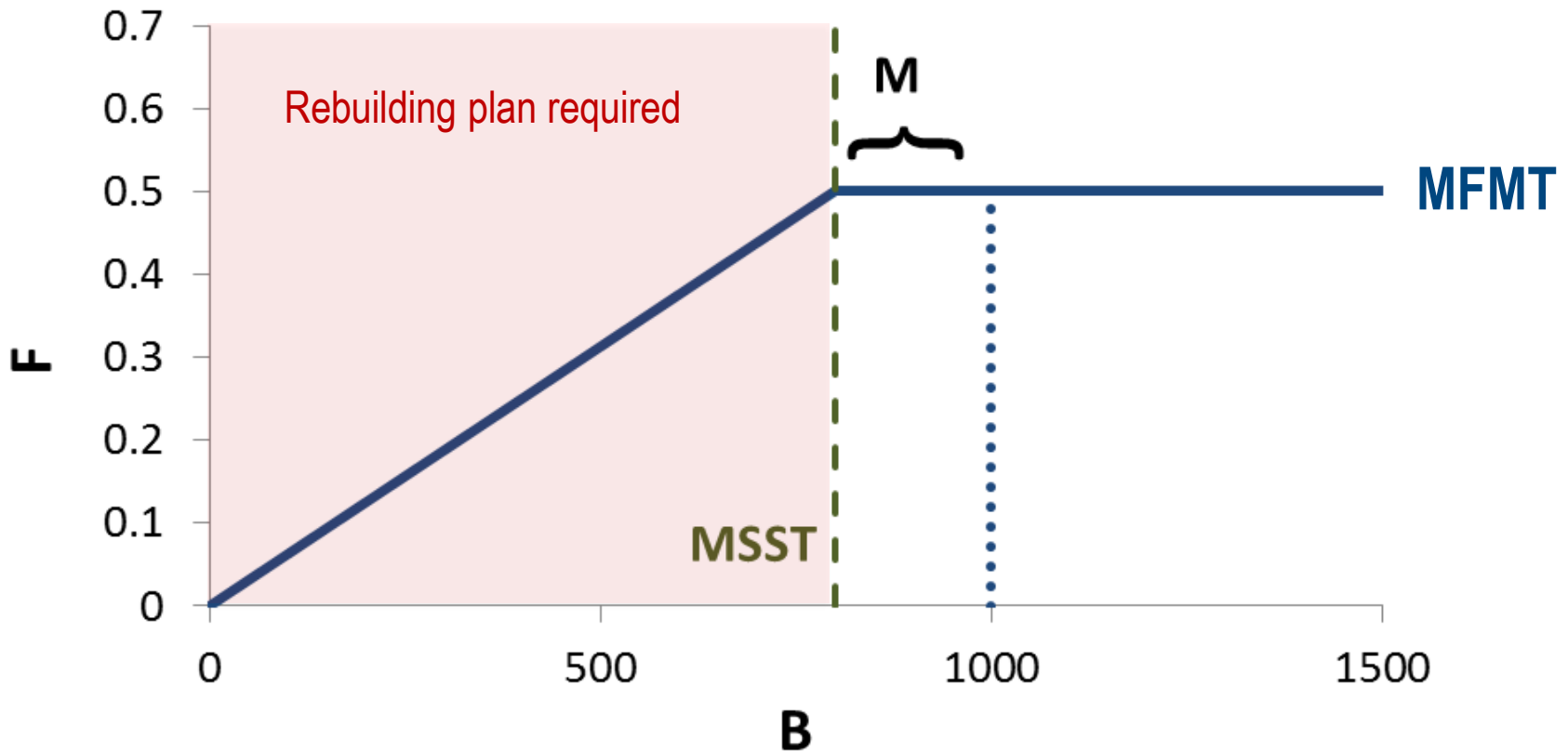
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- The determination of ABC should be based, when possible, on the probability that a catch equal to the stock's ABC would result in overfishing (P*). The probability of overfishing cannot exceed 50% and should be a lower value.

ABC Control Rule

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- The control rule may be used in a tiered approach to address different levels of scientific uncertainty

ABC Control Rule in words

Tier 1

- Condition for use: Assessment provides estimate of OFL based on maximum sustainable yield or its proxy and a probability density function of the OFL I will that reflects scientific uncertainty

- MFMT = dF_{MSY},   where $d = \begin{cases} 1 & \text{if } B \geq MSST \\ B / MSST & \text{if } B < MSST \end{cases}$

- OFL = catch at MFMT

- ABC determined from PDF of OFL where acceptable probability of overfishing is 40%

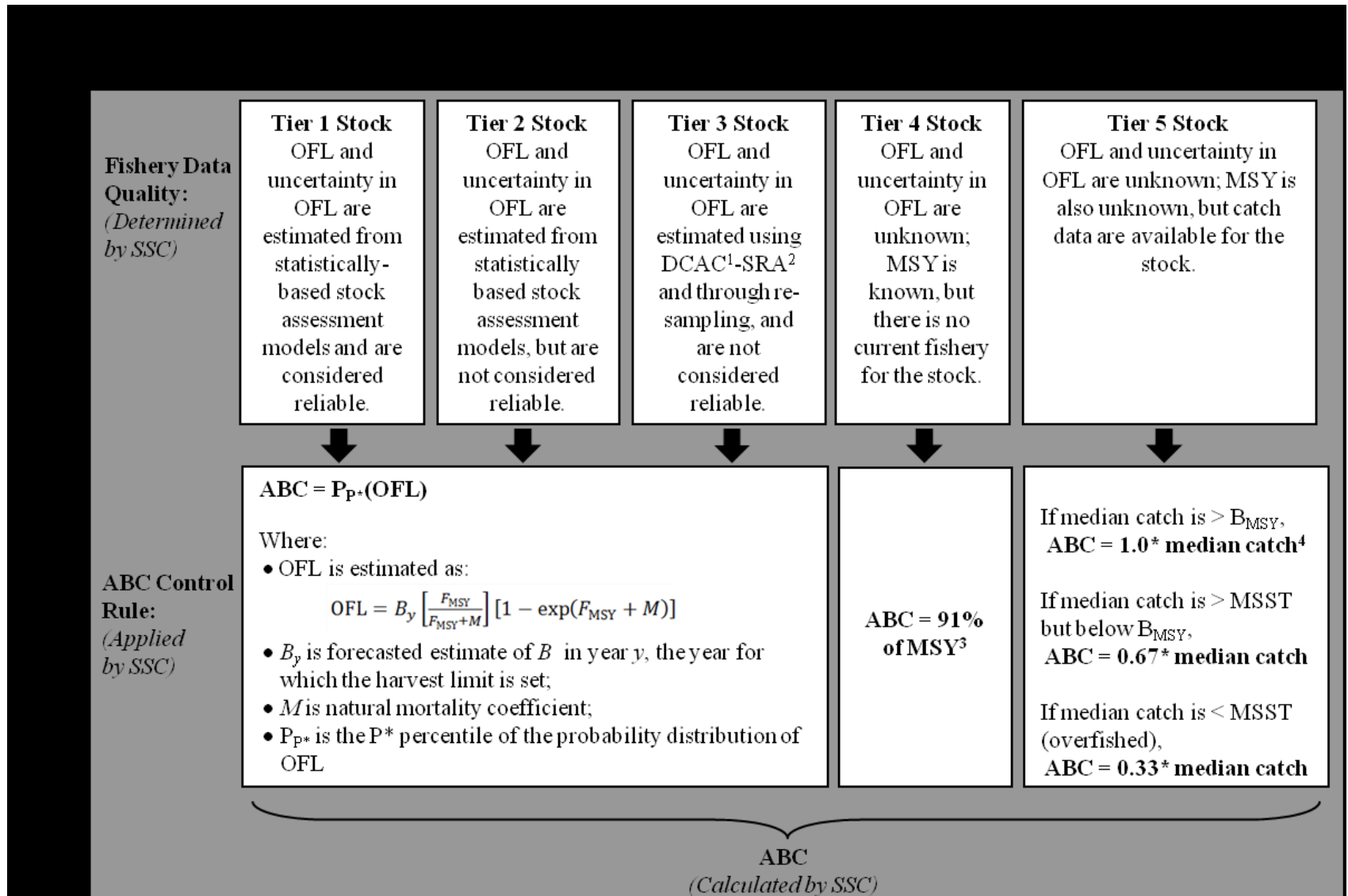NOAA FISHERIES

Actual ABC Control Rules Vary by Council

Some Councils have adopted a single framework for all Fishery Management Plans and others have different frameworks for each FMP

Most attempt to various degrees to set ABCs below the OFL in a way that reflects uncertainty…

…but how they do it varies a great deal

Example: WPFMC ABC Control Rule

Fishery Data Quality: *(Determined by SSC)*	Tier 1 Stock	Tier 2 Stock	Tier 3 Stock	Tier 4 Stock	Tier 5 Stock
	OFL and uncertainty in OFL are estimated from statistically-based stock assessment models and are considered reliable.	OFL and uncertainty in OFL are estimated from statistically based stock assessment models, but are not considered reliable.	OFL and uncertainty in OFL are estimated using DCAC[1]-SRA[2] and through re-sampling, and are not considered reliable.	OFL and uncertainty in OFL are unknown; MSY is known, but there is no current fishery for the stock.	OFL and uncertainty in OFL are unknown; MSY is also unknown, but catch data are available for the stock.

ABC Control Rule: *(Applied by SSC)*

$ABC = P_{P*}(OFL)$

Where:
- OFL is estimated as:

$$OFL = B_y \left[\frac{F_{MSY}}{F_{MSY}+M} \right] [1 - \exp(F_{MSY} + M)]$$

- B_y is forecasted estimate of B in year y, the year for which the harvest limit is set;
- M is natural mortality coefficient;
- P_{P*} is the P* percentile of the probability distribution of OFL

ABC = 91% of MSY[3]

If median catch is $> B_{MSY}$,
ABC = 1.0* median catch[4]

If median catch is $>$ MSST but below B_{MSY},
ABC = 0.67* median catch

If median catch is $<$ MSST (overfished),
ABC = 0.33* median catch

ABC *(Calculated by SSC)*

Existing GMFMC ABC Control Rule for Reef Fish

- Tier 1

  - **Condition for Use**: Assessment estimates MSY reference points and produces PDF of OFL. Choice of **P* based on level of uncertainty considered in the assessment using a risk determination table:**

    - Level of assessment and use of F_{MSY} proxies (e.g. F_{SPR30}, $F_{0.1}$).
    - Characterization of Uncertainty (e.g. fully integrated, sensitivity runs, none)
    - Severity of Retrospective Pattern
    - Use of Environmental Covariates

  - OFL = yield at MFMT

  - ABC = yield at P* percentile from projection of MFMT (or $F_{REBUILD}$)

Existing GMFMC ABC Control Rule for Reef Fish

- Tier 2 – Assessment cannot estimate MSY reference points, but use alternative methodology to estimate PDF of OFL (**NOT USED TO DATE**)

- Tier 3a – Condition for use: No assessment, but stock unlikely to suffer overfishing if future landings remain similar to recent landings

  - OFL = mean recent landings + 2σ (σ = std dev recent landings)

  - ABC = mean recent landings + [1.5, **1.0**, 0.5, 0] σ

- Tier 3b – Condition for use: No assessment, but stock likely to suffer overfishing

  - OFL = mean recent landings

  - ABC = mean recent landings [1.0, 0.85, **0.75**, 0.65] OFL

The Hidden Details

Credit: Kathryn L. Porch

The Hidden Details

Calculation of MSY and OFL depends on knowing (or assuming) the nature of reproduction, growth and natural mortality
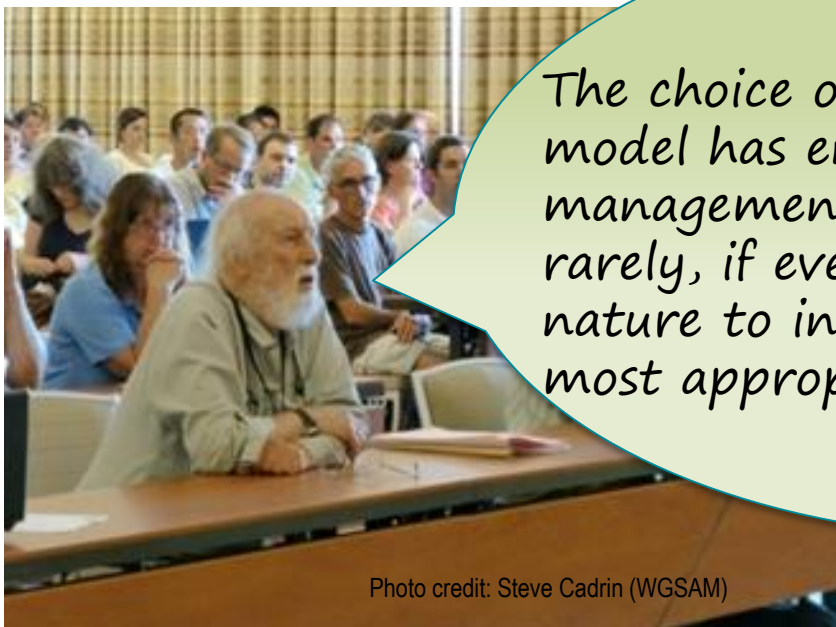
Photo credit: Steve Cadrin (WGSAM)

The choice of the specific mathematical model has enormous consequences for management. However, there are rarely, if ever, sufficient data from nature to indicate which model is most appropriate.
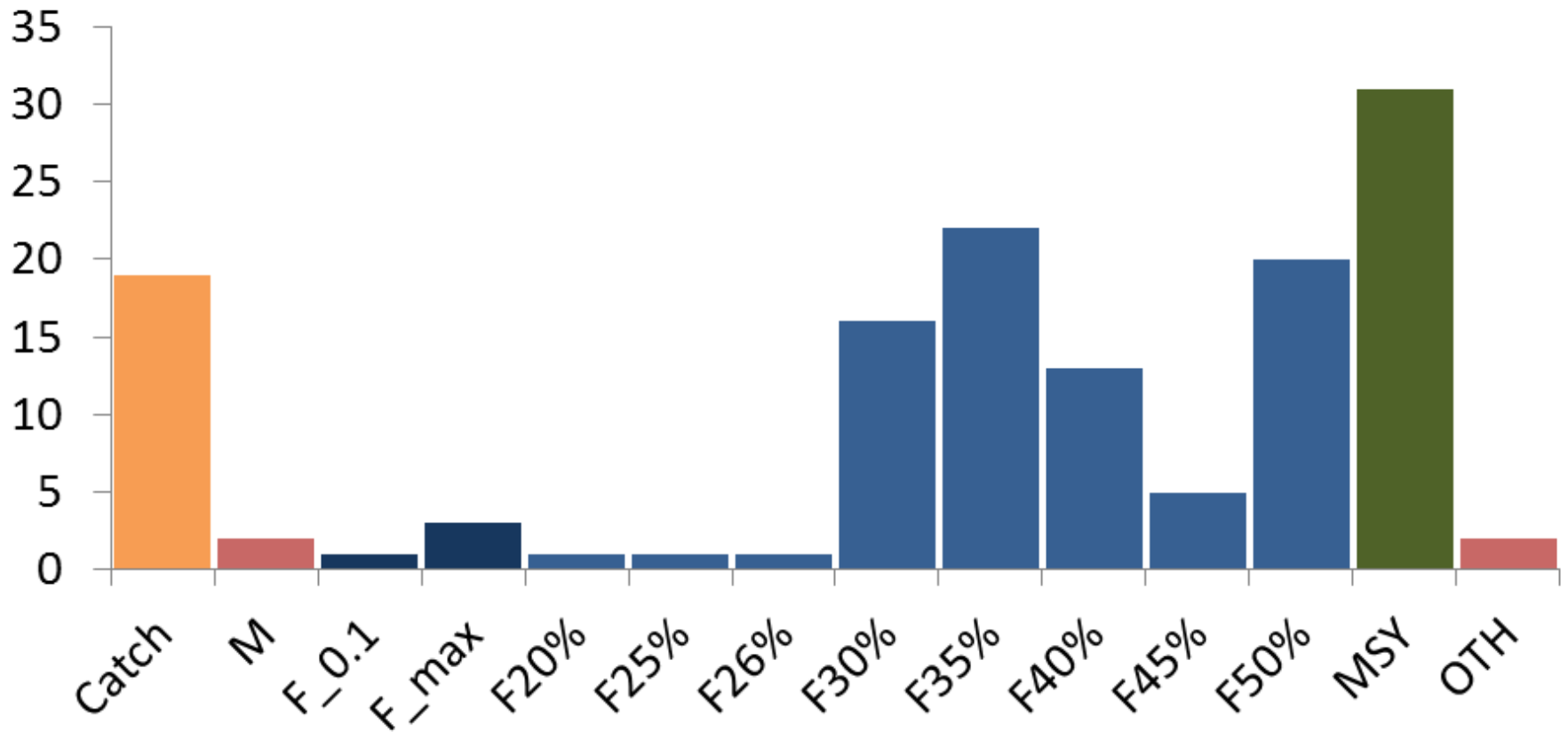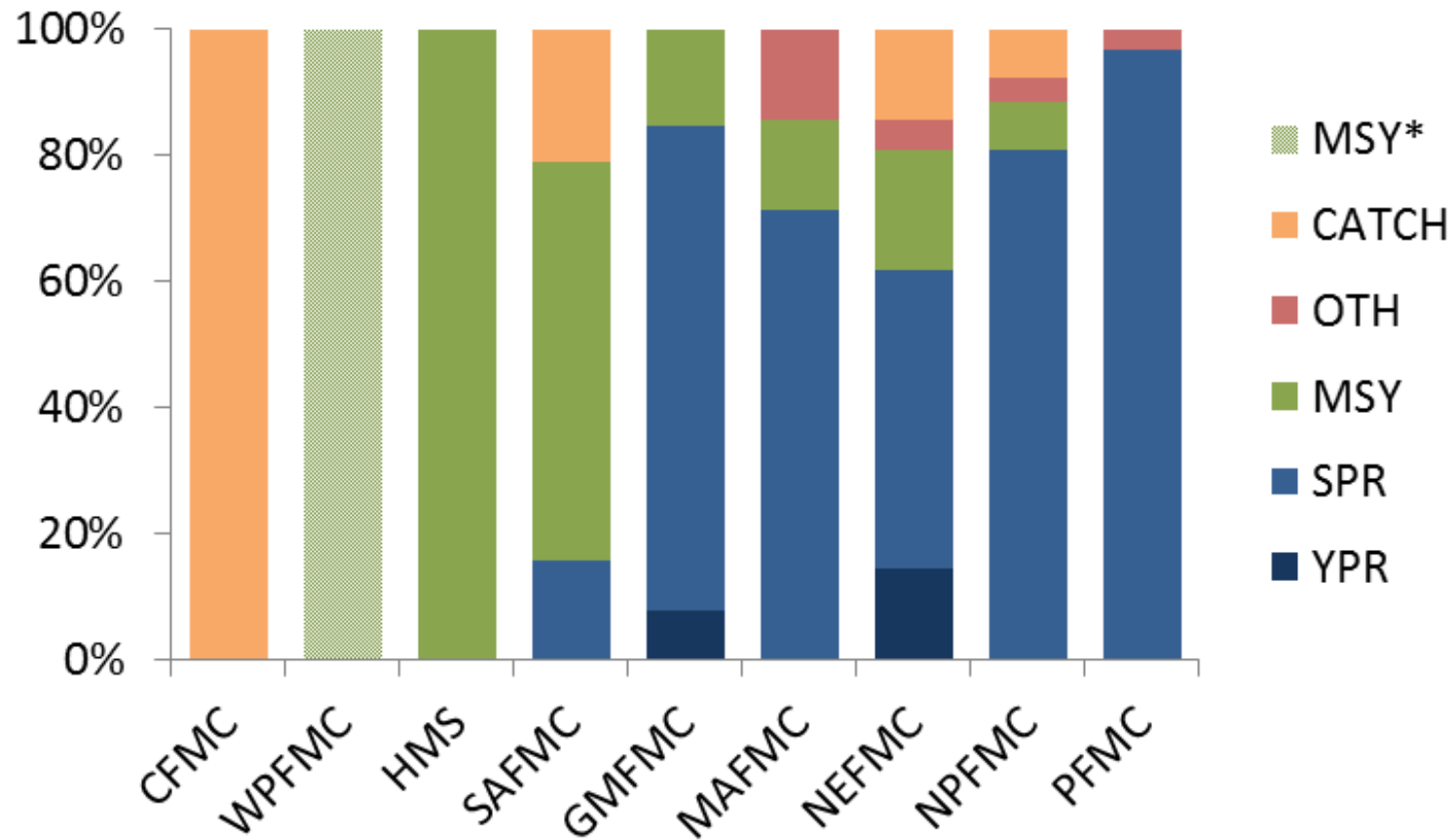
Sydney Holt

What are safe proxies for MSY?

Spawners per recruit

SPR 30%   SPR 100%

MSY region

Y-axis: R/R_0
X-axis: E/E_0
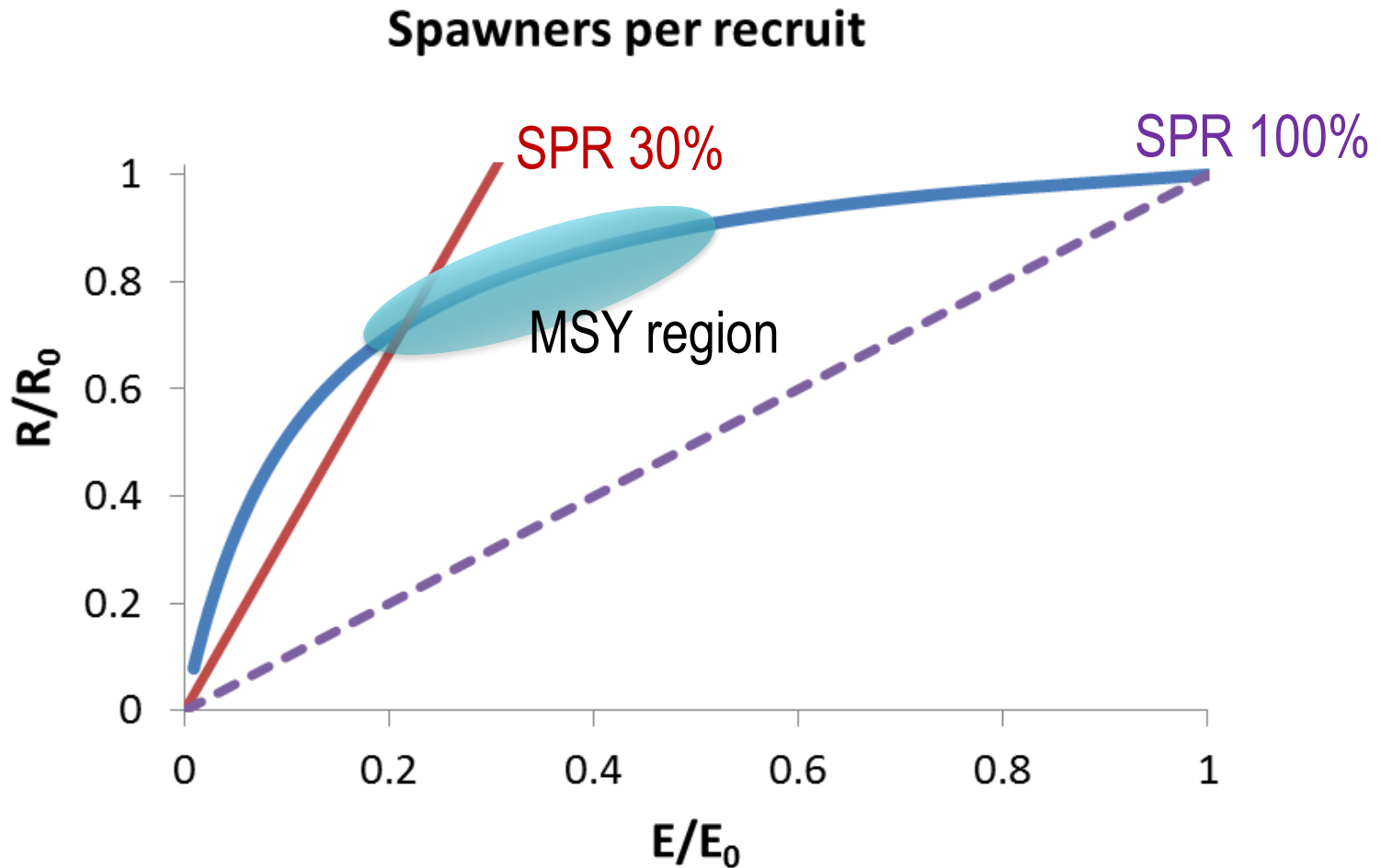
Definitions for MFMT across the U.S.A.

Fishing Mortality Reference Points in the Species Information System (mostly FSSI stocks)
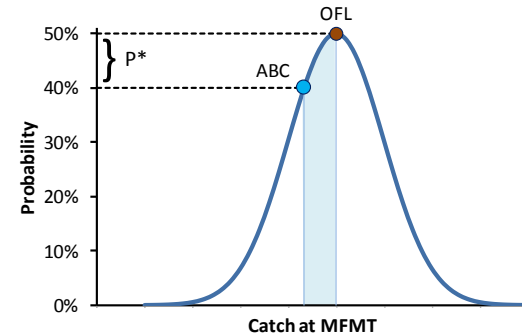
Differences among councils

Differences among councils in choice of SPR
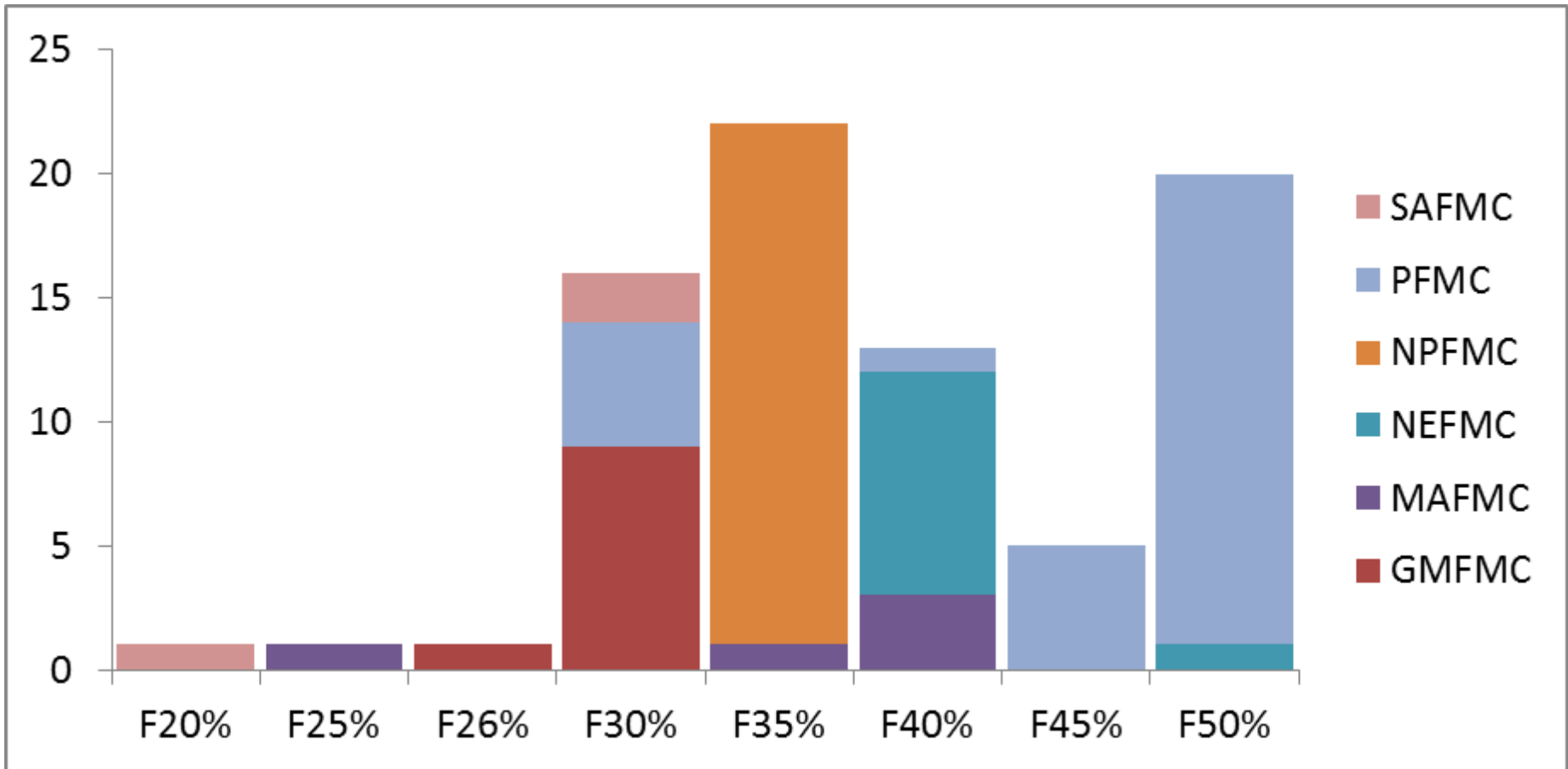
The Hidden Details

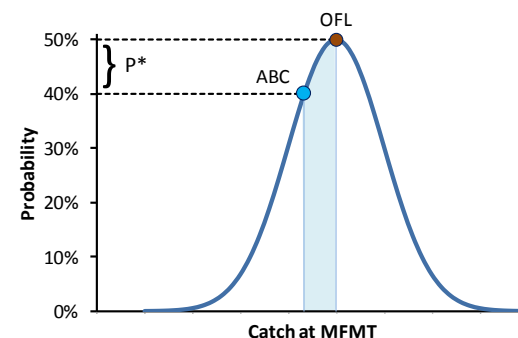## Calculation of ABC (from PDF of OFL) requires quantifying uncertainty

''there are known unknowns,... but there are also unknown unknowns — the ones we don't know we don't know. It is the latter category that tend to be the difficult ones.''

Donald Rumsfeld, 2002

The Hidden Details

## Calculation of ABC (from PDF of OFL) requires quantifying uncertainty

- Try to estimate variance of pdf as part of the assessment process

- Estimate variance external to assessment process
  - borrow from another assessment
  - compute from comparisons of estimates from multiple past assessments (Ralston et al.)

The Hidden Details

Calculation of ABC (from PDF of OFL) requires quantifying uncertainty

- Try to estimate variance of pdf as part of the assessment process

- Estimate variance external to assessment process
  - borrow from another assessment
  - compute from comparisons of estimates from multiple past assessments (Ralston et al.)

- Don't even try
  - $F_{ABC}=0.75MFMT$
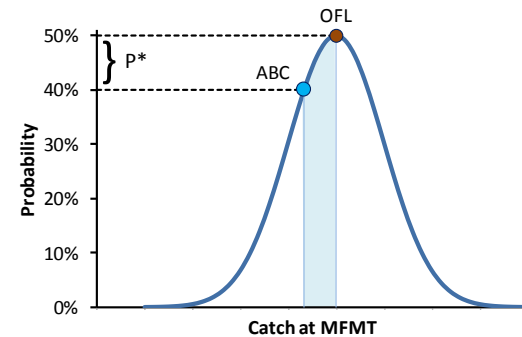
Moving Forward: A more flexible ABC control rule

1. Tier 1 should consider reducing fishing mortality (MFMT) as stock size declines

2. Tier's 2 and 3 should be made more flexible to accommodate data limited scientific advice

3. Role of Council and its SSC needs more separation:
   - Council should determine acceptable probability of overfishing
   - SSC should determine magnitude of scientific uncertainty criteria

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Example: CFMC ABC control rule

Tier 1 "Data Rich"

- *Condition for Use*: Full stage-structured assessment where reliable time series on catch, stage composition and index of abundance are available and the assessment provides estimates of MSST, MFMT, and PDF of OFL

- Maximum Fishing Mortality Threshold (MFMT) = $F_{MSY (or\ proxy)}$

- Minimum Stock Size Threshold (MSST) = $0.75 * B_{MFMT (MSY\ or\ proxy)}$ [1]

- MSY = Long-term Yield at MFMT[2]

- OFL = Yield at MFMT

- ABC = dX^* *where*

    X^* is the percentile of the PDF of OFL corresponding to the acceptable probability of overfishing (P*) determined by the council and the PDF is determined from the assessment (subject to $\sigma > \sigma_{min}$) [3]

$$d = \begin{cases} \text{Scalar} & \text{if } B \geq B_{msy} \\ \text{Scalar}*(B - B_{critical})/(B_{MFMT} - B_{critical}) & \text{if } B < B\ msy \end{cases}$$

    $B_{critical}$ = minimum level of depletion at which fishing would be allowed
    Scalar = 1 if *P* * < 50% specified by council, <1 otherwise

[1]Can use F_{MSY} proxies, such as %SPR (e.g. due to poor/unknown stock recruitment relationship), as appropriate with the level commensurate with the species life history and ecological function.
[2] Assuming the spawner-recruit relationship is well estimated, otherwise undefined.
[3] σ_{min} is the minimum acceptable standard deviation or coefficient of variation set by the SSC

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Ralston et al, 2011

A meta-analytic approach to quantifying scientific uncertainty in stock assessments

Stephen Ralston (contact author)[1]

André E. Punt[2]

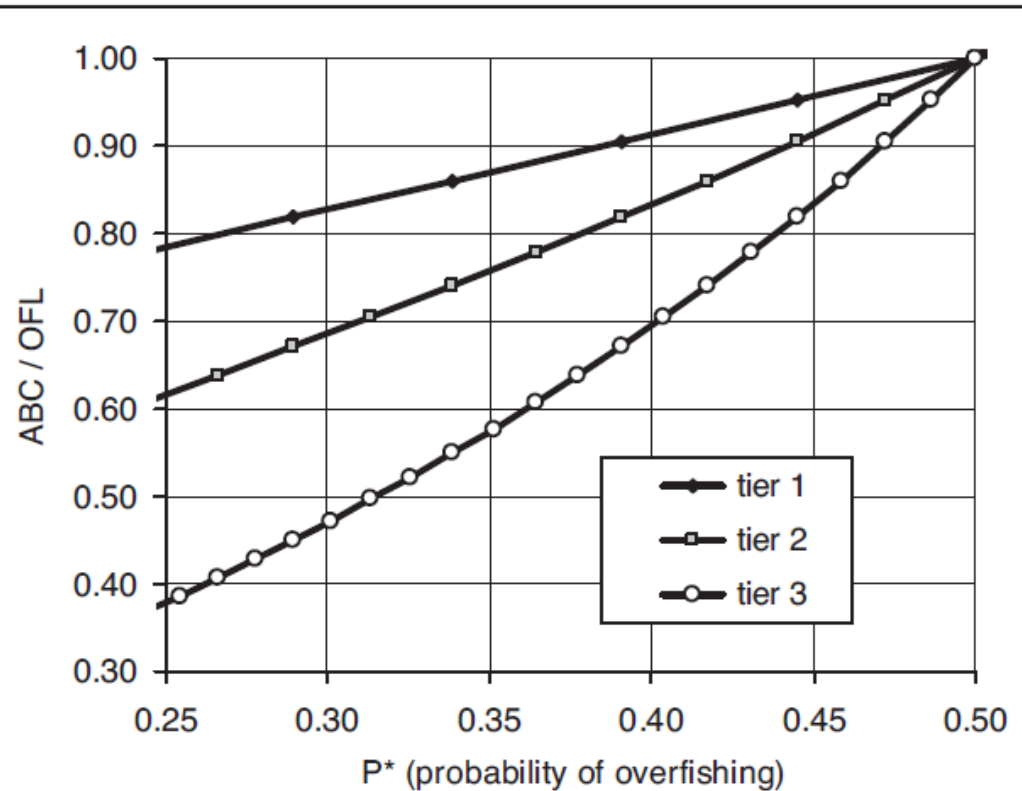Owen S. Hamel[3]

John D. DeVore[4]

Ramon J. Conser[5]

Figure 7

Relationship between the probability of overfishing ($P*$) and an appropriate buffer between the allowable biological catch (ABC) and the overfishing level (OFL), based on varying amounts of uncertainty ($\sigma=0.36$, 0.72, and 1.44) assigned to different stock assessment tiers (1=data-rich, 2=data-moderate, and 3=data-poor), respectively.

OFL = Fmsy * B

ABC = Fmsy * B * P*

ACL

$B_{critical}$

B_{MFMT}

Depletion Level
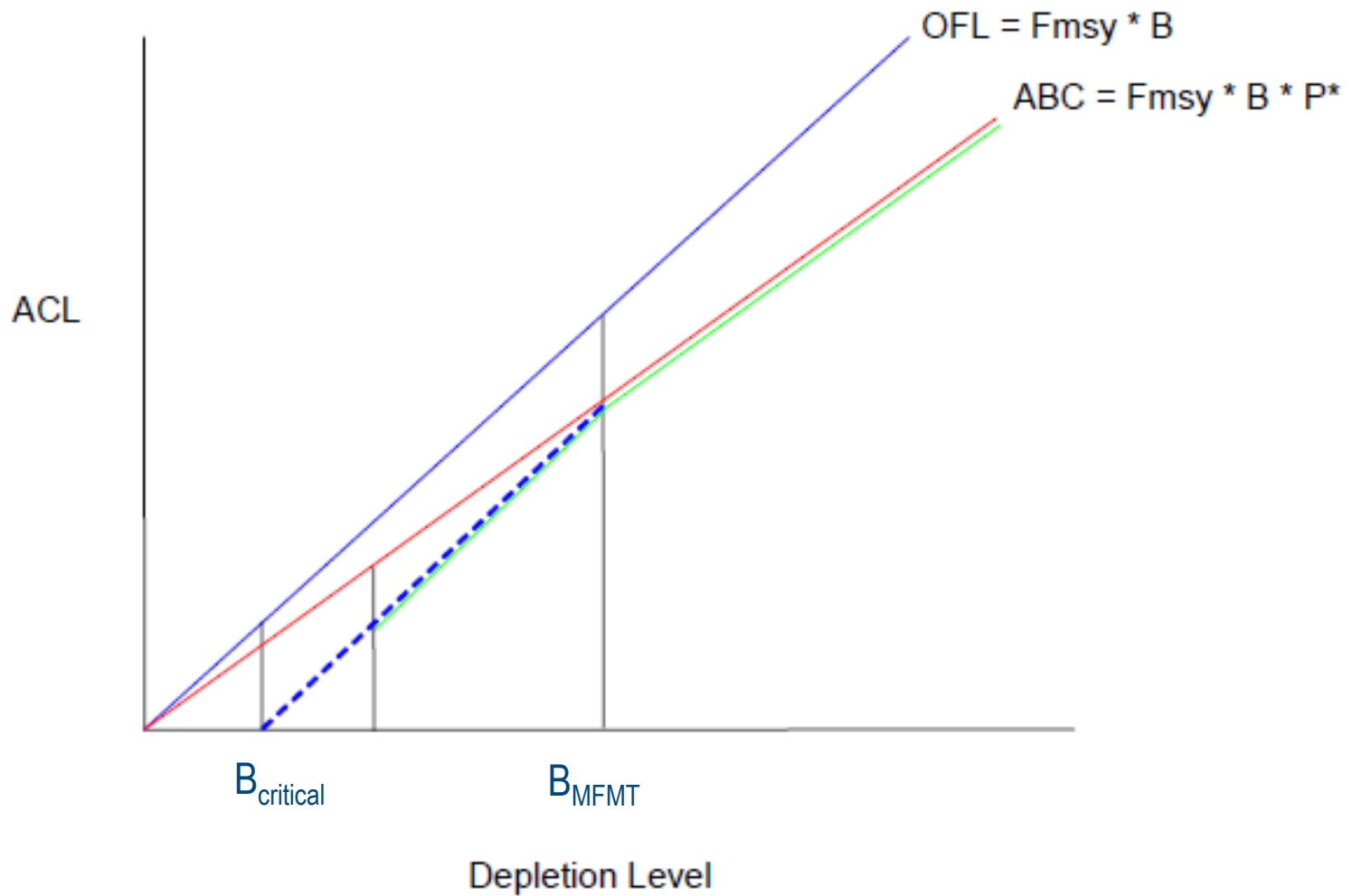
A 40:10 Control Rule

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Tier 2 "Data Moderate"

- ***Condition for Use***: Data-moderate approaches where two of the three time series (catch, stage composition and index of abundance) are deemed informative by the assessment process, and the assessment can provide MSST, MFMT, and PDF of OFL

- Same as Tier 1, but variation of the PDF of OFL (σ) must be greater than $1.5\, \sigma_{min}$ (in principle there should be more uncertainty with data-moderate approaches than data-rich approaches).

Tier 3 "Data Limited Quantitative Assessments"

- **Condition for use:** Relatively data-limited or out-of-date assessments

- MFMT = F_{MSY} (or proxy such as $F_{40\%}$)

- MSST = *unknown*

- OFL = catch at MFMT

- ABC determined from OFL as reduced by scientific uncertainty and acceptable probability of overfishing

  a. Percentile of PDF of OFL corresponding to P* where the PDF is determined from the assessment (but $\sigma \geq 2\sigma_{min}$), or

  b. ABC = *scalar* * OFL, where *scalar* must be ≤ 0.9

- **Tier 4a –Landings and Ancillary Information (e.g. Productivity, Susceptibility Analyses, Expert opinion)**

  - ***Condition for use:*** No accepted assessment, but stock <u>unlikely</u> to be subject to overfishing, and not likely to be overfished.

  - MSST, MFMT, MSY = unknown

  - OFL = Scalar * 75th percentile of reference period landings
    - Scalar =< 2 depending on perceived degree of exploitation, life history and ecological function

  - ABC = *buffer* * OFL, where *buffer* must be $\leq$ 0.9 (e,g, 0.9, 0.8, 0.75, 0.70…)

- **Tier 4b –Landings and Ancillary Information (e.g. Productivity, Susceptibility Analyses, Expert opinion)**

  - ***Condition for use:*** No accepted assessment, but stock <u>likely</u> subject to overfishing and/or overfished

  - MSST, MFMT, MSY = undefined

  - OFL = Scalar * ***mean*** of recent landings (most recent three years of available landings)
    - Scalar < 1 depending on perceived degree of exploitation, life history and ecological function

  - ABC = *buffer* * OFL, where *buffer* must be $\leq$ 0.9 (e,g, 0.9, 0.8, 0.75, 0.70…)