Towards an ABC Control rule for the Caribbean Fishery Management Council

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Caribbean Fishery Management Council
San Juan, Puerto Rico
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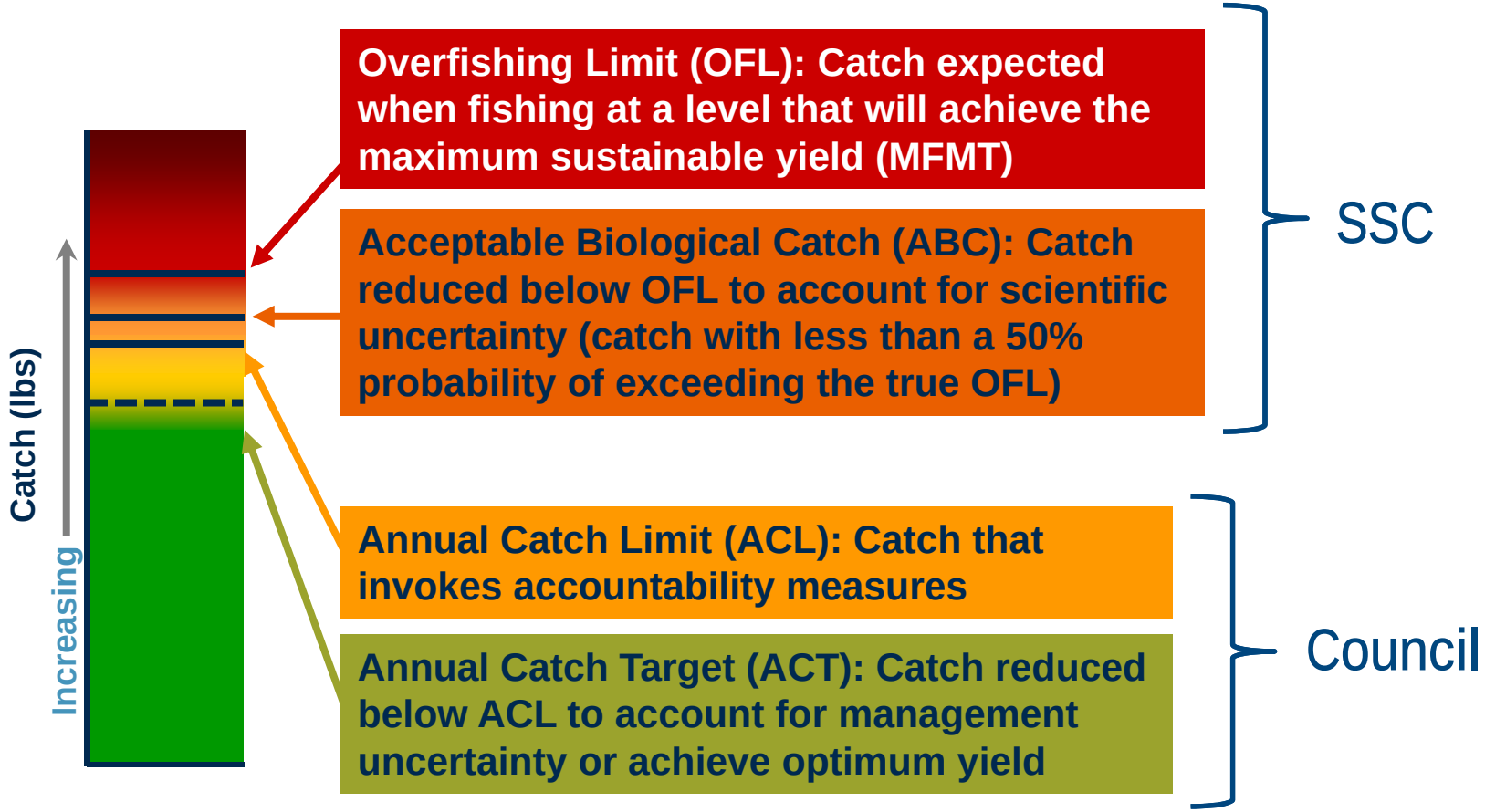
ABC in context: Sorting through the acronyms



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

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}

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--

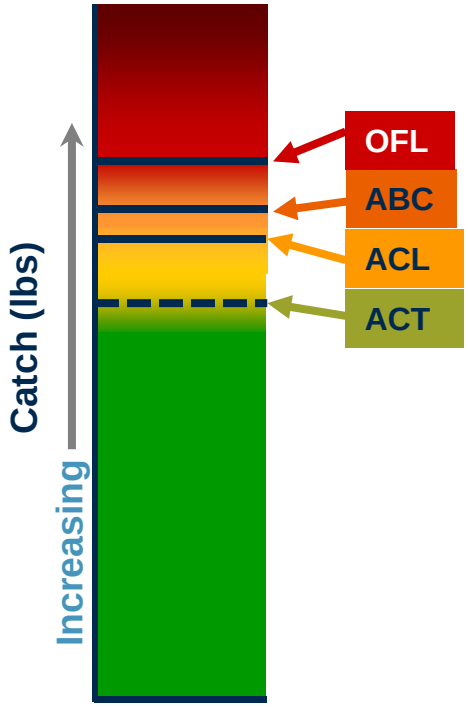
(A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

(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.

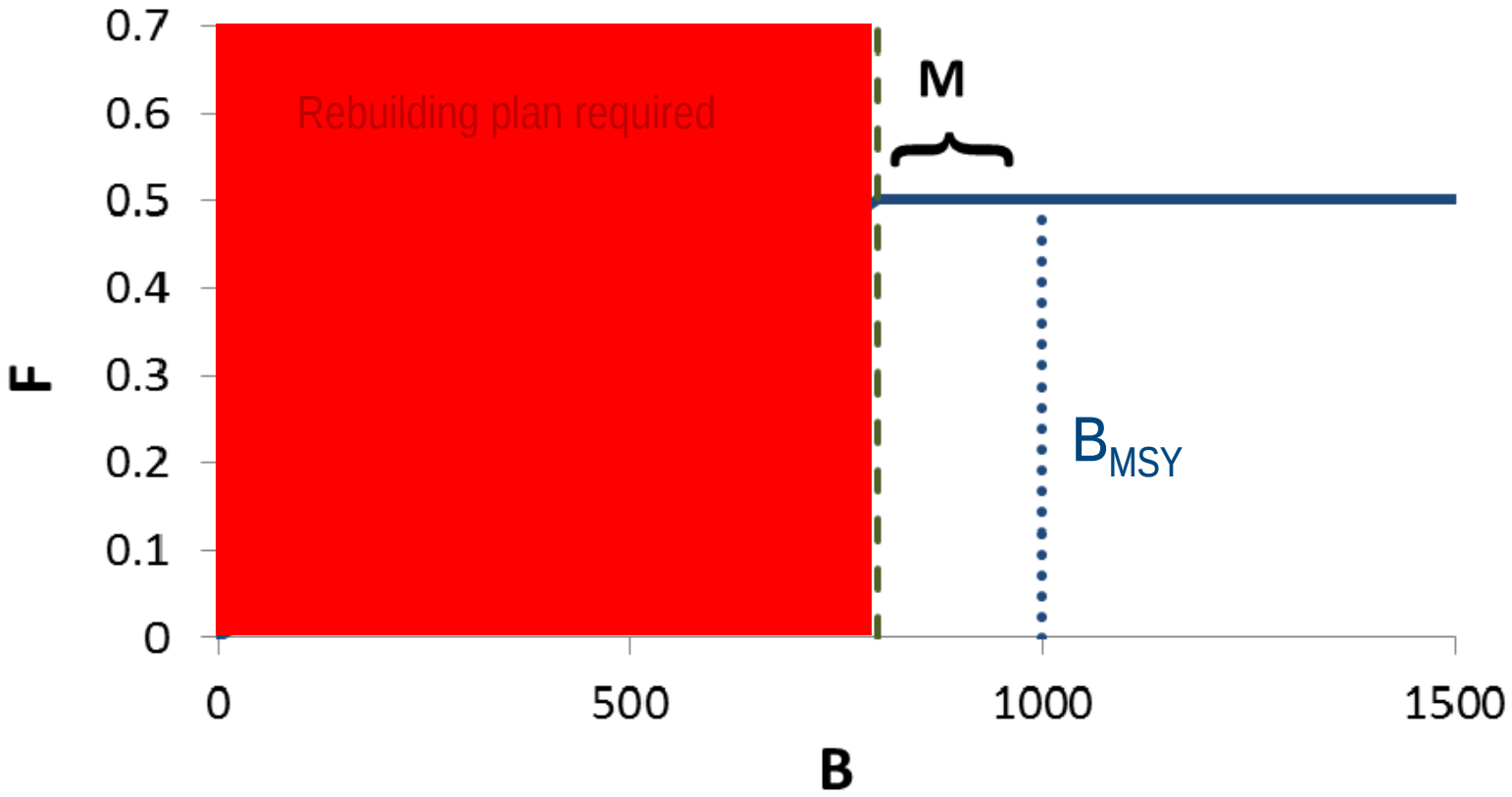
ABC Control Rule

- ABC control rule is a procedure, codified 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

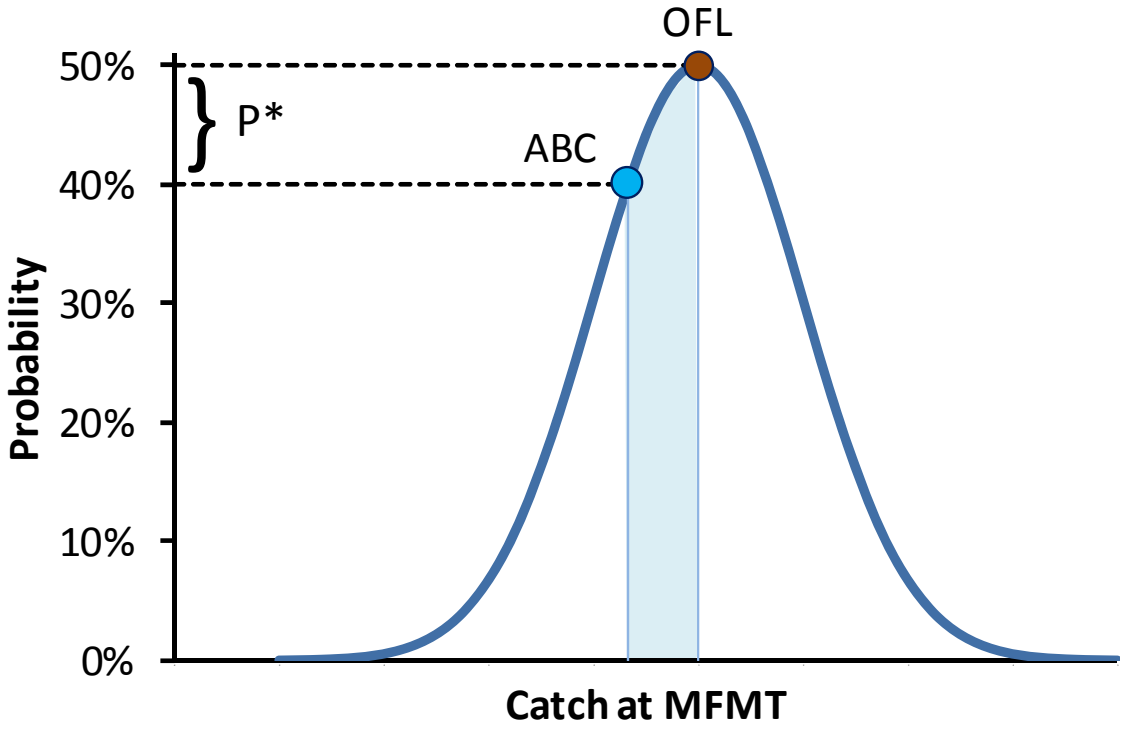
- The ABC control rule should consider reducing fishing mortality (MFMT) as stock size declines



ABC Control Rule

- The ABC control rule should consider reducing fishing mortality (MFMT) as stock size declines

- 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

- The ABC control rule should consider reducing fishing mortality (MFMT) as stock size declines
- 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.
- 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 that reflects scientific uncertainty

- MSST = (1-M)B_{MSY}
- MFMT = dF_{MSY}, where $d = \begin{cases} 1 & \text{if } B \geq \text{MSST} \\ B / \text{MSST} & \text{if } B < \text{MSST} \end{cases}$
- OFL = catch at MFMT
- ABC determined from PDF of OFL where acceptable probability of overfishing is 40%

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: GMFMC ABC Control Rule for Reef Fish

Gulf of Mexico Fishery Management Council Acceptable Biological Catch control rule – As Approved in the Generic ACL/AM Amendment 2011

Tier 1 Acceptable Biological Catch Control Rule	
Condition for Use	A quantitative assessment provides both an estimate of overfishing limit based on maximum sustainable yield or its proxy and a probability density function of overfishing limit that reflects scientific uncertainty. Specific components of scientific uncertainty can be evaluated through a risk determination table.
OFL	OFL = yield resulting from applying F_{MSY} or its proxy to estimated biomass.
ABC	The Council with advice from the SSC will set an appropriate level of risk (P*) using a risk determination table that calculates a P* based on the level of information and uncertainty in the stock assessment. ABC = yield at P*.
Tier 2 Acceptable Biological Catch Control Rule	
Condition for Use*	An assessment exists but does not provide an estimate of MSY or its proxy. Instead, the assessment provides a measure of overfishing limit based on alternative methodology. Additionally, a probability density function can be calculated to estimate scientific uncertainty in the model-derived overfishing limit measure. This density function can be used to approximate the probability of exceeding the overfishing limit, thus providing a buffer between the overfishing limit and acceptable biological catch.
OFL	An overfishing limit measure is available from alternative methodology.
ABC	Calculate a probability density function around the overfishing limit measure that accounts for scientific uncertainty. The buffer between the overfishing limit and acceptable biological catch will be based on that probability density function and the level of risk of exceeding the overfishing limit selected by the Council. a. Risk of exceeding OFL = 50% b. Risk of exceeding OFL = 40% c. Risk of exceeding OFL = 30% (default) Set ABC = OFL – buffer at risk of exceeding OFL
Tier 3a Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. The probability of exceeding the overfishing limit in a given year can be approximated from the variance about the mean of recent landings to produce a buffer between the overfishing limit and acceptable biological catch. Based on expert evaluation of the best scientific information available, recent historical landings are without trend, landings are small relative to stock biomass, or the stock is unlikely to undergo overfishing if future landings are equal to or moderately higher than the mean of recent landings. For stock complexes, the determination of whether a stock complex is in Tier 3a or 3b will be made using all the information available, including stock specific catch trends.
OFL	Set the overfishing limit equal to the mean of recent landings plus two standard deviations. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from the SSC as: a. ABC = mean of the landings plus 1.5 * standard deviation (risk of exceeding OFL = 31%) b. ABC = mean of the landings plus 1.0 * standard deviation (default) (risk of exceeding OFL = 16%) c. ABC = mean of the landings plus 0.5 * standard deviation (risk of exceeding OFL = 7%) d. ABC = mean of the landings (risk of exceeding OFL = 2.3%)
Tier 3b Acceptable Biological Catch Control Rule	
Condition for Use*	No assessment is available, but landings data exist. Based on expert evaluation of the best scientific information available, recent landings may be unsustainable.
OFL	Set the overfishing limit equal to the mean of landings. A time series of at least ten years is recommended to compute the mean of recent landings, but a different number of years may be used to attain a representative level of variance in the landings.
ABC	Set acceptable biological catch using a buffer from the overfishing limit that represents an acceptable level of risk due to scientific uncertainty. The buffer will be predetermined for each stock or stock complex by the Council with advice from its SSC as: e. ABC = 100% of OFL f. ABC = 85% of OFL g. ABC = 75% of OFL (default) h. ABC = 65% of OFL

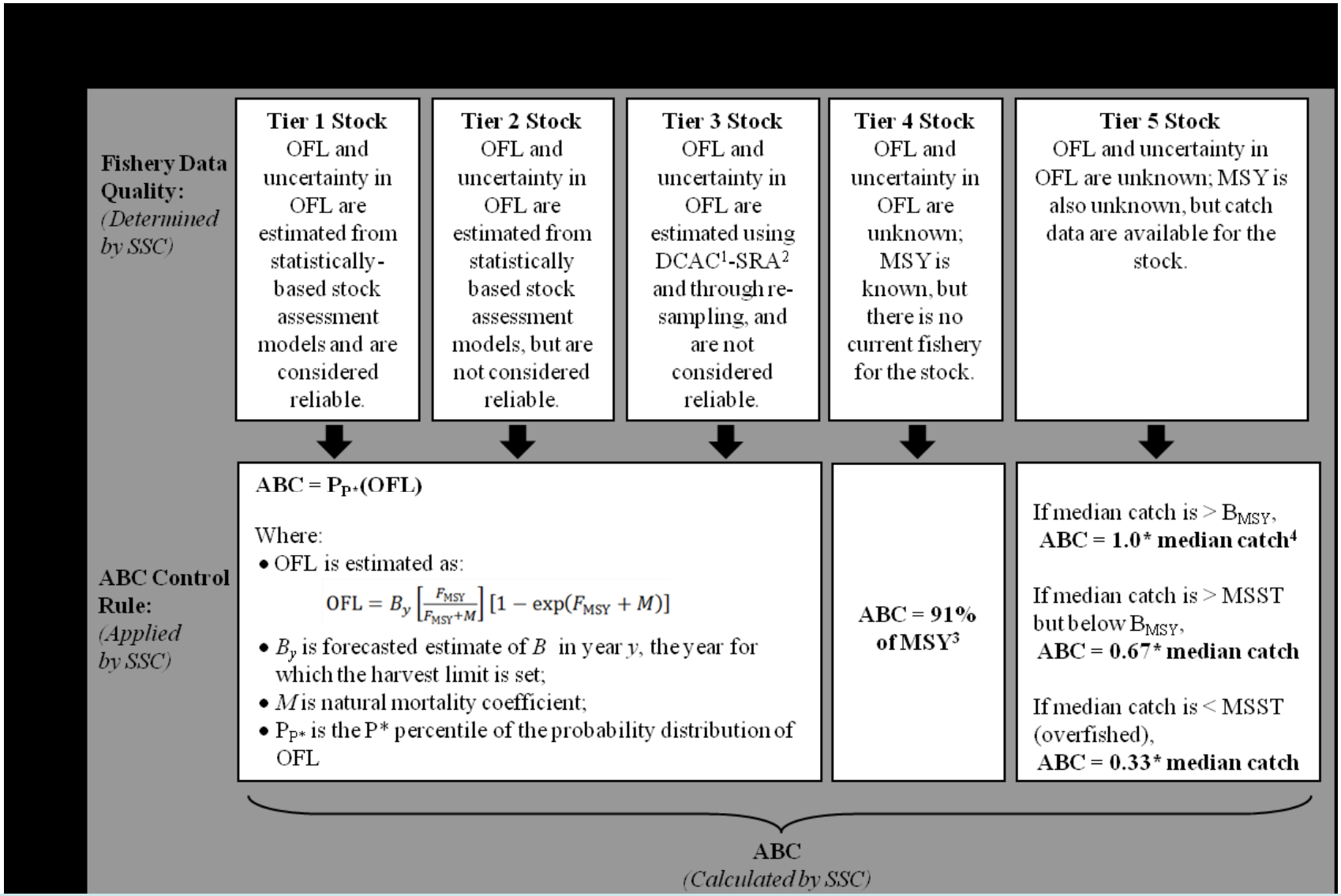
*Changes in the trend of a stock's landings or a stock complex's landings in three consecutive years shall trigger a reevaluation of their acceptable biological catch control rule determination under Tiers 2, 3a, or 3b.

Note: There may be situations in which reliable landings estimates do not exist for a given data-poor stock. The approach and methodology for setting OFL and ABC will be determined on a case-by-case basis, based on expert opinion and the best scientific information available.

Example: GMFMC ABC Control Rule for Reef Fish

- Tier 1 – 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
- Tier 2 – Assessment cannot estimate MSY reference points, but uses an alternative methodology to estimate PDF of OFL
- Tier 3a – 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 – 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

Example: WPFMC ABC Control Rule



The Hidden Details

Credit: Kathryn L. Porch

The Hidden Details

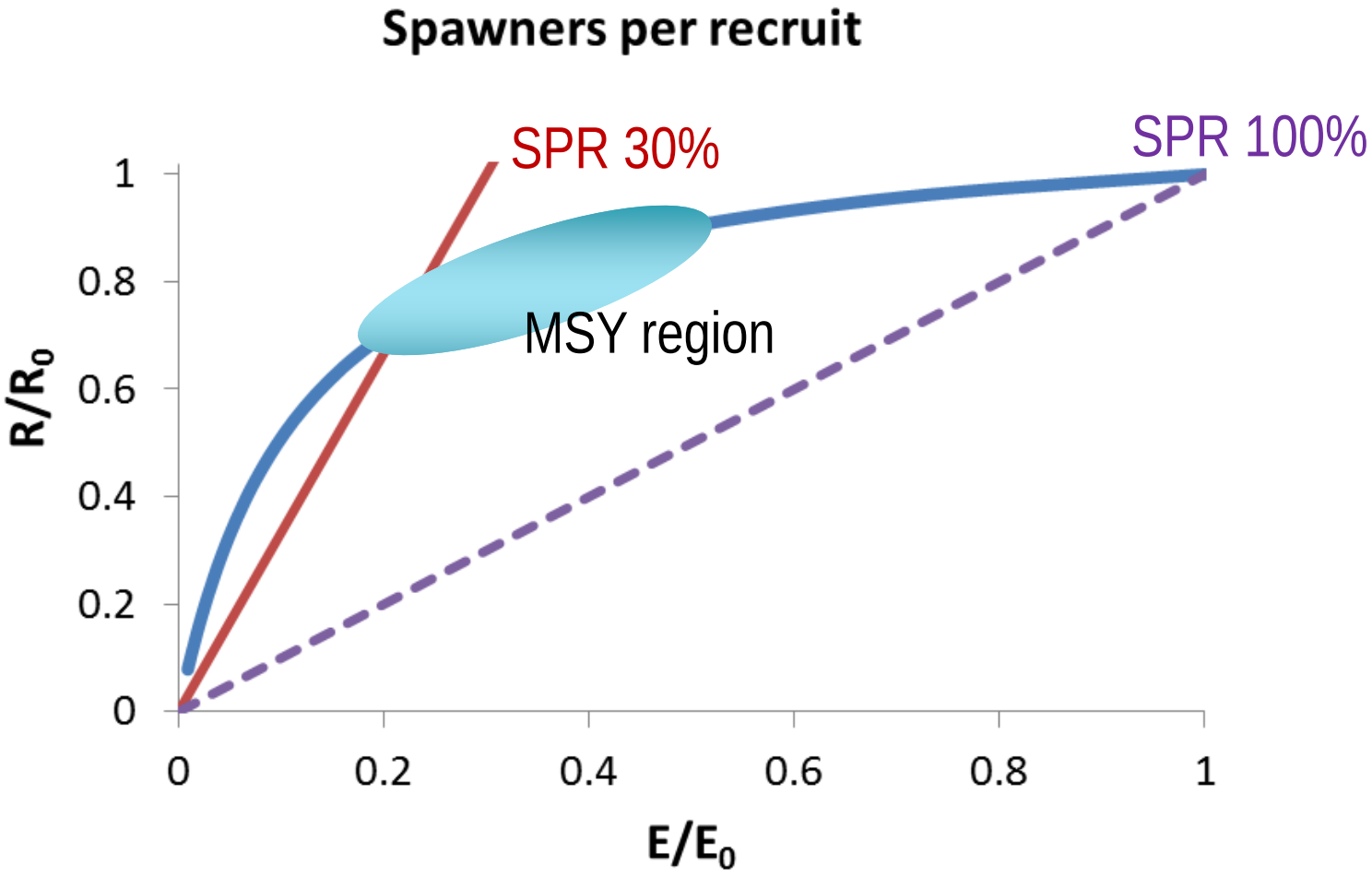
Calculation of MSY and OFL depends on knowing (or assuming) the nature of reproduction, growth and natural mortality

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.

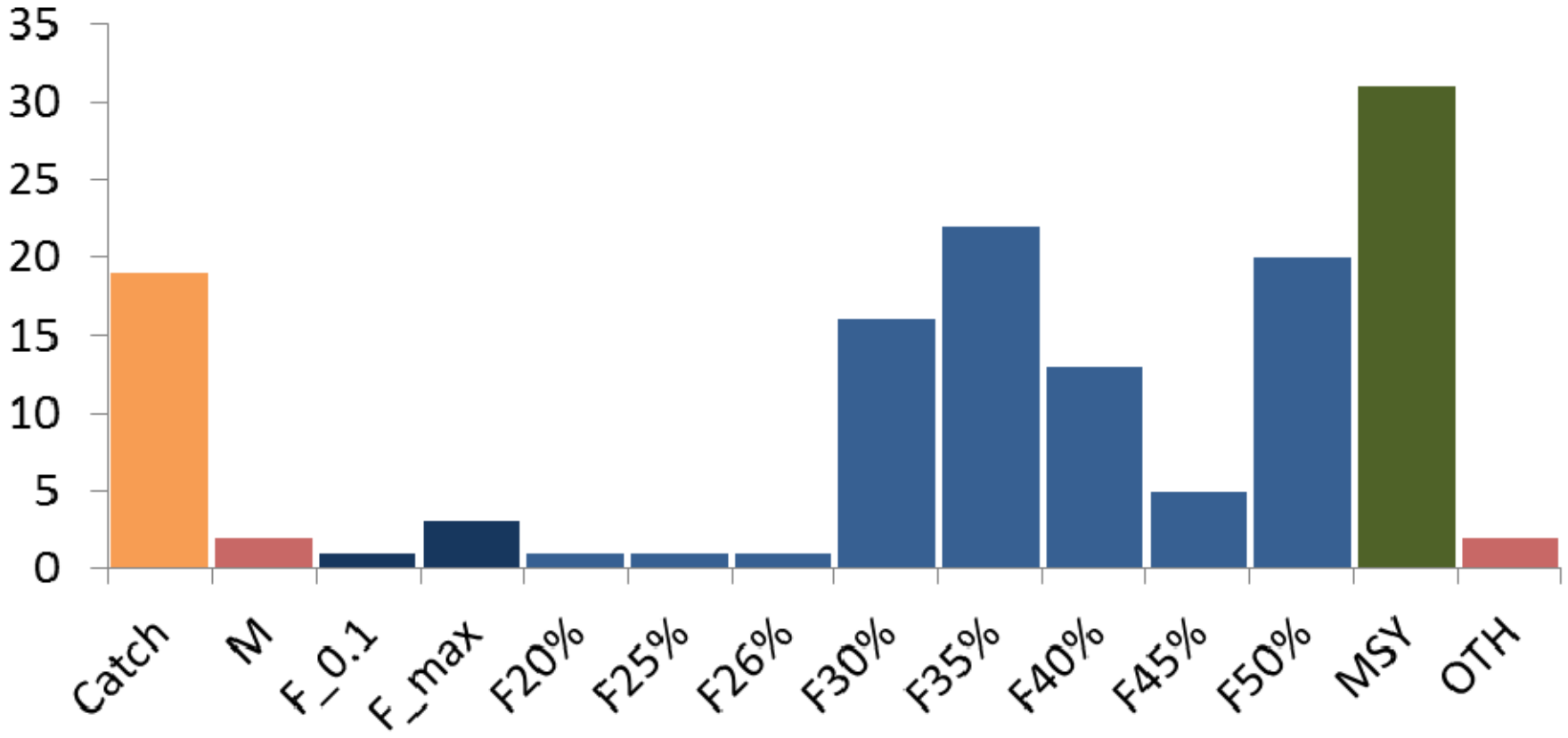
Sydney Holt

What are safe proxies for MSY?

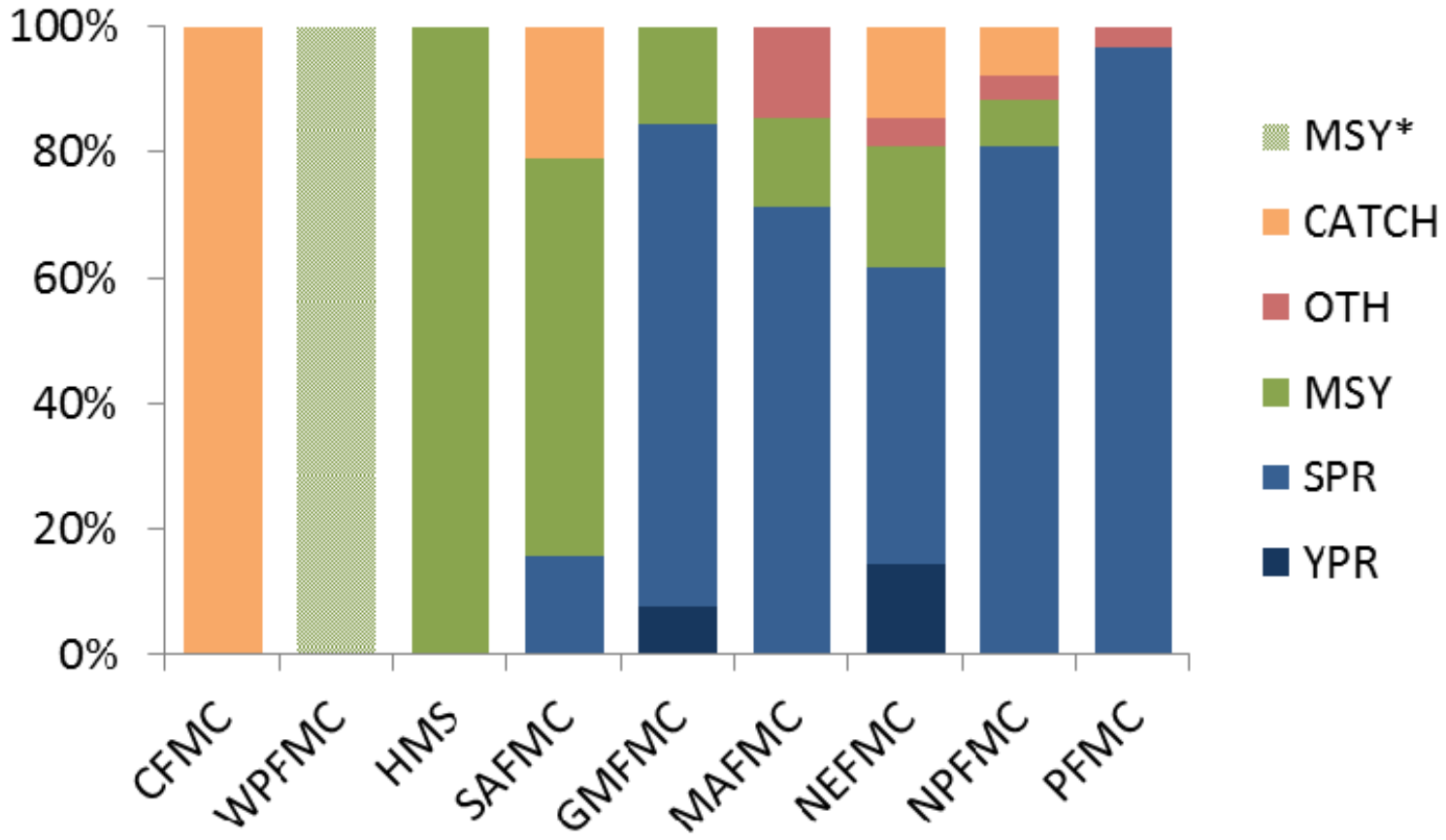


Definitions for MFMT across the U.S.A.

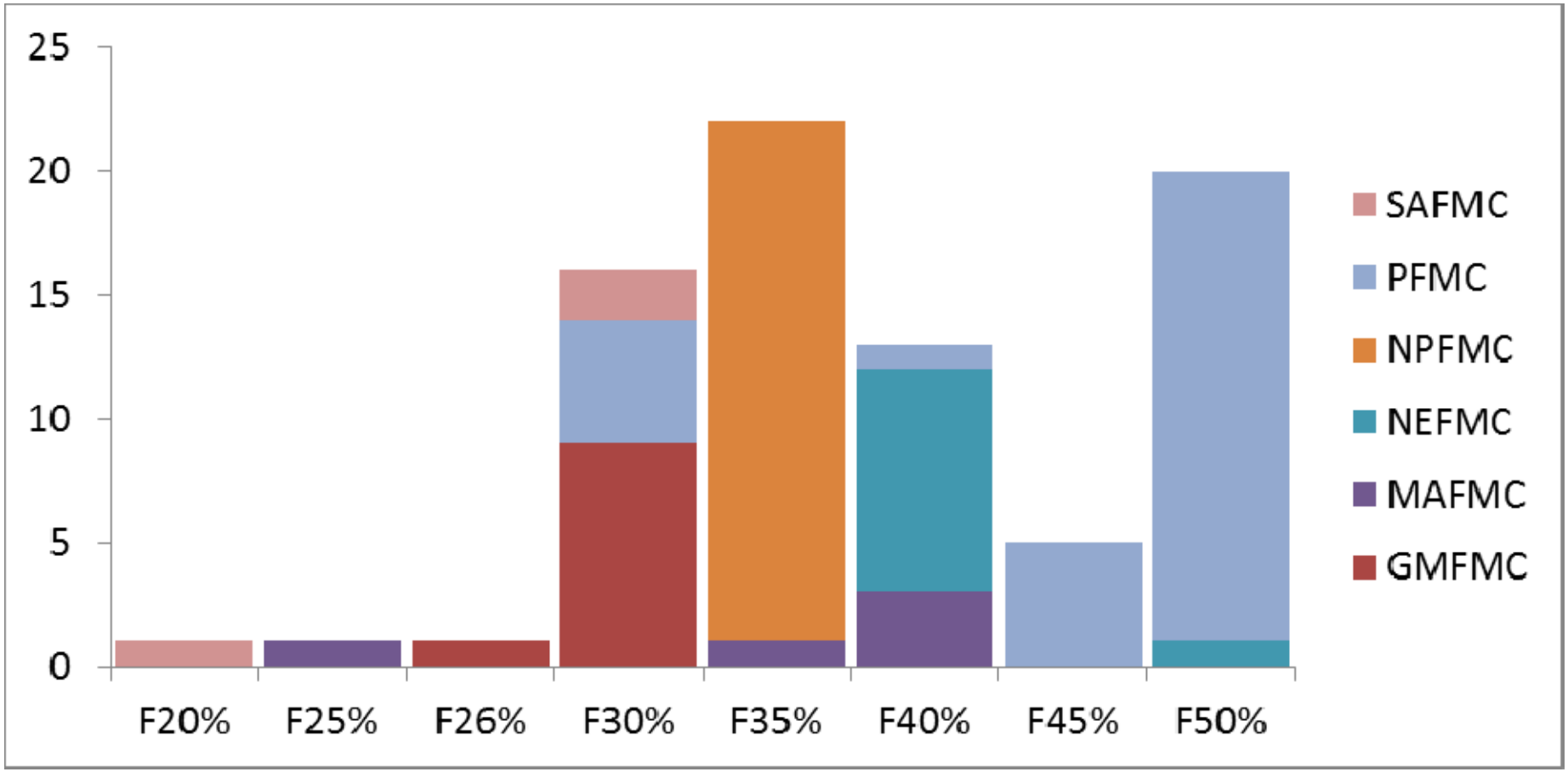
Fishing Mortality Reference Points in the Species Information System (mostly FSSI stocks)



Differences among councils

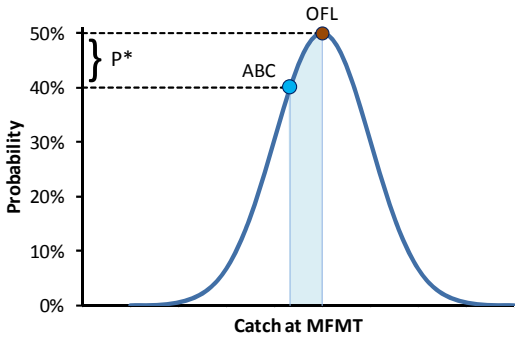


Differences among councils in choice of SPR



The Hidden Details

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

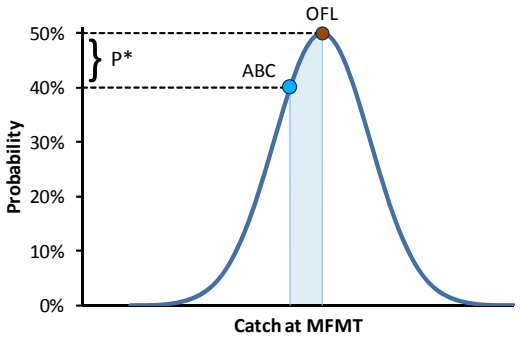


"there are known unknowns,... but there are also unknown unknowns – the ones we don't know we don't know. It is the latter category that tend to be the difficult ones."

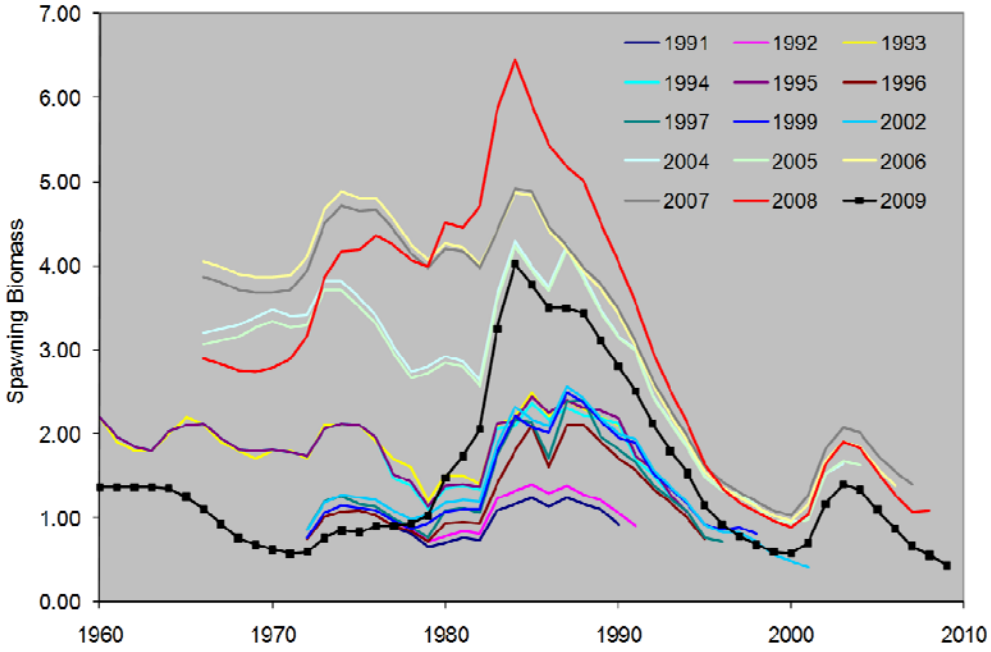
Donald Rumsfeld, 2002

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. 2011)



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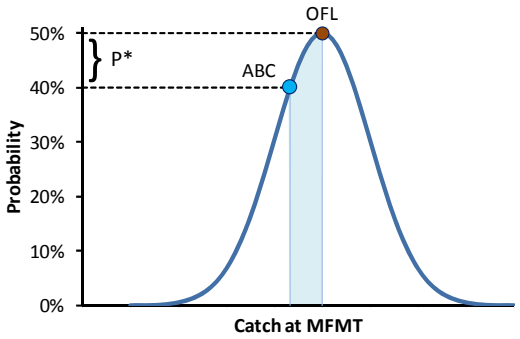


- Try to estimate variance of pdf as part of the assessment process
- Estimate variance external to assessment process
  - borrow from another assessment
  - compute from comparisons of estimates from multiple past assessments (Ralston et al.)
- Don't even try
  - F_{ABC}=0.75MFMT

The Trouble with Data-Limited Stocks

NS1 Under revision to provide greater flexibility to better manage data-limited stocks

- Allows alternative approaches to setting SDC when MSY cannot be calculated (but still require overfishing and overfished thresholds and related reference points like ABC, ACL, etc.). Some example approaches include:
  - Fish Density Ratio Control Rules
  - Only Reliable Catch Stocks (ORCS)
  - Depletion-Corrected Adjusted Catch (DCAC)
- Emphasizes use of assessed indicator stock(s) for management of data limited stock complexes

Example: Queen snapper *Etelis oculatus*

- Time-series of catch available, but not effort
- Time-series of size composition data (lengths from the fishery) available
- Limited life history information was available
- Cannot calculate MSY or associated SDC

Example: Deriving OFL

Can we get an OFL if we don't know MSY? Yes!

(1) $OFL_t = F_{MSY} N_t$ (but F_{MSY} and N_t are unknown)

If we can estimate average catch and fishing mortality for a reference period ***t***

(2) $C_t = F_t N_t$

Then equation (2) can be substituted into (1)

(3) $OFL_t = F_{MSY} \frac{C_t}{F_t}$

If we are willing to accept a proxy for F_{MSY} (like $F_{0.1}$, Fmax, Fspr)

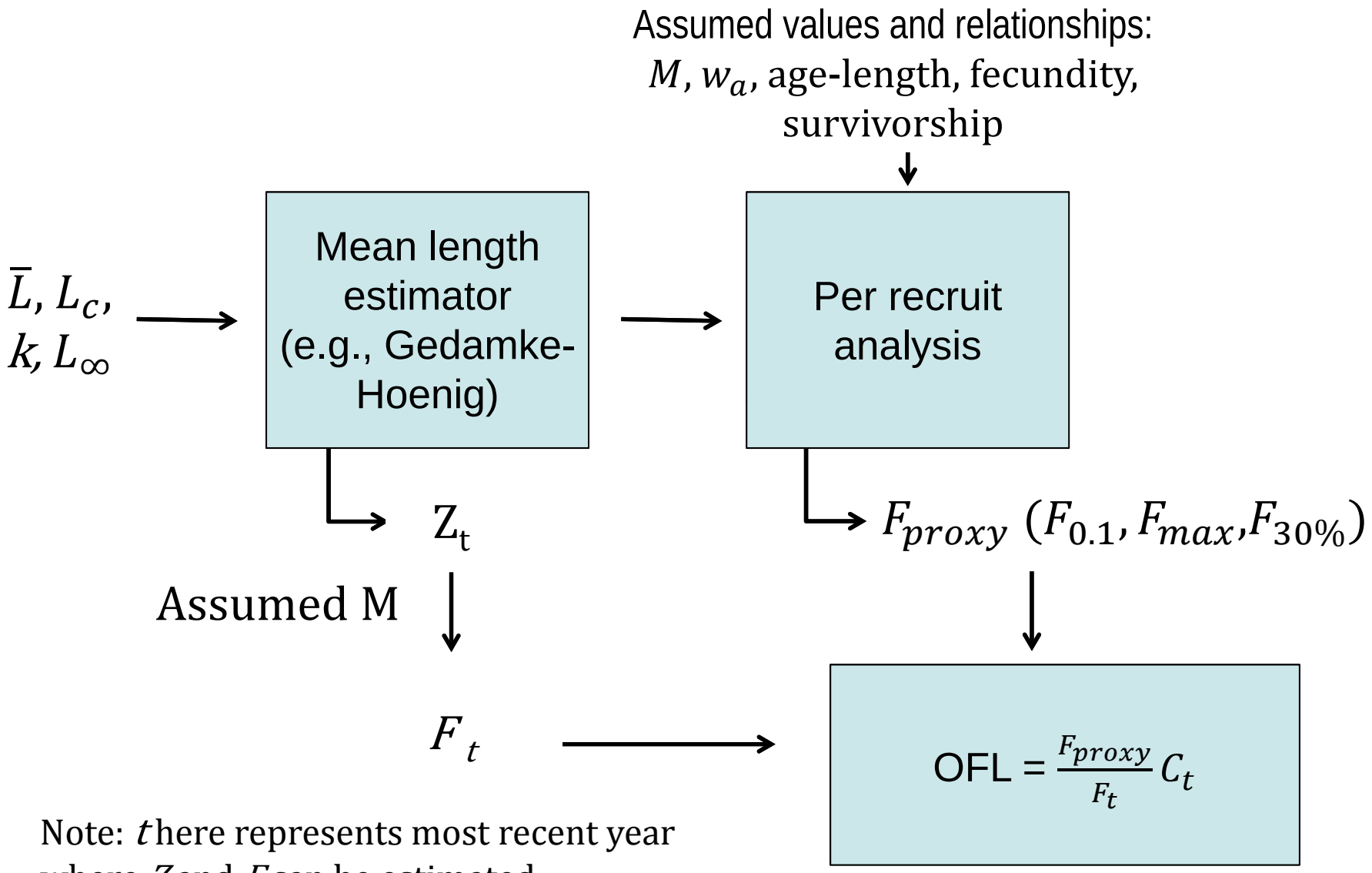
$$OFL_t = \frac{F_{proxy}}{F_t} C_t$$

MFMT = F_{proxy}

MSST = unknown

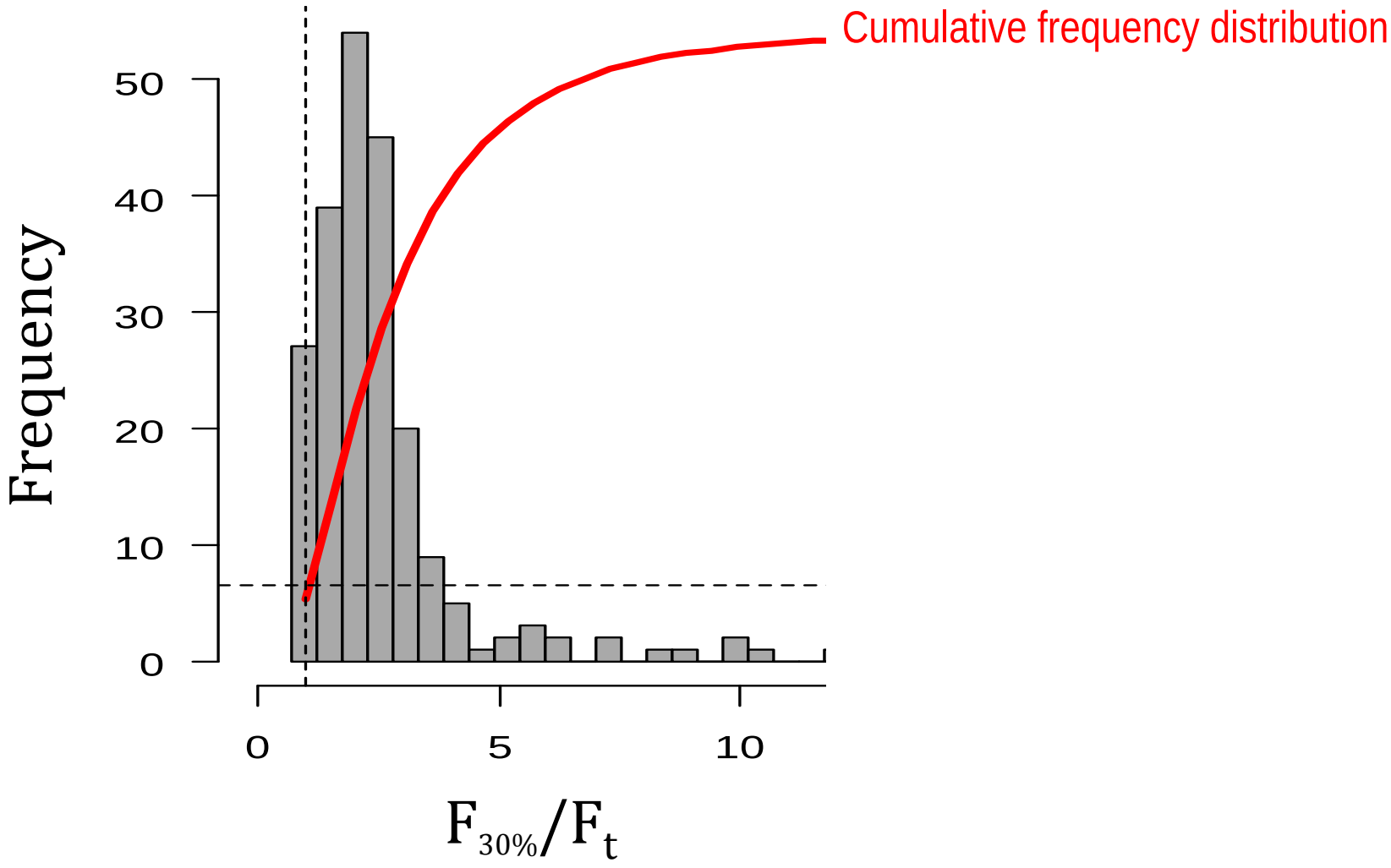
2 of the 3 required SDC

Example: Application of Mean-length estimator



Note: t here represents most recent year where Z and F can be estimated

Example: Deriving ABC



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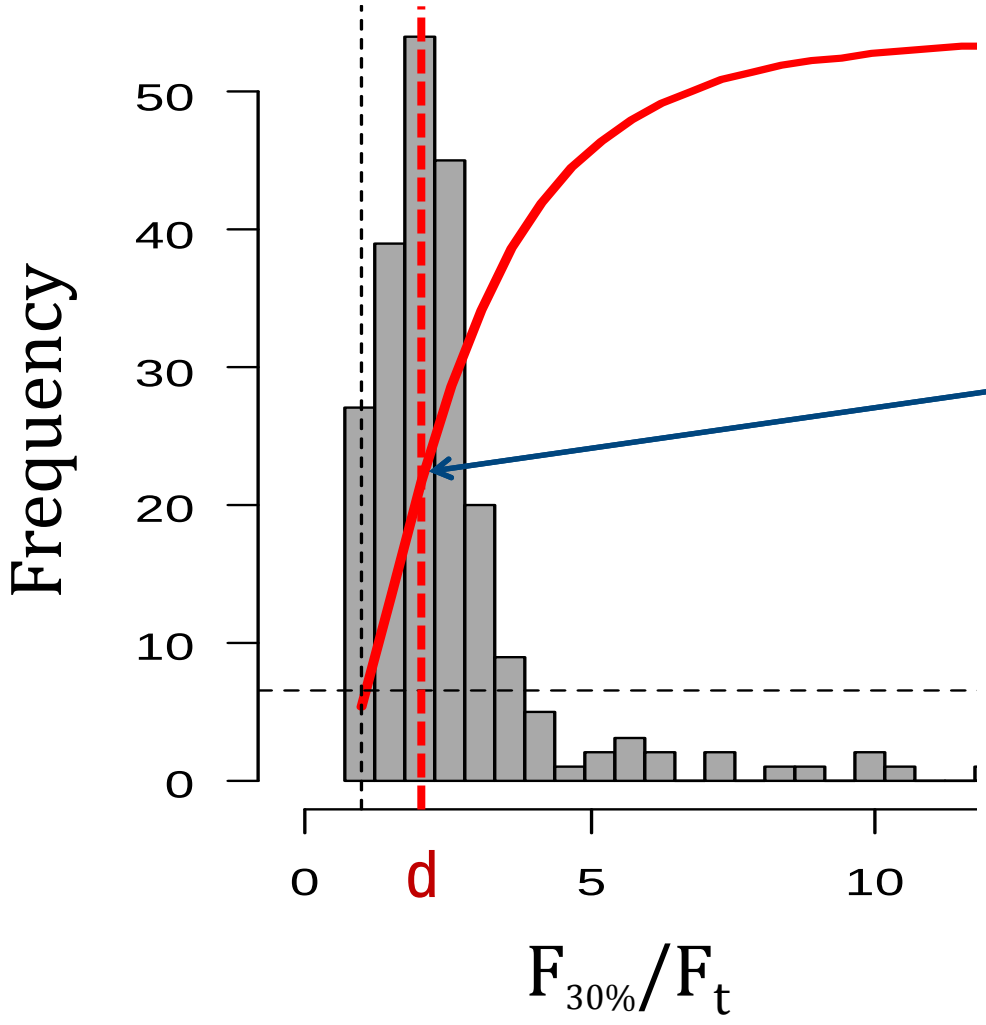


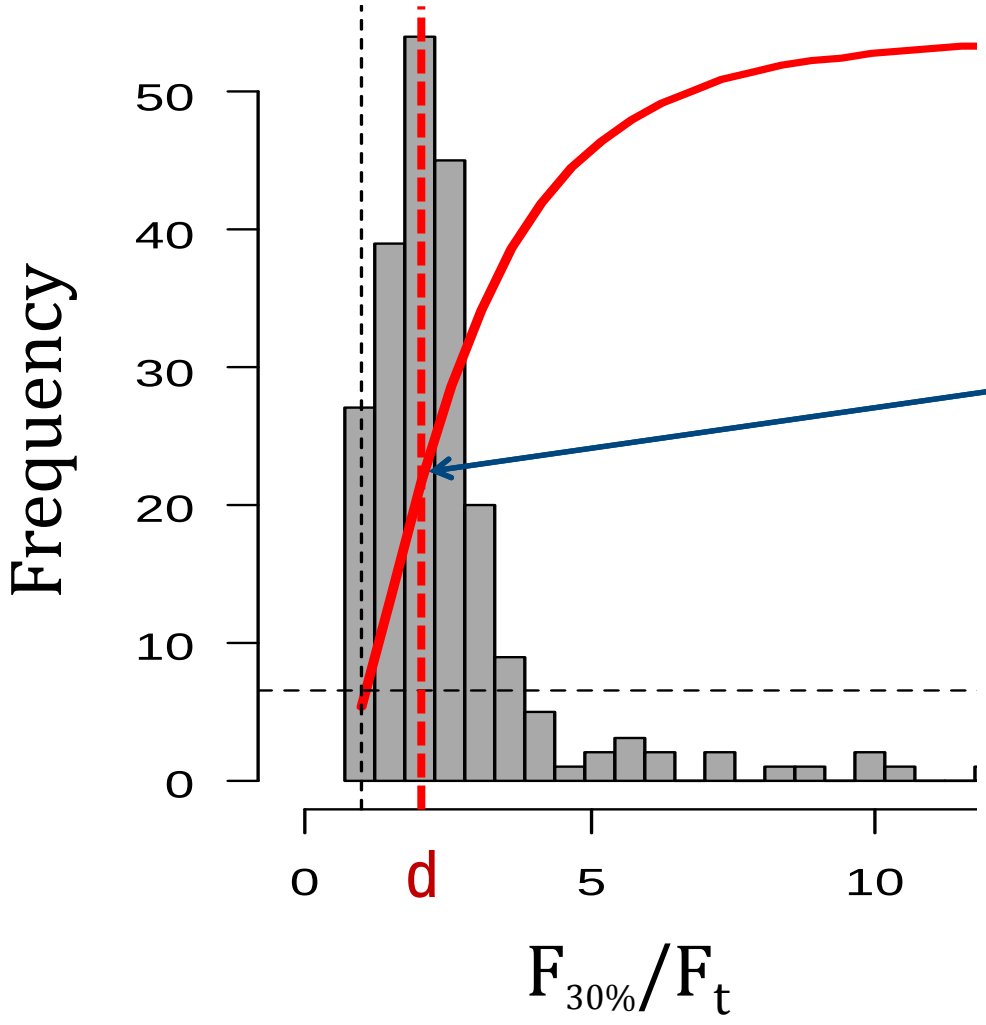
If C_t is treated as a scalar known without error then:

$P(OFL < d C_t) = P(F_{30\%}/F_t < d)$

Solve for *d* such that

$P(F_{30\%}/F_t < d) = P^*$

Example: Deriving ABC



If C_t is treated as a scalar known without error then:

$P(OFL < d C_t) = P(F_{30\%}/F_t < d)$

Solve for d such that

$P(F_{30\%}/F_t < d) = P^*$

If C_t is treated as a random variable then must solve

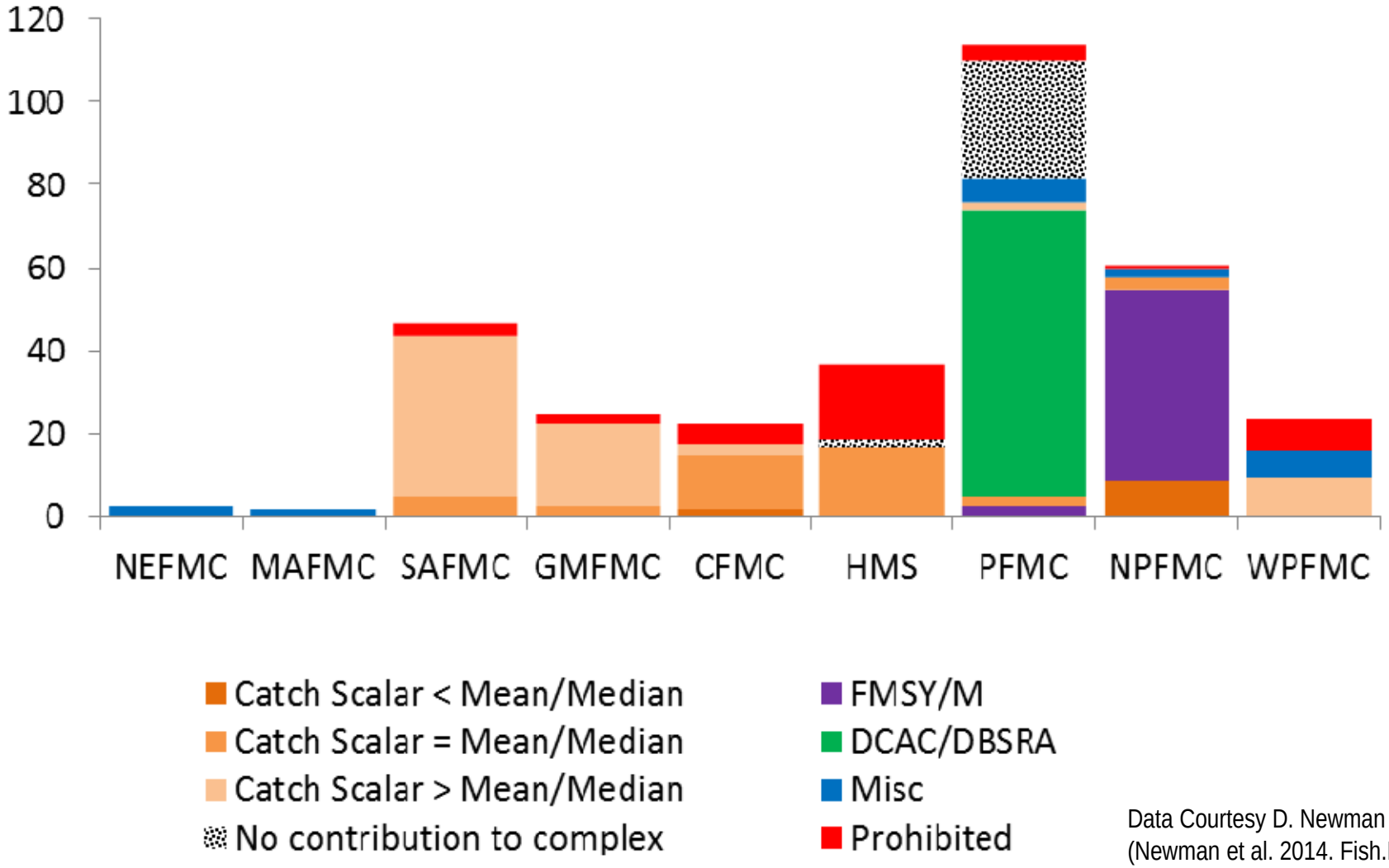
$P(OFL < x) = P^*$

From joint pdf $P(C_t, F_{30\%}/F_t)$

Actual ABC Control Rules

Council	Tiers	OFL (catch at MFMT)	ABC method
NPFMC	2 of 6	MFMT = M mean catch	catch at F = 0.75M 0.75 OFL
PFMC	2 of 3	DB-SRA, DCAC, mean catch	P* = 0.4, σ = 0.72 - 1.44
WPFMC	2 of 5	considered unknown	0.91 MSY [0.33 - 1]median catch
GMFMC	1 of 3	overfished: mean catch not overfished: mean catch + 2σ	overfished: [0-0.65]mean catch not overfished: mean catch+ [0-1.5]σ
CFMC	1 of 1?	Ad hoc (mean/median catch)	Usually ABC = OFL, ACL = [0.75-1]ABC
SAFMC	3 of 4	DB-SRA, DCAC, ORCS, Ad hoc	Ad hoc
MAFMC	1 of 4	Ad hoc	Ad hoc
NEFMC	varies	Ad hoc	Ad hoc
HMS sharks	1 of 2	Average catch, prohibited species	Ad hoc

Differences among councils in choice of DLMs



Data Courtesy D. Newman
(Newman et al. 2014. Fish.Res 164)

SEDAR 46: Final Report Due March 28

- 6 Stocks Selected

STT: Queen Triggerfish

STT&STX: Spiny Lobster

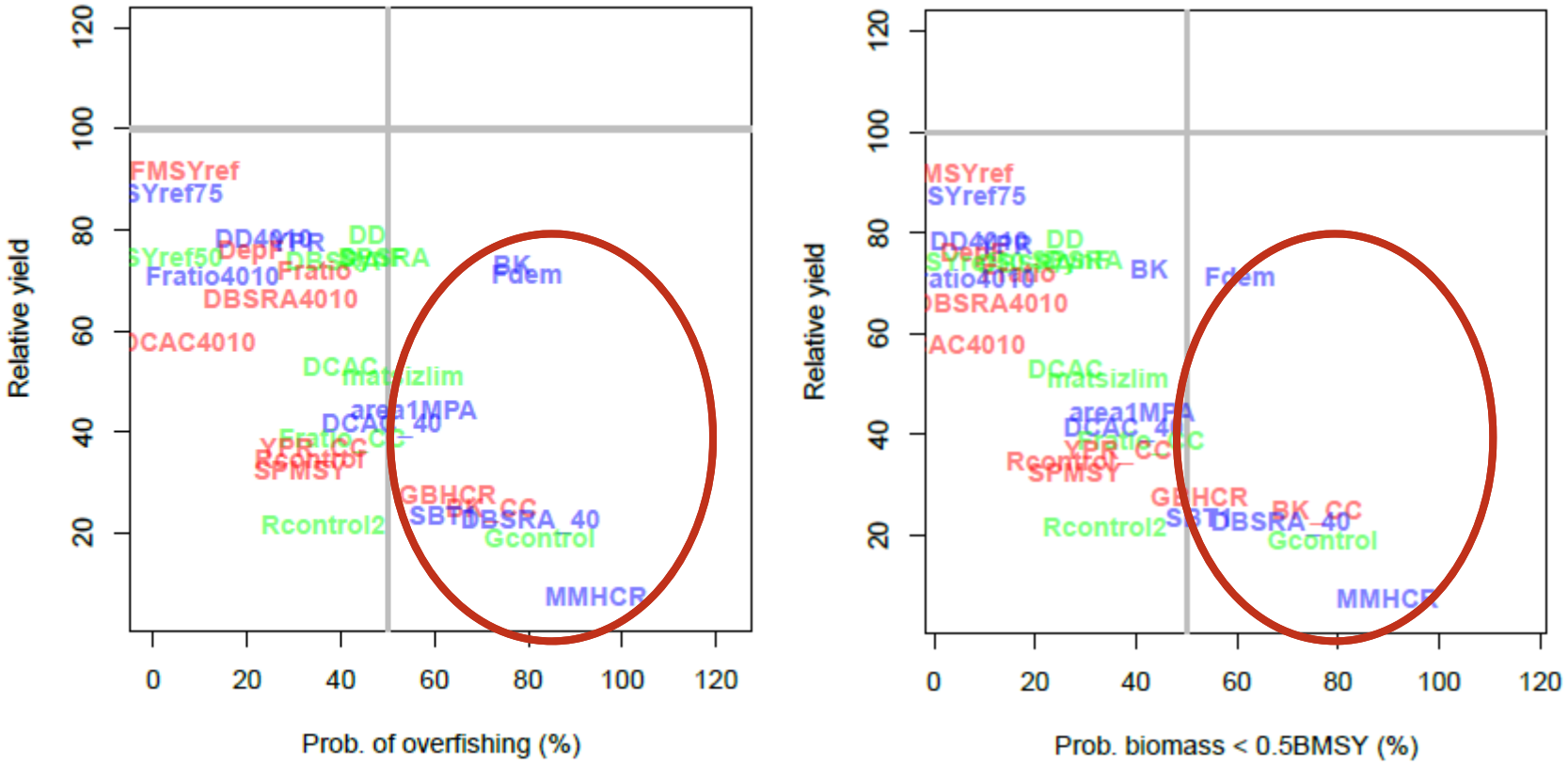
STX: Stoplight Parrotfish

PR: Hogfish

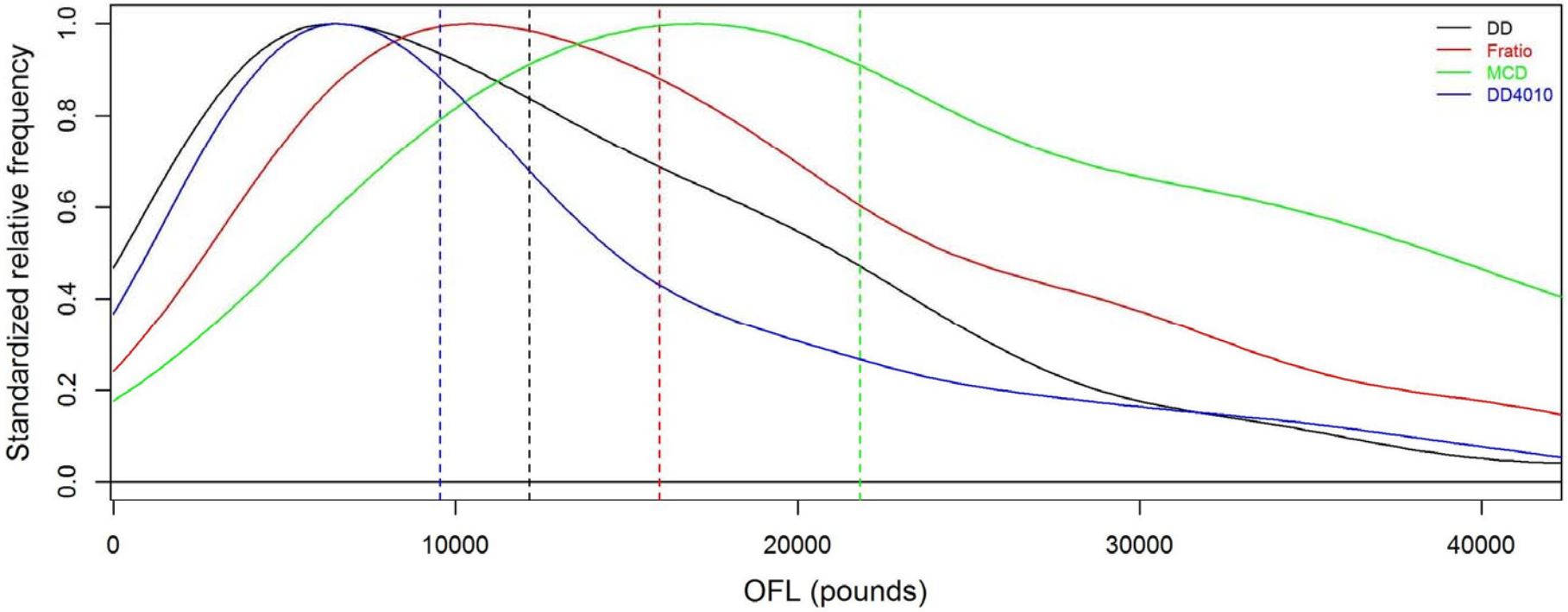
PR: Yellowtail Snapper

Results of MSE

- Eliminate models that are inconsistent with management objectives or show poor diagnostics



Results of “Best Available Methods”



Moving Forward: Need a more flexible plan

1. The Fishery Management Plans may need to be amended to allow for scientific advice beyond scalar multiples of average catch
2. Council needs to weigh in on management objectives (e.g., acceptable probability of overfishing, criteria for defining optimum yield if different from MSY)
3. SSC needs to develop an ABC control rule that is sufficiently flexible to accommodate scientific advice
   - Short-term (what to do with SEDAR 46?)
   - Long-term (anticipating advances in methods and data)

Moving Forward: Need a flexible ABC control rule

Need at least 2 tiers describing what to do if

1. If SSC "accepts" the assessment
   - Method for computing OFL (e.g., single base model or average of multiple models)
   - Method for computing ABC (buffering for scientific uncertainty)

   If P* approach taken the Council will need to specify the acceptable probability of overfishing (NS1: it must be less than 50%)

2. If SSC "rejects" the assessment
   - Interim OFL and ABC based on recent landings history (similar to current approach)
   - Include in a complex of species with a collective OFL and ABC

Moving Forward: Need a flexible ABC control rule

- Tier 1 – Full stage-structured assessment providing MSST MFMT, and PDF of OFL
- Tier 2 – Data-moderate approaches that can provide MSST, MFMT, and PDF of OFL
- Tier 3 – Data-limited approaches where catch is known that can approximate PDF of OFL
- Tier 4 – Data-poor approaches where catch is unknown that can provide relative stock-status (e.g. biomass / MSST)
- Tier 5 – Only Reliable Catch
- Tier 6 – No Reliable Data (include in complex with an assessible next of kin)

The process

You are here

Form a small ABC control rule group

Review latest research

Council/public feedback