Science, Service, Stewardship

Probability-based catch levels: OFLs, ABCs, ACLs, & ACTs

AFSC Workshop
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Outline

- Cliffs Notes review of probability-based approaches
- MSRA framework
  - OFL, ABC, ACL, ACT
  - Scientific uncertainty, management uncertainty
- Catch levels for “next” year
- Catch levels for multiple years
- Example: Atlantic vermilion snapper

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P* approach

- Define P* as the acceptable probability of overfishing
- Smaller P* provides larger buffer against overfishing
- Methods in this talk treat P* as input

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P* background

- Key to this discussion are *targets* and *limits*
  - Targets are management quantities to be achieved
  - Limits are bounds on exploitation not to be exceeded
- Caddy & McGarvey (NAJFM, 1996) computed target fishing rates, given three inputs:
  - P*
  - implementation uncertainty
  - limit fishing rate (e.g., F_{MSY})

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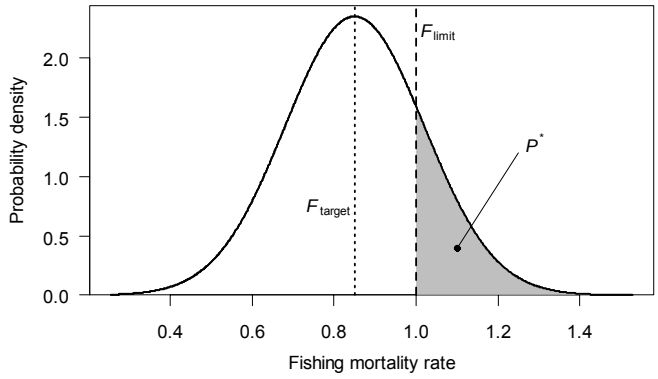
Caddy & McGarvey (1996) approach to setting a target fishing rate

$$P^* = \Pr(F_t > F_{\text{limit}}) = \int_{F_{\text{limit}}}^{\infty} \phi_{F_t}(F)dF$$



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P* background

- Prager et al. (NAJFM, 2003) extended the Caddy & McGarvey approach to include uncertainty in the limit fishing rate as well

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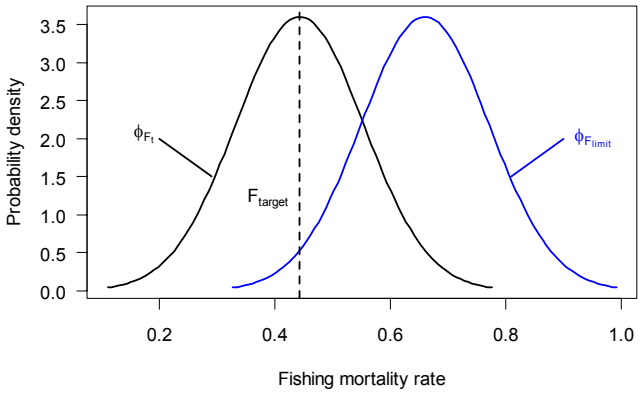
Prager et al. (2003) approach

$$P^* = \Pr(F_t > F_{\text{limit}}) = \int_0^{\infty} \left[\int_F^{\infty} \phi_{F_t}(\theta) d\theta \right] \phi_{F_{\text{limit}}}(F) dF$$



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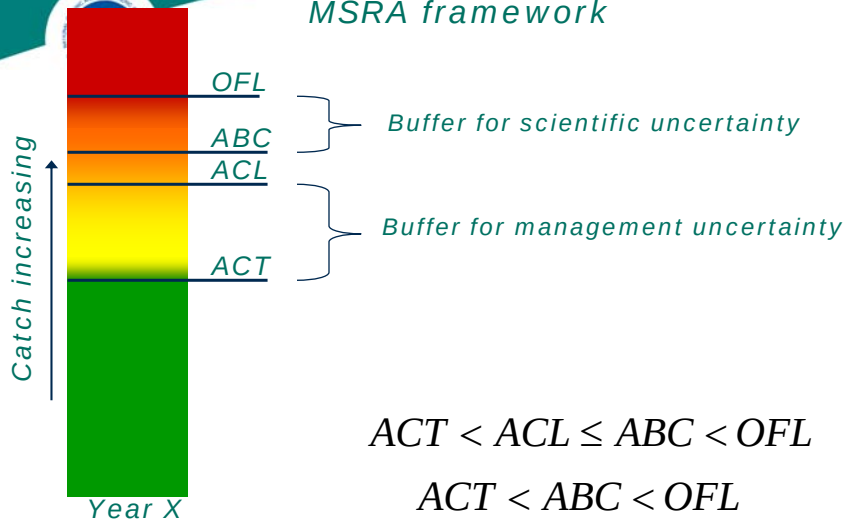
MSRA framework



$$ACT < ACL \leq ABC < OFL$$

$$ACT < ABC < OFL$$

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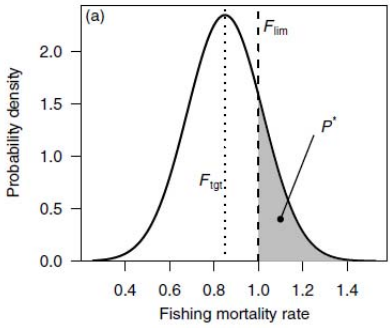
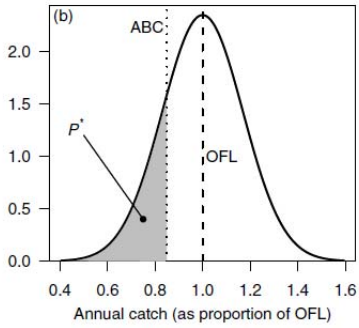
ABC (and ACT) "next" year

- Given the distribution of OFL, the Caddy & McGarvey approach could be modified to compute an ABC

Original C&M



Modified C&M



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Distribution of OFL

- It is preferable that the distribution of OFL be provided as assessment output.
- It is possible to compute the distribution post-hoc, given uncertainty in F_{MSY} and $B_{current}$, using the catch equation.
- However, our experience is that post-hoc analyses—numerical and analytical, log and arithmetic space, with and without covariance—do not work as well!

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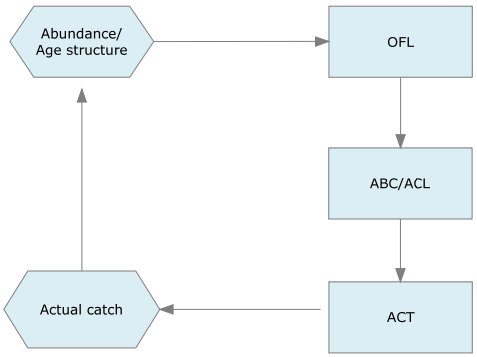
Multi-year catch levels

- Setting catch levels for multiple years requires a projection model, because of feedback among catch levels and the stock
- ABCs and ACTs should not be set independently



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Multi-year catch levels

- Common projection models only require modest modification to accommodate the P* approach
  - Projection input is P*
  - Projected F and catch are output
- Shertzer, Prager, & Williams. 2008. A probability-based approach to setting annual catch levels. Fish. Bull.
  - OFL → ACT
- NS1 Working Group tech memo chapter: consistency with NS1 Guidelines
  - OFL → ABC and OFL→ ACT

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Another buffer to consider

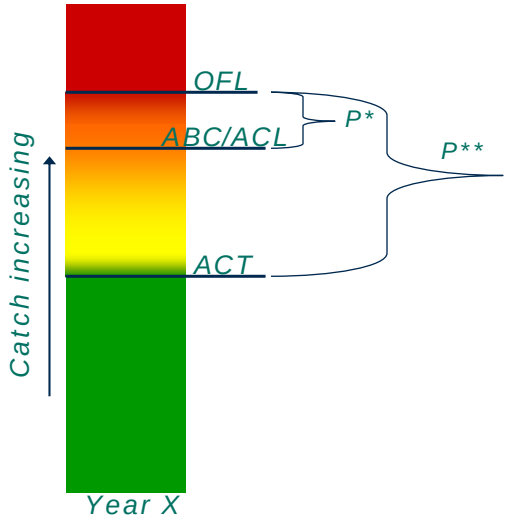
Definitions

- *P** is the allowable probability that the ABC will exceed the overfishing level
- *P*** is the allowable probability that catch from an ACT will exceed the OFL

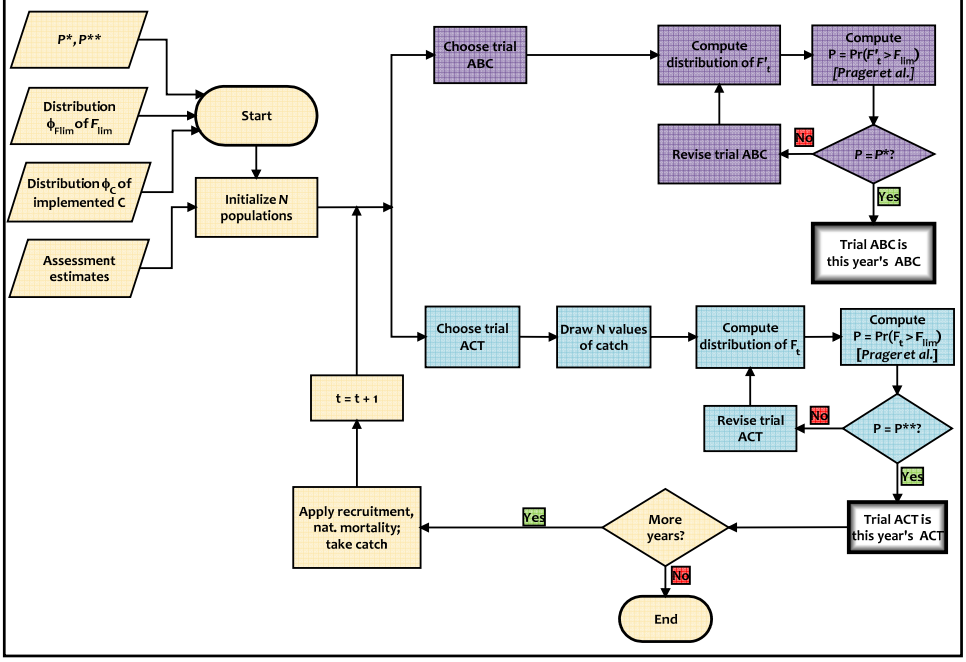
Comments

- P** must be less than P*, to ensure that ACT < ABC
- Controls the expected probability of overfishing explicitly (P**), which may be a desirable property

P* approach in the MSRA framework



Flowchart of projection



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Example: Atlantic vermilion snapper

- Stochastic projection with parameters from recent SEDAR assessment
  - lognormal variation in recruitment
  - variation in initial conditions (numbers at age)
- End of assessment in 2007; Beginning of new management in 2009; Fixed catch assumed in 2008.
- Uncertainty in F_{MSY} described by empirical distribution from bootstrap
- Implementation uncertainty assumed Gaussian with CV=0.2
- P*=0.4 and P**=0.2

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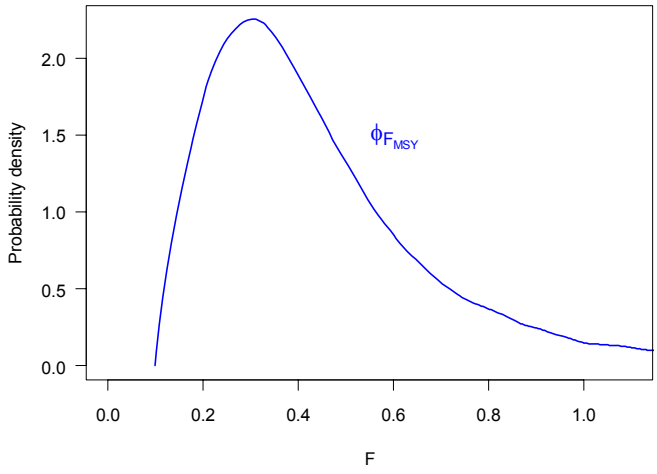
Distribution of F_{MSY}



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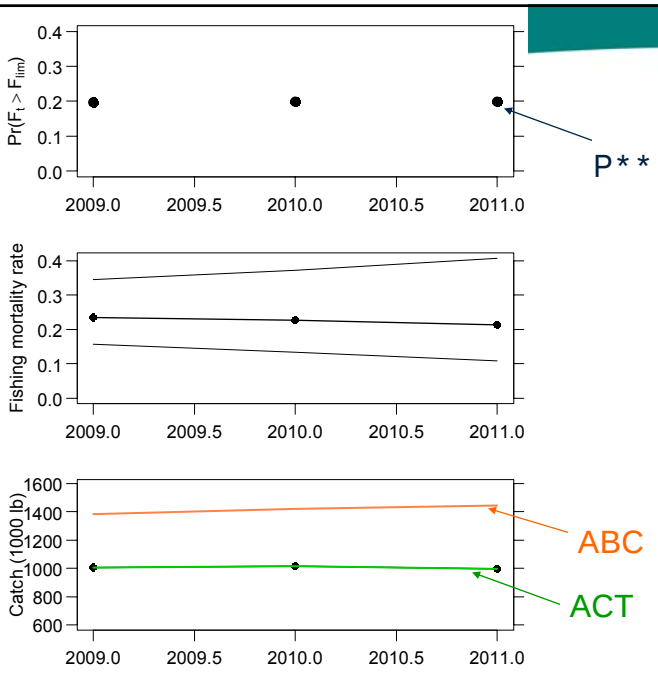

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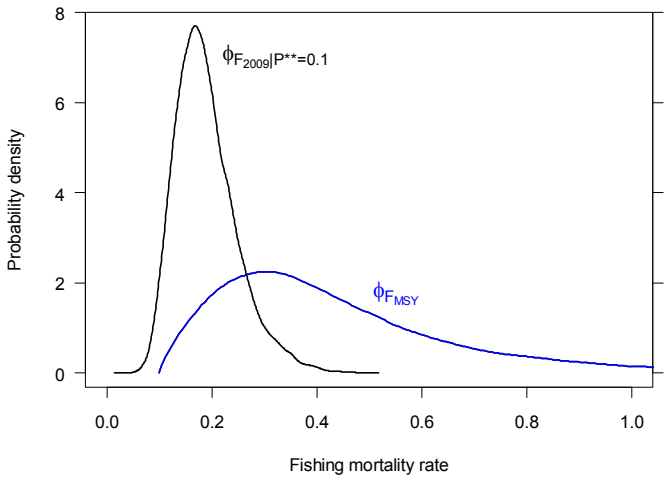
*Effect of P***



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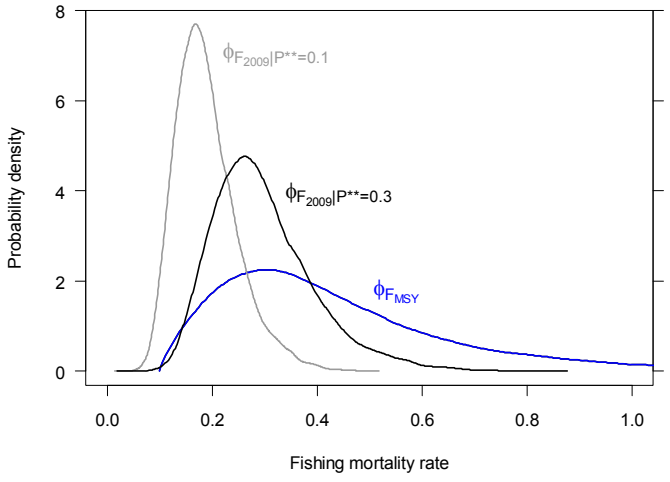
*Effect of P***



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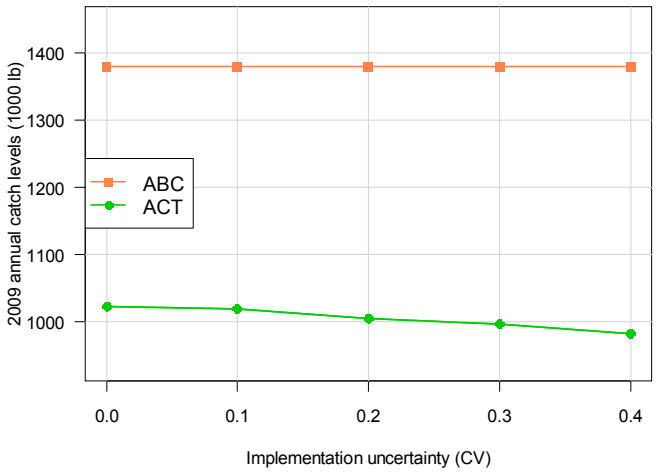
Effect of implementation uncertainty (P=0.4, P**=0.2)*



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Summary

- Probability-based approach to compute ABCs and ACTs
  - Uncertainty in future stock dynamics (stochastic projection model)
  - Uncertainty in F_{limit} or OFL (from assessment: parametric or empirical)
  - Uncertainty in management implementation
- Formalizes risk through P* and P**
  - Note: Risk is often defined as the product of occurrence probability and expected consequence. Not so here.
  - However, one could adjust P* based on expected consequences, e.g., as indicated by productivity-susceptibility analysis
- All else equal, precision in management allows larger catch levels

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Conclusions

- General framework: details can be customized to stock
- It does not require radical departure from the types of projections currently in use
- It has some desirable features:
  - Accommodates key sources of uncertainty
  - Managers can choose the levels of risk that they consider acceptable
  - Risk is quantified and transparent (P* and P**)
- Avoiding something bad (overfishing) is not the same as achieving something good (OY). The framework here maximizes fishing given the constraint of P* (or P**).

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The End

Probability of questions

$$P = \left\{\frac{\sigma^{2(\alpha+1)} y^{\alpha}}{(1-p)^{\alpha}(2-p)}\right\}\left\{\frac{1}{n!\Gamma(n\alpha)y}\right\}\exp\left\{-\frac{1}{\sigma^2}\left(\frac{\max(y,0)^{2-p}}{(1-p)(2-p)} - \frac{y\mu^{1-p}}{1-p} + \frac{\mu^{2-p}}{2-p}\right)\right\}$$