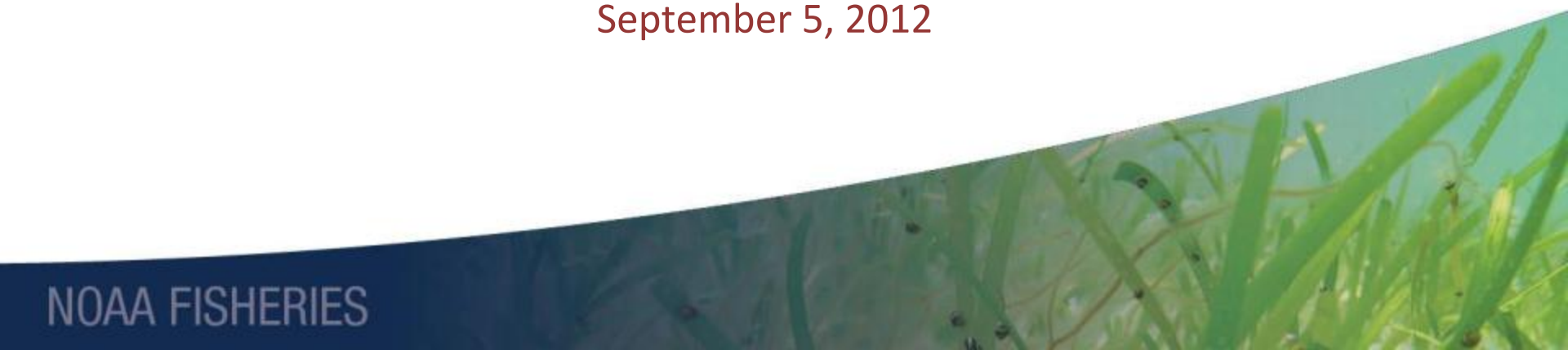
Maximum Sustainable Yield and Optimum Yield Concepts

Richard Methot, Ph.D.
NMFS, Office of Science and Technology

Fisheries Leadership & Sustainability Forum
Monterey, CA

September 5, 2012



NOAA FISHERIES

National Standard 1

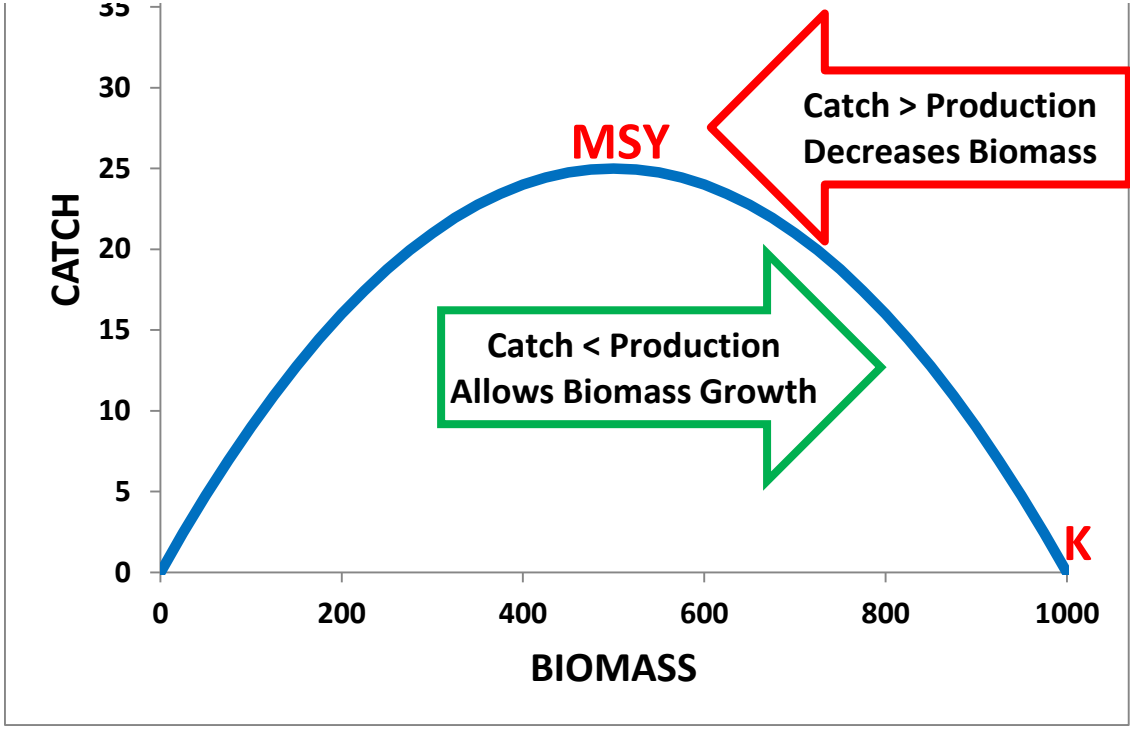
"Conservation and management measures shall **prevent overfishing** while **achieving, on a continuing basis, the optimum yield** from each fishery for the United States fishing industry."

NS1 – the foundation of management

- Sets the science-based boundary for catch levels – overfishing is not permitted.
- Provides, through the definition of OY, for economic, social, and ecological considerations to influence the choice of catch level **below** the overfishing limit.

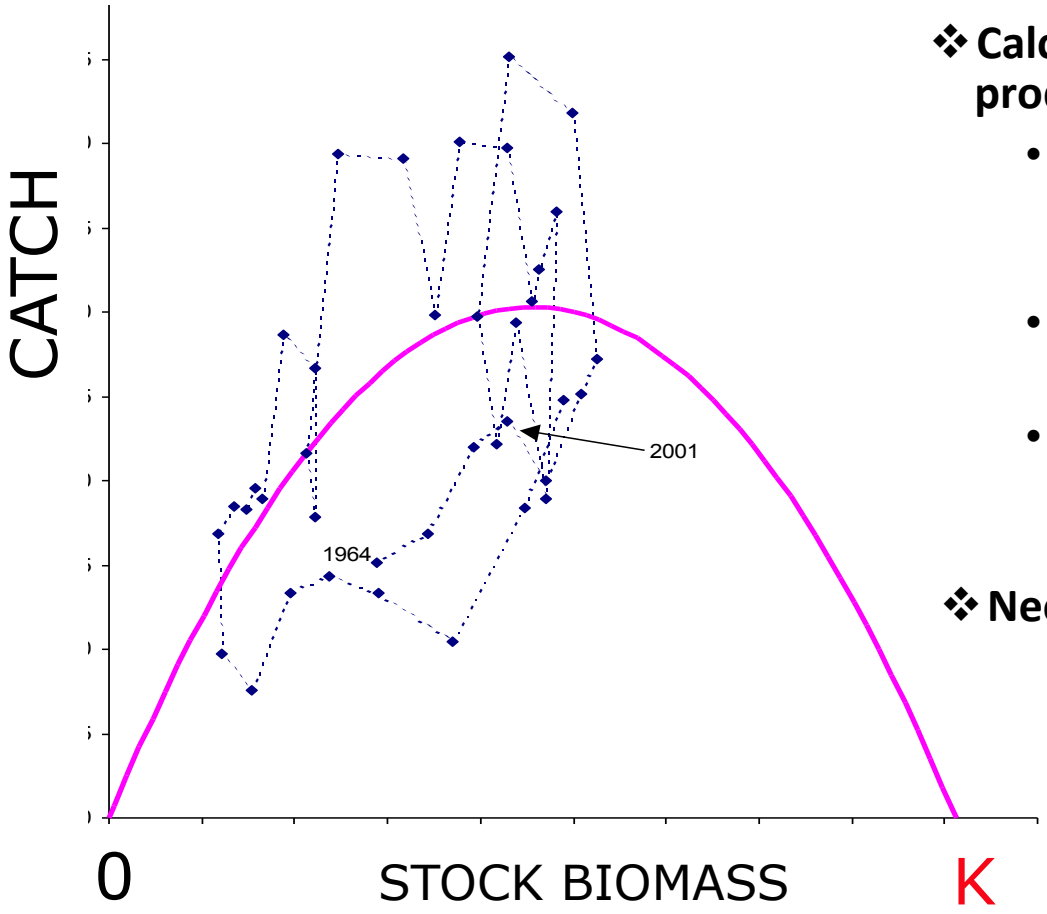
Maximum Sustainable Yield

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



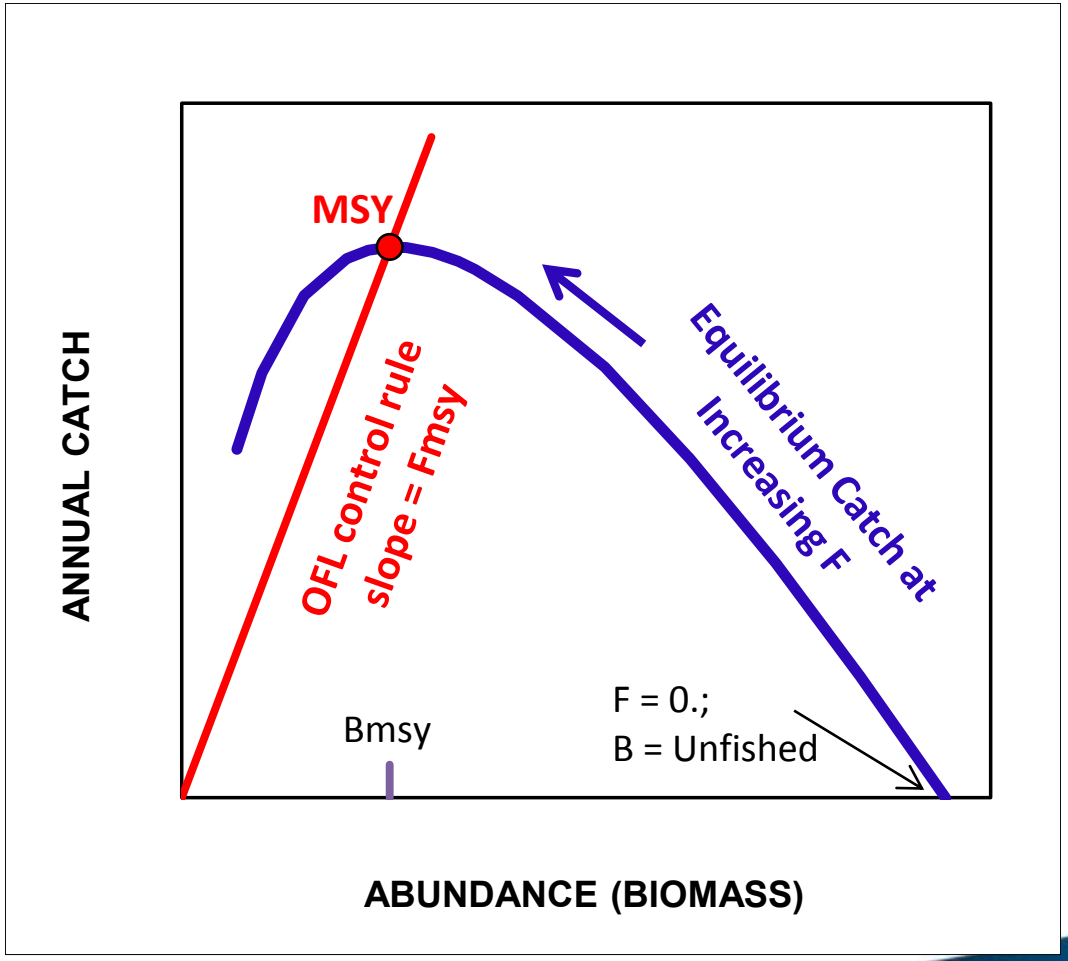
- Population production slows as the population approaches its carrying capacity (K).
- If removals can be replaced by production each year, on average, the fishery is sustainable at that level.
- If stock size is maintained near half its carrying capacity, the production is greatest, and sustainable yield is maximized (*MSY*).

Production Model - Reality



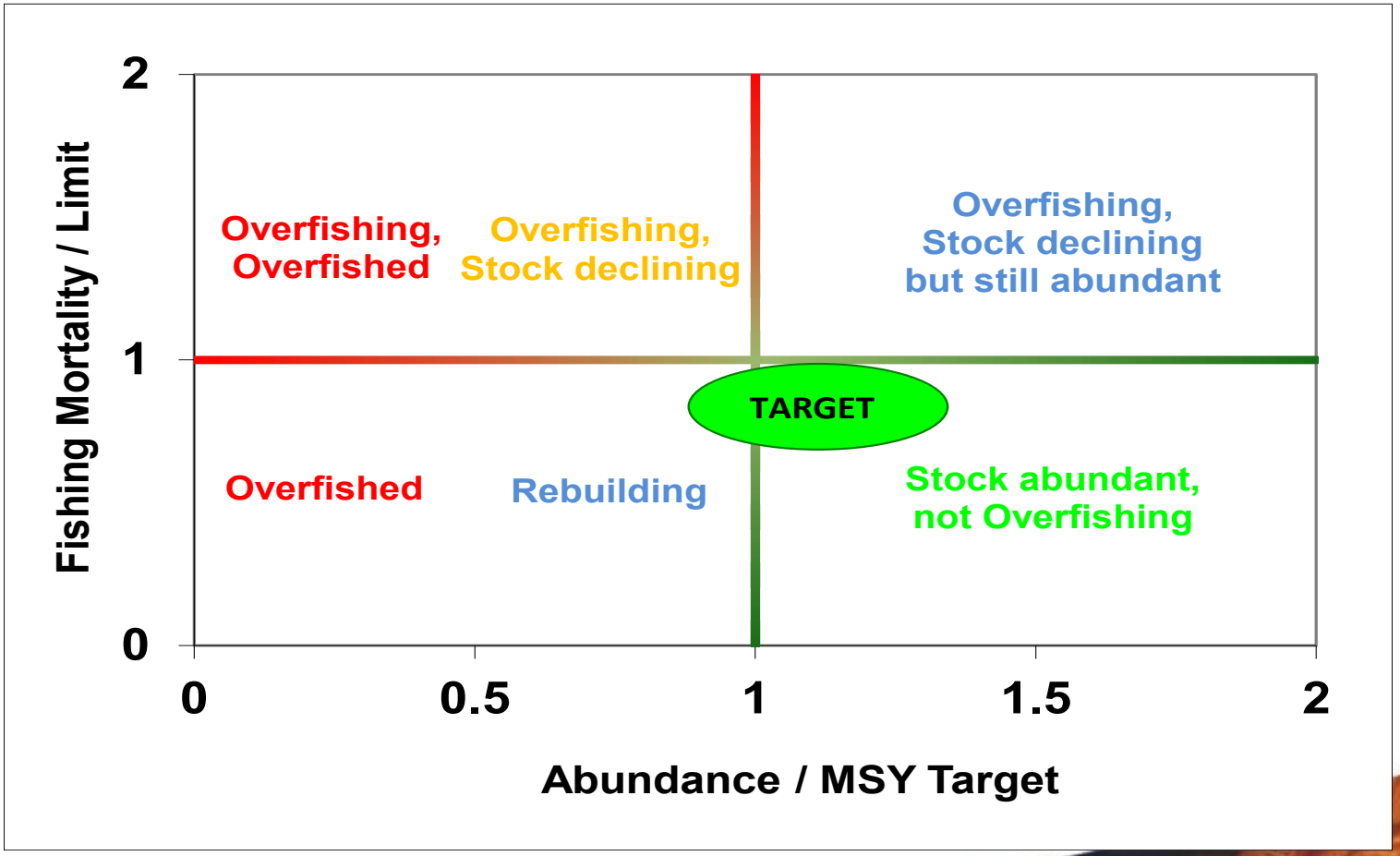
- **Calculating the shape and level of the production curve is difficult because:**
  - **Real populations show much natural fluctuation and real data have sampling error.**
  - **We may not have observed stock over the full range of biomass levels.**
  - **The "biomass" is not actually biomass, instead it is an index assumed proportional to biomass.**
- **Need to address scientific uncertainty.**

Model Results

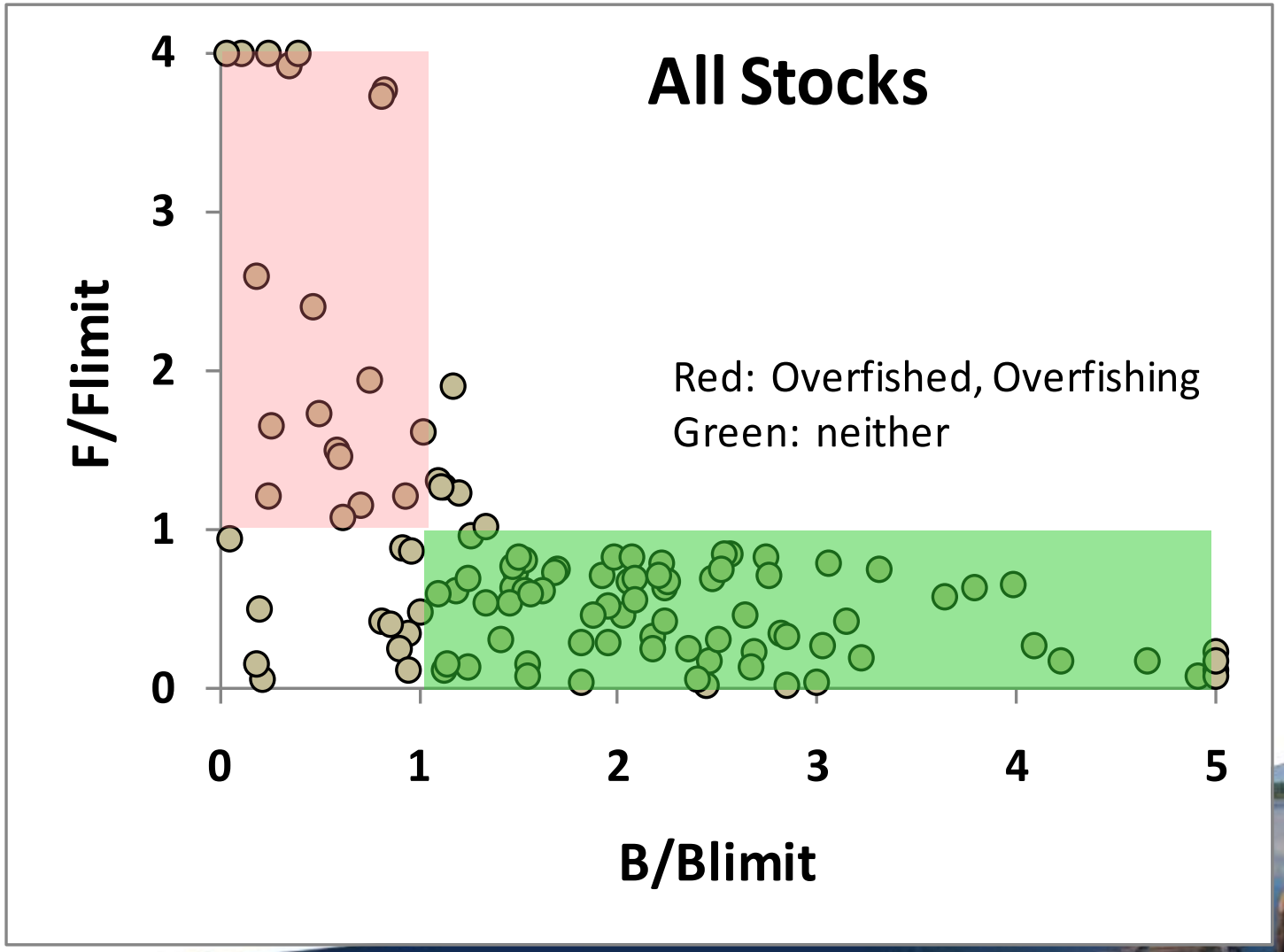


- When data are sufficient to calibrate the model, MSY, Fmsy, Bmsy can be estimated.

Status Determinations



Status of 140 U.S. fish stocks



What does it mean to prevent overfishing?

- Intentional overfishing; i.e. setting a target that is beyond the best estimate of the overfishing limit. In principal, the US has ended this type of overfishing.
- Management shortcoming: this occurs when fishery management procedures fail to keep the catch below the overfishing limit. This could be accidental (procedures were in place but they didn't work), or structural (no credible accountability measures were in place to keep catch under control within the fishing season).
- Science uncertainty: this leads to retrospective revision of calculated historical abundance and fishing mortality such that the revised level of the overfishing limit now appears to have been exceeded. This may happen every few years as major updates of assessments occur.
- Ecosystem overfishing: this occurs when the model/paradigm under which the tactical estimates of overfishing limits are calculated is wrong/biased/inadequate. We may not find out about this until decades later.

How/When is overfishing measured?

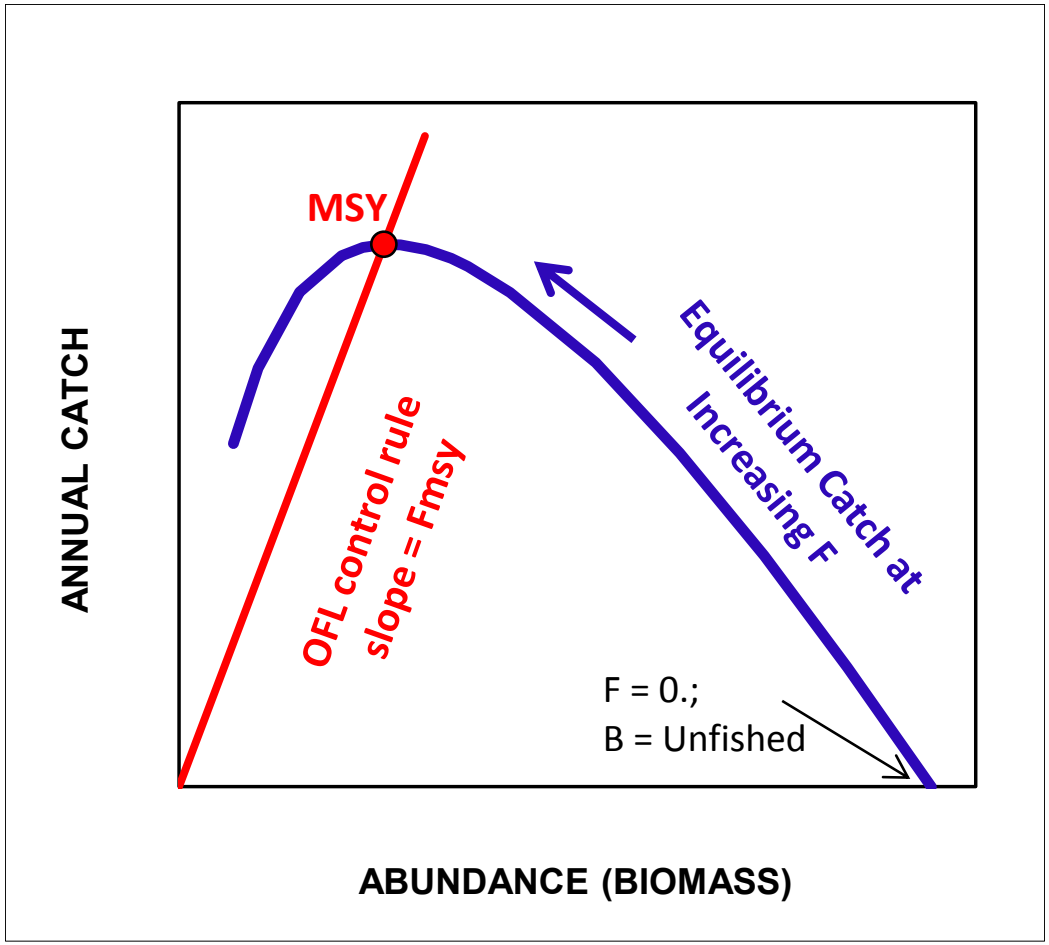
Catch compared to OFL

- Can be done each year, no new assessment needed
- High transparency for public, consistent with the ACL paradigm
- Forecast of ACL and OFL from past assessment does not account for recent recruitments, so need frequent assessment updates to keep ACL and OFL current
- Overfishing determination is only sensitive to management uncertainty
- Subsequent estimation of F by assessments does not result in overfishing determination

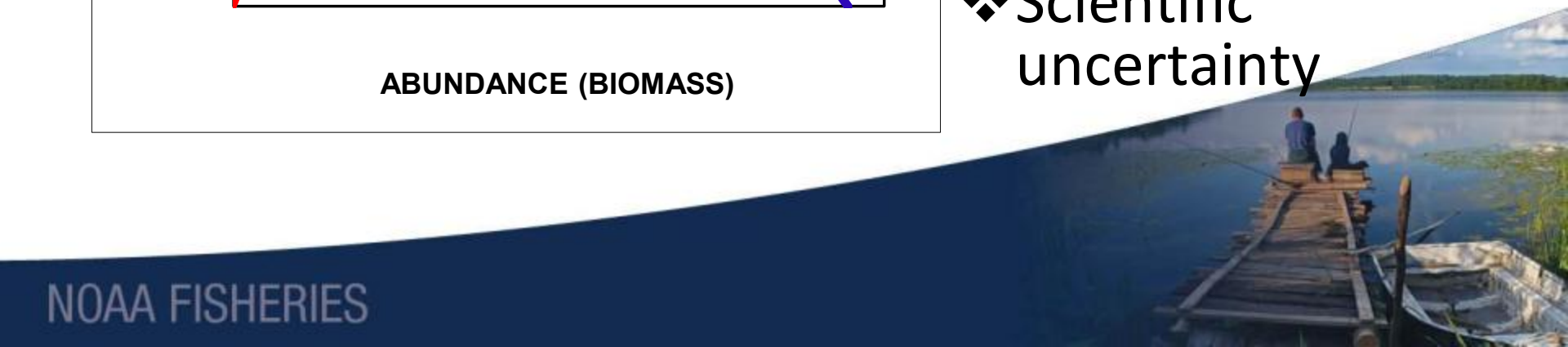
F compared to Flimit

- Requires assessment to calculate current F and update Flimit
- Low transparency for public, keeping catch < ACL does not mean that new estimate of F will be < Flimit
- Because this is a hindcast, it is not sensitive to recent recruitments, but associated ACLs are sensitive
- Overfishing determination could be caused by management uncertainty or scientific uncertainty

OFL Control Rules



- Now focus on pro-active; using the control rule to prevent overfishing
- But, info is never as definitive as implied by this neat figure
- Scientific uncertainty



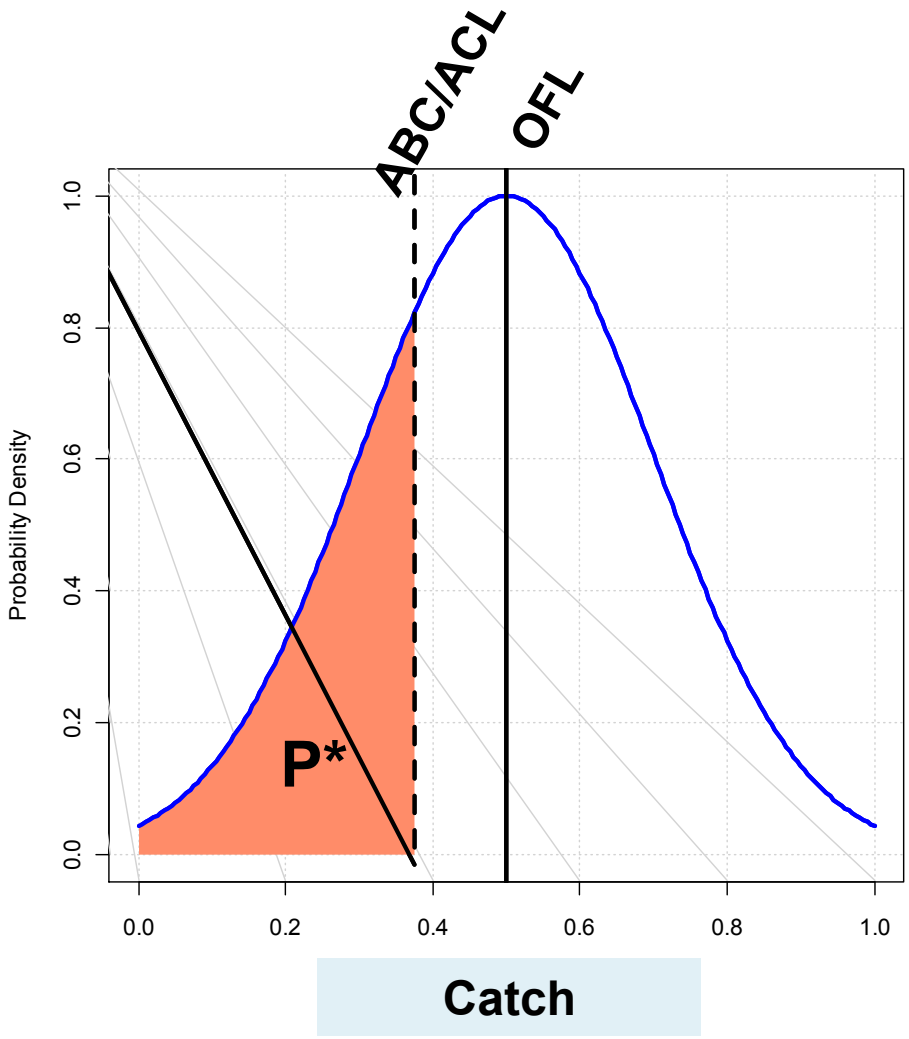
Targets and Limits

Apple = target

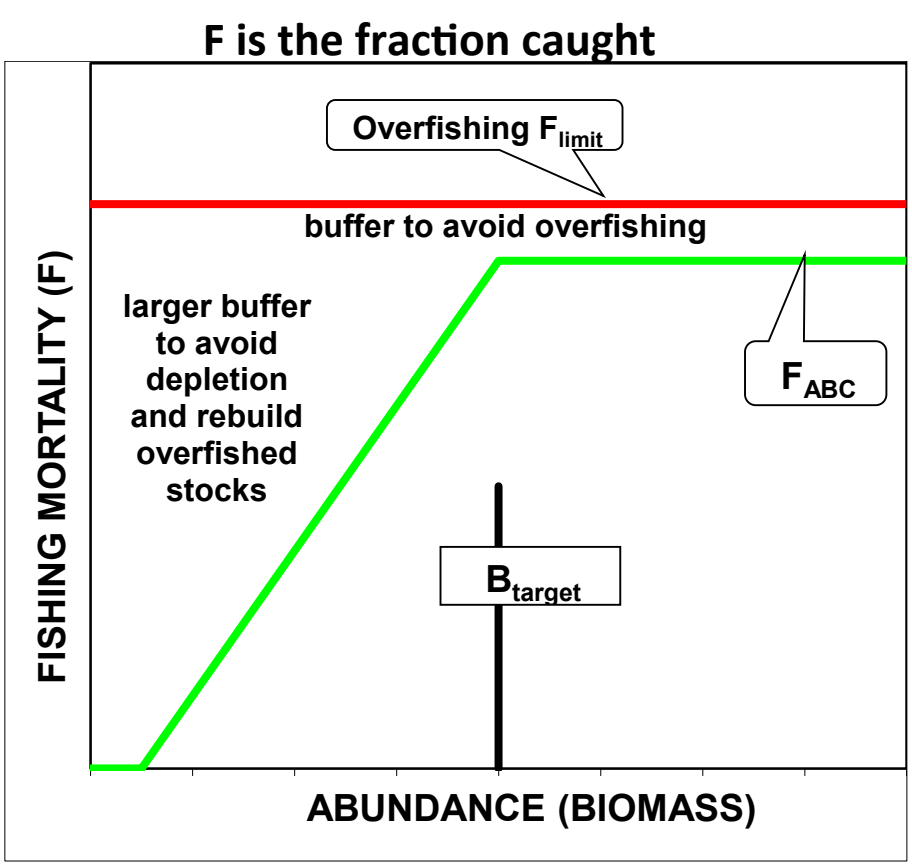
Head = limit

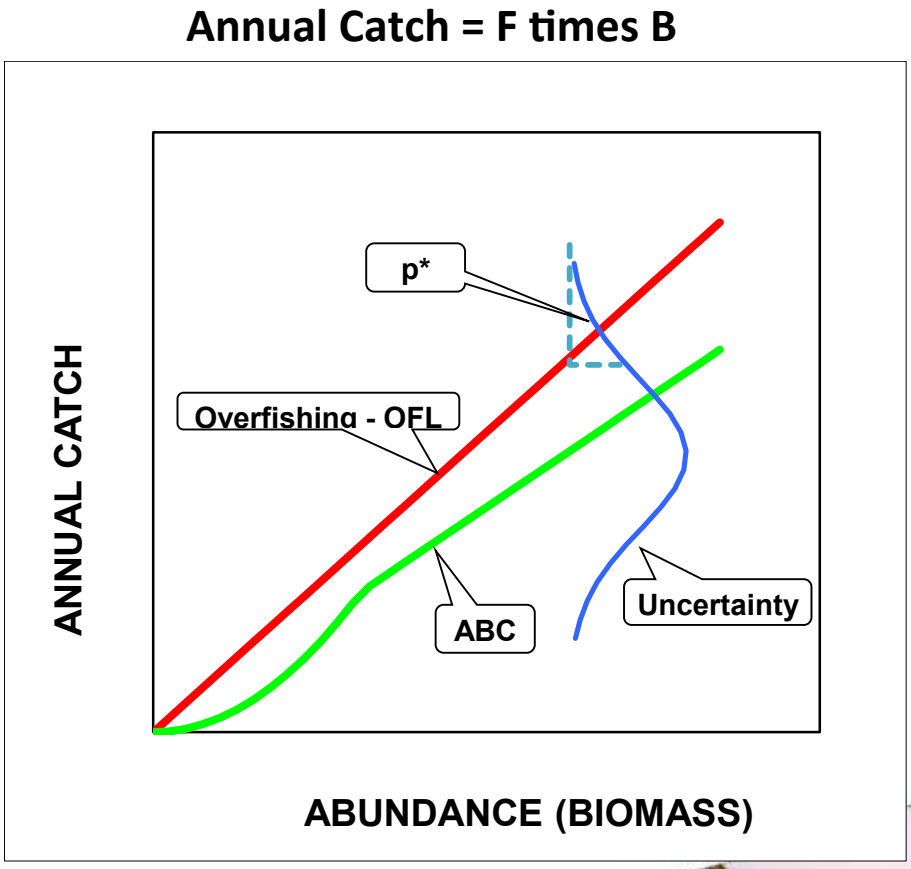
P*: Chance of Overfishing

- SSC is expected to address scientific uncertainty when setting ABC
- Curve shows scientific uncertainty in estimate of OFL
- True, but unknown, OFL could be higher or lower
- P* is chance that true OFL is less than ABC, the targeted catch
- Setting ABC < OFL reduces chance that catching this ABC will lead to overfishing
- Trade-off: How much catch is foregone to achieve an acceptably low chance of overfishing?

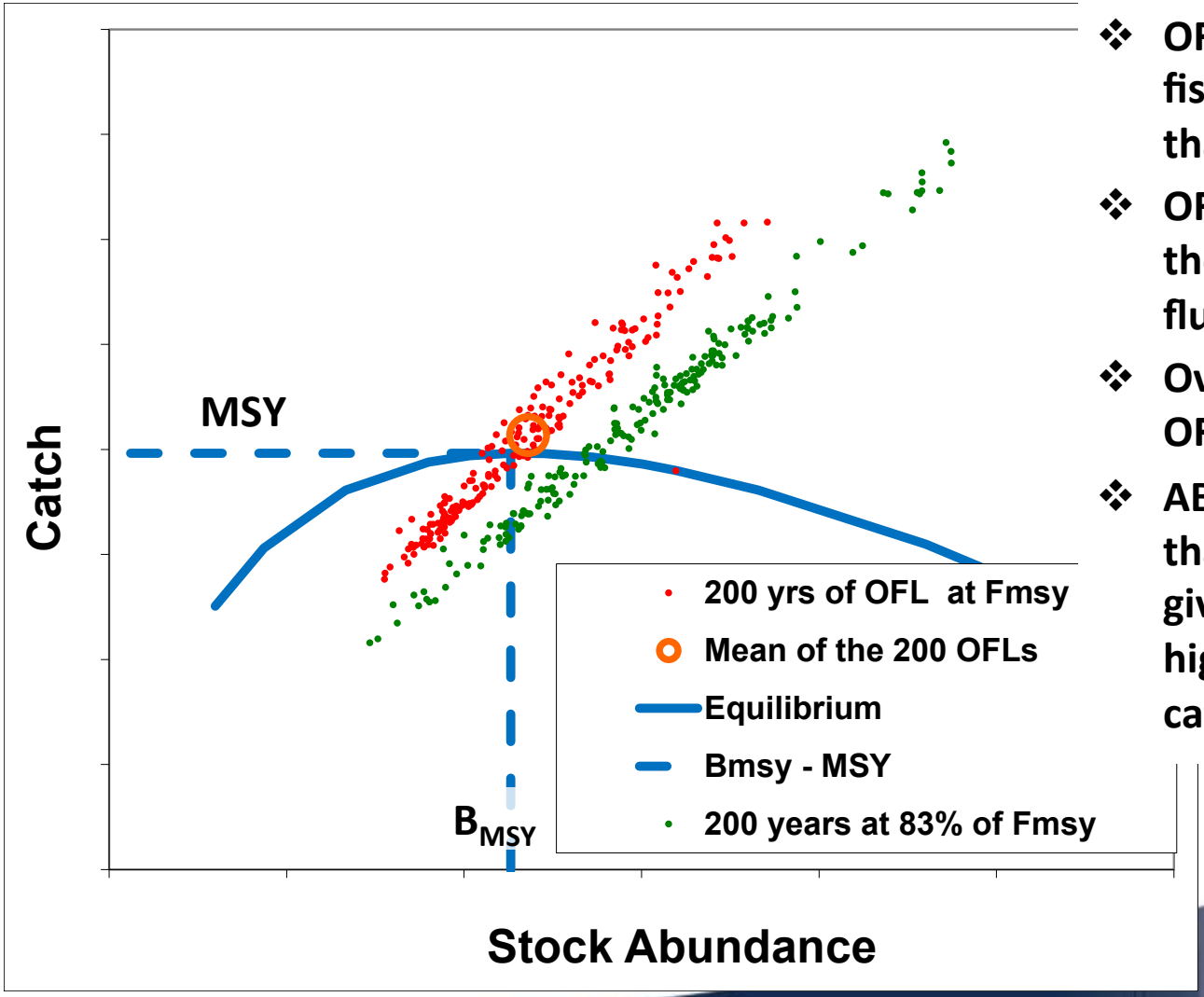


Limit and Target Control Rules





MSY and OFL

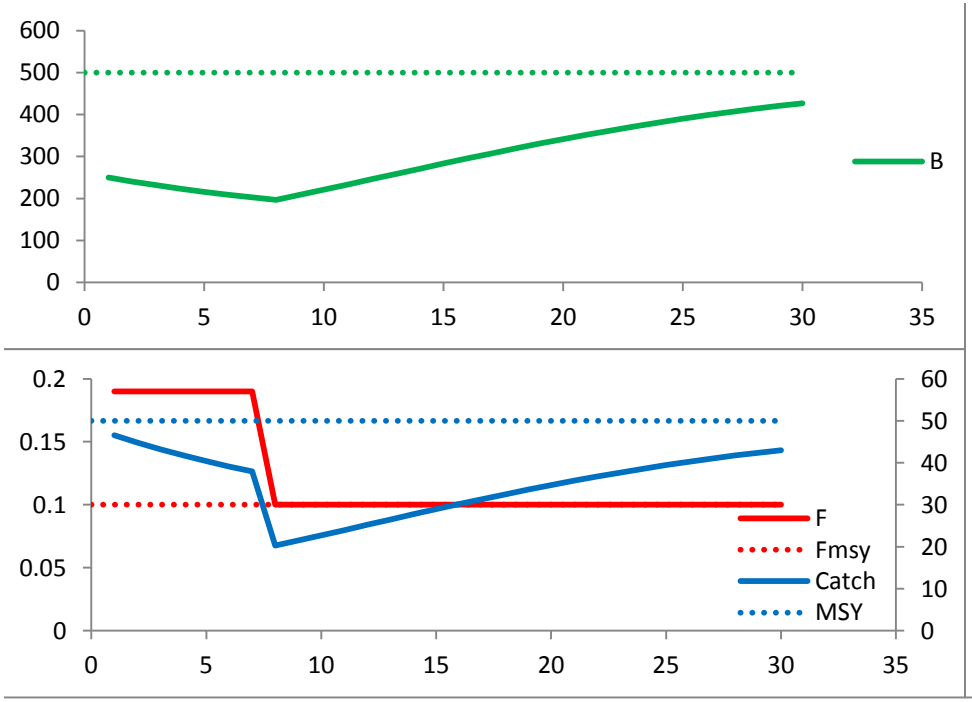


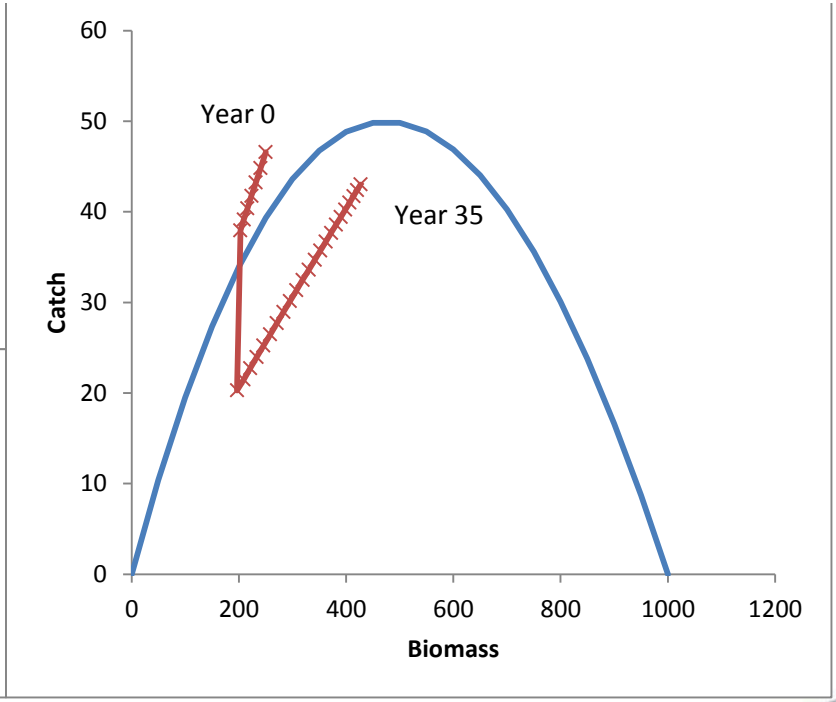
- OFL is the annual catch when fishing mortality is at the rate that gives MSY
- OFL varies above and below the MSY level depending on fluctuations in abundance.
- Over the long term, average OFL close to equilibrium MSY
- ABC: Fishing at slightly less than Fmsy gets less catch from given abundance level, but higher abundance and similar catch over long-term

Using Control Rules

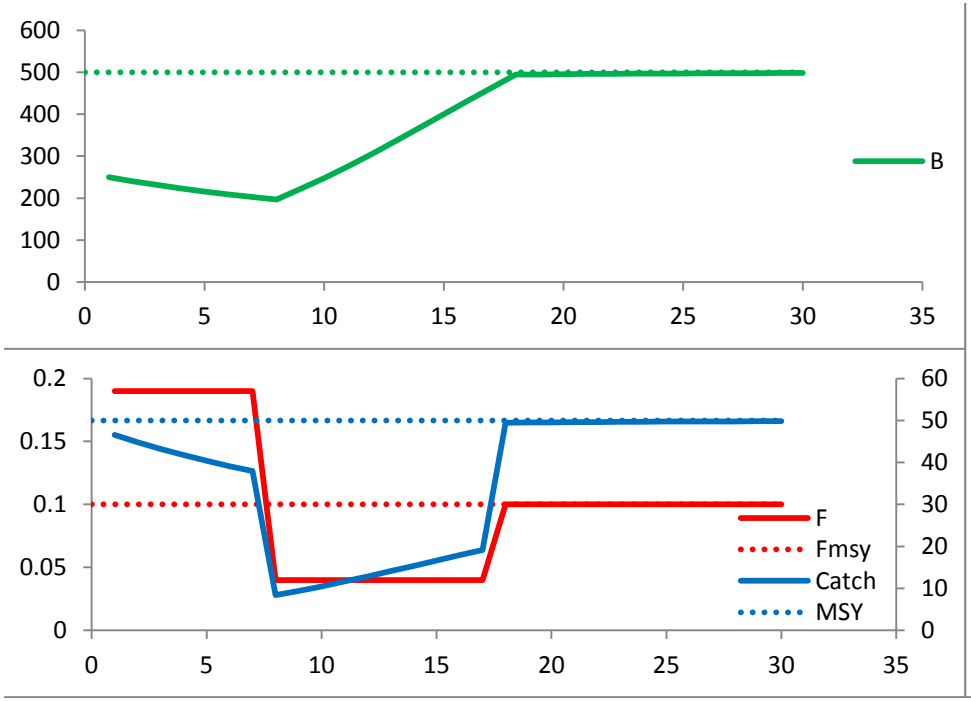
- Perfect system
  - No natural fluctuations
  - Perfect knowledge
  - Control rule followed exactly
- So, totally unrealistic in detail but still shows the basis patterns
- More sophisticated and realistic simulations in a Management Strategy Evaluation are within our capability

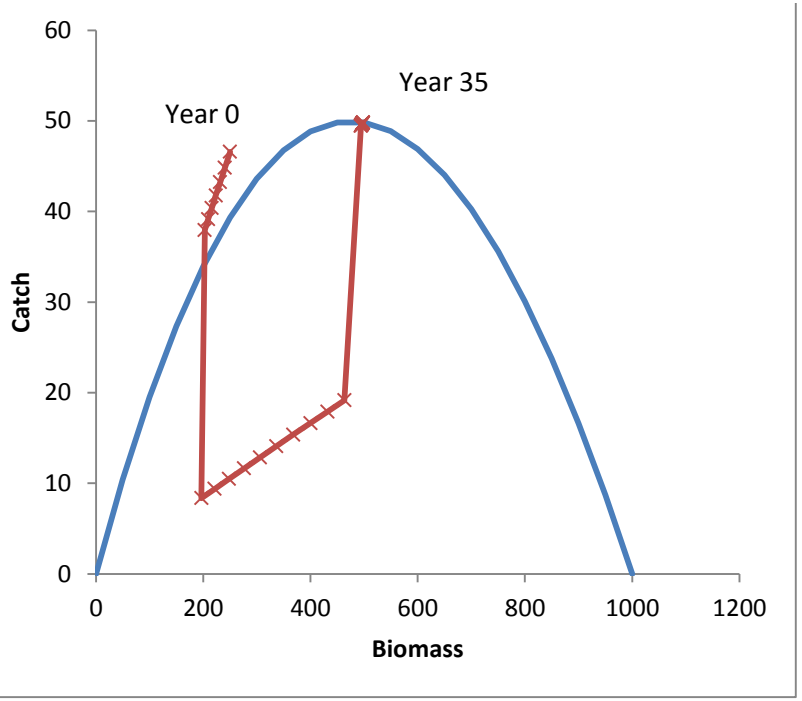
Jump to Fmsy; slow rebuild



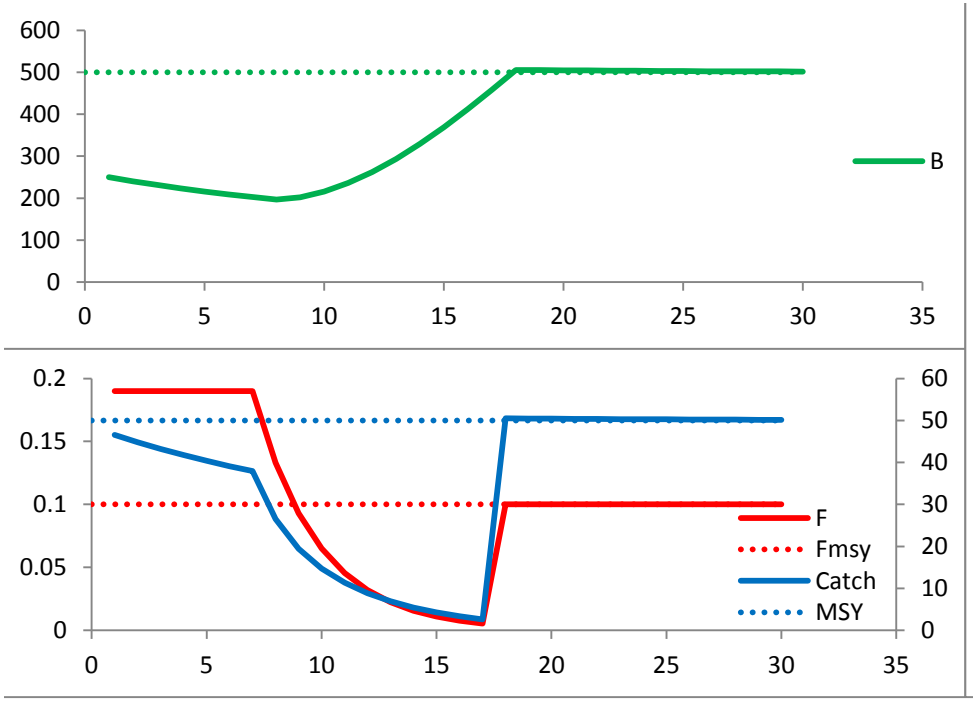


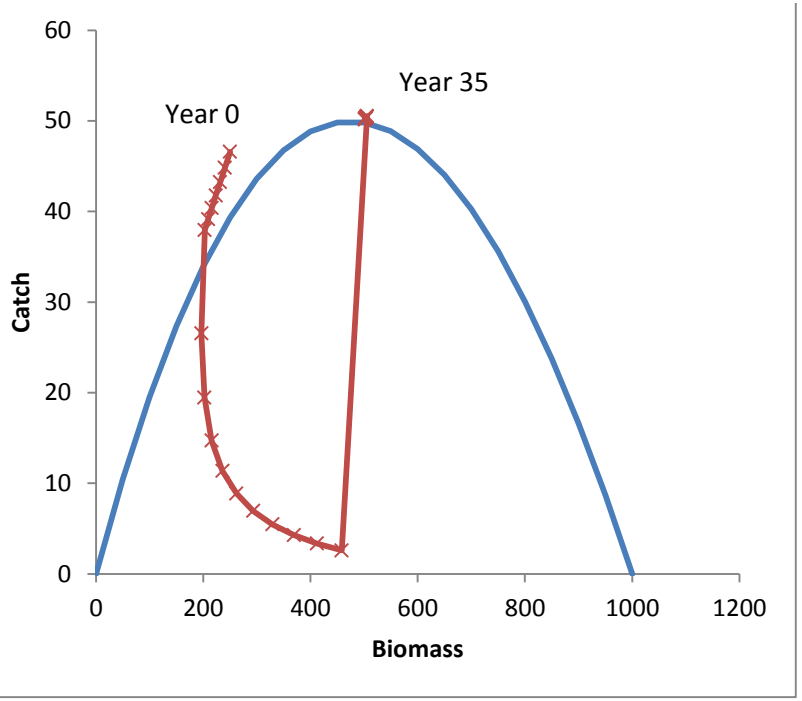
10 year rebuild





Phase-in; Delay the Pain





Long-Term Precautionary, with 5 year Phase-In