

# Economic Considerations and Methods for Evaluating Fishery Rebuilding Strategies

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Science. Education. Community.

# Introduction

- The FAO estimates that 25-30% of fish stocks are overexploited, depleted or recovering (FAO 2008)
- NMFS estimated that 24% of assessed US stocks were in an overfished state in 2007 (NMFS 2008).
- There are likely to be large gains from rebuilding overfished stocks
- But which ones, how fast should we try to rebuild them, to what level and how do we go about it?
- Calls for joint input from biologists, economists and stakeholders to evaluate:
  - the overall costs and benefits and the distributional impacts of alternative rebuilding trajectories and targets
  - Evaluate the efficiency and effectiveness of alternative management methods to achieve desired catch levels

# Optimal Rebuilding of Depleted Fish Stocks

- Economically optimal rebuilding:
  - A fish stock is overfished or depleted if allowing this stock to grow provides greater long-term value than not doing so
  - Optimal rebuild trajectory is one that provides the maximum net present value of future benefits
- Optimal strategies will depend heavily upon how benefits are defined and measured - not a trivial question
- Should we consider more than producer surplus (e.g., consumer surplus or ecosystem services of in-situ fish stocks)
- In many countries there are additional constraints on rebuilding when, how fast and to what level fisheries must be rebuilt

# Legal constraints on rebuilding overfished fisheries

- US Magnuson-Stevens Act and implementing guidelines for overfished fisheries are rigid
- Specify  $\frac{1}{2} B_{MSY}$  as a default for the level that constitutes overfished ( now referred to as “depleted”) and set rebuilding target  $\geq B_{msy}$
- **Rebuilding guidelines:**
  - (i) **be as short as possible**, taking into account the status and biology of any overfished stocks of fish, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock of fish within the marine ecosystem; and
  - (ii) **not exceed 10 years**, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise;

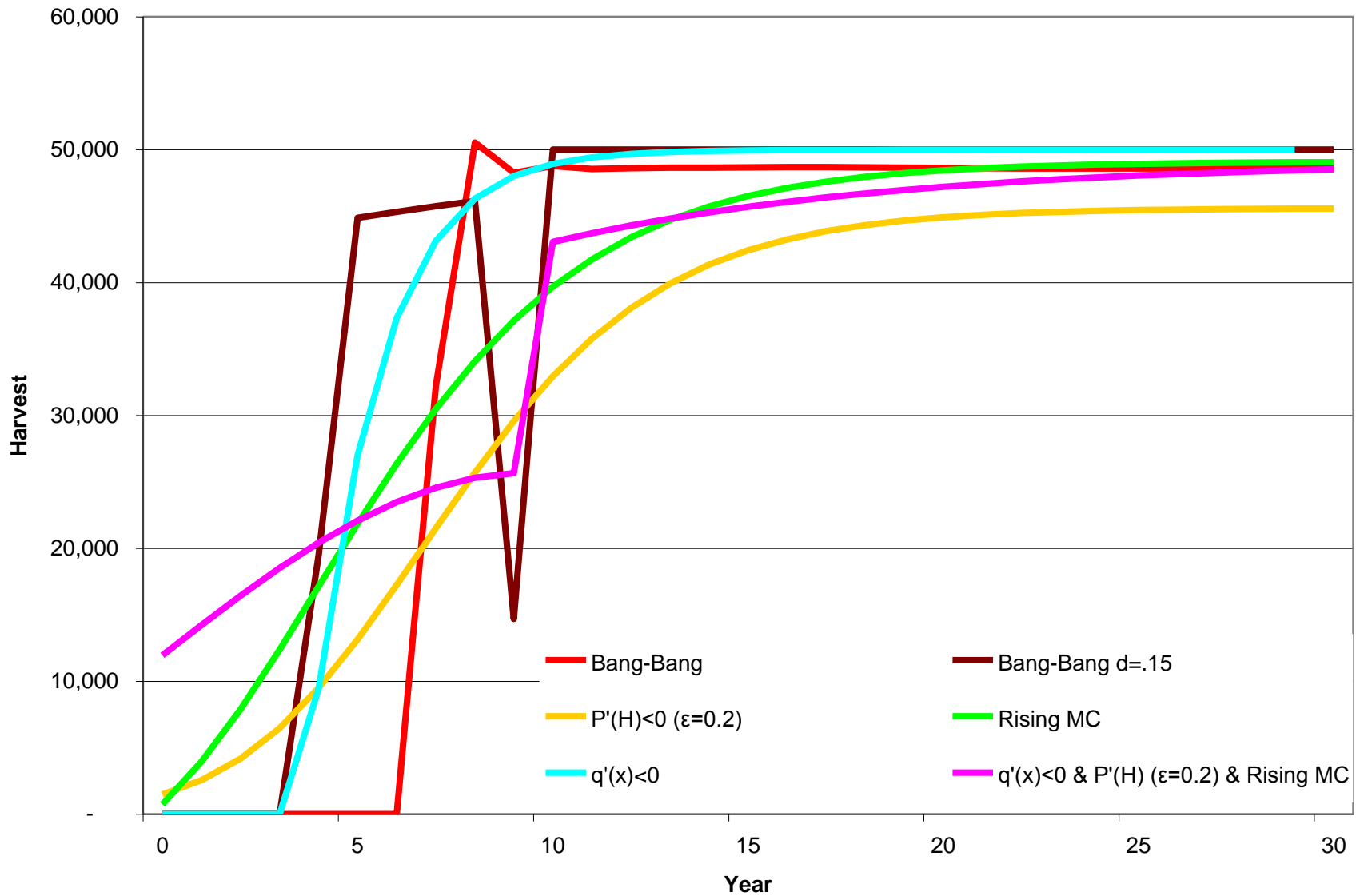
## Rational Reasons to Procrastinate

- The simplest bioeconomic models tend to suggest that the fastest rebuilding schedule is the best – shut the fishery down until it's rebuilt
- A number of economic and technical factors can make a more gradual rebuilding schedule preferable including but not limited to:
  - Inverse relationship between landings and prices
  - Increasing marginal cost of catch or effort
  - CPUE does not fall in proportion to biomass
  - High discount rates

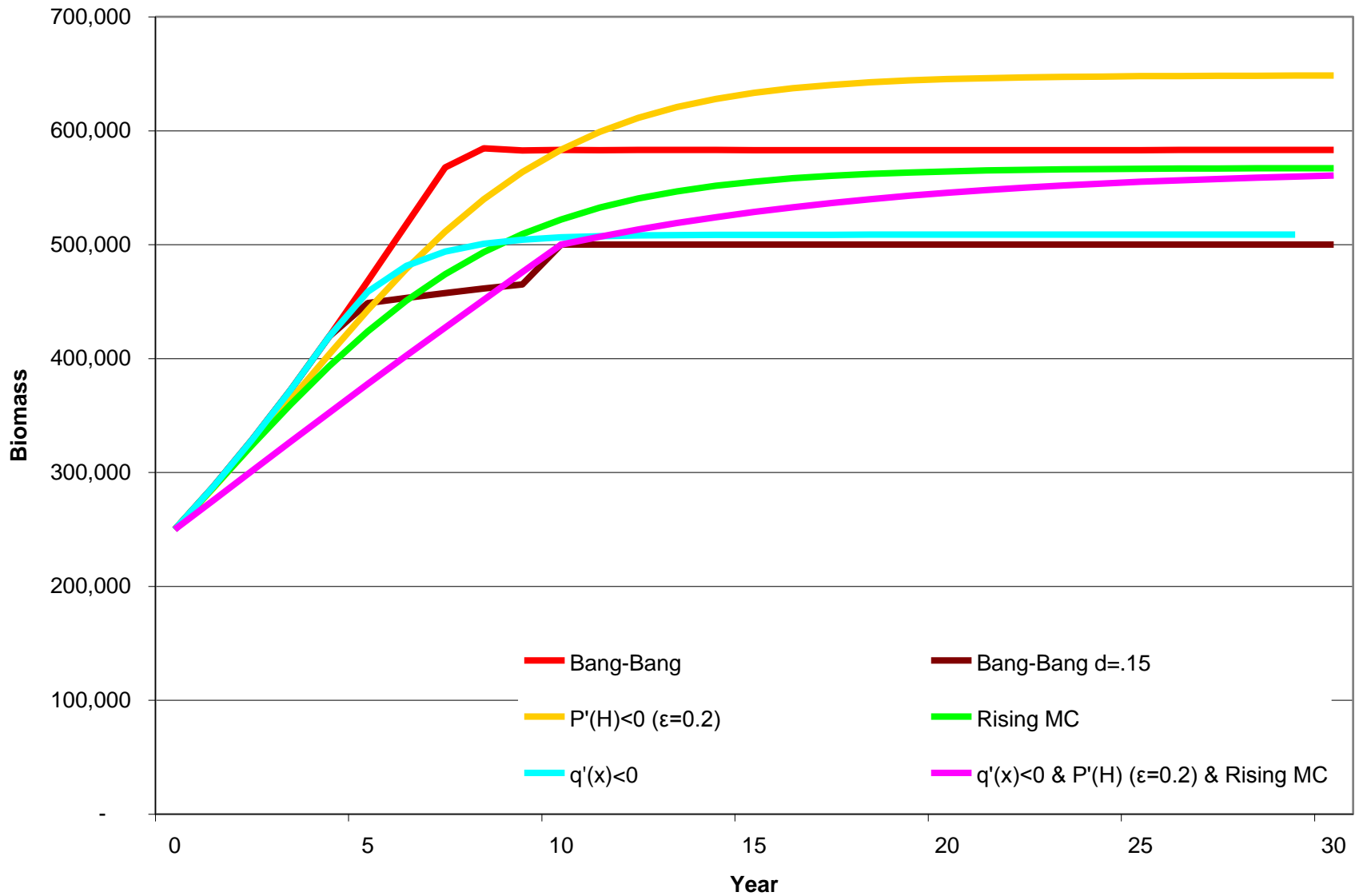
# A simple fishery rebuilding model

- Logistic growth  $\frac{dx}{dt} = .2x(1 - \frac{x}{1000000}) - H$
- Harvest  $E = \frac{H}{qX}$  where  $q = .0001$  or  $q = \frac{.0003}{(1 + \frac{4x}{K})}$
- Price  $P = 1$  or  $P = \exp(2 - .2H)$
- Cost  $C = 25E$  or  $C = 10000 + 5E + .01E^2$
- Discount Rate  $d = .03$  or  $d = .15$
- Objective  $Max \sum_{t=0}^{100} e^{-rt} (P_t H_t - C_t)$  s.t.  $H_t \leq x^* Fmsy$  and  $x_{10} \geq Bmsy$

# Optimal Constrained Harvest Path

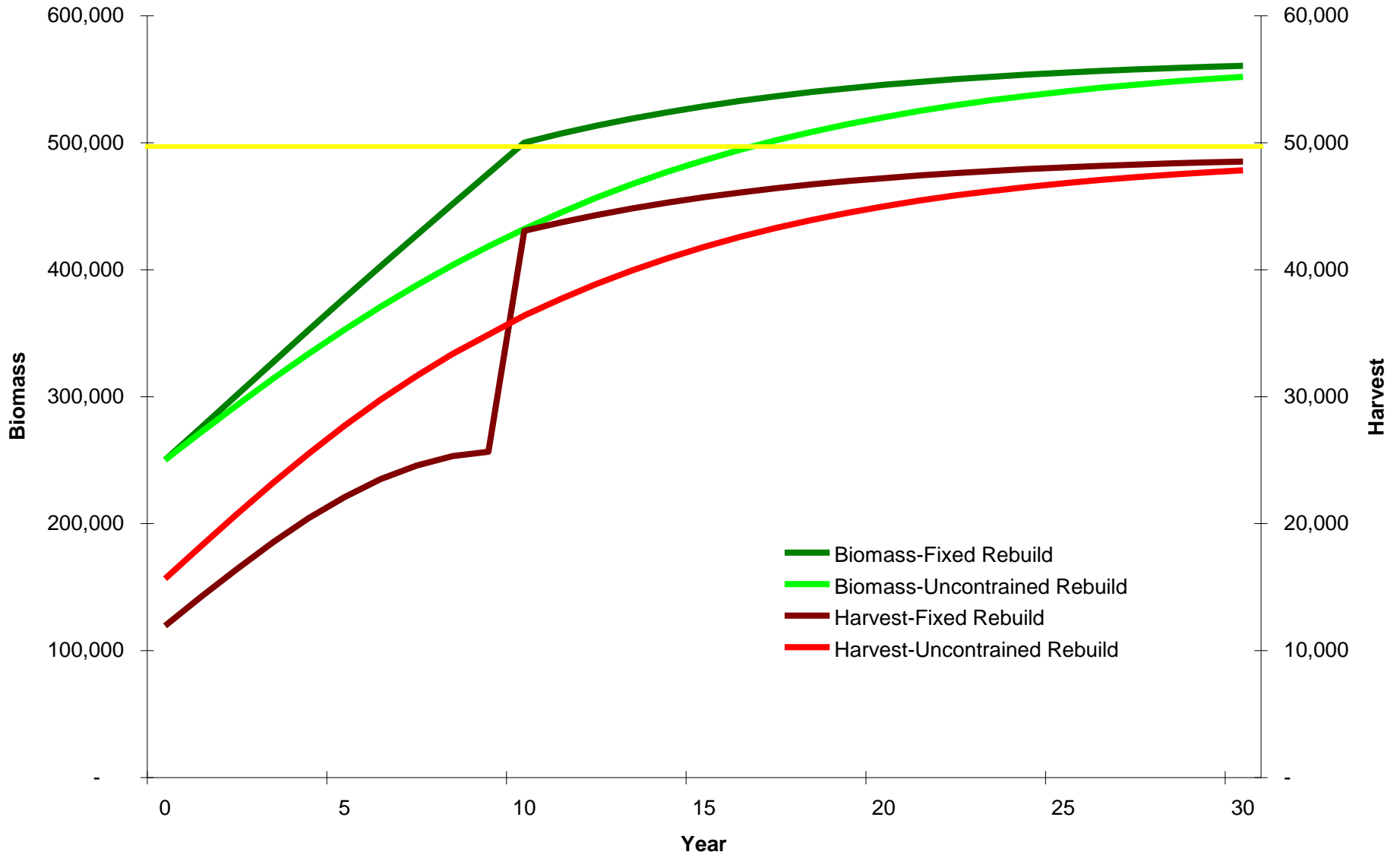


# Optimal Constrained Biomass Recovery Path

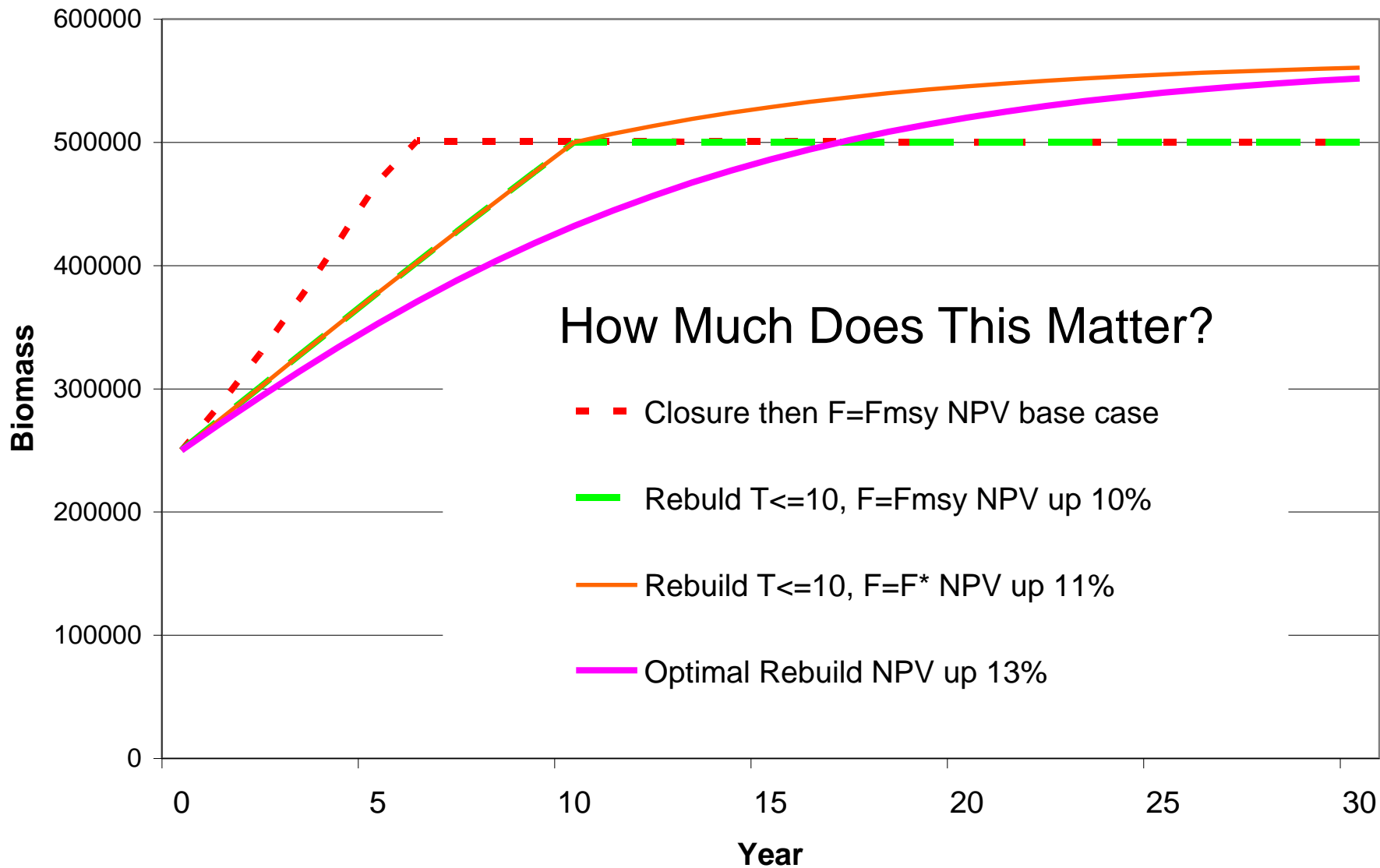




# Rebuilding Trajectories with Fixed and Unconstrained Rebuilding Time ( $q'(x) < 0$ & $P'(H)$ ( $\epsilon=0.2$ ) & Rising MC )

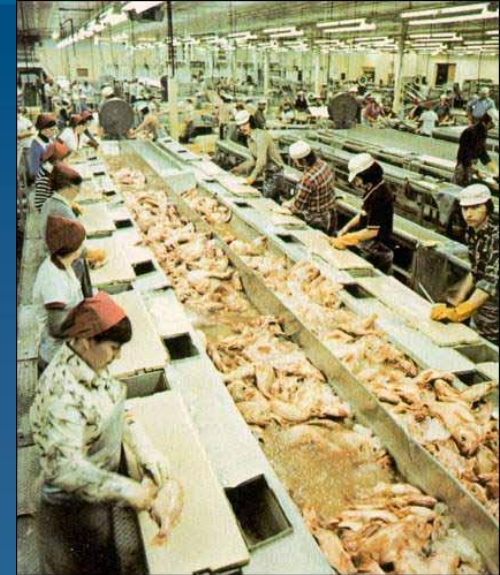


# Alternative Rebuilding ( $q'(x) < 0$ & $P'(H)$ ( $\epsilon=0.2$ ) & Rising MC )



# Other Social and Economic Considerations

- Many potential reasons to consider slower rebuilding plans may be difficult to quantify but may still be of great importance economically and socially
- Drastic harvest cuts or closure may result in loss of processing capacity and market access which may take time and be costly to regain
- A fishery closure or drastic cut may cause social dislocations that might be mitigated with a slower rebuilding plan – may also save the taxpayers from funding disaster assistance
- Smaller operators with less access to capital may be less able to survive a drastic cut in the TAC



# Multispecies Fisheries

- Single species rebuilding constraints may reduce value of multispecies fisheries
- Choice: either manage to the weakest stock or find a way to change the relative catch rates

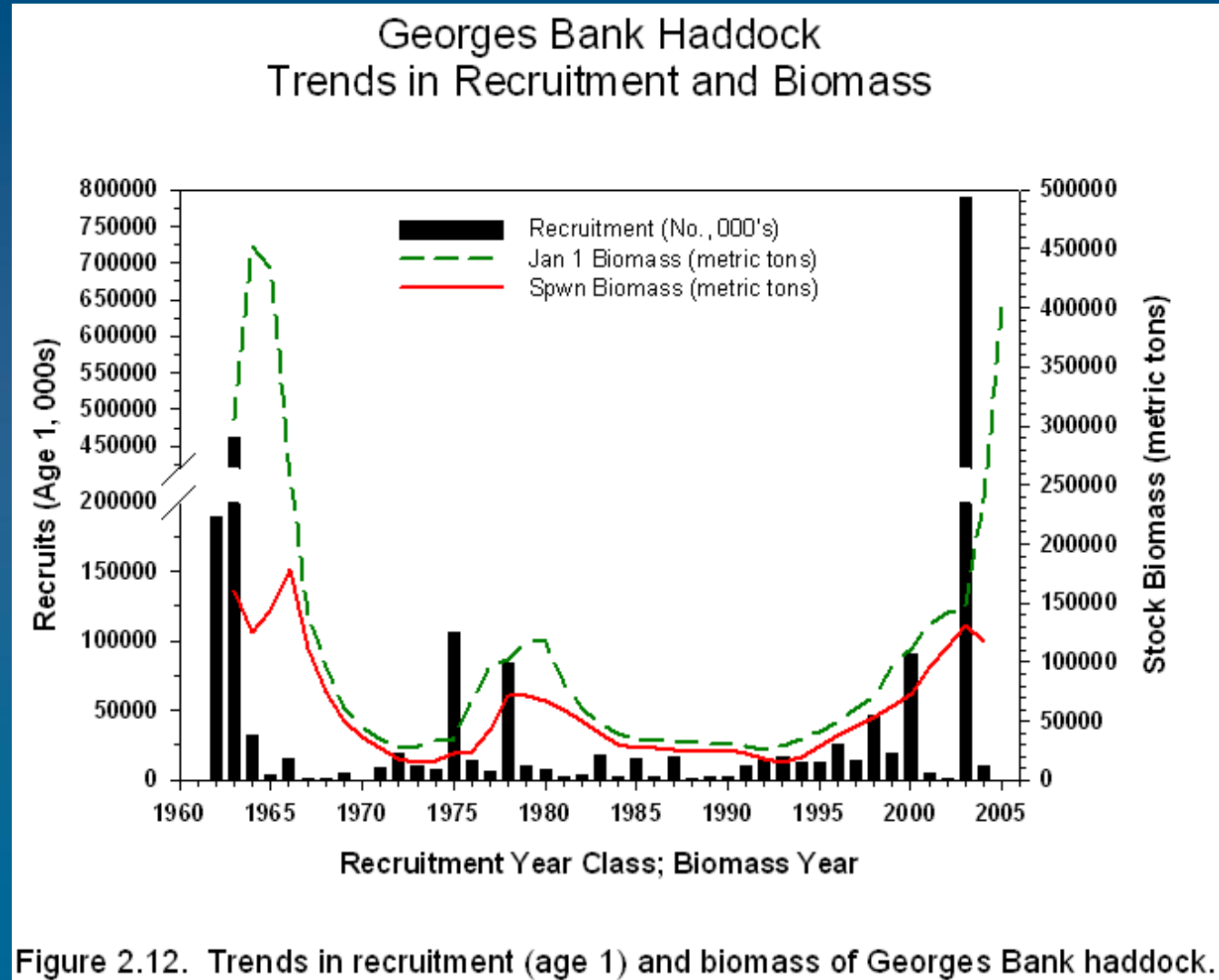
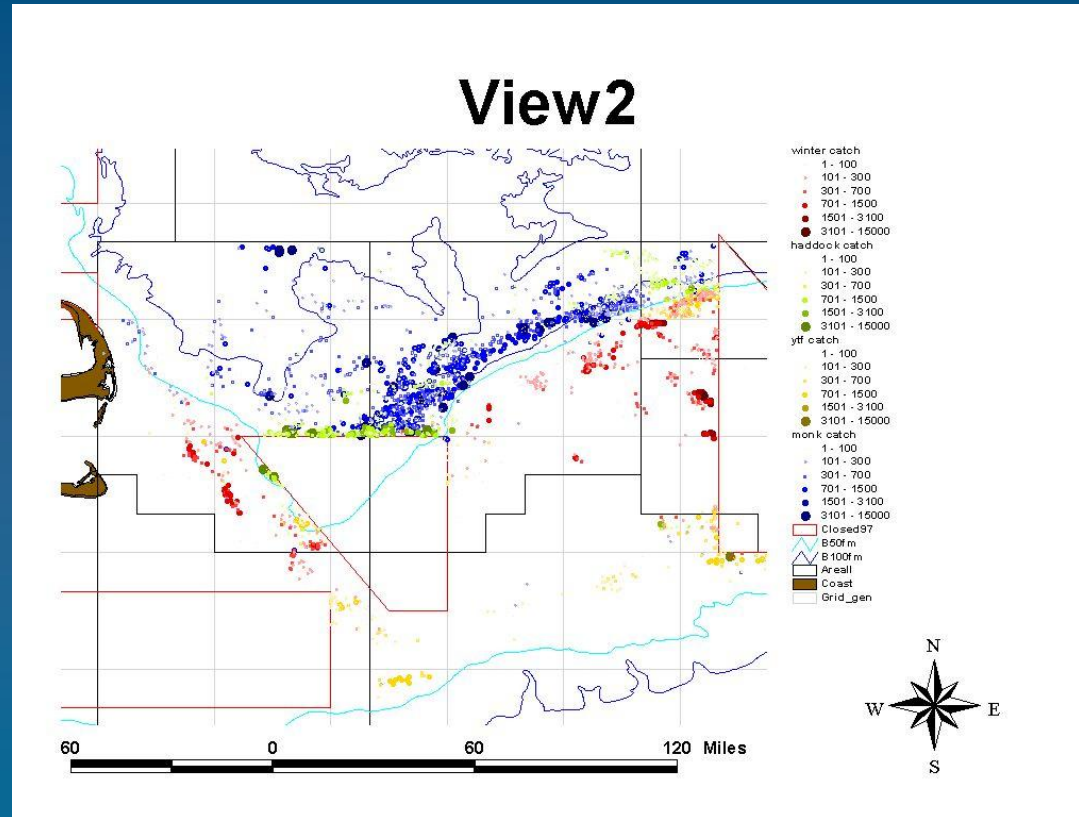


Figure 2.12. Trends in recruitment (age 1) and biomass of Georges Bank haddock.

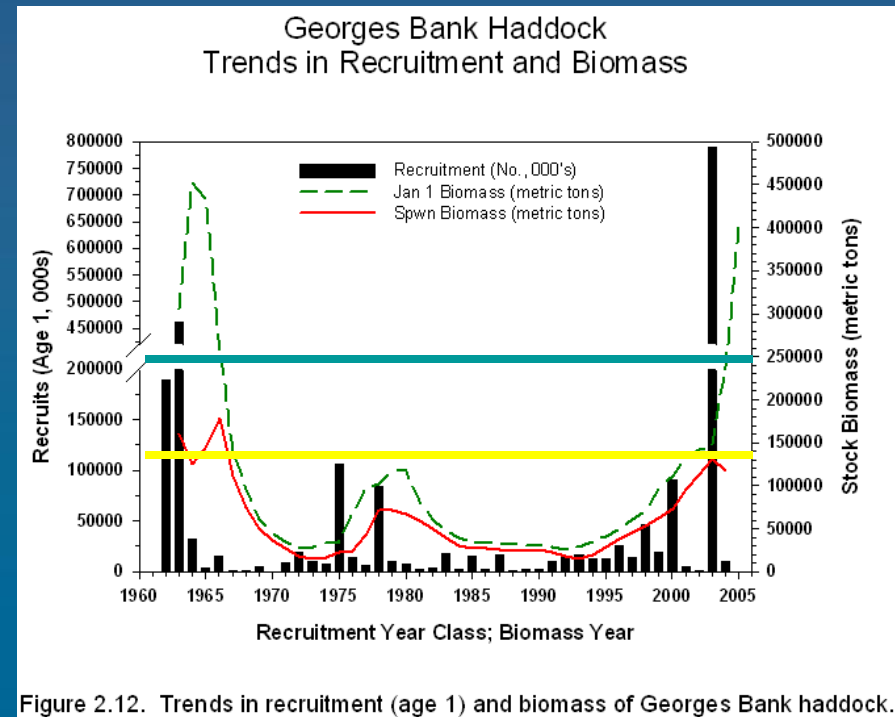
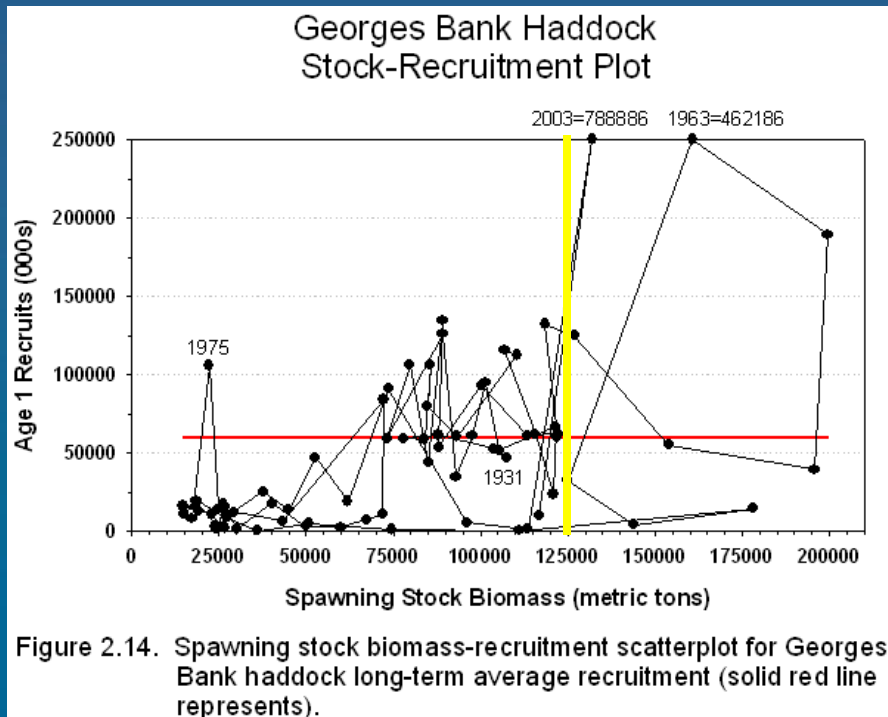
# Multispecies Fisheries

- Management methods are key to minimizing losses if these are strict constraints
- Hard TACs and trip limits have often caused discards
- Spatial effort and gear regulations can help but often do not take advantage of fishermen's ability to target at finer scales or alter fishing behavior
- Quotas for individuals or groups can provide strong incentives to find ways to alter relative catch rates – or decide not to and leave fish in the water



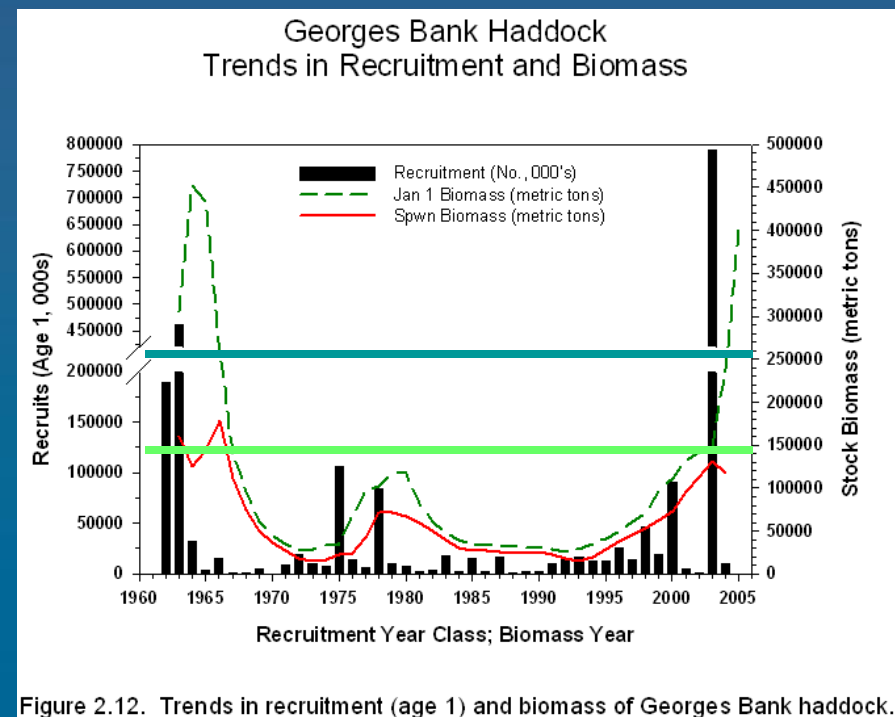
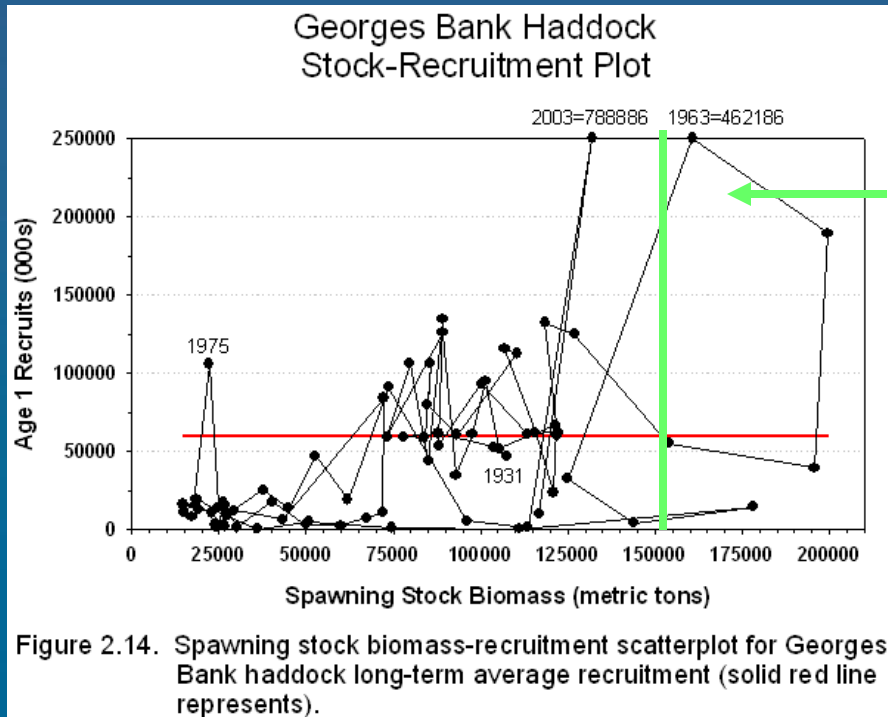
# Uncertainty and Variability in Fishery Productivity

- There is often little correlation between recruitment and biomass for many stocks and recruitment can be highly variable
- Is it sensible to design a rebuilding plan around static biomass limits and targets and average recruitment assumptions ?
- Blim 125,000 mt; Bmsy 250,000 mt



# Shooting for a moving target

- Biological reference points can be adjusted with new information
- GB Haddock
  - Bmsy: 250,000 mt dropped to 153,000 mt
  - Fmsy: .26 increased to .35
- Should we try account for the possibility of these types of changes when designing a rebuilding plan and if so how?



# Rational and “Irrational” responses to uncertainty

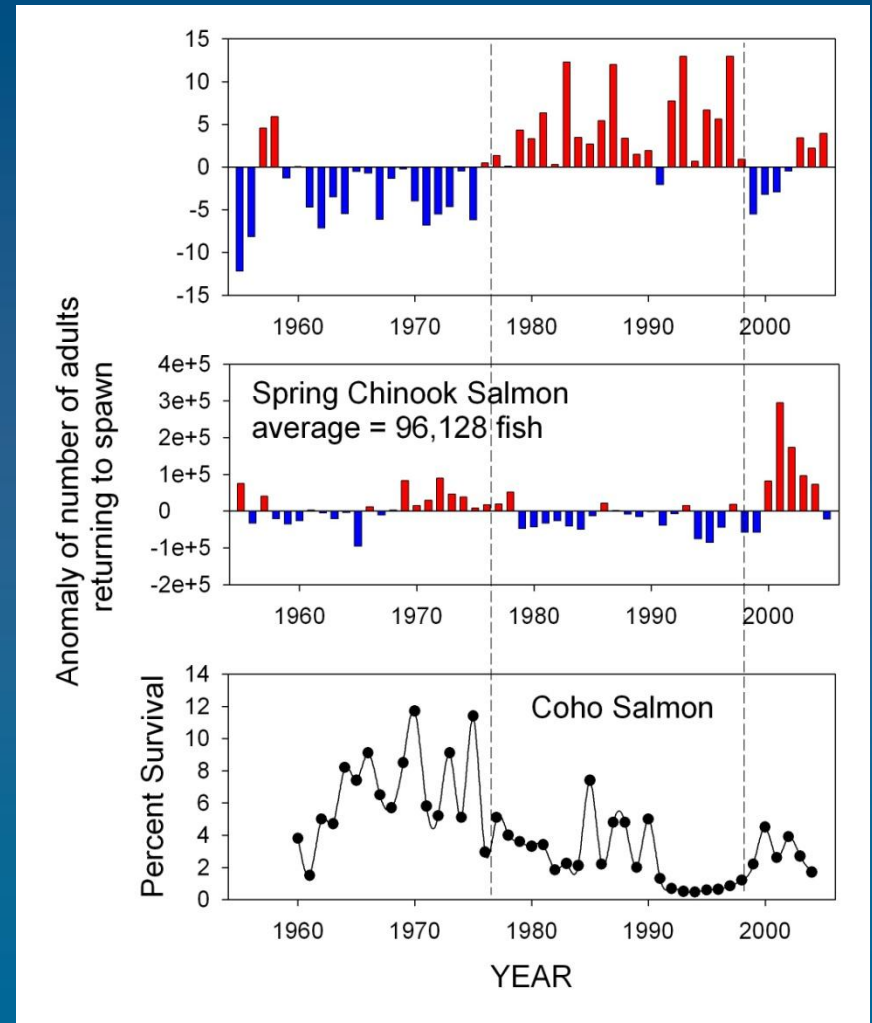
- While the precautionary approach suggests a more conservative rebuilding program in the face of uncertainty, this may not be the optimal response in terms of maximizing social welfare
- Investors generally require higher returns (have higher discount rate) with higher uncertainty about returns
- Expected value or even expected utility may not be the appropriate framework for evaluating risk (to match stakeholder values)
- Prospect theory suggest that the expected value of an uncertain gain from rebuilding will have to exceed the known loss associated with a cut in harvest to appeal to most people as the desirable choice



# Nature is not completely random

Do static biomass targets make sense for fisheries influenced by climate cycles?

Summer average PDO (top) vs. adult spring Chinook passing Bonneville Dam (middle) and survival of hatchery coho salmon (bottom), 1955–2006. Vertical lines indicate climate–shift points in 1977 and 1998.



# Optimal Escapement Varies When Productivity is Cyclic

- With cyclic productivity optimal escapement is lower (harvest rate increased) when recruitment conditions are poor and escapement is increased when recruitment conditions are good (Parma 1990).
- Reduce escapement and increase harvest when future expected growth is lower than average. Reduce harvest and increase escapement when expected growth in future is higher than average and Costello et al. (2001)
- Spencer (1997) surplus production model incorporating a nonlinear rate of predation yields multiple, stable equilibria and, when forced with autocorrelated variability, can result in rapid flips in marine fish abundances. The optimal policy requires conservative (exploitative) behavior during poor (good) environmental conditions with high stocks and rebuilding of low stocks.

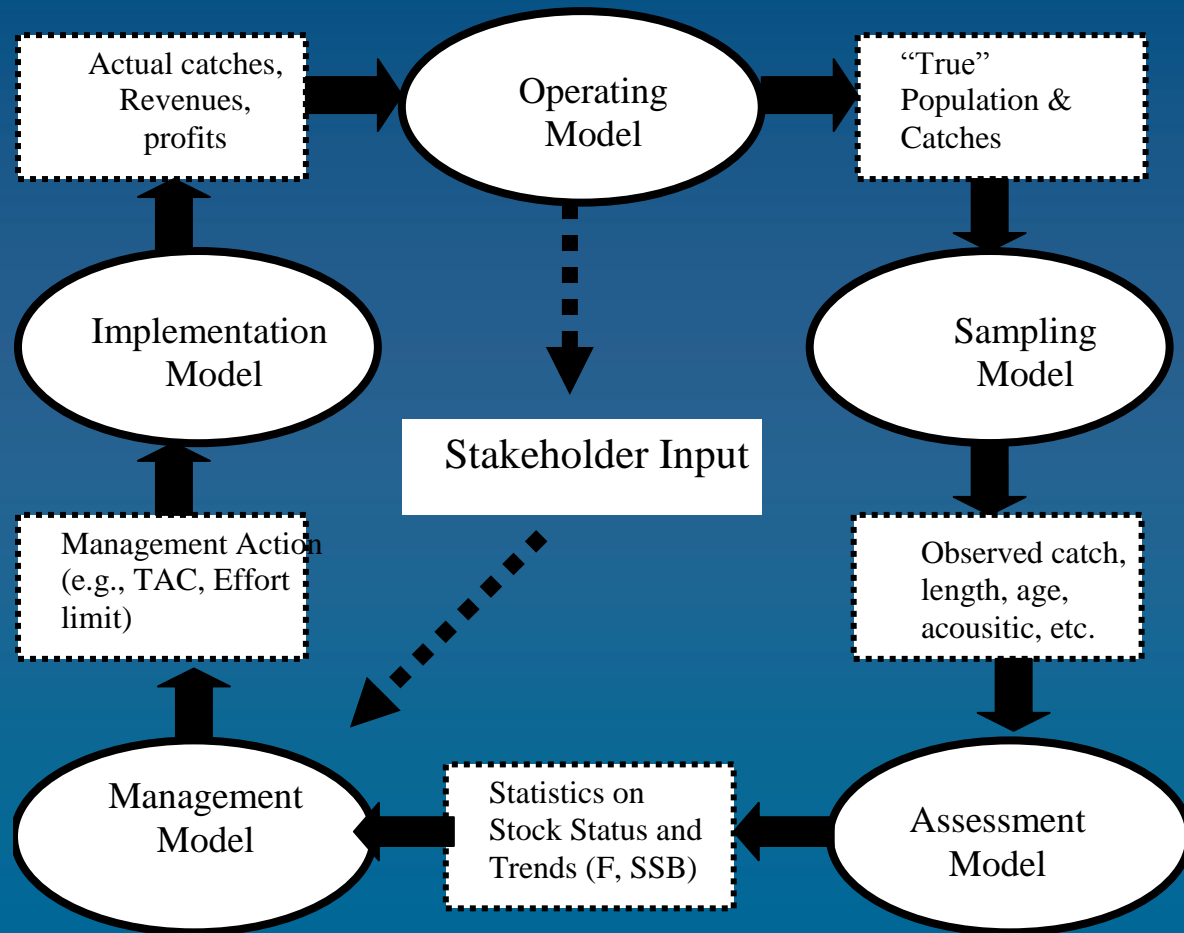
# Managing fisheries in a changing world

- Climate change and associated phenomena such as ocean acidification are likely to change the productivity of different fisheries
- Some will benefit and others will decline and perhaps disappear
- It may be infeasible and costly to try to rebuild some stocks to old targets.
- For other stocks we should be adjusting target biomass upward – not calling these underutilized fish stocks



# Integrating Economics Into Management Strategy Evaluations (MSE)

- Economic analysis is often limited to evaluating economic impacts/outcomes
- There are advantages to integrating economics more directly into the process of determining and assessing rebuilding strategies



# Conclusions

- Many fisheries have rigid rebuilding requirements that sometimes constrain optimal rebuilding strategies.
- Even with fixed targets, there is much room to affect economic outcomes for the better – many factors to consider
- Industry often prefers approaches that smooth harvest over time – may seem like putting off the hard choices but may also be rational and economically optimal
- Instrument choice can be critical particularly for multispecies fisheries
- More attention needs to be given to variability and uncertainty in fishery productivity, particularly with secular change
- Need to integrate economics with fishery projection modeling, ideally as part of a Management Strategy Evaluation approach