# Stock Assessments in Support of U.S. Fisheries

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# Presentation Outline

- Mandate for Assessments
- Supporting Fishery Management Plans
- Data Requirements
- Assessment Modeling
- Fishery Control Rules

Stock Assessment: Collecting, analyzing, and reporting demographic information for the purpose of determining the effects of fishing on fish populations

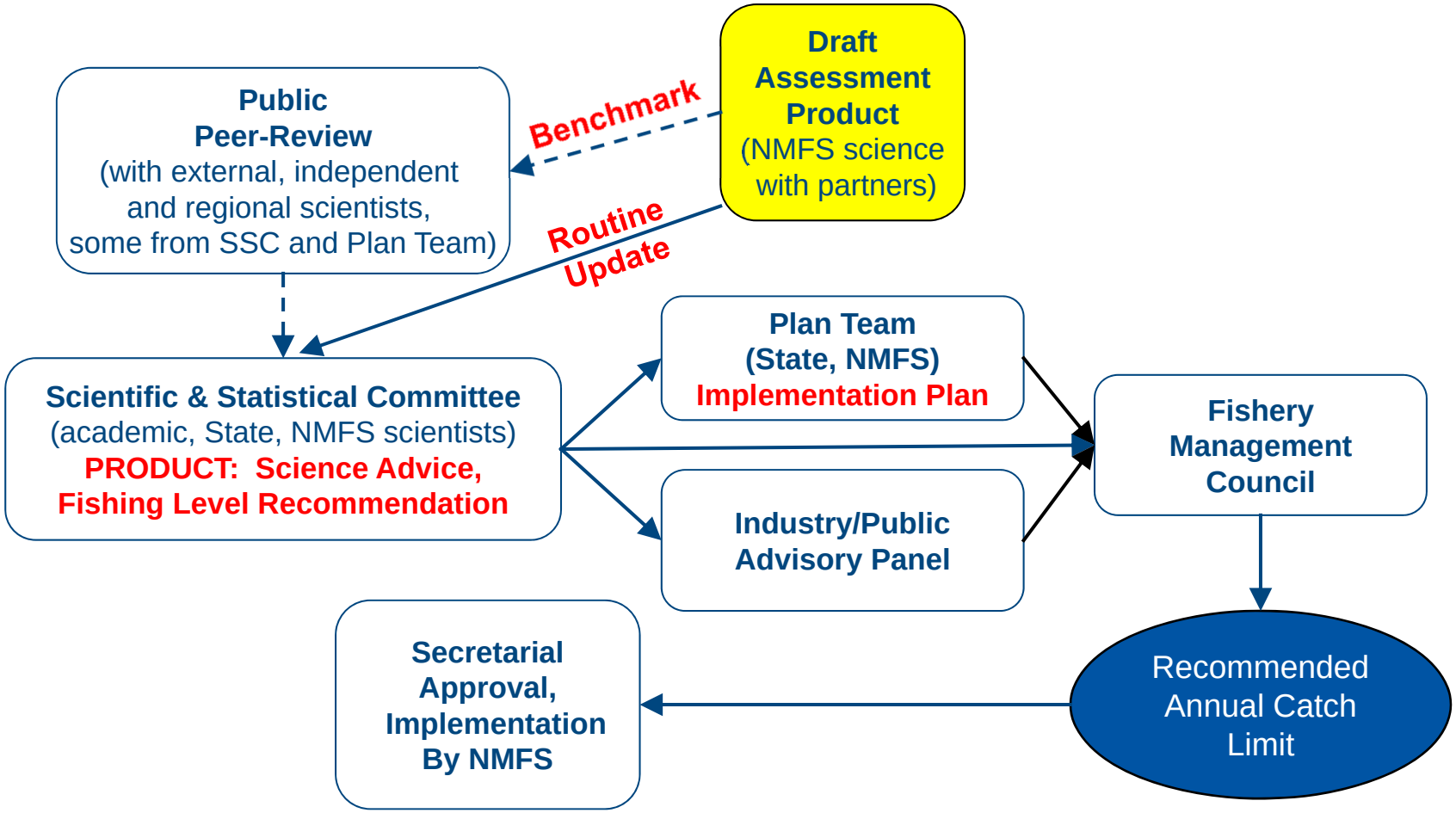
# MSFCMA: National Standard 1

"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."

# Fishery Management Plans

- *Establish a mechanism for specifying annual catch limits … at a level such that overfishing does not occur in the fishery, including measures to ensure accountability.*
- *Specify objective and measurable criteria for identifying when the fishery … is overfished*
  - *Related to reproductive potential of stock*
- Annual Catch Limits (ACLs) may not exceed Council's Scientific and Statistical Committee's fishing level recommendation
  - *Based on best scientific information available*

# Stock Assessment / Council Process



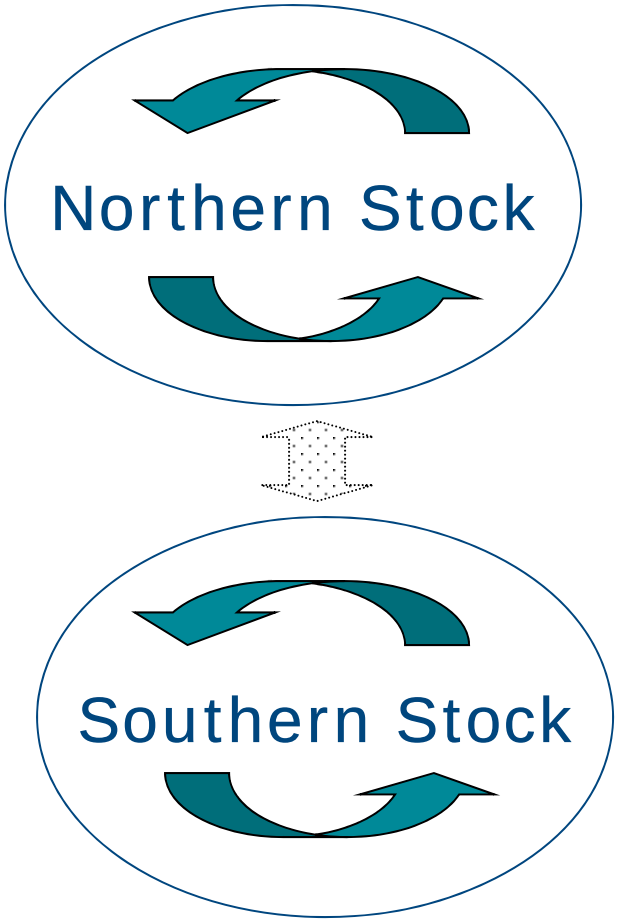

http://www.nrc.noaa.gov

# Key Assessment Concepts

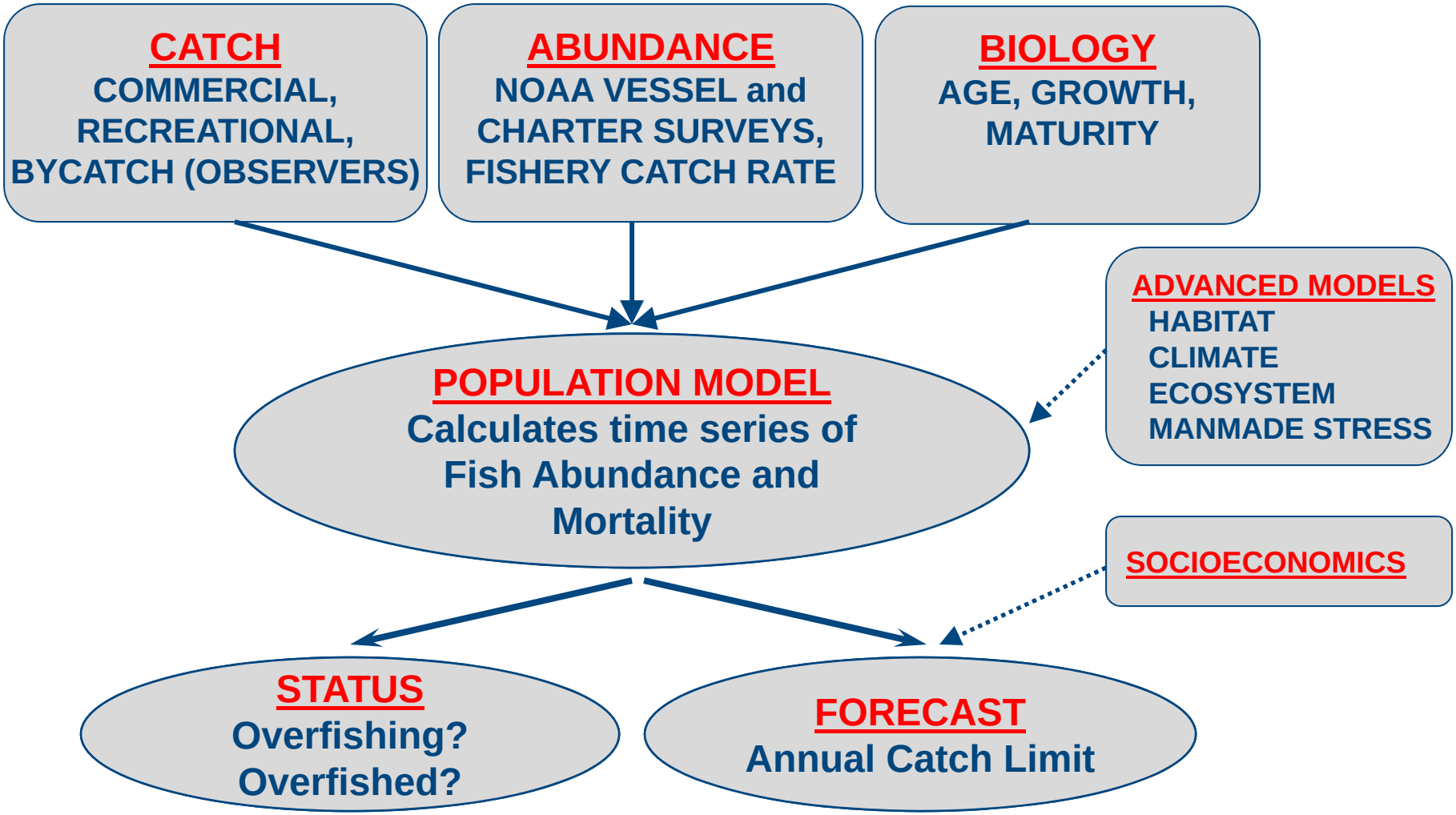
- Stock; Population
  - Biological unit being analyzed, and its fishery
- Abundance; Biomass (B)
  - how many fish out there; total weight of the stock
- Reproductive potential; Spawning biomass
  - Produce 1000s of eggs per female, small fraction survive to be young fish
- Recruitment; Year-class; Cohort
  - numbers of young fish entering stock each year
- Natural mortality
  - Fraction dying each year due to natural causes
- Fishing mortality (F); Exploitation rate
  - fraction caught each year by the fishery increases overall mortality
- Annual Catch Limit (ACL) = (recommended F) times (Current Biomass)
- The maximum long-term average catch that the stock can produce is MSY

# What is a “Stock”?

- A group of individuals of the same species
- That inhabit the same geographic region
- And that interbreed when mature
- Multi-species complex ≠ true biological stock



# Stock Assessment



# Total Catch

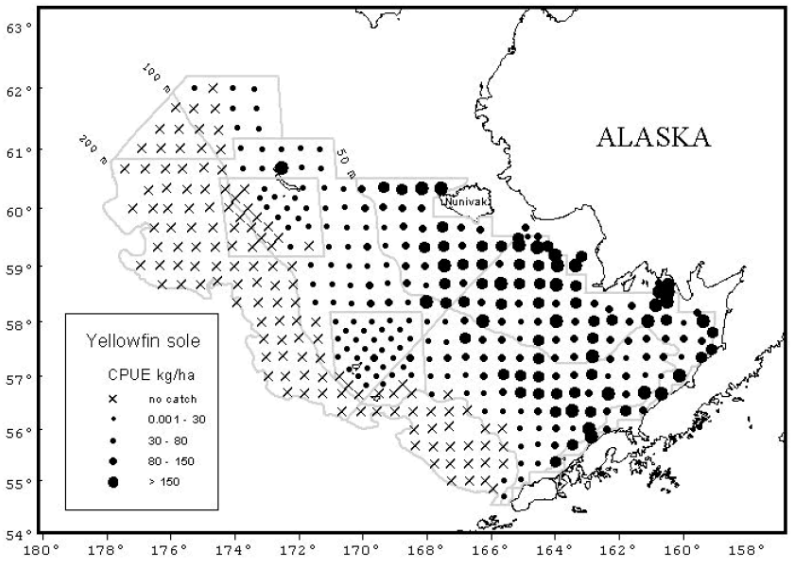
- A dead fish is a dead fish; count ‘em all
  - Commercial retained
  - Recreational kept
  - Commercial & recreational discard/release
    - %Survival of discard & released
  - Research take

- Data Sources
  - Fishery Information Networks:  State-federal-Commission
  - Fishery Statistics
  - Observer Programs
  - Marine Recreational Information Program

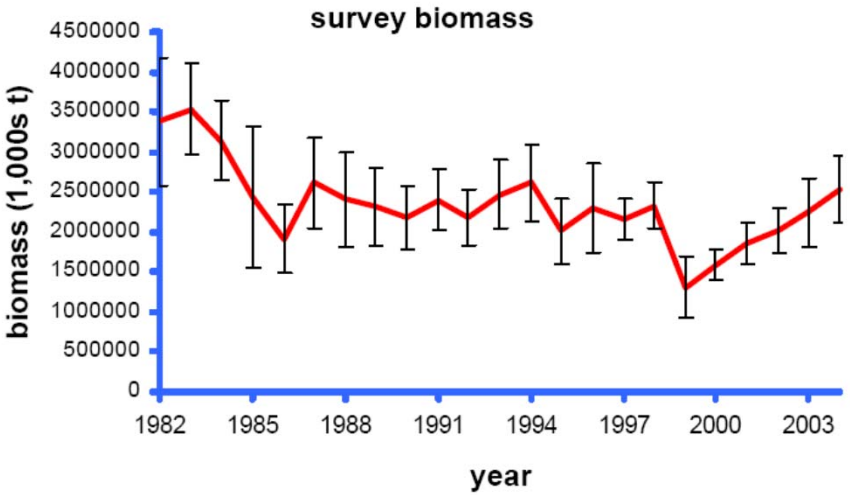
# Why Fishery-Independent Surveys?

- Fishery catch rates
  - Should go up and down with fish abundance
    - But, fishermen are businessmen seeking profits
    - Adjust fishing methods & locations
  - Difficult to be confident that calibration doesn't drift over time
- Fishery-independent surveys of abundance
  - Cover range of the stock (even areas with lower abundance)
  - Select sample locations with statistical plan
  - Use highly standardized sampling methods
  - With advanced technology (acoustics, optical, robotics, smart tags) can achieve even higher degrees of calibration

# Example: Bering Sea bottom trawl survey




**Count fish at 100s of locations each year**




**Average count with error bars for each year of survey**

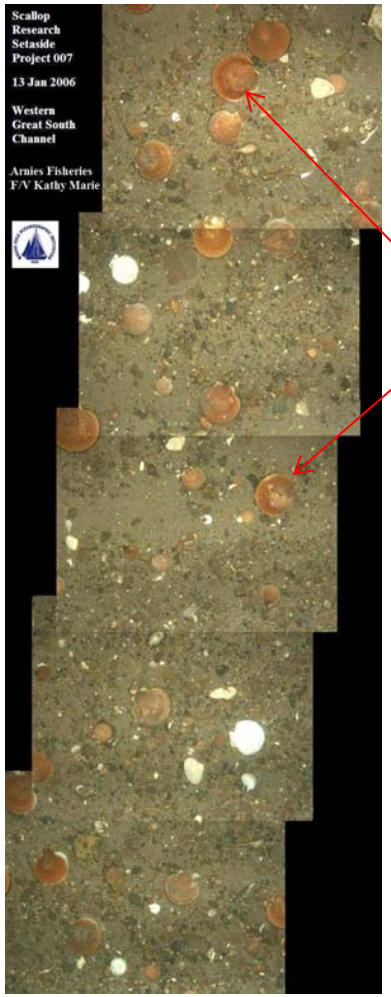
- Comparable bottom trawl surveys in Northeast, Gulf of Alaska, Pacific Coast, Gulf of Mexico provide data for assessment of many stocks
- Other survey methods provide data for additional stocks

# Advanced Technology

- Optical surveys for non-lethal absolute abundance estimates

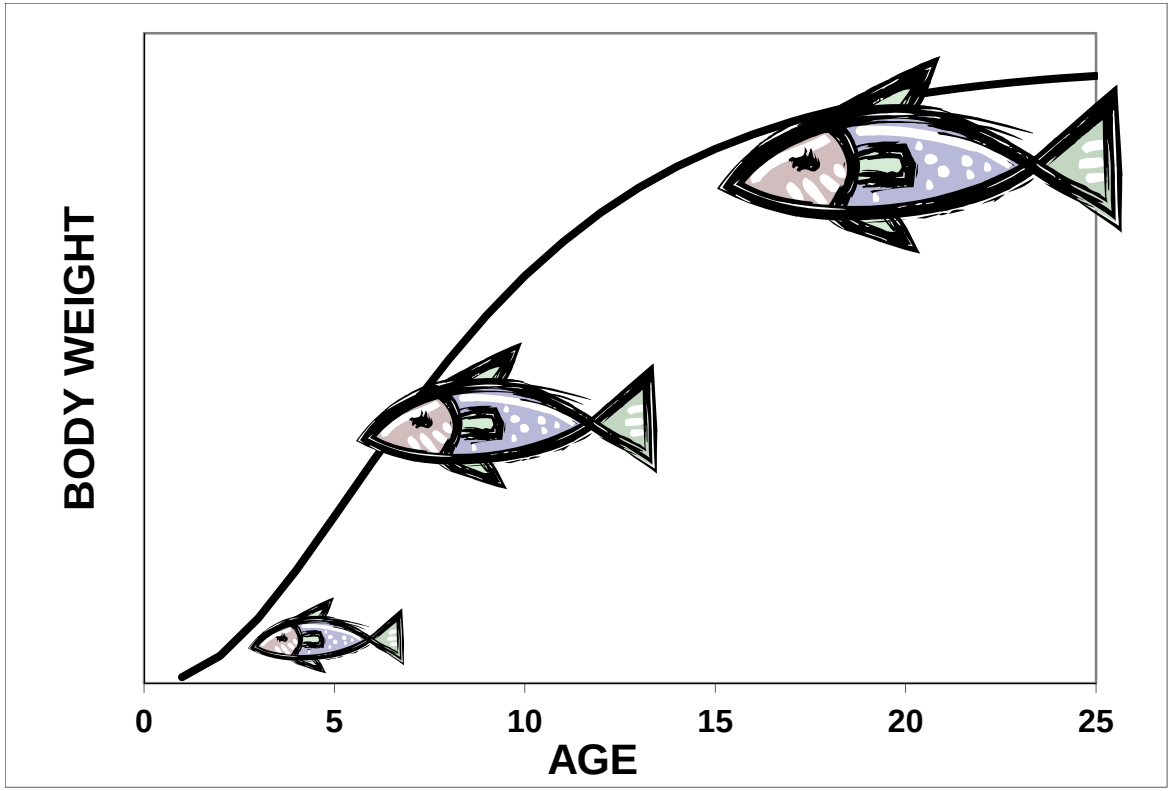
- Northeast Scallop Survey in FY12 will use towed camera system with automated optical recognition software for abundance estimates

- Towed and robotic systems being tested for reeffish/rockfish surveys in GOM, west coast, Pacific Islands and elsewhere

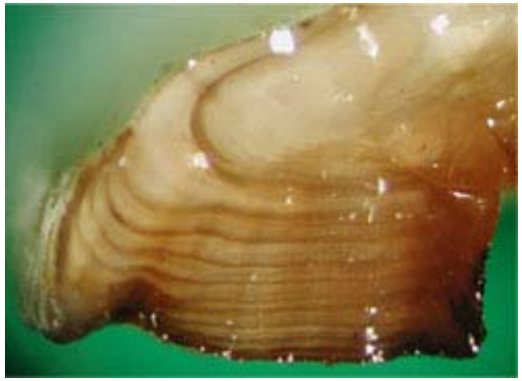


# Fish Biology and Life History

- Age, length, weight, maturity, fecundity, natural mortality




**Otolith (ear bone) with annual marks**



## Quiz Time!!!

# Which of these is NOT a Critical Assessment Data Component?

- 1. Catch
- 2. Environmental data
- 3. Abundance survey
- 4. Fish Biology

#2 is the correct answer.
Environmental factors affect fish stocks, but we lack enough i

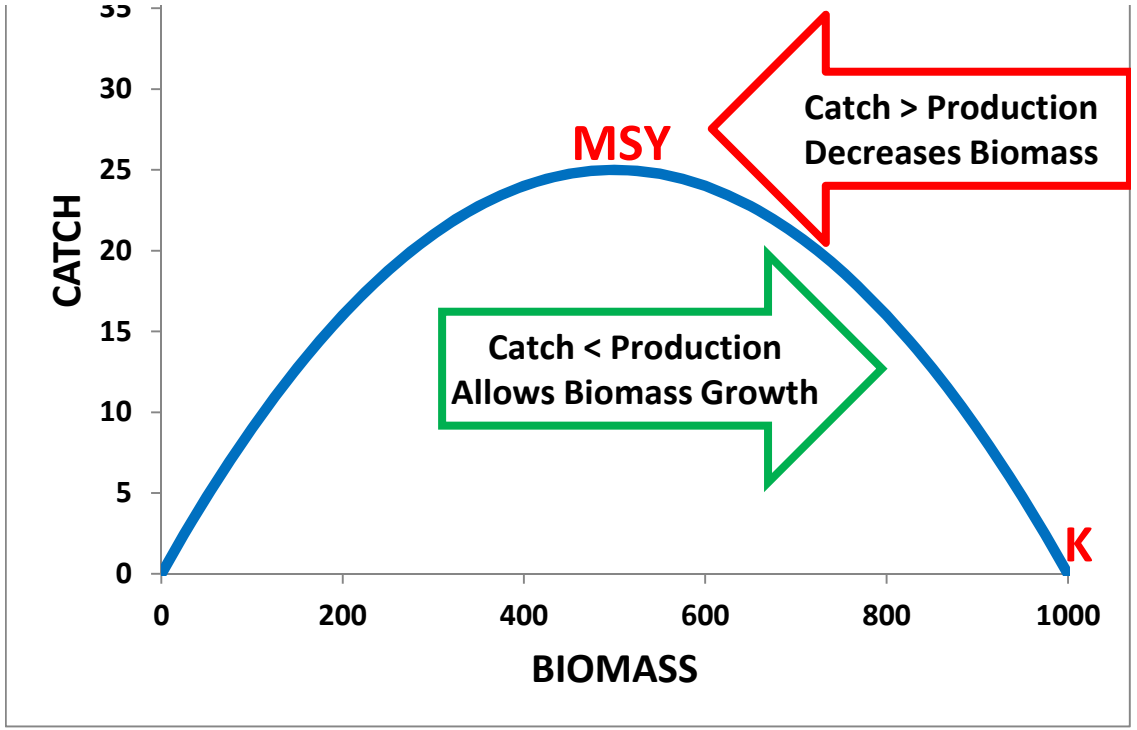
# Basic Assessment Approach

- Input: catch & relative abundance over time
  - How large must the population have been,
  - in order to have exhibited the observed trend in relative abundance over time,
  - while the observed amount of catch was removed?
- If observed decline was steep, then catch must have removed a large fraction of the stock. So stock is small and fishing mortality is high.
- Contrast helps calibrate population model

Advanced tech surveys will allow a more direct approach to the assessment calibration, so should be more accurate than the relative change approach used today

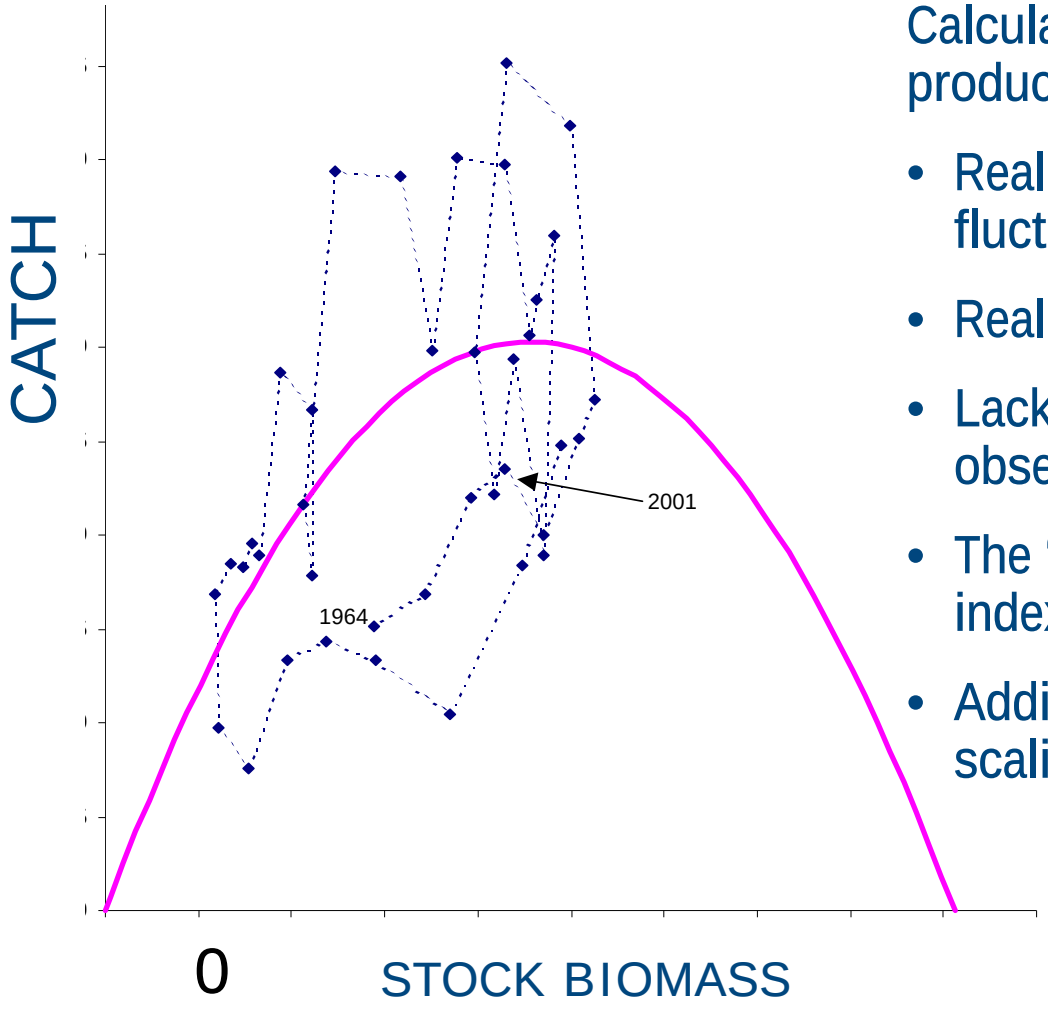
# Maximum Sustainable Yield - Concept

MSY: largest long-term average catch (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

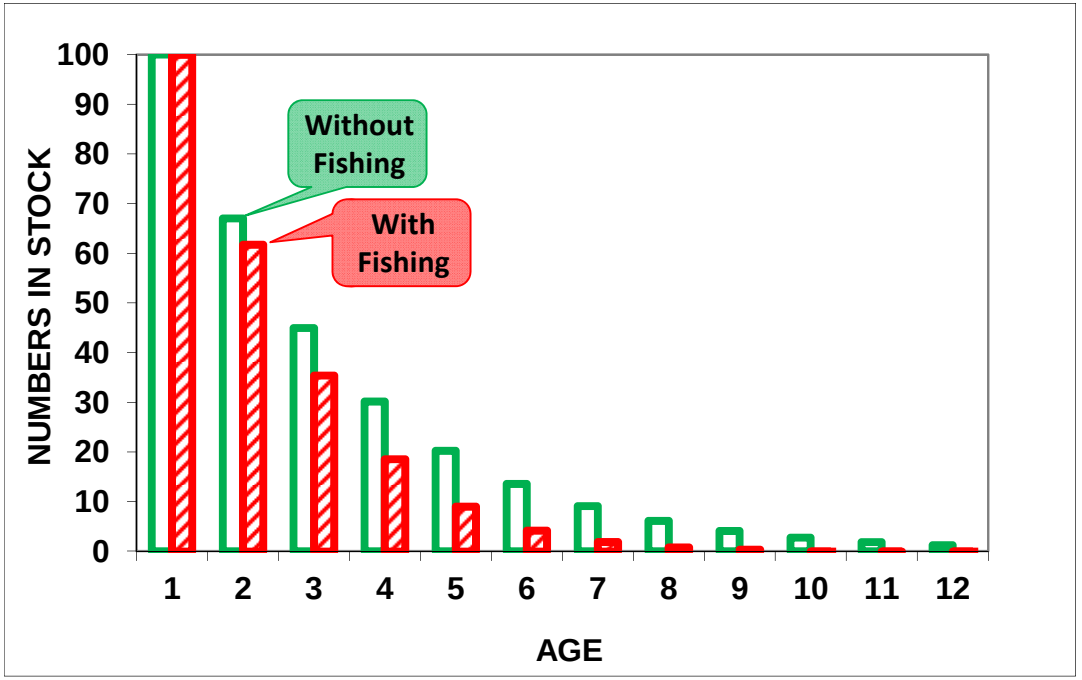



Calculating the shape and level of the production curve is difficult:

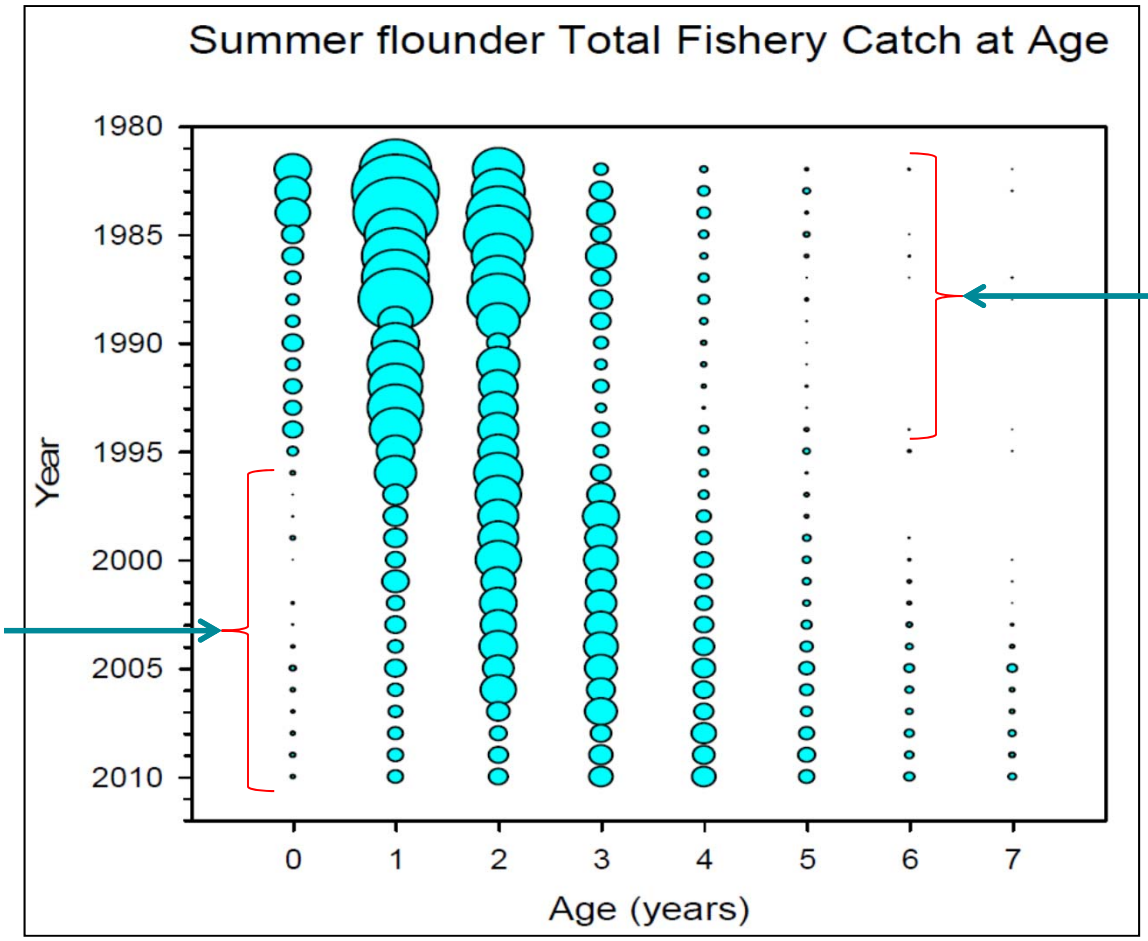
- Real populations show much natural fluctuation
- Real data have sampling error
- Lack of contrast: stock may not have been observed over full range of biomass levels
- The “biomass” is not actually biomass: index treated as proportional to biomass
- Adding age data will help pin down the scaling

# Direct Fishing Effects on Numbers at Age

- As fish age, they tend to die off at a consistent, natural mortality rate
- With fishing, the total mortality rate increases so:
  - Fewer old/large fish
  - Smaller mean body size
  - Shorter generation time
- Adding age data provides more information about the effect of fishing



# Age-Structured Data Provide Details

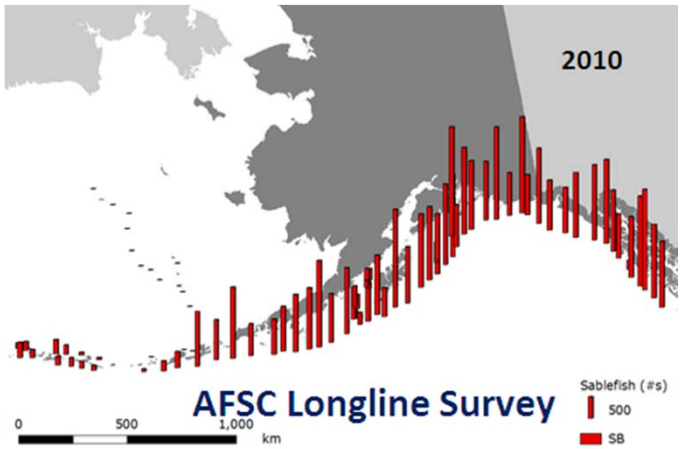


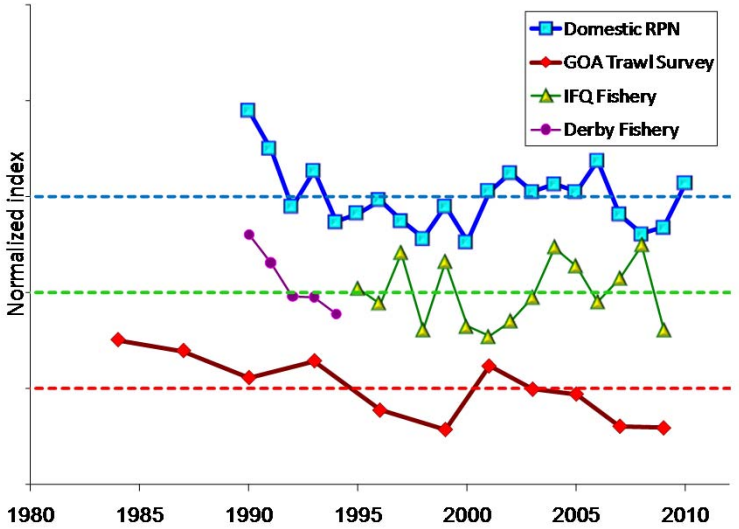

Higher F: faster die-off

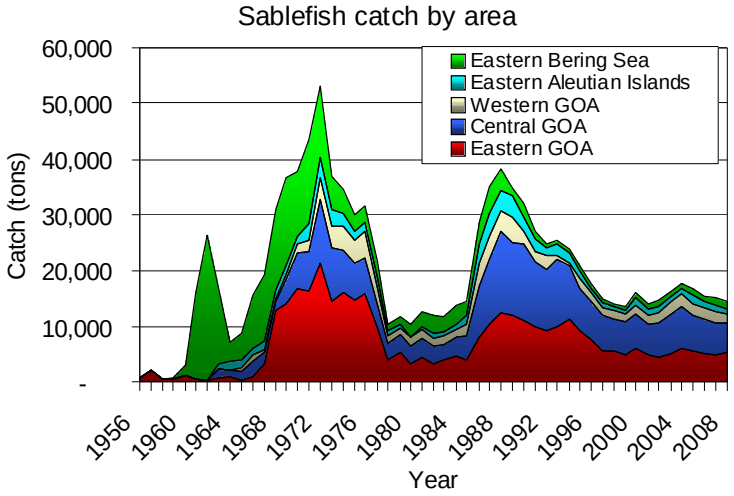
Gear regulations: reduced catch of young fish

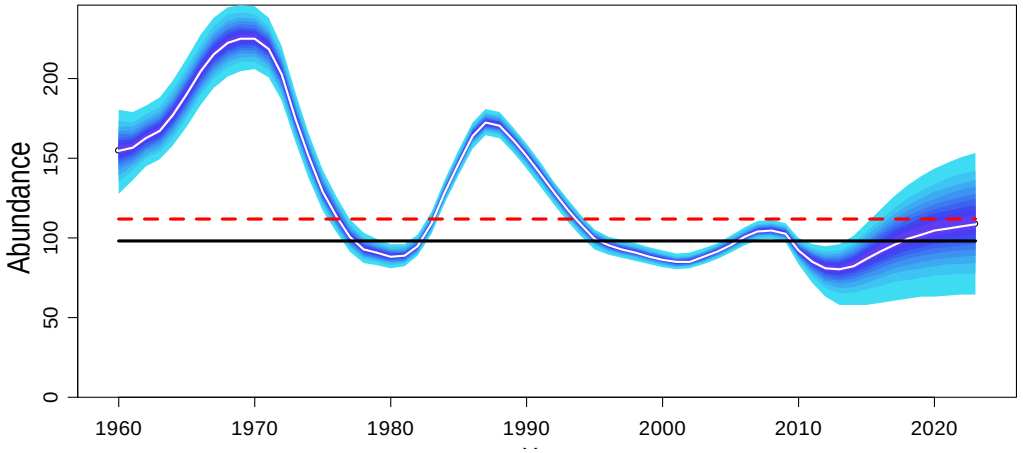
- Bubble size is amount of catch at age (column), year (row)
- Catch of youngest fish is lower because they are too small to be selected by fishery

# Sablefish Assessment in Gulf of Alaska

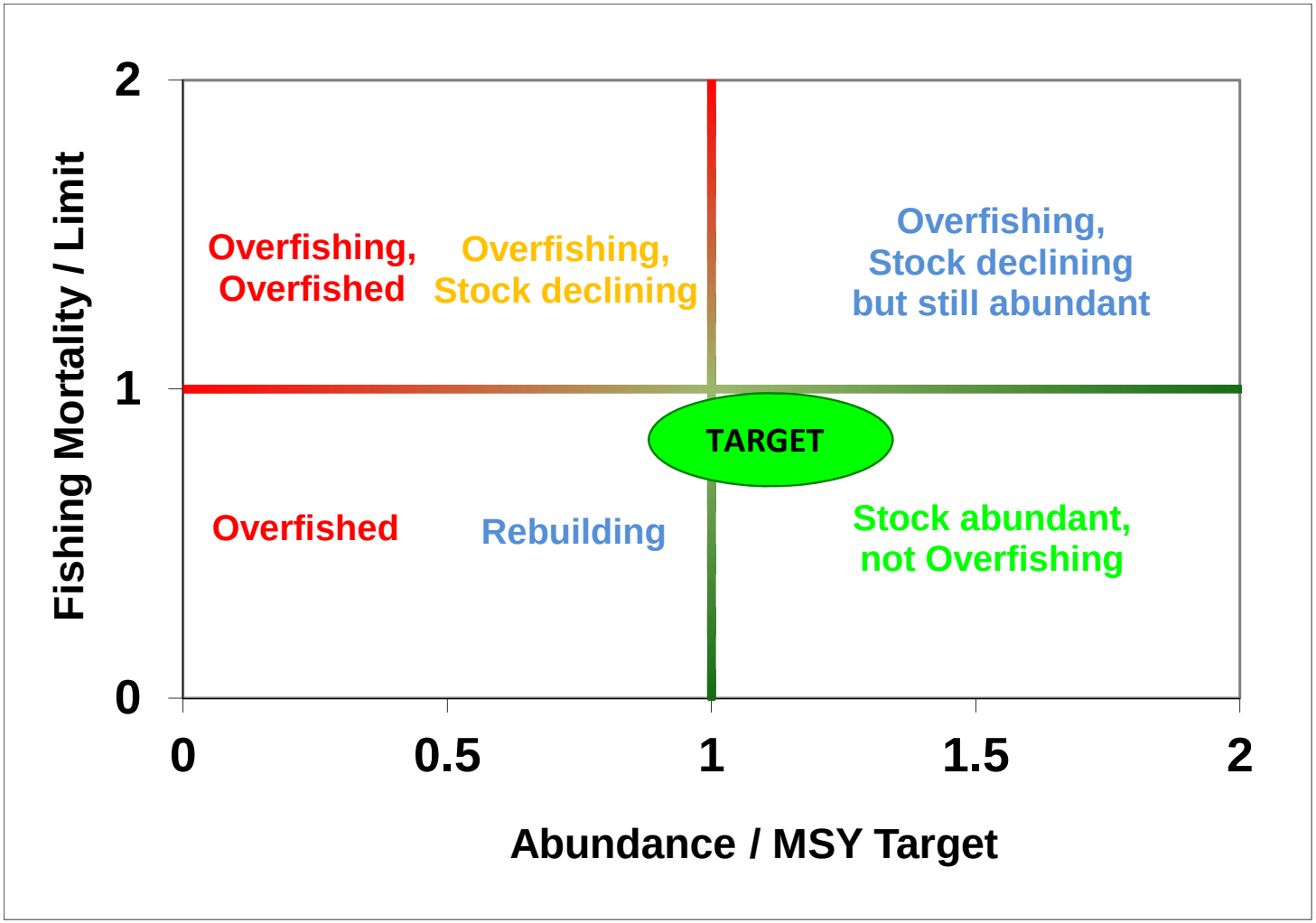


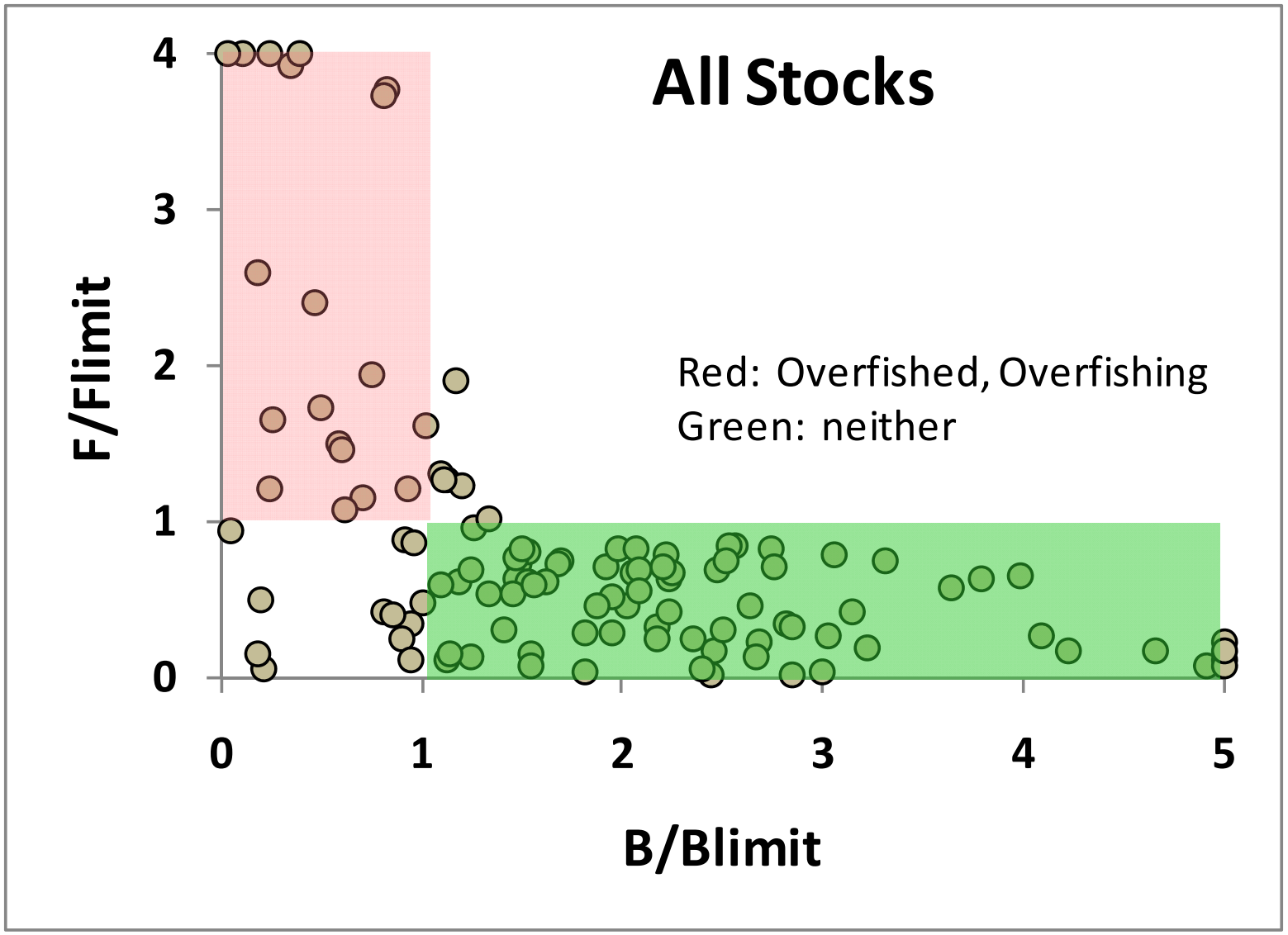



# Assessment Outcomes: Status Determinations



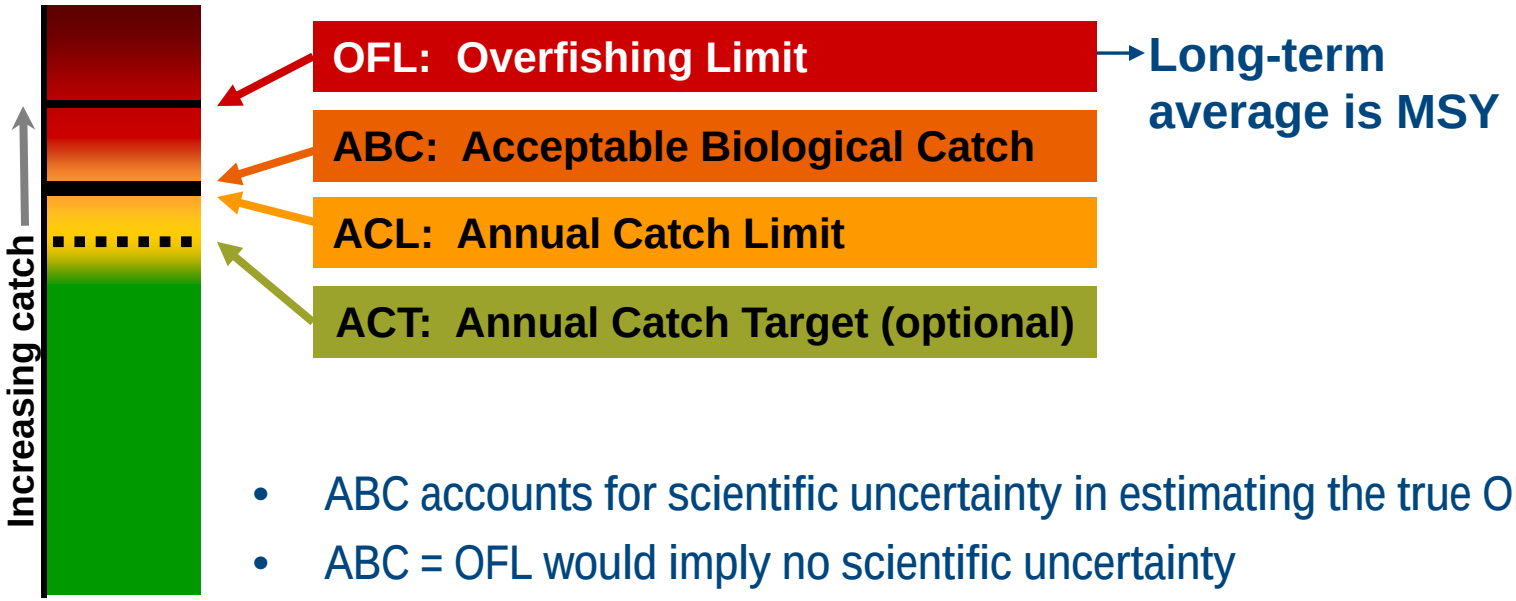
# Status of 140 U.S. Fish Stocks



# Pro-Active, Short-Term Advice

- What level of catch next year would correspond to the target harvest policy?
- What level of catch next year has no more than a specified (<=50%) chance of causing overfishing?
- Control Rule:  Formula that calculates future target catch level from forecast biomass level

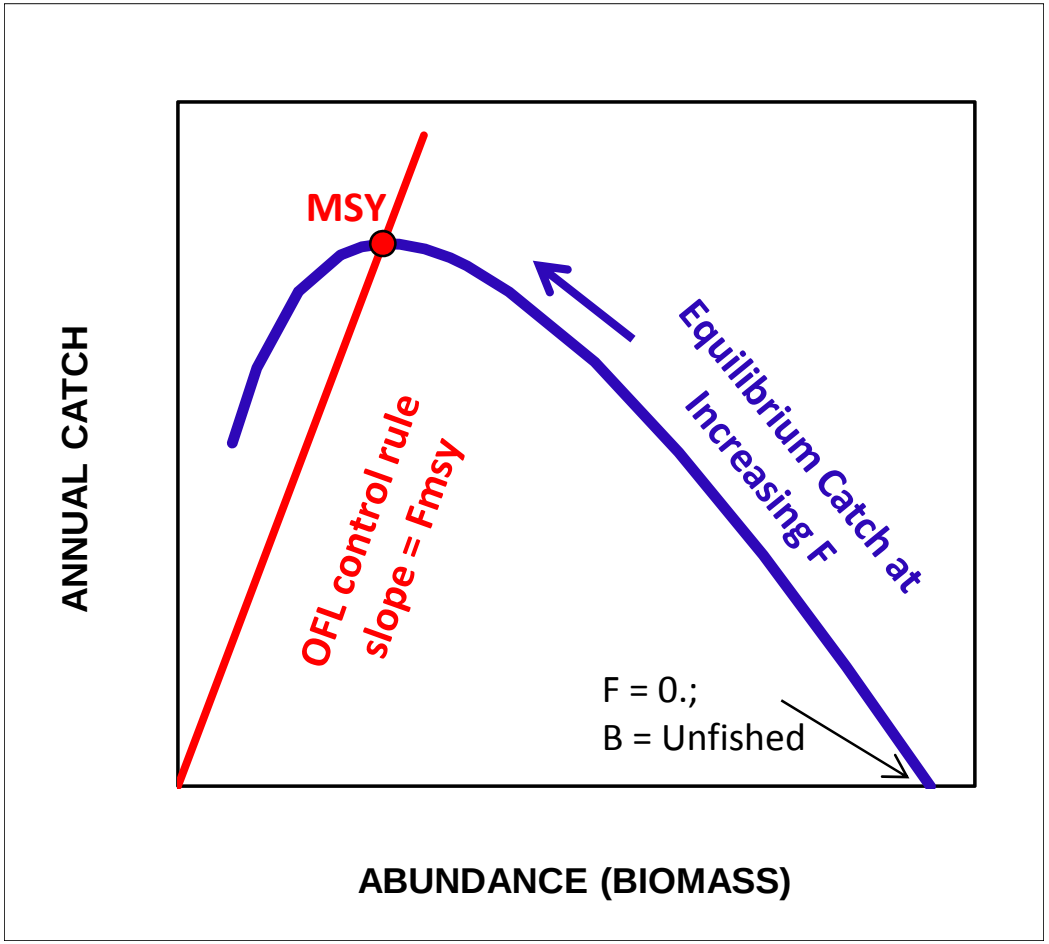
# Annual Catch Reference Points (per Nat. Std. 1 Guidelines – 2009)




- ABC accounts for scientific uncertainty in estimating the true OFL
- ABC = OFL would imply no scientific uncertainty
- ACL = ABC is OK, just the science-management hand-off
- ACL is trigger for accountability
- ACT = ACL, or no ACT, would imply perfect control of catch

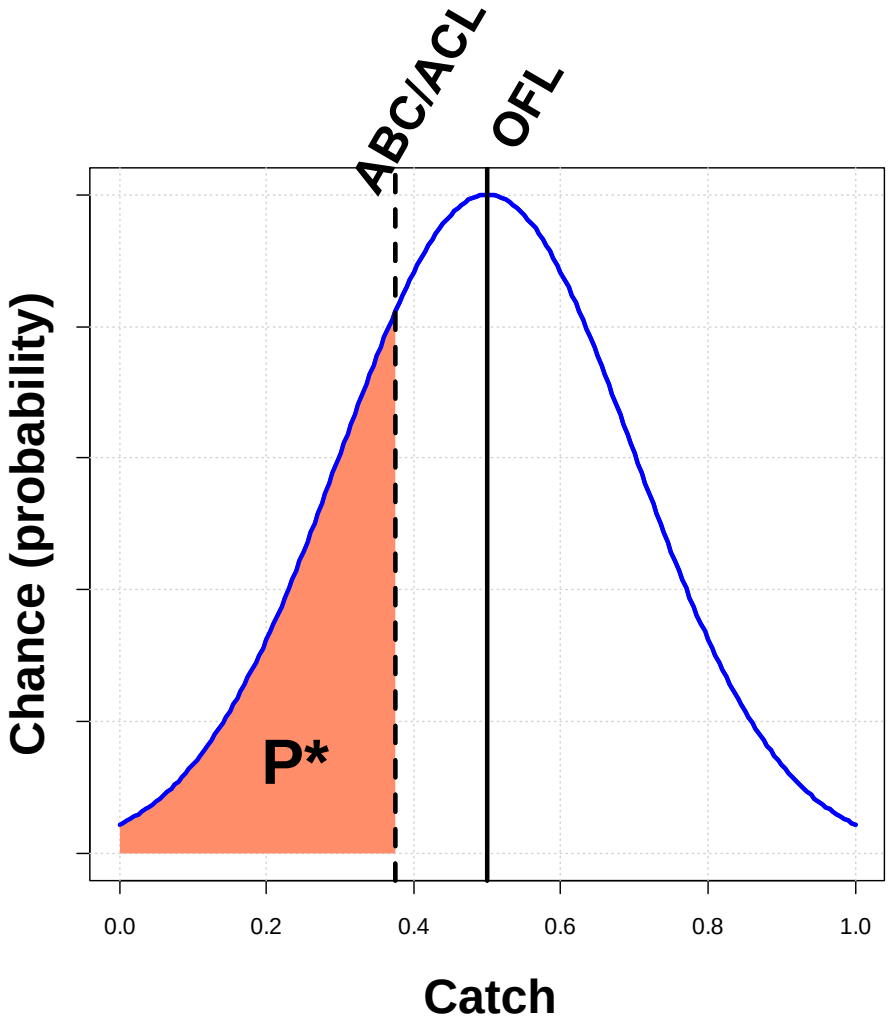
# OFL Control Rules

- 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



# 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?



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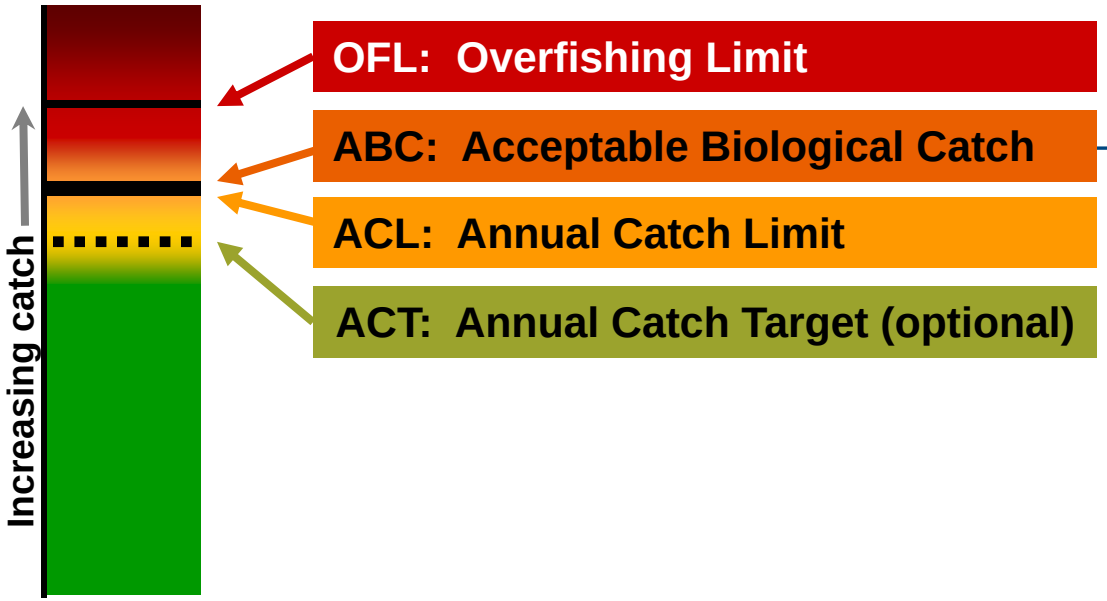
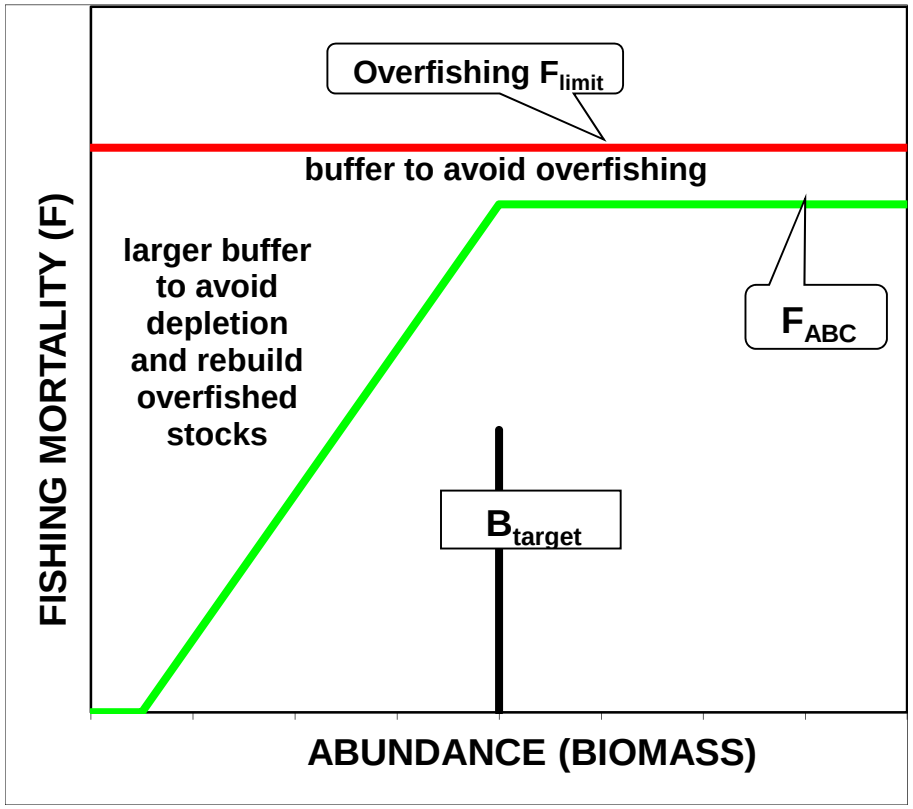



**Example: P* = 40%**

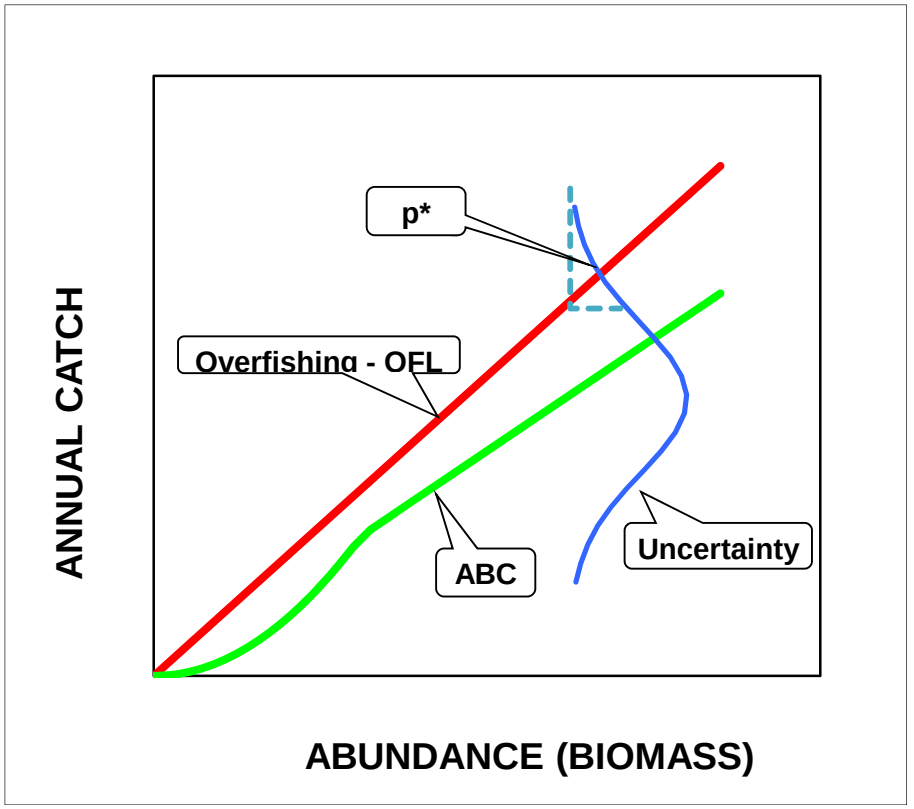
- **Reduce ABC to a level where there is a 40% chance that OFL<ABC**

# Limit and Target Control Rules

**F is the fraction caught**

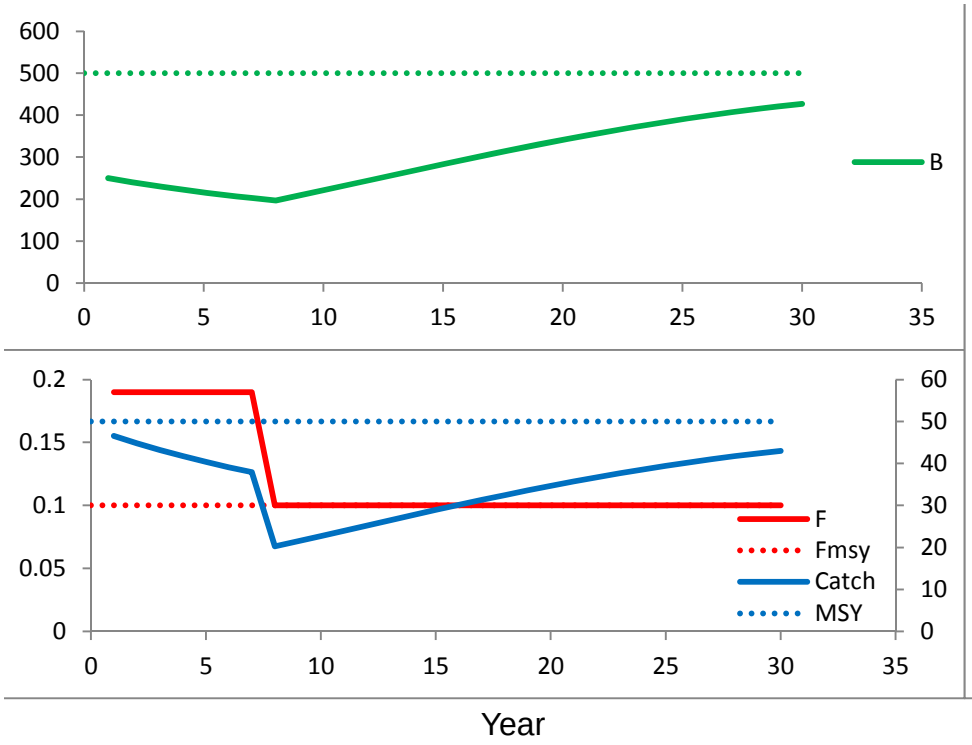


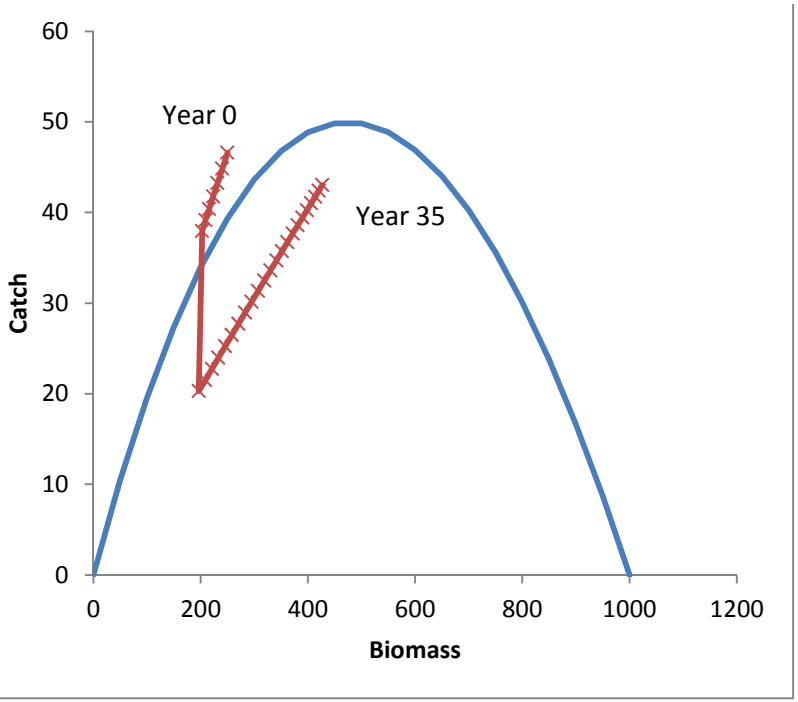

**Annual Catch = F times B**



# Control Rule Performance

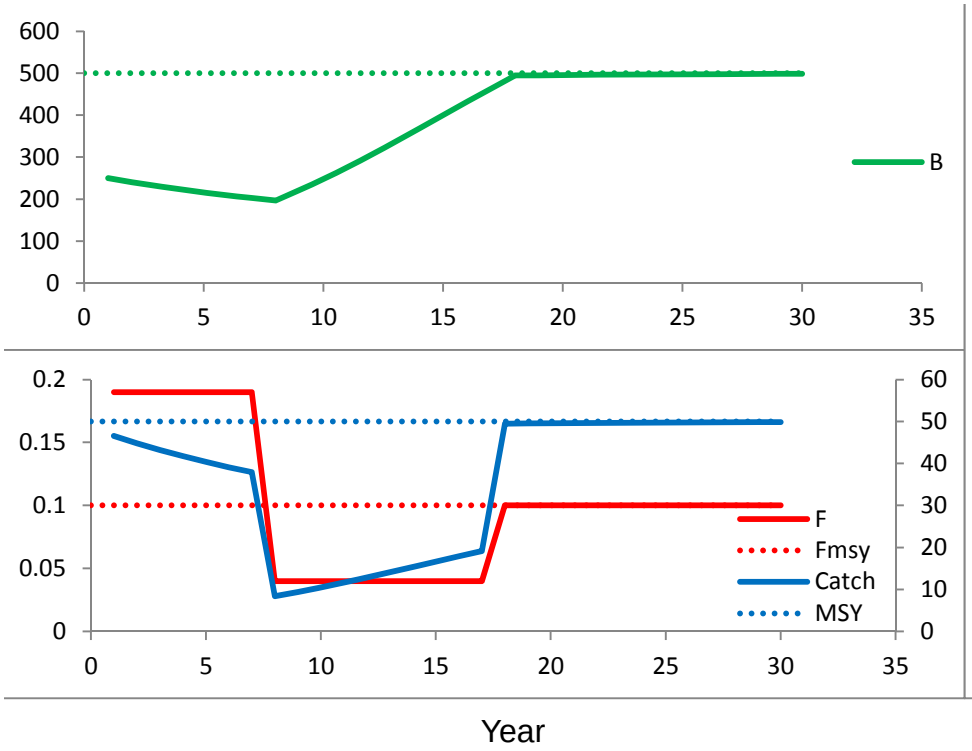
## 1. Jump to $F_{MSY}$; slow rebuild

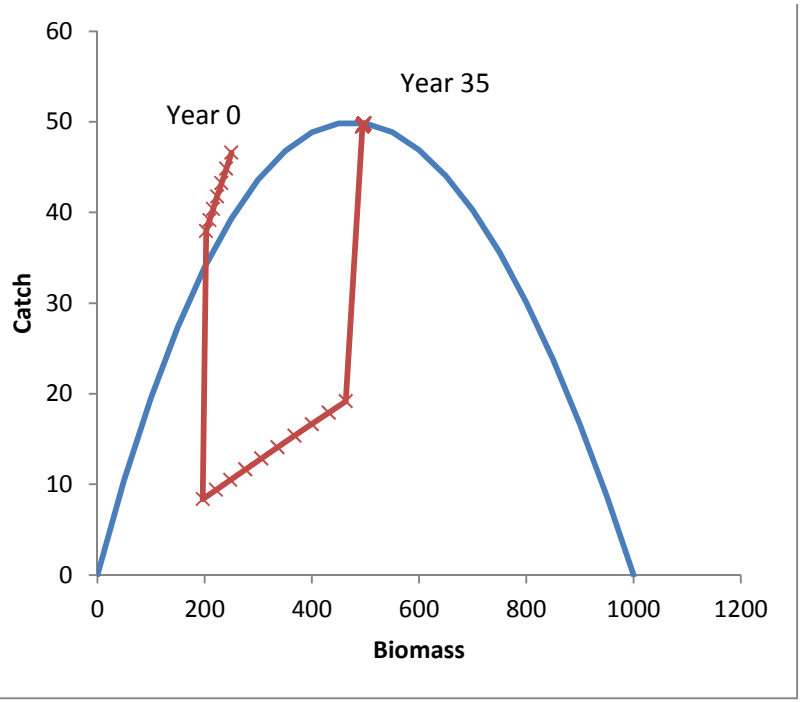


# Control Rule Performance

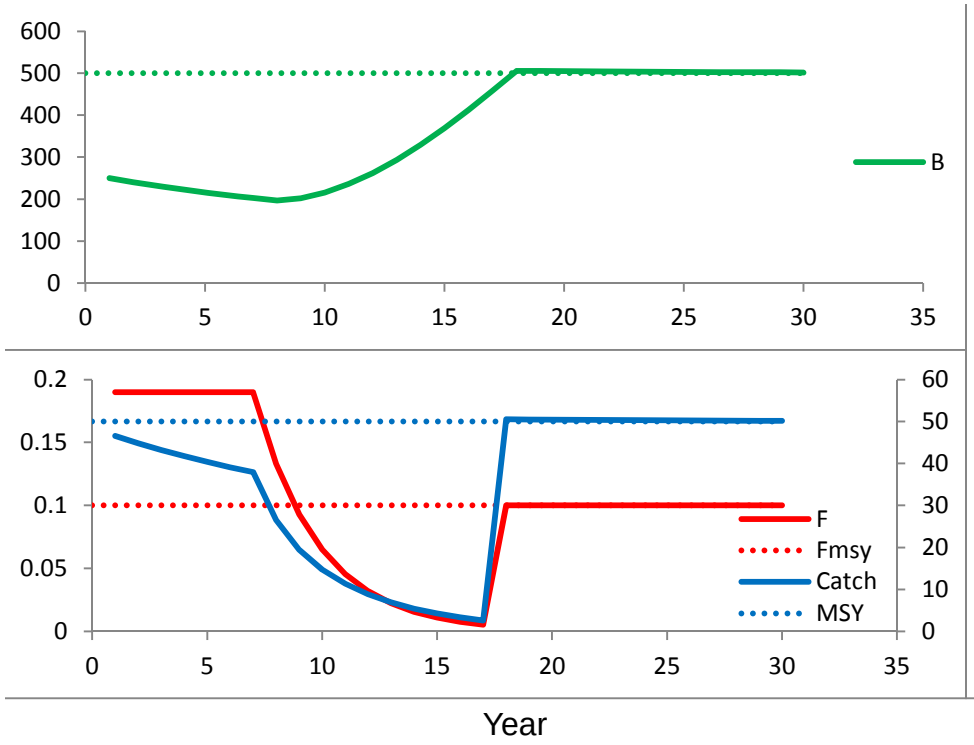
## 2. 10 year rebuilding plan

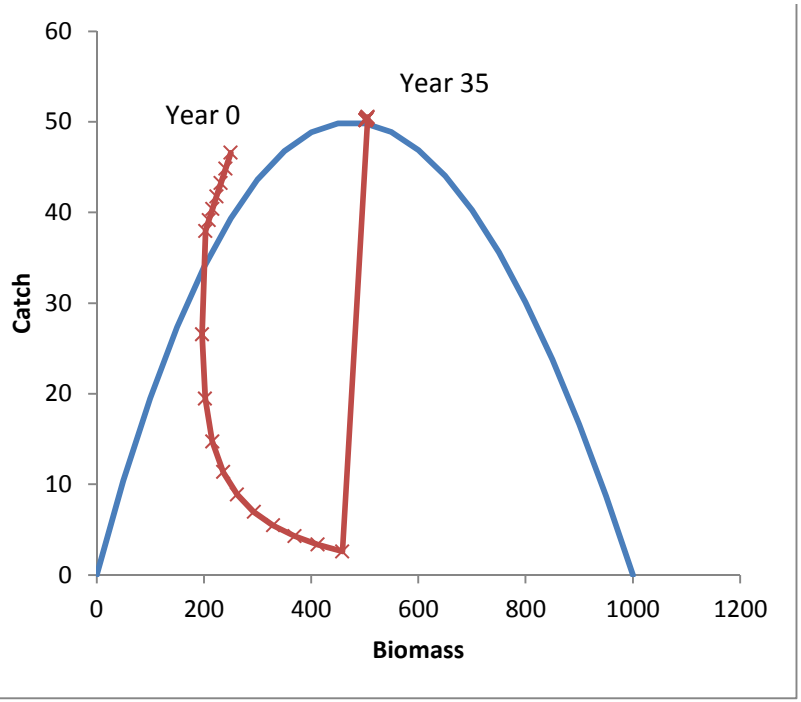


# Control Rule Performance

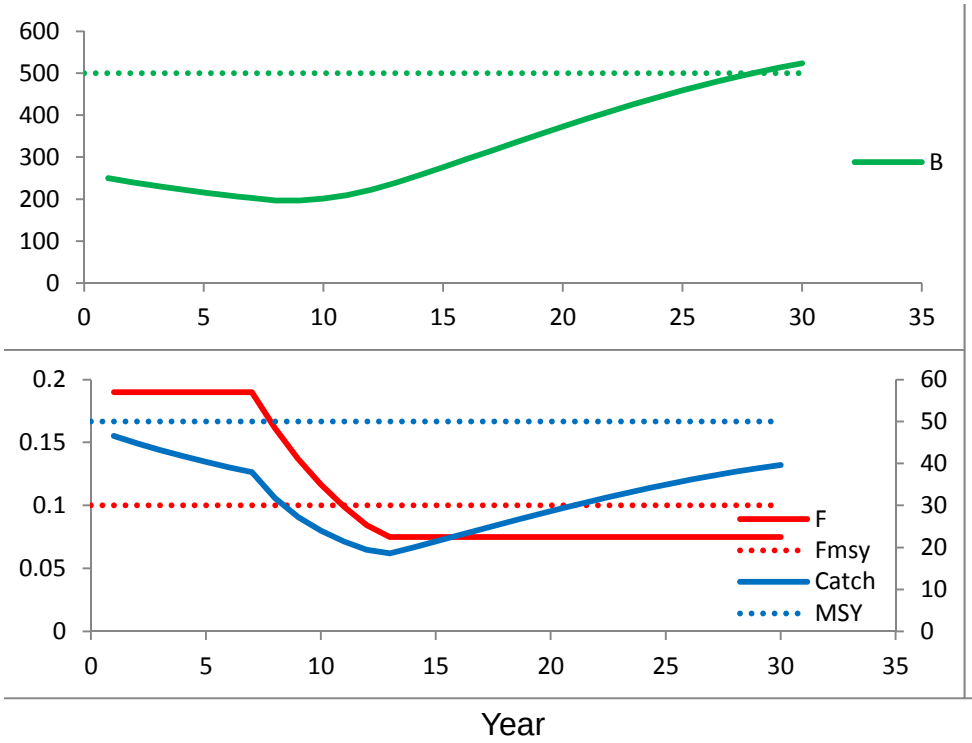
## 3. Delay the pain, but still rebuild in 10 years

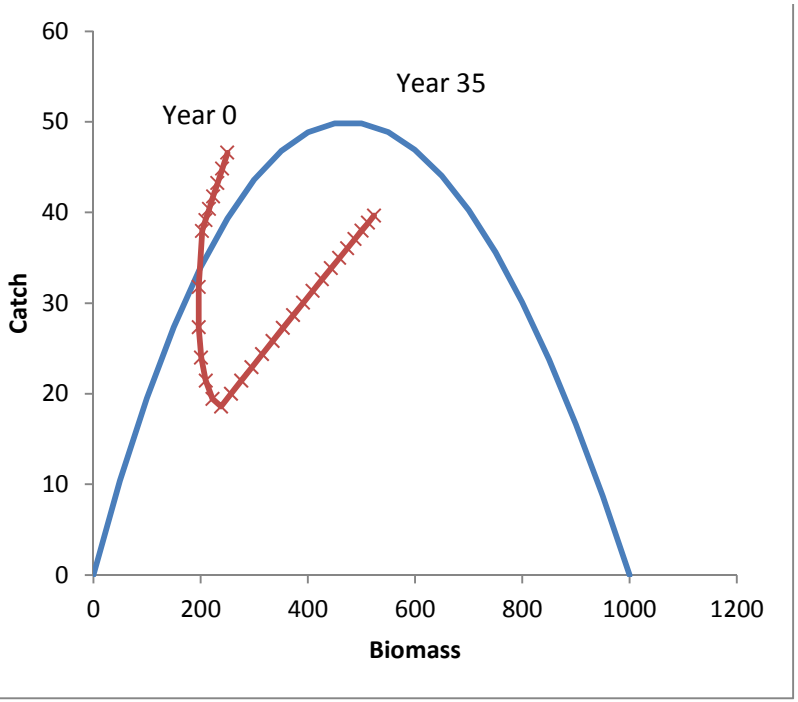


# Control Rule Performance

## 4. Long-term buffer with 5-year phase in

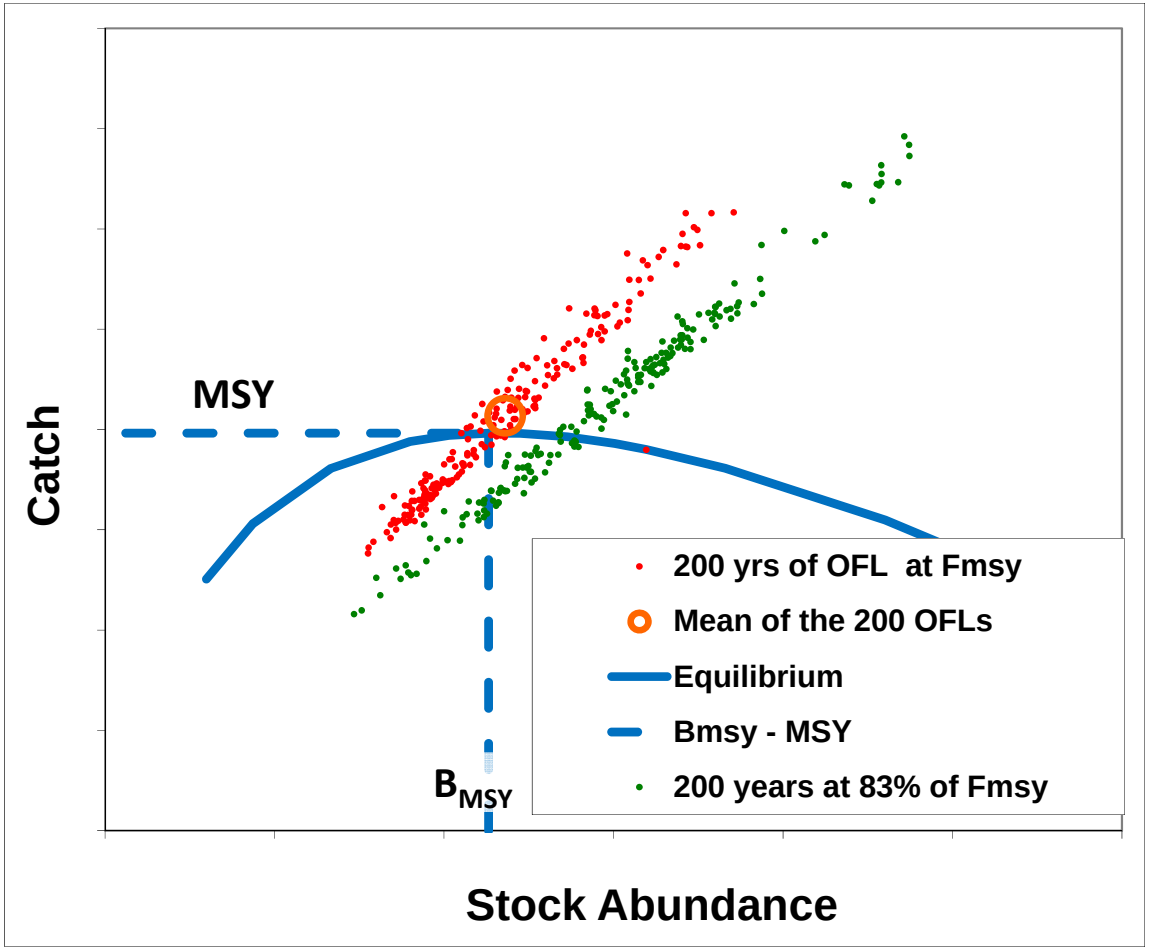



- Several options to consider: socioeconomics can guide selection
- Buffer is important, because the real world has uncertainty

# Management Strategy Evaluation

- 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 $F_{MSY}$ gets less catch from given abundance level, but higher abundance and similar catch over long-term



# Data-Poor Situation

- Fact:  for data-poor stocks, there is a level of catch that would be overfishing and will eventually deplete the stock;
  - We just don't know what it is;
- Estimate of uncertainty should reduce as we get more info, not get larger as we calculate more components of uncertainty;
  - So need proxy for unmeasured (likely) uncertainty;
- Data-poor approach to management should be at least as conservative as the approach used when a data-weak assessment can be done;
  - Difficult because we usually have only past catch as an indicator of the situation.

## Quiz Time!!!

# When assessments cannot calculate uncertainty, SSCs should set ABC:

- 1. At the overfishing limit, OFL
- 2. Below the OFL using uncertainty proxy from other stocks
- 3. Refuse to set an ABC

#2 is the correct answer.
They are expected to do the best they can to account for scie

# Summary

- Assessments are designed to answer management questions
- Catch, abundance patterns, biology are key inputs
- Variety of advanced technical methods tuned to diverse data availability scenarios
- Assessments produce estimates of stock abundance, fishing mortality, and productivity
- Stock forecasts provide technical basis for guiding the level of Annual Catch Limits

# For More Information

## NMFS stock assessment site

http://www.st.nmfs.noaa.gov/stock-assessment/index

## FishWatch

http://www.nmfs.noaa.gov/fishwatch/

## Status of Fisheries and FSSI Quarterly Reports

http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

## Species Information System for stock assessment and status determination data

https://www.st.nmfs.noaa.gov/sisPortal/sisPortalMain.jsp

# Group Exercise

## Set P* - the chance of overfishing for a stock

- New assessment has much uncertainty
- Indicates stock as been declining
- Now approaching both overfishing and overfished levels

Options:

- Set P*=49%; ABC would decline just 2% while tracking decline in stock
- Set P*=40%; short-term ABC would decline 20%, then begin to increase after 3 years

# BACK-UP SLIDES

# 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 historical level now appears to have exceeded the limit, even though the catch was not over the ACL. 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