# Considering Results from Multiple Plausible Models for Catch Recommendations

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… with thanks to

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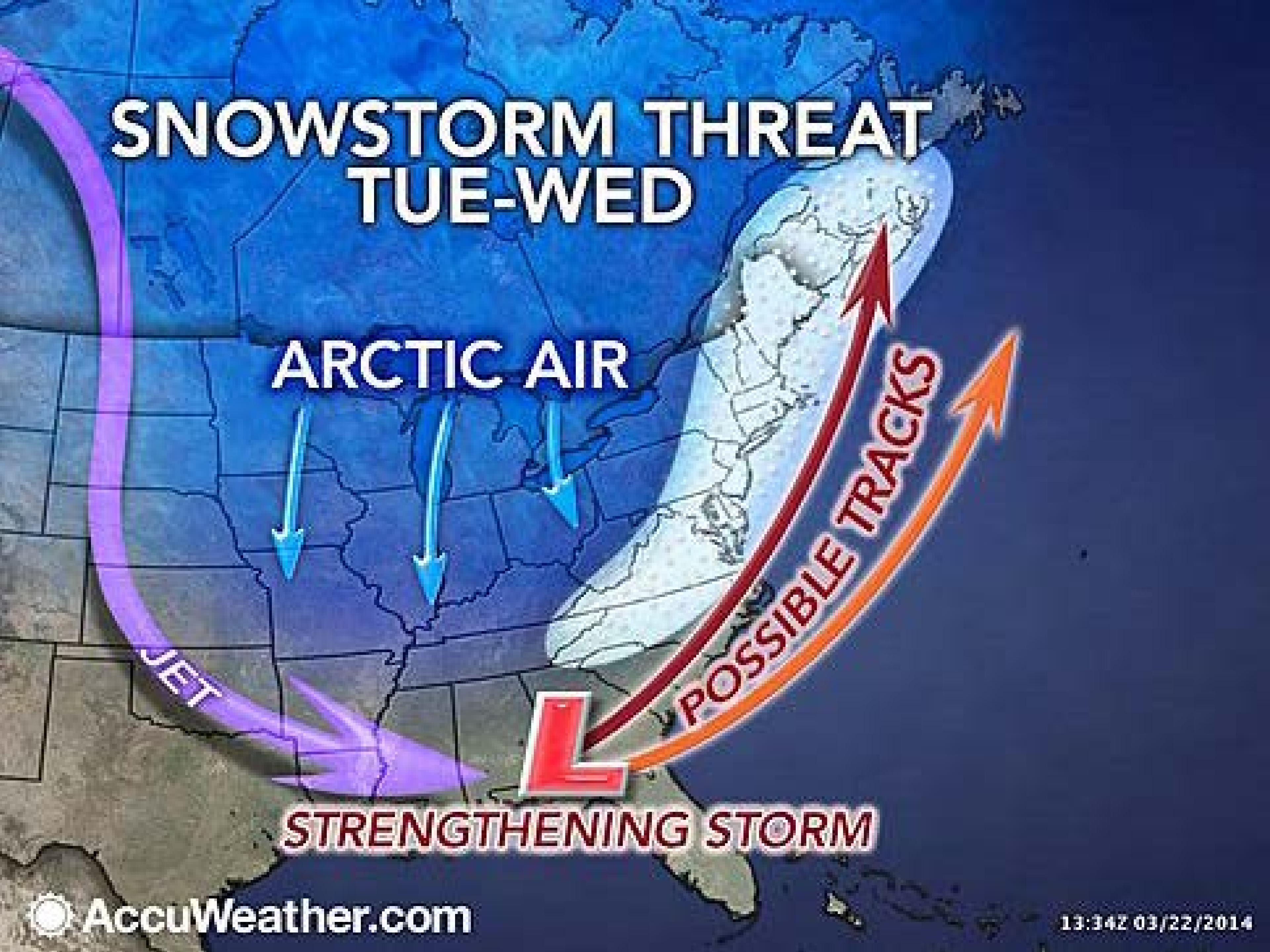

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# Definitions

- Risk
  - Chance of something happening that will negatively impact achievement of objective
  - Consequences (Impacts) x their probability given management decision

- Risk Analysis
  - Risk Assessment:  Evaluate risks
  - Risk Management: Mitigate risks
  - Risk-Based Decision Making: consider probabilities of negative outcomes and consequences of alternative decisions

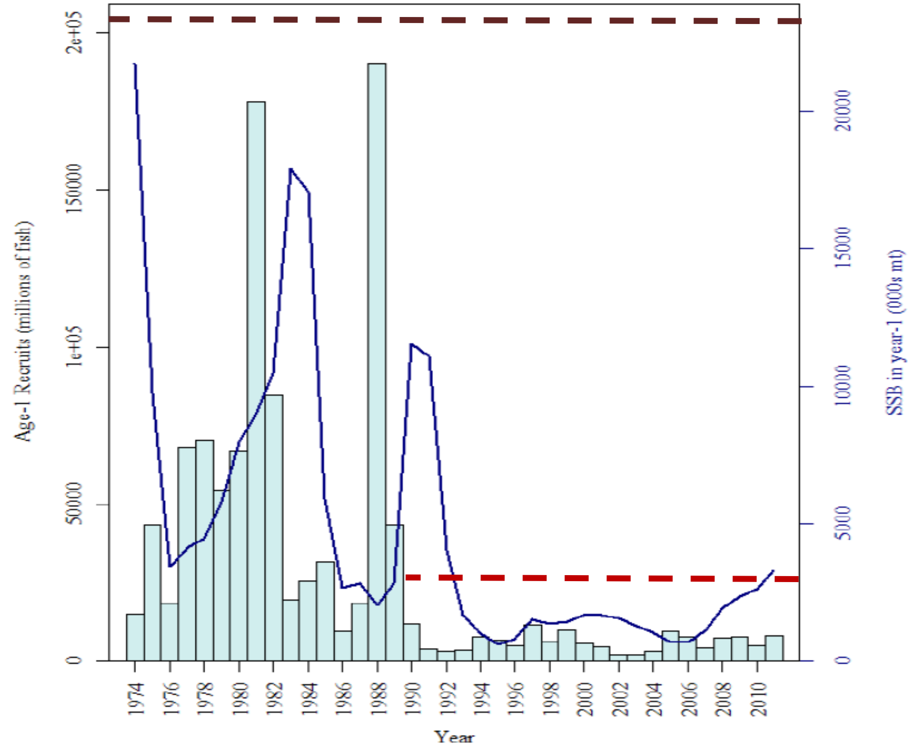
**We are doing (somewhat) Risk Assessment**
**Need tools to aid Risk Management**

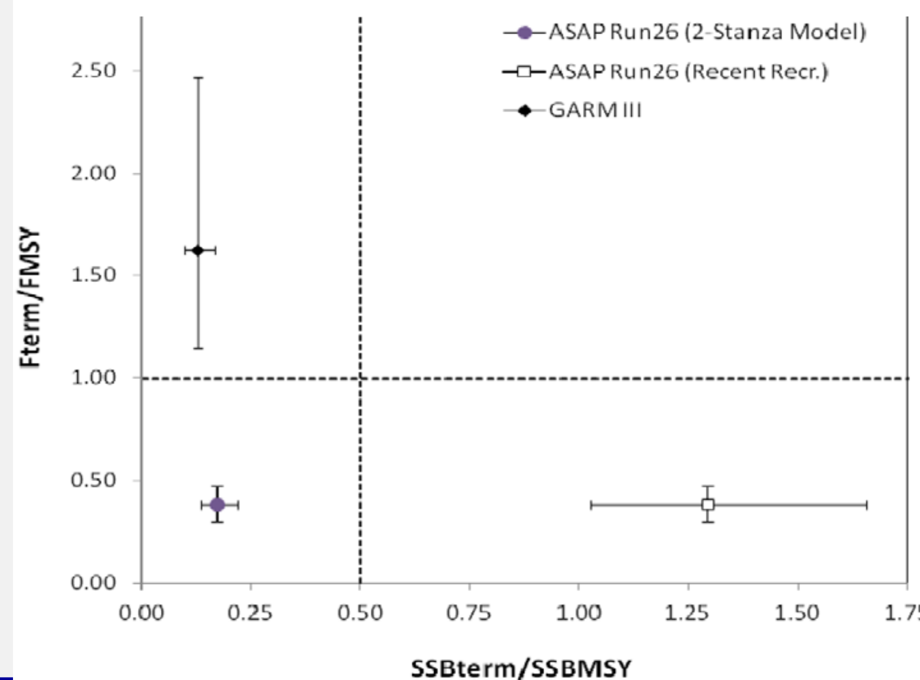
# Considering Multiple Models

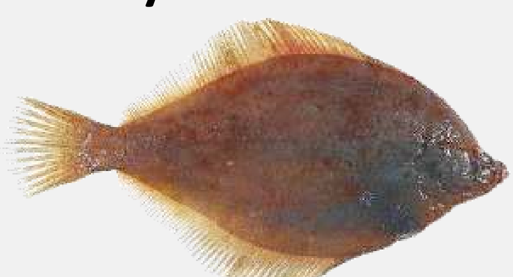
- Past Experiences:
  - Acceptable Catch based on projected catch at $F_{MSY}$ with uncertainty from the 'best model' (NS1 Guidelines, Prager & Shertzer 2010)
  - Sensitivity analyses to evaluate 'model uncertainty' (routine practice in SAWs)
  - Results from multiple candidate models communicated to managers with one model preferred (e.g., SAW54 S New England yellowtail flounder, …)
  - Consequence analysis of multiple plausible models (2009 TRAC/PDT Georges Yellowtail, SAW55WG Gulf of Maine cod, 2013 TRAC Eastern Georges cod, …)
- A more formal approach to considering information from multiple models.

# SNE Yellowtail

- The 2012 stock assessment offered two perspectives on stock status, and both were communicated to managers, with the ‘recent recruitment’ expectation considered as more likely.



NEFSC 2012

# S. New England Yellowtail

- The SSC considered the reference points based on recent recruitment to be more appropriate, because the low recruitment has persisted for more than two decades and high recruitment has been observed in the past at spawning stock biomass similar to current estimates.
- The SSC recommended acceptable catch based on the long term 75%Fmsy catch to allow an examination of how recruitment responds to low fishing mortality rates for a number of years.
  - If recruitment considerably increases for multiple years, then the biomass reference point should be updated.
  - If recruitment remains low, the change in productivity will be confirmed, and acceptable catch can be based on applying 75%Fmsy to the projected stock abundance.

# Georges Yellowtail

- The 2009 TRAC assessment reported results using two VPAs including and excluding the Canadian spring trawl survey in 2008 and 2009, and the PDT projected catch and rebuilding probability from both.

| | Assessment Model | | | |
|---|---|---|---|---|
| | Excluding | | Including | |
| Catch (mt) | F | Rebuilt | F | Rebuilt |
| 450 | 0.02 | 2014/75% | NA | NA |
| 1,500 | 0.068 | 2015/75% | 0.048 | 2013/75% |
| 2,100 | 0.097 | 2016/75% | 0.068 | 2014/75% |
| 2,300 | 0.107 | 2014/52% | NA | NA |
| 2,600 | NA | NA | 0.085 | 2014/75% |
| 3,300 | NA | NA | 0.107 | 2014/69% |

# SAW 55
# Assessment Models & Issues Considered

| Component | Data/Parameter | Options |
|---|---|---|
| Age / Year | Start Year | **1932 with internal SR vs. 1982 with SPR proxies** |
| | End Year | **2011** vs. 2012 |
| | Start & end age | Age 0 vs. **1** & 9+ |
| Fishery | Error in catch | CV = 0.05 |
| | Selectivity blocks | Four (Pre-1982, 1982-88; 1989-2004; 2005-2011) |
| | Selectivity at age | **Flat-topped** vs. Domed |
| Survey | Aggregate index | **Numbers** vs. biomass |
| | Bigelow/Albatross calibration | Estimated internally vs. **externally** |
| | Error in proportions at age | **Multinomial** vs. **Sqrt (p)** |
| | Weightings in OF | **Square of Sums** vs. **Sum of Squares** |
| | Selectivity at age | **Flat-topped** vs. Domed |
| Biology | Natural Mortality | **M = 0.2 vs M ramp** |

# Assessment Options

- Lack of consensus on which model should serve as basis for current stock status & management advice
  - Difference in support for models small & debated at length
- ‘Newly proposed model’ that of each lead scientist
  - ASAP: Proxy based RPs (1982 – present) & M = 0.2
  - SCAA: SR based RPs (1932 – present) & M ramp
- Support for & against SR data uncertainty & M developed
  - Similar to qualitative `Weight of Evidence’ approach of SAW 54; did not explicitly assign weight to each model

# Consequence Analysis

- Risks associated with 2013 – 2015 projections (at 75% $F_{MSY}$) under competing assumptions of state of nature
  - i.e. if true state is M = 0.2 & 1982 – present productivity, what are consequences of setting catch based on alternative (3) states of nature
- 2012 catch provided by NEFMC Groundfish PDT
- Projections only until 2015
  - Longer term consequences beyond current terms of reference

**Risk Assessment**

**Consequence = Stock Indicator in relation to Reference Point**

**Pr (consequence) = 50%**

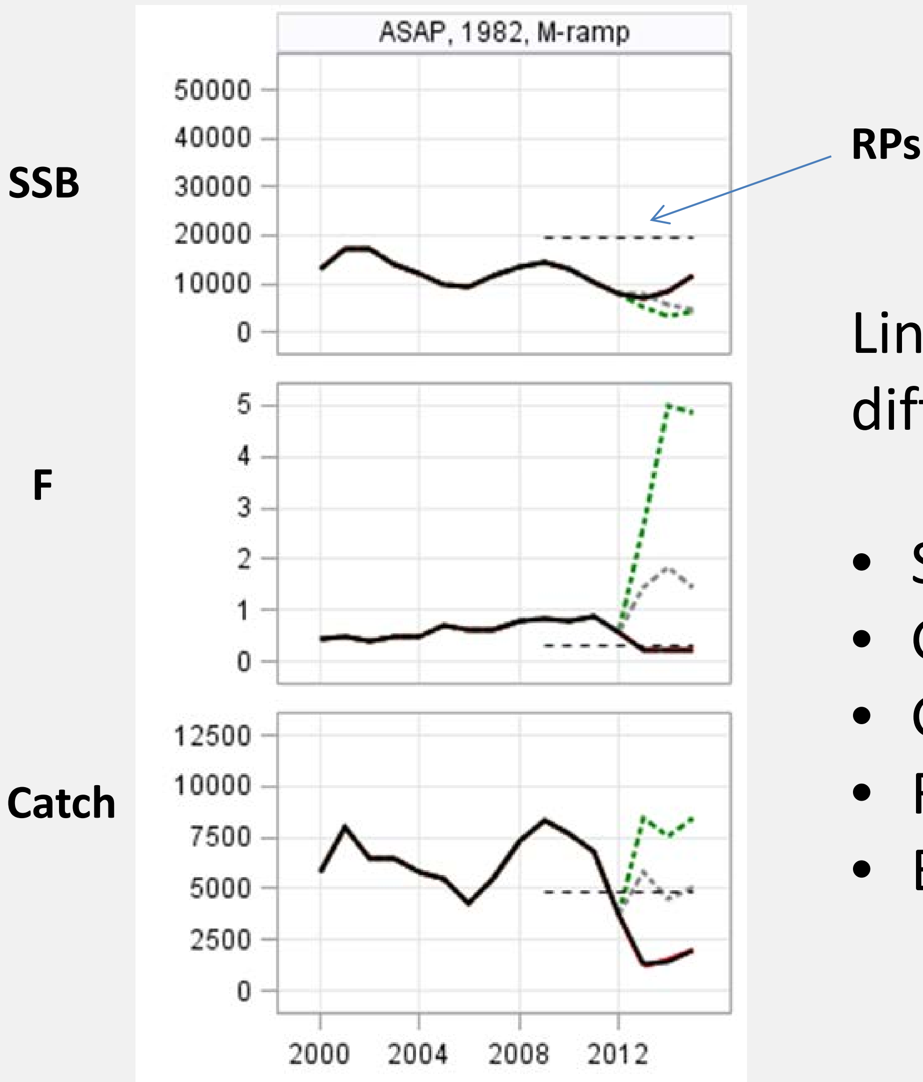
# Consequence Analysis

- 16 scenarios of SSB, F & Catch
- 'True State of Nature' x Basis of Management Action

| | | | True State of Nature | | | |
|---|---|---|---|---|---|---|
| | | | Proxy (1982+) | | Stock – Recruit (1932+) | |
| | | | M 0.2 | Mramp | M 0.2 | Mramp |
| Basis of Management Action | Proxy (1982+) | M 0.2 | Correct | Mis-spec | Mis-spec | Mis-spec |
| | | Mramp | Mis-spec. | Correct | Mis-spec | Mis-spec |
| | Stock – Recruit (1932+) | M 0.2 | Mis-spec | Mis-spec | Correct | |
| | | Mramp | Mis-spec | Mis-spec | Mis-spec | Correct |

# State of Nature x Management Action

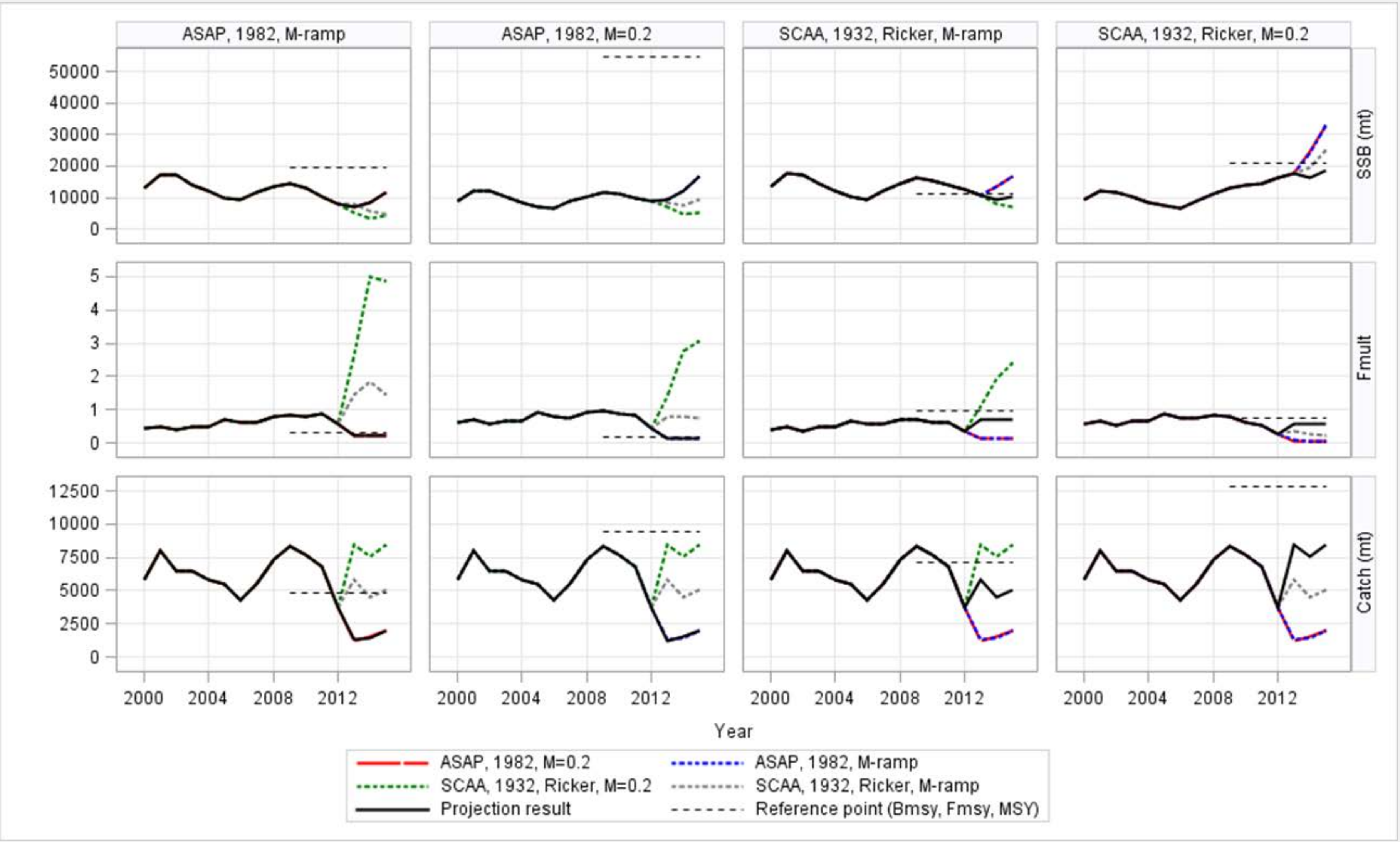
## State of Nature




Lines of stock Indicators under different states of nature

- Solid = 'True' state
- Green = SCAA & M = 0.2
- Grey = SCAA & M ramp
- Red = ASAP & M = 0.2
- Blue = ASAP & M ramp

# All States & Actions



# Summary of Consequences (Risks)

- Mis-specification of stock-recruit dynamics has greater implications for management actions during 2013 – 2015 than mis-specification of natural mortality

- Mis-specification of natural mortality inconsequential (short-term but not long-term) if stock-recruit dynamics conform to SPR considerations but are more of an issue when recruitment is based on SR function

# 2013 Status (Decision Table)

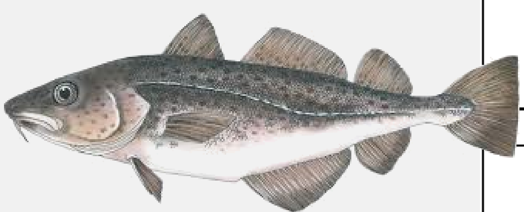
| | | | State of Nature | | | |
|---|---|---|---|---|---|---|
| | | | ASAP, 1982 start | | SCAA, 1932 start, Ricker | |
| | | | M=0.2 | M ramp | M=0.2 | M ramp |
| Basis of Management Action | ASAP, 1982 start | M=0.2 | Overfished, overfishing is not occuring | Overfished, overfishing is not occuring | Not overfished, overfishing is not occuring | Not overfished, overfishing is not occuring |
| | | M-ramp | Overfished, overfishing is not occuring | Overfished, overfishing is not occuring | Not overfished, overfishing is not occuring | Not overfished, overfishing is not occuring |
| | SCAA, 1932 start, Ricker | M=0.2 | Overfished, overfishing is occuring | Overfished, overfishing is occuring | Not overfished, overfishing is not occuring | Not overfished, overfishing is occuring |
| | | M-ramp | Overfished, overfishing is occuring | Overfished, overfishing is occuring | Not overfished, overfishing is not occuring | Not overfished, overfishing is not occuring |

# What did we learn?

- Management system not designed to address model uncertainty which can be large (Mohn, 2009: Fig 25.4)
- Consequence analysis informative to scientific community but not managers (communication issue)
  - Need better means & tools to communicate Risk

# Eastern Georges Bank Cod

- A consequence analysis was communicated to managers for from two models with different natural mortality of the oldest age.

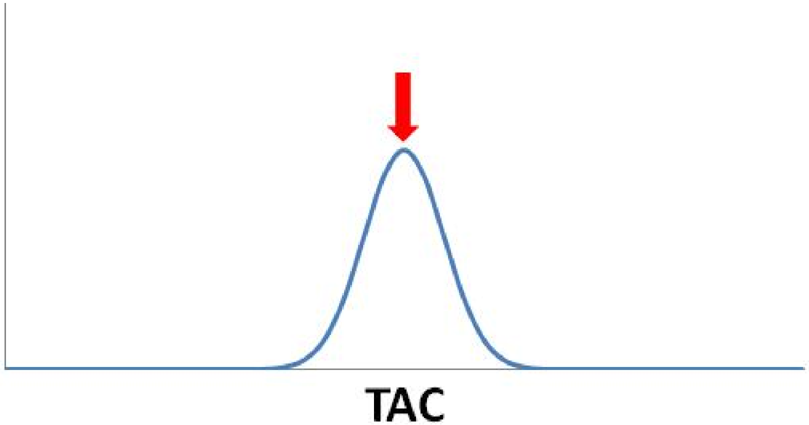


| | | VPA 0.8 | ASAP |
|---|---|---|---|
| Catch 2012 | | 613 mt | 613 mt |
| quota 2013 | | 600 mt | 600 mt |
| 2012 biomass (3+) | | 7700 mt | 2091 mt |
| 2013 biomass (3+) | | 11160 mt | |
| **Projected Catch** | | | |
| **2028 mt** | 2014 F | 0.18 | 0.75 |
| (VPA F=0.18) | 2015 Biomass | 13314 | 3328 |
| | % inc B from 2014 | 0.4% | -20.2% |
| | | | |
| **1225 mt** | 2014 F | 0.11 | 0.40 |
| (VPA F=0.11) | 2015 Biomass | 14018 | 4153 |
| | % inc B from 2014 | 6% | -0.42% |
| | | | |
| **601 mt** | 2014 F | 0.05 | 0.18 |
| (ASAP F=0.18) | 2015 Biomass | 14646 | 4794 |
| | % inc B from 2014 | 10.0% | 15.0% |
| | | | |
| **378 mt** | 2014 F | 0.03 | 0.11 |
| (ASAP F=0.11) | 2015 Biomass | 14858 | 5029 |
| | % inc B from 2014 | 12% | 20.6% |
| | F<=Fref and a 10% biomass increase in 2015 | | |
| | F< =Fref and biomass increase less than 10% in 2015 | | |
| | F>Fref and biomass increase less than 10% in 2015 | | |
| | not feasible projection | | |

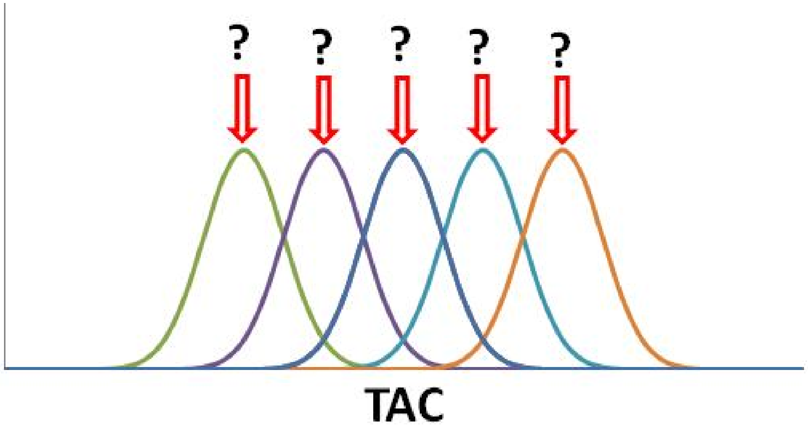
TRAC 2013

# Considering Multiple Models

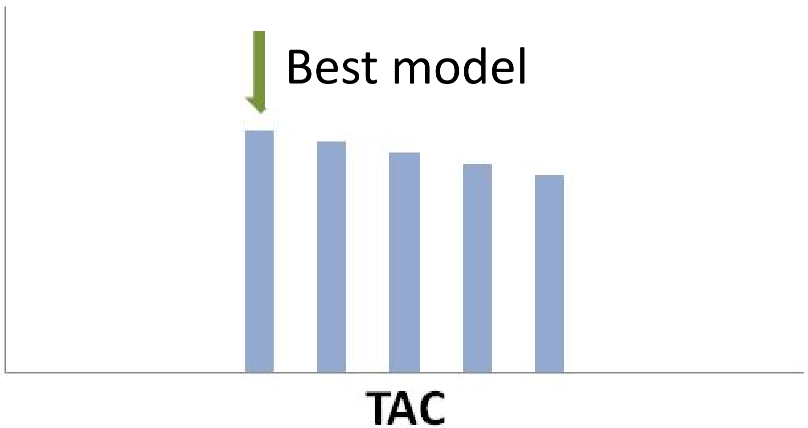
## Single assessment



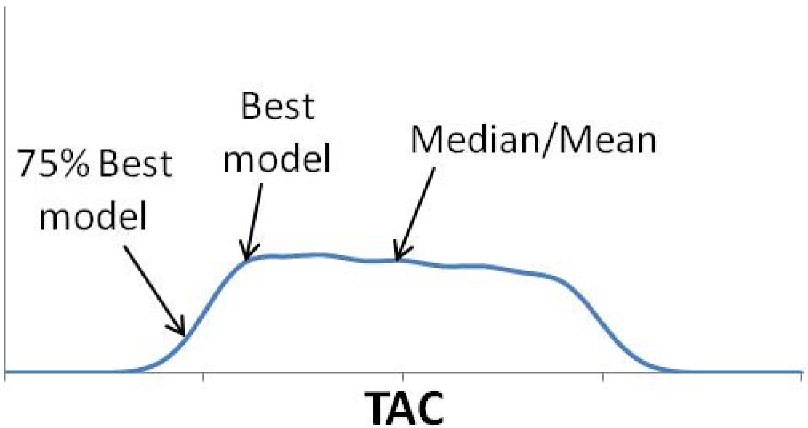

## Multiple competing models




## Relative weights




## OFL probability distribution




Butterworth 2013

# PRINCIPLE:

Model averaging (sensu Burnham & Anderson) can give more reliable estimates and **larger** estimated standard errors than unimodel estimates: the estimated standard errors are larger because they are **more realistic**

Caveats:

(a) Set of models is chosen a priori based on biological intuition
(b) Models

Caveats for model averaging:

(a) Set of models is chosen *a priori* based on biological intuition

(b) Models are rejected before model averaging if diagnostics show problems.

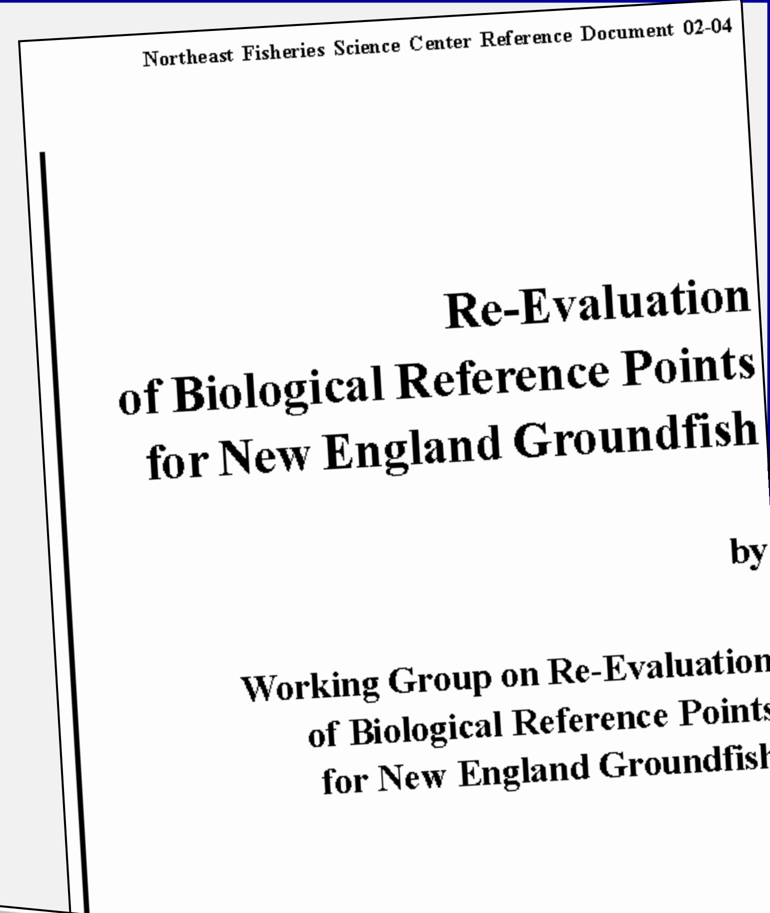
Given (a) & (b), a weighted average is computed

# 4) SSC catch recommendations should be:

| Lower when | Higher when |
|---|---|
| Models imprecise or have problems | Models precise/no problems |
| Little/dependent corroboration | Much, independent corroboration |
| Models are in strong conflict | Models largely agre |
| Biomass could be low | Biomass appears high |
| Updated information not timely | Rapid updating of information |

# Adaptive Management

- The resource response to management decisions should be monitored when:
  - There are multiple plausible state of nature (e.g., SNE yellowtail, cod), or
  - Reference points are uncertain, but the direction of management is more certain (New England groundfish; NEFSC 2002, Brodziak et al. 2008).
- Operating models with different states of nature can be used for Management Strategy Evaluation


Northeast Fisheries Science Center Reference Document 02-04

Re-Evaluation
of Biological Reference Points
for New England Groundfish

by

Working Group on Re-Evaluation
of Biological Reference Points
for New England Groundfish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Goals and strategies for rebuilding New England groundfish stocks

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ABSTRACT

Rebuilding depleted fishery resources is a worldwide problem. In the U.S., the Ma
Conservation and Management Reauthorization Act (MSRA) of 2007 requires that "
agement measures shall prevent overfishing while achieving, on a continuing ba
from each fishery...". However, translating this legal mandate into tangible goal
several technical challenges, especially for resources that have been chronically
ple, maximum sustainable yields and biomass

- Scientists should make scientific decisions, and managers should make policy decisions, but reference points and uncertainty buffers often have scientific and policy aspects.
  - An active and iterative feedback loop between science and management will help to coordinate scientific and policy decisions.
  - The Fishery Management Council should clearly define objectives to scientists, including factors to consider in optimum yield (e.g., social, economic, ecological) and risk tolerance in the short-term and long-term.
  - Scientists should effectively communicate the basis of a catch recommendation (without jargon), including plausible scenarios considered in the determination of the recommendation, and their relative plausibility.