

*Science, Service, Stewardship*



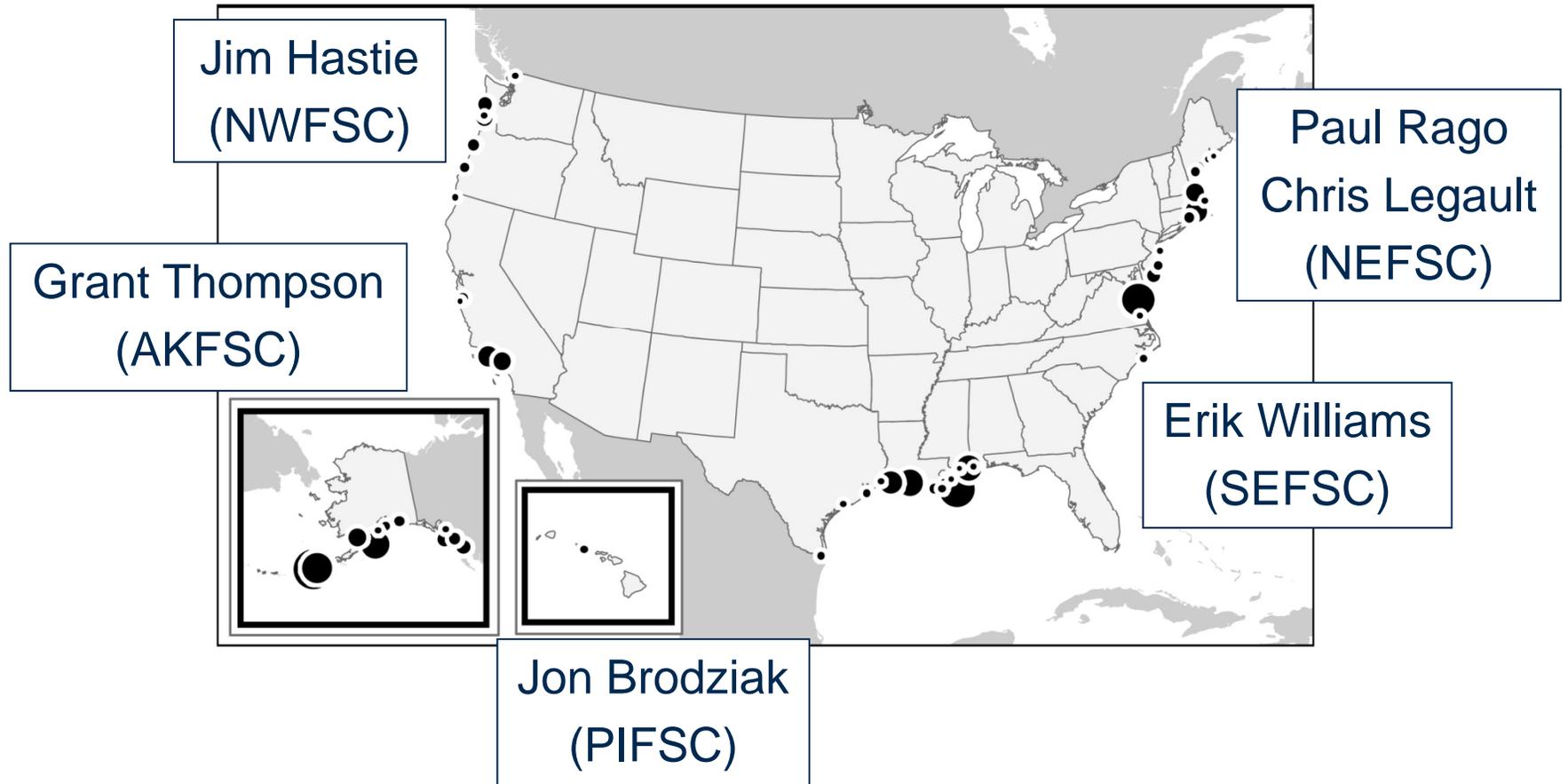
# ACL Science Workshop: Quantifying Uncertainty in Forecasts

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**NOAA  
FISHERIES  
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# Team Members



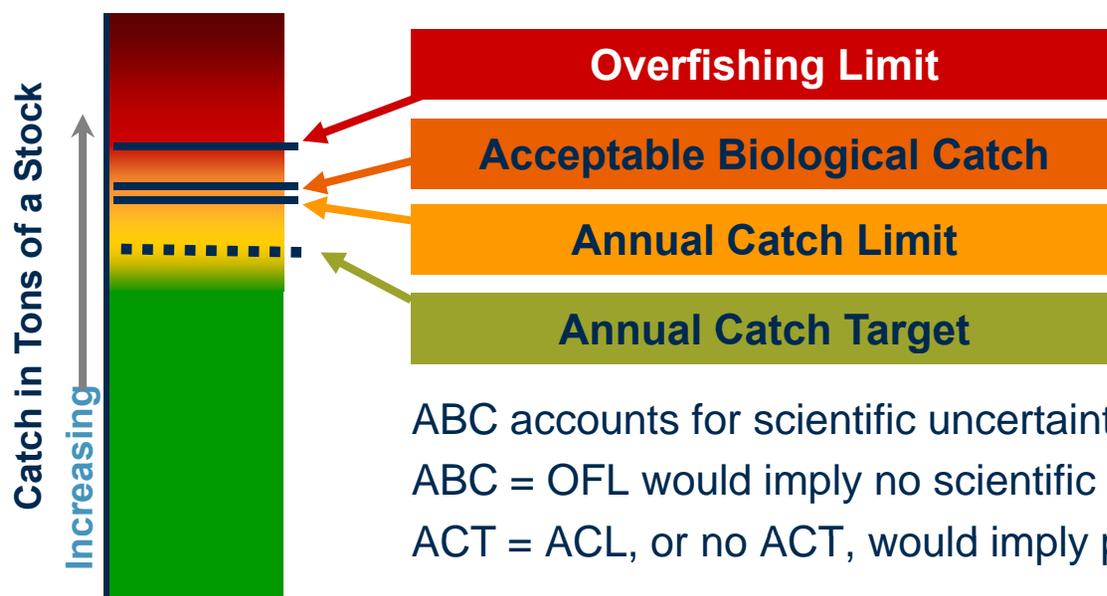
# Outline

- Role of uncertainty and forecasting in setting ACLs
- Uncertainty
- Forecasting
- Uncertainty and Forecasting Improvements
- Communicating the Science
- Benefits of Improvements

# Role of Uncertainty and Forecasting in determining ACL's

**OFL** should not account for precaution, but does have uncertainty  
— should correspond to long-term MSY

↑**Uncertainty** leads to ↑**Precaution** leads to ↑**Buffer** and ↓**ACL/ACT**  
— Tolerance for risk is an important part of this



ABC accounts for scientific uncertainty in estimating the true OFL  
ABC = OFL would imply no scientific uncertainty  
ACT = ACL, or no ACT, would imply perfect control of catch

## “OFL should not account for precaution”— What does this mean?

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- **In the context of assessments for which sufficient data exist to support statistical estimation, specification of OFL is based on a point estimate, which in turn is based on three choices:**
  1. Choice of model
  2. Choice of data
  3. Choice of estimator
- **The process of making each of these choices may involve many factors, some or all of which may have implications for the resulting point estimate of OFL**
- **However, the likely impact on the resulting point estimate of OFL should not be included among these factors**
  - E.g., do not choose a model *because* of the resulting OFL estimate
- **The above choices, along with the final estimate of OFL, should be subject to an open and transparent scientific review process**

# Some Major Sources of Uncertainty For Stock Assessment and Management Advice Processes

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## Determination of ABC

- Model Uncertainty/Structural Complexity
- Estimation Error
- Sampling/Observation Error
- Random Natural Variability/Process Error

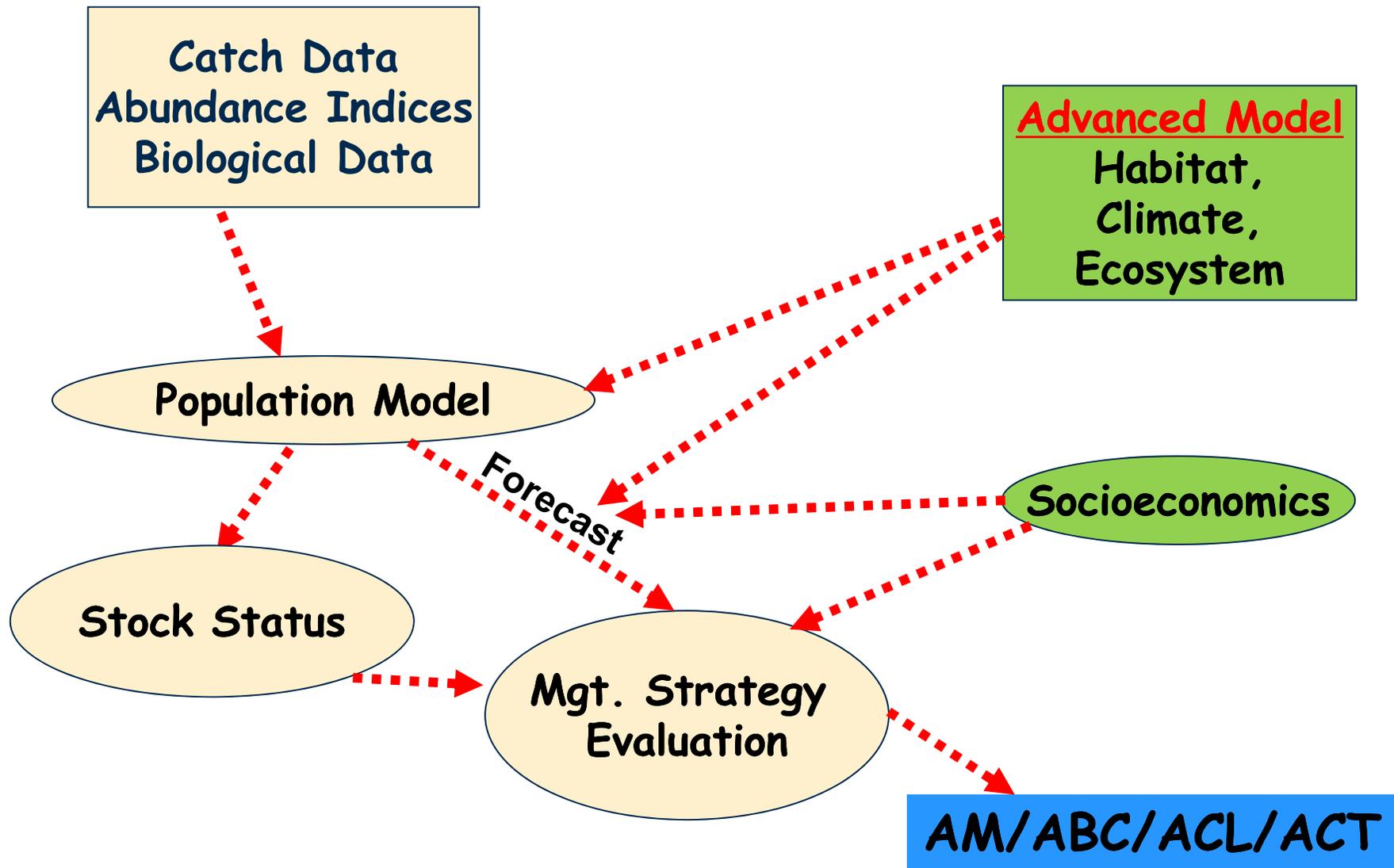
## Determination of ACL/ACT

- Implementation Uncertainty
- Inadequate Communication

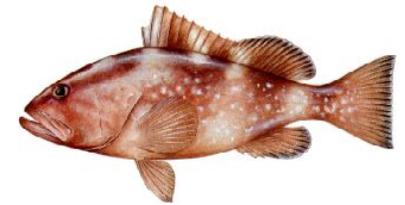
*"To know one's ignorance is the best part of knowledge"*

~ Lao Tzu, Tao-te Ching, no. 71

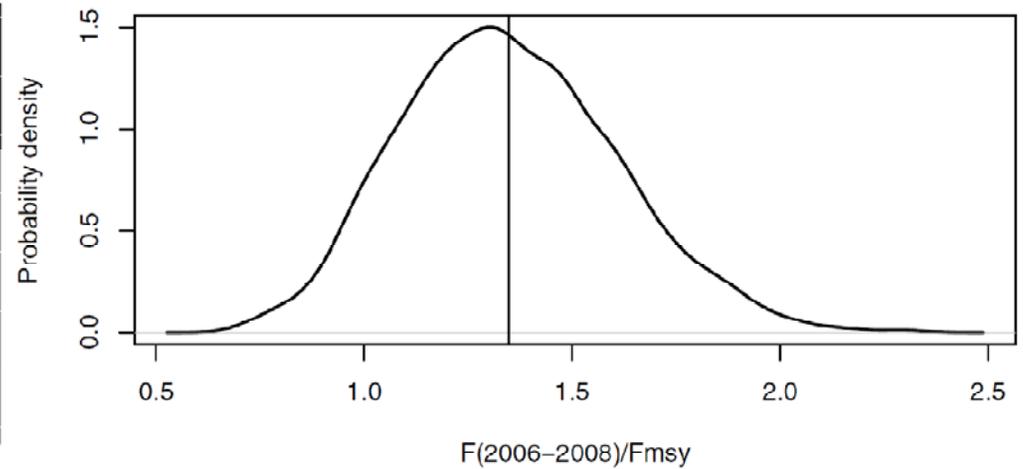
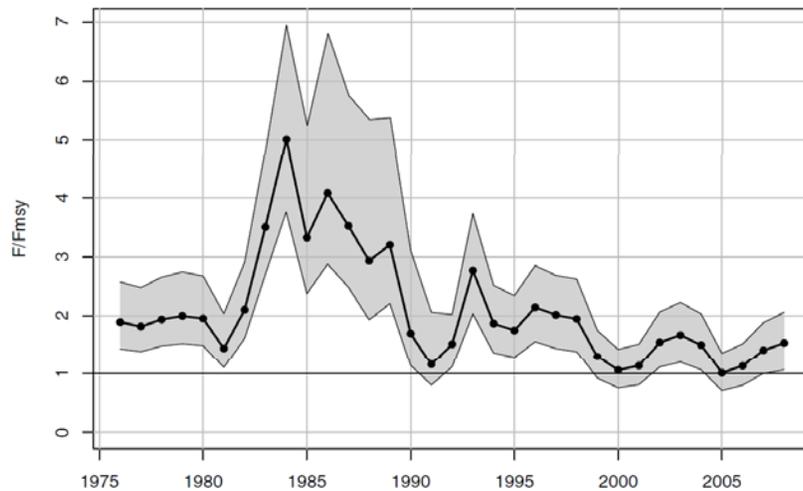
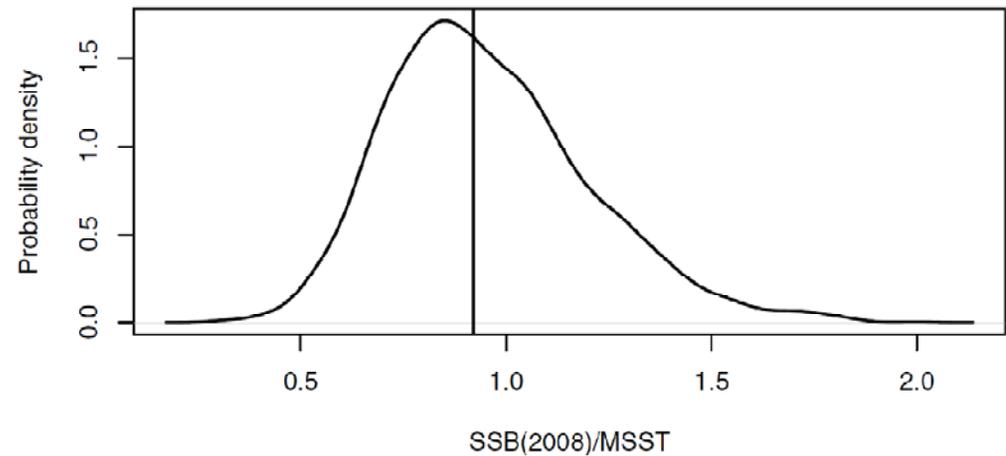
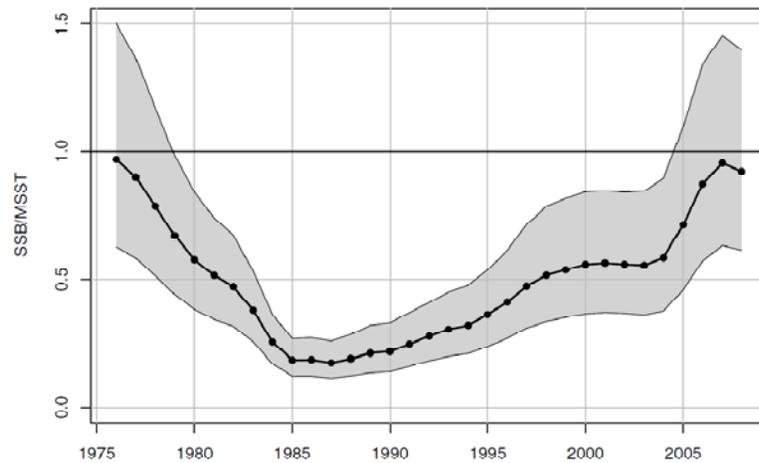
# Stock Assessment and Management Strategy Evaluation Process



# Uncertainty – current practices

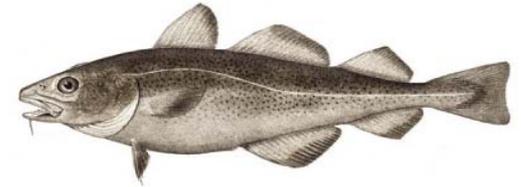


## Ex: SA red grouper

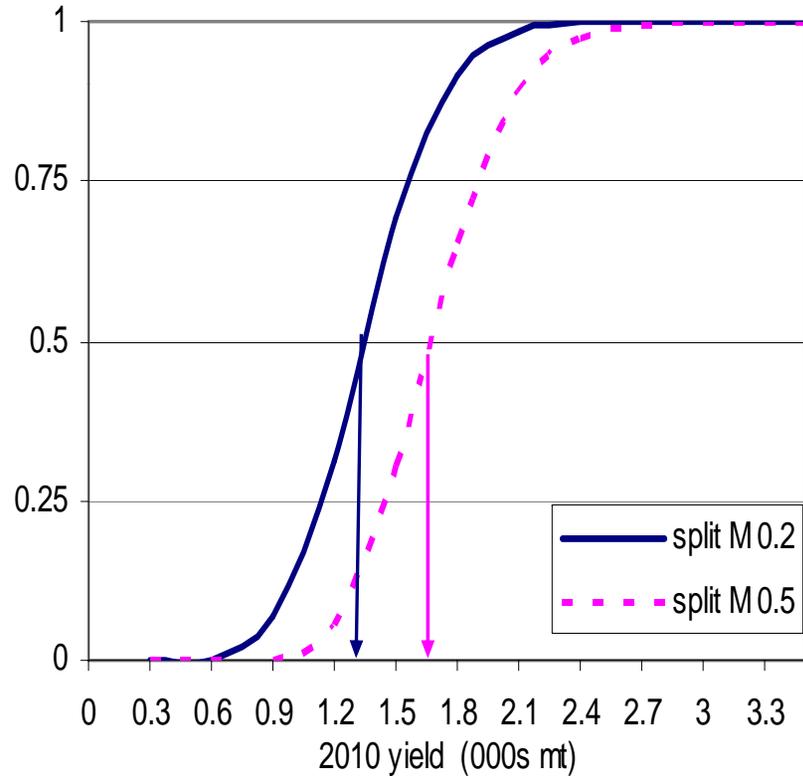


# Uncertainty – current practices

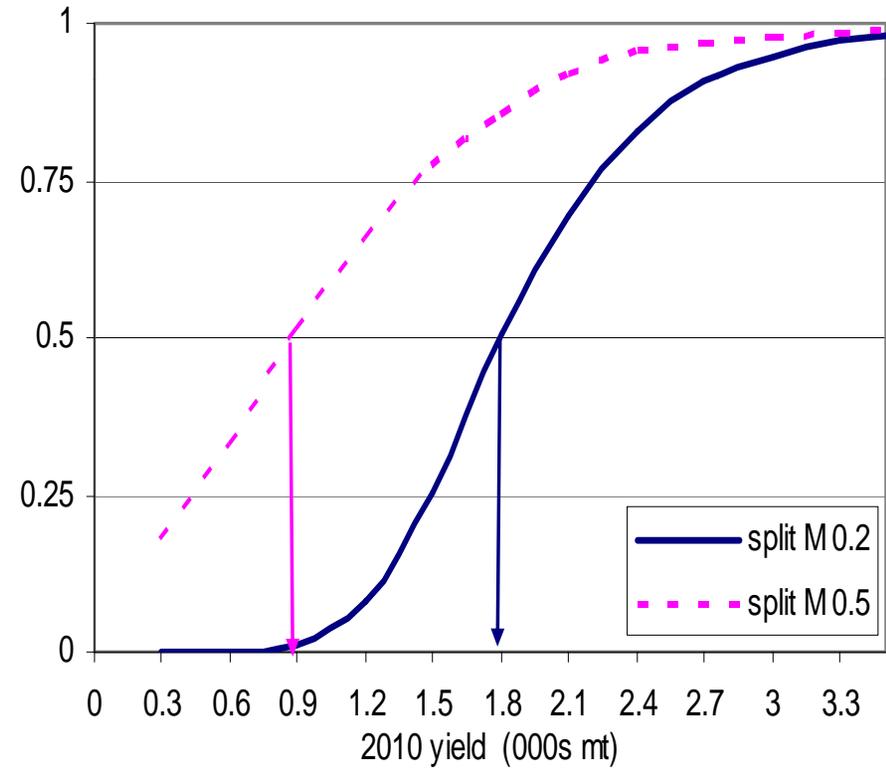
## Ex: Eastern Georges Bank Cod



Probability  $F_{2010}$  greater than  $F_{ref}=0.18$



Probability  $B_{2011}$  at age 4+ will not increase



# ACLs and Uncertainty – current practices

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- $P^*$  analysis is one way to formalize this, but it only focuses on a single metric, probability of overfishing
  - management may desire other metrics (e.g. bycatch, economic yield, ecosystem measures, etc.)
- Flat rates (e.g.  $ACL = 75\% F_{msy}$ )
  - implies a variable risk tolerance
- Use of decision theory, where ACL is set at a value that minimizes risk (= expected loss) under some positive level of risk aversion

# Forecasting

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**Forecasts are processes by which hypothetical control rules are translated into practical regulations**

Considerations:

- Current state of the resource
- Desired goal or state of the resource
- Time frame
- Feasible control measures
- Model of resource dynamics

# Forecasting – current practices

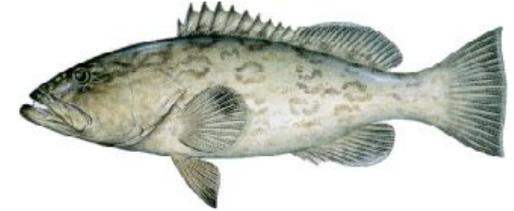
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## **Common models/methods currently in use**

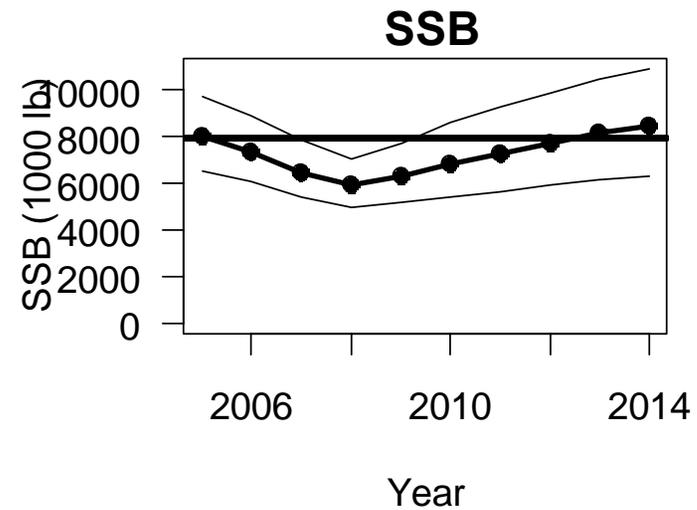
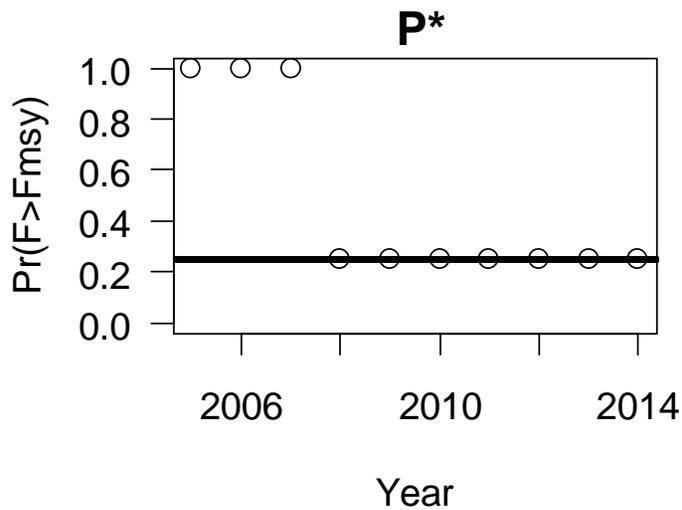
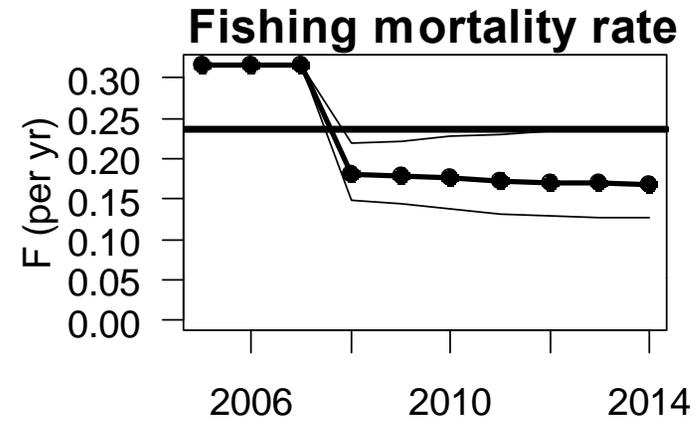
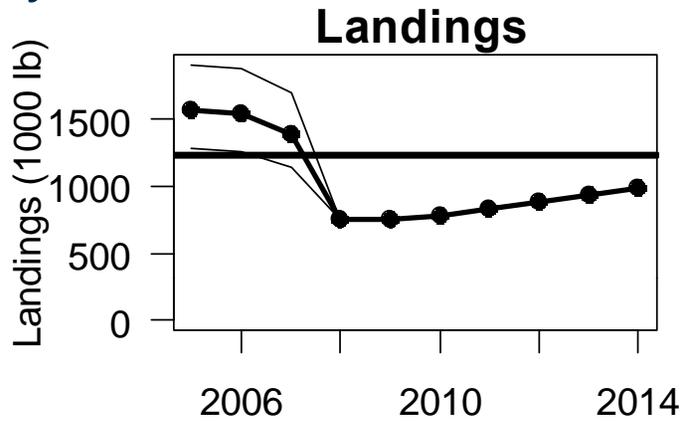
- Stochastic short term and long term projections using a constant/variable fishing mortality rate or landings
  - Model stochasticity and complexity may be too limited
- Incorporating management feedback, implementation uncertainty
  - Need for increased communications to prevent management and models from diverging
- Technical interactions
  - Caps on aggregate TACs (ACTs) across species
  - Fishery closures due to incidental catch caps
  - Fishery closures due to incidental catches of another species
- Ecosystem dynamics

# Forecasting

Ex: gag grouper



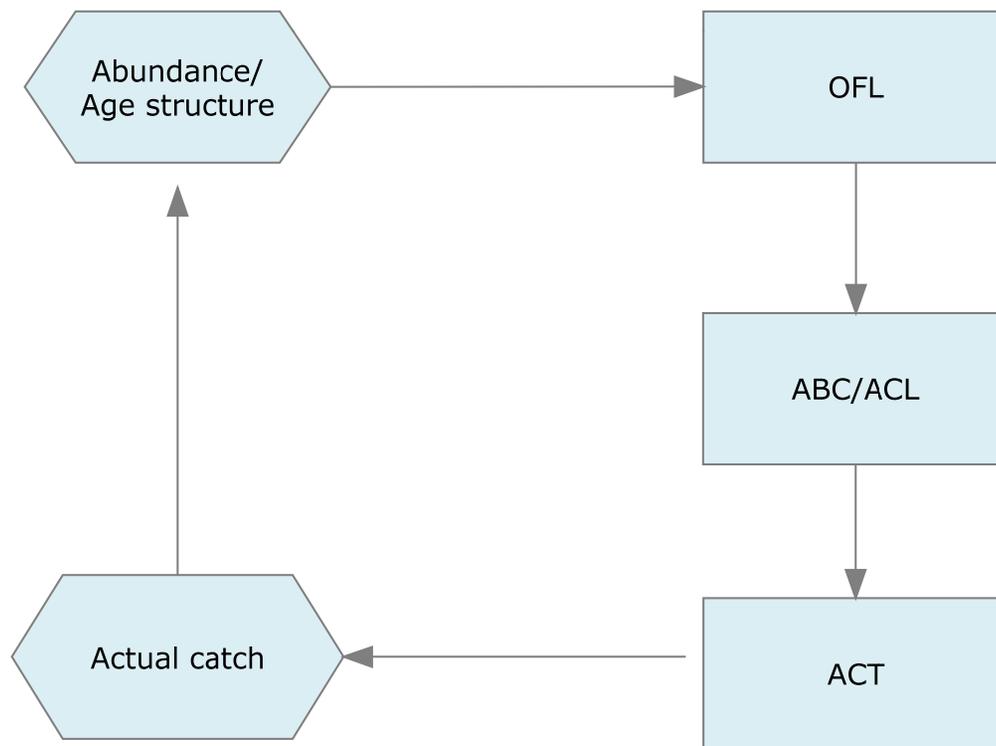
## P\* analysis



# Forecasting

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- Setting catch levels for multiple years requires a projection model, because of feedback among catch levels and the stock
- Second year and beyond ABCs should not be set without explicit consideration of ACTs



# Uncertainty and Forecasting Improvements

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- **Improved Data Collection (both timeliness and types)**
  - Increase sample sizes of input data
  - New data sources
  - New surveys (e.g. fishery independent monitoring, recreational surveys)
  - More timely data could improve forecasting
  
- **Improved Monitoring of the Fishery System**
  - Realize unaccounted uncertainty
  - Better understanding of what works and what doesn't

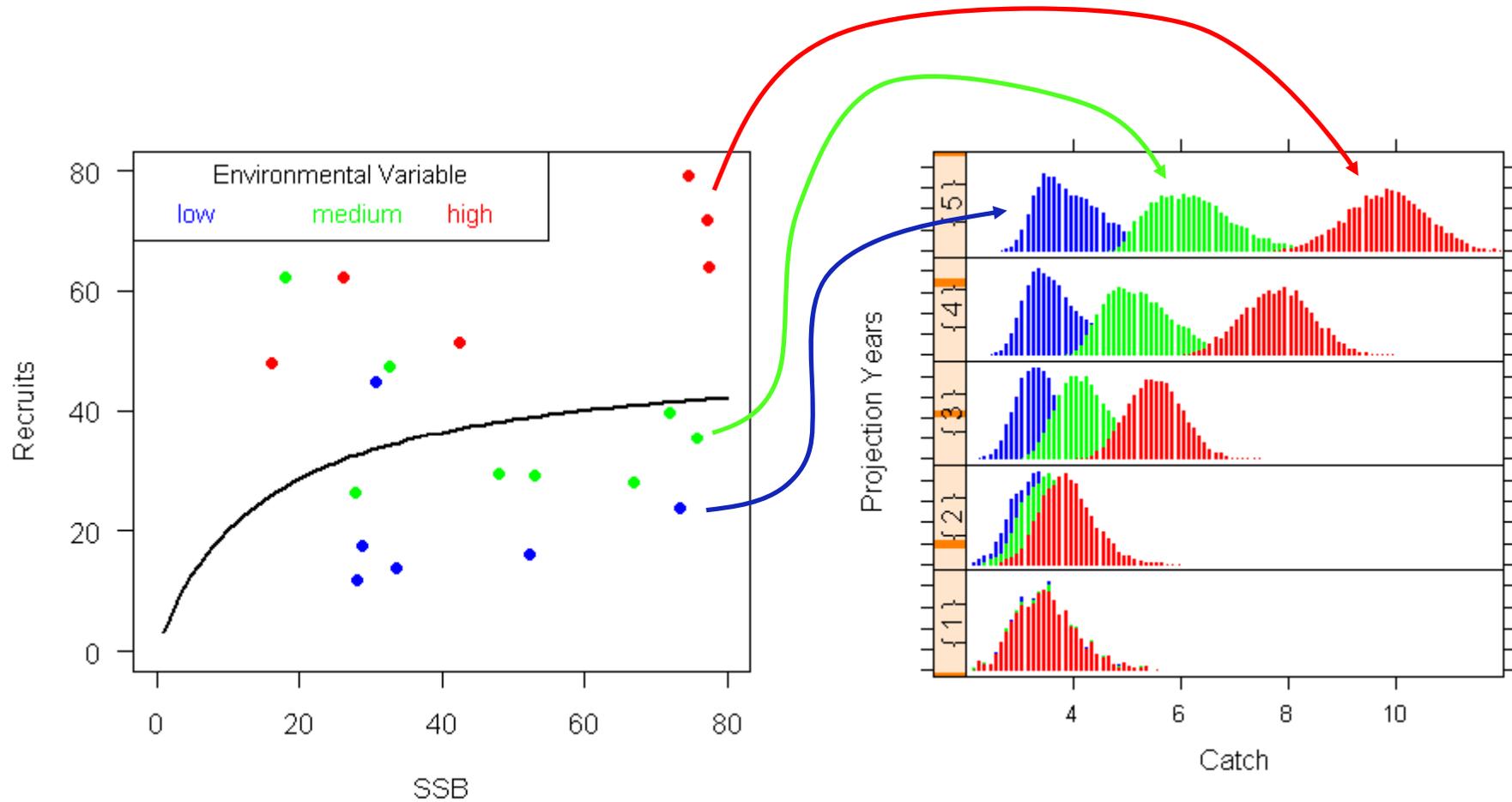
# Uncertainty and Forecasting Improvements

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## Modeling Improvements

- Use model ensembles
- Improved predictive accuracy from more realistic models
- Improved use of environmental linkages
- Improved use of socio-economic linkages (e.g. fleet behavior)
- Improved accounting for interactions with other fisheries in the multi-species complex (e.g. bycatch quotas for other species)
- Improved treatment of uncertainty in parameter values

# Incorporating Environmental Signals into Recruitment and Catch Forecasts



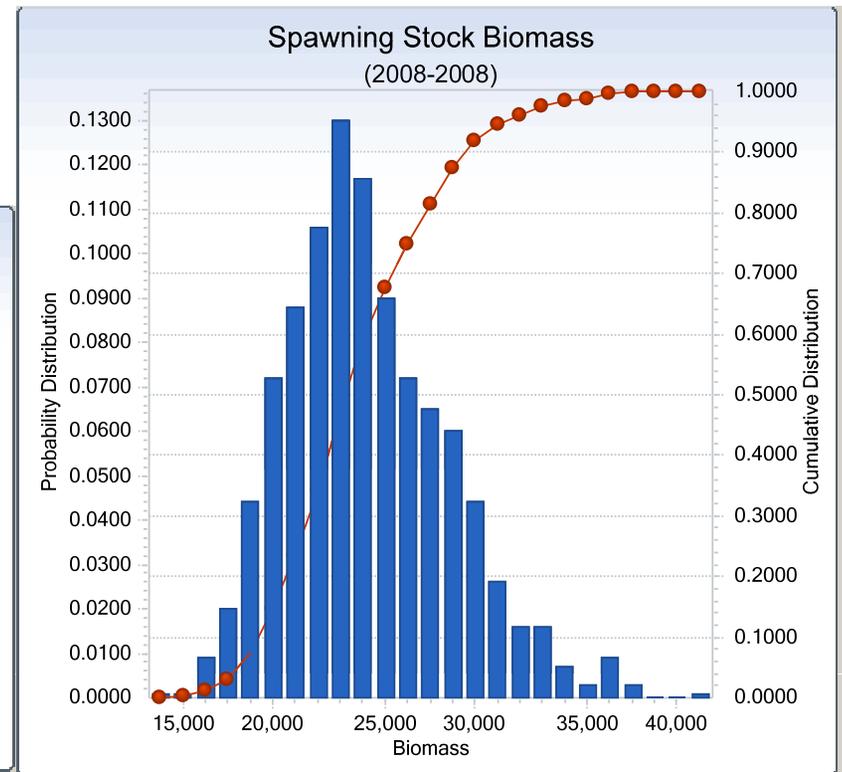
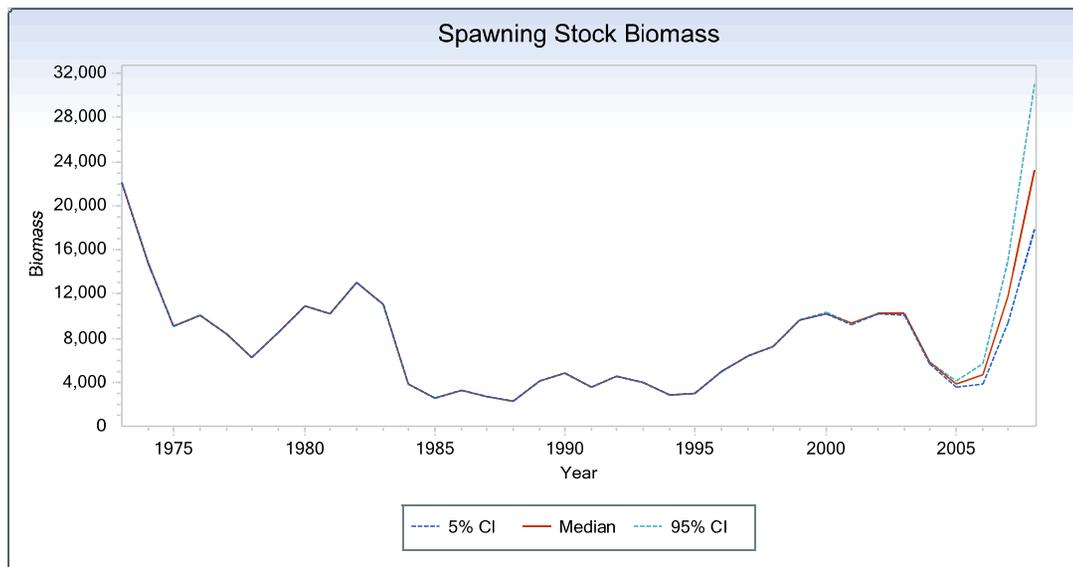
# Uncertainty and Forecasting Improvements

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- **Move beyond just probabilities**
  - More explicit about consequences
  - Trade-offs
- **Understanding the limits to reducing uncertainty**
- **Communicating uncertainty**

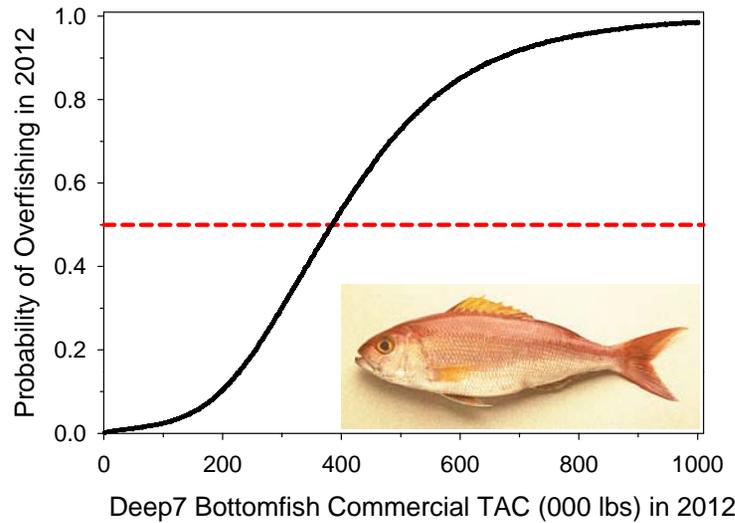
# Communicating the Science

- Time series plots with confidence intervals
- Probability density curves of current estimates
- Risk plots
- Multiple Models
- Multivariate benefit streams

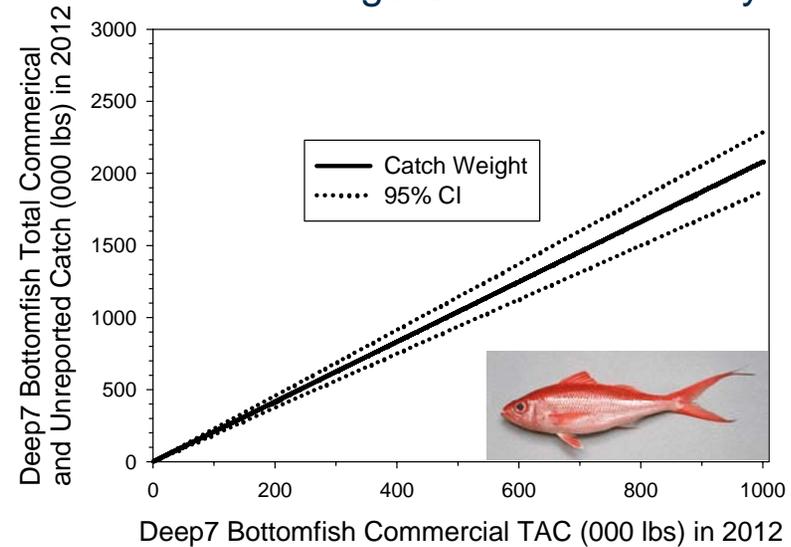


# Ex: Multivariate Benefit Streams for Forecasts - Hawaii Bottomfish

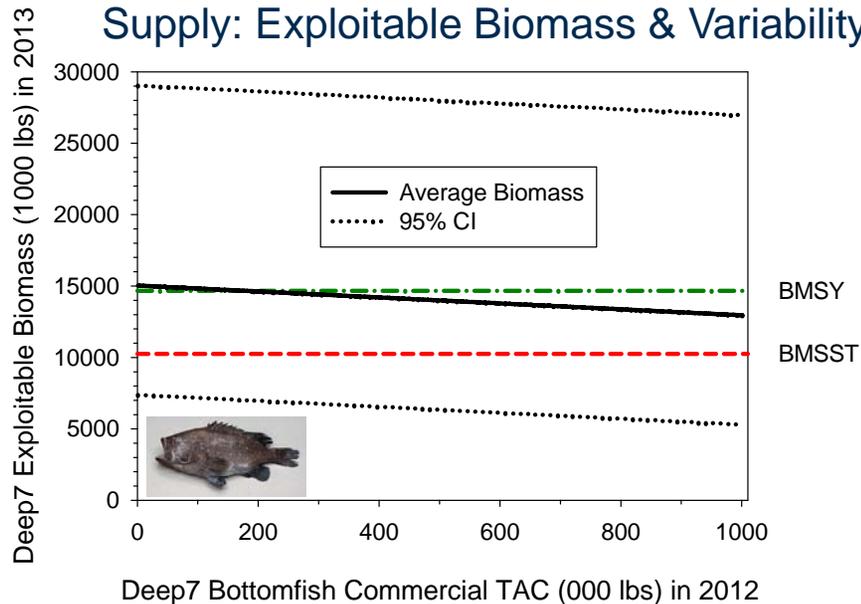
### Status: Probability of Overfishing



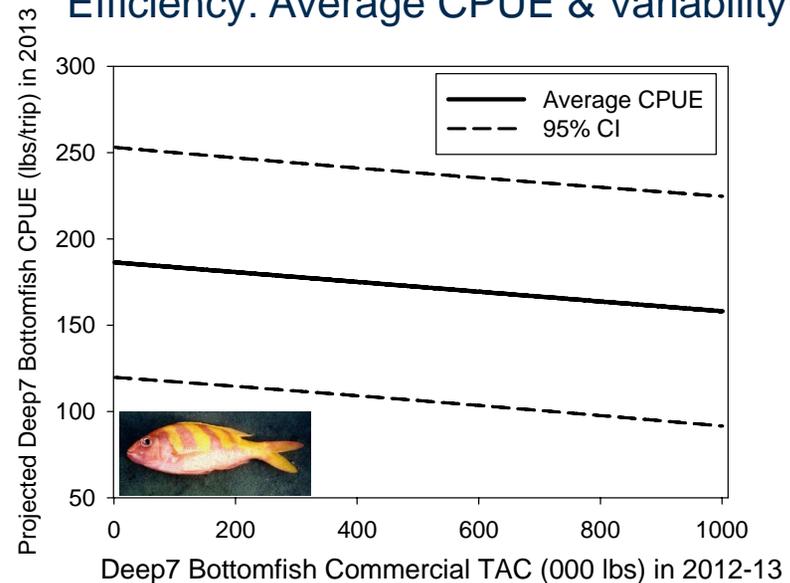
### Yield: Average Catch & Variability



### Supply: Exploitable Biomass & Variability



### Efficiency: Average CPUE & Variability



# Communicating

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- Our goal is to provide managers with a clear and complete description of all the “important” uncertainties and trade-offs involved in setting an ACL/ACT.
- “Important” is a relative term. Each region will have its own list of uncertainties and trade-offs to consider.
- This will require scientists, economists, and managers to communicate with each other in order to avoid miscommunications or decisions based on incomplete information.

# Benefits of Improvements

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- “Bang for the buck” analysis of data collection systems
  - ✓ Targeted data collection to reduce uncertainty which could lead to increased ACLs.
- Further monitoring of fishery system will help to reveal more effective management measures.
- Non-quantified sources of uncertainty may eventually be quantified, through long term monitoring.
- Better communications between managers and scientists will increase efficiency and timeliness.

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**Questions?**