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Implementation of Monte-Carlo Bootstrap Ensembles to Assess Uncertainty and Provide Management Advice

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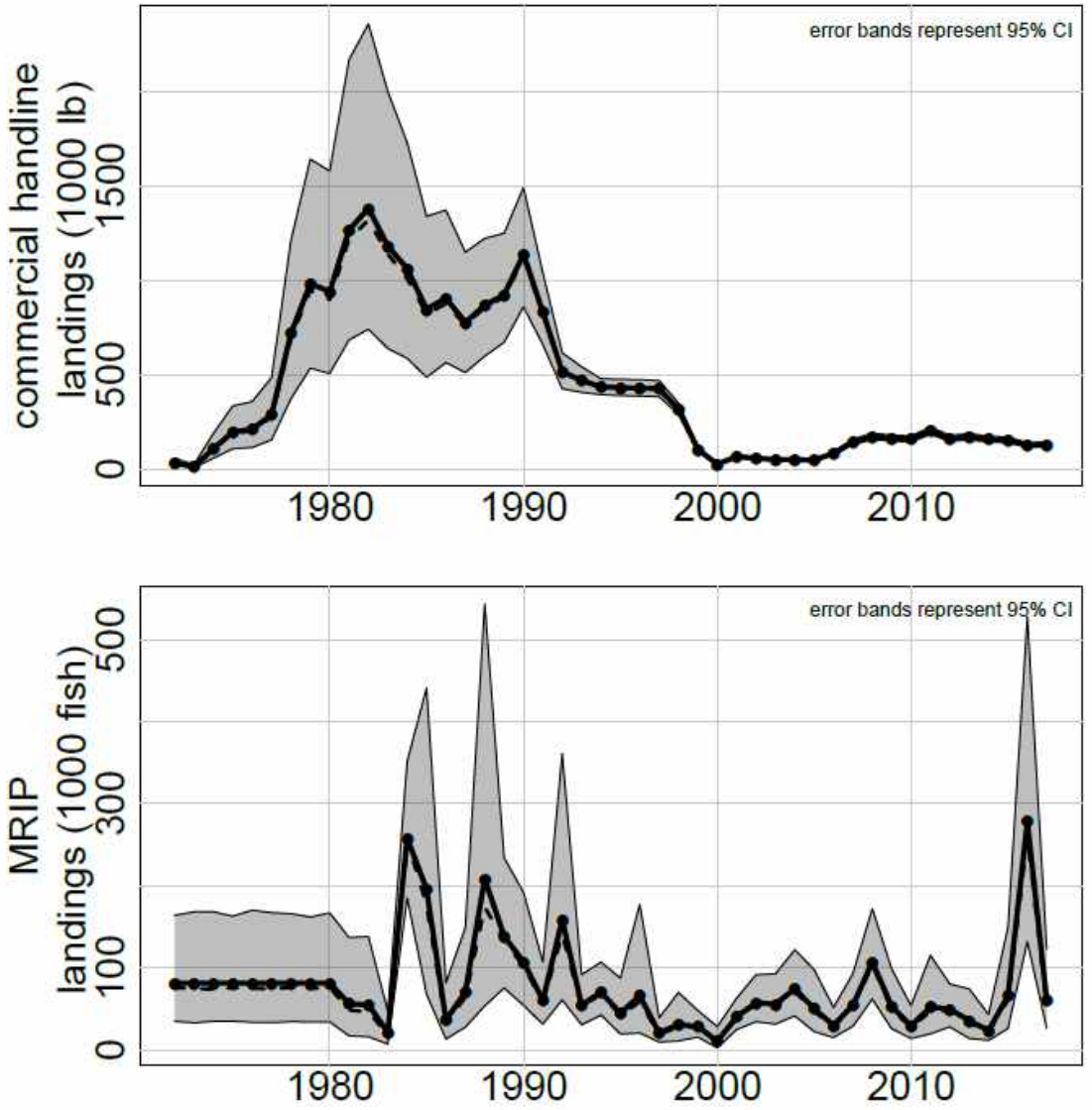
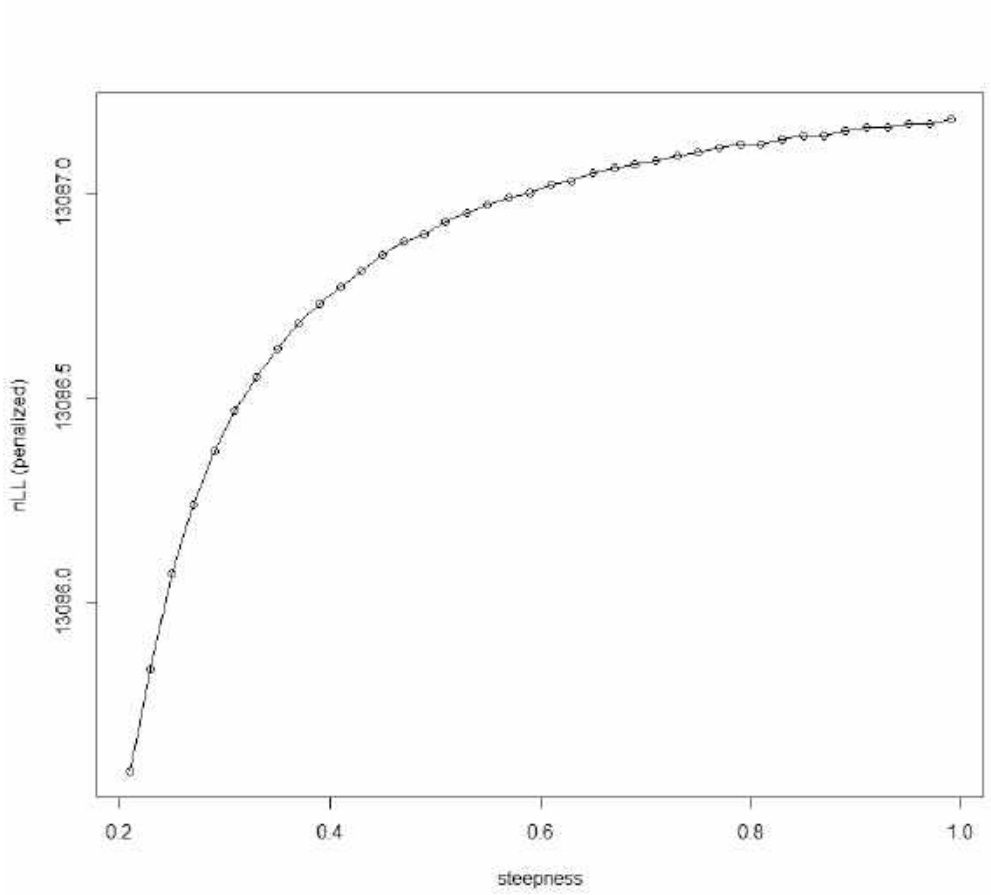
Data Uncertainty for SE Atlantic Fisheries

- Many species in the region are recreationally harvested
- Large uncertainty often present in:
  - recreational harvest
  - historical commercial landings
  - fishery independent surveys
- Recreational harvest includes discards of fish
  - Discard mortality is not well understood for most species
- Moderate to small sample sizes of age and length compositions



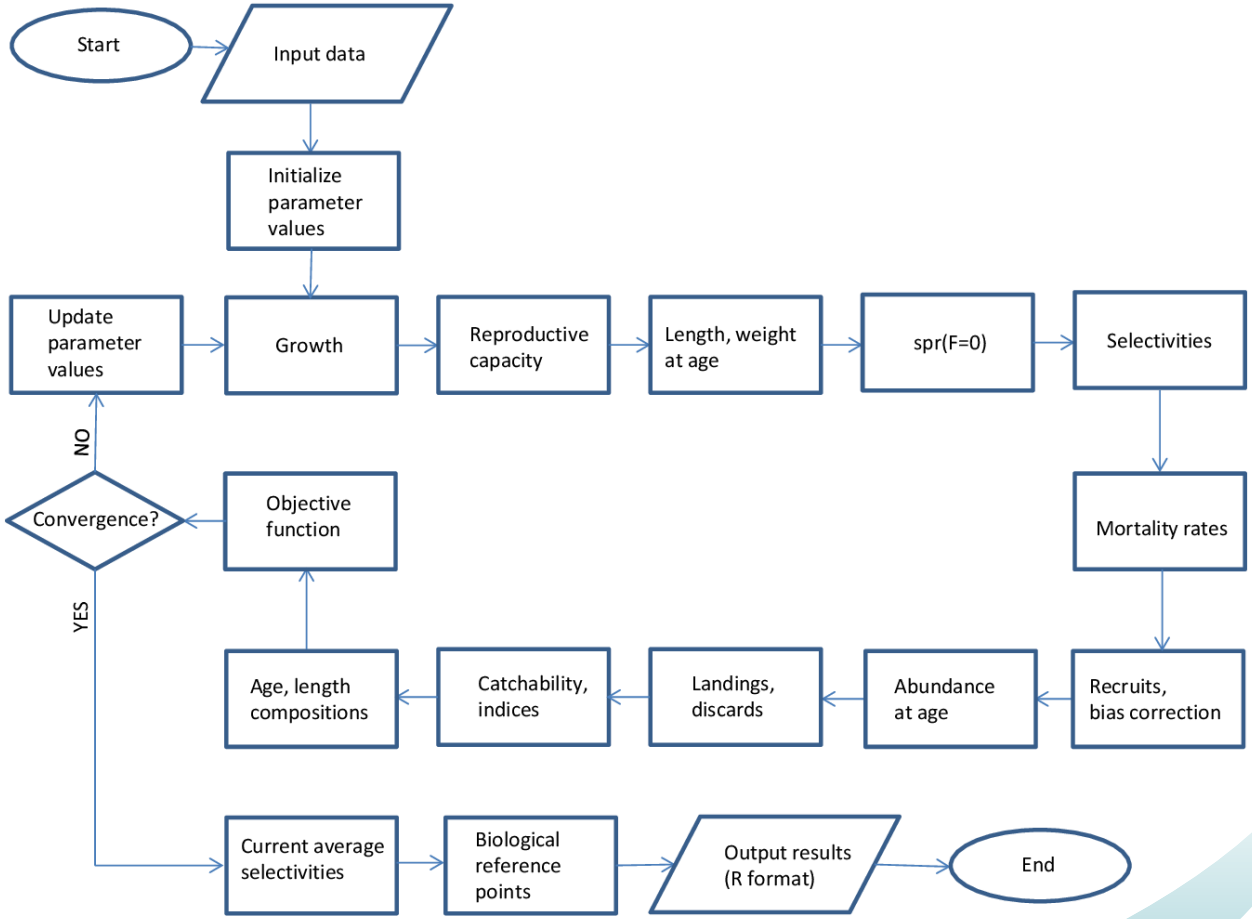
Parameter uncertainties in SE Atlantic stock assessments

- Few species with estimates of natural mortality or sufficient age composition samples to estimate M
- Estimation of steepness difficult due to flat likelihood profiles
- These parameters have large impact on status estimates



Stock Assessments in the SE Atlantic

- Conducted using Beaufort Assessment Model (BAM)
- A generalized statistical catch age model in ADMB
- Bespoke by species
- Typically runs in a few minutes



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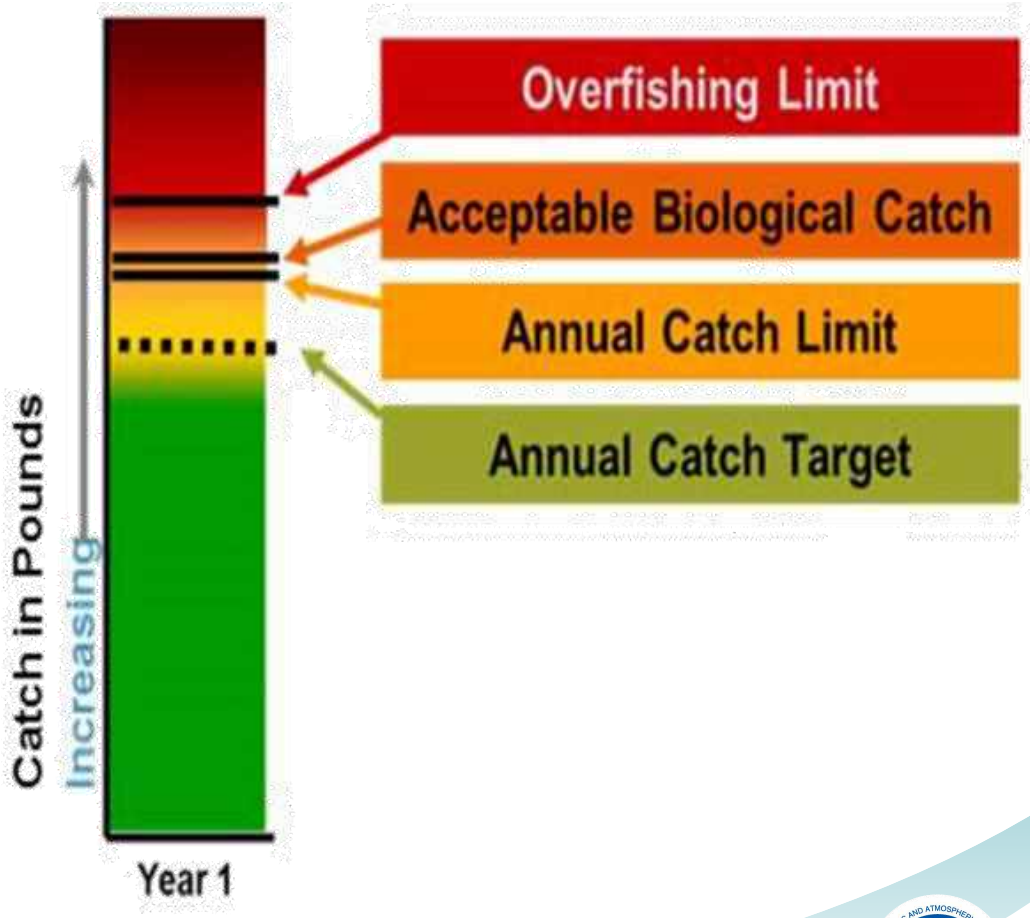
Management Limits in SE

- Overfishing limit (OFL) is determined based on output of assessments - usually MSY based
- Acceptable biological catch (ABC) is the OFL reduced by an amount associated with scientific uncertainty
- Annual Catch Limit and Catch Targets may be further reduced if other concerns suggest additional precaution



P-Star Approach

- Two step approach intended for use with formal stock assessments
- The scientific and statistical committee (SSC) assigns the amount of scientific uncertainty in the stock assessment (P*)
  - Determined from available information about species, data quality, etc.
- The P* is applied to the F_{MSY} in projections used by managers

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Main steps in current Monte Carlo/ Bootstrap Ensemble (MCBE) implementation

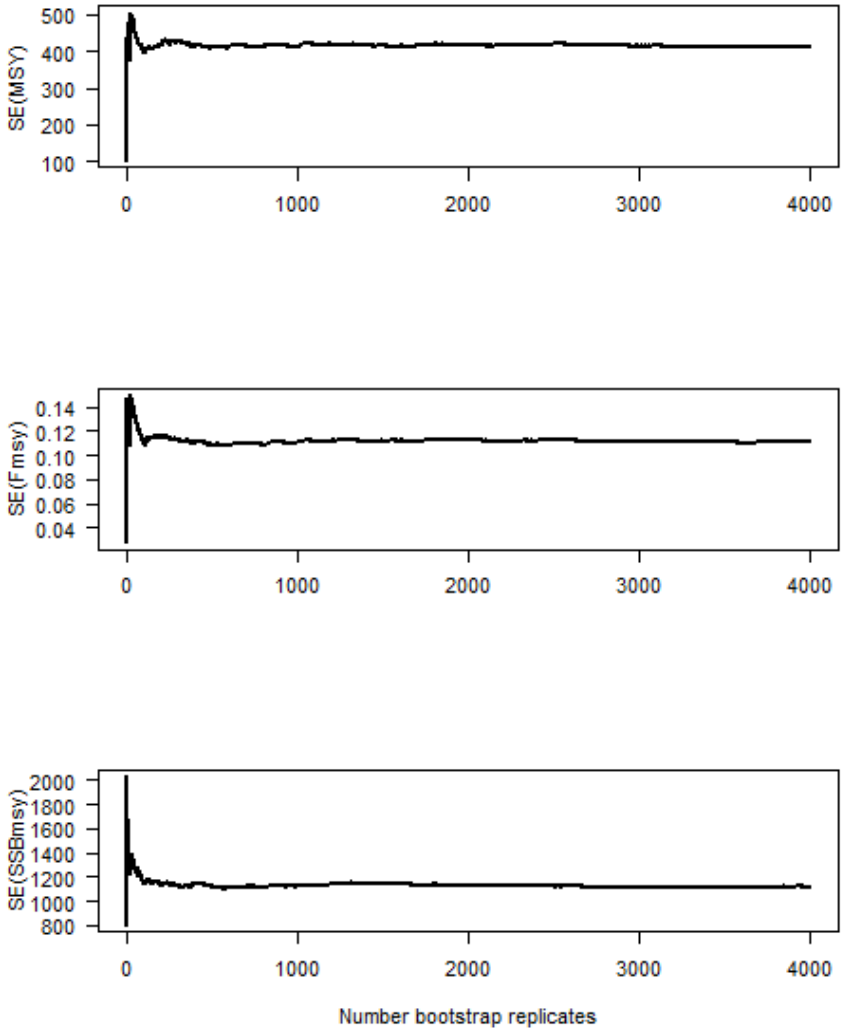
1. Create reference model
2. Monte Carlo/Bootstrap data sources and parameters
3. Refit models
4. Summarize output from models as distributions of management quantities

Monte Carlo Bootstrap Ensemble (MCBE)

- Resample various components of input data
  - Landings, indices, and discards sampled from lognormal distributions
  - Resample length and age compositions from multinomial distribution with sample sizes as the number of fish collected and observed proportions
- Incorporate uncertainty in fixed parameters
  - Sample values for mean M, discard mortality, and steepness
  - Typically a uniform or normal distribution
- Typically around 4000 models are attempted

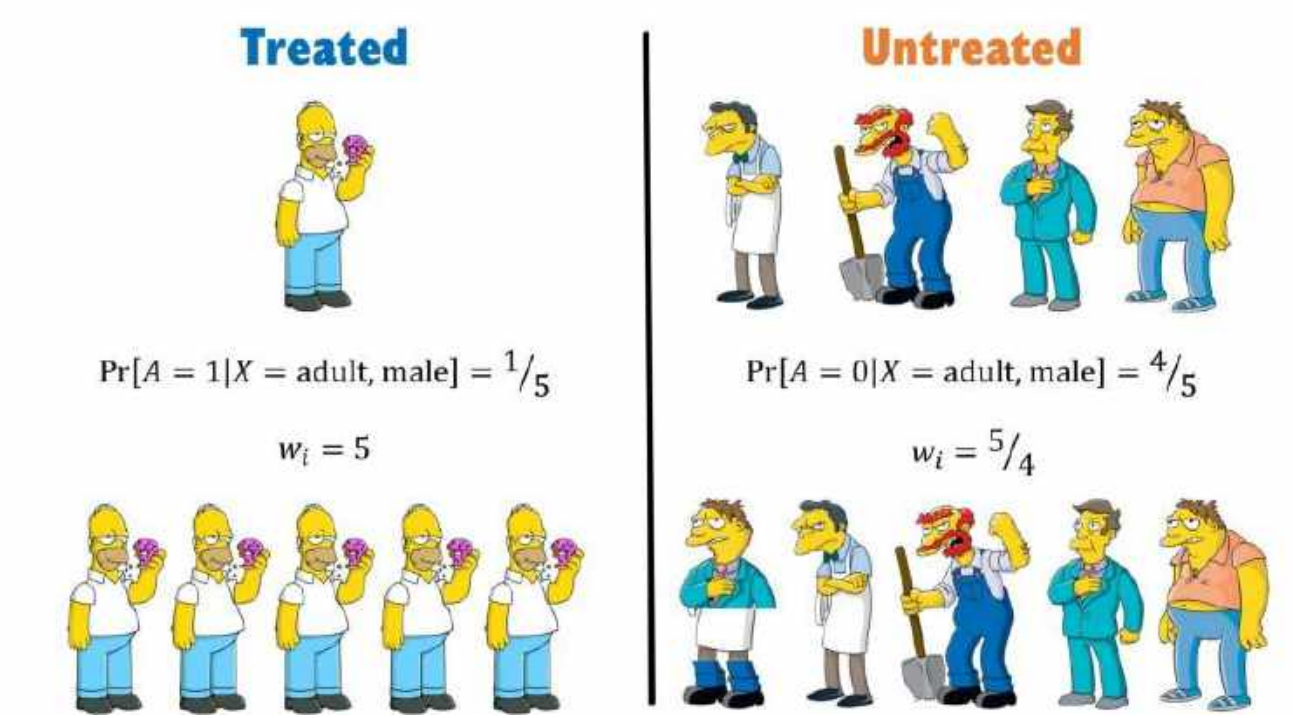
Models used in MCBE

- Models are checked for convergence
  - Remove models without a positive definite Hessian
  - Remove models with large gradients
  - Remove models with parameters estimated close to bounds
- Extreme values of biomass, F_{MSY}, and others are sometimes filtered
- Do not use other diagnostic tests for rejecting models in ensemble

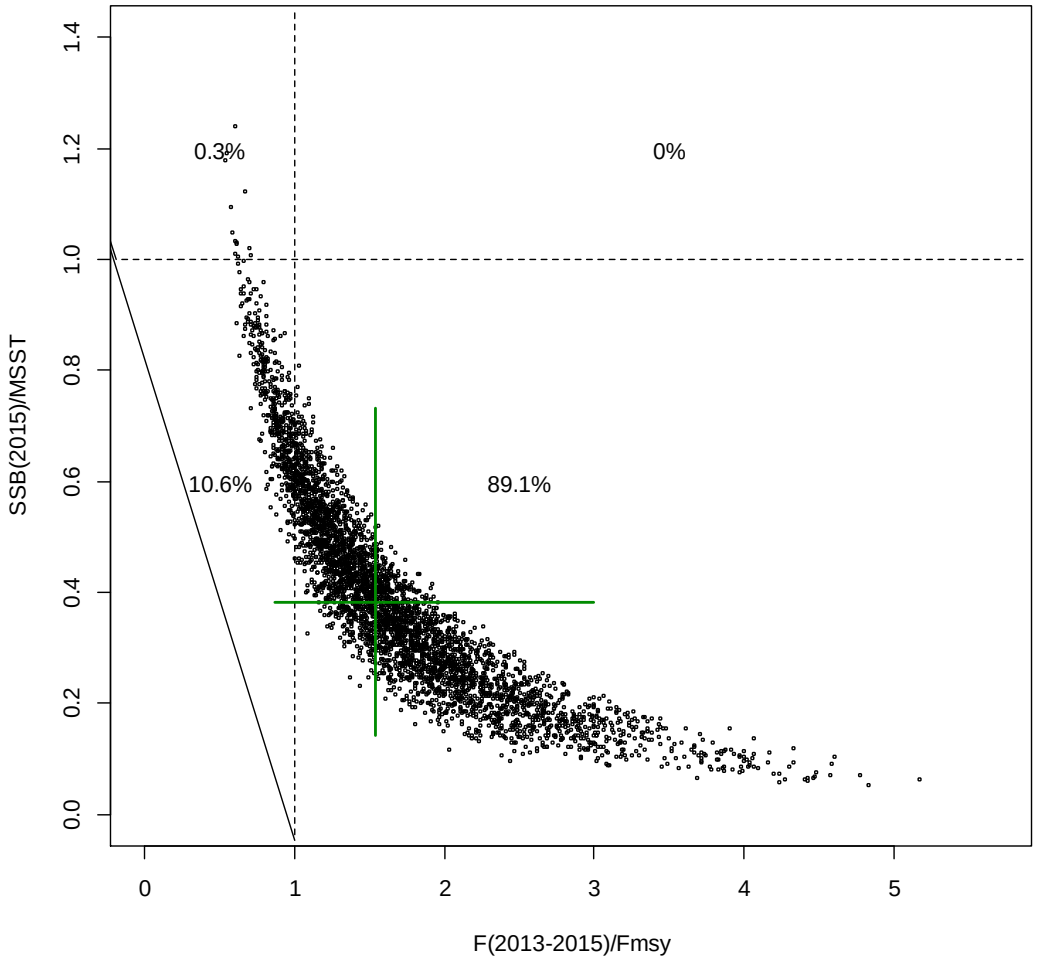


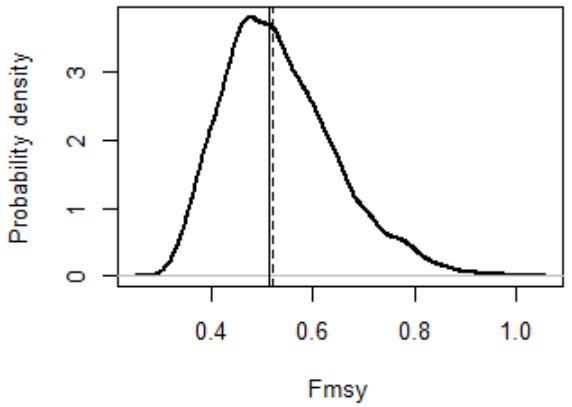
Model weighting

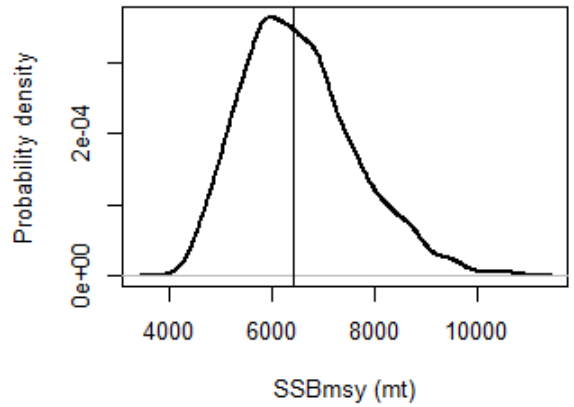
- Assume equal weights for all models in ensemble (1/M)
- Combine all models in ensemble as if independent observations of the distribution of the management quantities
- Inherently assume weight of distribution from the bootstrapped/Monte Carlo datasets and parameters
  - If multivariate distributions were used these would be present in ensemble results

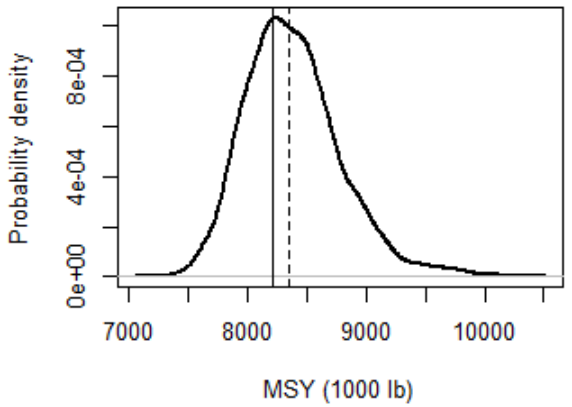


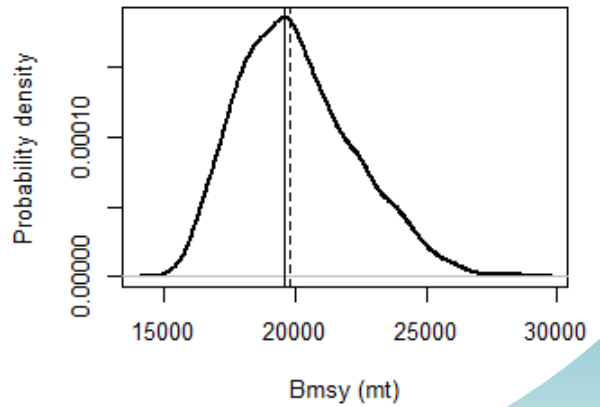
MCBE Outputs











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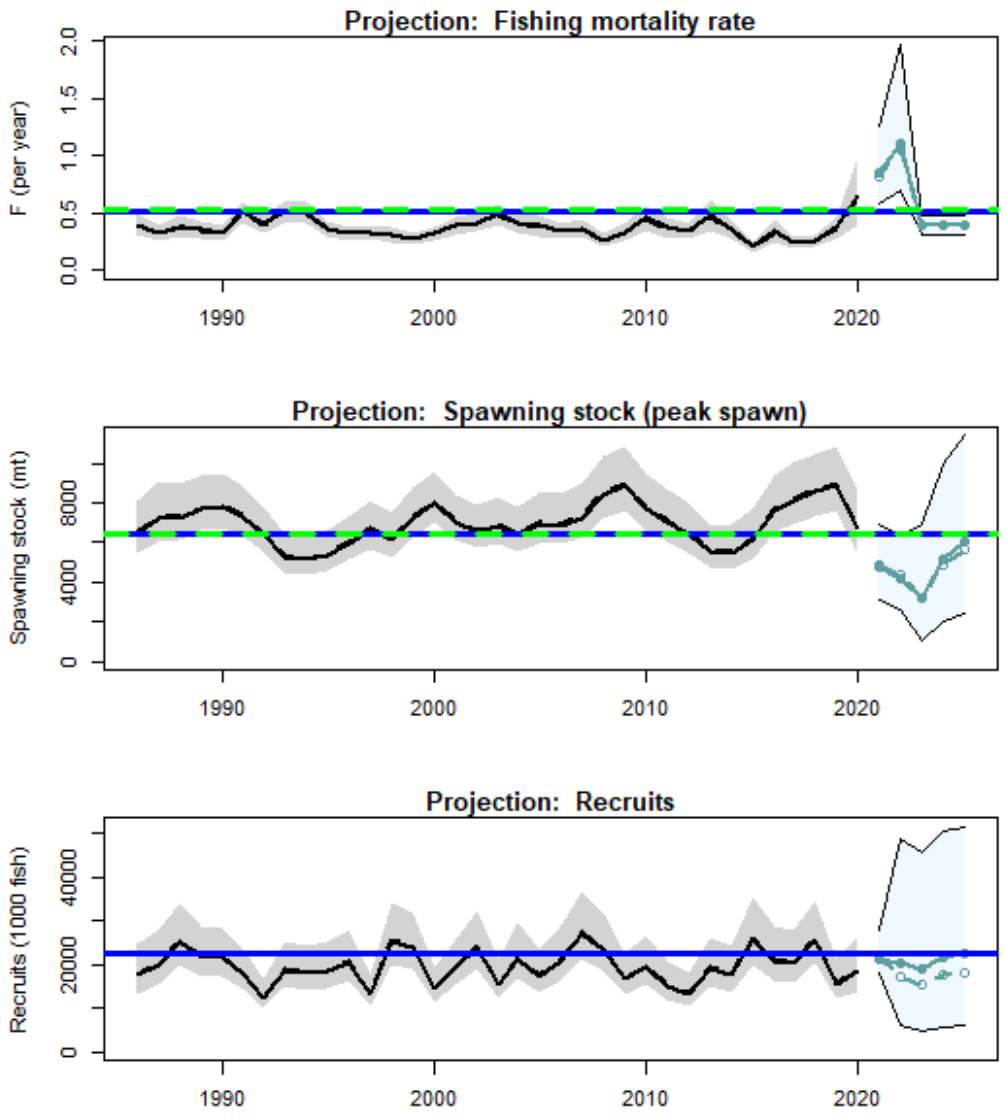
Projections

- Uncertainties in stock assessment are carried forward into management decisions
- Randomly sample model from MCBE with replacement and project forward with stochastic recruitment
- Use assumptions and starting conditions from sampled model



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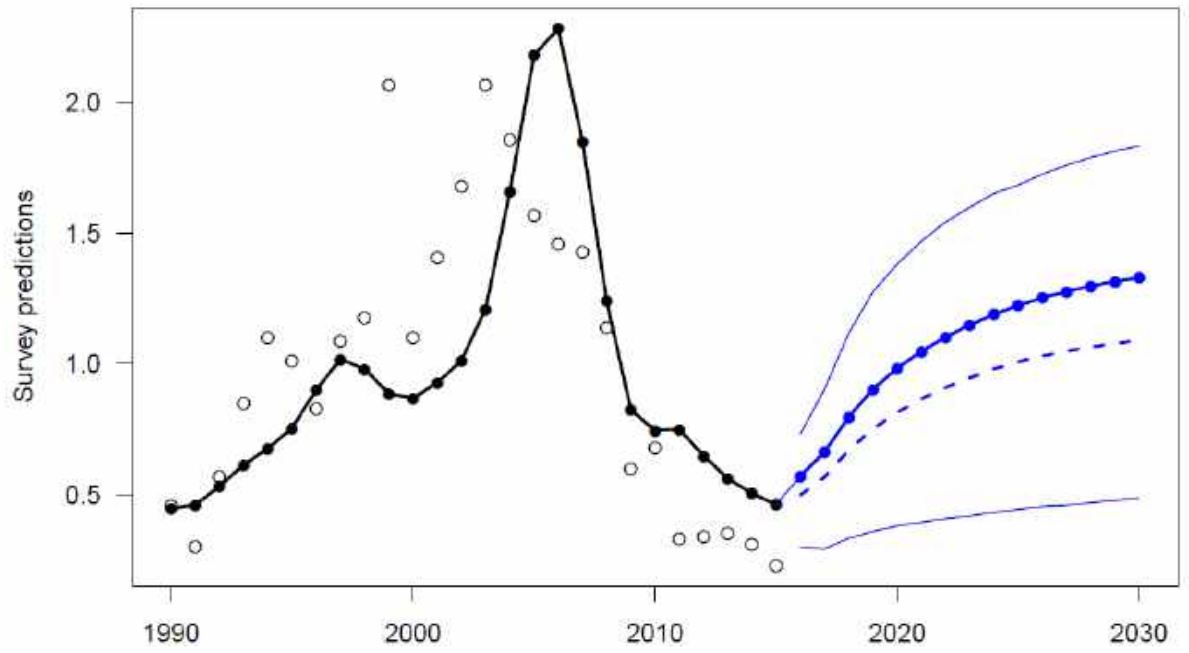
Projections Continued

- The P* value assigned by the SSC is used to calculate F from F_{MSY}
- Generally conduct ~12000 projections
- If species is overfished projections are used to create rebuilding plans
- Can produce projected indices of abundance for managers to make sure stock is on track



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Limitations of current MCBE approach

- Does not account for uncertainty in estimates of stock status from each model in the ensemble (i.e. only model uncertainty)
- Does not incorporate models with structural differences
  - i.e. no differing hypotheses of states of nature incorporated
- Is an extension of the single best model paradigm
- Typically assume independent distributions for each fixed parameter

Future Expansion of MCBE

- Incorporate uncertainty in more fixed biological relationships
  - Use output from external models to create covariance matrix for growth and length-weight relationship
  - Uncertainty in assumed σ_R can be included in MCBE
- Incorporate covariation among parameters when drawing values
  - M assumed correlated with growth or other biological parameters
- Incorporate estimation uncertainty into results

Potential uses for tuna species

- Species composition in the purse seine tuna sets is a prime example of where MCBE could be applied
  - This could cascade to other model inputs in the stock assessment
- Can also incorporate uncertainty in growth parameters or assumed relationships
- Uncertainty in M and h

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Questions

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