Moving up the assessment ladder: A flexible and integrated approach to modelling data-limited stock assessments

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CAPAM Next Generation Models

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Data-limited methods configurations

Method	Data	Output
LBSPR	Length compositions	Stock status: F
Indicator method	Abundance index	Catch or F
Multiple indicator	Length composition + abundance index	Catch or F
DBSRA; CMSY	Catch history	Catch
Production model (JABBA)	Catch history + abundance index	Catch: F
CC-SRA	Catch history + length compositions (1 yr)	Catch; status; F
Statistical-catch-at-age	Catch history + index + length comps	Catch; status; F

Tool selection should be situation specific

- In areas where the goal is capacity building – simpler may be better

- However, in regions with knowledge, expertise, and an existing management structure:
  - Can we harness existing tools?

- Keys to appropriate data-limited assessments (Dowling et al. 2019):
  - Acknowledge and interpret uncertainty
  - Embed data-limited methods in robust harvest strategies
  - Apply data-limited methods in appropriate species specific context

Dowling et al., 2019. Fish and Fisheries 20: 174-188

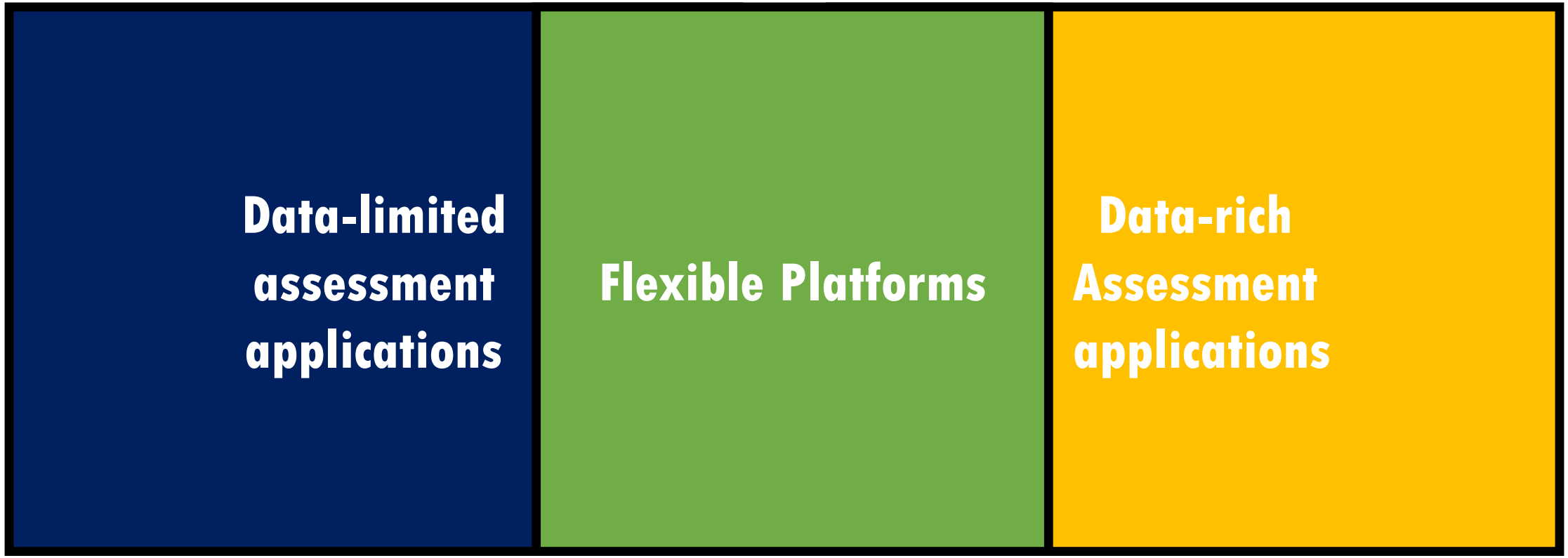
Development

Data-limited assessment applications

Data-rich assessment applications

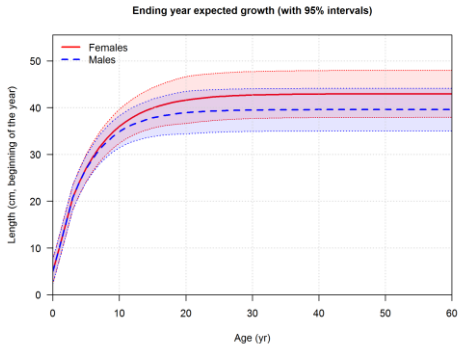
So many tools…what if these could all be done in one platform?

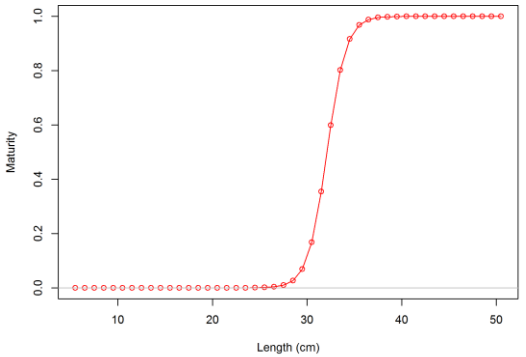
Development: Create clear bridges and linkages

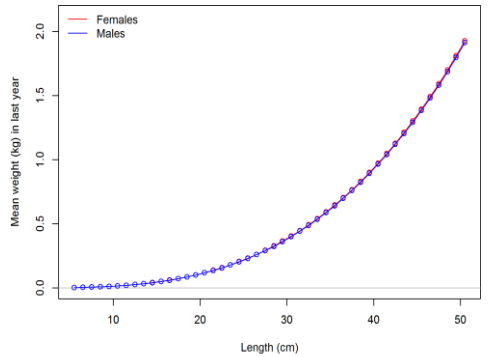


Complex model platforms force you to be explicit

- Data-limited methods make simplifying assumptions
  - Population in equilibrium
  - Asymptotic and constant selectivity
  - Non – intuitive parameterization
- Integrated age-structured models require explicit specification for:
  - Growth
  - Productivity
  - Selectivity







- Apply existing harvest strategies

Scaling up with data: Stock Synthesis Example

Removals

Abundance indices

Size & Age compositions

Simple Stock Synthesis (SSS)
github.com/shcaba/SSS

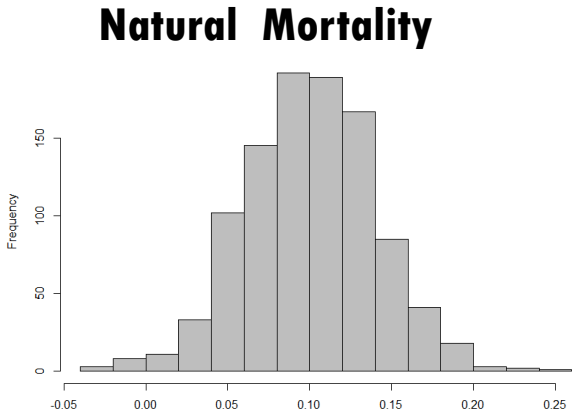
eXtended Simple Stock Synthesis (XSSS)
github.com/chantelwetzel-noaa/XSSS

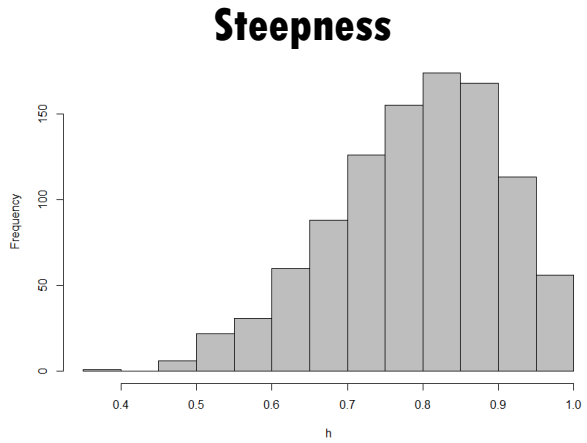
Stock Synthesis (SS)

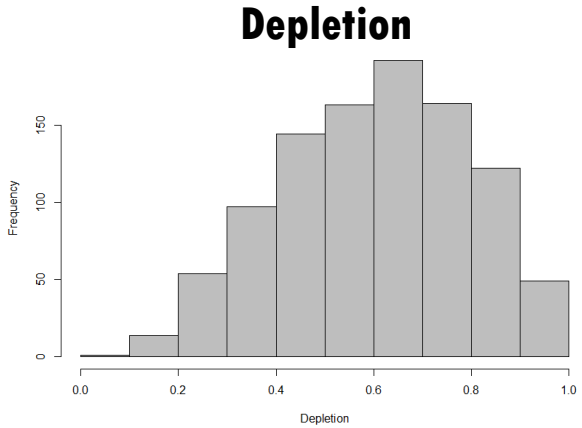
Stock Synthesis nesting doll

Catch only method: Simple Stock Synthesis (SSS)

- Data
  - Catch
- Explore uncertainty about:
  - Natural Mortality
  - Steepness
  - Depletion
- Fixed assumptions:
  - Growth
  - Weight length
  - Fecundity
  - Selectivity
- Solve for initial biomass (log(R0))



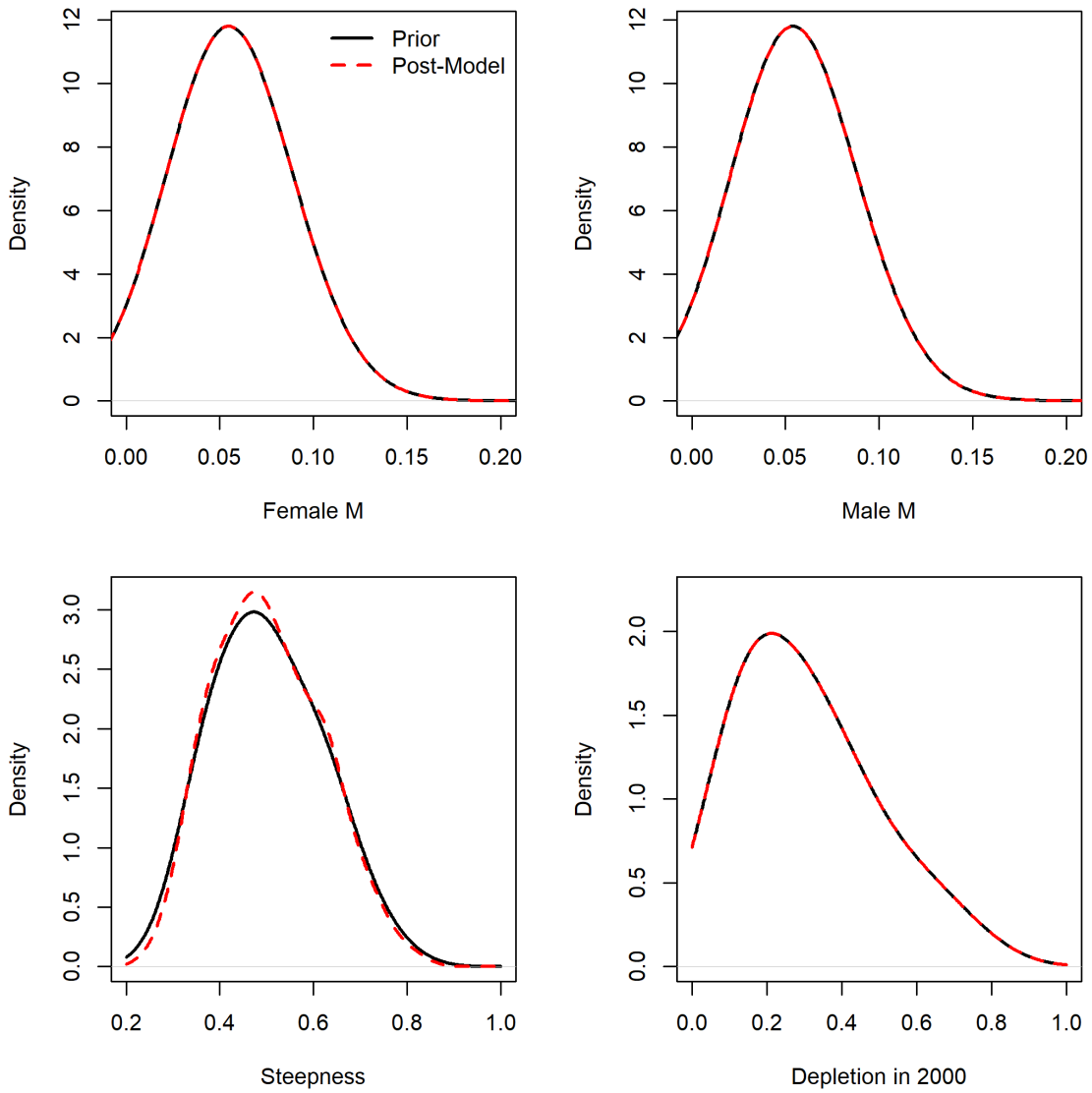




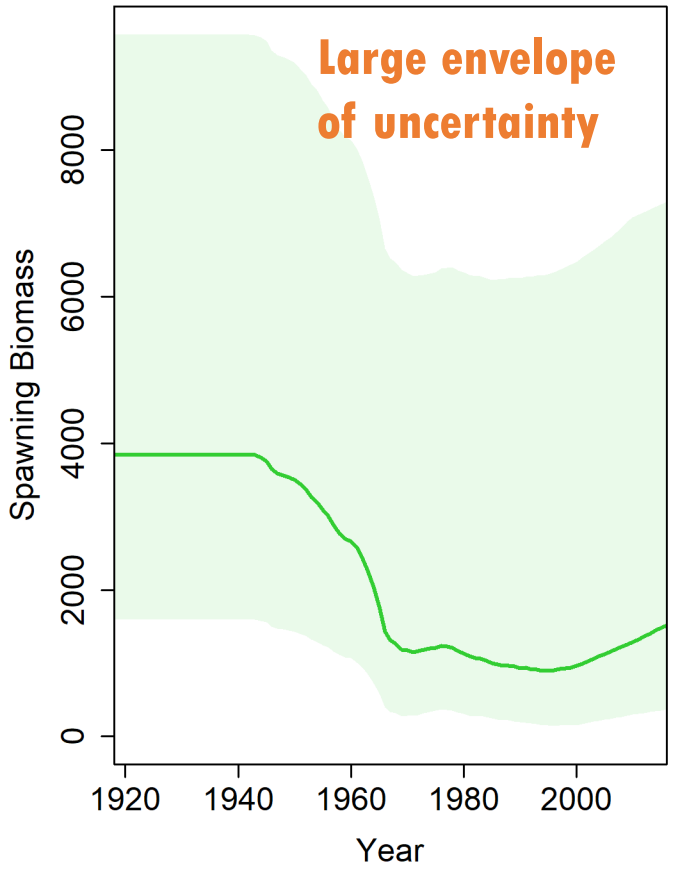
Cope, 2013. Fisheries Research 142: 3-14

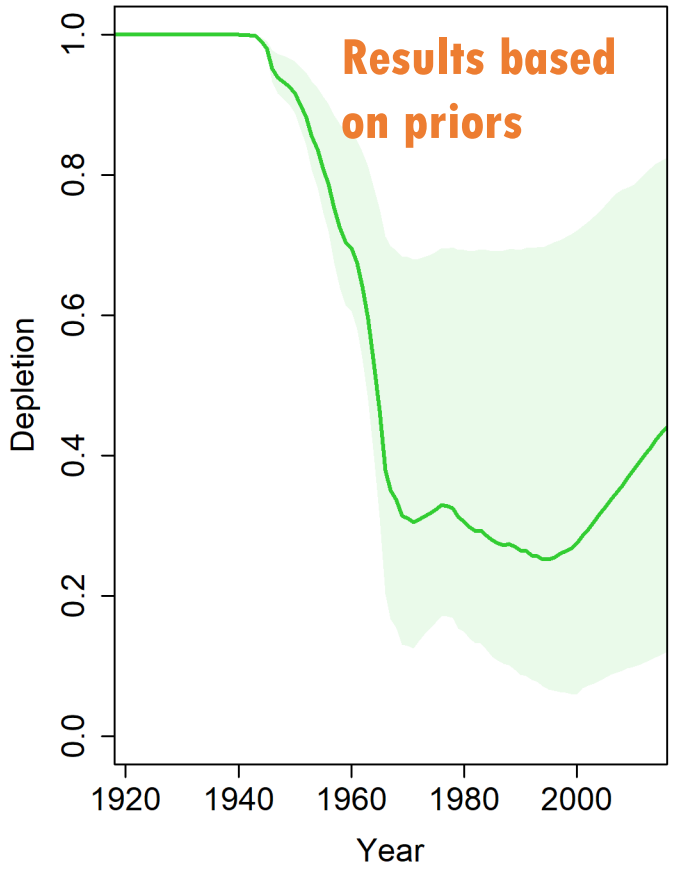
SSS: Catch only

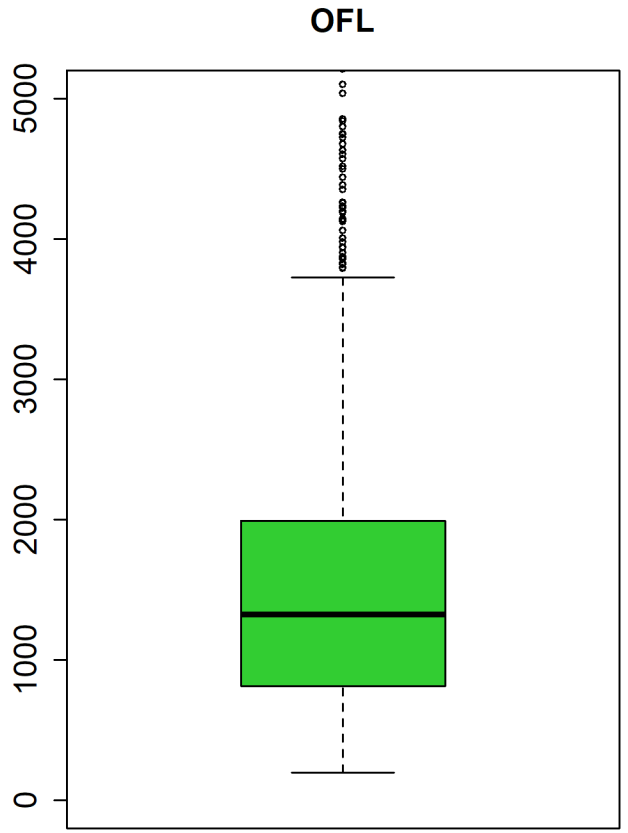
- U.S. West Coast stock
  - Stock was based on a full SS modeled stock
- Compare input priors to the post-model priors



SSS: stock size, status, and harvest







Able to harness harvest control rules and/or precautionary buffers

Incorporating Data:
Extended Simple Stock Synthesis (XSSS)

- Data
  - Time-series of catches
  - Index Data

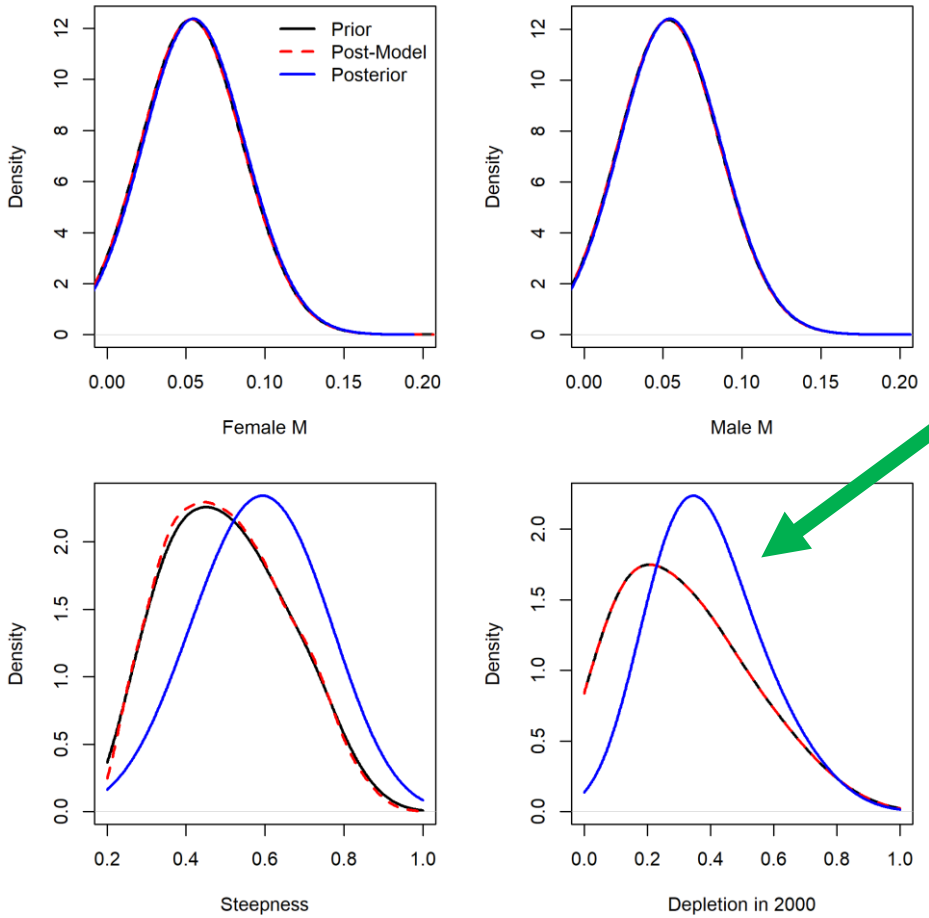
- Updating parameter distributions based on index data
  - Depletion
  - Natural Mortality
  - Steepness

- Work with model developers for efficiency in data-limited applications

Wetzel and Punt, 2015. Fisheries Research 171: 170-187

Add an index of abundance

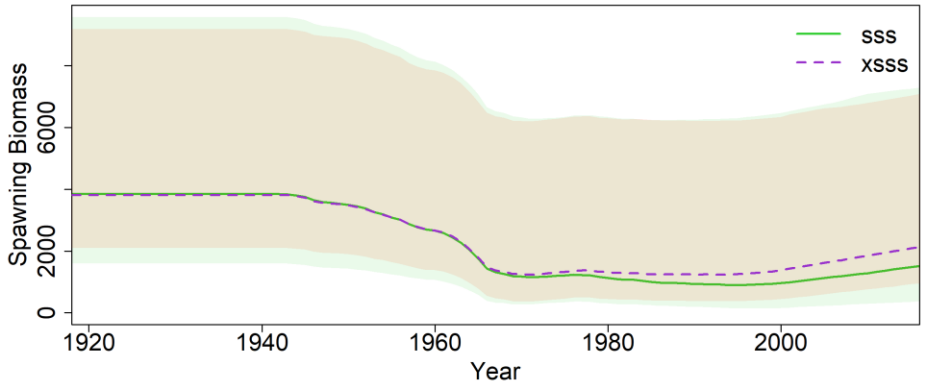
XSSS Posteriors

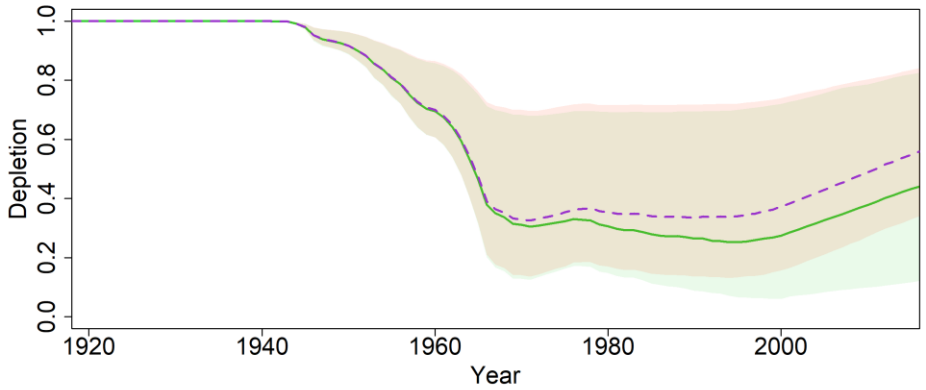


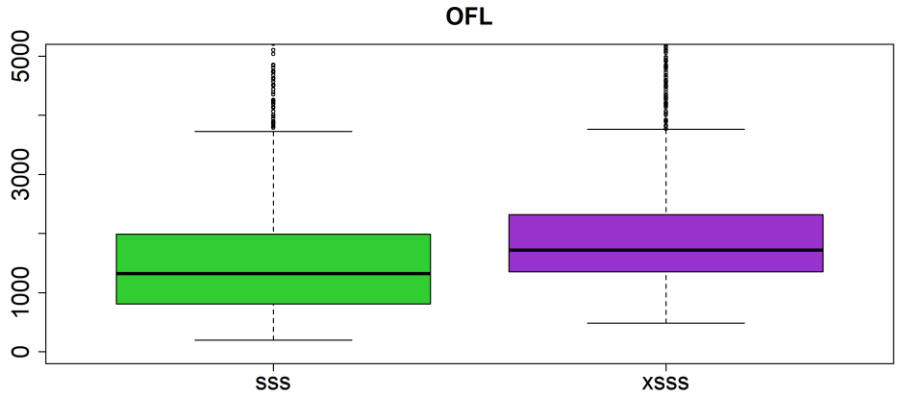
Data reduces the uncertainty

Posteriors updated based on the data

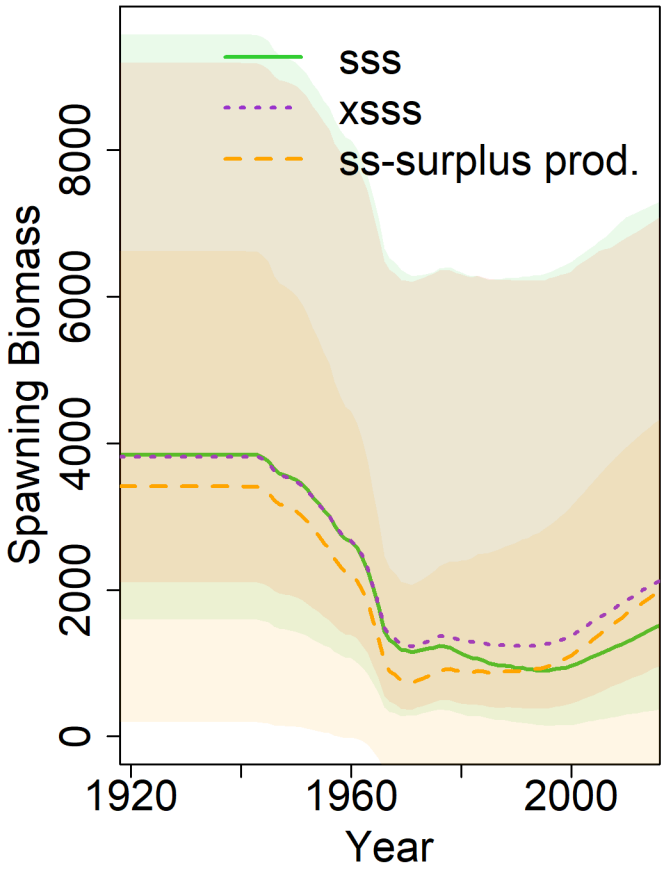
M and steepness posteriors may not update to "true" values

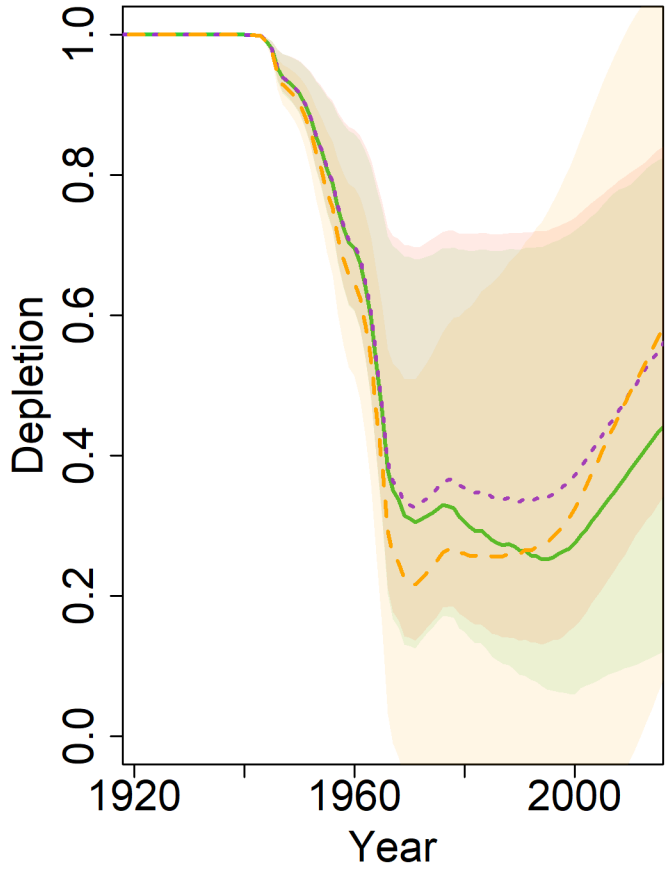


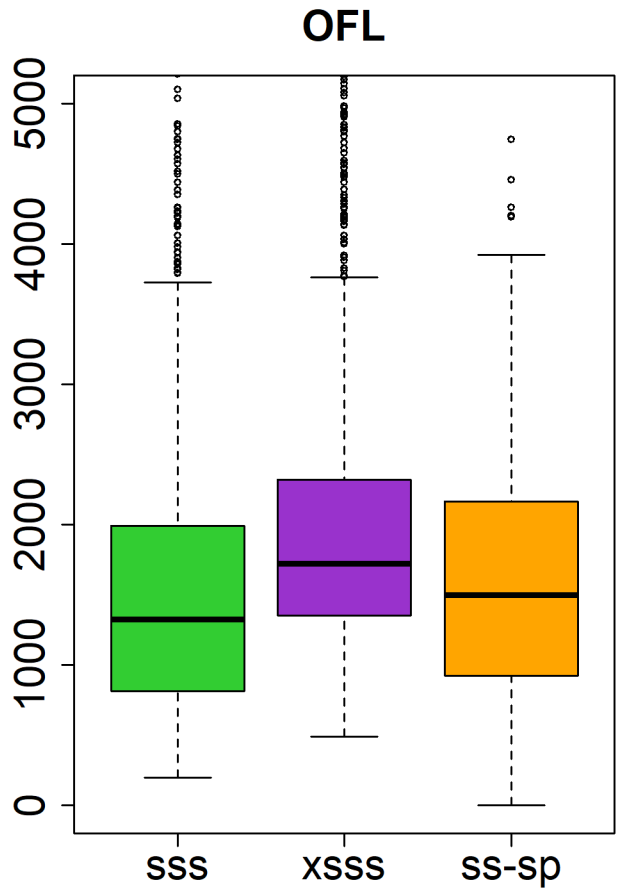




Compare with an age-structured surplus production model



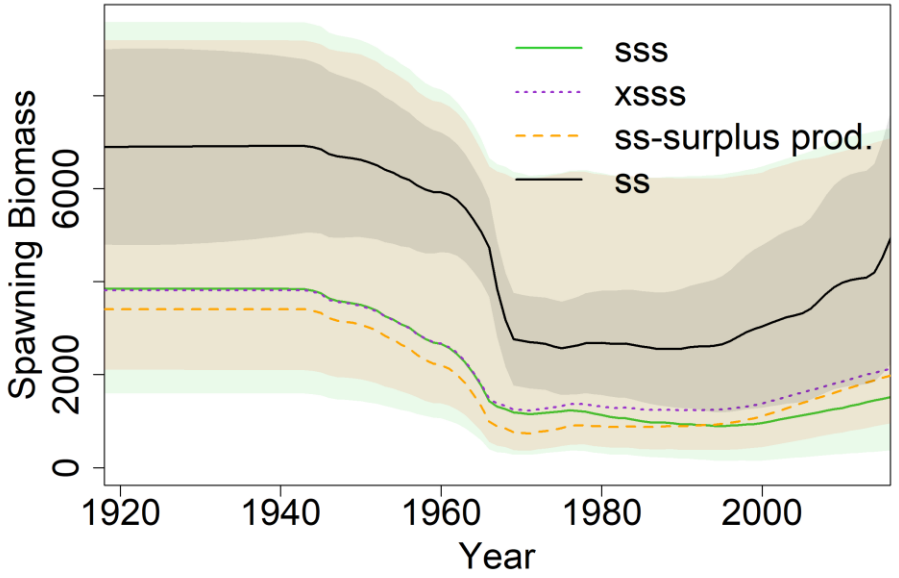


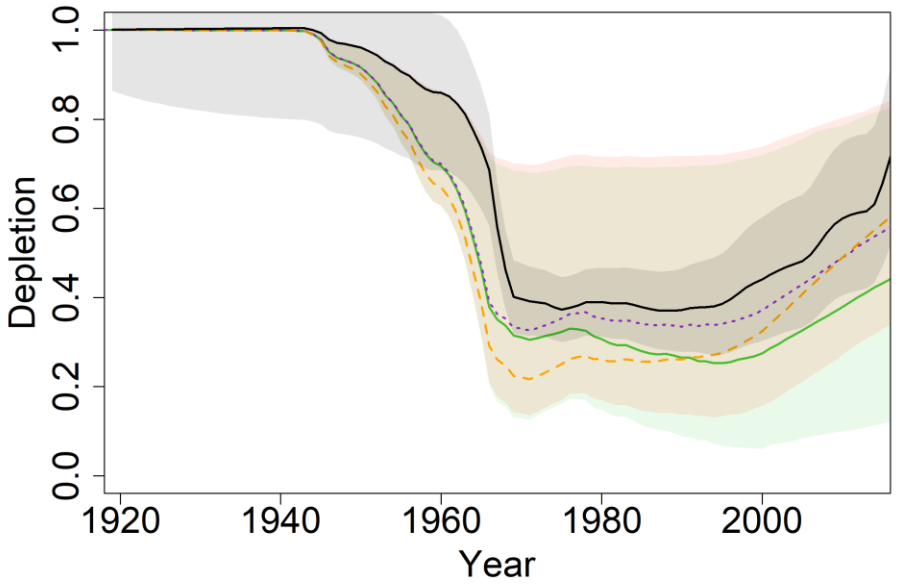


SS–surplus production model eliminates the depletion prior, estimates M, steepness, R0

Compare across models: data-limited to data-rich

- Full SS model has a higher spawning biomass
  - Log(R0) in the full model informed by recruitment deviations
  - Composition data heavily influential in the full model
- Relative scale
  - The data-limited approaches are in the right ballpark despite the simplifications

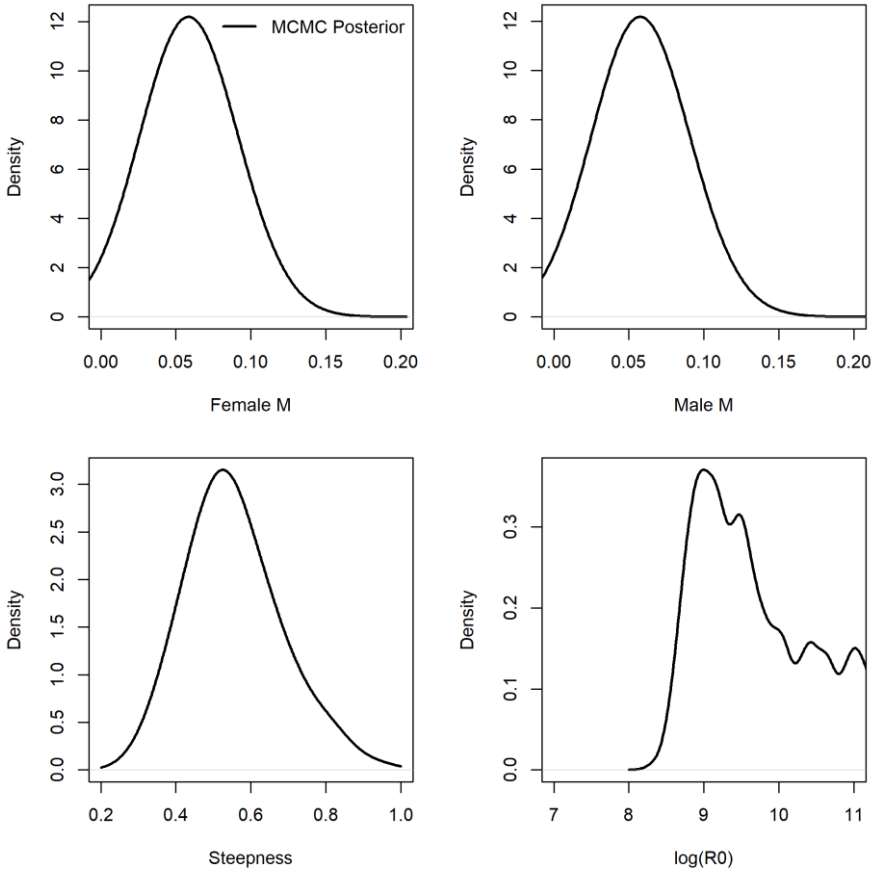




Areas of ongoing research: MCMC

- XSSS is time intensive
- Eliminates the depletion prior

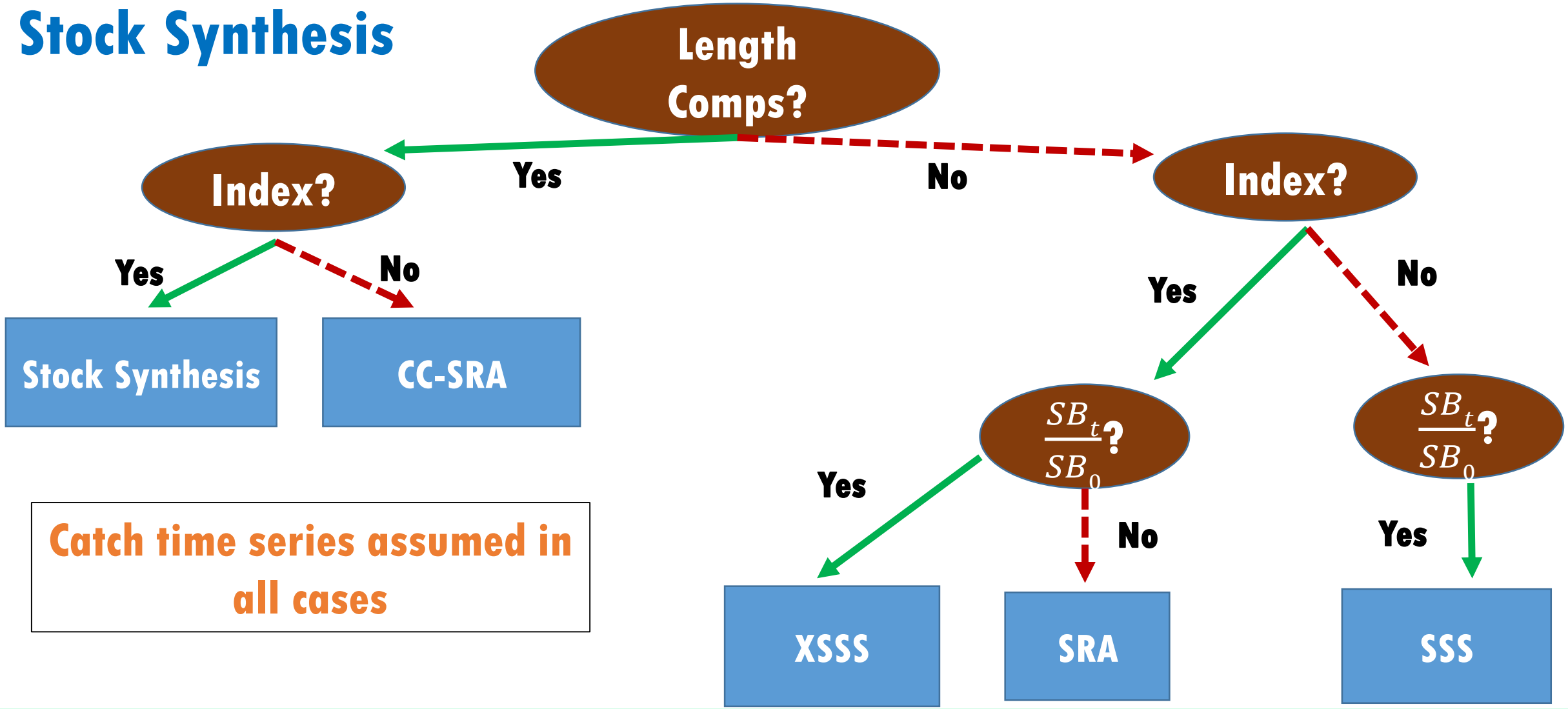
- Can we harness the power no-U-turn sampler for MCMC with Stock Synthesis?
  - https://github.com/colemonnahan/adnuts
  - The upper end of spawning biomass often highly uncertain.
    - Thorson and Cope 2017. Fisheries Research 194: 164-172



Areas of ongoing research: Add composition data

- What if you have composition data but not an index of abundance?
  - Add several years of length- or age-composition data to inform depletion in an CC-SRA type model (with or without index).
  - Thorson and Cope 2015. Fisheries Research 171: 33-41

Integrated approach to data-limited methods: Stock Synthesis



Catch time series assumed in all cases

Moving up the assessment "ladder"

- Avoids the jump from platform to platform when adding new data
- Inherit the structure and parameterization of the integrated platform
- Facilitates the application of harvest strategies
- Forces to confront hidden model assumptions that are common in data-limited methods and allows for sensitivities to those assumptions (e.g., selectivity, biology)