DORR COMMENTOR COMMENT

NOAA FISHERIES Impacts of the process error variance prior configurations on a state-space Bayesian production model performance

Xinsheng Zhang and Enric Cortés

Southeast Fisheries Science Center

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Outline

- Rationale
- Data inputs
- Model description
- Base model and results
- Projections
- Impacts of process error variance prior configurations:
 - 1. Time invariant process error variance priors
 - 2. Time varying process error variance priors
- Conclusions



Why use state-space Bayesian surplus production model?

- State-space Bayesian surplus production model (Meyer and Millar1999) considers not only observation error, but also process error
- Bayesian methods combine the *likelihood* with the *prior* distributions of each parameter to calculate a *posterior* distribution including both sources of information
- Demographic information allows us to develop an informative prior for *r* for smoothhound sharks



Data inputs

- Catch (one single series)
- Indices of abundance:
 - 1. NMFS SE Bottom Longline (NMFSSEBLL)
 - 2. Groundfish Trawl_Fall (GROUNDTRF)
 - 3. Groundfish Trawl_Summer (GROUNDTRS)
 - 4. Small Pelagics Trawl (SMALLPELTR)



Catches of smoothhound sharks in the U.S. Gulf of Mexico, 1982-2012



NOAA FISHERIES

Linear coverage of abundance indices for *Mustelus* spp. in the U.S. Gulf of Mexico





Model configuration

- Model started in 1982 and ended in 2012
- The first year in which both CPUE and catch data were available was 1982
- Each individual index of abundance value was weighted equally
- Model is fitted to the CPUEs and catch is treated as a known constant
- Time invariant process error variance prior was assumed for the base run



State-space Bayesian surplus production model

Surplus production model is reparameterized by expressing the annual abundance as a proportion of carrying capacity:

$$P_{1} = (P_{1982})e^{P\varepsilon_{1}}$$
Hierarchical for the initial year
$$P_{t} = \left(P_{t-1} + rP_{t-1}(1 - P_{t-1}) - \frac{C_{t-1}}{K}\right)e^{P\varepsilon_{t}}$$
For $t=2,...,N$

$$P_{t} = \left(\frac{N_{t}}{K}\right)$$

Observed catch rates $(I_{j,t})$ relate to unobserved states (P_t) through a stochastic observation model for $I_{j,t}$ given P_t

$$I_t = qKP_t e^{O\varepsilon_t}$$

MCMC simulation

- Two chains
- A thinning interval of 5 was used to minimize parameter autocorrelation
- An initial 50,000 iterations were discarded
- Another 20,000 iterations with a thinning interval of 5 were run to generate the posterior distributions and DIC (sample size: 2*20,000/5=8,000)



Prior and posterior distributions for key model parameters in the base run











Predicted fits to the four indices of abundance in the base run







Year

Year

Predicted exploitable number and exploitation rate in the base run





Phase plot of the combined relative exploitable number and exploitation rate trajectories in the base run





Projections

$$P_{t} = \left(P_{t-1} + rP_{t-1}(1 - P_{t-1}) - \frac{C_{fixed}}{K}\right)$$

Projection period (2013-2022)

$$P_t = \left(\frac{N_t}{K}\right)$$

- Projections were governed by the same population dynamics used to fit the model during 1982-2012, but without process error
- Unknown parameters and unobservable states were estimated given the data and priors during model fitting using MCMC
- Estimated values of K, r, P₂₀₁₂, and a fixed Total Allowable Catch (TAC) were used for projections 10 years (ca. 1.5 generation times) of stock status under six alternative constant catch level harvesting strategies (no catch (0), the catch in 2012 (1xC₂₀₁₂), 2xC₂₀₁₂, 3xC₂₀₁₂, 4xC₂₀₁₂, and MSY)
- Variability in estimated *K*, *r*, and *P*₂₀₁₂ is thus propagated into the future through each MCMC iteration



Projected probability of overfished and overfishing trajectories under six alternative constant catch levels for the base run





Projected probability of overfished and overfishing in 2022 under six alternative constant catch levels for the base run



Tripling the 2012 catches would still provide a sufficient buffer from both the overfished and overfishing limits



Prior and posterior distributions of process error variances for the base and time invariant process error variance runs



 σ^2

Fits to abundance indices under time invariant process error variance priors



Year

Year

Predicted exploitable number and exploitation rate under time invariant process error variance priors

- Small - Moderate (base) - Large





Prior and posterior distributions of process error variances for the base and time varying process error variance runs



Moderate-Then-Small

Fits to abundance indices under time varying process error variance priors



Year

Year

Predicted exploitable number and exploitation rate under time varying process error variance priors

- Small-Then-Moderate — Moderate (base) — Moderate-Then-Small



Year





Stock status in 2012 for all runs, and relative exploitable number and exploitation rate trajectories for the base run





Benchmarks and reference points







Scenario



Scenario



Scenario



Scenario

Scenario

Scenario

Model performance



Scenario

Scenario



Conclusions

- The base run model fit well captured the increasing trend in the four indices available with the proper process error variance configurations
- The base run indicated a not overfished/no overfishing stock status in the terminal year (2012)
- The base run projections suggested that tripling the 2012 catches would still provide a sufficient buffer from both the overfished and overfishing limits
- Phase plot depicting the probability of overfished/overfishing could be used as a convenient management tool to implement overfished/overfishing policies at a variety of risk tolerance levels
- Model fit to the CPUE series, predicted abundance, harvest rate, N_{MSY} , H_{MSY} , and stock status were all affected by the process error variance prior configurations
- Best model may be identified by finding the process error variance prior configuration that yields the lowest normalized RMSE and/or DIC values
- It is very challenging to explicitly use natural variability information to set and justify a given process error variance prior configuration





