Metamodeling for Bias Estimation of Biological Reference Points.

Nick Grunloh

Introduction

- Hello. My name is Nick Grunloh.
- Talking about: A Metamodeling approach for assessing RP bias in two parameter models of productivity.
- Collaboration with UC Santa Cruz, SWFSC, and funded by NOAA Sea Grant.

Basic Modeling Structure

- Context: Single Species Surplus-Production Models.
- Production models are an admittadly simple setting, but...
  - have plenty of dark secrets that we dont tend to talk about.
- Even being simple:
  - they capture many relevant dynamics for management sake
  - and are plenty instructive.
- General Structure:
  - Observe an index of abundance
  - Assume the index is proportional to biomass with proportionality constant q.
  - I_t forms a response variable with lognormal residuals.
- Most of the action here comes from the biomass process model.
  - Biomass is modeled as a (typically) nonlinear ODE.
  - Growth via a nonlinear production function, $P(B)$
  - Removals via natural mortality and catch.
    - Instantaneous removal rates lumped here under $Z(t)$.
- For management mostly interested in Biological RP Inference.
  - I should say: RP are functions of productivity parameters.
- Commonly RPs are ways of noticing MSY.
  - Here I focus on two:
    - Fmsy: fishing rate to result in MSY (Relative. Fmsy/M)
    - Bmsy: population biomass at MSY (Relative. Bmsy/B0)

RP Constraints

- Conceptually $\frac{F^*}{M}$ and $\frac{B^*}{B_0}$ coexist in an entire 2D space.
- (Mangel et.al., 2013) Canadian Journal of Fisheries
  - Two parameter BH model: RP space is limited to a 1D curve
  - **Right:** Plot Relative Bmsy against Relative Fmsy
    - black: posterior samples of the RPs for a 3 parameter Shepherd-like model. (cowcod)
    - red: posterior samples of the RPs for a 2 param BH model.
    - the red posterior is squashed into the curve $\frac{1}{x+2}$
    - Refer to this subspace of RP's as the BH line.
  - **Next:** Mangel et. al. suggests looking into 3-parameter curves

Schnute (1985)

- I'm working with a 3 parameter production function as developed in Schnute (1985)
  - A number of important 2 parameter special cases (Logistic, Ricker)
    - Most importantly here the Beverton-Holt when $\gamma = -1$.
- Generate a species off of the BH line, with the 3 parameter Schnute model.
- Simulate Schnute data and fit those data under the BH Model.

  * Observe how RPs under BH model are biased relative to true Schnute RPs.

- **Right Panel:** On the right you can see the Schnute production function and how it uses its third γ parameter to get dramatically different productivity behavior.
- In terms of RPs these different behaviours move us off the BH line.

Breadcrumb Slide

- Understanding the mapping of broad RP space onto these constrained 2 parameter spaces is complicated even in simple cases.
  - Chaos in the Dynamical System -Time Integrator Inaccuracy
  - Model Identifiability -Global Optimization
- Production models are simplified places which are easier to hunt down the many computational issues, and are simple enough to make it possible to understand the mechanisms
- At the link provided here you can see our anlysis of the mechanisms of Bias for the Schaefer Model.

Simulation Design

- Again, we use Schnute to generate data broadly in RP-space.
- In order to do this, one would need to invert the relationship between RPs and productivity parameters.
- Schnute and Richards (1998) show that it's not analytically possible to invert this relationship and numerically inverting is unstable.
- However Schnute and Richards (1998) do provide some results which we have used to generate approximate LHS designs in RP space.
- **Next:** With a design in place Schnute data can be generated for example in the upper right.
- Fitting the BH model against those data will neccessarily land somewhere on the $1/(x+2)$ BH line. (Say the red dot)
- The aim is then to understand the behaviour of these bias arrow broadly in RP space.
- **Next:** A GP metamodel of the biases over RP space is fit using the observations at each design location
- Particular BH fits are only as helpful as their standard errors allow, but when you observe trends in RP bias on repeated sampling the metamodel can discern patterns of inferential bias and how it changes across RP space.

Catch

- Assume synthetic catch series, To complete the model specification.
- I show Catch in red and the population in black.
- Two cases: Low and High contrast
- In all cases, the intitial biomass is fixed to K.
- Low Contrast:
  - Catch held at to come to equilibrium at MSY
  - low contrast, relatively low information setting
  - Exponential decay from K to Bmsy
- High Contrast:
  - fishing increases accelerates as technology and fishing techniques improve rapidly until management practices are applied to bring the stock into equilibrium at MSY.
  - high contrast, relatively high information setting
  - wiggles about until coming to equilibrium