Problems for assessment in highly exploited ecosystems

Single species stock assessment is difficult in highly exploited ecosystems

Introduction

Sustainable exploitation of marine resources is often achieved by identifying reference points associated with maximum sustainable yield.

Assessment models can be simple or complex, with complexity often relying on the amount and quality of data available. For example, SIMPLE MODEL used in management. This requires only THESE DATA. On the other end of the spectrum, COMPLEX MODEL used in management. This assessment model makes use of THESE DATA. Regardless of the complexity of the assessment model, they are generally fit to data to estimate population parameters, which are then used to calculate quantities to be used in management, like biomass or fishing mortality reference points.

A host of assumptions are implicit within the assessment process and these assumptions vary by the model and data used. LIST PRODUCTION MODEL ASSUMPTIONS. PRODUCTION MODELS APPEAR TO WORK WELL WHEN… Some of the assumptions are not realistic, and more complicated methods are often aimed at aligning the modeling framework with reality. For example, age-structured models correct THESE ASSUMPTIONS. AGE STRUCTURED MODELS WORK WELL WHEN… Although an age-structured model is likely an improvement over a production model in many cases, it, too, assumes many things about the population in question. For example, AGE-STRUCTURED ASSUMPTIONS.

Assumptions of stationarity implicit in many assessment methods can be violated by several processes. LIST THEM HERE WITH EXAMPLES. Retrospective patterns and biases in quantities used in management can arise when models that do not allow flexibility in the processes varying over time. Population managed with biased management advice will likely be under- or over-harvested.

Many of the cases of allowing population processes to vary over time in the assessment allow only one process to vary. However, large-scale ecosystem reorganization (via environmental change or exploitation) can cause several population parameters to vary. For example, EAST CHINA SEA example. Small yellow croaker makes up XX% of the commercial catch in the East China Sea and has undergone changes in life history over the period of exploitation that has resulted in smaller maximum sizes, higher growth rates, and earlier ages at maturity. Over the same period, fishery selectivity has also changed.

Here we tuned an operating model to the observed catch and life history data for small yellow croaker in the East China Sea. Production models have often been used to assess stocks in China’s domestic waters, given the relatively low data requirements, so we first evaluated the performance of a production model in estimating quantities used in management. Age-structured assessments could be applied to the small yellow croaker population if additional data sources were available, so we also evaluated an age-structured assessment. The last assessment we evaluated allowed growth, natural mortality, and selectivity to vary over time. We conclude with a discussion about THESE THINGS.

Methods

Case study

Small yellow croaker fishing and life history, other background

Steps for small yellow croaker:

1. Parameterize the operating model to match observed catch, given changes in life history, exploitation.
2. Input

Known: Growth, weight at length, natural mortality? (probably not), selectivity, maturity

Estimated: Rzero

Tuned/sensitivities: natural mortality

1. Fit production model to data derived from that operating model.
2. Show differences in reference points estimated from production model and the true underlying dynamics.

1. TUNE OPERATING MODEL

Find\_rzero<-function(x,…)

{

Write\_CTL() # takes input of x, makes GeMS CTL

Run\_GeMS() # you know what that does

Gather\_output() # pull ‘true’ catch from GeMS--

Calc\_like() # calculate the likelihood for fitting to observed catch data

Return(calc\_like)

}

Nlminb(x,find\_rzero…)

FINISHED—AND WE GET A VECTOR OF RZERO THAT FITS THE OBSERVED CATCH.

Need to do this for several ‘realities’ looking over trends in natural mortality and steepness.

2. Fit GeMS

How well does a production model fit these sorts of data?

How big of an improvement is an age-structured assessment?

Projection for plastic vs. selection

OM1: Population parameters stay the same starting at the year of projection (selection hypothesis)

OM2: Population parameters are linked to fishing mortality (or biomass or selectivity?) (plastic hypothesis)

HCR1: Status quo fishing (hard and indiscriminate)

HCR2: Reform toward single species reference points (optimal selectivity and F)

Results

*Tuning*

*Production model*

Not allowing initial B to vary

Allowing initial B to vary

*Age structured model*

Time invariant

Time-varying

Discussion

Main results

Explanation for main results

How can this be applied elsewhere?

Where in the world are these assumptions met?

A need to quantify how well single species models can be expected to work in ecosystems.

Regime shifts in Bering and Gulf of Alaska have required considering different portions of the data. Ecosystem changes in the north atlantic have precipitated a shift from biomass based reference points to F based.

DISCUSS PLASTICITY VS SELECTION, SET UP NEXT PAPER

Figure 1. Map, history of fishery (catch and effort)

Figure 2: life history changes.

Figure 3. Fits of production model with and without estimating initial biomass.

Figure 4. Fits of age-structured model.

Figure 5. Estimated population processes for age-structured model.

Figure 6. Relative error in reference points

SYC

Research question:

How does time-variation in population processes affect the estimation ability of commonly used stock assessment models?

Break a production model. Age-structured has more flexibility, does it do better? Nope. What if we tell the age-structured model something it needs to know (i.e. how natural mortality changes over time?).

Methods

Describe tuning process

Operating models:

1. One ‘base’ case to show the estimation models will do their job. Pick a year in the middle of the time series to specify all parameters.
2. All time-varying parameters from the GAMs.
3. Time-varying parameters from GAMs except M, M is a declining function of effort. We do this because their estimates all come directly from ln(K) and some dumb formula. Make end point 0.2/year.
4. Be sure to estimate different Rzeros for each OM.

EM:

1. Production model
2. Age-structured
3. Age-structured with some parameters fixed at ‘observed’ and allowing other parameters to vary? Perhaps natural mortality would be easiest here?
4. What year makes sense to start the assessment? (Change control file and pull code to make this work)

Figures:

1. Time-variation in parameters, catch, fishing effort.
2. Implied changes in population processes from 1.
3. Production model fits, production model RE in ref points from last year (this may also need a new function)
4. Age-structured fits (this will need a new function)
5. RE in age ref points (this should be fine)
6. Estimated population processes

Conclusions:

Time-variation messes up production models bad. (Probably don’t even converge?)

Time-variation messes up age-structured models bad. (Probably at least converges?)

Knowing the changes over time in one or more processes can get you closer to the ‘truth’.