Communicating uncertainty in policy advice: The case for fisheries quota advice based on confidence intervals

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Summary

The current harvest control rule (HCR) for Northeast Arctic cod depends on point estimates of the size of the spawning stock biomass (SSB) and fishing mortality (F). We make a case for an alternative formulation of the HCR that uses confidence intervals that accurately describe the underlying data.

Introduction

The 2013 ICES advice for cod was based on, among other factors, a SSB estimated at 1,986,000 metric tons, where the relative standard error is likely to be >10% of that estimate. However, the quota agreed by the Joint Norwegian-Russian Fisheries Commission overshot the ICES advice by 6%. When the TAC advice is based on a point estimate for SSB, the propagation of uncertainties (assessment models of varying complexity, variable data sources and variable degrees and structures of uncertainty) and subjective expert decisions, is contained, at best, in the "Stock Annex". TAC advice as a single number (sometimes with five significant digits) often occurs when clients expect more of science than science can deliver. For example, the TAC can be based on, say, confidence intervals (CIs) of 90% of the uncertainty of the biomass estimate. Thus, the 90% CI for SSB may be between a range, say, of ± 20%×SSB. Our CI-HCR determines the TAC advice given the range of SSB and *F* assessed.

We outline an alternative formulation of the HCR that reflects the knowledge base with confidence intervals (CIs) dictated by the quality of data from catch sampling, scientific surveys and model uncertainties. We then compare the performance of a CI-HCR with a traditional formulation of an HCR based on a point-estimate of biomass. We test each of these HCRs with two different observation scenarios based on empirical data of assessment uncertainty and various survey coverage.

Method

We are interested to know the pros and cons of the performance of a traditionally formulated HCR based on a point estimate of biomass versus the performance of a HCR based on the lower 10th percentile of the abundance estimate The basis of the fish population dynamical model are fully described in Aanes et al. (2007). In order to limit the impact of uncertainties in the population parameters interacting with each other, we keep natural mortality constant.

With the underlying population model, we test two examples of underlying information error and two formulations of the harvest control rule, for a total of 4 unique scenarios. Results will be presented at the ICES Annual Science Conference in September 214.

Discussion

We hypothesize that, due the inherent uncertainties in the biomass estimates for marine fisheries, a harvest control rule that is able to deliver TAC advice robust to these uncertainties would perform better in terms of risk of population collapse and stability of yield.

What do we gain from a CI-HCR in comparison to the status quo HCR for NEA cod? In the comparison of CI-HCR to SQ-HCR, we focus on communicating the extent to which the HCRs perform from an uncertainty standpoint. In order to do this, we will present a summary of the data parameters that go into the stock assessment that give us the state of the stock (X), and their respective uncertainties.

But what about the uncertainties in the underlying population dynamics and model parameterization? We have not accounted for those in the scope of this work. We are critical to the limited scope of our analysis; uncertainties are all over the place and impact and interact with each other. We are very aware that estimated biological parameter values, natural mortality is a good example, are poorly understood and estimated. But there are sophisticated ways to communicate and track the quality of the input data in an assessment.

One way to do this is qualitatively in a "Pedigree Matrix" which is part of the post-normal science toolbox, described in a fisheries context in Dankel et al. (2011). There are many other inputs, so we can discuss what else is important to input there. By completing a Pedigree Matrix (Dankel et al. 2011) for the key parameters of the NEA cod HCR, we can focus in on where the weakest points are and discern how they affect the HCR. For example, if natural mortality has a very low Pedigree score, we would want to focus on an HCR formulation that is robust to that uncertainty. At the moment, we can mitigate uncertainty in a CI-HCR either by the discrete steps in biomass, state of the stock, or TAC.

We can never rid ourselves of the "propagation of uncertainties" underlying the scientific basis for management advice. We can account for inherent errors and uncertainties in robust frameworks. In the absence of putting uncertainty at the center of the table and designing advice frameworks that are robust to these uncertainties, we fear there is a risk for mistrust by stakeholders and other recipients of our advice. We therefore make the case for harvest control rules based on confidence intervals with supporting pedigree matrices.

References

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