TESTING BLUE CRAB MANAGEMENT

Simulating the Present to Sustain the Future

The blue crab is iconic to the Chesapeake Bay's ecology and culture. Sound management of the Bay's crab fisheries is required to maintain this status. To support this, the first scientific assessment of management goals for blue crab was completed in 1997. Subsequent benchmark assessments occurred in 2005 and 2011. This final benchmark assessment has been updated with new data regularly since. However, the performance of these assessments has never been evaluated.

THE OPERATING MODEL APPROACH

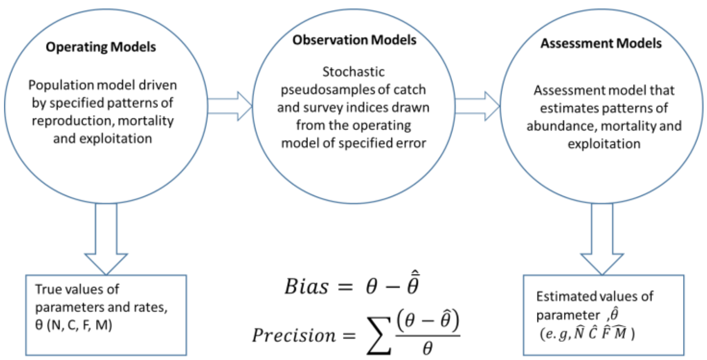

Figure 1. *The operating model concept. The operating model represents the consequence of known population dynamics. Pseudo-samples are collected in the observation model and entered into the assessment model. Estimates from the assessment model are compared to their "true" equivalents to estimate bias and precision.*

Evaluating the performance of assessments is an essential element of modern fisheries management. Most often this is achieved by using an operating model approach (Fig. 1). This approach involves developing a population model of blue crab. The population model, also called the operating model, projects the patterns within a blue crab population when its dynamics are specified. Simply stated, we know the "true" values all of the key parameters in this model, including abundance, catch, as well as the rates of fishing and natural mortality. We then take statistical samples from this model, in much the same way as we take samples from the real blue crab population in the Bay. Next, we input the samples into the assessment model to estimate the population parameters. Comparing the population parameters estimated from the assessment model to the "true" values from the operating model allows us to assess the accuracy and precision of population parameters derived from the assessment model.

THE OPERATING MODEL

We developed a base operating model that reflected the abundance and size of crabs in a population. The model was driven by estimates of recruitment, and informed by tag-based estimates of mortality rate. Growth in the operating model included temperature dependence to reflect what is known about crab growth. The expected size distribution of blue crab in the population was projected at monthly intervals. Crabs were assigned to 10 mm size bins. We observed monthly samples from the population, as might be collected by a survey. These samples provided information on crab sizes. We also "caught" crabs from the population in a monthly fishery modeled to represent a pot fishery.

More complex operating models were also explored. Higher resolution length models were less reliable as crabs transitioned across multiple size bins per time step and degraded the reliability of subsequent estimation. The operating model could generate multiple surveys with differing characteristics. Spatial models involving tributaries and main stem segments were explored, but limitations in data available meant that such models could not be easily parameterized and biologically reasonable "true" values could not be specified. This deficiency represents gaps in both biological knowledge on factors driving movements at the scales of 10s of kilometers, and existing data on movements other than large scale seasonal movements of mature females.

HOW WELL DID WE DO?

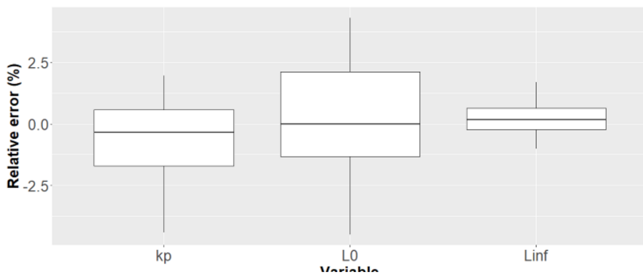

***Figure 2**. Relative error of growth parameters sampled from the operating model and estimated in the assessment model.*

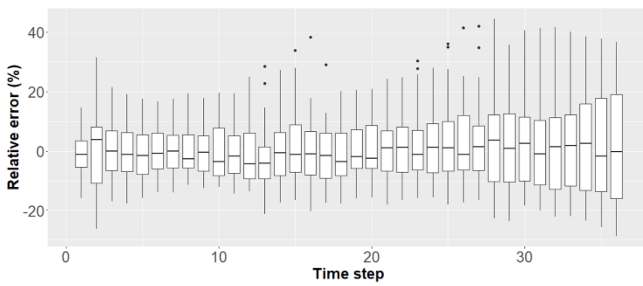

***Figure 3.** Relative error of abundance estimates sampled from the operating model and estimated in the assessment model.*

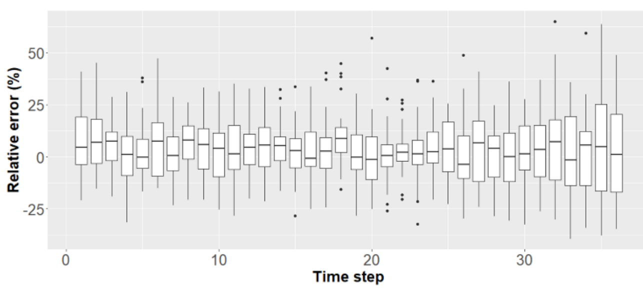

***Figure 4**. Relative error of fishing mortality rate estimates from the operating model and estimated in the assessment model.*

When given perfect information - surveys and catches every month – from the base operating model, a prototype assessment model of the kind that will be developed for the next stock assessment, was able to estimate population parameters of interest with high accuracy. Shown in Figure 2 are relative errors of growth rates parameters, which can be seen are estimated without bias (relative error ~ 0%) and quite precisely (~ 2% error). We can also estimate abundance without bias, but with lower precision (~10% error – Fig. 3). Fishing mortality rates estimates were biased (Fig. 4).

Analysis of the operation model indicated that estimation of recruitment of new, young crabs into the population is a particularly sensitive parameter. We had to provide highly quality information about recruitment for the assessment model to provide accurate results. Unfortunately, recruitment is one of the parameters we know with the least precision in the field. Biological samples only become reliable during winter months, when crabs are already 6 months old and at least 30 mm in carapace width. This suggests a limitation that will likely apply to the development of the final assessment model.

Although the operating model was able to generate multiple fishery independent surveys, the assessment model struggled fitting multiple surveys. This is likely because of conflicting information in the different surveys. This has challenged previous assessments and will likely challenge assessment work moving forward.

An important feature of the operating model is the ability it affords to evaluate the benefits of future changes or investments in sampling, catch reporting systems or advances in our understanding of crab biology and ecology. The impacts of planned changes in these activities can be evaluated prior to implementation to evaluate whether the costs incurred or saved can be justified by changes in the precision or reliability of our understanding of the status of the crab population.