Improving the communication and transparency of stock assessment using interactive visualization tools

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# Introduction

A primary role of stock assessment is to provide fisheries managers with the information needed to adequately manage a fishery. Stock assessment involves the use of various sources of data and statistical methods to determine the status of one or more fish stocks and to make quantitative predictions of the consequences of different management choices (Hilborn and Walters 1992). A wide array data may be collected for an assessment and, formally, an assessment often reduces to algorithms that convert these data to advice for fisheries managers. In some cases, particularly for commercially valuable species, this means that hundreds or thousands of historical data points from the monitoring program of a stock gets reduced into a single policy value, such as a recommended catch quota (Maunder, Schnute, and Ianelli 2009).

The data sets used in stock assessments are constantly growing. This growth in data either stems from the continuation of long-term monitoring efforts or from the addition of new monitoring programs. As such, stock assessment biologists often have to manage large volumes of data from a variety of sources. For instance, time series of reported landings and catch-at-age are “fishery-dependent” data that are frequently used in stock assessments. These data are often analyzed in conjunction with data from “fishery-independent” surveys that track changes in abundance and, in many cases, also monitor trends in biological factors such as age composition, growth rates, sex ratios and maturation stages. For some data-rich stocks, mark and recapture studies are also carried out to estimate movement, migration, growth rate, natural mortality, and discard mortality. All of the above-mentioned data sets are multidimensional and as the volume and variety of these data increases, it becomes more difficult to be aware of the details of each data set and to synthesize the results.

Synthesizing data from multiple sources presents a key challenge to stock assessment. Analyses of different data sources were traditionally carried out independently and the summaries or parameters from these analyses were used in the assessment model. This approach, however, is less than ideal because information may be lost and uncertainty may be unaccounted for when we “do statistics on the statistics” (Link 1999; Maunder and Punt 2013). Such issues have largely been curtailed in contemporary stock assessments thanks to advances in software that have facilitated the analysis of all available data, in as raw a form as appropriate, in a single integrated analysis (Maunder and Punt 2013). Specifically, the application of statistical modeling tools such as JAGS (Plummer and others 2003), AD Model Builder (Fournier et al. 2012) and Template Model Builder (Kristensen et al. 2015) allow the construction of a joint likelihood for an array of observations to, in theory, extract as much information as possible about the biological and fishery processes. However, integrated analyses are not a panacea because model misspecifications and data conflicts are an inevitable consequence of simplifying reality to a small series of equations (Maunder and Piner 2017). A potential solution to this quandary to use a superensemble model, whereby multiple models with different structures are run and their predictions are supplied as covariates to an additional superensemble model (Anderson et al. 2017). Ensemble approaches reduce the risk of picking the “wrong” model and also expands the range of hypotheses explored (Dietterich 2000). These advances greatly improve our ability to assess the status and trends of fish populations, however, modern stock assessment biologists are now faced with the overwhelming task of understanding an ever expanding array of data inputs and model outputs.

“We are in an age of data-intensive science and big data, and ecologists must develop the capabilities to deal with their data.” (Hampton et al. 2013)

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