Strategies for the conditioning of operating models for IOTC stocks

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Executive Summary

- This paper explores the process of conditioning OMs in the IOTC MSE context. The current suite of MSE evaluation work has used the stock assessment as the basis for the suite of OMs used to test candidate MPs
- Given issues arising for at least two of the stocks, we outline what could be done to conditions representative OMs if the stock assessment is not accepted and doesn't form a workable OM basis
- This does not mean a suggested change to how OMs have been conditioned previously; it is simply a suggested augmentation to the current suite of OM conditioning methods that can deal with insurmountable stock assessment problems

Background

This paper was motivated by the following question: the current suite of Operating Models (OMs) used in the various IOTC management procedure (MP) evaluations are conditioned using the stock assessment model structure as a basis, but what do we do if the stock assessment does not work adequately? While , the OMs for the key species where MPs are being evaluated are all constructed using the respective stock assessment models, all differ slightly in how they use the stock assessments. The main advantage of using a stock assessment as the basis is that the OMs are conditioned on the historical data, with the most up to date information on stock status and productivity embedded within them. The obvious difficulty arises when the stock assessment itself is either not accepted, or cannot reasonably be shown to be adequate in parameterising a suite of acceptable OMs.

The current yellowfin tuna assessment has proven very difficult to structurally configure to both fit to the available data *and* demonstrate the ability to recreate observed catches outside the estimation period or plausible future catches in short-term projections. In the case of albacore tuna, the accepted stock assessment sits at one extreme of the distribution of trajectories generated by the OM grid, and a large proportion of model runs cannot explain the most recent catches. The corollary for OM conditioning based on the stock assessment is clear: if we cannot accept, or have sufficient doubts about the stock assessment, we cannot realistically condition OMs based upon it for the purposes of MP testing.

A more familiar process would be when we *can* fix the stock assessment and then use it to condition our OMs. This is still arguably the most efficient path – though we stress the caveat that the OMs should always have a wider view than the assessment in terms of both historical stock dynamic hypotheses, alternative model structures, and future scenarios explored. We should not be trying to replicate the 'best assessment' approach when constructing and conditioning the OMs – almost all work in this area has shown the advantages of MPs in avoiding the pitfalls of this approach and this begins at the OM construction phase (Punt et al., 2014). Pragmatically, if this approach is not tenable we need to explore what else can be done in its place. In this paper we explore the strengths and weaknesses of using the stock assessment as the base construction material for the OMs, relative to a less historically conditioned approach that still has uncertainty (both structural and parametric) at its core but does not rely so heavily on the stock assessment to inform on current stock status and initial conditions for projections.

OM construction using the stock assessment

Within the IOTC context, aside from the previous skipjack OM (Bentley & Adam, 2016), construction of the suite of OMs used across the species can be generally categorised as follows:

- Stock assessment structure (population and fishery dynamics) forms the basis for the historical conditioning model and the projection model to generate future population and fishery trajectories as well as observations for input to the candidate MPs
- An uncertainty grid approach, possibly utilising fractional factorial design for efficency purposes, is employed to represent the inherent parametric and structural uncertainty in the historical population and fishery dynamics to construct the reference set of OMs
- An additional suite of robustness tests (alternative hypotheses, model structures and future scenarios) are included to ensure that less plausible or qualitative uncertainties not included in the reference set of OMs are still accounted for.

The strengths of this approach are:

1. A plausible population and fishery model have been fitted to the available historical data, producing estimates (including the uncertainty therein) of current stock status and the other key variables required to define the parameters of, and initial conditions for, OM projections.
2. There are a number of powerful stock assessment packages (Stock Synthesis, CASAL, MULTIFAN-CL) used across the globe that can be used to construct complex stock assessment models such as those required for tuna and billfish stocks.
3. The relevant scientific fora within the RMFO have some familiarity with the stock assessment and, hence, hopefully associated understanding and “buy-in” when it comes to the OMs.

The main weaknesses of this approach are:

1. If using a particular package, we are bound to what is possible within that package – even the most “generic” stock assessment package usually requires some kind of structural compromises when configuring the model given the known population/fishery dynamics and the data. This essentially controls the space of what is possible for the OMs by construction.
2. There is no guarantee that we can obtain a realistic, acceptable (conditional on various diagnostics relating to fits, dynamics etc.) assessment in all cases. If this occurs this essentially leaves us without a basis from which we can construct a suite of OMs.

In the weaknesses side of the equation, points 1 and 2 are often deeply inter-connected. Often, the reason we cannot obtain a workable answer, even with apparently informative data on absolute abundance, is that – if we accept the data as correct – there is something *wrong enough* (all models are wrong at some level) with our suite of model structures that, when faced with the data, they fail in some way. One could arguably define the most recent status of the yellowfin assessment in this way. We have a flexible but, ultimately, constrained assessment modelling framework (Stock Synthesis). The data - in terms of fishery length composition, mark-recapture and CPUE indices that do appear to indicate the presence of a production function – at face value appear likely to be informative on overall abundance and regional dynamics (relative scaling, migration). However, over the last few years it has proved very challenging to obtain recent estimates of abundance that appear capable of sustaining either reported catches just after the estimation period ends, or likely catch levels in the first few years of any projections. That alone is a logical inconsistency that makes it very difficult to accept the assessment and then use it as the basis for OM construction.

For the vast majority of stock assessments, most of the data tends to be concentrated in the most recent years. Naturally, if there are model structure issues, it is in these time periods that we tend to see them simply because the data are concentrated there. For example, in spatial models we almost always assume that movement, while possibly length/age dependent, is time-invariant. When one has, for example, electronic tagging data, this assumption has often shown to be incorrect (Basson *et* al., 2012). The effects of this structural problem in a model will not be seen in the time periods with little to no data for obvious reasons; it will manifest itself in the most recent periods where the majority of the data are available. If this is coupled with a stock where fishing mortality rates are estimated to be high and/or the abundance is depleted, we can see sporadic cases where the model-predicted abundance in a particular region (or overall) is simply not large enough to support the observed catches, or the fishing mortality is so high future likely catches cannot be taken because the abundance in some particular cohorts is so low. In the estimation phase we can penalise particular combinations of parameters that result in these pathological cases (which can solve the first problem) but it doesn't really solve the problem of very high current fishing mortality where future catches aren't achievable. Also, while we can penalise these problematic parameter combinations, if there is insufficient flexibility in the model there may not be a part of possible model space that both fits to the data *and* solves the catch removal problem.

Conditioning the OM without an accepted stock assessment

We may not be able to directly translate a stock assessment to a suite of OMs if that assessment is not accepted for fundamentally sound reasons. That doesn't mean we cannot use the available suite of data, life-history and fishery information to construct OMs by other means. Fundamentally, we require an OM to be able to represent a plausible range of current status scenarios and initial conditions for the stock, be able to simulate future population dynamics, and generate representative observations (i.e. that possess the properties of the actual observed data) for use in the candidate MPs. If we are not using the stock assessment as the basis for OM construction we have to then define in some way what the recent stock status and other initial conditions required for the projections are. An important point to reinforce is that we still have the same fundamental OM structure (and candidate MPs and summary statistics) as before, it is just being parameterised in a different way. In the absence of basically *any* status information – very data poor scenarios – or when exploring generic performance attributes of MPs (Carruthers *et al.*, 2015) one often defines a wide suite of starting stock status scenarios (e.g. over exploited, fully exploited, under exploited). A fully accepted robust assessment sets a high bar where abundance and mortality is well estimated, the data are well explained, and there are no pathological dynamics emerging. It is a false dichotomy to suggest that an unaccepted stock assessment means that we have no information that could be used when conditioning an OM. In the IOTC context, even if we have a stock assessment that has not been accepted, there is still going to be a variety of information we could use to assist in conditioning an OM:

- A plausible range of recent stock status – it may be wider than the "true" underlying status but from the MSE perspective that is not necessarily a negative property
- Recent recruitment dynamics e.g. higher or lower than the long-term average
- Movement parameters: some measure of "average" likely migration scenarios

The key to utilising the available information is translating quantitative and semi-quantitative scenarios into probability distributions for key parameters and a suite of plausible initial conditions for OMs that can generate representative future observations. Figure 1 shows a relative simple schematic of the key features of this approach to conditioning. The natural setting for conditioning OMs via this method is using likelihood free methods like Approximate Bayesian Computation (Sunnåker et al, 2013; Wilkinson, 2013.), synthetic likelihood (Wood, 2010), or a a fully Bayesian version of synthetic likelihood (Price *et al*., 2018). A specific example of this, although not clearly identified with ABC methods, was the method in Bentley and Langley (2011), termed feasible stock trajectories. This was the method used in the first OM for IOTC skipjack, used in the analysis for the adoption of the current skipjack HCR. A similar example would be the conditioning of the OMs for the MSE work done for Australia’s small pelagic fishery (Punt *et al*., 2016), where an Annual Egg Production survey of absolute spawning biomass, life-history and selectivity assumptions were combined with a suite of plausible hypotheses for current depletion. The main point is that there are well established probabilistic tools available that can be used to condition the OMs that can accommodate all the available information, as well as ensure that the future data are representative and consistent with observed data. One of the advantages of this approach is that we need not necessarily be bound to the more rigid structures that a stock assessment requires (e.g. stationary migration) to fully estimate historical dynamics and fit to all the available data. By statistically imposing plausible distributions of current stock status and other key variables, we have more flexibility to explore a wider array of hypotheses – particularly in terms of spatial issues and non-stationarity of parameters – for the most recent years, where they often influence the projections the most.

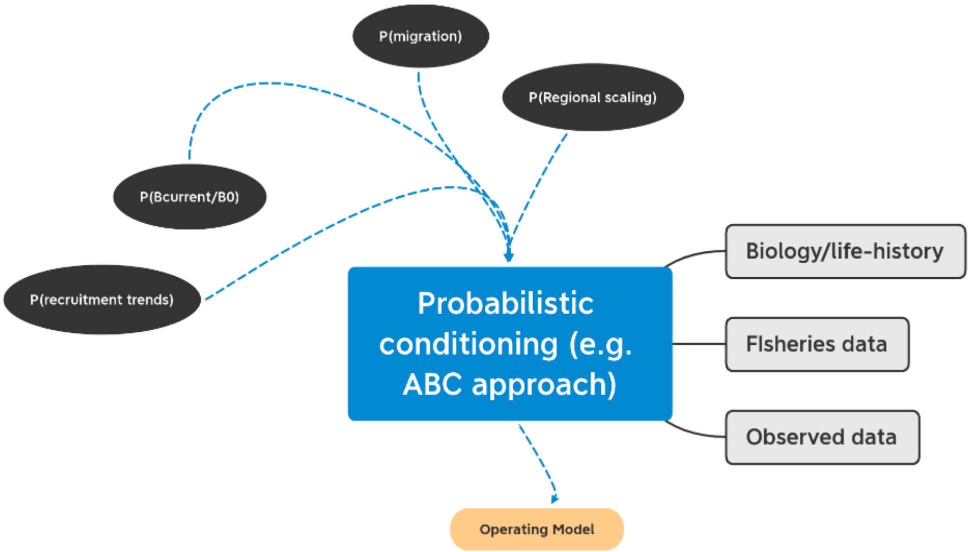

Figure 1: Schematic of the alternative OM conditioning approach. The grey rectangles represent the usual stock assessment inputs (biology, catches, observational data); the black ovals represent the key distributions that will inform current status and initial conditions for the OM projections; the blue rectangle is the probabilistic conditioning algorithm that feeds into the Operating Model (salmon box) and into the existing MSE framework.

Summary

This paper explores the process of conditioning OMs in the IOTC MSE context. Initially, and for very good reasons, that process has been driven by translating the stock assessment model to a set of OMs, with uncertainty represented using the grid approach and additional robustness tests. Additionally, we then outline what could be done if an acceptable stock assessment cannot be obtained. The reason for exploring the second option is scientific pragmatism: ideally we would like a robust and well-posed assessment model (or suite of models) upon which to base OM construction. Realistically, and given the yellowfin tuna experience over the last few years, this may not be achievable for a number of stocks. It is our contention that we can still construct robust and representative OMs for use in the MSE work, and in this paper we describe the non-technical details behind how we might achieve this goal. An important point we want to make is that this is not a suggestion of a fundamentally new approach to be applied to all IOTC stocks – those with acceptable, robust and reasonably mature stock assessments already have a logical and well established OM conditioning approach being used. What we seek to introduce to the Working Party are some ideas to stimulate discussion on what we can do if we have stocks where the assessment is no longer a workable basis for conditioning the OMs.

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