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Development of a Management Strategy Evaluation process for IOTC *

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Introduction

The adoption of management plans for Indian Ocean tuna stocks appears to be in the IOTC agenda for the near future, as expressed by both Commission and Scientific Committee. Scientific backing for any management plan needs to be the result of careful and detailed work that attempts, to the best capacity of the IOTC scientific community, to acknowledge all sources of error and variability, explore possible measures robust to those uncertainties, and present this in a clear and direct manner to managers and stakeholders.

The use of Management Strategy Evaluation, also termed Management Procedure approach (Rademeyer *et al.*, 2007), was proposed as a way of developing management plans for IOTC stocks years ago (Basoon, 2002). MSE has been widely used in the years since, in various stocks and management settings, from EU waters (Rice & Conolly, 2007), to Southern Bluefin Tuna, whaling (Punt & Donovan, 2007), or even mammals (Bunnefeld *et al.*, 2011).

In this document, some issues relevant to the development and testing of management procedures for Indian Ocean tuna stocks are presented, and a number of suggestions are made on which way the IOTC scientific community could tackle this work successfully.

*This document does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area.

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What to model

Evaluating a management procedure is a three step process, involving (1) the development and fitting of data to a model of the natural world, including the ability to generate future data, (2) the application of an estimation model to assess stock and fishery status against a set of indicators, and (3) a decision rule to choose an appropriate management action according to the value of those indicators.

The first element is termed Operating Model (OM), and should generally consist of the best representation of the known dynamics of the natural and human fishery system. Although a strong temptation exists in the development of complex such as this models to incorporate every single process suspected to occur in nature, or for which we have some information (Hilborn & Walters, 1992), a pragmatic approach is certainly required when developing an OM and a simulation procedure for a system like the Indian Ocean tuna fisheries. No definite program from the possible range of models and approaches is presented here. Instead, a number of issues worth of attention are brought up to guide the initial discussion, to be continued by the relevant Working Parties of IOTC.

Operating model(s)

A model or set of models of the underlying true dynamics of the system forms the experimental basis for testing management strategies under simulation. A population model similar to those employed in stock assessment is commonly applied, or used in the initial phase, but it might also include associated species or even whole ecosystems (Smith *et al.*, 2007). The models are then fit to the available data, a process sometimes called OM conditioning (Butterworth, 1999, Rademeyer *et al.*, 2007).

The essential question here is for the most influential processes in the system to be incorporated explicitly: their importance, and the uncertainty around their strength and direction, should be carefully assessed from available information and, if deemed significant and well established, should become part of the OM. This should apply for both the functional form and the parameter values employed (Butterworth & Punt, 1999)

A first take at a simple OM for single stock is commonly based on a detailed stock assessment (Kell *et al.*, 2007), such as those carried out for some IOTC stocks like yellowfin and bigeye. It is important to recognize that this could limit the range of scenarios that the simulations are able to cover, as certain processes are not included in the stock assessment model, or their uncertainty is absent or not well estimated.

Subsequent work should focus on establishing a set of reference OMs, combined with the appropriate robustness trials, as outlined below. Some relevant thoughts on what an OM for IOTC stocks should include has already been brought up (Anganuzzi, 2002), and should form the basis for the necessary discussion, with the incorporation of all that has been learned about the tuna stocks of the Indian Ocean.

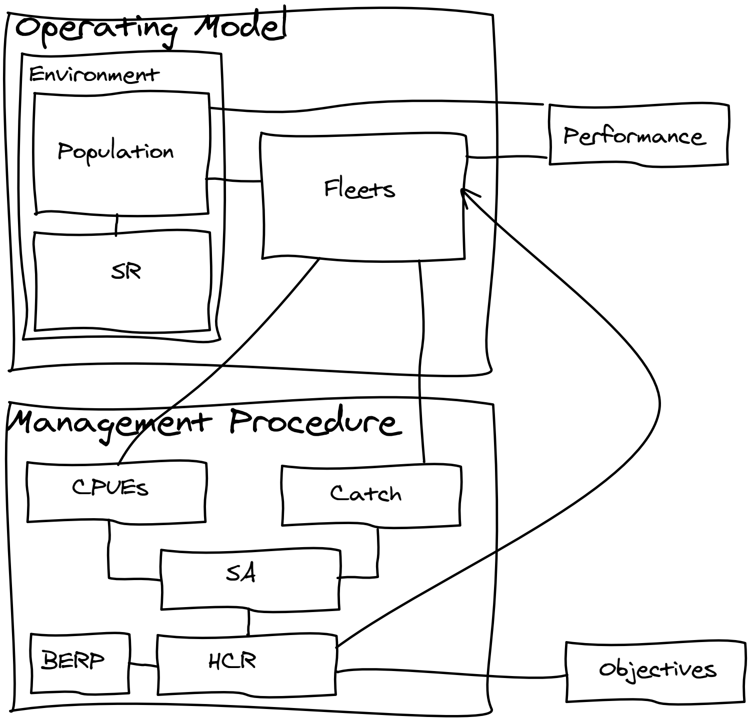

Figure 1: Diagram of MSE structure and main flows.

Robustness trials

A number of assumptions will be present in the OM, as is the case in any statistical model. Once a reference set of OMs as been chosen, they should be tested for robustness against a set of scenarios (Cooke, 1999). They should include more extreme situations than those present in the reference set, and should provide useful guidance on the limits under which the included assumptions still hold true. Rademeyer *et al.* (2007) provide a set of possible scenarios, which could be reinterpreted in IOTC terms as follows:

- *past data*: bias in CPUEs due to technological creep, errors in catch statistics for certain fleets
- *future availability of data*: data currently available not being provided, deterioration in data quality, role of tagging data

- *resource dynamics*: different growth models, alternative stock-recruitment curves, existence of sub-stocks
- *environment*: changes in productivity

One of the first tasks related to the development of OM for Indian Ocean stocks would be identify the range of factors assumed or known to affect population dynamics and catchability, compile the available information that would allow for their characterization (i.e. parametrization of some kind of model), and explore the possibilities of using those models to further widen the range of OM or to provide a set of robustness trials. Part of this discussion will have to be driven by the agreed management objectives, in order to prioritize those elements we are more interested in understanding. For example, if uncertainty on the exact role of efficiency on the Longline CPUEs is thought to be an important consideration, then the chosen OM should be robust against this factor and reproduce the dynamics of the resource in the absence of that information.

Management Procedure

The Management Procedure is formed by the combination of data collection, Stock Assessment (SA), and a Harvest Control Rule (HCR). The first provides with the necessary information, and issues on data quality are always important to consider. They are likely to have a significant effect in the ability of a HCR to behave as expected, and the costs and ability to collect it might need to match the objectives set for management in terms of, for example, permitted risks of dropping below reference points. To detect certain changes with a given probability will depend greatly on what data is available to infer population trends.

The stock assessment element of the management procedure could be of lesser or greater complexity, but ideally should concentrate on using the most important elements of available information (CPUEs, catch data, . . .). For reasons of computational speed, the SA model here is commonly far simpler than the population model used in the OM, and could even be substituted for certain stocks with a simple set of indicators. The trade-off between computational capacity and realism needs to be solved for each particular implementation, but recent examples exist in which simple models, such as biomass dynamics, have been shown to perform well enough for informing a HCR in tuna stocks (Kell *et al., in press*).

Economic indicators and feedback models

Evaluations of management plans under the EU Common Fisheries Policy, as carried out by STECF[1], routinely include economic aspects. Yield and effort, as predicted in the model projections, is translated into income and costs, and the relative economic performance of different management options, once the well-being of the stocks is ensured, can be used to recommend among alternative plans (see, for example STECF, 2010b).

[1]Scientific, Technical and Economic Committee for Fisheries

Fully incorporating the impact and responses on and of the various fleets, of and to management measures, has been attempted in various EU research projects, for example, but the difficulty of accurately predicting responses to regulations, as well as price and cost dynamics, mean there has not been many examples in which predicted responses to management have been fully applied in choosing among management plans. Recent developments are pointing in an interesting direction, in which aggregated responses to management are being modelled as random processes, and attention is paid only to strong signals in costs and prices (Da Rocha *et al.*, 2010).

Data availability is likely to be a major concern in IOTC for any attempt at evaluating the performance of management plans in economic terms. The scale at which any indicator can be constructed is likely to be fairly large, and the complexity of the price dynamics, given the global nature of part of the tuna market, combined with the multiple small-scale markets in coastal countries, appears to make any attempt futile. The advantages of incorporating economics into the analysis are likely to come from its role in dialogue with the various stakeholders, so it might still be a viable and worth proposition to bring experts in the field into this modelling exercise.

Organizing the development

Development of a modelling exercise like the one proposed here is an arduous and complicated task, and even more so when carried out by a range of researchers across various disciplines and institutes. The core of the proposal here is to agree on a development model along the lines outlined below, and a simple set of procedures that attempt to ensure equal chances of participation, full transparency and accountability, a high quality final product, and a process that benefits from wide acceptance and participation.

Development framework

Development of a set of simulations like those required here, should be well planned and follow an agreed protocol, for example STECF (2010). Issues of procedure and responsibility should not stand in the way of achieving the agreed objectives. The current availability of internet tools for distributed development and collaboration allows for inter-seasonal work to be conducted despite distances and time-differences

Platform

The choice of an unified software platform would greatly benefit the ability of scientists to exchange ideas and their precise implementation, the capacity of the group to peer-review the process, and to benefit from outside contributions. The R statistical language (R Development Core Team, 2011) has become the de-facto *lingua franca* of statistical computing. Its flexibility, relatively-smooth learning curve, and the availability of a wide range of contributions makes it a good choice for this task (Schnute *et al.*, 2007). The usually-cited shortcomings of the language, most notably regarding speed, can be overcome by use of distributed High Performance Computing (clusters and grids), the combination of R with compiled languages (like C, C++ and Fortran), and by careful consideration of the data structures employed (Kell *et al.* 2007).

Building on the advantages and richness of R, the FLR Project (Kell *et al.*, 2007; `http://flr-project.org`) has developed a set of libraries containing data structures, methods and procedures that simplify the assemblage of many types of models and simulations of fisheries systems. It is currently being applied by working groups of various fisheries scientific and management organizations for tasks such as:

- Stock assessment using surplus production or age-structured models by ICCAT and ICES.
- Evaluation of the impact of policy decisions on European stock, by EC DG Mare on the new CFP.
- Analysis of management plans for swordfish, yellowfin and albacore by ICCAT.

This framework is under active development, with a core team comprised of 10 researchers from various institutes in Europe and elsewhere, and keeps an active community of users that engage via mailing lists and an open wiki website. A training program is now underway, with introductory courses on R and FLR, and advanced ones on stock assessment and MSE using FLR. See, for example, the information at ICES' Training Programme (`http://www.ices.dk/iceswork/training/training.asp`).

Organization and responsibilities

The development workflow that is necessary for the modelling exercise propose here is clearly different from the one Working Parties employ to conduct the yearly cycle of stock assessment. There is a greater need for coordinated inter-sessional work, for coherent developments that are able to be incorporated into a larger modelling framework, and for progress to be achieved at a faster pace that what the usual yearly meetings allow.

The usual structure for scientific work in IOTC, in which the members of a working Party is in charge of carrying out the necessary ground-level work that will later inform the discussions of the Scientific Committee, will possibly need to be supplemented by some arrangement providing basic support to the development work, probably carried out around the Working Party on Methods (WPM). An essential element in this arrangement will be the election or nomination of a coordinator that should act as central gatekeeper of the development process.

The role of such co-ordinator is not to limit the input that WPM members are able to provide, but to ensure that common standards of quality, replicability, code efficiency and documentation are followed. Contributions made according to the set procedure (e.g. changes to existing code using a diff algorithm[2]; new functions following the agreed guidelines on input/output, testing and documentation, ...) are then reviewed by the coordinator before being added to the common source code tree, and the necessary simulations are then run.

[2] `http://en.wikipedia.org/wiki/Diff`

Distributed framework

Development of these simulations should make use of tools now commonly applied for distributed software development projects, such as the Linux kernel, or the R language. The basic elements are:

- A Version Control System[3], where source code, documentation, inputs and outputs are stored. All changes are recorded, so it is possible to undo modifications, track development along time, and have parallel versions where different approaches are tested.
- Access to some High Performance Computing system, such as a dedicated cluster or a grid server, allowing for efficient and quick runs of simulations and procedures
- A dedicated server that will automatically assemble code packages and run an standard set of tests at given intervals (e.g. daily or weekly). The test reports will the be made available online.
- A set of web tool for communication, for example a wiki site for discussion and assembling of documents, a dedicated mailing list that receives notifications of changes to source code, runs of simulations, ...

Protocol

It would be useful for the smooth running of inter-sessional work to define a number of basic protocols, which should be more a reminder of steps than a rulebook, built around the main workflows that could be identified, like, for example:

- Submission of a new dataset: CPUEs, catch series, environmental variables. . . .
- Reporting a bug in the code or an error in the output files
- Adding a new function or method to replace or complement existing ones
- Proposing a new set of outputs, plots or indicators to be extracted from simulation results

Dialogue and presentation

The impact on management of a MSE procedure is likely to depend on several factors. The political will to better manage the fisheries, and even the support of fishery stakeholders for doing so, is a necessary although not sufficient condition for achieving success (Holland, 2010). The first element in which stakeholder and manager input is required relates to the objectives for the fishery, both in terms of stock status and economic or yield expectations.

[3] `http://en.wikipedia.org/wiki/Revision_control`

Deciding on precise objectives for management is an essential component for the development of HCRs. Discussion on this issue could be best carried out in some multi-lateral meeting, where scientists, managers, industry and other stakeholders, can be introduced into the precise ways in which IOTC finally decides to conduct the development of management plans, feedback can be obtained on the issues of interest to various parties, and agreement could be attempted on the exact objectives that the plans should attempt to provide for.

Given the likely diversity of the audience, an extra effort needs to be made to make the presentation of model and results as clear and attractive as possible. The issue of communication of scientific results, always difficult, is likely to be of major impact for the acceptance of modelling exercise on great complexity.

Finally, some kind of external review process is probably appropriate, both in terms of internal quality assurance, and for external accreditation of results and methods.

Workplan and calendar

A realistic workplan, although one requiring substantial efforts by those involve, could be devised with a view to deliver a final set of results to the 16th Session of the Scientific Committee, in 2013.

- JAN-APR 2012 - Inter-sessional work
- FEB-JUN 2012 - Multilateral meeting on management objectives
- APR 2012 - Meeting of the Commission
- JAN-OCT 2012 - Inter-sessional work
- OCT 2012 - Meeting of the Working Party on Methods
  - Review of first results on exploration of OM uncertainties and robustness tests
  - Agreement on final reference set of OMs
- DEC 2012 - Meeting of the Scientific Committee
  - Presentation of OMs and exploration of most relevant uncertainties
  - Agreement on choice of OMs
  - Agreement on precise interpretation of HCR objectives and priorities
- APR 2013 - Meeting of the Commission
- OCT 2013 - Meeting of the Working Party on Methods
- DEC 2013 - Meeting of the Scientific Committee

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