**SHORT-TERM CONTRACT FOR MODELLING APPROACHES: SUPPORT TO BFT**

**ASSESSMENT (GBYP 02/2014) OF THE ATLANTIC-WIDE RESEARCH PROGRAMME ON**

**BLUEFIN TUNA (ICCAT-GBYP – Phase 4)**

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**Progress Report 1**

**Simulation evaluation of management procedures**

A spatial operating model was defined for three life-history types of varying longevity, including Atlantic bluefin tuna (ABT). The operating model follows biological parameters established in recent stock assessments (ICCAT 2012). Twenty seven management procedures (MPs) were subject to simulation testing including those recently published by Geromont and Butterworth (2014a; b) those established for Southern Bluefin Tuna (CCSBT 2011) and a set of novel MPs based on the surplus production theory of Maunder (2014). We also included simple delay-difference stock assessment methods as reference approaches.

In collaboration with members of the core modelling group, a research paper (Carruthers et al. 2014) has been drafted that summarizes the results of the simulation testing and identifies avenues for future research. The paper is undergoing revision to accommodate the feedback of the coauthors.

The simulation analysis has led to the compilation of a wide range of MPs that are now available for future ABT MSEs. Each of the MPs has parameters that may be tuned to the specific stock status and biology of ABT. The MPs may then be subject to robustness trials.

**Construction of an MSE framework for the testing of MPs for Atlantic bluefin tuna**

The core programming work for establishing a preliminary MSE for ABT is in its final stages. The simulation software has been designed in the R statistical environment using object-oriented programming and is compatible with parallel processing. Once the code has been thoroughly tested it will be made available to the core modelling group on the development site GitHub.

The central object classes are operating model definition (OMd), operating model (OM), observation model (Obs), implementation (Imp) and management procedure (MP) classes (Fig 1). The simulation model is structured by age, space, stock and sub-year time steps and can simulate time varying biology (growth parameters, natural mortality rate, deviations in recruitment strength) and exploitation of by multiple fleets with varying age-selectivity dynamics.

The OMd class describes the range of characteristics of the simulation including the dimensions (number of years, areas, stocks, fleets, sub-year time steps), simulated stock status, stock-recruitment model, growth etc. The OMd class sets up the operating model for undertaking projections using MPs. While the OMd class can define an OM, where appropriate it may be supplemented with the results of detailed stock assessments or other data analysis (for example tagging data used to define credible movement matrices).

The Obs class defines the observation model that controls the quality of data generated by the operating model that is used by the management procedures (for example imperfect information in natural mortality rate, precision and bias in historical catches). The Imp model controls how well management recommendations are followed and can simulate a range of phenomena from overages to effort reductions at low catch rates.



Figure 1. The MSE design.

The OM object class stores all the outputs of the simulation itself and has slots for variables such as population numbers, movement, mortality rate, fishing selectivity, exploitation rate and catches.

Using the OM class we can derive any number of standardized functions for tabulating and graphing performance. In this preliminary analysis we use four different performance metrics that are also described in Carruthers et al. 2014: the expected long-term yield, probability of depleting the stock below 10% of BMSY, the inter-annual variability in yield and the probability of obtaining pretty good yield (greater than 50% of an optimal fixed fishing rate strategy).

**Bayesian belief networks for communicating MSE dynamics**

Once a preliminary MSE has been undertaken it is possible to summarise the results in a Bayesian Belief Network (BBN) using freely available software such as GeNIe. The BBN maps out the performance of candidate MP across a range of simulation variables. This allows users to dynamically and intuitively understand how performance of an MP relates to central variables such as recent recruitment strength, movement rate, implementation error and bias in catch observations.

The intention of the BBN is to engage a wider group of stakeholders and initiate discussion on objectives and the central axes of uncertainty for the operating model.

This stage relies on the outputs of the preliminary ABT MSE which is still in development. However as a test of concept, trial BBNs using GeNIe have are being investigated for summarising the results of the performance review of MPs (Carruthers et al. 2014).

**References**

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