PROPOSED WORK ON STOCK STATUS INDICATORS FOR BILLFISH AND TROPICAL TUNAS

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SUMMARY

This document presents a summary of the objectives and workplan of a project to develop stock status indicators for billfish and tropical tunas. The three year project is jointly funded by the Australian Fisheries Research and Development Corporation and CSIRO, and started in September 2003. The project is relevant to the work of the IOTC both directly with regard to stock status indicators and indirectly with regard to an operating (operational) model for stocks and fisheries in the Indian Ocean.

INTRODUCTION

We have recently begun work on a project to develop robust stock status indicators for billfish and tropical tunas. The project was developed with two needs in mind: (1) a need in the domestic context to monitor and manage the Eastern (ETBF) and Southern and Western (SWTBF) tuna and billfish fisheries of Australia, and (2) a need in the international context for robust stock status indicators in situations where standard stock assessments are impossible, difficult or not likely to be feasible in the near future. The three target species in the SWTB Fishery, broadbill swordfish *(Xiphias gladius),* bigeye tuna *(Thunnus obesus)* and yellowfin tuna *(Thunnus albacares)* form part of the Indian Ocean stocks which fall under the remit of the IOTC. The research proposed in this project was identified as a high priority task at recent IOTC Working party meetings. Although some aspects of the work will be specific to the Australian domestic fisheries, a large proportion will be of a general nature and therefore relevant to the work of the IOTC.

PROJECT OBJECTIVES AND RELEVANCE TO THE WORK OF THE IOTC

The main objectives of the project are:

1. Design a candidate set of potential stock status indicators (SSIs) which reflect a wide range of aspects of stock and fishery status, including spatial aspects, and develop appropriate standardisation procedures for the SSIs.
2. Develop candidate frameworks and methodology for a management system based on a suite of indicators
3. Test the robustness of SSIs (individually and jointly in framework) and develop meaningful reference points and decision rules, in consultation with fishery assessment groups (FAGs) for domestic fisheries

The third objective will be addressed by constructing a flexible operating model which can be parameterised and/or conditioned to reflect different species and different hypotheses about each species' life history and dynamics. Therefore, in addition to the obvious relevance of robust stock status indicators to the work of the IOTC WPs on billfish and on tropical tunas, there is also potential relevance of the operating model(s) which will be developed and used in this project. This is further considered below.

Although not an objective as such, a key component is ongoing communication and interaction with domestic stakeholders and the relevant working parties of the IOTC throughout the life of the project.

This project will build on the work by Punt *et. al.* (1999) who evaluated the performance of indicators for swordfish stocks off eastern Australia in a preliminary study. Although results from that study are relevant to the ongoing task of identifying stock indicators, several key aspects were not investigated. For example, only a small number of indicators for swordfish were considered and standardisation of the indicators was not considered. Robustness testing with regard to uncertainty in parameters other than stock structure was also limited. Only the performance of single indicators (rather than a collective suite of indicators) was evaluated, and this was done without management feedback control. Finally, while this project indicated that the performance of any single indicator may be poor, it remains to evaluate the performance of indicators jointly and with management feedback control.

The project will also build on a recently completed project on Swordfish off the East Coast of Australia (Campbell & Dowling, 2003). In particular, we intend to take the operating model developed and used in that project, and modify it as necessary for the work of this project. Annex 1 (below) gives details of the model as it currently stands, and compares its characteristics with the key requirements of an operating model for use in the IOTC context as identified in Anganuzzi (2002).

It should be noted that there are limits to the scope of the project. For example, it is beyond the scope of the project to construct detailed fleet dynamics for the non-domestic fleets. Also, consideration of spatial stock indicators will primarily focus on the area fished by the domestic fleet. The operating model needed for this project will therefore not contain all the components with sufficient detail to use directly as a model in the IOTC context. We are, however, keen to construct our components in such a way that they could easily be linked with components programmed by other scientists in future.

PROJECT WORKPLAN

During the first year of the project, the focus will be on the definition of a set of candidate SSIs and standardisation processes to use, where applicable, for all three target species (broadbill swordfish, yellowfin and bigeye tuna) in the SWTBF fishery. We will evaluate which modifications need to be made to the existing model (from the ETBF project), and start making those modifications, particularly for swordfish. This is therefore and opportune time to discuss any additional requirements or any specific hypotheses that should be considered for incorporation into such a model for swordfish.

In the second year of the project, the focus will be on first stage robustness trials of candidate stock status indicators and frameworks, and the completion of further modifications to allow operating model versions for other species. Work in the final year will complete robustness trials, conduct further trials on feed-back management strategies, and synthesise results.

CONCLUSION

We welcome feedback from the Working Party on Billfish at this early stage of the project, particularly with regard to:

> the criteria for an IOTC operating model, aspects of stock status which should be reflected by indicators and tested for robustness, and key alternative hypotheses for broadbill swordfish population structure and dynamics.

REFERENCES

ANGANUZZI, A. 2002: Some notes on the structure of an operational model in the IOTC context. WPMO2-01, IOTC: Proceedings *no.5*, p^{70}-^{73}.

PUNT, AE; CAMPBEL, RA; SMITH, ADM. 1999: Evaluation of Performance Indicators in the Eastern Tuna and Billfish Fishery - A preliminary study. Final Report to AFMA.

CAMPBELL, R AND N. DOWLING 2003: 'Development of an operating model for evaluation of harvest strategies in the ETBF', Final Report to the FRDC.

ANNEX 1.

Development of an Operating Model and Evaluation of Harvest Strategies for the Eastern Tuna and Billfish Fishery: Overview of operating model and criteria for an IOTC operating model.

This project was undertaken to gain an understanding of sustainable catch and effort levels in the Australian Eastern Tuna and Billfish Fishery (ETBF) and to provide management advice on harvest strategies to managers. A Management Strategy Evaluation (MSE) framework was developed for broadbill swordfish *(Xiphias gladius)* assuming a single stock in the south-west Pacific. The operating model is area-specific with 5 regions, and the time step is quarterly (seasonal movement and reproduction). The model considers catch and effort patterns across 3 fleets (Australia, New Zealand and Japan). Catch and effort data for artisinal fleets is incorporated in the Japanese data. Input parameters pertaining to population biology were obtained from the literature and from recent studies in the ETBF. Uncertainties in these inputs were accounted for by testing a suite of alternative operating models.

The model has a historical component which is conditioned on historical data, and a projection component. The projection component can be run with a range of different feedback harvest control rules or with non-feedback assumed effort series.

HISTORICAL DATA USED IN THE MODEL

The model incorporates the following catch data, and the conditioning phase fits to the following length- and weight-freqeuncy data:

Japanese catch and effort data: monthly, area-specific: 1971-2001

New Zealand catch and effort data: monthly, area-specific: 1991-2001

Australian catch and effort data: monthly, area-specific: 1990-2001

Quarterly catch by 10kg weight class for the Australian fleet in 3 areas: 1997-200 1

Quarterly catch by 10cm length class for the Japanese fleet in 1 area (recorded by New Zealand

observers): 1991-1999

In total, 12 parameters are estimated in the conditioning phase (11 movement parameters, 1 initial recruitment parameter). The level of depletion of the stock in 2001 is treated as an input parameter, and a wide range of scenarios are explored for this parameter.

TYPES OF OUTPUT AND PERFORMANCE INDICATORS

Simulated catch, effort, CPUE and the upper ~ mass percentile, were used in empirical decision rules and in the production model.

The following were used to evaluate the performance of the harvest strategies:

"True" quantities from the operating model: average final spawning/fishable/total stock biomass relative to initial spawning/fishable/total stock biomass, average probability of spawning/fishable biomass dropping below 20%, 30% and 50% of its initial level.

Simulated data (averages taken across 100 Monte Carlo simulations): average annual Australian catch, average mean and upper 95~ percentile length and mass of fish in Australian catch, average percentage Australian catch by 3 size classes, average percentage of fish in Australian catch >50kg, average Australian dollar value of catch, median inter-annual change in catch/catch rate.

Estimated indicators from the Prager production model: Bo, MSY, Bmsy, Fmsy, Emsy

APPLICATIONS TO DATE

- • Evaluation of alternative initial domestic TAE levels to provide scientific advice to the MAC in setting the initial TAE.
- Testing alternative harvest strategies with respect to fixed increases in levels of domestic and foreign effort, application of effort creep, and the rate of effort increase.
- Testing the effectiveness of an empirical assessment based on temporal catch rate patterns, and of a simple Prager production model.
- Identification of biological inputs to which the model performance indicators are robust, and those to which they are sensitive, thus focusing future research needs

COMPUTER TECHNICALITIES (I.E. C++, ADMB)

The historical model on which the parameters are conditioned was written in A-D Model Builder, which facilitates rapid convergence of the 12-parameter model (11 movement parameters, 1 initial recruitment parameter).

The operating, assessment, sampling and management models are all written in Visual C++. The code is not object-oriented but the model is comprised of modular functions.

COMMENT AGAINST ANGANUZZI'S (2002) CRITERIA FOR AN IOTC OPERATING MODEL:

The model should be age, size, time and space-structured

- The model has quarterly ages up to a maximum age of 20 years. Length-at-age is defined using 10 von-Bertalanffy growth curves. Time-step is quarterly. Model is area-specific with *5* spatial regions within the SW Pacific

It should allow for multiple fleets with different and variable selectivity

- Currently the model includes 3 fleets but could easily adapt to an alternative number of fleets. All fleets have identical selectivity, but variable selectivities could again be readily accommodated.

It should **allow for testing trends and variability in catchability, including effects due to targeting**

- The model currently has fleet-specific temporal catchability curves. Catchability for the Japanese fleet is modelled as a linear function of time, while catchability for the Australian and New Zealand fleets is modelled as an inverse exponential curve to account for the rapid shift in targeting to broadbill swordfish.

It should allow for the distribution of fishing effort and catchability to change spatially and temporally

- The model is conditioned on quarterly, area-specific effort data. Catchability is modelled as a function of time for each fleet, and this could easily be a function of area also.

The spatial structure should be sufficient to allow testing for effects due to concentration of effort and density-dependent population responses in habitat use, but it does not necessarily need to he a hh~hlv realistic renresentation of the Indian Ocean

- The SW Pacific model covers 40 degrees of latitude and 40 degrees of longitude, which is divided into *5* areas. These *5* areas were divided based on historical trends in catch and effort for each fleet. Aside from a Beverton-Holt stock-recruitment relationship, there are currently no density-dependent population responses incorporated in the model.

The spatial component should allow for movement between areas that contains both random and directed components. This may need to vary with age and season to account for spawning behaviour etc.

- Movement between the 5 areas in the model is currently a function of fish length. While it is underpinned by a directed component, temporal noise is imposed on the probability matrix. However, the population is not divided into fish that move in a directed versus random manner, although this could easily be done.

The model should allow for flexibility in modelling of growth. It should allow for both density-**dependent and size-based models to be incorporated. However, this** is not seen as **an initial high priority and the initial modelling of growth would be done using a standard** VBG **formulation**

- Currently fish are assigned to one of 10 different von-Bertalanffy growth curves (5 each for males and females). The 5 curves for each gender are centered around a "best guess" curve based on the literature. However, alternative modelling of growth is certainly feasible within the model framework.

Recruitment should be flexibly modelled to include a range of possible stock recruitment relationships with a random component. It should also allow for a range of different hypotheses for how recruitment is spatially distributed, including the possibility of localised stock-recruitment relationships.

- A random noise term is applied to the Beverton-Holt stock-recruitment curve. Alternative stock-recruitment relationships could readily be incorporated. Currently recruitment is assumed to occur in the first two quarters of the year, and is spatially distributed according to average Japanese catch-rate patterns. Again, this is easily adapted to accommodate alternative spatial recruitment hypotheses.

The observational data produced by the model need to include realistic levels of variability and potential biases

- The model framework allows for both random error and bias to be imposed on the observational catch data produced by the model. Additionally, the modelled (effective) effort is standardised for the effect of increased targeting, as described by the catchability function, and a random error is also imposed.