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An Example Management Strategy Evaluation North Atlantic Bluefin Tuna Of A Model Free Harvest Control Rules

Laurence T. Kell [*], Richard Hillary [†],
Jean Marc Fromentin [‡], Sylvain Bonhommeau [‡]

SUMMARY

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[*] ICCAT Secretariat, C/Corazón de María, 8. 28002 Madrid, Spain; Laurie.Kell@iccat.int; Phone: +34 914 165 600 Fax: +34 914 152 612.
[†] CSIRO, Australia
[‡] Ifremer

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1. Introduction

A Harvest Control Rule (HCR) relates the recommended catch, or other fishery control measure, to the current value of selected control variables. A HCR may be empirical where control variables are directly measurable quantities (e.g., catch rate, size composition, tag recovery rate, survey estimates of abundance or species composition) or model based on an Estimator which is a statistical procedure that provides information on resource status and productivity from past resource monitoring data.

An empirical HCR has been adopted for Southern bluefin tuna *(Thunnus maccoyii)* (SBT) where the TAC is set using data solely from a fisheries dependent Catch Per Unit Effort (CPUE) index of adult abundance and a fisheries independent aerial survey of juveniles (i.e. empirical indicators). The HCR uses a relative procedure based on year-to-year changes and in the indicators. Before the HCR can be implemented appropriate reference levels (e.g. based on historical catch, effort or CPUE) must be selected and parameters tuned to meet management objectives using Management Strategy Evaluation (MSE). Where the HCR is evaluated as part of a Management Procedure (MP), i.e. the combination of pre-defined data, together with an algorithm to which the data are input to provide a value for a TAC or effort control measure.

We first describe the empirical (i.e model free) HCRs used by CCSBT and then conduct an MSE for Atlantic bluefin tuna.

2. Management Strategy Evaluation

Data for use in the MP are sampled from the Operating Model (OM) via the Observation Error Model (OEM). Where the OM is a mathematicalstatistical model used to describe the actual resource dynamics in simulation trials and to generate resource monitoring data when projecting forward. The OM generates fishery-dependent and/or fishery-independent resource monitoring data for input to the MP. The aim of an MSE is to demonstrate through simulation trials the robust performance of feedback control rules in the presence of uncertainties.

2.1 Operating Model

The OM is based on the East Atlantic and Mediterranean BFT assessment (SCRS 2012) and projection (SCRS2013-186). The assessment was conducted using Virtual Population Analysis (VPA) in 2012 (SCRS, 2013) when two historical catches and three future recruitment scenarios were considered (six in total). The two levels of catch were the **reported** and the **inflated** scenarios. In the latter case catches were raised to 50,000 tonnes from 1998 to 2006 and to 61,000 tonnes in 2007. Three recruitment scenarios acknowledged that there was insufficient scientific information to determine precisely the productivity of the stock and so projections were conducted with three recruitment levels corresponding to **low**, **high** and *medium* scenarios estimated from recruitment over different historical periods.

2.2 Management Procedure

The MPs are based on the model free HCR developed by CCSBT.

2.21 Harvest Control Rules

The MP implemented by CCSBT is an average of candidate TACs obtained from two harvest control rules. Here we run the two HCRs separately in order to compare their performance.

The first HCR is based on a single index i.e.

$$TAC^1_{y+1} = TAC_y \times \begin{cases} 1 - k_1|\lambda|^{\gamma} & \text{for} \quad \lambda < 0 \\ 1 + k_2\lambda & \text{for} \quad \lambda \geq 0 \end{cases} \tag{1}$$

where λ is the slope in the regression of $\ln B_y$ against year for the most recent n years, k_1 and k_2 are *gain* parameters.

giving 4 tunable parameters (**Table** 1)

The second HCR uses both a biomass and a juvenile index i.e.

$$TAC_{y+1} = 0.5 \times \left(TAC_y + C^{\text{targ}}_y \Delta^R_y\right), \tag{2}$$

and

$$\begin{aligned} TAC^2_{y+1} &= 0.5 \times \left(TAC_y + C^{\text{targ}}_y \Delta^R_y\right), \\ C^{\text{targ}}_y &= \begin{cases} \delta \left[\dfrac{B_y}{B^*}\right]^{1-\varepsilon_b} & \text{for} \quad B_y \geq B^* \\ \delta \left[\dfrac{B_y}{B^*}\right]^{1+\varepsilon_b} & \text{for} \quad B_y < B^* \end{cases}, \\ \Delta^R_y &= \begin{cases} \left[\dfrac{\bar{R}}{\mathcal{R}}\right]^{1-\varepsilon_r} & \text{for} \quad \bar{R} \geq \mathcal{R} \\ \left[\dfrac{\bar{R}}{\mathcal{R}}\right]^{1+\varepsilon_r} & \text{for} \quad \bar{R} < \mathcal{R} \end{cases} \end{aligned} \tag{3}$$

where δ is the *target* catch; B^* the *target* CPUE (i.e. the mean observed CPUE corresponding to some multiple of a biomass reference point such as B_0 or M_{MSY}) and $\bar{R}$ is the average recent juvenile biomass i.e.

$$\bar{R} = \frac{1}{\tau_R} \sum_{i=y-\tau_R+1}^{y} R_i, \tag{4}$$

$\mathcal{R}$ is a "limit" level derived from the mean recruitment over a reference period;
while $\varepsilon_{\bullet} \in [0, 1]$ actions asymmetry so that increases in TAC do not occur at the same level as decreases.

There are therefore 5 tunable parameters, **Table** 2

In our example we use reference periods to set δ as well as $\mathcal{R}$.

2.22 Observation Error Model

A simple OEM was constructed to generate two unbiased abundance indices corresponding to the adult biomass and numbers of recruits. A log normal random error of 30% was added to these time series.

2.23 Scenarios

The scenarios are given in **Table** 3.

The MP operates every three years, i.e.

1. In year t historical data up to and including $t - 1$ are sampled from the OM by the OEM
2. These data are then used by the MP to set a quota for 3 years starting in years $t + 1$.
3. repeat step 1 for year $t + 4$

3. Example

The catches, SSB and fishing mortalities are compared in **Figure ??**

References

4. Tables

Parameter	default
k_1	1.5
k_2	3
γ	1
n	-

Table 1: HCR 1 tunable parameters

Parameter	BP
ε_b	0.25
ε_r	0.75
δ	-
τ_B	7
B^*	-
τ_r	5

Table 2: HCR 2 tunable parameters

Factor	Levels	ΣN	Values
Historic Catch	2	2	Reported, Inflated
Recruitment	2	4	Low,Medium,High
HCR	2	8	1,2

Table 3: OM options

5. Figures

Figure 1: