Contents

1 Introduction

1.1 Background

The Indian Ocean Tuna Commission (IOTC) has committed to a path of using Management Strategy Evaluation (MSE) to meet its obligations for adopting the precautionary approach. IOTC Resolution 12/01 "On the implementation of the precautionary approach" identifies the need for fishery reference points and harvest strategies to help maintain stocks at levels consistent with the reference points. Resolution 15/10, that superseded Resolution 13/10, provided a renewed mandate for the Scientific Committee to evaluate the performance of harvest control rules with respect to the species-specific interim target and limit reference points, no later than 10 years following the adoption of the reference points, for consideration of the Commission and their eventual adoption. A species-specific workplan was re-affirmed at the 2017 Commission Meeting, outlining the steps required to adopt simulation-tested Management Procedures for the highest priority species (included in Attachment 1). Recognizing the iterative nature of the MSE process, the workplan identifies 2019 as the earliest probable date for MP adoption.

1.2 SWO assessment

2 Structural uncertainty grid

The initial strategy to follow for the development of the SWO MSE platform were discussed by the WPM in 2017 (IOTC 2017a). It was agreed to use the stock assessment carried out and reviewed by the WPB in 2017 (IOTC 2017b) based on SS3 - Stock Synthesis 3.24z - CHECK VERSION (Methot and Wetzel 2013), as a basis for the population and fishery model to build the OM for this stock. Uncertainties concerning structural elements of the model formulation were considered to be the primary factor of concern.

The WPB proposed an initial grid of options for characterizing the structure of the uncertainty grid for generating the OM, based on a set of SS3 model runs (IOTC 2017a). During the 1st workshop meeting of the authors to start the conditioning of the OM, those were discussed. The decision was to construct a grid of model runs built around those suggested by the WPB on feasible, or at least not too extreme, values for a number of assumptions and fixed parameters in the population model. The impact of some of these elements in the model were already explored in some detail by the researchers carrying out past stock assessments (Fu, 2017).

The main points relevant to this preliminary OM are: i. OM-reference (OM-ref) derived from the 2017 SS3 SWO assessment model (SA-base) used for management advice; ii. Uncertainty in the OM grid as discussed below and shown further down in Table XX.

2.1 Selectivity

Two distributins were considered for the fleets selectivity:

- Double Normal
- Logistic

2.2 Steepness

Steepness (h) from Beverton and Holt stock-recruitment function is often a very influential parameter which is difficult to estimate or caractherize in most stock assessments. The base case SA models used 0.75, and the other options (0.6 and 0.9) reflect plausible uncertainty with lower and higher values. Three values for steepness were used:

- 0.6,
- 0.75,
- 0.9.

2.3 Growth & Maturity

Growth and maturity are very important parameters in stock assessments. Swordfish exhibit a marked difference in growth between male and female, therefore sex-specific growth and maturity estimates are used. There are concerns in the age estimation of swordfish, with differences being found between the structures used to estimate age (fin rays or otoliths). This uncertainty also undermines the maturity by age relationship. Two growth curves and maturity estimates are considered for the preliminary OM:

- slow growth/late maturity (Wang et al., 2010)
- fast growth/early maturity (Farley et al., 2016 - otoliths)

The Fig below represents the options used for growth - ADD FIG WITH growth Curves The Fig below represents the options used for maturity - ADD FIG WITH maturity Curves

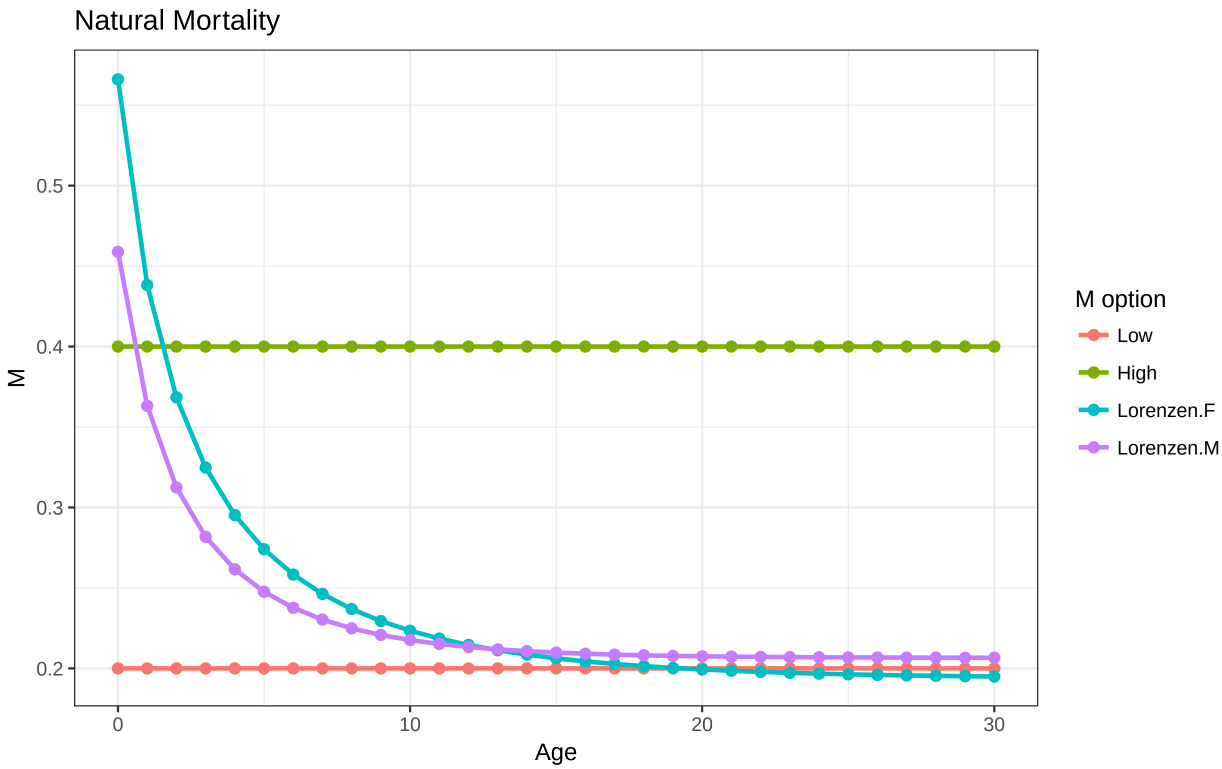
2.4 Natural Mortality M)

Natural mortality is a common unknown in most stock assessment models. The base case considered in the stock assessment model was 0.2 constant for all ages, which was supplemented with an alternative value of 0.4 also constant for all ages as suggested by the WPM. Additionally, after some additionaly considerations on the use of fixed versus age-specific M, the authors also decided to add a 3rd possibility using age-specific

M values, based on the the Lorenzen equation. A total of 3 possibilities were therefore considered for M in this preliminary model grids:

- 0.2, constant for all ages;
- 0.4, constant for all ages;
- Age-specific values based on the Lorenzen equation.

The Fig XXX below represents the options used for M



2.5 Efective Sampling Size of each length data point (ESS)

Two values were used for the relative weight of length sampling data in the total likelihood, through changes in the efective sampling size parameter, of 2 and 20. This alters the relative weighting of length samples and CPUE series in informing the model about stock dynamics and the efects of fishing at length.

2.6 CPUEs

2.7 CPUE scaling schemes

2.8 Catchability increase

Two scenarios were considered for the efective catchability of the CPUE fleet. On the first one it was assumed that the fleet had not improved its ability to fish for swordfish over time, or that any increase had been captured by the CPUE standardization process (0% increase). An alternative scenario considered a 1%/year increase in catchability by correcting the CPUE index to reflect this.

2.9 SigmaR

Two values were considered for the true variability of recruitment in the population (sigmaR), specifically 0.2 and 0.6, as set by the variable SR_sigmaR in the control file.

Table XX below summarizes the grid of uncertanties considerred for the conditioning of the OM. This initial grid results in a total of XXXX models.

Variable	Values		
Selectivity	Double Normal	Logistic	
Steepness	0.6	0.75	0.9
Growth + Maturity	Slow growth, late maturity (Wang et al., 2010)	Fast growth, early maturity(Farley et al., 2016 - otoliths)	
M	Low = 0.2	High = 0.4	Sex-specific Lorenzen M(based on Farley et al. (2016) - otoliths)
ESS	2	20	
CPUE scaling schemes	Area effect*Surface	Catch	Biomass
CPUEs	JPN late + EU.PRT	JPN late	TWN + EU.PRT
Catchability increase	0%	1% / year	
SigmaR	0.2	0.6	

According to the results of the last stock assessment, shown in Figure 1 the biomass of SWO XXXXX

OLD from ALB has been slowly declining as catches increased over the 1950-2000 period, having probably fallen below the BMSY target at some point in the past. The stock then recovered, as a result of a decrease in catches after 2001, and is now considered to be around the target level of B = BMSY

2.10 Selectivity of the CPUE fleets

2.11 Steepness

```
0.2 1 0.75 0.75 1 0.1 -10 # SR_steep
```

- h=0.6
- h=0.75
- h=0.9

2.12 Growth + maturity

2.12.1 Slow growth, late maturity (GtMF)

- Maturity

```
0 0 0 0 0.02 0.1 0.5 0.9 0.98 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 # TWN/Hawai'i
Maturity 50% age 4
```

- Growth

`70 90 66.2     66.2 0 0.1 -2 0 0 0 0 0.5 0 0   # Wang IO L_at_Amin_Fem_GP_1  310 340 274.9 274.9 0 0.1 -2 0 0 0 0 0.5 0 0   # Wang IO L_at_Amax_Fem_GP_1  0.05 0.26 0.138 0.138 0 0.1 -3 0 0 0 0 0.5 0 0 # Wang IO VonBert_K_Fem_GP_1`

2.12.2 Fast growth, early maturity

- Maturity

‘0.001 0.006 0.027 0.109 0.354 0.711 0.917 0.98 0.996 0.999 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 # Farley 2016 Ootlith

- Growth

`70 90 78.70 78.70   0 0.1 -2 0 0 0 0 0 0 0 # Farley Otolith L_at_Amin_Fem_GP_1_   310 340 275.8123 275.8123 0 0.1 -2 0 0 0 0 0 0 0 # Farley Otolith Ray L_at_Amax_Fem_GP_1_    0.05 0.2 0.157 0.157 0 0.1 -3 0 0 0 0 0 0 0 # Farley Otolith Ray VonBert_K_Fem_GP_1_`

2.13 Natural mortality

- Low, 0.2
- High, 0.4
- Test: Lorenzen M

Lorenzen M for FEMALES (age 0 to 30) 0.5660322 0.4382228 0.368445 0.3248203 0.295235 0.2740602 0.2583189 0.2462855 0.23689 0.2294327 0.2234366 0.2185649 0.2145735 0.2112806 0.2085487 0.2062716 0.204366 0.2027662 0.2014195 0.2002831 0.1993224 0.1985089 0.1978191 0.1972334 0.1967357 0.1963124 0.1959521 0.1956453 0.1953838 0.1951609 0.1949708

Lorenzen M for MALES (age 0 to 30) 0.4588258 0.3631227 0.3124604 0.2817323 0.2615569 0.2476183 0.2376487 0.2303405 0.2248866 0.220762 0.2176113 0.2151861 0.2133084 0.2118481 0.2107082 0.2098161 0.2091164 0.2085667 0.2081342 0.2077936 0.2075252 0.2073135 0.2071465 0.2070146 0.2069105 0.2068282 0.2067633 0.2067119 0.2066714 0.2066393 0.206614

2.14 ESS

- 2
- 20

2.15 CPUE scaling schemes

- area effect * surface
- Catch
- Biomass

2.16 CPUEs

- JAP late + PT
- JAP late
- TWN + PT

2.17 Yearly catchability increase

- 0% / year
- 1% /year

2.18 SigmaR

```
0 2 0.2 0.2 -1 0.8 -3 # SR_sigmaR
```

- 0.2
- 0.4/0.6

3 References

Fu, 2017 - SS3 SWO assessment

IOTC 2017a - WPM 2017 report

IOTC 2017b - WPB 2017 report

Methot, R.D.; Wetzel, C.R. 2013. Stock Synthesis: A Biological and Statistical Framework for Fish Stock Assessment and Fishery Management. Fisheries Research 142, 86-99.