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The *Mterm* projections from the 2017 assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M

By

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Introduction

In June 2017 3M beaked redfish was fully assessed, with 2015-2016 natural mortality at 0.1. Results show a stock still high on biomass and spawning biomass (as result of high 2002-2006 recruitment) but declining in abundance and recruitment. In 2015 and 2016 recruiting year classes were among the lowest on record while fishing mortality increased but is kept at low level.

Taking into account the consistency of this latest assessment with the previous ones, the 2017 XSA assessment was accepted. And NAFO Scientific Council agreed to proceed with a 2018-2019 recommendation based on stock projections under most recent level of natural mortality and considering four options for fishing mortality as follows:

1. No fishing, F_0
2. $F_{statusquo}$@age (last year $F_{bar6\text{-}16,2016}$ times average partial recruitment for the last three years)
3. $F_{0.1}$
4. F_{max}

Fishing mortality reference points were given by the revised yield per recruit analysis included in the assessment (Ávila de Melo *et al.*, 2017; NAFO, 2017).

Background, input data and projections tool

Short (three years, 2018-2020) and medium term (ten years, 2018-2027) stochastic projections of yield and female spawning stock biomass (SSB) under the four F options were obtained with *Mterm*, a program of the CEFAS laboratory (Lowestoft/UK), first applied to a NAFO stock in 2000 (Mahe and Darby, 2000). The program has been upgraded to allow projections for long living stocks with a large number of ages included in the analytical assessment (Smith and Darby, *pers. comm*. 2001).

The *Mterm* algorithm use input abundance@age (5 and older) at the beginning of projections (20189 abide to a measure of uncertainty. The initial 2018 population at age (5 and older) is the forward projection of the XSA survivors by the end of 2016 assuming $F_{statusquo}$@age during 2017. The coefficients of variation for population@age at the beginning of 2018 were set as the internal standard errors from 2017 XSA diagnostics. All other inputs@age are the last three year averages with associated errors at age.

Recruitment (age 4) entering in 2017 and 2018 is assumed constant at the geometric mean of below average recruitments (age 4 XSA, 1989-2014). For 2019 till 2027, recruitment is randomly re sampled with residuals from the geometric mean of below average recruitments.

Input data were aggregated in two categories of files:

a. *.srr* stock-recruitment file (Table 1), assuming no stock recruitment relationship and with a random recruitment around the geo-mean of the 1989-2014 recruitments (numbers at age 4, from the 2017 XSA). From the third year of projection onwards, age 4 is given by the re-sampling of the *log* residuals of the 1989-2014 recruitments. The recruitment from last years (2015-2016) were excluded from average due to greater uncertainty of their estimates.

b. *.sen* sensitivity file (Table 2), with the all vectors needed to forward projections. Natural mortality was fixed at 0.1 for all ages and years. Other inputs at age (relative fishing mortality, stock and catch weights and maturity ogive) are the last three year averages with associated errors at age. Each F option was kept constant through projection interval (2018-2027).

Results and discussion

Main results of short term projections for female SSB and yield under several F options and M at 0.1 are summarized on Table 3, extended to medium term SSB trajectories on Table 4 and Fig. 1 ($50\%_{ile}$). All F options are suitable to pursue a short term exploitation that will keep SSB by the entry of 2020 at the 2016 high level of 54 000t, if the historical average low level of recruitment prevails. However, from 2020 onwards SSB will start to decline regardless the F option considered (except no fishing), at faster pace if either one of the two higher options ($F_{statusquo}$ or F_{max}) is implemented. And this decline can be even steeper for all options if instead low recruitments randomly around the historical low average assumed in the projections, extremely low recruitments continue to occur at the minimum most recent level (2015-2016),.

References

Ávila de Melo, A., Saborido-Rey, F. , Fabeiro, M., Rábade, S., González Troncoso D., González-Costas, F., Pochtar M., and R. Alpoim (2017). An assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M, from a biological based approach to recent levels of natural mortality (2011-2016). *NAFO SCR Doc.* 17/032 Ser. No N6687, 69 pp.

NAFO (2017). Report of the Scientific Council Meeting, 1-15 June 2017, Halifax, Nova Scotia. *NAFO SCS Doc.* 17-16 Ser. No N6718, 216 pp.

Table 1. stock recruitment 2017 Mterm input file

5	Nparams
5	Geometric mean model
28.262	1989-2014 age 4 XSA low geomean in millions
0.00000E+000	
0.00000E+000	
0	
0.00000E+000	
26	Ndata log residuals
0.657	
0.404	
-0.176	
-0.252	
-0.129	
-0.129	
-0.020	
-0.765	
-0.542	
-0.626	
-0.178	
-0.048	
0.204	
0.733	
0.695	
0.695	
0.695	
0.695	
0.695	
0.695	
0.695	
0.695	
0.695	
0.656	
0.483	
-0.531	
0	No extra data

Table 2: An explanation of the red.sen file input data with an exploitation pattern corresponding to Fstatusquo

N4=1989-2014 age 4 XSA geometric mean lowrecruitments
F@age2017-2019=Fbar2016x averagePR@age2014-2016

Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.	Name	Value
Population at age at the beginning of 2018			Exploitation pattern (H - Human consumption)			Exploitation pattern (D - Discards)			Exploitation patter (I - Industrials)	
'N4'	28262	0.745	'sH4'	0.2871	0.180	'sD4'	0.00	0.00	'sI4'	0.00
'N5'	19190	0.630	'sH5'	0.7674	0.768	'sD5'	0.00	0.00	'sI5'	0.00
'N6'	2222	0.518	'sH6'	0.4328	0.447	'sD6'	0.00	0.00	'sI6'	0.00
'N7'	1003	0.394	'sH7'	0.1308	0.113	'sD7'	0.00	0.00	'sI7'	0.00
'N8'	2899	0.336	'sH8'	0.0598	0.044	'sD8'	0.00	0.00	'sI8'	0.00
'N9'	14898	0.299	'sH9'	0.0440	0.029	'sD9'	0.00	0.00	'sI9'	0.00
'N10'	20278	0.277	'sH10'	0.0391	0.029	'sD10'	0.00	0.00	'sI10'	0.00
'N11'	37373	0.249	'sH11'	0.0540	0.033	'sD11'	0.00	0.00	'sI11'	0.00
'N12'	42022	0.233	'sH12'	0.0643	0.044	'sD12'	0.00	0.00	'sI12'	0.00
'N13'	37987	0.218	'sH13'	0.0455	0.029	'sD13'	0.00	0.00	'sI13'	0.00
'N14'	26031	0.207	'sH14'	0.0883	0.041	'sD14'	0.00	0.00	'sI14'	0.00
'N15'	13245	0.202	'sH15'	0.1648	0.061	'sD15'	0.00	0.00	'sI15'	0.00
'N16'	9732	0.198	'sH16'	0.1071	0.028	'sD16'	0.00	0.00	'sI16'	0.00
'N17'	6231	0.199	'sH17'	0.1841	0.045	'sD17'	0.00	0.00	'sI17'	0.00
'N18'	4155	0.185	'sH18'	0.1578	0.068	'sD18'	0.00	0.00	'sI18'	0.00
'N19'	3107	0.185	'sH19'	0.1578	0.068	'sD19'	0.00	0.00	'sI19'	0.00
Stock weight at age			Catch weight at age (H - Human consumption)			Catch weight at age (D - Discards)			Catch weight at ag (I - Industrials)	
'WS4'	0.121	0.006	'WH4'	0.109	0.005	'WD4'	0.00	0.00	'WI4'	0.00
'WS5'	0.165	0.003	'WH5'	0.144	0.005	'WD5'	0.00	0.00	'WI5'	0.00
'WS6'	0.212	0.007	'WH6'	0.174	0.004	'WD6'	0.00	0.00	'WI6'	0.00
'WS7'	0.273	0.009	'WH7'	0.234	0.011	'WD7'	0.00	0.00	'WI7'	0.00
'WS8'	0.312	0.003	'WH8'	0.272	0.012	'WD8'	0.00	0.00	'WI8'	0.00
'WS9'	0.351	0.007	'WH9'	0.328	0.017	'WD9'	0.00	0.00	'WI9'	0.00
'WS10'	0.402	0.015	'WH10'	0.394	0.037	'WD10'	0.00	0.00	'WI10'	0.00
'WS11'	0.404	0.013	'WH11'	0.404	0.028	'WD11'	0.00	0.00	'WI11'	0.00
'WS12'	0.434	0.013	'WH12'	0.439	0.042	'WD12'	0.00	0.00	'WI12'	0.00
'WS13'	0.459	0.032	'WH13'	0.449	0.033	'WD13'	0.00	0.00	'WI13'	0.00
'WS14'	0.507	0.037	'WH14'	0.486	0.056	'WD14'	0.00	0.00	'WI14'	0.00
'WS15'	0.511	0.051	'WH15'	0.525	0.053	'WD15'	0.00	0.00	'WI15'	0.00
'WS16'	0.564	0.077	'WH16'	0.552	0.025	'WD16'	0.00	0.00	'WI16'	0.00
'WS17'	0.590	0.054	'WH17'	0.599	0.088	'WD17'	0.00	0.00	'WI17'	0.00
'WS18'	0.609	0.085	'WH18'	0.557	0.051	'WD18'	0.00	0.00	'WI18'	0.00
'WS19'	0.679	0.066	'WH19'	0.793	0.022	'WD19'	0.00	0.00	'WI19'	0.00
Natural mortality at age			Maturity							
'M4'	0.1	0.00	'MT4'	0.006	0.003					
'M5'	0.1	0.00	'MT5'	0.020	0.004					
'M6'	0.1	0.00	'MT6'	0.047	0.017					
'M7'	0.1	0.00	'MT7'	0.134	0.102					
'M8'	0.1	0.00	'MT8'	0.245	0.176					
'M9'	0.1	0.00	'MT9'	0.373	0.195					
'M10'	0.1	0.00	'MT10'	0.528	0.208					
'M11'	0.1	0.00	'MT11'	0.549	0.121					
'M12'	0.1	0.00	'MT12'	0.605	0.120					
'M13'	0.1	0.00	'MT13'	0.614	0.130					
'M14'	0.1	0.00	'MT14'	0.664	0.054					
'M15'	0.1	0.00	'MT15'	0.707	0.218					
'M16'	0.1	0.00	'MT16'	0.753	0.216					
'M17'	0.1	0.00	'MT17'	0.721	0.221					
'M18'	0.1	0.00	'MT18'	0.752	0.182					
'M19'	0.1	0.00	'MT19'	0.790	0.237					
Natural mortality multiplier in year			Effort multiplier in year (H - Human consumption)							
'K2016'	1	0.0	'HF2014'	1.0	0.0					
'K2017'	1	0.0	'HF2015'	1.0	0.0					
'K2018'	1	0.0	'HF2016'	1.0	0.0					

Table 3: Female SSB at the beginning 2020 (50th %ile) and
average 2018-2019 yield under four F options and M at 0.10

SSB		F_0	F_{2016}	$F_{0.1}$	F_{max}
$2020_{50th\ \%\ ile}$		64977	53964	58437	53319
$2020_{25th\ \%\ ile}$		60681	50347	54611	49747
2016	54017				
Yield beaked redfish		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			10248	5778	10230
2016	6232				
TAC		F0	F_{2016}	$F_{0.1}$	F_{max}
2018-2019			12092	**6817**	12070
2016	7000				

average beaked redfish proportion in the 2015-20163M redfish catch 0.85

Table 4: SSB 50% probability profiles under under four
F options and M at 0.10, 2018-2027.

Year	**SSB 50th %ile**			
	F_0	F_{2016}	$F_{0.1}$	F_{max}
2018	61784	61809	61811	61811
2019	63682	58639	60683	58145
2020	**64977**	**53964**	**58437**	**53319**
2021	66506	48941	56080	48334
2022	68144	43285	53160	42883
2023	70718	37935	50604	37931
2024	72731	32700	47748	33144
2025	74604	28094	45023	28908
2026	75751	24086	42245	25227
2027	76416	20761	39693	22180

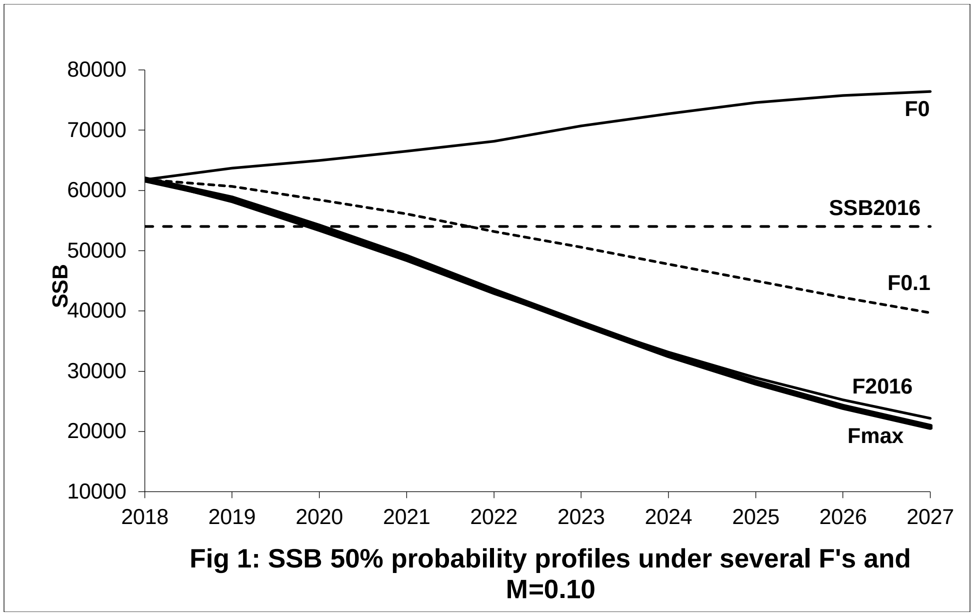

Fig. 1. SSB 50% probability profiles under under four F options and M at 0.10, 2018-2027.