PART D: SCIENTIFIC COUNCIL *AD HOC* WORKING GROUP ON MANAGEMENT STRATEGIES FOR REDFISH IN DIV. 3LN, 13 MAY 2014

Contents

Scientific Council *ad hoc* Working Group on Management Strategies for Redfish in Div. 3LN

13 May 2014

1. Opening

Scientific Council met via WebEx to discuss the ongoing development of a management strategy for redfish in Div. 3LN on 13 May 2014.

2. Appointment of rapporteur

The Scientific Council Coordinator, Neil Campbell, was appointed as rapporteur.

The agenda was reviewed. An item on the recent Div. 3M cod catch estimation meeting was added to other business, and the agenda adopted (see Part J, this volume).

3. Review of recommendations

The following request for advice was made by Fisheries Commission, to be addressed in June 2014:

The Fisheries Commission ***requests*** *the Scientific Council to explore models that could be used to conduct a Management Strategy Evaluation for Div. 3LN redfish and report back through the Working Group on Risk- Based Management Strategies during their next meeting.*

Furthermore, at the recent FC-SC Working Group on Risk Based Management Strategies (WG-RBMS) there were a number of recommendations directed to Scientific Council, including two relating to the ongoing development of a management strategy for Redfish in Div. 3LN:

The WG ***recommends*** *SC discuss selection of operating models and evaluate the Div. 3LN Redfish management strategy relative to the performance statistics prior to the 2014 Annual Meeting.*

The WG ***recommends*** *SC comment on likely by-catch levels associated with the implementation of the proposed HCR for 3LN Redfish.*

4. Review of operational models

Details of four operating models were presented to Scientific Council:

a. ASPIC (current stock assessment model)

i. Background

Currently, a non-equilibrium (dynamic) surplus production model (ASPIC; Prager, 1994) is used to assess the status of the stock. The model is adjusted to the updated surveys series (including 2013 catch and survey data if possible) arranged under the formulation adopted on the "The 2nd Take of the 2008 Assessment of Redfish in NAFO Divisions 3LN," (Ávila de Melo and Alpoim, 2010).

ii. Data used

The 2012 input series are summarized below (Ávila de Melo et al., 2012):

- STATLANT catches(1959-2011) and CPUE(1959-1994)
- Spring survey on Div. 3LN combined (1991-2005,2007-2011)
- Autumn survey on Div. 3N (1991, 1993-2011)
- Autumn survey on Div 3L (1985-1986, 1990-1994, 1996-2011)
- Russian survey on Div. 3LN combined (1984-1991)
- Winter survey in Div. 3L (1985-1986,1990)
- Summer surveys in Div. 3L (1978-1979,1981,1984-1985,1990-1991,1993)

This data are to some extent spatially explicit since surveys carried out in one of the Division are related to the total biomass of redfish in Div. 3LN.

In the current assessment some data points considered as outliers are removed from the dataset in order for the ASPIC model to converge (Avila de Melo *et al.*, 2012). These years are assumed to have higher values because of one or two large redfish hauls which are not representative of the average density in the stratum. In 2012, the

Spanish spring survey in Div. 3N was tentatively incorporated in the stock assessment but it was decided not to keep these data in the model at that time (Ávila de Melo and Alpoim, 2012).

iii. Modelling framework:

The ASPIC package (http://nft.nefsc.noaa.gov/ASPIC.html)was used to fit the logistic form of a surplus production model (Schaefer, 1954) relying on the minimization of an objective function (see Prager, 1994 for detailed description of the algorithm).

ASPIC constrains catchabilities according to the initial values. Is the initial value (q^{init}) divided by 100. If q^{init} is higher or equal to 0.5 the catchability is bounded to be smaller than $6 \times q^{init}$. If q^{init} is comprised between 0.1 and 0.5, the catchability is bounded to be smaller than 1.2. if q^{init} is smaller than 0.1 then the catchability is bounded to be smaller than 0.5.

Table 1: Summary of the initial values and minimum and maximum boundaries for all catchabilities in the ASPIC framework

Catchabilities	q^{init}	q^{min}	q^{max}
q^{CPUE}	9.007×10^{-6}	9.007×10^{-8}	0.5
q^{3LN_sp}	6.58×10^{-1}	6.58×10^{-3}	3.948
q^{3N_aut}	7.59×10^{-1}	7.59×10^{-3}	4.554
q^{3LN_rus}	6.58×10^{-1}	6.58×10^{-3}	3.948
q^{3L_win}	3.22×10^{-1}	3.22×10^{-3}	1.2
q^{3L_sum}	2.75×10^{-1}	2.75×10^{-3}	1.2
q^{3L_aut}	2.75×10^{-1}	2.75×10^{-3}	1.2

Additionally ASPIC allows the user to constrain some of the other parameters. In the 2012 assessment the constraints are MSY is bounded between 5×10^3 and 5×10^4, K is bounded between 10^5 and 10^6 and F maximum value is 6.

b. ASPIC-like model in a Bayesian framework (ASPIC-BAYES)

i. Background

The Bayesian framework is very convenient approach for dealing with uncertainties and missing data in a consistent way and also has flexibility to construct and test various models. One of the key elements of this approach is that it considers all unknowns as probability distribution and is therefore very convenient when dealing with risk. This makes this approach a strong candidate for an operating model. This first Bayesian model is as similar as possible to the current stock assessment model. It includes all the constraints applied in the application of ASPIC in the current assessment.

ii. Data used

Same datasets as the ASPIC OM.

iii. Modelling Framework

The population biomass in 3LN is written as follow:

(Eq. 1) $$Log(P\_3LN_t) = \mu\_3LN_t + \eta_t$$

Where μ_3LN_t is the average relative abundance calculated as a surplus model with a Shaefer (1954) functional form:

(Eq. 2) $$\mu\_3LN_t = Log\left(P\_3LN_{t-1} + r \cdot P\_3LN_{t-1} \cdot (1 - P\_3LN_{t-1}) - \frac{C\_3LN_{t-1}}{K\_3LN}\right)$$

Where P_3LN_{t-1} and C_3LN_{t-1} denote exploitable biomass (as a proportion 3LN Division's carrying capacity K_3LN) and catch respectively, for year t-1. Carrying capacity, K_3LN, is the level of stock biomass at equilibrium prior to commencement of the fishery (carrying capacity), r is the intrinsic rate of population growth.

The process errors η_t are drawn independently from a Normal distribution centered on 0 with a random residual variation σ^P as follow:

(Eq. 3) $\eta_t|\sigma^P \sim Normal(0, \sigma^P)$

The estimated biomass P_3LN_t is related to the CPUE and various survey indices:

(Eq. 4a) $I\_CPUE_t = Log(q\_CPUE \cdot P\_3LN_t) + \varepsilon_t^{CPUE}$
(Eq. 4b) $I\_can\_spr\_3LN_t = Log(q\_can\_spr\_3LN \cdot P\_3LN_t) + \varepsilon_t^{Ca\_spr}$
(Eq. 4c) $I\_can\_aut\_3N_t = Log(q\_can\_aut\_3N \cdot P\_3LN_t) + \varepsilon_t^{Ca\_aut\_3N}$
(Eq. 4d) $I\_can\_aut\_3L_t = Log(q\_can\_aut\_3L \cdot P\_3LN_t) + \varepsilon_t^{Ca\_aut\_3L}$
(Eq. 4e) $I\_Rus\_3LN_t = Log(q\_Rus \cdot P\_3LN_t) + \varepsilon_t^{Rus}$
(Eq. 4f) $I\_can\_win\_3L_t = Log(q\_can\_win \cdot P\_3LN_t) + \varepsilon_t^{Ca\_win}$
(Eq. 4g) $I\_can\_sum\_3L_t = Log(q\_can\_sum\_3L \cdot P\_3LN_t) + \varepsilon_t^{Ca\_sum}$

Where q are the catchabilities associated with each survey index and ε the associated observation error for each surveys. The observation errors are drawn from a Normal distribution as follow:

(Eq. 5a) $\varepsilon_t^{CPUE}|\sigma^{CPUE} \sim Normal(0, \sigma^{CPUE})$
(Eq. 5b) $\varepsilon_t^{Ca\_spr}|\sigma^{Ca\_spr} \sim Normal(0, \sigma^{Ca\_spr})$
(Eq. 5c) $\varepsilon_t^{Ca\_aut\_3N}|\sigma^{Ca\_aut\_3N} \sim Normal(0, \sigma^{Ca\_aut\_3N})$
(Eq. 5d) $\varepsilon_t^{Ca\_aut\_3L}|\sigma^{Ca\_aut\_3L} \sim Normal(0, \sigma^{Ca\_aut\_3L})$
(Eq. 5e) $\varepsilon_t^{Rus}|\sigma^{Rus} \sim Normal(0, \sigma^{Rus})$
(Eq. 5f) $\varepsilon_t^{Ca\_win}|\sigma^{Ca\_win} \sim Normal(0, \sigma^{Ca\_win})$
(Eq. 5g) $\varepsilon_t^{Ca\_sum}|\sigma^{Ca\_sum} \sim Normal(0, \sigma^{Ca\_sum})$

All priors of the model's parameters can be found in Table 2.

Table 2: Prior distribution of the main parameters of the ASPIC-BAYES model. I(a,b) after a distribution indicates a censorship on the left (a) or right (b) side of the distribution.

Parameters	Prior distribution
r	$Gamma(0.01,0.01)$
$Log(K_{3LN})$	$Unif(11.51,13.82)$
MSY	$LogNormal(10,0.001)I(5000,50000)$
σ^{P}	$Uniform(0,10)$
q_CPUE	$Uniform(9.007 \cdot 10^{-5}, 0.5)$
$q\_can\_spr\_3LN$	$Uniform(9.58 \cdot 10^{-3}, 3.948)$
$q\_can\_aut\_3N$	$Uniform(7.59 \cdot 10^{-3}, 4.554)$
$q\_can\_spr\_3N$	$Uniform(6.58 \cdot 10^{-3}, 3.948)$
q_rus	$Uniform(3.22 \cdot 10^{-3}, 1.2)$
q_can_win	$Uniform(2.75 \cdot 10^{-3}, 1.2)$
$q\_can\_sum\_3L$	$Uniform(2.75 \cdot 10^{-3}, 1.2)$
σ^{CPUE}	$Uniform(0,10)$
σ^{Ca_spr}	$Uniform(0,10)$
$\sigma^{Ca\_aut\_3N}$	$Uniform(0,10)$
$\sigma^{Ca\_aut\_3L}$	$Uniform(0,10)$
σ^{Rus}	$Uniform(0,10)$
σ^{Ca_win}	$Uniform(0,10)$
σ^{Ca_sum}	$Uniform(0,10)$

c. ASPIC-like model in a Bayesian framework with all available data (ASPIC-BAYES-FULL)

i. Background

In order to minimise the selection of outliers we designed an OM that has the same structure as ASPIC-BAYES but incorporates all CPUE and survey data available (i.e. no outliers removed) and relaxes the constraints applied in the current ASPIC assessment.

ii. Data used

- o STATLANT catches(1959-2011) and CPUE(1959-1994)
- o Spring survey in Div. 3LN combined (1991-2005,2007-2011)
- o Autumn survey in Div. 3N (1991-2011)
- o Autumn survey in Div 3L (1985-1986, 1990-2011)
- o Russian survey in Div. 3LN combined (1984-1991)
- o Winter survey in Div. 3L (1985-1986,1990)
- o Summer surveys in Div. 3L (1978-1979,1981,1984-1985,1990-1991,1993)
- o Spanish surveys in Div. 3N (1995-2011)

ii. Modelling Framework

Same equations as the ASPIC-BAYES OM with in addition the relationship between the Spanish surveys and the redfish Biomass in 3LN:

(Eq. 6) $$I\_Spa_t = Log(q\_spa \cdot P\_3LN_t) + \varepsilon_t^{Spa}$$

And the associated observation error:

(Eq. 7) $\varepsilon_t^{Spa}|\sigma^{Spa} \sim Normal(0, \sigma^{Spa})$

Additionally, as mentioned in the background section, prior distributions for the different parameters of the model have been loosened (see Table 3 for comparison).

Table 3: Prior distribution of the main parameters of the ASPIC-BAYES and ASPIC-BAYES-FULL models. I(a,b) after a distribution indicates a censorship on the left (a) or right (b) side of the distribution.

Parameters	Prior ASPIC BAYES	Prior ASPIC BAYES FULL
$Log(K_{3LN})$	$Unif(11.51,13.82)$	$Unif(11.51,15.82)$
MSY	$LogNormal(10,0.001)I(5000,50000)$	$LogNormal(10,0.001)\ I(1000,)$
σ^P	$Uniform(0,10)$	$Uniform(0,10)$
q_CPUE	$Uniform(9.007 \cdot 10^{-5}, 0.5)$	$Uniform(0,10)$
$q\_can\_spr\_3LN$	$Uniform(9.58 \cdot 10^{-3}, 3.948)$	$Uniform(0,10)$
$q\_can\_aut\_3N$	$Uniform(7.59 \cdot 10^{-3}, 4.554)$	$Uniform(0,10)$
$q\_can\_spr\_3N$	$Uniform(6.58 \cdot 10^{-3}, 3.948)$	$Uniform(0,10)$
q_rus	$Uniform(3.22 \cdot 10^{-3}, 1.2)$	$Uniform(0,10)$
q_can_win	$Uniform(2.75 \cdot 10^{-3}, 1.2)$	$Uniform(0,10)$
$q\_can\_sum\_3L$	$Uniform(2.75 \cdot 10^{-3}, 1.2)$	$Uniform(0,10)$
	N/A	$Uniform(0,10)$
σ^{CPUE}	$Uniform(0,10)$	$Uniform(0,10)$
σ^{Ca_spr}	$Uniform(0,10)$	$Uniform(0,10)$
$\sigma^{Ca\_aut\_3N}$	$Uniform(0,10)$	$Uniform(0,10)$
$\sigma^{Ca\_aut\_3L}$	$Uniform(0,10)$	$Uniform(0,10)$
σ^{Rus}	$Uniform(0,10)$	$Uniform(0,10)$
σ^{Ca_win}	$Uniform(0,10)$	$Uniform(0,10)$
σ^{Ca_sum}	$Uniform(0,10)$	$Uniform(0,10)$
σ^{spa}	N/A	$Uniform(0,10)$

d. Spatially disaggregated model (BAYES-SPATIAL)

i. Background

This is an operating model that is structured to be consistent with the spatial structure in the data collection (i.e. look at Division 3L and 3N individually when the survey/catch data allows for it)

ii. Data used

Same datasets as in ASPIC-BAYES-FULL but when possible using split data for 3L and 3N.

- o Catches in 3L from 1959 to 2011 (STATLANT)
- o Catches in 3N from 1959 to 2011 (STATLANT)
- o CPUE for 3LN from 1959 to 1994

- o Canadian surveys:
    - Spring 3L : 1980, 1985, 1991-2011
    - Spring 3N: 1991-2005, 2007-2011
    - Summer 3L from to: 1978-1979, 1981, 1984-1985, 1990-1991 and 1993
    - Summer 3N: 1991, 1993
    - Autumn 3L: 1985-1986, 1990-2011
    - Autumn 3N: 1991-2011
    - Winter 3L: 1985-1986 and 1990
- o Spanish survey in 3N from1995 to 2011
- o Russian survey for 3LN combined from 1984 to 1991 (Power & Vaskov revised)

iii. Modelling Framework

This model's equations are similar to the ones in ASPIC-BAYES and ASPIC-BAYES-FULL. The main difference being that biomass for division 3L and 3N are estimated separately as follow:

(Eq. 8a) $Log(P\_3N_t) = \mu\_3N_t + \eta_t$

(Eq. 8b) $Log(P\_3L_t) = \mu\_3L_t + \eta_t$

Where $\mu_3L_t$and μ_3N_t are the average relative abundance calculated as a surplus model with a Shaefer (1954) functional form:

(Eq. 9a) $\mu\_3N_t = Log\left(P\_3N_{t-1} + r \cdot P\_3N_{t-1} \cdot (1 - P\_3N_{t-1}) - \frac{C\_3N_{t-1}}{K\_3N}\right)$

(Eq. 9b) $\mu\_3L_t = Log\left(P\_3L_{t-1} + r \cdot P\_3LN_{t-1} \cdot (1 - P\_3L_{t-1}) - \frac{C\_3L_{t-1}}{K\_3L}\right)$

Where P_3L_{t-1}, P_3N_{t-1} and C_3L_{t-1}, C_3N_{t-1} denote exploitable biomass (as a proportion of each division's carrying capacity K_3L and K_3N) and catch respectively, for year *t-1*. Carrying capacity, K_3L and K_3N, are the level of stock biomass at equilibrium prior to commencement of the fishery, r is the intrinsic rate of population growth and is assumed to be the same in 3L and 3N.

We assume the variability in the biological process are similar in the two divisions occupied by the population. Therefore the process errors η_t are shared for both divisions drawn independently from a Normal distribution centered on 0 with a random residual variation σ^P as follow:

(Eq. 10) $\eta_t|\sigma^P \sim Normal(0, \sigma^P)$

The total population abundance for 3LN is calculated as follow

(Eq. 11) $P\_3LN_t = P\_3L_t + P\_3N_t$

The estimated biomass P_3L_t and P_3N_t are related to various survey index:

For 3L Division:

(Eq. 12a) $I\_can\_spr\_3L_t = Log(q\_can\_spr\_3L \cdot P\_3L_t) + \varepsilon_t^{Ca\_spr}$

(Eq. 12b) $I\_can\_sum\_3L_t = Log(q\_can\_sum\_3L \cdot P\_3L_t) + \varepsilon_t^{Ca\_sum}$

(Eq. 12c) $I\_can\_aut\_3L_t = Log(q\_can\_aut\_3L \cdot P\_3L_t) + \varepsilon_t^{Ca\_aut}$

(Eq. 12d) $I\_can\_win\_3L_t = Log(q\_can\_win \cdot P\_3L_t) + \varepsilon_t^{Ca\_win}$

For 3N Division:

(Eq. 13a) $I\_can\_spr\_3N_t = Log(q\_can\_spr\_3N \cdot P\_3N_t) + \varepsilon_t^{Ca\_spr}$

(Eq. 13b) $I\_can\_sum\_3N_t = Log(q\_can\_sum\_3N \cdot P\_3N_t) + \varepsilon_t^{Ca\_sum}$

(Eq. 13c) $I\_can\_aut\_3N_t = Log(q\_can\_aut\_3N \cdot P\_3N_t) + \varepsilon_t^{Ca\_aut}$

(Eq. 13d) $I\_spa\_3N_t = Log(q\_spa \cdot P\_3N_t) + \varepsilon_t^{Spa}$

For 3LN Div. combined:

(Eq. 14) $I\_Rus\_3LN_t = Log(q\_Rus \cdot P\_3LN_t) + \varepsilon_t^{Rus}$

Where q are the catchabilities associated with each survey index (catchabilities are assumed to be different over 3L and 3N for a survey taking place at the same time) and ε the associated observation error. It is assumed that there are no differences in the observation process for the same survey carried out in 3L or 3N (e.g. the observation error for $I\_can\_sum\_3L$ and $I\_can\_sum\_3N$ are the same). The observation errors are drawn from a Normal distribution as follow:

(Eq. 15a) $\varepsilon_t^{Ca\_spr} | \sigma^{Ca\_spr} \sim Normal(0, \sigma^{Ca\_spr})$

(Eq. 15b) $\varepsilon_t^{Ca\_sum} | \sigma^{Ca\_sum} \sim Normal(0, \sigma^{Ca\_sum})$

(Eq. 15c) $\varepsilon_t^{Ca\_aut} | \sigma^{Ca\_aut} \sim Normal(0, \sigma^{Ca\_aut})$

(Eq. 15d) $\varepsilon_t^{Ca\_win} | \sigma^{Ca\_win} \sim Normal(0, \sigma^{Ca\_win})$

(Eq. 15e) $\varepsilon_t^{Spa} | \sigma^{Spa} \sim Normal(0, \sigma^{Spa})$

(Eq. 15f) $\varepsilon_t^{Rus} | \sigma^{Rus} \sim Normal(0, \sigma^{Rus})$

All priors of the model's parameters can be found in Table 4. Note that the model was slightly re-parameterised and a prior was attributed to r instead of MSY for better convergence purposes ($MSY = r \times (K\_3L + K\_3N)/4$)

Equations 8-15 can be represented graphically in a Directed Acyclic Graph (DAG, Fig. 1) to visualise the model's structure.

Table 4: Prior distribution of the main parameters of the model. I(a,b) after a distribution indicates a censorship on the left (a) or right (b) side of the distribution.

Parameters	Prior distribution
r	$Gamma(0.01,0.01)$
K_3L	$LogNormal(1,0.001)I(,10^6)$
K_3N	$LogNormal(1,0.001)I(,10^6)$
σ^P	$Uniform(10^{-3},10)$
$q\_can\_spr\_3L$	$Uniform(0,10)$
$q\_can\_sum\_3L$	$Uniform(0,10)$
$q\_can\_aut\_3L$	$Uniform(0,10)$
$q\_can\_spr\_3N$	$Uniform(0,10)$
$q\_can\_sum\_3N$	$Uniform(0,10)$
q_can_aut _3N	$Uniform(0,10)$
q_can_win	$Uniform(0,10)$
q_spa	$Uniform(0,10)$
q_rus	$Uniform(0,10)$
σ^{Ca_spr}	$Uniform(10^{-3},10)$
σ^{Ca_sum}	$Uniform(10^{-3},10)$
σ^{Ca_aut}	$Uniform(10^{-3},10)$
σ^{Ca_win}	$Uniform(10^{-3},10)$
σ^{Spa}	$Uniform(10^{-3},10)$
σ^{Rus}	$Uniform(10^{-3},10)$

5. Discussion on alternate HCRs

It was proposed that the EU-Spanish Div. 3L survey results be included in the fourth operating model, and their performance be evaluated at or after the June meeting, once an accepted assessment is in place.

6. Review of performance statistics

The objectives and performance statistics, as defined by WG-RBMS, are as follows:

a. Objective

  a: Maintain the stock at or above B_{msy}, achieve a TAC of 20 000 t within 7 years, and maintain a TAC at or above[1] 20,000t for subsequent years.

b. Performance Statistics:

  a. Low (30%) probability of exceeding F_{msy} in any year

  b. Very low (10%) probability of declining below B_{lim} in the next 7 years

  c. Less than 50% probability of declining below 80% B_{msy} in the next 7 years

[1] Evaluating at 5 000t increments, *i.e.* 25 000, 30 000, etc.

Some concerns were expressed that evaluating the performance of the management strategy over seven years was not suitable for a long-lived species such as redfish, and as a consequence it was suggested that performance of the management strategy over 30 years also be evaluated. Further discussion of this issue was deferred to the June meeting.

7. Discussion of exceptional circumstances

Discussion of this process was deferred to the June meeting.

8. Discussion of review process (*i.e.* biennial assessment of the stock)

Discussion of this process was deferred to the June meeting.

9. Other Matters

Scientific Council were informed of the outcomes of the WebEx meeting on estimation of Div. 3M cod catches, namely that the Secretariat were to provide SC with daily catch and effort data for 2011 – 2013 for exploration of trends in catch rate.

10. Adoption of Report

The SC Coordinator was asked to prepare a report of the meeting and circulate it to participants for adoption by correspondence.

11. Adjournment

The Chair thanked participants for their efforts, and noted the concerns expressed by a number of delegates that this manner of *ad hoc* webex meeting was not the ideal way to conduct work. The meeting was adjourned at 1200h.

ANNEX I. REFERENCES

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