Additional material for the 2014 MSC assessment of N.Z. orange roughy fisheries: supplement 1

P.L. Cordue, ISL
2 September 2014

Introduction

This document contains supplementary material which was produced in response to queries by the MSC assessment team. The results contained within were produced using either the 2014 orange roughy stock assessments (Cordue 2014a) or the Management Strategy Evaluation (Cordue 2014b).

For the three orange roughy stocks being considered against the MSC standard, the limit reference point (LRP) is 20% B_0 and the target biomass range is 30–50% B_0.

Stock status posteriors: medians and probabilities

Estimates were produced for the last five years from the stock status (spawning-stock biomass divided by virgin spawning-stock biomass) posteriors for the base models (Cordue 2014a).

The estimates of stock status show an increasing trend for each of the stocks over the last five years (Table 1). For ESCR and NWCR the median stock status is below the lower bound of the target biomass range (LB = 30% B_0) in 2010. It reaches the LB for ESCR in 2014 and is well within the range for NWCR in 2014. For ORH7A, the stock status is within the target range from 2010 to 2014 (Table 1).

The estimated probabilities of stock status being below the LB decreased for each of the stocks from 2010 to 2014 (Table 2). For 2014, it is close to zero for NWCR and ORH 7A, but above 50% for ESCR (Table 2). The estimated probability for ESCR is above 50% despite the median estimate of stock status being given as 30% B_0. The apparent discrepancy is because the median of the posterior has been rounded up from 29.6% B_0 (since the estimate is not accurate to 1 decimal place).

The estimated probabilities of stock status being below the LRP (20% B_0) are close to or equal to zero for each of the three stocks from 2010 to 2014 (Table 3). The estimates are all zero with regard to the probability of stock status being below 10% B_0 (Table 4).

Table 1: Estimated stock status (*%B_0*) for ESCR, NWCR, and ORH 7A base models from 2010 to 2014. The medians of the marginal posterior distributions are given in each year for each stock (see Cordue 2014a).

Year	ESCR	NWCR	ORH 7A
2010	25	27	35
2011	26	29	37
2012	27	32	39
2013	28	34	40
2014	30	37	42

Table 2: Estimated probabilities of stock status being below the lower bound (30% B_0) of the target range for ESCR, NWCR, and ORH 7A base models from 2010 to 2014.

Year	ESCR	NWCR	ORH 7A
2010	0.99	0.78	0.06
2011	0.96	0.59	0.02
2012	0.89	0.34	0.00
2013	0.75	0.14	0.00
2014	0.57	0.04	0.00

Table 3: Estimated probabilities of stock status being below the LRP (20% B_0) for ESCR, NWCR, and ORH 7A base models from 2010 to 2014.

Year	ESCR	NWCR	ORH 7A
2010	0.01	0.05	0.00
2011	0.00	0.01	0.00
2012	0.00	0.00	0.00
2013	0.00	0.00	0.00
2014	0.00	0.00	0.00

Table 4: Estimated probabilities of stock status being below 10% B_0 for ESCR, NWCR, and ORH 7A base models from 2010 to 2014.

Year	ESCR	NWCR	ORH 7A
2010	0.00	0.00	0.00
2011	0.00	0.00	0.00
2012	0.00	0.00	0.00
2013	0.00	0.00	0.00
2014	0.00	0.00	0.00

Expected recruitment at the LRP

The LRP is 20% B_0 which, conveniently, is equal to the percentage of virgin biomass which is used in the definition of steepness (h) in the stock-recruitment relationships (Beverton-Holt and Ricker). That is, h is defined to be the expected proportion of virgin recruitment when stock status is 20% B_0. The only information on the expected level of recruitment at the LRP comes from the MEC assessment model runs when h was estimated (Cordue 2014b).

The MEC assessment runs in which h was estimated gave similar results for Beverton-Holt and Ricker stock-recruitment relationships (Cordue 2014b, Table 1, Appendix B). The combined results (giving both runs equal weight) gave a median steepness of 60% (i.e., an average of 60% of virgin recruitment when at 20% B_0) with a 95% CI of about 30-90% (Table 5).

Table 5: Bayesian estimates of the expected proportion of virgin recruitment at the LRP for the MEC assessment models that assumed a Beverton-Holt or a Ricker stock-recruitment relationship. The median and 95% CIs are given as a percentage of virgin recruitment (R_0).

	Steepness (h) (% R_0)	
	Median	**95% CI**
Beverton-Holt	68	39–93
Ricker	53	28–99
Combined (equal weight)	60	31–95

Estimates of mean generation time

Two estimates of mean generation time were made for each of the three stock assessment models: G = mean age of mature fish in the virgin population; and G_w = mean age of mature fish in the virgin population weighted by their contribution to egg production. Note, the models are single sex and mature fish are equivalent to spawning fish.

Let,

a index age in years
N_a = number of mature fish at age a in the virgin population (assumed to be at deterministic equilibrium)
m_a = proportion of mature fish at age a in the virgin population
$p = e^{-M}$
R = virgin recruitment to age 0.

Then, $N_a = p^a R m_a$, and $G = \frac{\sum_a N_a a}{\sum_a N_a} = \frac{\sum_a p^a m_a a}{\sum_a p^a m_a}$ (which is, of course, independent of R).

In the stock assessment models, egg production is assumed proportional to fish weight and mean fish-weight at age is assumed constant over time.

It is easy to show that $G_w = \frac{\sum_a p^a m_a a w_a}{\sum_a p^a m_a w_a}$ where w_a = mean fish weight at age a.

The estimators of mean generation time use fixed parameters for each stock and the estimated maturation ogives (see Cordue 2014a). The Bayesian estimates of G and G_w were obtained by applying the estimation formulae to the samples from the marginal posterior distributions of a_{50} and a_{to95} from the stock assessments (Cordue 2014a) with summation from ages 1–200 years.

The median estimates of mean generation time ranged from 50–60 years and were approximately equal to the median estimates of a_{50} plus 20 years, with the weighted estimates about 3 years higher than the un-weighted estimates (Table 6). The median estimates of a_{50} were 41 years, 37 years, and 32 years for ESCR, NWCR, and ORH 7A respectively (Cordue 2014a).

Table 6: Bayesian estimates of mean generation time (years) for ESCR, NWCR, and ORH 7A using the mean age of mature fish in the virgin population (G) and a weighted mean age (G_w).

	ESCR		NWCR		ORH 7A	
	Median	**95% CI**	**Median**	**95% CI**	**Median**	**95% CI**
G	60	58–63	56	53–58	52	50–54
G_w	63	60–66	59	57–61	55	53–57

Mean rebuild times for the generic model used in the MSE

The generic model is not a model of a particular stock but it was used to determine a HCR with good long-term properties (e.g., very low LRP risk and very low depletion risk – see Cordue 2014b). The question of whether the HCR can rebuild a stock within the (MSC) required timeframe is only relevant to a stock which is deemed to be depleted (i.e., consistently below the LB). The short term performance of the HCR was examined in the MSE for each stock and the only stock which could possibly be interpreted as being depleted (ESCR) rebuilt satisfactorily under the HCR (Cordue 2014b).

Nevertheless, the long-term performance of the HCR as a rebuilding rule was examined for the generic base model by estimating the mean rebuild time for each h and M pair in the joint posterior used in the MSE (Cordue 2014b). The rebuild time is an average (for given h and M) because it was calculated over the last 15,000 years of a 16,000 year simulation (during which time the stock may have had to rebuild on several occasions). The rebuild time was defined to be the number of years it took the stock to return to the target range after it was deemed to have been depleted. A stock was deemed to be depleted if it had been below the LB for 6 years (which is two consecutive stock assessments as assessments occurred every 3 years).

The median rebuild time was 15 years with a 95% CI of 10–22 years. The short rebuild times correspond to high values of h and M; conversely rebuild times above 20 years are only found for low values of h and M.

Incorporation into the MSE of a possible effect of fishing on spawning plumes

The three stocks under consideration all have some fishing occurring on spawning plumes. For ORH 7A and NWCR the main fishing activity does occur during the spawning season. It is possible that fishing on spawning plumes may disrupt spawning to some extent and have a detrimental effect on spawning success. This has not been modelled in the MSE because there are no data available on what effect, if any, such fishing activity would have on spawning success.

However, the posterior distribution for h used in the MSE was taken from an assessment of the MEC stock which historically has had substantial fishing on spawning plumes (Dunn 2011). Any effect that such fishing has had would have been passed through to the posterior on h and the distribution would be shifted to the left because of it (i.e., lower values of h estimated because of lower spawning success caused by fishing on plumes – if such an effect exists).

In the MEC stock assessment run where h was estimated the most recent estimated year class strength was in 1996. It is probably the last 10 year class strengths estimated that would have the most influence on the estimate of h (as they have the lowest stock status of those years in which year class strengths were estimated). Dunn (2011) estimated the spawning season (June-July) catch for the MEC stock. In 7 out of the 10 fishing years from 1986-87 to 1995-96 the estimated catch exceeded 1500 t (with a maximum of 3000 t). This probably represents a much greater level of spawning disruption than could be expected for ESCR, NWCR, and ORH 7A in the future under the HCR. This is especially true for NWCR which has one of the main spawning plumes contained within a closed area (i.e., Morgue).

References

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