A brief and preliminary stock assessment of ORH 7B to the end of 2017–18

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ISL Client Report to DWG

Executive Summary

The most recent accepted assessment for ORH 7B was in 2004. It used CPUE indices as biomass indices, a practice that is no longer considered acceptable for orange roughy stock assessment. Successful orange roughy assessments generally require acoustic biomass estimates from spawning aggregations and age frequency data so that the year class strengths (YCS) can be estimated.

In 2017 there was an acoustics survey of a spawning aggregation in Cook Canyon from which preliminary estimates are available. The average of three snapshots was 824 t (CV 26%). Otoliths were collected but an age frequency has not yet been produced. The survey was late in the spawning season (over 40% spent fish in the first snapshot). It is not known how much the timing may have reduced the acoustic biomass estimate or whether it will make the age data unrepresentative of the whole spawning population.

In this preliminary assessment a simple model was used to investigate likely stock size (virgin biomass, B_0) and current stock status (in 2018). MPD estimates were made assuming average YCS and also two non-average patterns of YCS that supported the early catch history and implied a slow rate of rebuild (20 years of above average YCS followed by 20 years of below average YCS). An MCMC run was also done where YCS were estimated, despite the lack of data, to see what the consequences were in terms of stock size and current stock status (for a large variety of different YCS patterns).

The MPD estimates of B_0 ranged from 9 000 to 12 000 t with current stock status from 18% to 50% B_0. The high estimate of current stock status was associated with average YCS which were not consistent with the observed acoustic estimate (giving a very bad fit for a variety of assumptions). The MCMC run allowed for the possibility that the acoustic biomass estimate was very late in the spawning season and may have been low for that reason. This model was consistent with the observed acoustic biomass estimate and gave a 95% CI for B_0 of 10 900–15 500 t with current stock status at 37–62% B_0.

The late timing of the survey was bad luck in that the season was a bit earlier than expected. However, it means that the acoustic estimate is lower than it would have been (by an unknown amount) and also that the age frequency data may have been compromised. For example, it may be that older fish tend to spawn earlier or later than the younger fish.

The production of an age frequency from the late season samples is probably not warranted. Fitting an age frequency is not going to make much difference to the assessment unless it shows an extreme pattern – but an extreme pattern could be attributed to sampling late in the season.

There is only circumstantial evidence of a rebuild. However, unless there has been bad recruitment failure current stock status is very likely to be above 20% B_0 and could even be

in the 30–50% B_0 range. Another acoustic survey is needed together with an associated age frequency. The longer the duration of the survey the more chance there is of getting the timing right. It should be noted that this is a small stock and if the stock were managed using the orange roughy HCR then long term annual yield of only about 200 t can be expected.

Introduction

The most recent ORH7B assessment was in 2007 using CPUE indices and deterministic recruitment (see 2017 Plenary report). The assessment was rejected by the DWFAWG due to the bad fit to the CPUE indices. CPUE was flat but the model prediction had biomass increasing (due to deterministic recruitment and very low recent catch). The 2004 assessment, which also used CPUE indices remains as the must current accepted assessment (see 2006 Plenary report). In the 2004 stock assessment (under the assumption that CPUE was proportional to biomass), B_0 was estimated at 12,000 t and (then) current biomass at 17% B_0. There was also a 2001 assessment which gave similar results under the assumption that CPUE was proportional to biomass (O'Driscoll 2001).

It is not appropriate to use CPUE on aggregated species in stock assessments because catch rates are extremely unlikely to be related to biomass in any consistent manner. In June 2017 there was an acoustic survey of the spawning aggregation in Cook Canyon and a preliminary biomass estimate is available. The aggregation was sampled by trawl and otoliths have been collected although an age frequency has not been produced. From gonad stage data collected during the survey it is apparent that peak spawning occurred before the survey commenced.

This is a preliminary assessment using the preliminary acoustic biomass estimate and a simple model with a single spawning fishery at the end of the year. The focus is on MPD estimates with assumed patterns of year class strength (YCS) although one MCMC run is done where the YCS pattern is estimated.

Methods

A single-sex, single-area, age-structured model with maturity in the partition was used to fit the single acoustic biomass estimate in 2017. A single spawning fishery at the end of the year was assumed. The focus was on MPD estimates as no age frequency data were available. Virgin biomass (B_0) was estimated together with the acoustic proportionality constant q. The acoustic q was estimated with an informed prior: lognormal with a mean of 0.6 and a CV of 19%. The usual assumption for the mean of the prior is 0.8 but because the estimates were obtained late in the spawning season the mean was reduced to 0.6 (alternative runs are done with the mean at 0.4 and 0.8).

Natural mortality (M) was fixed at 0.045 and a Beverton-Holt stock recruitment relationship with steepness (h) of 0.75 was assumed. Growth and maturity parameters were fixed and assumed equal to those for ESCR or ORH 7A. The growth parameters are not important as no length frequency data are fitted. The maturity parameters were assumed equal to the median estimates for ESCR or ORH 7A (these have respectively the oldest and youngest median ages at maturity for the five assessed orange roughy stocks, see Cordue 2017).

The maximum exploitation rate was set to 0.67 which is usually used for orange roughy fisheries. Some sensitivities were done using a value of 0.8.

For the single MCMC run, YCS and the maturity parameters were estimated in addition to B_0 and the acoustic q. It is unusual to estimate YCS and maturity without any age frequency data but this was done because the MPD estimates were all at B_{min} (the minimum biomass that allows the given catch history to be caught under the assumed maximum exploitation rate). It was apparent that average YCS were not consistent with the catch history and the acoustic biomass estimate. A near uniform prior was used for the free YCS parameters (Haist parameterisation) and the maturity parameters were estimated with informed normal priors (a_{50}: N(37, CV 10%) and a_{to95}: N(12, CV 10%)) which had the means set to the medians of the point estimates for the five assessed orange roughy stocks – see Cordue 2017).

Given the MPD results (especially the lack of fit to the acoustic estimate) the mean of the acoustic q prior was set to 0.4 and the CV increased to 35% (to reflect the large uncertainty as to how low the biomass estimate was because of the late timing of the survey). Three chains of 5 million were run with 1 in every one thousand samples retained. The first 500 retained samples were discarded as a burn-in and the estimates based on the three chains combined after the burn-in (13 500 samples).

The catch history was taken from the 2017 Plenary report with the addition of a catch of 11 t for 2016–17 (taken during the acoustic survey)(Figure 1). No over-runs were applied which is precautionary as the results are driven by the catch history. Most of the catch was taken during the spawning season (especially in the early years) which is why a single end-of-year spawning fishery was used in the model. However, if the assessment is revised then it would be best to have two fisheries to account for the non-spawning season catch (which is a significant proportion in some of the later years).

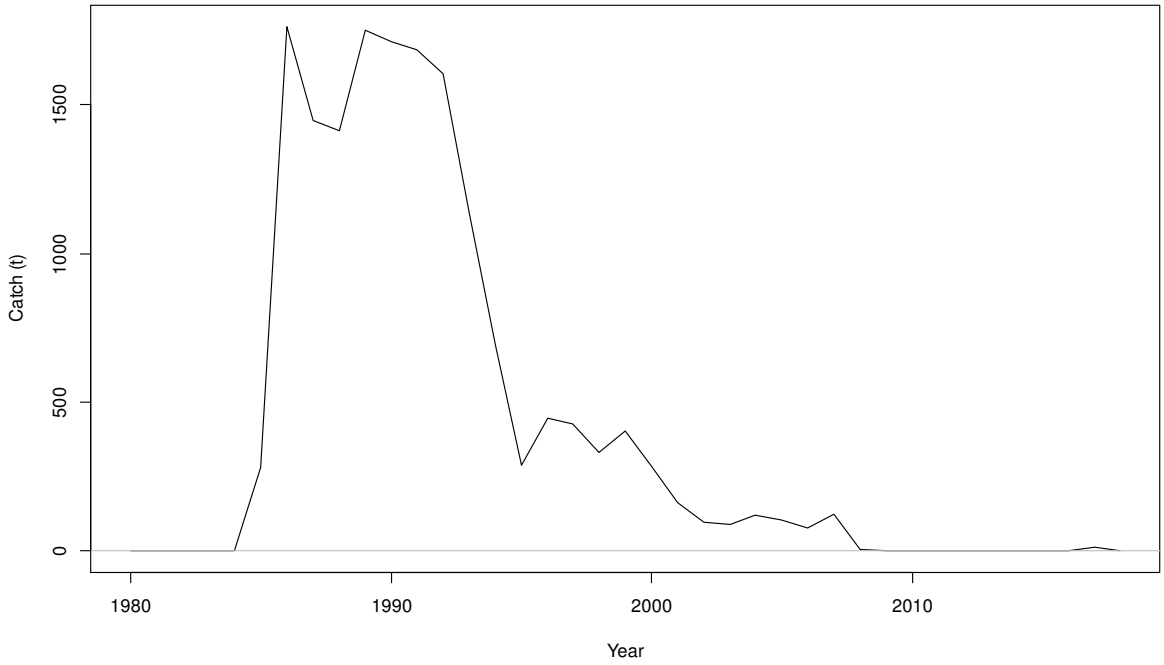

Figure 1: Catch history for ORH 7B.

Three alternative YCS patterns were used in the MPD runs: average YCS, 20 years with YCS = 1.5 followed by 20 years of YCS = 0.5; and 20 years with YCS = 1.75 followed by 20 years with YCS = 0.25 (Figure 2). For each pattern the YCS average to 1 so that the meaning of B_0 is preserved. The purpose of investigating the two YCS patterns with above average recruitment followed by below average recruitment is to illustrate the effect of non-average YCS. If there is above average recruitment early on it supports the catches that were taken and allows a lower B_{min} and combined with the subsequent below average recruitment results in a lower current stock status.

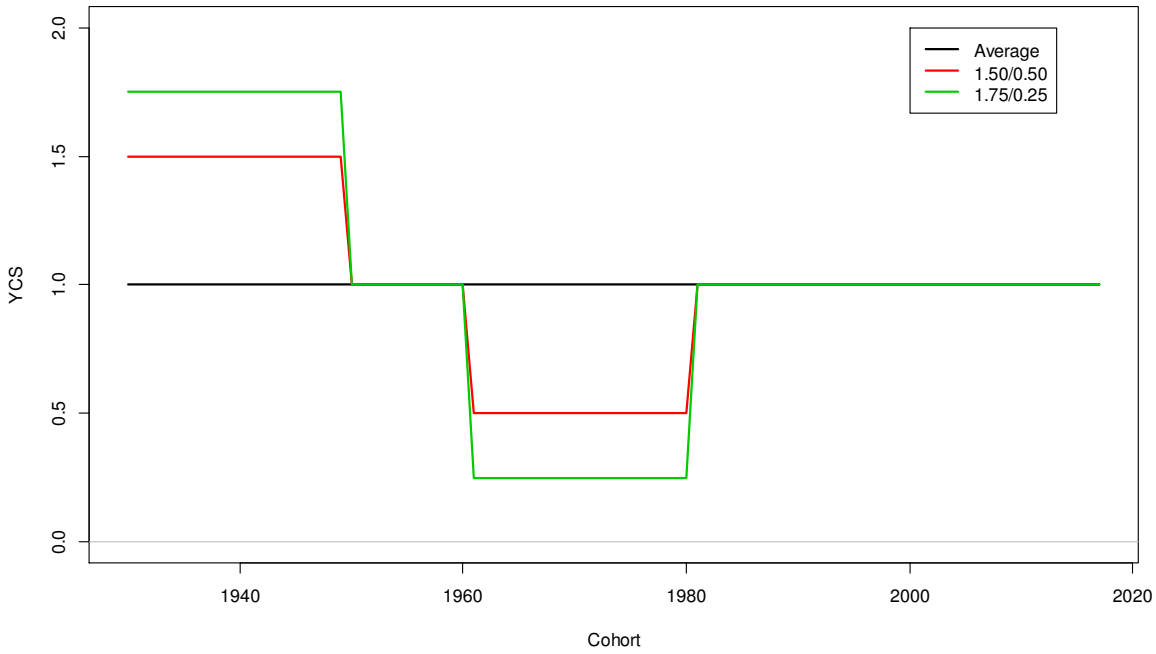

Figure 2: The three alternative YCS patterns used in the MPD runs. The patterns with above average YCS (1.75/0.25 and 1.5/0.5) have twenty years above average (1.75 or 1.5) and twenty years below average (0.25 or 0.5).

The acoustic estimates are from the three AOS 38 kHz snapshots undertaken by CSIRO on the *Amaltal Explorer* from 4–6 July 2017. The snapshots had similar estimates and averaged 824 t with a CV of 26% (Table 1). The 38 kHz estimates were consistently larger than the corresponding estimates from 120 kHz. The reasons for this are not yet fully understood. The deadzone contribution to the total estimates was small ranging from just 3–7%.

Table 1: Acoustic biomass estimates at 38 kHz for the spawning aggregation at Cook Canyon in July 2017. The surveys were conducted by CSIRO using the Sealord AOS on board *Amaltal Explorer*.

Date	Total biomass (t)	CV (%)
4 July 2017	627	53
5 July 2017	930	32
6 July 2017	915	50
Mean	824	26

The survey was late in the spawning season with estimated proportion of spent females greater than 40% on 5 and 6 July and exceeding 70% on 11 July. Fish were sampled for otoliths from 3 trawls and 520 otolith pairs are available.

Results and Discussion

The MPD estimates of B_0 were all at B_{min} for the respective YCS patterns (Table 2). The use of $U_{max} = 0.8$ compared to the usual $U_{max} = 0.67$ made little difference to the estimates (Table 2). The ESCR maturation runs had lower estimates of B_0 for the two non-average recruitment patterns because the model was able to use the above average YCS to generate adequate biomass by the start of the fishery to support the catch history (Table 2, Figure 3). When the younger ORH 7A maturation parameters were used the estimated B_0s were similar across the YCS patterns but for the non-average YCS there was a buildup of biomass prior to the start of the fishery (Figure 4).

Table 2: MPD estimates of B_0 and current stock status (ss_{18}) for the three YCS patterns and alternative growth and maturation parameters. The estimates were the same when the mean of the acoustic q prior was set to 0.4 or 0.8 (instead of 0.6).

		YCS 1.75/0.25	YCS 1.5/0.5	YCS average
ESCR pars	B_0 (t)	9 240	9 860	11 770
	ss_{18} (%)	18	28	50
ORH 7A pars	B_0 (t)	11 130	11 220	11 880
	ss_{18} (%)	24	31	47
ORH 7A pars	B_0 (t)	11 070	11 160	11 720
$U_{max} = 0.8$	ss_{18} (%)	24	31	46

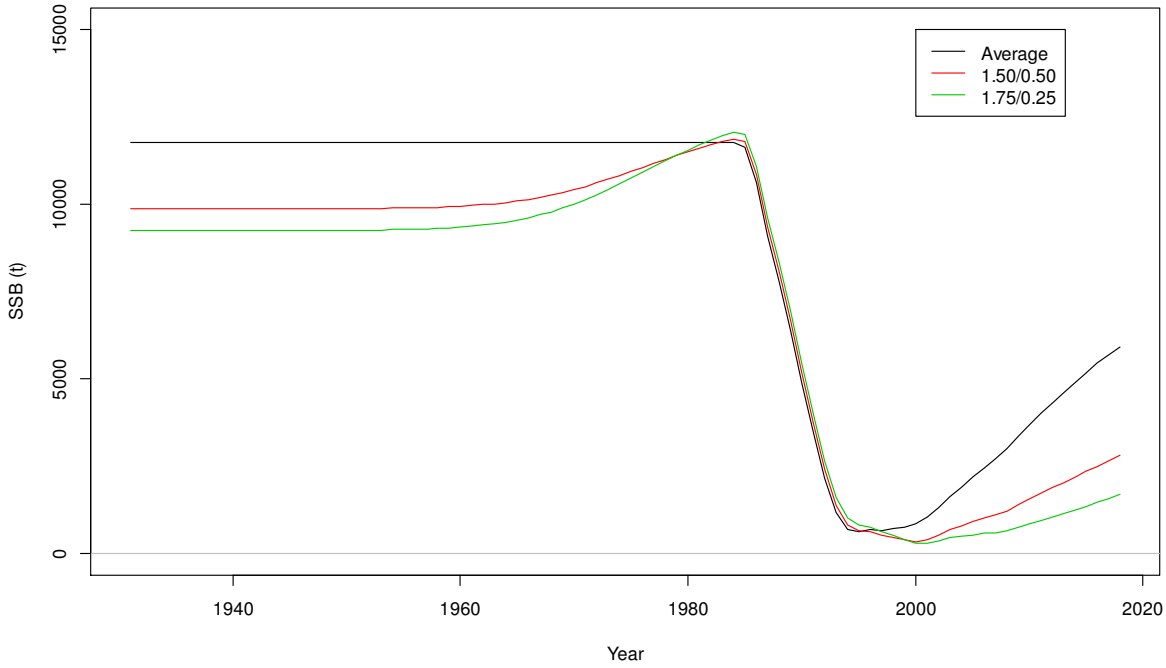

Figure 3: Spawning biomass trajectories for the MPD estimates of B_0 when using the ESCR growth and maturation parameters with the three alternative YCS patterns. All estimates are at B_{min}.

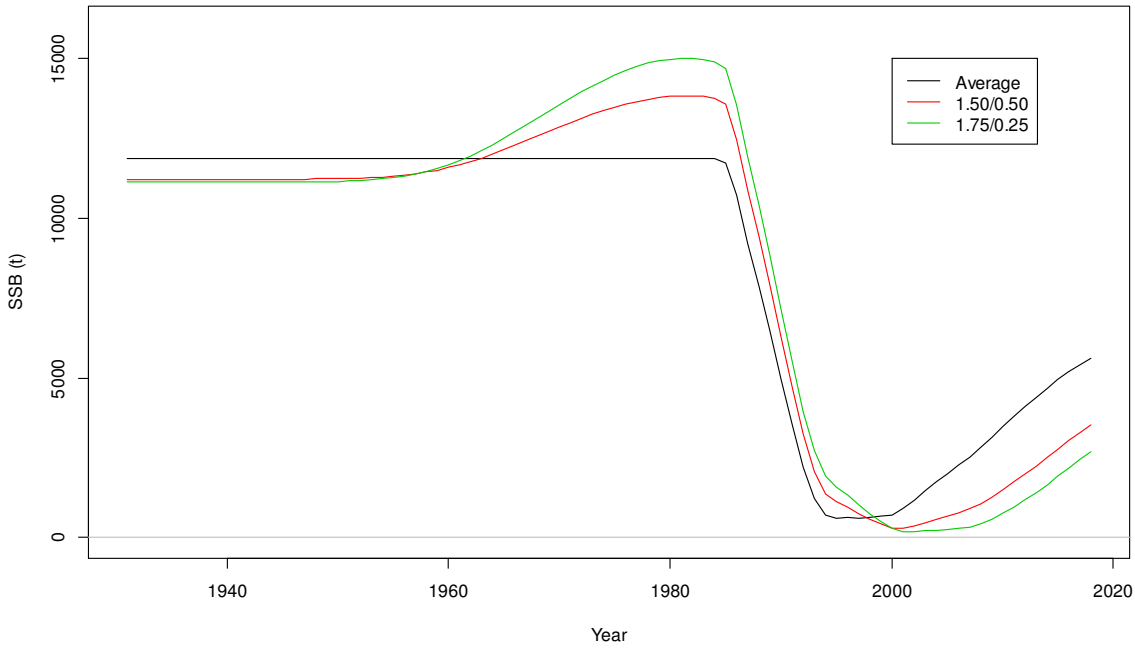

Figure 4: Spawning biomass trajectories for the MPD estimates of B_0 when using the ORH 7A growth and maturation parameters with the three alternative YCS patterns. All estimates are at B_{min}.

Estimated stock status varied across the YCS patterns with stock status lower the more extreme the pattern (Table 2, Figures 5 and 6).

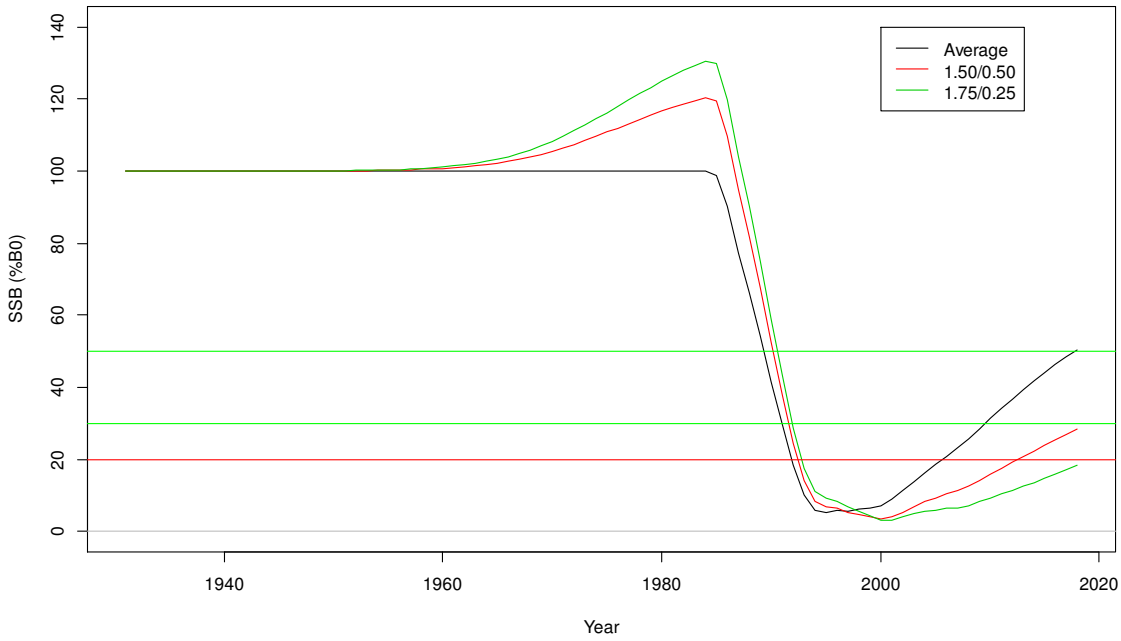

Figure 5: Stock status trajectories for the MPD estimates of B_0 when using the ESCR growth and maturation parameters with the three alternative YCS patterns. All estimates are at B_{min}. Horizontal green lines at 30% and 50% B_0.

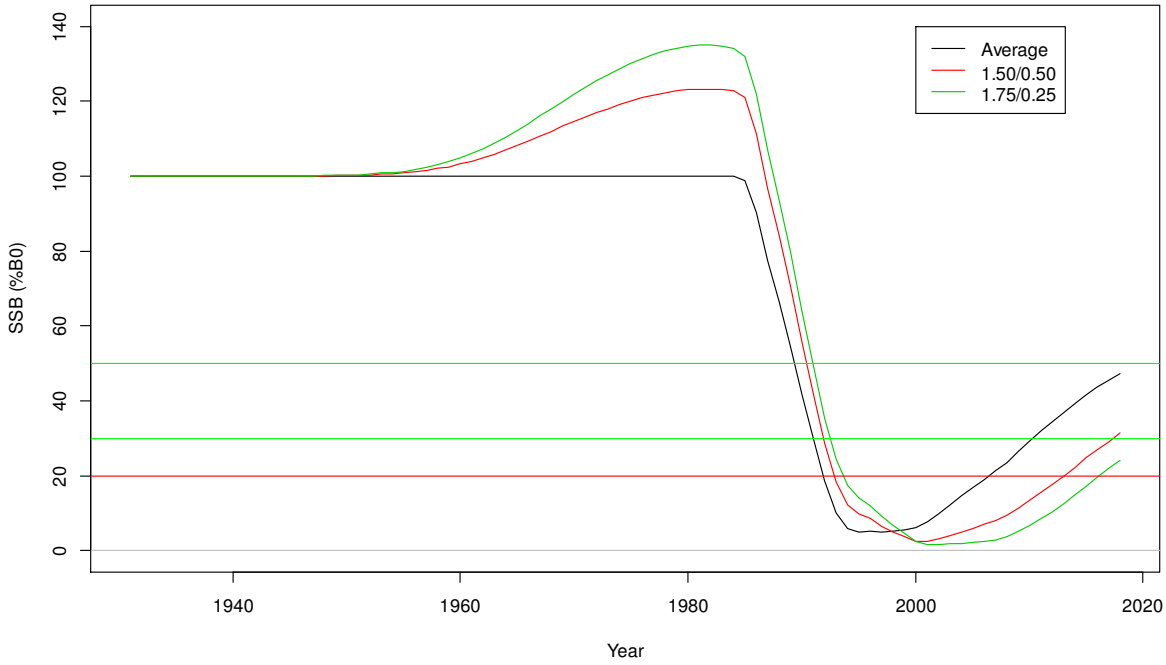

Figure 6: Stock status trajectories for the MPD estimates of B_0 when using the ORH 7A growth and maturation parameters with the three alternative YCS patterns. All estimates are at B_{min}. Horizontal green lines at 30% and 50% B_0.

The year of highest exploitation rate varied with the YCS pattern with the non-average patterns pushing the year out to 2000 compared to the mid 1990s (Figure 7).

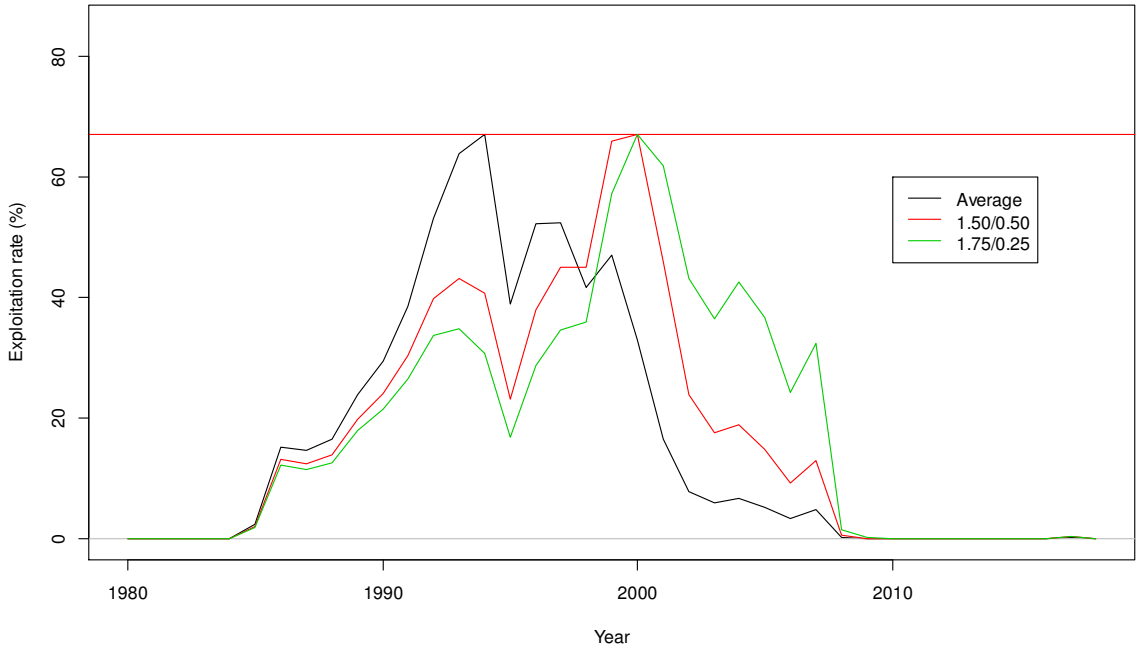

Figure 7: Exploitation rate trajectories for the MPD estimates of B_0 when using the ORH 7A growth and maturation parameters with the three alternative YCS patterns. All estimates are at B_{min}. U_{max} = 0.67.

Although the estimates of B_0 and stock status were independent of the mean of the prior of the acoustic q, the same was not true for the estimates of q or the fit to the acoustic estimate. The estimates of q were lower when the mean of the prior was lower (Table 3). Also, the fit to the acoustic estimate was very poor for the average YCS pattern irrespective of the mean of the prior, the maturation parameters, or the value of U_{max} (Table 3). A negative residual shows that the model was estimating a higher acoustic estimate than was observed.

Table 3: MPD estimates of the acoustic q and the normalised residual for the three YCS patterns, alternative growth and maturation parameters, and different values for the mean of the acoustic q prior (in the case that the ORH 7A parameters were used). Normalised residuals greater than 2 indicate a very poor fit and are highlighted in red.

	Mean aco q	YCS 1.75/0.25	YCS 1.5/0.5	YCS average
ESCR pars	0.6	0.56 -0.12	0.47 -1.45	0.36 -3.39
ORH 7A pars	0.4	0.37 -0.20	0.33 -0.95	0.28 -2.24
	0.6	0.48 -1.23	0.43 -1.98	0.36 -3.26
	0.8	0.58 -1.96	0.52 -2.71	0.44 -3.99
U_{max} = 0.8	0.6	0.48 -1.17	0.44 -1.93	0.37 -3.17

The fit to the acoustic estimate is adequate for the non-average YCS patterns (Table 3) and the more extreme the pattern the lower is the estimate of current stock status (Table 2). In order to investigate a full range of YCS patterns and the consequences for current stock status an MCMC run was done with YCS estimated. The primary information on YCS is coming from the catch history and the maximum exploitation rate assumption. We expect to mainly

get back the prior for each YCS but the overall pattern each time must be consistent with the catch history and the maximum exploitation rate assumption. This was indeed the case for the MCMC run with the estimated YCS showing little pattern except for a tendency to be above average before the mid 1960s and below average after the mid 1960s (Figure 8).

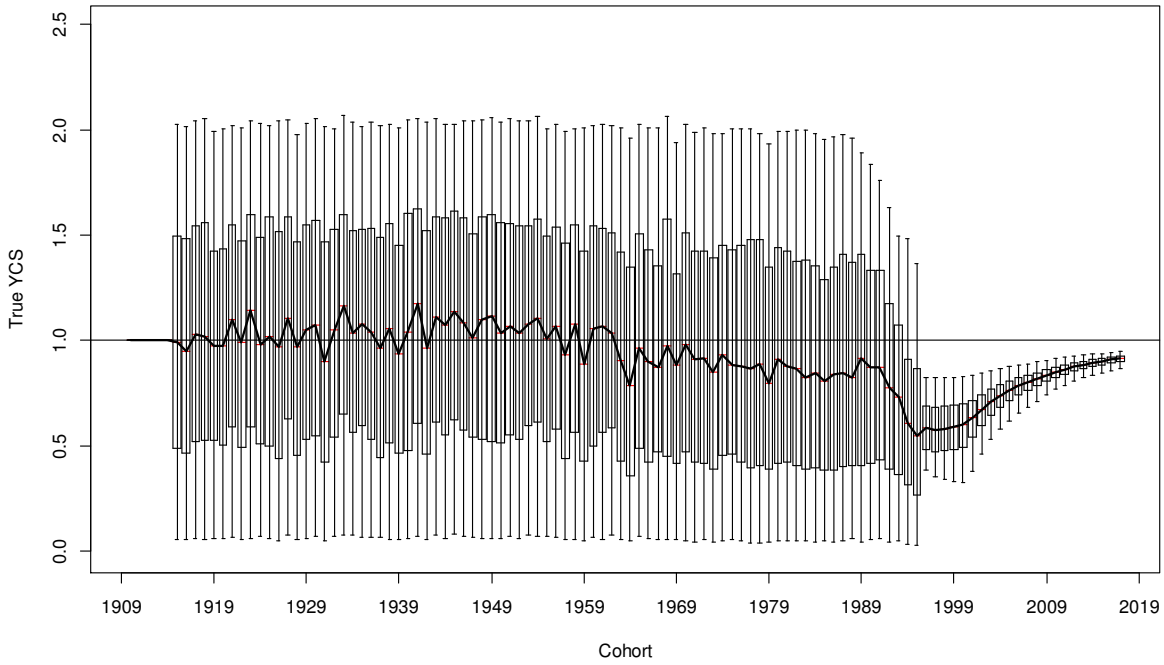

Figure 7: Boxplot of the estimated true YCS (R_y/R_0). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The median estimates are marked by the continuous line.

The acoustic q was estimated in the left-hand tail of the prior (Figure 8). However, there was still a strong tendency for the predicted estimate to be higher than the observation (negative residuals as shown in Figure 9).

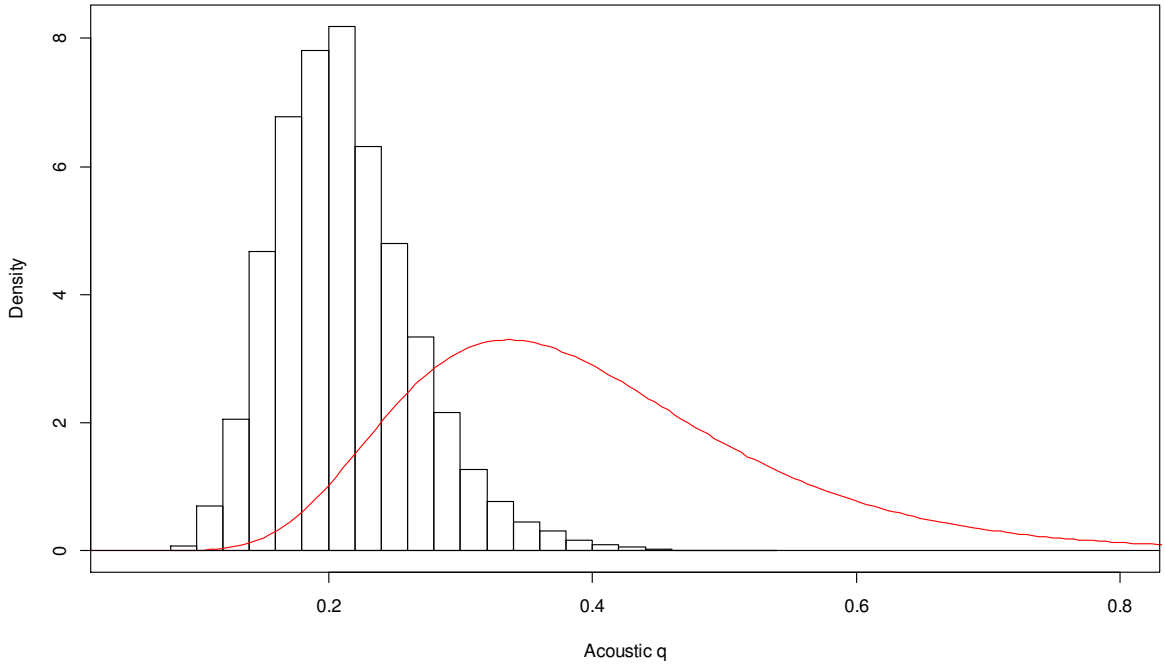

Figure 8: Histogram of the marginal posterior distribution of the acoustic q and the prior (red line).

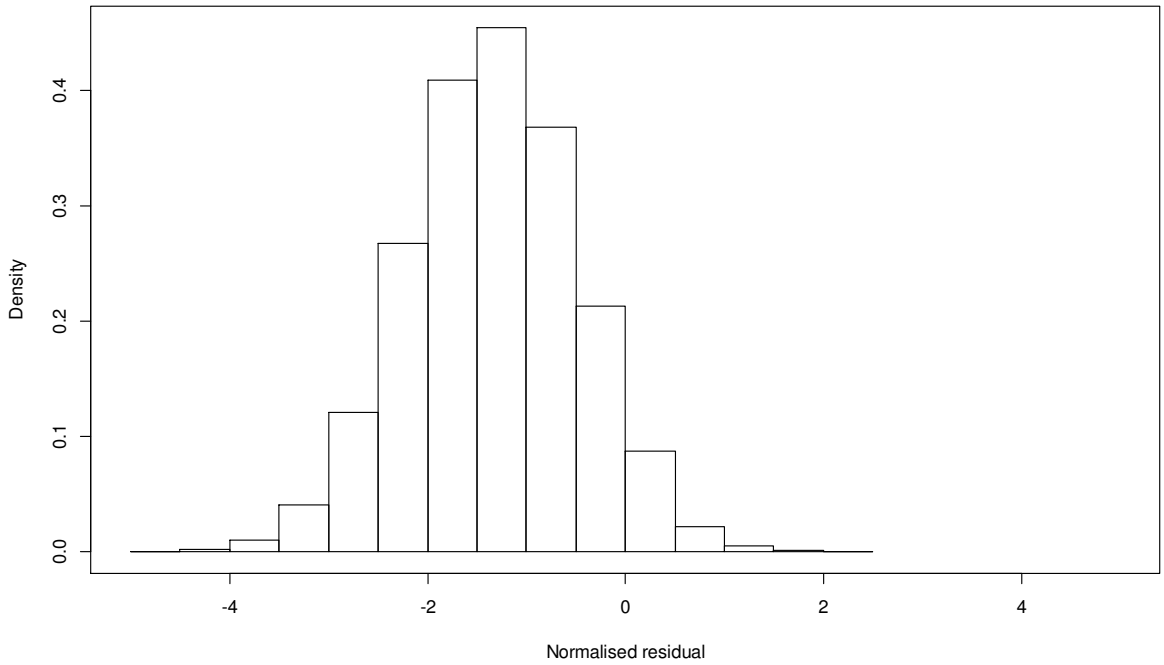

Figure 9: Histogram of the normalised residuals for the acoustic estimate. Negative residuals occur when the predicted value is higher than the observation.

The spawning biomass trajectory shows a strong rebuild which is consistent with the lack of pattern in the YCS estimates and the absence of fishing for a decade (Figure 10). Virgin spawning biomass was estimated at 12 300 t with a 95% CI of 10 900–15 500 t. The estimated exploitation rates are very high through the 1980s and 1990s (Figure 11).

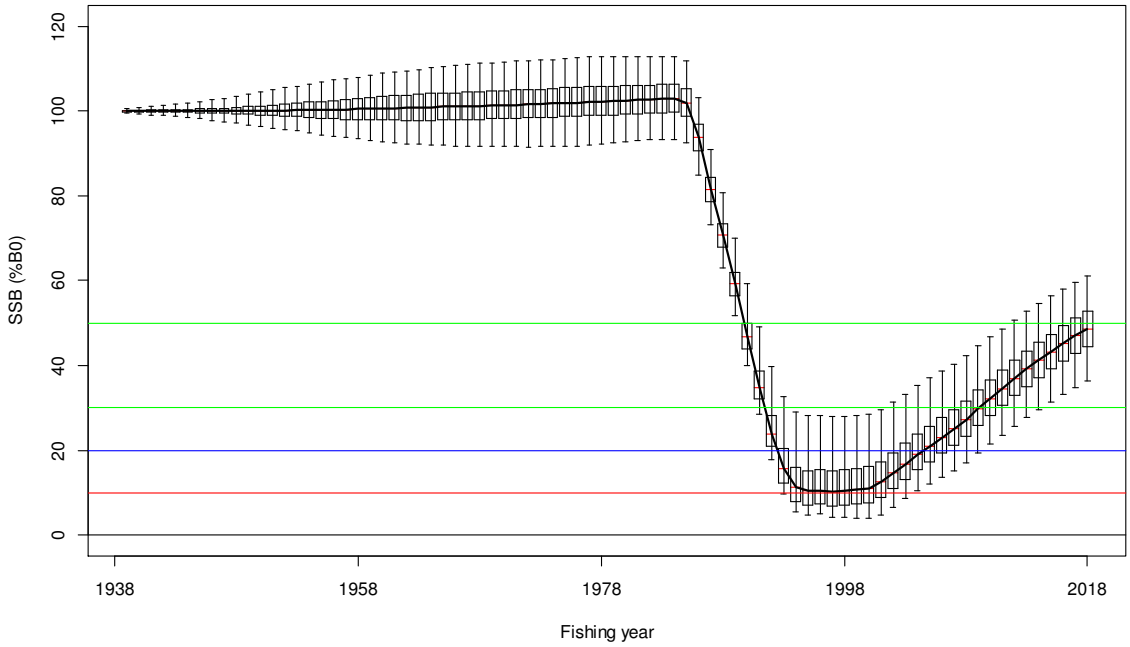

Figure 10: Spawning stock biomass trajectory (%B_0). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The median estimates are marked by the continuous line. Horizontal lines are plotted at 10%, 20%, 30%, and 50% B_0.

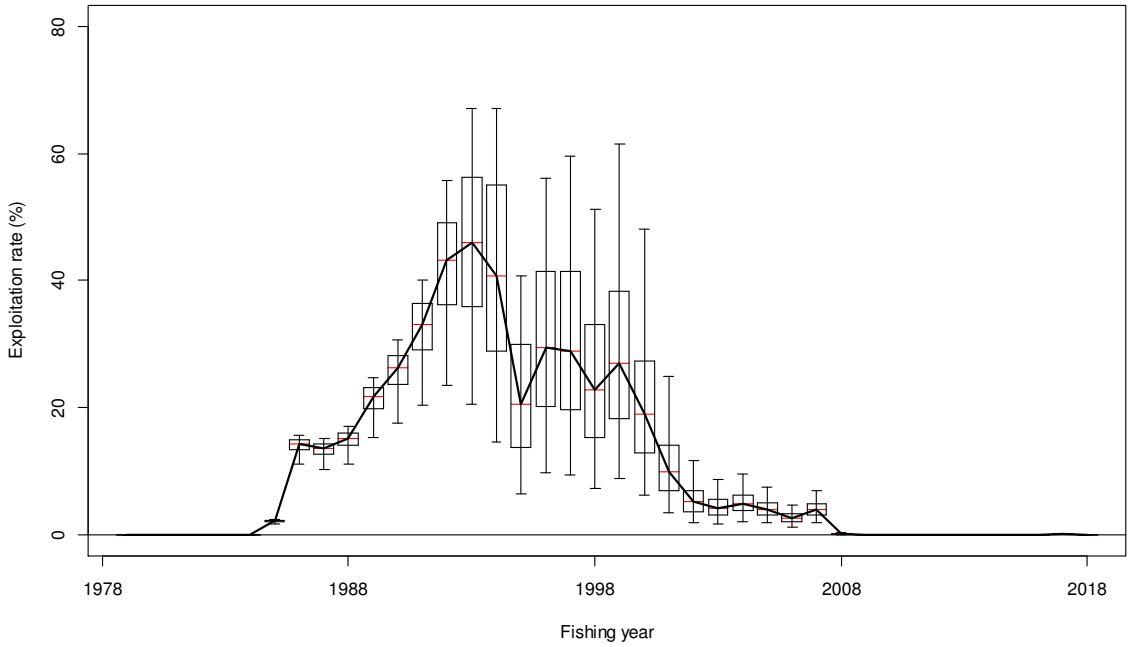

Figure 10: Exploitation rate trajectory (%). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The median estimates are marked by the continuous line.

The very large uncertainty is how much the late timing of the acoustic survey contributed to the low acoustic biomass estimate. In terms of the model, this is uncertainty in the acoustic q. If an extreme YCS pattern is assumed then current status could be as low as 20% (18% for one of the MPD estimates). If the YCS pattern is close to average (with some "noise") then current stock status is very likely to be in the target biomass range (the 95% CI for the MCMC run was 37–62% B_0).

The late timing of the survey was bad luck in that the season was a bit earlier than expected. However, it means that the acoustic estimate is lower than it would have been (by an unknown amount) and also that the age frequency data may have been compromised. For example, it may be that older fish tend to spawn earlier or later than the younger fish.

The production of an age frequency from the late season samples is probably not warranted. Fitting an age frequency is not going to make much difference to the assessment unless it shows an extreme pattern – but an extreme pattern could be attributed to sampling late in the season.

There is only circumstantial evidence of a rebuild. However, unless there has been bad recruitment failure current stock status is very likely to be above 20% B_0 and could even be in the 30–50% B_0 range. Another acoustic survey is needed together with an associated age frequency. The longer the duration of the survey the more chance there is of getting the timing right. It should be noted that this is a small stock and if the stock were managed using the orange roughy HCR then long term annual yield of about 170 t can be expected (1.4% of 12 300 t, see Cordue 2014).

Acknowledgements

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