ORANGE ROUGHY CHALLENGER PLATEAU (ORH 7A)

1. FISHERY SUMMARY

1.1 Commercial fisheries

Historically, the fishery mainly occurred in the south-western region of the Challenger Plateau, both inside and outside the EEZ. Fish were caught throughout the year, with most effort in winter when the orange roughy form aggregations for spawning. Domestic vessels caught most of the quota. Total landings peaked at 10 000–12 000 t annually from 1986–87 to 1988–89 (Table 1). Total landings and ORH 7A landings were less than 2100 t annually from 1990–91 until the closure in 2000–01 (Table 1, Figure 1), when the TACC for this stock was reduced to 1 t.

Recent surveys have shown an increase in biomass in the area. On 1 October 2010 the TACC was increased from 1 t to 500 t, with a 25 t allowance for other mortality, raising the TAC to a total of 525 t. This was to allow research surveys to be conducted using commercial fishing vessels. The TACC was further increased to 1600 t following a stock assessment in 2014. Total landings have closely followed the TACCs in recent years, averaging 1595 t in 2014–15 to 2018–19.

Table 1: Reported landings (t) and TACCs (t) from 1980–81 to present. QMS data from 1986-present. The last two columns are for research surveys on commercial vessels and give the research catch that was not recorded against ACE (WP = Westpac Bank).

Fishing year	EEZ	Outside	Total landings	TACC	EEZ extra	WP extra
1980–81†	1	32	33	-	0	0
1981–82†	3 539	709	4 248	-	0	0
1982–83†	4 535	7 304	11 839	-	0	0
1983–84†	6 332	3 195	9 527	-	0	0
1984–85†	5 043	74	5 117	-	0	0
1985–86†	7 711	42	7 753	-	0	0
1986–87†	10 555	937	11 492	10 000	0	0
1987–88	10 086	2 095	12 181	12 000	0	0
1988–89	6 791	3 450	10 241	12 000	0	0
1989–90	3 709	600	*4 309	2 500	0	0
1990–91	1 340	17	1 357	1 900	0	0
1991–92	1 894	17	1 911	1 900	0	0
1992–93	1 412	675	2 087	1 900	0	0
1993–94	1 594	138	1 732	1 900	0	0
1994–95	1 554	82	1 636	1 900	0	0
1995–96	1 206	463	1 669	1 900	0	0
1996–97	1 055	253	1 308	1 900	0	0
1997–98	+	+	1 502	1 900	0	0
1998–99	+	+	1 249	1 425	0	0
1999–00	+	+	629	1 425	0	0
2000–01	+	+	0.2	1	0	0
2001–02	+	+	0.1	1	0	0
2002–03	+	+	4	1	0	0
2003–04	+	+	< 0.1	1	0	0
2004–05	+	+	< 1	1	141	17
2005–06	+	+	< 1	1	196	22
2006–07	+	+	< 0.1	1	0	0
2007–08	+	+	< 0.1	1	0	0
2008–09	+	+	0.12	1	218	22
2009–10	+	+	< 0.1	1	339	5
2010–11	476	0	476	500	0	5
2011–12	504	7	511	500	0	0
2012–13	513	0	513	500	259	4
2013–14	484	13	497	500	0	50
2014–15	1 594	0	1 594	1 600	0	0
2015–16	1 248	320	1 568	1 600	0	0
2016–17	1 595	28	1 623	1 600	0	0
2017–18	1 026	575	1 601	1 600	126	53
2018–19	+	+	1 589	1 600	0	0
2019–20	+	+	1 897	2 058	0	0
2020–21	+	+	2 074	2 058	0	0

†FSU data
*This is a minimum value, because of unreported catches by foreign vessels fishing outside the EEZ.
+Unknown distribution of catch between inside and outside the EEZ

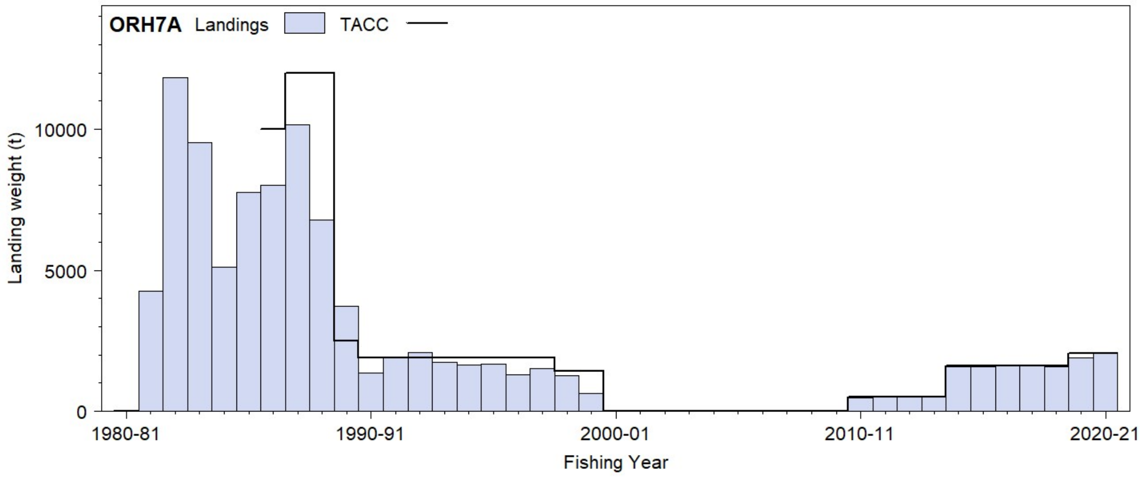


Figure 1: Reported commercial landings and TACC for ORH 7A.

1.2 Recreational fisheries
There is no known recreational fishing for orange roughy in this area.

1.3 Customary non-commercial fisheries
There is no known customary non-commercial fishing for orange roughy in this area.

1.4 Illegal catch
There is no quantitative information available on illegal catch which is likely to be negligible.

1.5 Other sources of mortality
Catch overruns from various sources (including lost and/or discarded fish, use of nominal tray weights and low conversion factors) have been estimated as: 1980–81 to 1987–88, 30%; 1988–89, 25%; 1989–90, 20%; 1990–91, 15%; 1991–92 to 1992–93, 10%; 1993–94 onwards, 5%. These estimates are used in the current stock assessment.

2. BIOLOGY

Biological parameters used in this assessment are presented in the Biology section at the beginning of the Introduction – Orange Roughy chapter.

3. STOCKS AND AREAS

There is no new information on orange roughy stock structure beyond that presented in previous assessment documents.

Orange roughy on the southwest Challenger Plateau (Area 7A, including Westpac Bank) are regarded as a single stock. Size structure, parasite composition, flesh mercury levels, allozyme frequency and mitochondrial DNA studies show differences to other major fisheries. Spawning occurs at a similar time to fish on the Chatham Rise, Puysegur Bank, Ritchie Banks, Cook Canyon and Lord Howe Rise.

4. STOCK ASSESSMENT

From 2010 to 2013, assessments were conducted using an ad hoc approach which combined the virgin biomass estimate from the 2000 assessment (Annala et al 2000, Field & Francis 2001) and current biomass estimates from annual combined acoustic and trawl surveys (see Clark et al 2006, NIWA & FRS 2009, Doonan et al 2010, Hampton et al 2013, Hampton et al 2014, Cordue 2010a, 2012, 2013).

A model-based Bayesian stock assessment was carried out for this stock in 2019 following a similar assessment conducted in 2014 (Cordue 2014a).

The 2014 assessment for this stock was one of four orange roughy assessments carried out in 2014 which all used similar methods (see Introduction – Orange Roughy chapter). The same approach was continued in 2019 although there was a review of previous data inputs and a substantial amount of new data were available. An age-structured population model was fitted to acoustic and trawl-survey estimates of spawning biomass and six age frequencies.

4.1 Model structure

The model was single-sex and age-structured (1–100 years with a plus group), with maturity estimated separately (i.e., fish were classified by age and as mature or immature). Two time steps were used: a full year of natural mortality followed by an instantaneous spawning season and fishery on the spawning fish. Two fisheries were modelled, one within the EEZ and one on Westpac Bank (which is outside of the EEZ). The fishery selectivity for the EEZ was uniform across ages (for spawning fish) while a logistic selectivity (on spawning fish) was used for Westpac Bank where slightly older fish are caught. 100% of mature fish were assumed to spawn each year.

The catch history was constructed from the catches in Table 1 and the over-run percentages in Section 1.5. Natural mortality was assumed to be constant across ages at 0.045 and the stock-recruitment relationship was assumed to follow a Beverton-Holt function with steepness of 0.75. The remaining fixed biological parameters are given in the Introduction – Orange Roughy chapter.

4.2 Input data and statistical assumptions

There were three main data sources for observations fitted in the assessment: spawning biomass estimates from acoustic and trawl surveys (2005, 2006, 2009–2014, 2018); an early trawl survey time series of relative spawning biomass (1987–1989); four age frequencies from the trawl surveys (1987, 2006, 2009, and 2018); and two age frequencies from Volcano (a UTF on the Westpac Bank) (2014 and 2018).

4.2.1 Research surveys

Trawl surveys of orange roughy on the Challenger Plateau were conducted regularly from 1983 to 1990. However, a variety of vessels and survey strata were used which makes comparisons problematic (Dunn et al 2010). Wingtip biomass estimates in 1983–1986 ranged from 100 000–185 000 t but the 1989 and 1990 survey estimates were much lower at approximately 10 000 t. From these early trawl surveys a "comparable area" time series, defined by Clark & Tracey (1994) and covering the period 1987–89, was selected for use in the assessment to provide some information on the early rate of spawning biomass decline (see the *Amaltal Explorer* time series in Table 3).

In 2005, a new series of combined trawl and acoustic surveys was begun using the FV *Thomas Harrison* with a survey area comparable to that used from 1987–1990 (Clark et al 2005). The survey was repeated in 2006 (with an enlarged survey area) and was then conducted annually from 2009–2013 (Clark et al 2006, NIWA & FRS 2009, Doonan et al 2010, Hampton et al 2013, Hampton et al 2014) with another survey in 2018. It was apparent from the later surveys that the 2005 survey did not cover an appropriate area as the spawning biomass distribution had shifted somewhat in the intervening years. The surveys from 2006 onwards appear to have covered the bulk of the spawning biomass. Also, in 2014 an acoustic survey of Volcano was conducted using an Acoustic Optical System (AOS) (Ryan et al 2015) in addition to a hull-mounted transducer. The data from all of the surveys since 2005 have been analysed to produce acoustic and trawl survey indices of spawning biomass.

Acoustic survey indices

For the 2014 assessment, the method of Cordue (2010a, 2012) was used to produce combined acoustic and trawl survey indices for 2010 and 2013. This method used an estimate of orange roughy trawl vulnerability to allow the trawl survey estimates to be combined with the acoustic estimates (trawl estimates were essentially scaled down by a vulnerability distribution with a mean of 1.66). This assumed that the scalar (1.66) had been reliably estimated. To avoid this assumption in the 2019 assessment the acoustic data and trawl data were used separately.

The acoustic biomass estimates from 2005 to 2018 were reviewed and a number of adjustments were required to ensure that the time series of estimates were consistent.

Acoustic estimates of spawning aggregations on Volcano and in the west and east of the flats within the EEZ were used in three separate time series (Table 2). Estimates from the hull-mounted transducer were adjusted as necessary so that they all used the latest length to target strength relationship, the Doonan et al (2003) absorption coefficient, and a combined motion and bubble layer correction (1.33) borrowed from work done on the Chatham Rise (Cordue 2010b, Doonan et al 2012). The estimates from the AOS (2014 and 2018) were adjusted to use the Doonan et al (2003) absorption coefficient. In 2005, 2011, and 2013, the motion corrections applied to the snapshots were not documented and a factor of 1.06 (the mean for snapshots in 2006 and 2009) was used in the adjustment calculations. In those years the acoustic indices were assigned an additional 20% of process error to account for the approximate adjustment.

Table 2: Acoustic biomass estimates of spawning aggregations surveyed on Volcano, and the West and the East within the EEZ. The model CV is the observation error CV with an additional 20% of process error in the years when the vessel motion correction was unknown (2005, 2011, and 2013).

	West		East		Volcano	
Year	**Biomass (t)**	**Model CV (%)**	**Biomass (t)**	**Model CV (%)**	**Biomass (t)**	**Model CV (%)**
2005	4 210	53			2682	39
2006	4 383	59			6329	39
2009	13 555	22	8471	61		
2010	8 114	14	1707	34		
2011	13 340	33				
2013	10 183	22	5365	26	4559	34
2014					3954	29
2018	9 966	9				

The acoustic biomass estimate for each aggregation in each year is an average of a number of "snapshots" (individual surveys/estimates) of the aggregation in that year. Some of the snapshots in some years were not used in the average because they appeared to have been taken before the aggregation was fully formed (judged on the basis of female gonad stages from trawl catches at the time of the snapshot). Some snapshots in the eastern area (in 2010 and 2011) were not used as an examination of the distribution of backscatter on the transects showed that a genuine spawning aggregation was not surveyed (e.g., just a single transect on which positive backscatter was recorded).

In 2018 there were a number of snapshots of Volcano which showed substantial biomass (about 4000 t) but it was unclear from the gonad staging whether spawning was underway. These snapshots were not used in the assessment (and there is no estimate for Volcano in 2018). In 2009, there was a single snapshot on Volcano which satisfied the timing criteria but it was a very low estimate (671 t) compared to all of the other years. It was considered that this estimate was unlikely to be representative of the spawning biomass on Volcano in 2009. It was not used in the base model but was used in a sensitivity run.

Informed priors on the proportionality constants (q) were used for the acoustic time series. The means of the priors were derived from the 2013 proportions across aggregations and the assumption that all three aggregations combined represented "most" of the spawning biomass (80%). The prior used in this case for orange roughy assessments (since 2014) is LN(mean=0.8, CV=19%) (Cordue 2014a). Splitting this prior into three components gave priors for the West, East, and Volcano qs respectively: LN(0.41, 30%), LN(0.22, 30%), LN(0.18, 30%).

Trawl survey indices

The spawning biomass estimates from the *Thomas Harrison* trawl surveys (Table 3) were used as relative biomass with an informed prior. They excluded the rough terrain strata 9–11 and the mean of the informed prior was: 0.9 × 0.85 × 1.25 = 0.95 (allowing for total-survey availability (0.9), exclusion of strata 9–11 (0.85) and trawl vulnerability – adjusted mean of estimated vulnerability distribution = 1.25). Given the problematic nature of these trawl surveys (fish pluming and moving within the area), a process error CV of 20% was added to the estimated CVs (Table 3).

Table 3: Biomass indices from trawl surveys used in the stock assessment. The model CV is the observation error CV with an additional 20% of process error.

Vessel	Year	Biomass (t)	Model CV (%)
Amaltal Explorer	1987	75 040	33
	1988	28 954	34
	1989	11 062	23
Thomas Harrison	2006	13 987	34
	2009	34 864	31
	2011	18 425	33
	2012	22 451	27
	2013	18 993	55
	2018	48 038	55

Age frequencies

Age frequencies were available from four of the trawl surveys for use in the assessment. A previous analysis produced age frequencies for the 1987 *Amaltal Explorer* survey and the 2009 *Thomas Harrison* survey (Doonan et al 2013), although that study was based on a relatively small number of otoliths, it showed that the 2009 age frequency had much younger fish than the 1987 age frequency. For the 2014 stock assessment, the existing age frequencies were augmented with an increased number of otoliths (for a total of about 300 for each survey) and a new age frequency (from about 300 otoliths) was produced for the 2006 *Thomas Harrison* survey. For the 2019 assessment the age data from the 2018 survey were used to produce an age frequency for the EEZ (750 otoliths) and Volcano (150 otoliths). An age frequency was also produced from the 2014 survey of Volcano (470 otoliths) (Doonan et al 2015).

The age frequencies were assumed to be multinomial and were mainly assigned effective sample sizes of 300/5 = 60 (with the sample size reflecting the number of trawl stations rather than the number of otoliths). However, the 2018 age frequency from Volcano was obtained from only one targeted trawl and this was given a much lower effective sample size of 30 (to reflect that it may not have been representative of the spawning plume). No reweighting was attempted because of the short time series.

There are no age frequencies from the commercial fishery.

4.3 Model runs and results

In the base model, natural mortality (M) was fixed at 0.045. There were numerous MPD and MCMC sensitivity runs but four main sensitivities are presented in this report: "All trend" (informed priors removed), estimate M, and the *LowM-Highq* and *HighM-Lowq* runs (see the Introduction – Orange Roughy chapter for specifications).

In the base model the main parameters estimated were: virgin biomass (B_0), the maturity ogive, the selectivity for Westpac Bank and year class strengths (YCS) from 1925 to 1995 (with the Haist parameterisation and "nearly uniform" priors on the free parameters). There were also the five proportionality constants (q) for the two trawl and three acoustic survey time series.

4.3.1 Model diagnostics

The MCMC (and MPD) fits to the data in the base model were very good except in two cases.

The *Amaltal Explorer* time series shows a very steep decline over only three years in the late 1980s (Figure 2). The steep decline cannot be fitted by the model unless a very high weight is placed on the time series and all other data are down-weighted. In this case the estimate of the minimum stock status is reduced to about 5% B_0 (compared to 15% B_0 for the base) but the estimate of current stock status is unchanged from the base model. It is likely that the *Amaltal Explorer* indices do not reflect true stock abundance in those years.

There are good fits to the main biomass indices, the West aggregation (Figure 3) and the *Thomas Harrison* trawl indices (Figure 4). Both sets of indices and the fits show an increase from 2005/2006 through to 2018.

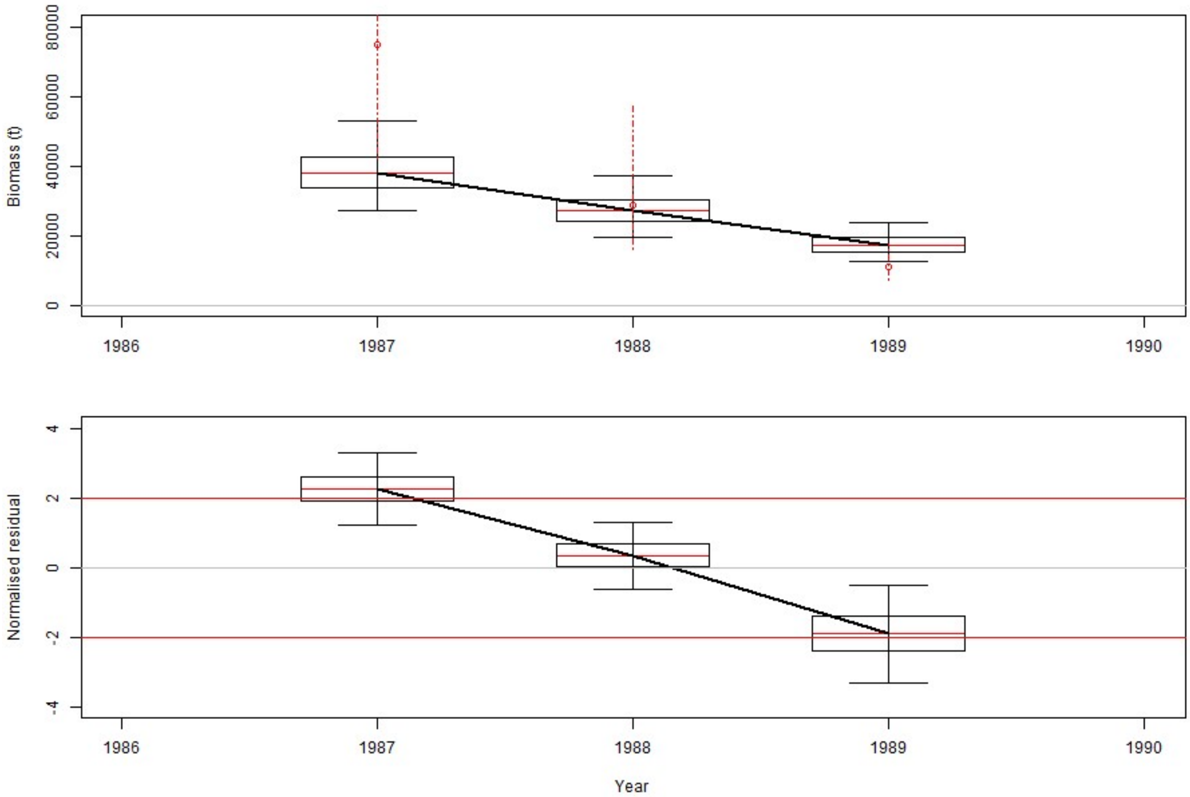


Figure 2: Base, MCMC: fit to the *Amaltal Explorer* trawl indices (top panel) and the associated normalised residuals (bottom panel). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The indices are plotted in the top panel (open circles) with 95% CIs (dashed red lines).

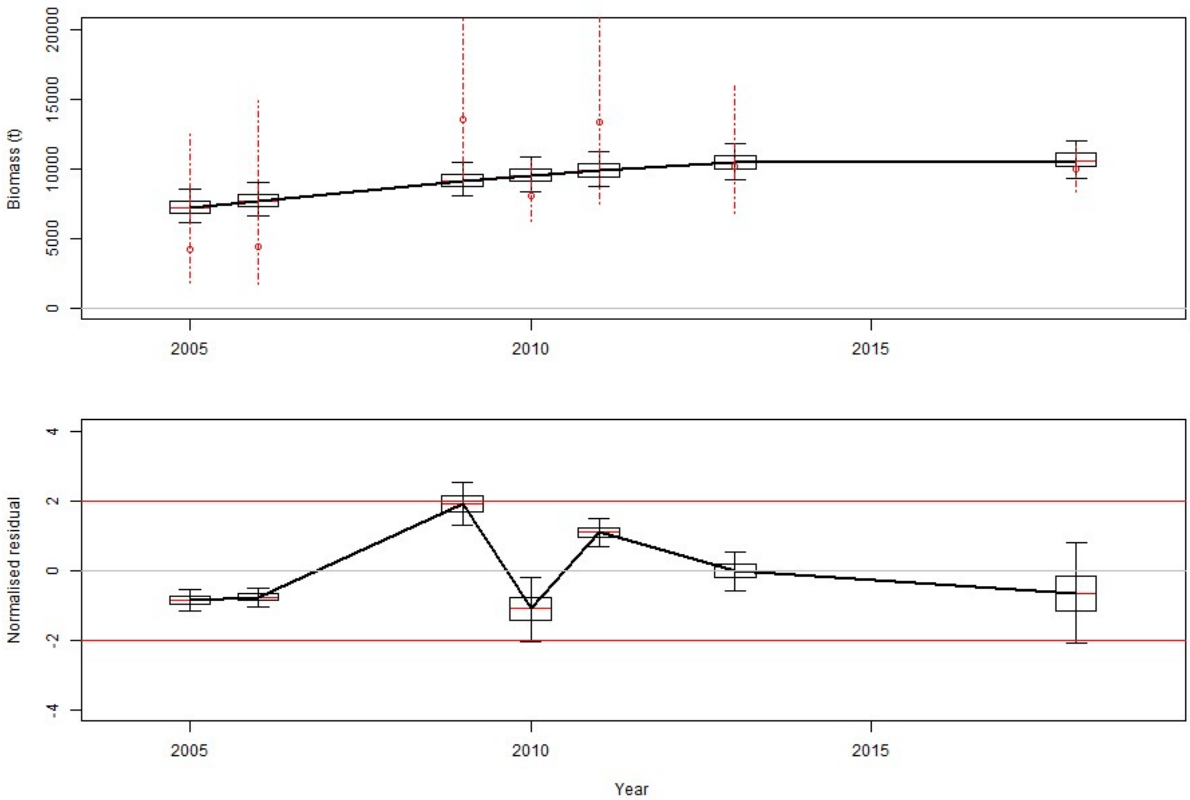


Figure 3: Base, MCMC: fit to the West spawning aggregation (top panel) and the associated normalised residuals (bottom panel). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The indices are plotted in the top panel (open circles) with 95% CIs (dashed red lines).

The second poor fit is for the 2018 Volcano age frequency (Figure 5). This age frequency was obtained from a single large catch on Volcano and only 150 otoliths. It has much older fish than the age frequency from Volcano in 2014 which was obtained from samples from six trawl catches on Volcano. It is possible that the 2018 age frequency is not representative of the age distribution of the spawning aggregation on Volcano in 2018. Compared to 2018, the fit and associated residuals for the 2014 age frequency are excellent (Figure 6).

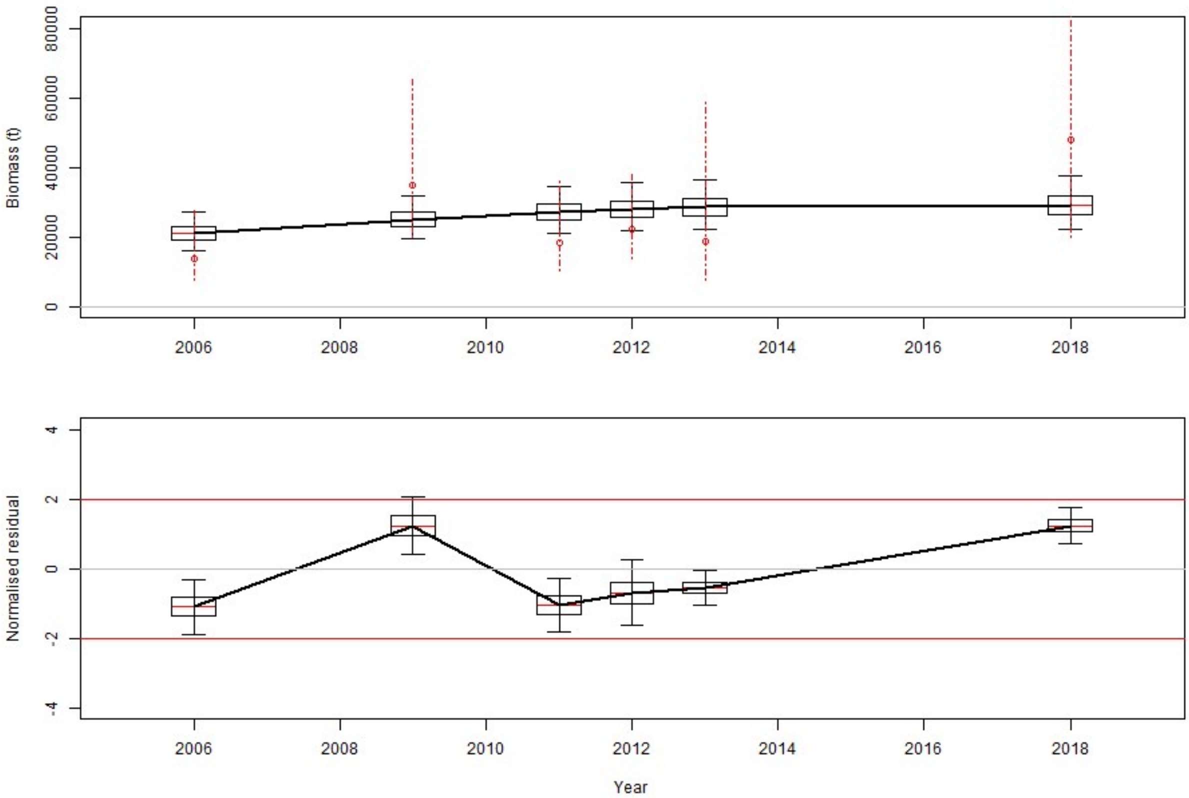


Figure 4: Base, MCMC: fit to the *Thomas Harrison* trawl indices (top panel) and the associated normalised residuals (bottom panel). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The indices are plotted in the top panel (open circles) with 95% CIs (dashed red lines).

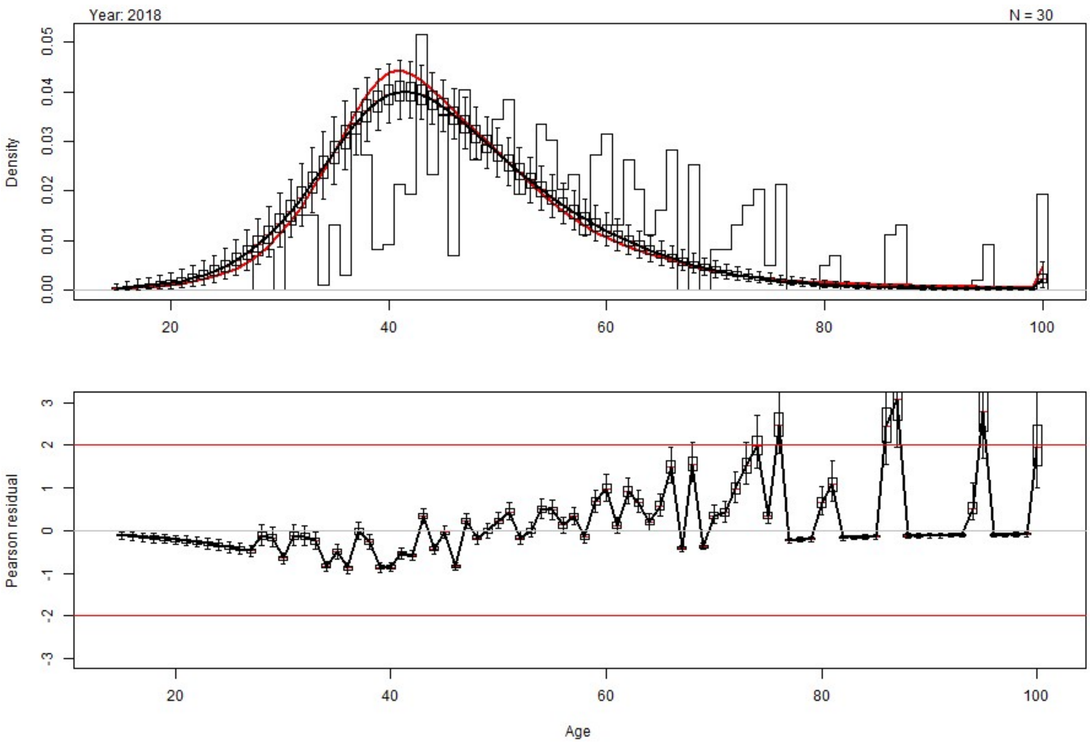


Figure 5: Base, MCMC: fit to the 2018 Volcano age frequency (top panel) and the associated Pearson residuals (bottom panel). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The indices are plotted in the top panel (open circles) with 95% CIs (dashed red lines). The MPD fit is shown in red (top panel).

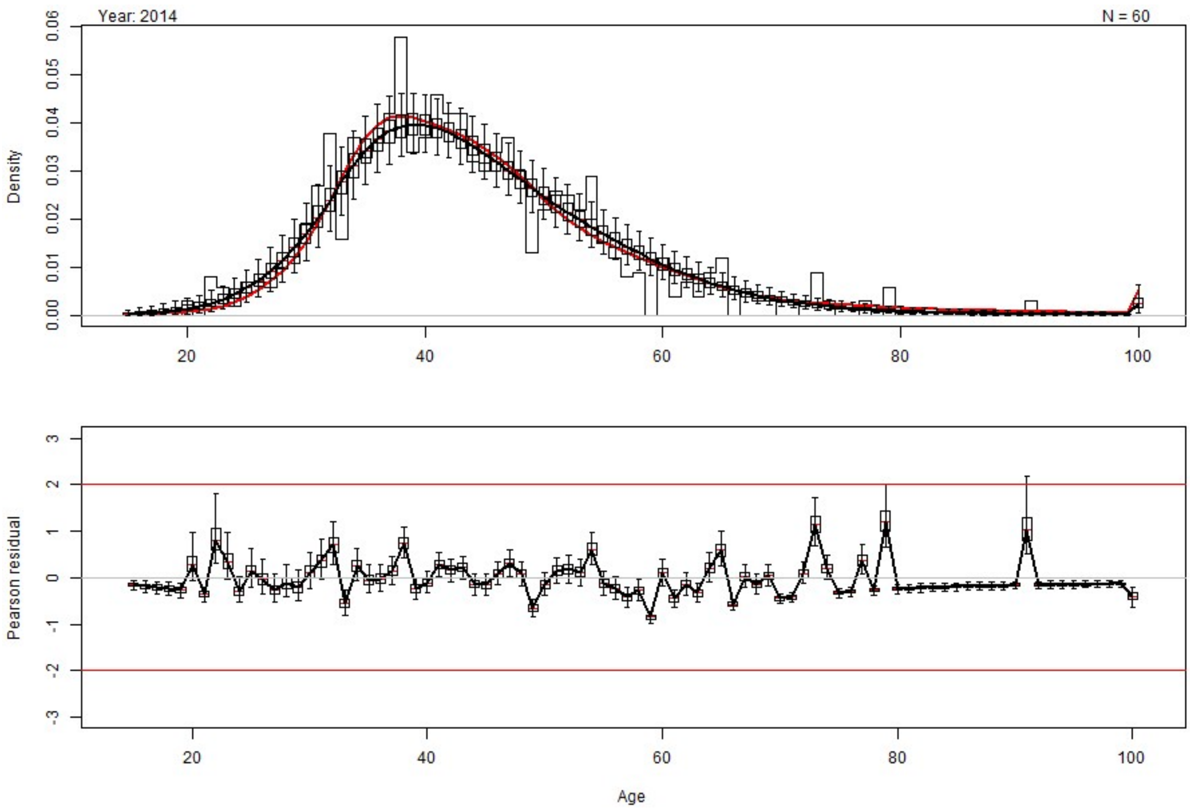


Figure 6: Base, MCMC: fit to the 2014 Volcano age frequency (top panel) and the associated Pearson residuals (bottom panel). Each box covers the middle 50% of the distribution and the whiskers extend to 95% CIs. The indices are plotted in the top panel (open circles) with 95% CIs (dashed red lines). The MPD fit is shown in red (top panel).

The posterior distributions of the *q*s, which had informed priors, show movement to lower values of *q* for *Thomas Harrison*, the West, and the East aggregations, with a shift to higher values for Volcano (Figure 7). Although there is a substantial move to the left (for West and East), the posterior distributions are still within the range of the prior distributions and so the estimates of *q* are credible. For Volcano, the move to higher values probably reflects the nature of the associated selectivity which is to the right of maturity (which is the selectivity for the West and East aggregations).

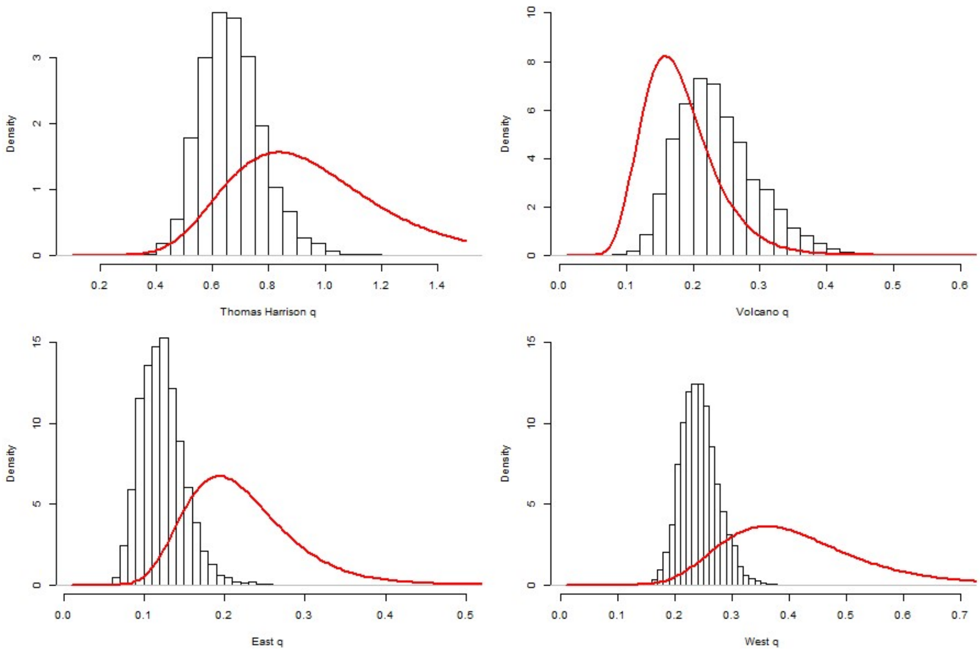


Figure 7: Base, MCMC: Prior distributions (solid red lines) and marginal posterior distributions (histograms) for the *Thomas Harrison* and acoustic *q*s.

MCMC results

For the base model, and the sensitivity runs, MCMC convergence diagnostics were excellent. Virgin biomass (B_0) was estimated to be about 95 000 t for all runs except when the informed priors on the *q*s were removed (Table 4). When the informed priors were removed, virgin biomass was estimated to be higher than in the base model (Table 4). This indicates that the trend in the biomass indices, and to some extent the age frequencies, support a higher virgin biomass than was implied by information on the scale of the stock from the informed priors. The base model estimates are to be preferred as the informed priors contain information on orange roughy target strength and spawning biomass areal availability that is not otherwise available to the model. For all runs, current stock status was estimated to be within or above the target biomass range of 30–50% B_0 (Table 4).

Table 4: MCMC estimates of virgin biomass (B_0) and stock status (B_{2019} as %B_0) for the base model and four sensitivity runs.

	M	B_0 (000 t)	95% CI	B_{2019} (%B_0)	95% CI
Base	0.045	94	86–104	47	39–55
All trend	0.045	107	94–126	57	46–67
Estimate M	0.037	97	89–106	40	31–51
LowM-Highq	0.036	95	88–103	37	30–45
HighM-Lowq	0.054	94	85–106	56	48–65

The estimated YCS show little variation across cohorts but exhibit a long-term trend (Figure 8). The cohorts from 1989–1995 were spawned when SSB was at about 20% B_0 (Figure 9). It is encouraging that the YCS estimates for these cohorts was about average (Figure 8). This suggests that steepness in the assumed Beverton-Holt stock recruitment relationship for this stock is not particularly low.

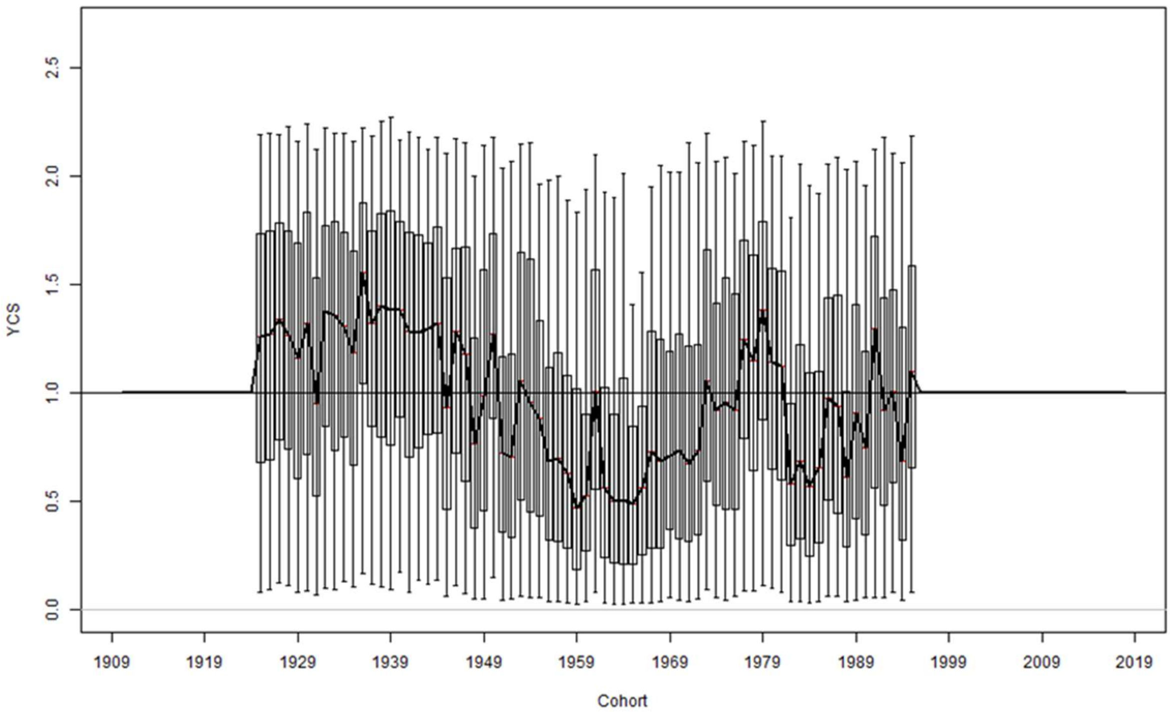


Figure 8: Base, MCMC estimated YCS. The box in each year covers 50% of the distribution and the whiskers extend to 95% of the distribution.

The stock status trajectory shows a steep decline to about 15% B_0 in 1990, reflecting the large removals during the initial fish-down phase of this stock (Figure 9). From 1990 stock status remains at about 15% B_0 until an upturn in the late 1990s (Figure 9). Biomass is estimated to have peaked in 2015, near the top of the target biomass range, before the increased catches (enabled by a TACC increase) caused a levelling out of the biomass trajectory (Figure 9).

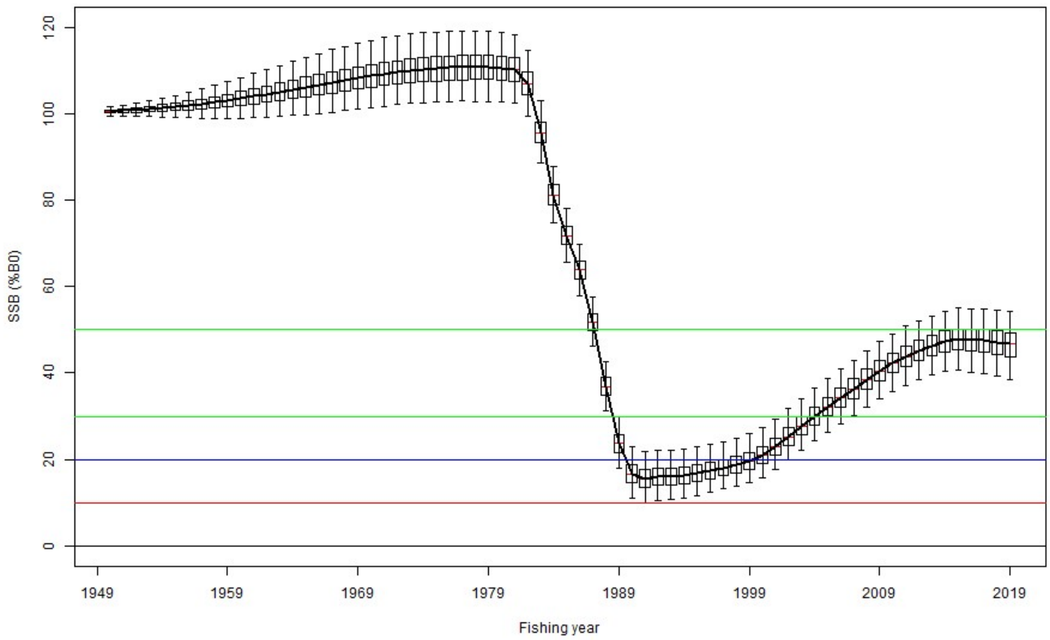


Figure 9: Base, MCMC estimated spawning-stock biomass trajectory. The box in each year covers 50% of the distribution and the whiskers extend to 95% of the distribution. The hard limit 10% B_0 (red), soft limit 20% B_0 (blue), and biomass target range 30–50% B_0 (green) are marked by horizontal lines.

Fishing intensity was estimated in each year as the total exploitation rate (total catch over beginning of fishing season spawning biomass) for each MCMC sample to produce a posterior distribution for fishing intensity by year. The fishing intensity reference points $U_{30\%B0}$ and $U_{50\%B0}$ were also calculated in terms of exploitation rate (for the assumed catch split in the 2018–19 fishing year).

Estimated fishing intensity was generally well above the target range ($U_{30\%B0}$–$U_{50\%B0}$) up until the closure of the fishery in 2001. Subsequently, it was well below the target range up until 2014, and from 2015 until now it is at the lower end of the range (Figure 10).

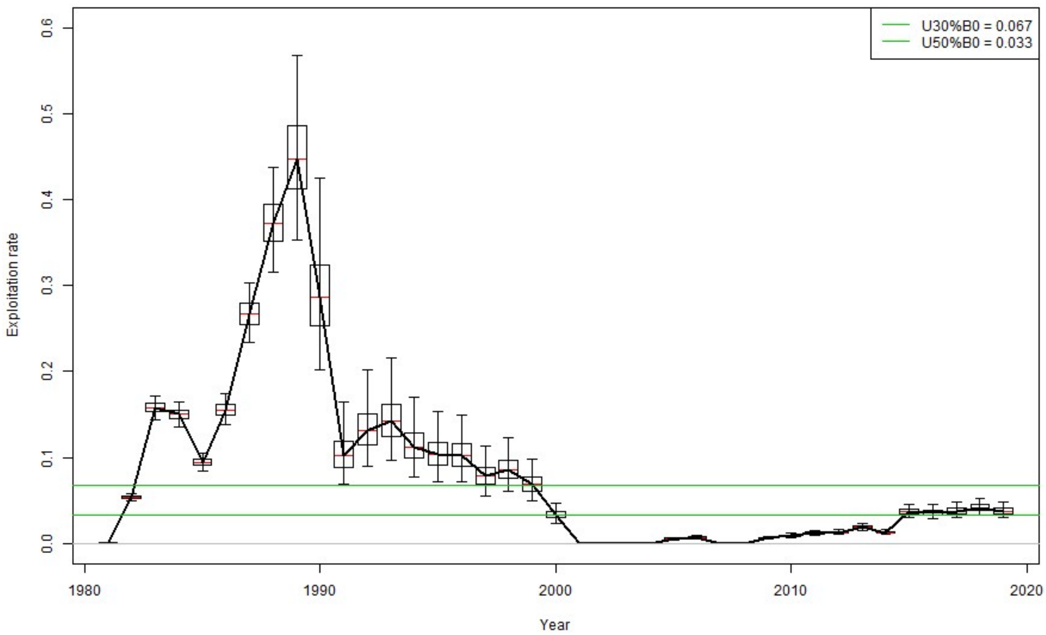


Figure 10: Base, MCMC estimated fishing-intensity trajectory. The box in each year covers 50% of the distribution and the whiskers extend to 95% of the distribution. The fishing-intensity range associated with the biomass target of 30–50% B_0 is marked by horizontal lines.

Projections

Five-year projections were conducted (with resampling from the last 10 estimated YCS, 1986–1995) for a constant catch of 1600 t (the current TACC). A 5% catch over-run was assumed. Projections were done for the base model and for the *LowM-Highq* sensitivity model (as a "worst case" scenario).

At the current TACC (1600 t), SSB is predicted to decrease slowly over the next five years for both models, while staying within the target biomass range (Figure 11). For both models the estimated probability of SSB going below either the soft limit (20% B_0) or the hard limit (10% B_0) is zero. For the base model projection, exploitation rates are predicted to slowly increase but still be at the lower end of the fishing intensity target range in 2024 (95% CI 0.030–0.054 compared to the target range of 0.033–0.067).

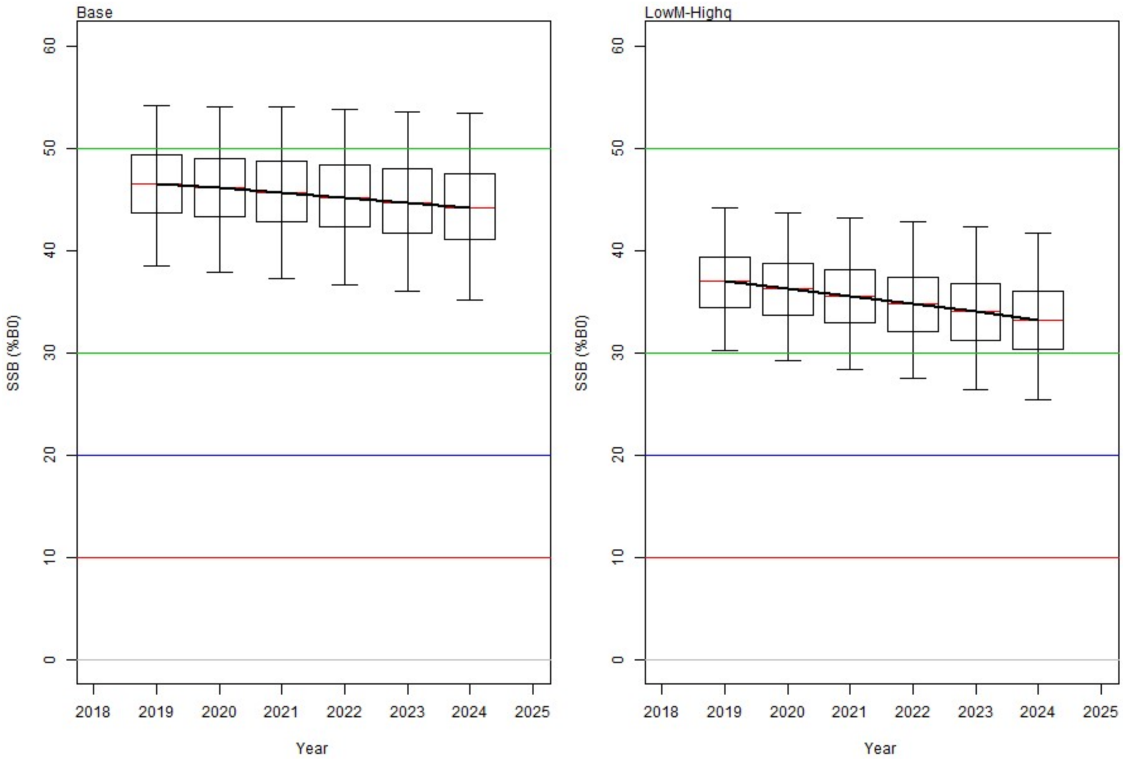


Figure 11: MCMC projections for a constant catch of 1600 t (plus a 5% allowance for incidental catch) for the base model and the LowM-Highq model. The box in each year covers 50% of the distribution and the whiskers extend to 95% of the distribution. The target biomass range (30–50% B_0) is indicated by horizontal green lines, the hard limit (10% B_0) by a red line and the soft limit (20% B_0) by a blue line.

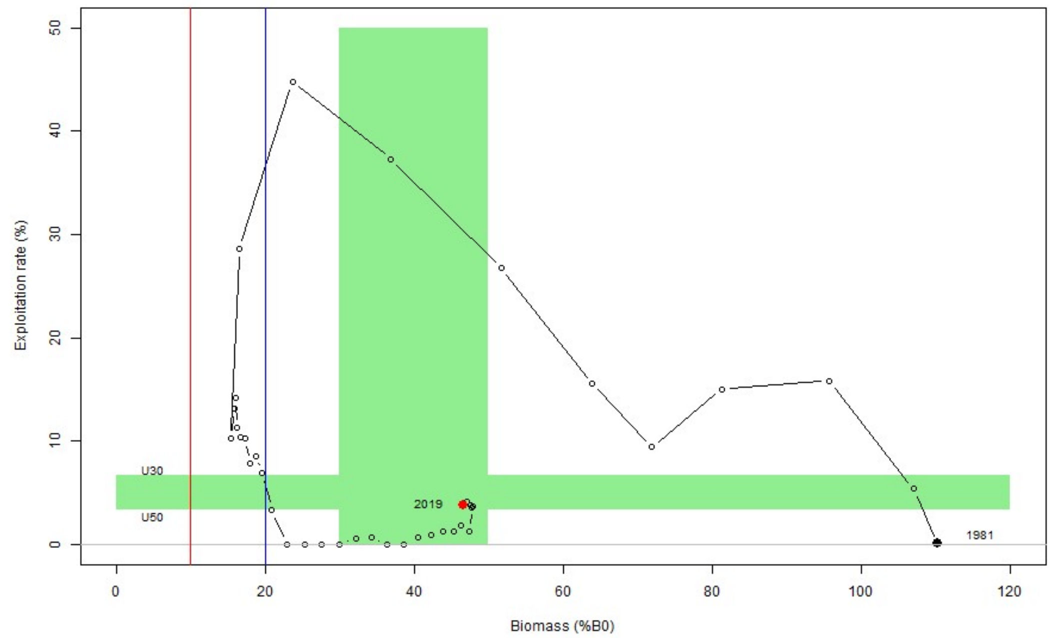
5. FUTURE RESEARCH CONSIDERATIONS

- Revise the acoustic survey design and implementation to ensure (i) improved estimation of the abundance in the 'East' aggregation and (ii) abundance estimates are obtained for all three aggregations ('East', 'West' and Volcano) in the same year.
- Reconsider the otolith sampling approach from acoustic surveys to ensure that adequate otoliths are obtained from each aggregation and that these are obtained from multiple tows to support the stock assessment.
- Review current arrangements for sampling commercial catches for age to ensure that adequate samples are being obtained from both spawning and non-spawning fisheries.

6. STATUS OF THE STOCK

Orange roughy on the southwest Challenger Plateau (Area 7A, including Westpac Bank) are regarded as a single stock.

Stock Status	
Year of Most Recent Assessment	2019
Assessment Runs Presented	Base model only
Reference Points	Management Target: Biomass range 30–50% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: Fishing intensity range $U_{30\%B0}$–$U_{50\%B0}$
Status in relation to Target	B_{2014} was estimated to be 47% B_0 Very Likely (> 90%) to be at or above the lower end of the management target range and About as Likely as Not (40–60%) to be at or above the upper end of the management target range
Status in relation to Limits	B_{2019} is Exceptionally Unlikely (< 1%) to be below the Soft Limit B_{2019} is Exceptionally Unlikely (< 1%) to be below the Hard Limit
Status in relation to Overfishing	Fishing intensity in 2018–2019 was estimated to be below or within the fishing intensity range. Overfishing is Very Unlikely (< 10%) to be occurring.



Historical trajectory of spawning biomass (%B_0) and fishing intensity (exploitation rate) (base model, medians of the marginal posteriors). The biomass target range of 30–50% B_0 and the corresponding exploitation rate (fishing intensity) target range are marked in green. The soft limit (20% B_0) is marked in blue and the hard limit (10% B_0) in red.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Spawning biomass is estimated to have peaked in 2014–2015 near the top of the target biomass range and to have declined slightly since then.
Recent Trend in Fishing Intensity or Proxy	Fishing intensity has been near the bottom of the fishing intensity target range since 2014–15.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Biomass is expected to slowly decrease at the current TACC (1600 t) over the next 5 years, but to remain within the target range.

Probability of Current Catch or TACC causing Biomass to remain below, or to decline below, Limits	Soft Limit: Exceptionally Unlikely (< 1%) within the next 5 years Hard Limit: Exceptionally Unlikely (< 1%) within the next five years
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Unlikely (< 10%) within the next five years

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment: 2019	Next assessment: 2023
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Acoustic survey indices for West, East, and Volcano aggregations	1 – High Quality
	- Two trawl survey time series: 1987–1989 and 2006, 2009–2012	1 – High Quality
	- Age frequencies from the trawl surveys in 1987, 2006, 2009, and 2018	1 – High Quality
	- Age frequencies from Volcano in 2014 and 2018	1 – High Quality
Data not used (rank)	- commercial CPUE	3 – Low Quality: unlikely to be indexing stock-wide abundance
	- Acoustic surveys of UTFs other than Volcano	2 – Medium or Mixed Quality: species identification and dead zone problems
	- Other acoustic estimates which did not meet the selection criteria	2 – Medium or Mixed Quality: not surveys of a spawning aggregation or timing too early
	- Early trawl surveys with different vessels covering different areas	2 – Medium or Mixed Quality: not a consistent time series
Changes to Model Structure and Assumptions	- Acoustic biomass estimates were adjusted using a combined correction for vessel motion and the bubble layer estimated for a different vessel on the Chatham Rise. In the 2014 assessment, estimates were not corrected for the bubble layer. - Two fisheries were modelled instead of a single fishery.	
Major Sources of Uncertainty	- The proportion of the stock that is indexed by the acoustic and trawl surveys.	

Qualifying Comments
-

Fishery Interactions
Since the fishery re-opened with a low level of catch and effort, bycatch levels have been relatively low at about 4 to 5%, with spiky oreo being 1.4% of the average catch for 2008-09 to 2013-14. The bycatch of low productivity species over this period includes a number of deepwater shark and coral species. There were no observed incidental captures of seabirds or marine mammals between 2002–03 and 2017–18. Orange roughy are caught using bottom trawl gear. Bottom trawling interacts with benthic habitats.

6. FOR FURTHER INFORMATION

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