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Assessments of orange roughy stocks in SIOFA statistical areas 1, 2, 3a, and 3b

P.L. Cordue
Innovative Solutions Ltd
Consultant

Relates to agenda item: **4**   Working paper ☒ Info paper ☐

Abstract

Stock assessments and application of New Zealand's harvest control rule to several orange roughy stocks within SIOFA statistical areas 1, 2, 3a, and 3b are presented.

For six stocks a catch-history based assessment is performed. For three of those stocks a simple model-based assessment is also done using acoustic biomass estimates (and some results from the Walter's Shoal Region assessment).

The assumption of an historical maximum exploitation rate of 50% leads to very conservative catch limits for 2018 (ranging from 5-300 t). Given the very tricky nature of fishing on many of the features it may be that 20% or even 10% is a more appropriate assumption for some or all of the stocks. The model-based yield estimates are far larger than the catch-history based estimates. They rely very much on the validity of the acoustic biomass estimates. There is potential for investigation and discussion at the SAWG meeting with regard to the likely veracity of the acoustic biomass estimates on different features.

Recommendation

That the Stock Assessment Working Group

1. Accept the methods used to produce the stock assessments and the yield estimates.
2. Accept the preliminary results or revised results based on updated inputs to the stock assessments agreed during the SAWG meeting.

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Executive Summary

Innovative Solutions Ltd (ISL) was contracted to provide a stock assessment for orange roughy in the Walter's Shoal region (WSR) and to apply the New Zealand Harvest Control Rule (HCR) to other orange roughy stocks in the SIOFA area. SAWG(2018)-01-05 describes the stock assessment for the WSR. This paper presents the assessments and application of the HCR to several other stocks within SIOFA statistical areas 1, 2, 3a, and 3b.

Seven stocks are considered in this document. For six of the stocks a catch-history based assessment is performed. For three of those six stocks a simple Bayesian assessment is also done using acoustic biomass estimates from features within the stock boundaries and results from the WSR assessment. For one stock, no assessment is attempted as there was little catch and no acoustic estimates.

A given catch history implies a minimum level of virgin biomass – the amount necessary to allow the catch to have been taken. Also, the catch cannot have reached 100% of the available biomass in any year as it is not physically possible for vessels to take every last fish. In these assessments three different levels of maximum exploitation rate (50%, 20%, 10%) were used to calculate a virgin biomass consistent with the maximum exploitation rate and the given catch history. A simple model with deterministic recruitment, a Beverton Holt stock recruitment relationship (steepness = 0.75), fixed natural mortality (0.045), and a single fishery (at the end of the year) on the spawning fish was used to do the calculations.

For the three stocks with acoustic biomass estimates, a full Bayesian approach with MCMC samples from the posterior distribution was not attempted as no age frequency data were available for any of the stocks. Instead, MPD estimates (the Mode of the Posterior Distribution) from three models using different treatments of the acoustic biomass estimates were used to capture the uncertainty.

The assumption of an historical maximum exploitation rate of 50% leads to very conservative catch limits for 2018 (ranging from 5-300 t). Given the very tricky nature of fishing on many of the features it may be that 20% or even 10% is a more appropriate assumption for some or all of the stocks. This is something that can perhaps be investigated and discussed at the SAWG meeting. Catch limits at a maximum exploitation rate of 20% range from 160-960 t while at 10% they range from 430-2420 t.

The MPD yield estimates are far larger than the catch-history based estimates. They rely very much on the validity of the acoustic biomass estimates. The main concern with the acoustic estimates is that some estimates could be inflated by species contamination for some of the features. The potential biases due to target strength, absorption coefficient, and analysis method are dealt with by having the three treatments of the acoustic biomass estimates. There is potential for investigation and discussion at the SAWG meeting with regard to the likely veracity of the acoustic biomass estimates on different features.

Introduction

Innovative Solutions Ltd (ISL) was contracted to provide a stock assessment for orange roughy in the Walter's Shoal region (WSR) (defined to be the region enclosed by the rectangle 33 50' to 34 41' S, 44 00' to 46 00' E) and to apply the New Zealand Harvest Control Rule (HCR) to other orange roughy stocks in the SIOFA area. SAWG(2018)-01-05 describes the stock assessment for the WSR. This document presents the assessments and application of the HCR to several other stocks within SIOFA statistical areas 1, 2, 3a, and 3b.

Seven stocks are considered in this document. For six of the stocks a catch-history based assessment is performed. For three of those six stocks a simple Bayesian assessment is also done using acoustic biomass estimates and results from the WSR assessment. For one stock no assessment or calculation of yields is attempted as there has been little catch from the stock and there are no acoustic estimates for the any part of the stock (Western Walters – see below).

Methods

Stock hypotheses

Various stock boundaries were defined by Graham Patchell of Sealord Group (Figure 1). The Walters Shoal Region (WSR) was assessed using a full Bayesian stock assessment (SAWG(2018)-01-05) and is not considered in this report. The Walters Seamounts stock also includes a feature to the north of the given box and the west of WSR (Figure 1). It was assumed that all catch for a stock was within its stock boundary.

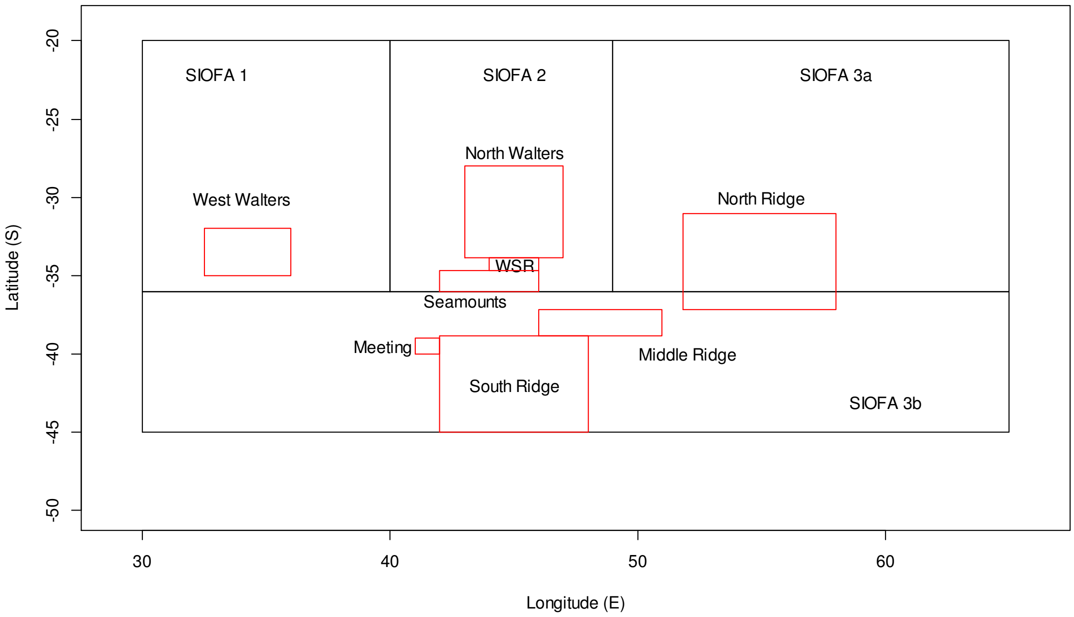

Figure 1: SIOFA statistical regions (1, 2, 3a, and 3b) and the stock boundaries defined for the purposes of these stock assessments. WSR = Walter's Shoal Region which was assessed separately. "Seamounts" also includes a feature to the north of the given box and the west of WSR.

Catch histories

Catch and position data were supplied by SIOFA and by Graham Patchell from Sealord Group. The SIOFA data were primarily from New Zealand, Australia, and Japan. The Sealord data were supplied as a catch history from 1999 to 2017 inclusive for a range of underwater features/hills for each stock. The remaining data were tow by tow with catch, year, and position. Where accurate positions were given the catch was assigned to the nearest feature within 5 n.m. of the starting tow position. Otherwise if the catch was within a given stock boundary it was assigned to that stock under "Other" (where any catch not allocated to one of the features within a stock was accumulated).

For the catch-history based assessment method only the total catch for each year was required (Table 1). Western Walters has hardly been fished and there are no acoustic biomass estimates available for any of the features in its boundary so it is not suitable to be assessed by either method used in this paper and is not considered further.

Table 1: Catch (t) for calendar years 1999 to 2017 for each defined stock considered in this report. See Figure 1 for the stock boundaries.

	Meeting	Middle Ridge	North Walters	North Ridge	Walters Seamounts	South Ridge	Western Walters
1999	0	1840	0	4967	0	1044	0
2000	655	3563	0	3904	880	1048	250
2001	869	631	200	1219	243	506	120
2002	1	226	0	1581	350	14	0
2003	32	283	6	859	883	275	0
2004	2	733	0	217	780	51	0
2005	0	555	995	59	1016	704	0
2006	0	112	79	120	666	694	243
2007	0	97	16	32	1907	97	32
2008	0	577	2	122	1100	294	0
2009	0	800	200	33	944	155	0
2010	4	223	119	23	514	88	24
2011	1	311	9	75	289	39	2
2012	0	164	54	65	108	61	0
2013	1	1	24	124	69	433	0
2014	0	36	6	62	252	119	0
2015	10	24	22	26	316	4	0
2016	0	10	44	89	160	198	28
2017	0	380	8	64	157	439	24
Total	**1576**	**10 568**	**1784**	**13 643**	**10 636**	**6262**	**722**

The highest catches for these stocks occurred in 1999 and 2000 for North Ridge and Middle Ridge when 2000-5000 t was taken each year from each stock (Figure 2). Since then catches have declined markedly with the largest catch of about 2000 t being taken from Walters Seamounts in 2007 (Figure 2).

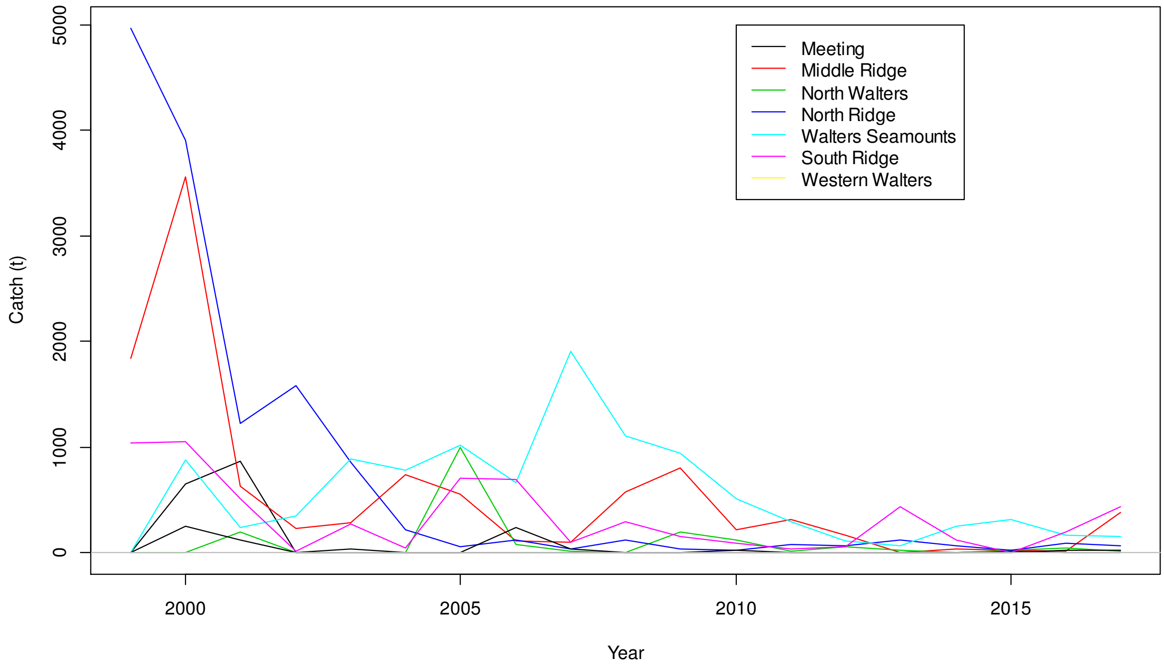

Figure 2: Catch (t) for calendar years 1999 to 2017 for each defined stock considered in this report.

Acoustic biomass estimates

Acoustic biomass estimates were available from some of the features in North Walters, Walters Seamounts, and Middle Ridge in some of the years since 2004 (see Niklitschek and Patchell 2015). Unlike the WSR acoustic biomass estimates, none of the estimates used in these stock assessments have been revised/refined. However, no estimates that covered a "large" area were used as such estimates are prone to double counting due to fish movement. Also, any estimates with very large CVs were ignored, as were estimates outside the peak of the spawning season.

Three different variations of the acoustic estimates were used in stock assessment models: Low, Middle, and High (Tables 2a-2c). The different variations used combinations of alternatives: Doonan et al. (2003) or Francois and Garrison (1982) for the absorption coefficient; geostatistical or design based ("EDSU") estimation; and the McClatchie-Kloser target strength (TS) relationship or the best fit 16.15 revised relationship (see Appendix C in SAWG(2018)-01-05 – some new TS data were collected). The existing biomass estimates used Doonan, geostatistics, and McClatchie-Kloser.

The "low" estimates were calculated by using Doonan, geostatistics, and the new TS measurement. For this variation the original estimates were reduced to 63% of the original value.

The "middle" estimates were calculated by using Doonan, EDSU, and best fit 16.15. For this variation the original estimates were used because the adjustments for EDSU and best fit 16.15 cancel out (1.27 × 0.79 = 1.00) (see Appendix C in SAWG(2018)-01-05).

The "high" estimates were calculated using Francois and Garrison, EDSU, and McClatchie-Kloser. The adjustment required is 1.3 × 1.27 = 1.65 (see Appendix C in SAWG(2018)-01-05).

Table 2a: Acoustic biomass estimates for features in Walters Seamounts. See the text for the low, middle, and high treatments. The features are identified by a number only for confidentiality.

Feature	**Year**	**Low estimate (t)**	**Middle estimate (t)**	**High estimate (t)**	**CV (%)**
1	2009	240	**381**	629	55
	2010	847	**1345**	2219	35
2	2010	2099	**3331**	5496	18
3	2009	6070	**9635**	15 898	16

Table 2b: Acoustic biomass estimates for features in North Walters. See the text for the low, middle, and high treatments. The features are identified by a number only for confidentiality.

Feature	**Year**	**Low estimate (t)**	**Middle estimate (t)**	**High estimate (t)**	**CV (%)**
1	2009	3050	**4841**	7988	36
2	2009	1976	**3136**	5174	30

Table 2c: Acoustic biomass estimates for features in Middle Ridge. See the text for the low, middle, and high treatments. The features are identified by a number only for confidentiality.

Feature	**Year**	**Low estimate (t)**	**Middle estimate (t)**	**High estimate (t)**	**CV (%)**
1	2004	5332	**8463**	13 964	58
2	2004	4342	**6892**	11 372	26
	2008	1544	**2451**	4044	37
3	2004	5866	**9311**	15 363	57
4	2009	4362	**6924**	11 425	30
	2011	9850	**15 635**	25 798	34
5	2008	2003	**3179**	5245	25

Stock assessment methods

For all of the stocks except Western Walters a catch-history based method of assessment was used. Also, for the three stocks with acoustic biomass estimates a simple Bayesian approach was used which borrowed some estimates and marginal posterior distributions from the WSR assessment (SAWG(2018)-01-05). All models were implemented in NIWA's stock assessment package CASAL (Bull et al. 2012).

Catch history based method

A given catch history implies a minimum level of virgin biomass – the amount necessary to allow the catch to have actually been taken. Also, the catch cannot have reached 100% of the available biomass in any year as it is not physically possible for vessels to take every last fish. In New Zealand the standard assumption for fisheries operating on orange roughy spawning plumes is that the exploitation rate cannot exceed 67% (which is 2/3 rounded to 2 significant figures). This assumption is reasonable for New Zealand orange roughy fisheries but for the SIOFA fisheries it seems implausible that such a high exploitation rate could occur for the whole "stock" given the difficult nature of fishing on many of the features.

In this assessment three different levels of maximum exploitation rate (50%, 20%, 10%) have been used to calculate a virgin biomass consistent with the maximum exploitation rate and the given catch history. A simple model with deterministic recruitment, a Beverton Holt stock recruitment relationship (steepness = 0.75), natural mortality fixed (0.045), and a single fishery (at the end of the year) on the spawning fish was used to do the calculations. Fish were categorized by age (1-120 with a plus group) and maturity state (immature or mature). Growth and length-weight parameters were borrowed from those estimated from the Sleeping Beauty data (SAWG(2018)-01-05) as the results are completely insensitive to those parameters (it is the level of the catch relative to biomass that matters, not the number of fish in a given biomass). Also, the maturation parameters were taken to be the point estimates from the base WSR assessment (SAWG(2018)-01-05: a_{50} = 37 years, a_{to95} = 14 years).

Bayesian method

A full Bayesian approach with MCMC samples from the posterior distribution was not used as no age frequency data were available for any of the stocks. This means that the year class strengths (YCS) and the maturation parameters cannot be estimated and natural mortality (M) also should be fixed. With so many fixed parameters the uncertainty associated with a single run would be vastly under-estimated. It is simplest to just use MPD estimates (the Mode of the Posterior Distribution) and capture the uncertainty across models (rather than within a model).

Three different approaches were used with the acoustic estimates: Low, Middle, High. And, for each approach, different estimates and marginal posterior distributions were borrowed from the WSR assessment. The maturation parameters were borrowed from the Low, Middle, and High points estimates of the WSR assessment and were fixed in the corresponding Low, Middle, and High assessment models for each of the three stocks (Table 3). Also, informed priors were used for the acoustic q for each of the assessments, being set equal to the marginal posterior distribution of the acoustic q from the WSR assessment (Table 3).

Table 3: The marginal posterior distributions for the acoustic q and the point estimates of maturation from the WSR assessment (see SAWG(2018)-01-05).

	Acoustic q		Maturation	
	Mean	CV (%)	a_{50}	a_{to95}
Low	0.59	18	37	13
Middle	0.70	22	37	14
High	0.76	21	36	13

For North Walters the simple model used in the catch-history based approach was also used here. This was possible because both features had been surveyed in the same year so a combined acoustic estimate and catch history could be used. For the other two stocks, the migration model used for the WSR assessment was adopted (see SAWG(2018)-01-05). For Walters Seamounts the proportion migrating to the Other area was assumed to be 10% for the Middle model, 5% for the Low model, and 15% for the High model. For Middle Ridge a higher proportion migrating to Other had to be used because there had been a lot of catch from the un-numbered features (represented by Other): 10% for Low, 15% for Middle, and 20% for High.

Application of the HCR

New Zealand's MSC certified orange roughy stocks are managed using a HCR that specifies an F or a U (exploitation rate) for the next fishing year using the current year's estimate of stock status (Cordue 2014) (Figure 3). The HCR was applied to the stock assessments in this document. The estimates of stock status in 2017 were translated to possible catch limits for 2018 by applying the indicated exploitation rate to the 2018 beginning-of-season estimate of mature biomass.

The exploitation rate from the HCR (U_{HCR}) depends on estimated stock status (ss):

$$
\begin{aligned}
U_{HCR} &= 0.05625 && \text{for } ss > 50\%\ B_0 \\
&= 0.1125\ ss && \text{for } 30\%\ B_0 < ss \leq 50\%\ B_0 \\
&= 0.16875\ (ss - 0.1) && \text{for } 10\%\ B_0 < ss \leq 30\%\ B_0 \\
&= 0 && \text{for } ss \leq 10\%\ B_0.
\end{aligned}
$$

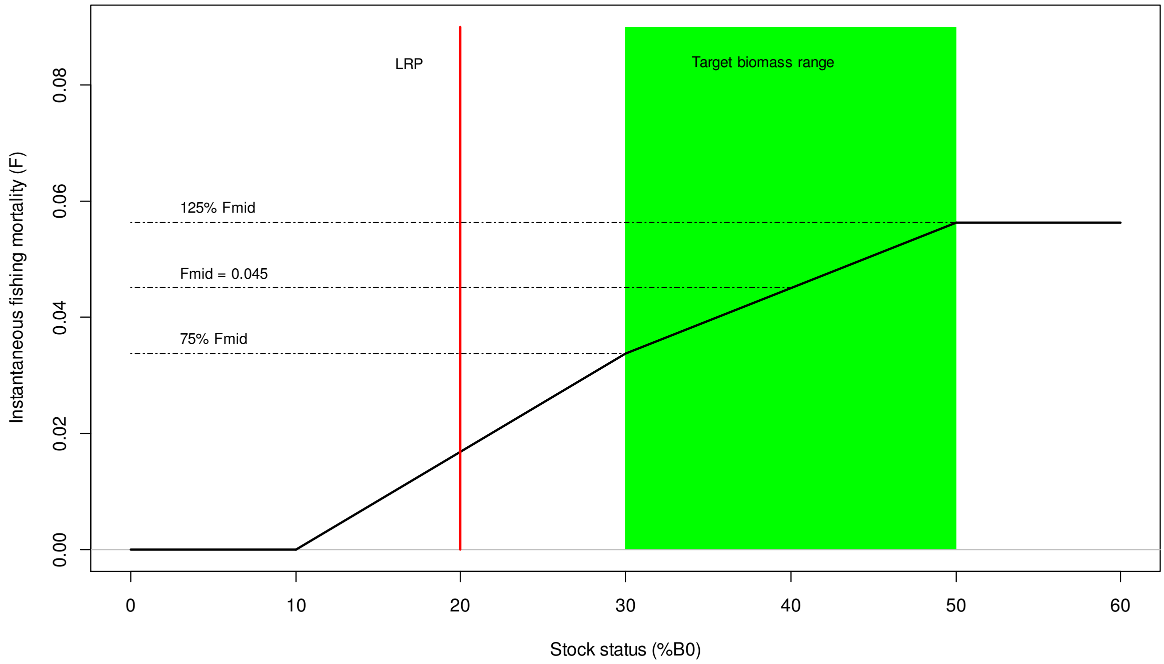

Figure 3: The HCR used for New Zealand's MSC certified orange roughy stocks. The target biomass range is 30-50% B_0 and the limit reference point is 20% B_0. Instantaneous *F* (or an exploitation rate) is calculated using the ramped line shown from the current estimate of stock status.

Results

Catch-history based method

The assumption of an historical maximum exploitation rate of 50% leads to very conservative catch limits for 2018 (Table 4). Given the very tricky nature of fishing on many of the features it may be that 20% or even 10% is a more appropriate assumption for some or all of the stocks. The question is what is the maximum proportion of the spawning biomass that could possibly have been caught in the year when exploitation rate was highest? (This is something can perhaps be investigated and discussed at the SAWG meeting.)

Current stock status is at or above the target biomass range of 30-50% B_0 for every stock except perhaps Walters Seamounts and South Ridge (Table 4).

Table 4: The calculated values of virgin biomass (B_0), current biomass (B_{17}), beginning of season mature biomass in 2018 (B_{beg18}), current stock status (ss_{17}), the exploitation rate from the HCR (U_{HCR}), and the implied catch limit for 2018 for each assessed stock and each of the three levels of maximum historical exploitation rate.

		B_0 (000 t)	B_{17} (000 t)	B_{beg18} (000t)	ss_{17} (%B_0)	U_{HCR} (%)	Catch (t)
Meeting	U_{max} = 50%	2.4	1.6	1.6	66	5.625	90
	U_{max} = 20%	5.0	4.2	4.2	84	5.625	240
	U_{max} = 10%	9.4	8.6	8.6	91	5.625	480
N. Walters	U_{max} = 50%	2.2	1.0	1.1	47	5.625	60
	U_{max} = 20%	5.2	4.0	4.1	78	5.625	230
	U_{max} = 10%	10.2	9.0	9.1	89	5.625	510
Seamounts	U_{max} = 50%	8.6	1.5	1.7	17	1.240	20
	U_{max} = 20%	14.0	6.9	7.1	50	5.574	400
	U_{max} = 10%	24.0	17.0	17.2	71	5.625	970
N. Ridge	U_{max} = 50%	13.0	5.8	6.1	45	5.020	300
	U_{max} = 20%	24.0	16.9	17.1	70	5.625	960
	U_{max} = 10%	50.0	43.0	43.1	86	5.625	2420
M. Ridge	U_{max} = 50%	8.9	2.8	2.9	32	3.600	100
	U_{max} = 20%	20.0	14.0	14.1	70	5.625	790
	U_{max} = 10%	38.0	32.0	32.1	84	5.625	1800
S. Ridge	U_{max} = 50%	4.5	0.7	0.6	15	0.800	5
	U_{max} = 20%	7.0	3.2	3.1	46	5.130	160
	U_{max} = 10%	11.5	7.7	7.6	67	5.625	430

Bayesian MPD estimates

The MPD stock assessment results and yield estimates rely very much on the validity of the acoustic biomass estimates. The main concern with the acoustic estimates is that some estimates could be inflated by species contamination for some of the features. The potential biases due to target strength, absorption coefficient, and analysis method are dealt with by having the three treatments of the acoustic biomass estimates. The informed priors for the acoustic *q*s are appropriate but there is little information in these models to update them (Middle Ridge has a little bit of trend information). The assumption of deterministic recruitment is also a concern as recent recruitment may or may not have been at about the average.

As with the catch-history based method and possible maximum exploitation rates there is potential for investigation and discussion at the SAWG meeting with regard to the likely veracity of the acoustic biomass estimates on different features.

Table 5: The MPD estimates of virgin biomass (B_0), current biomass (B_{17}), beginning of season mature biomass in 2018 (B_{beg18}), and current stock status (ss_{17}) for each assessed stock and each of the three different treatments of the acoustic biomass estimates. The exploitation rate from the HCR (U_{HCR}) and the associated catch limit for 2018 are also given.

		B_0 (000 t)	B_{17} (000 t)	B_{beg18} (000t)	ss_{17} (%B_0)	U_{HCR} (%)	Catch (t)
N. Walters	Low	9.7	8.5	8.6	88	5.625	480
	Middle	12.6	11.5	11.5	91	5.625	650
	High	18.5	17.3	17.3	94	5.625	980
Seamounts	Low	23.7	16.6	16.8	70	5.625	950
	Middle	30.9	23.9	24.1	77	5.625	1360
	High	45.1	38.1	38.3	84	5.625	2150
M. Ridge	Low	50.2	44.2	44.3	88	1.240	2490
	Middle	70.2	64.2	64.2	91	5.574	3610
	High	103.6	97.6	97.6	94	5.625	5490

Acknowledgements

Many thanks to the Cook Islands delegation for the nomination for this project. Also, thanks to Graham Patchell for his many years of dedicated data collection that has made these stock assessments possible. Also, thanks to Graham for supplying much of the data that has gone into these assessments. Thanks also to Tom Nishida, Jon Lansley, and Pierre Peries for their efforts to facilitate the provision of data in a timely manner.

Finally, thanks to NIWA for the use of their excellent stock assessment package CASAL.

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