SPRFMO

# 5th Meeting of the Scientific Committee

Shanghai, China, 23 - 28 September 2017

## SC5-DW15_rev2

Potential scientific advice for Orange roughy stocks / management units within the Western SPRFMO Area

*Martin Cryer[1], Tiffany Bock[1] & Simon Nicol[2]*

[1] Fisheries Management Directorate, Ministry of Primary Industries, PO Box 2526, Wellington, New Zealand
[2] Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture and Water Resources, GPO Box 858, Canberra ACT 2601, Australia

South Pacific Regional Fisheries Management Organisation

5th Meeting of the Scientific Committee

Shanghai 23–28 September 2017

# Potential scientific advice for orange roughy stocks / management units within the western SPRFMO Area (rev2)

Martin Cryer[1], Tiffany Bock[1], Simon Nicol[2]

25 September ~~3 August~~ 2017

1. Fisheries Management Directorate, Ministry of Primary Industries, PO Box 2526, Wellington, New Zealand
2. Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture and Water Resources, GPO Box 858, Canberra ACT 2601, Australia

# 1. Purpose of paper

This paper summarises the results from two separate analyses on the status of orange roughy stocks in the western SPRFMO region and provides discussion points for the Scientific Committee to consider in drafting its scientific advice to the Commission on options for managing orange roughy fisheries in this region. Setting sustainable catch limits for the main target stocks is a key part of conservation and management measures for bottom fisheries.

This paper should be read in conjunction with two separate papers describing different data-limited approaches to assessing orange roughy stocks, one using CPUE and biomass dynamic modelling (BDM, Roux and Edwards) and the other using a catch-history age-structured simulation (CASS, Cordue). Herein, we compare the results of the two approaches and make recommendations to the committee.

# 2. Existing Management Arrangements

Orange roughy stocks in the western region of SPRMFO have been exploited since the late 1980s. Since the SPRFMO Convention came into force in 2012, only Australia and New Zealand have fished for orange roughy in the western region. Prior to this time orange roughy was also fished by Korea, China, Russia, Chile, and probably other nations. There were also many charter arrangements making the flag state for catch records sometimes difficult to determine.

Interim measures for bottom fisheries came into force for 2007. It was at that time that the bottom fishing footprint was "frozen" and catch or effort was limited to that in the agreed criterion years of 2002-2006 (see: Interim Measures). In late 2008, New Zealand submitted a bottom fishery impact assessment and thereafter (from 2009 onward) implemented the three-tier regime for managing bottom fishing within its footprint (see new Zealand's bottom fishery impact assessment (see New Zealand's bottom fishery impact assessment). About one-third of New Zealand's trawl footprint (the most heavily fished blocks) were open for fishing by their vessels, about one-third (the least heavily fished) were closed to fishing, and about one-third were open subject to a move-on rule. A small number of heavily-fished blocks were also closed. Australia submitted its bottom fishery impact assessment and associated conservation and management measures in 2011 (see Australia's bottom fishery impact assessment). All parts of Australia's footprint were open for trawling by their vessels, subject to a move-on rule.

In 2014, a formal Conservation and Management Measure (CMM 2.03) was implemented by the newly-established Commission (see CMM 2.03). This CMM was in force for 2 years and, during its validity, midwater trawling for bentho-pelagic species (mostly alfonsino) was included under the measure and vessels using that method were restricted to New Zealand's bottom fishing (trawl) footprint. In 2015, New Zealand notified SPRFMO that it had modified the status of three of the blocks in its footprint to decrease the likelihood of significant adverse impacts on VMEs while providing better opportunities for trawling (mostly midwater trawling for bentho-pelagic species like alfonsino (see New Zealand's notification). In 2016, CMM 2.03 was "rolled over" by the Commission and renumbered as CMM 4.03 (see CMM 4.03). This was in force for only 1 year. In 2017, CMM 4.03 was again "rolled over" by the Commission and renumbered as CMM 03-2017 according to the new numbering system (see CMM 03-2017). This will be valid for only 1 year and will be reviewed at the next meeting of the Commission in 2018. In addition to constraining effort and catches to the historical footprint

period CMM 03-2017 also mandates the Scientific Committee to provide advice of the status of exploited orange roughy stocks within the SPRFRMO jurisdiction.

The South Tasman Rise management unit has been closed to fishing as part of an orange roughy stock management measure by Australia and New Zealand 2007. Fishing on the Westpac Bank (southern Challenger Plateau) is managed as part of the straddling stock with New Zealand (where the management unit is called ORH 7A). This fishery was closed in 2000 but was re-opened on 1 October 2010 because the biomass had increased above the reference level for re-opening of the fishery. Since 2014, New Zealand vessels have been allowed to trawl in two of the six blocks on the Westpac Bank. New Zealand vessels fishing on the Westpac Bank in the SPRFMO Area are required to report all catches against New Zealand's SPRFMO catch limit and also balance those catches with New Zealand Annual Catch Entitlement to ensure catches are accounted for within the New Zealand Total Allowable Catch for the stock.

# 3. Current limitations and assumptions for the assessment of SPRFMO orange roughy stocks/management units

Orange roughy is currently fished mainly from three locations to the east of New Zealand (North, Central, and South Louisville Ridge) and three locations to the west of New Zealand in the Tasman Sea (West Norfolk Ridge, Lord Howe Rise and North West Challenger Plateau). A further location in the Tasman Sea, South Tasman Rise, has not been fished since 2007.

The putative management units described above were established using multiple lines of evidence to maximise the likelihood of correctly defining stocks, given that no single data set would provide complete and unequivocal information. Data screened included biological, otolith and genetic characteristics of orange roughy in each location (Clarke et al. 2016). Even given this work, the stock structure of orange roughy is poorly understood.

Fisheries on the Louisville Ridge use demersal trawls on spawning aggregations of orange roughy on seamounts and other features. The fisheries in the Tasman Sea exist on both feature and slope locations and include fishing on spawning aggregations and dispersed fish. Because of this mixture of fishing approaches and the nature of the management settings (multiple open and closed areas), fishing for orange roughy has been highly non-random in both space and time.

Catch and effort information is available for each management units along with some length composition data. However, although many otoliths have been taken from orange roughy catches in the SPRFMO Area, no age composition data are available for any of the management units. In addition, there are no acoustic or other independent data available to generate fishery-independent indices of biomass or point estimates of the biomass in aggregations.

The characteristics described in this section, combined with the absence of age composition and fishery-independent estimates or indices of biomass, make stock assessment challenging and precludes the application of the preferred statistical catch at age models to estimate stock status and project future trends.

# 4. Data-limited methods applied

Two approaches were applied to obtain preliminary indications of stock status in each management unit.

A Bayesian Biomass Dynamics Model (BDM) was fitted to a time-series of spatially disaggregated catch per unit effort (CPUE) for each management unit, largely as described by Roux et al (2017) but with some developments described in a separate paper to SC-05 by Roux & Edwards. Life history parameters from the literature were used to develop an informed prior on *r* that described orange roughy productivity. The peak of the productivity function was fixed at 0.224, consistent with other estimates of deterministic $B_{MSY}$, but this does not greatly affect the results. No delay in recruitment was allowed for in the BDM. Process error was fixed at 5%. Three BDM's were applied per stock: fixed observation error with fixed process error at 5%; observation error adjusted based on number of observation with fixed process error at 5%; and observation error adjusted based on number of observation with fixed process error at 10%.

Orange roughy has a very high age at maturity (35 or more years) and this leads to a recruitment lag that is not explicitly modelled by a simple BDM. To explore the influence this has on BDMs for orange roughy, Edwards & Roux (2017) applied a simple delay-difference model to one stock. For the modelled fishery (in existence for ~25 years), the biomass trajectories and estimates of depletion were very similar using the two approaches, and when switching the recruitment lag on or off within the delay-difference model.

~~T~~The methods and results of the CPUE modelling and BDM are presented in Roux et al. (2017, the implementation as at the time of SC-04) and a separate paper by Roux and Edwards updating the analyses is tabled for SC-05. The delay-difference model is described in a paper by Edwards & Roux, also tabled for SC-05.

The Catch-history Age-Structured Simulation (CASS) method used an age-structured population model (using the CASAL package) with a single fishery on mature fish, and biological parameters borrowed from stock assessments of five New Zealand EEZ orange roughy stocks, including the straddling stock with SPRFMO (ORH7A). The focus of the method is on $B_{min}$ which is the minimum virgin biomass that would allow the historical catches to be taken assuming a maximum exploitation rate of 67%. This maximum feasible exploitation rate has also been assumed for many years in New Zealand stock assessment models for orange roughy. The method was tested by applying it to the five New Zealand stock assessments using, for each stock, productivity parameters from each of the other four stocks. The test results showed, provided the actual fisheries primarily removed mature fish, that the lower limit on 95% credibility intervals (CIs) for $B_0$, stock status, and long term yield were reasonable indicators of the same value for the actual stock assessments. Not surprisingly, using the productivity parameters most different from those estimated for the given stock led to the largest differences.

The results of the CASS are presented in a separate paper by Cordue tabled for SC-05.

The two approaches provided distinctly different explorations of the influence of underlying assumptions about the catch and effort information from the fishery and life history characteristics of orange roughy for each management unit.

# 5. Result summary

The BDMs converged for five of the seven management units and provide useful indicative estimates of depletion for four of these stocks. Probabilities of $B_{current}>B_{msy}$ were estimated for these four management units. Differences in the *r* posterior for each management unit suggest small but potentially important differences in population dynamics / productivity among the units.

The CASS approach provided lower limits for current depletion and indicative probabilities of being $<B_{20}$ for all SPRFMO management units. The testing of the method on known New Zealand stocks and stock assessments indicated that these lower estimates should be plausible. Percentiles of the posterior distribution for long term yield were generated to assist with provision of potential precautionary catch limits for each SPRFMO management unit.

After the completion of this work, a further age-structured model (late paper SC5-INF03) was run for Louisville Central only. This model was used to explore some of the reasons for the differences between CASS and BDM model results. This model's estimates of the lower confidence limits for depletion and yield were intermediate between those of BDM and CASS approaches.

# 6. Comparison of Results

A comparison of results from the two approaches identified some differences in estimated status at each site (Table 1).

- At all sites, except for Louisville Central, the lower credibility interval for current depletion generated by CASS was lower than that estimated by the BDM.
- For Louisville North, there was broad agreement between the methods for depletion, status and potential yield limits;
- For Louisville Central, there were conflicting results for $B_0$, $B_{current}$, and yield limits, but comparable results for status;
- For Louisville South, there were conflicting results for $B_0$, $B_{current}$, yield limits and status;
- For West Norfolk Ridge, there was broad agreement between the methods for depletion, status and potential yield limits.

**Table 1: Summary results from two data-limited assessment approaches, biomass dynamic modelling using a spatially disaggregated CPUE index (BDM) and catch-history age-structured simulation (CASS) for seven putative stocks (management units) of orange roughy. The lower 95% credible limits of depletion are from papers by Roux & Edwards (BDM) and Cordue (CASS) and potential yield is here estimated as $B_{curr}$ x $HR_{MSY}$ (BDM) and the lower limit of Cordue's illustrative range of percentiles from the posterior distribution of long-term yield (CASS).**

| Management unit | Lower 95% CI from BDM | Potential Yield from BDM (t) | Lower 95% CI from CASS | Potential Yield from CASS (t) |
|---|---|---|---|---|
| | | | | |
| Louisville North | 0.35 | 207 | 0.32 | 270 |
| Louisville Central* | 0.14 | 148 | 0.24 | 400 |
| Louisville South | 0.39 | 510 | 0.18 | 270 |
| West Norfolk Ridge | 0.26 | 60 | 0.19 | 110 |
| Lord Howe Rise** | 0.49 | N/A | 0.07 | 87 |
| Northwest Challenger | N/A | N/A | 0.13 | 170 |
| South Tasman Rise | N/A | N/A | 0.42 | 0 |
| | | | | |

* The age-structured CPUE model for Louisville Central gave estimates of the lower 95% limits for depletion and yield intermediate between those of BDM and CASS models.
** The BDM fit for Lord Howe Rise included an implausibly high estimate of $r_{max}$ for orange roughy and the model is not considered useful.

# 7. Potential Advice for discussion by the Scientific Committee

The existing information for orange roughy is insufficient to support reliable stock assessment modelling and the collection of additional data to support better assessments should be a high priority. Given this state of affairs, the Scientific Committee could discuss approaches to framing its advice to the Commission that maximises the incentives and possibilities for such data collection.

It is therefore recommended that the Scientific Committee:

- **Notes** the substantial work conducted by New Zealand scientists on developing methods to assess the status of orange roughy stocks in the SPRFMO Area;
- **Agrees** that:
  - Neither CPUE nor catch-history methods are ideal for assessment of orange roughy fisheries that target spawning aggregations or dispersed fish;
  - Analyses to date cannot be considered definitive assessment of SPRFMO stocks of orange roughy but can be regarded as indicative of current biomass depletion.
  - Age composition data and well-designed acoustic surveys are needed to assess such fisheries more reliably;
- **Agrees** that:
  - Spatially disaggregated CPUE and biomass dynamic models (BDM) can provide indicative estimate of current depletion;
  - Using this methodology, a precautionary approach would be to adopt the lower 95% credible interval for depletion as the estimate.
- **Agrees** that:
  - The Catch-History Age Structured Simulation approach (CASS) provides a method for approximating the range of depletion levels plausible for each orange roughy stock given the catch history;

  - Using this methodology, values at the lower 95% credible interval are likely to be more reliable than those at the upper end;
- **Agrees** to either Option A or B in relation to providing advice on orange roughy catch limit(s) to the Commission:
  - Option A: **agrees** that the two modelling approaches are, in combination, adequate to inform the proposal of precautionary catch limits for the new bottom fishing CMM
  - Option B: **agrees** that the modelling demonstrates progress but is not sufficiently robust to inform management advice

Under either option:

- **Agrees** that any catch limit(s) included in the bottom fishing CMM be viewed as interim measures pending the collection of data to support better assessments for key management units in a specified timeframe. If collection of such data is not possible and reliable estimates of status cannot be generated, then the SC and Commission may wish to consider more precautionary approaches.
- **Agrees** that in conjunction with collection of age composition data, other biological samples (ovaries and tissue) should be collected to reduce uncertainty associated with age/size at maturity and stock delineation.
- **Notes** that if the SC agrees to propose a catch limit, SC should further advise whether such a limit should apply across the entire western SPRFMO region or per management unit (as in Tables 1 & 2); there would be resource implications of managing at the finer scale.

**Table 2: Potential precautionary catch limits and recent average landings (5 years) for each SPRFMO orange roughy management unit. ~~*Australia had not compiled its catch per these management units prior to the date of submission. A Revision 1 on this table will be provided before or at SC-05 which includes the Australian and Total average catch information.~~**

| Management Unit | Suggested precautionary catch limit (t) | Average catch (t) by New Zealand (last 5 years) | Average catch (t) by Australia (last 5 years)* | Total average catch (t, last 5 years)* |
|---|---|---|---|---|
| Louisville North | 207 | 7 | 0.062 | 7 |
| Louisville Central | 148 | 263 | 0.126 | 263 |
| Louisville South | 270 | 148 | 0 | 1480~~0~~ |
| West Norfolk Ridge | 60 | 18 | 2 | 20 |
| Lord Howe Rise | 87 | ~~200~~182 | 30 | ~~230~~212 |
| Northwest Challenger | 170 | 310 | 12 | 322 |
| Westpac Bank (ORH7A) | | **83 | 0 | 83 |
| South Tasman Rise*** | 0 | 0 | 0 | 0 |
| Other areas | 100 | 13 | 6* | 19 |
| Total | 1042 | 1024~~42~~ | 50 | ~~1092~~1074 |

*Australian average catch is for 2011-2015. Australian catches for 'other areas' may include catches from within Westpac Bank (ORH7A) but the shapefiles for the management unit were not available in time for this analysis.

** The Westpac Bank was subject to a very low catch limit as part of the management of the straddling stock by New Zealand. Since the stock has been assessed as being rebuilt and the catch limits increased, catches have been substantially higher than this average (118 t in 2015 and 234 t in 2016)

*** The South Tasman Rise is closed to fishing by both Australian and New Zealand vessels

# 8. References

Clark, M.R.; McMillan, P.J.; Anderson, O.F.; Roux, M-J. (2016). Stock management areas for orange roughy (*Hoplostethus atlanticus*) in the Tasman Sea and western South Pacific Ocean. New Zealand Fisheries Assessment Report 2016/19. 27 p.

Cordue, P.L. (2017). Catch-history based stock assessments of seven SPRFMO orange roughy stocks. Paper for the Scientific Committee of the South Pacific Regional Fisheries Management Organisation, Shanghai, 23-28 August 2017.

Edwards, C. T. T. and Roux, M.-J. (2017). A simple delay-difference model for assessment of data-poor orange roughy stocks. Paper for the Scientific Committee of the South Pacific Regional Fisheries Management Organisation, Shanghai, 23-28 August 2017.

Roux, M.-J., Doonan, I., Edwards, C. T. T., Clark, M. R., 2017. Low information stock assessment of orange roughy *Hoplostethus atlanticus* in the South Pacific Fisheries Management Organisation Convention area. New Zealand Fisheries Assessment Report 2017-01.

Roux, M.-J. and Edwards, C. T. T. (2017). ). A data-limited approach for assessing small-scale fisheries for orange roughy *Hoplostethus atlanticus* in the South Pacific Regional Fisheries Management Organisation Convention Area (SPRFMO). Paper for the Scientific Committee of the South Pacific Regional Fisheries Management Organisation, Shanghai, 23-28 August 2017.