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A draft stock assessment framework for bottom fisheries within the SPRFMO Convention Area

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

[1] Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture and Water Resources, GPO Box 858, Canberra ACT 2601, Australia.

[2] Fisheries Management Directorate, Ministry of Primary Industries, PO Box 2526, Wellington, New Zealand.

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1. Purpose of paper

This paper provides for the Scientific Committee's consideration a draft assessment framework for bottom fisheries in the SPRFMO Convention Area. This framework has been proposed to provide direction for future work on bottom fisheries and to increase the efficiency of the Scientific Committee's future considerations, given the large number of species involved.

2. Rationale for a Tiered Assessment Framework

The SPRFMO Scientific Committee may be requested to provide scientific advice on stock status and catch limits for over 30 demersal species, as well as advice on the impact of fishing on associated and dependent species with which the fishery interacts. The quantity, quality and suitability of data will be variable among species over time and space. This variability is likely to influence the parameters that can be estimated and associated uncertainties which, in turn, will influence the scientific advice that the Scientific Committee can provide to the Commission. To improve the efficiency of processes run by the Scientific Committee, a tiered framework for assessing and prioritising stocks for status assessment is proposed based on the parameters that can be estimated given the data available. Such a tiered framework is expected to assist the Scientific Committee with developing transparent decision rules for advice on recommended biological catches and potential buffers (e.g. 'discount factors') that may be applied to account for assessment uncertainty. The recommended tiered levels consist of:

1. Full Benchmark Assessment that utilises catch data from fishery monitoring, ideally in combination with stock abundance from independent surveys, catch rates and biological data with the purpose of estimating depletion levels and fishing mortality rates;
2. Data Limited Assessment that may utilise catch only or simple indicators to track status (e.g. CPUE, size composition, Productivity-Susceptibility Analysis);
3. No assessment necessary.

Two subsets, may apply after initial classification of stocks into Tier 1 Tier 2 or Tier 3.

i. Research Assessment where new methods or data types are applied which may require substantive review of the methods by the Scientific Committee; and
ii. Update Assessment where previous accepted assessments are updated with new data.

3. Categorisation of stocks into the Tiered Framework

A Scoping Analysis for each SPRFMO demersal stock should be undertaken to initially categorise each stock into Tier 1 or Tier 2. The Scoping Analyses should include, a description of the fishery, documentation of management objectives and existing measures, the risks associated with fishing, and where possible, the entire catch history for each species and other data available. Much of this information is already contained with Members' Bottom Fishery Impact Assessments and other papers to Scientific Committee. Catch data, observer records, expert opinion, and/or species distribution maps should also be considered as part of the Scoping Analysis. Fishing-specific risks may include (but not

limited to): capture and retained; capture and discarded, capture and live release; direct impact without capture; disturbance of physical processes.

Where Management Objectives are not defined a priori, generic objectives to promote discussion and agreement may be required such that the Scientific Committee can consider and advise "acceptable bounds" for fishing mortalities. The description of the fishery should include any measures currently in place to manage fishing mortality and/or species interactions. The identification of objectives and existing measures allows for an initial Scientific Committee screening on the appropriateness of the current approach to precaution and stock management (i.e. what are the acceptable bounds of any impact, is the impact within these acceptable bounds and is there evidence that current measures ensure that impact does not exceed the precaution applied).

Prior to categorisation into Tier 1 or Tier 2 the Scientific Committee may place some species into Tier 3 (No Assessment required) based on the presentation of sufficient evidence that existing measures provide adequate precaution for the interactions known (e.g. for species that rarely (if ever) interact with the SPRFMO demersal fisheries).

Categorisation into Tier 1 and Tier 2 of the framework should be based on the data available. Species/stocks with data suitable for estimation of current fishing mortality and depletion should be categorised to Tier 1. Species/stocks initially considered for Tier 1 may be subsequently classified for Tier 2 assessment if the Tier 1 assessment diagnostics fail to satisfy Scientific Committee review. Species not placed into Tier 1 or Tier 3 categories by default are placed in Tier 2.

Species/stocks placed into Tier 2 should be subjected to semi-quantitative risk assessment methods such as Productivity-Susceptibility-Analyses and/or Sustainability Assessment for Fishing Effects (SAFE). These methods rank species/stocks into priority from high to low relative risk, with SAFE also being capable of generating indicative estimates of fishing mortality. This step should identify to the Scientific Committee the Tier 2 species/stocks requiring immediate attention (if any). It may be determined by the Scientific Committee that stocks assessed to this level may not require further assessment if the risks from fishing are assessed to be low, or if adequate management measures are in place to mitigate moderate or high risks.

4. Buffers or Discount Factors for advice on "Recommended Biological Catch"

Buffers can be used to provide a precautionary safeguard between the model-derived estimates of appropriate levels of catch and the scientific advice that accounts for assessment uncertainty. Ideally, assessment methods and harvest control rules have undergone a "Management Strategy Evaluation" to test their robustness to uncertainty but, in the absence of such MSE, generic precautionary buffers can be applied. These are typically derived from a meta-analyses of assessment models (e.g. Ralston et al 2011). Tier 1 buffers that have been applied in other demersal fisheries have varied between 0% and 0.9% with increasing assessment uncertainty (e.g. Ralston et al 2011).

Meta-analyses have shown that the more data-limited a fishery is, the poorer the performance of a stock assessment and harvest strategy in terms of risk (Ralston et al. 2011; Dichmont et al. 2016). The meta-analyses also highlight that broad generic guidelines should be tested on a species by species basis. Generic buffers have also been applied to data-limited stocks in other demersal fisheries. Such scalars have varied from 0.9 to 0.7 depending upon the method applied (Ralston et al 2011; Dichmont et al 2016). As an example the table below summarises how generic buffers could be incorporated into the proposed SPRFMO Tiered Framework.

Tier	Advice Parameter	RBC Buffer (as a scalar on model outputs)
1	Fishing mortality (F) and spawning biomass (SB), based on fishery-dependent and/or independent data. Advice provided in relation to Limit Reference Points & Target Reference Points for $F_{current}$ and $SB_{current}$	1 to 0.9 dependent on variance and bias in estimates
2	Empirical estimates of a) trends in relative biomass based on catch-per-unit-effort (CPUE) data b) within-season changes in relative biomass based on CPUE data c) availability of relative biomass based on informal fishery-independent surveys	0.85
2	Empirical estimates of F based on size and/or age data	0.8
2	Empirical estimates of F based on the spatial distribution of effort relative to the distribution of the species (SAFE method)	0.7
3	No estimate of biomass or F; management decisions based on precautionary fishery-dependent species-specific triggers	N/A
3	No estimate of biomass or F; management decisions based on precautionary fishery-dependent triggers and/or indices for groups of species	N/A

5. Potential Biological Reference Points

Reference points are benchmarks against which the biomass or abundance of the stock, or the fishing mortality rate (or exploitation rate), or catch itself can be measured in order to determine stock status. Reference points may also be required for setting harvest control rules to enable fishing towards a target reference point. These reference points can be targets, thresholds or limits depending on their intended use (e.g., see Harvest Strategy Standard for New Zealand Fisheries, 2008 and its updated Operational Guidelines, 2011).

Reference Points defined in New Zealand and Australia:

Soft limit: A biomass limit below which the requirement for a formal, time-constrained rebuilding plan is triggered (Harvest Strategy Standard for New Zealand Fisheries 2008).

Hard limit: A biomass limit below which fisheries should be considered for closure (Harvest Strategy Standard for New Zealand Fisheries 2008).

Biomass limit reference point (B_{LIM}): the point beyond which the risk to the stock is regarded as unacceptably high (Commonwealth Fisheries Harvest Strategy Policy, 2007). Stocks below B_{LIM} are subjected to a time-constrained rebuilding plan and F is typically set at zero until the stock builds to above B_{LIM}.

Target biomass (B_{TARG}): the desired condition of the stock (Commonwealth Fisheries Harvest Strategy Policy, 2007).

Reference points often vary between different jurisdictions, and may also vary within those jurisdictions based on the species, fishery characteristics and other factors. For example, New Zealand and Australia adopt slightly different limit and target reference points as part of their domestic fishery harvest strategies. In Australia, the Commonwealth Fisheries Harvest Strategy Policy defines its reference points as follows:

Reference Point	Definition
B_{TARG} (or proxy)	equal to or greater than B_{MEY}. In cases where B_{MEY} is unknown, a proxy of $1.2B_{MSY}$ (or a level 20% higher than a given proxy for B_{MSY}) is to be used. The regulator may approve the use of an alternative proxy for B_{MEY} if it can be demonstrated that a more appropriate alternative exists
B_{LIM} (or proxy)	equal to or greater than ½ B_{MSY} (or proxy)
F_{LIM} (or proxy)	less than or equal to F_{MSY} (or proxy)
F_{TARG} (or proxy)	at the level required to maintain the stock at B_{TARG}

In New Zealand, the Harvest Strategy Standard for New Zealand Fisheries recommends default proxies for B_{MSY} (expressed as $\%B_0$) and F_{MSY} (expressed as $F_{\%SPR}$ levels from spawning biomass per recruit analysis) as follows.

Productivity level	$\%B_0$	$F_{\%SPR}$
High productivity	25%	$F_{30\%}$
Medium productivity	35%	$F_{40\%}$
Low productivity	40%	$F_{45\%}$
Very low productivity	≥45%	≤$F_{50\%}$

An important next step for application of the assessment framework will be developing agreed reference points for SPRFMO demersal fisheries. A merge of the Australia and New Zealand definitions and proxies could be a useful starting point as this would provide consistency between SPRFMO and the policies of the two Members currently bottom-fishing in SPRFMO. An example of a potential merge between Australia and New Zealand definitions is provided below.

Reference Point	Proxy Biomass	Fishing Mortality	Response advised to Commission
Hard Limit	≤B_{10}		Close Fishery
Soft Limit	<B_{20} to B_{10}	≥F_{MSY}	Consider time-bound plan (1 mean generation time plus 10 years or 3 mean generation times, whichever is shorter) to rebuild Biomass to above soft limit
Target	B_{MSY} to $1.2B_{MSY}$	$F_{B(MSY\ -1.2BMSY)}$	Modify F to build stock to target if below range but soft limit is not exceeded.

Similarly, agreed SPRFMO terminology for demersal fish stock status will need to be developed. An example of potential terminology is provided below.

Reference Point	Status Determination
<B_{20}	Overfished
≥B_{20}	Not overfished
>$F_{B(MSY)}$	Subject to overfishing
≤$F_{B(MSY)}$	No subject to overfishing

6. Potential Harvest Control Rules

Many SPRFMO demersal species also occur within the EEZ boundaries of Australia and New Zealand and are there subject to formal harvest strategies implemented by each jurisdiction. In Australia, the most relevant harvest strategy framework is for the Southern and Eastern Scalefish and Shark Fishery (SESSF). Under this framework, stocks are managed using the proxy biomass limit and target reference points (B_{20} and B_{48}, respectively). The SESSF harvest strategy framework applies a tiered framework with MSE tested harvest control rules (HCR).

Similarly New Zealand's Orange Roughy Harvest Strategy includes a HCR which has been MSE tested for New Zealand stocks. The MSE demonstrated that the HCR will maintain stock status around 42% B_0 and within the management target range ($B_{30\text{ to }60}$) 97% of the time and not decline below B_{20}. If a stock is estimated to be within the target range, the recommended catch limit would be estimated, based on the slope of the HCR within this range (i.e. between 0.034 at B_{30} and 0.056 at B_{50}). When the stock status is estimated to be greater than B_{40}, the HCR allows removal of more catch to return the stock to B_{40}. Conversely, when the stock size is estimated to be at the lower bound of the management target range, the recommended catch limit would be reduced to 75% of F_{mid} (i.e. to F = 0.034) to provide for the stock size to increase back towards B_{40}. If the stock is outside the management target range (either higher or lower) the HCR provides an additional 'rescaling' multiplier to provide the required robustness at low stocks sizes and to enable a greater catch to be taken at high stock sizes. The rescaling is designed to prevent the stock declining below B_{20} and results in a very high probability of stocks fluctuating within the management target range in the long term.

The Table below provides a summary of the HCRs that have been MSE tested in Australia and New Zealand. The Table also provides an indicative SPRFMO Assessment Tier to which they may apply and some example fisheries and species where they have been applied. A more extensive review of existing HCRs for demersal fisheries may assist the Scientific Committee with selecting potential options for MSE testing.

	HCR	Example Species
Tier 1		
NZ OR HS	If B_{curr} within the management target range ($B_{30\text{ to }60}$), RBC ranges from F=0.034 at B_{30} to F=0.056 at B_{50}. If B_{curr} outside the management target range, an additional multipliers provide lower F at low stocks sizes (to prevent the stock declining below $0.2B_0$) and higher F at high stock sizes.	Orange Roughy
SESSF	($0.2B_0$:$0.35B_0$:$0.48B_0$) "broken stick" HCR to select the target fishing mortality (F_{TARG}). F_{TARG} (F_{48} is the F that achieves $0.48B_0$) is applied to the available biomass to calculate the RBC.	Orange Roughy Deepwater Flathead blue grenadier pink ling silver warehou
Tier 2		
SESSF	CPUE (Little et al 2011) The RBC is given by:	blue warehou redfish blue-eye trevalla

	$RBC = C_T \max\left(\frac{\overline{CPUE}-CPUE_L}{CPUE_T-CPUE_L}, 0\right)$ where C_T is a catch target, $CPUE_L$ is the limit CPUE, $\overline{CPUE}$ is the average CPUE over the most recent four years, and $CPUE_T$ is the target CPUE. Both catch and CPUE targets were taken as the average for the reference years.	Mirror Dory Ocean perch Ribaldo
	Catch curves F_{CUR}, and F_{20}, F_{40} and F_{48} are taken from the relationship between yield and fishing mortality. F_{RBC} is determined from the HCR, and the RBC is calculated using the equation: $RBC = \max\left(\frac{1-e^{-F_{RBC}}}{1-e^{-F_{CUR}}}, 3\right) C_{CUR}$ where C_{CUR} is the current catch.	Alfonsino John Dory
	Average length of fish in the catch to determine F_{CUR} based on average length expected as a function of fishing mortality from a yield-per-recruit calculation (Haddon et al., 2015). F_{CUR} is then used in Catch Curve HCR above.	
	SAFE method for calculating fishing mortality for species *i* (F_i) as outlined in Zhou *et al* (2011): $F_i = \frac{q_i^h \times q_i^l \times (1 - S_i) \sum_t a_{t,i} \times E_t}{A_i}$ where q^h is habitat-dependent encounterability (parameterised using the relative habitat use and overlap defined for the stocks and fleets in the operating model), q^λ is size- and behaviour-dependent selectivity (also parameterised from the effort allocation model), S is the discard survival rate, a_t is the area covered in time step t, E_t is the effort applied in time step t and A_i is the area the species occupies. An aggregate annual F is provided by summing over all time steps fished in a year. The reference exploitation rates F_{20}, F_{40} and F_{48} are given by $F_{20} = 1.5\omega M$, $F_{40} = \omega M$ and $F_{48} = 0.8F_{40}$ with ω set to 0.91 for teleosts and 0.43 for chondrichthyans. *N*atural mortality, M, was estimated using the Jensen (1996) relationship: $M = 1.65/t_{am}$ where t_{am} is the age-at-maturity. F_i vs reference F is then used to determine the RBC and any further assessment actions.	

7. Implications of Assessment Framework for the SC Workplan

- MSE testing of HCRs and BRPs will be required – this is a longer term issue for the SC workplan as currently no adopted assessment or candidate operating models are discussed.
- A discussion paper for SC6 reviewing buffers, HCRs and BRPs would assist the Scientific Committee with developing options for interim rules and developing a focussed MSE work plan.
- Scoping Analysis – this should be a priority to give direction to future assessment work on bottom fisheries. The SC may wish to consider this as a living document that is updated annually (or as required) as new information becomes available. It could act as a list of data holdings for SPRFMO demersal species.
- Tier 2 risk analyses should be included in the 2017-2018 SC workplan, some of which are already underway

8. Recommendations

It is recommended that the Scientific Committee:

- **Adopts** the proposed generalised assessment framework for bottom fisheries to provide direction for future assessment work and speed the committee's processes in developing advice for the Commission.
- **Requests** Members with bottom fisheries or an interest in finalising the framework to work together to develop proposals for biological reference points and harvest control rules for SPRFMO bottom fisheries.
- **Recommends** to the Commission that it agrees to the nature and structure of advice on precautionary catch limits for bottom fisheries that will stem from such an assessment framework.
- **Requests** Members with bottom fisheries to cooperate in the development of a Scoping Analysis for their SPRFMO bottom fisheries.
- **Requests** Members with bottom fisheries to work towards the development of Management Strategy Evaluations to develop robust Harvest Control Rules for their SPRFMO bottom fisheries.
- **Recommends** to the Commission that the Committee's Workplan and Roadmap are amended to include the work described above.

9. References

Commonwealth Fisheries Harvest Strategy Policy 2007. Commonwealth Fisheries Harvest Strategy Policy and Guidelines. Commonwealth of Australia.

Dichmont et al 2016. Operationalising the risk-cost-catch trade-off. FRDC Project Number 2012-202.

Harvest Strategy Standard for New Zealand Fisheries 2008. Harvest Strategy Standard for New Zealand Fisheries. Ministry of Fisheries.

Operational Guidelines for HSS 2011. Operational Guidelines for New Zealand's Harvest Strategy Standard. Ministry of Fisheries.

Ralston et al 2011. Fishery Bulletin 109, 217-231.