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Evaluation of proposed stratum-scale catch limits for the krill fishery in Subarea 48.1 to assess whether they are likely to be precautionary

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ABSTRACT

CCAMLR's Scientific Committee and its working groups are developing a revised management approach for the Antarctic krill fishery in Subareas 48.1 to 48.4. A critical phase is the development of an interim approach that can be applied to Subarea 48.1 to update the measures within CM-51-07, which expires before the next (2022/23) krill fishing season. Progress has been made in terms of defining potential spatial management units, establishing biomass estimates for these units and identifying potential proportional catch allocations between them. Additional progress has been made in updating the Generalised Yield Model, which is used to compute precautionary harvest rates (i.e. the proportion of the krill biomass that can be harvested). However, agreement has not yet been reached on parameterisation of this model and so there is a need to make progress in the absence of formally agreed precautionary harvest rates.

Interim management options for Subarea 48.1 have already been proposed and it is possible to evaluate such options in terms of the implied harvest rates. This is possible because the proposed interim management options define catch limits (or allocations of a total catch limit) at the same spatial scale for which WG-ASAM has produced timeseries of biomass density estimates. The evaluation approach uses retrospective analysis to calculate the probability that harvest rates would exceed candidate precautionary levels. We demonstrate this approach and use it to evaluate two illustrative management options.

INTRODUCTION

CCAMLR's Scientific Committee and its working groups are developing a revised management approach for the Antarctic krill fishery in Subareas 48.1 to 48.4. A critical phase is the development of an interim approach that can be applied to Subarea 48.1 to update the measures within CM-51-07, which expire before the next (2022/23) krill fishing season. The approach being developed will be based on a combination of local-scale biomass estimates, precautionary harvest rates computed using the generalised yield model implemented in R (Grym) and a catch allocation between spatial management units based on the "risk assessment" procedure for quantifying spatial overlap between krill, predators and fishing.

Progress has been made in terms of defining potential spatial management units, establishing biomass estimates for these units (e-asam-2022) and identifying potential proportional catch allocations between them (fsa-2021-16, emm-2022-17). Additional progress has been made in updating the Generalised Yield Model, which is used to compute precautionary harvest rates (i.e. the proportion of the krill biomass that can be harvested) (wg-sam-2022). However, agreement has not yet been reached on parameterisation of this model. This may take more time than is available to provide advice this year, so there is a need to make progress in the absence of formally agreed precautionary harvest rates.

We consider that there is sufficient information available to evaluate whether proposed management options for Subarea 48.1 are likely to allow CCAMLR to fulfil its obligations under Article II of the Convention, and to objectively compare alterative management options. We propose an approach that uses retrospective analysis to evaluate whether a candidate management option for Subarea 48.1 is likely to result in harvest rates exceeding candidate precautionary levels. We explain the approach and use it to evaluate two illustrative krill management options for Subarea 48.1.

METHODS

The approach uses historic biomass estimates to calculate implied harvest rates at the scale of putative management units (i.e. the strata shown in Fig 1 of e-asam-2022, herein **Fig 1**). The implied harvest rate is the catch limit for a particular stratum (specified in a management option) divided by a biomass estimate for that stratum. One implied harvest rate is calculated for each stratum-year combination for which there was a krill biomass survey. The implied harvest rates are used to assess the probability that the specified catch limit will result in harvest rates that exceed various reference levels.

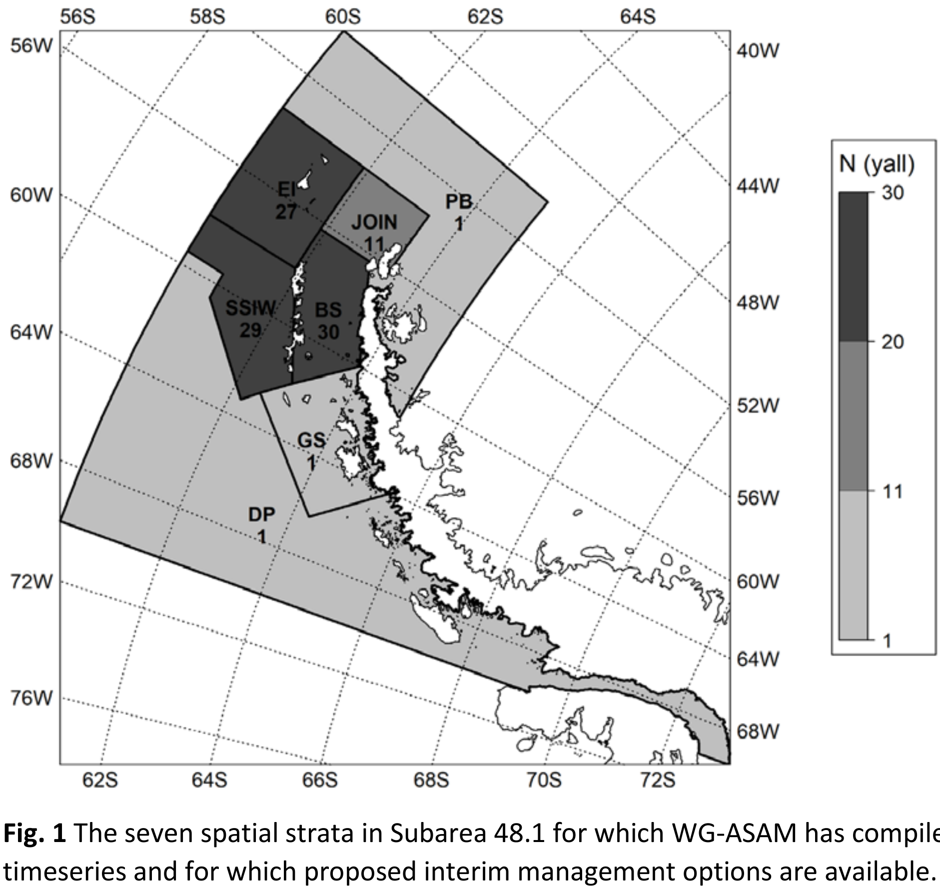

Fig. 1 The seven spatial strata in Subarea 48.1 for which WG-ASAM has compiled biomass density timeseries and for which proposed interim management options are available. Shading indicates the number of surveys conducted in each stratum (Figure from e-asam-2022)**.**

The information requirements for our approach are:

(1) One or more candidate management options consisting of annual catch limits, C_a, for defined spatial units, a. In our examples, the spatial units are the strata shown in **Fig. 1**.
(2) A series of biomass estimates, $K_{a,I}$, for the defined spatial areas, a (where i represents year). In our examples the biomass estimates are derived from the krill biomass density estimates shown in Fig 2 of e-asam-2022).
(3) One or more reference harvest rates, $\breve{\gamma}_a$, for each spatial area, a, representing a precautionary proportion of the biomass in that area that can be harvested in a single fishing season (year). These reference levels can be any of agreed, proposed or illustrative. In our examples we use the same set of reference levels (1%, 3%, 5%, 7%, 9% and 10%) for each stratum

We calculate an implied harvest rate, $\gamma_{a,i}$, for any area-year combination for which a biomass estimate is available as:

$$\gamma_{a,i} = \frac{C_a}{K_{a,i}} \qquad [1]$$

We then assess whether this implied harvest rate exceeds the reference level $\breve{\gamma}_a$. The one-year risk, $P_{a,i}$,for each area is the proportion of years in which the reference level is exceeded. The risk, $P_{t,i}$ over a longer period of time, t, that the catch limit applies is:

$$P_{t,i} = 1-(1-P_{a,i})^t \qquad [2]$$

EXAMPLES

WG-ASAM has compiled biomass density estimates for a set of strata in Subarea 48.1 (e-asam-2022 Fig 2). These can be multiplied by stratum area (**Table 1**) to produce timeseries of biomass estimates which, in turn, can be used to evaluate management options that define catch limits at the stratum scale.

Four of the seven strata in Subarea 48.1 have data from at least 11 surveys (conducted during a minimum of 8 years in the period 1996-2020, **Table 1**). For these strata we used the ”weighted mean krill density” (indicated by dots in Fig 2 of e-asam-2022) to estimate the biomass in each survey year. Each of the remaining strata (DP, GS, PB) has only one density estimate. Consequently there is no information about how biomass in these strata varies between years, and it is appropriate to use a lower estimate of biomass, as noted by WG-EMM (wg-emm-2022, paragraph 2.31). We therefore use an estimate of the lower bound of the one-sided 95% confidence interval assuming a lognormal distribution and based on CV estimates provided by WG-ASAM.

We demonstrate the approach by applying it to two illustrative management options which allocate catches across strata in Subarea 48.1 using the baseline “alpha” (proportional catch allocation) values for the “AMLR strata new5” scenario in Warwick-Evans & Trathan (2021) (**Table 1**). The allocations represent a possible use of the “risk assessment” within Subarea 48.1. The total Subarea 48.1 catch limits for these illustrative options are the Subarea 48.1 trigger limit defined in CM 51-07 (155,000 tonnes) and the tigger limit for Subareas 48.1 to 48.4 combined defined in CM 51-01 (620,000 tonnes). These options are not presented as candidates for developing a conservation measure. Rather, they are used to illustrate the approach.

The ”risk assessment” approach allocates catches on the basis of management unit and season (summer or winter). For the purposes of the current examples we calculate implied harvest rates by year rather than season. This is consistent with the available biomass density information and the operation of the Generalised yield model and krill decision rules (Constable 2011).

Table 1 Details of the seven strata with two illustrative management options consisting of stratum-specific catch limits which divide either 155,000 tonnes (CL1) or 620,000 tonnes (CL2) between strata according to ”Risk assessment” results for the “AMLR strata new5” scenario in Warwick-Evans & Trathan (2021). Here, “alphas” are the sum of winter and summer alphas provided by Warwick-Evans & Trathan (2021).

Stratum	Years surveyed	Surveys	Area (km^2)	alpha	CL1 (tonnes)	CL2 (tonnes)
BS	21	30	34,732	0.12	18,600	74,400
EI	18	27	51,648	0.18	27,900	111,600
JOIN	8	11	23,001	0.02	3,100	12,400
SSIW	21	29	47,066	0.12	18,600	74,400
DP	1	1	204,531	0.23	35,650	142,600
GS	1	1	44,198	0.23	35,650	142,600
PB	1	1	144,680	0.1	15,500	62,000

For the purposes of these examples, and in the absence of information on how precautionary harvest rates might vary between strata we apply the same reference levels (1%, 3%, 5%,7%, 9% and 10%) to all strata.

Our justification for using reference levels in the range 1% to 10% is as follows: Hill et al. (2016) used a harvest rate of 9.3% to assess whether CM 51-07 is precautionary at the subarea scale. This 9.3% value is the harvest rate used to set the “precautionary catch limit” defined in CM 51-01. Watters et al (2020) reported that ecosystem effects of fishing occur when harvest rates at a similar scale to the strata in **Table 1** exceed 10%. Thus a value of around 10% might be considered an appropriate upper limit to the precautionary harvest rate for these strata.

We evaluate the probability of exceeding each reference rate at least once during a two-year period. We selected a two-year period because we expect any potential revision to CM 51-07 to apply for two fishing seasons. Equation 2 could be used to calculate the probability for any other period over which an interim management option is expected to apply.

RESULTS

Fig 2 Illustrates the interannual variability in implied harvest rates in a single stratum (BS). The CL1 option (**Table 1**) results in harvest rates greater than a reference level of 10% in 1 out of 21 years while the CL2 option results in harvest rates greater than this reference level in 9 out of 21 years

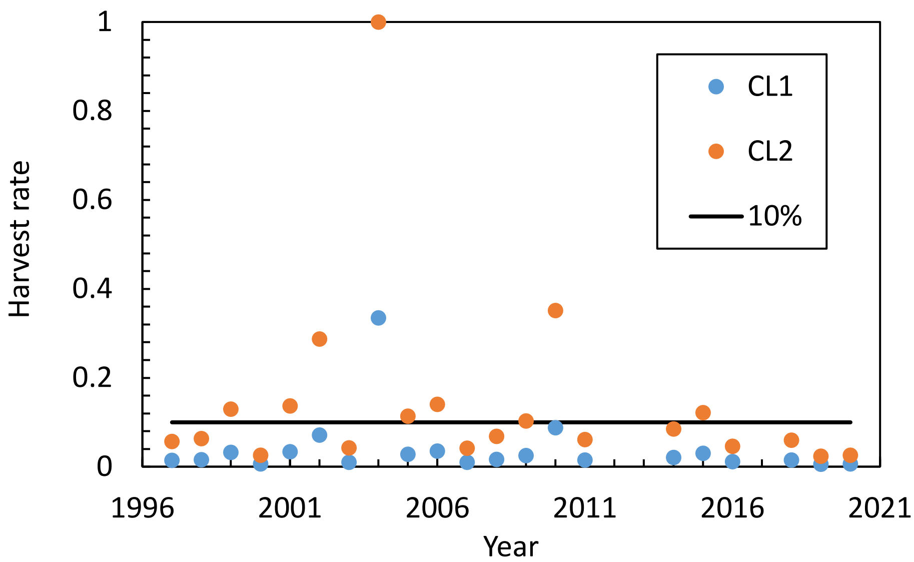

Fig. 2 Harvest rates in the Bransfield Strait stratum implied by illustrative management options CL1 (total Subarea 48.1 catch limit: 155,000 t) and CL2 (620,000 t) (**Table 1**). These rates are shown relative to a reference level of 10%

The probabilities of exceeding each reference harvest rate at least once during a two-year period are provided in **Table 2**. From this table it is clear that:

(1) The apparent risk (i.e. the probability of exceeding a reference harvest rate, $\breve{\gamma}_a$) increases with catch limit.

(2) The apparent risk is highest with low values of $\breve{\gamma}_a$.

Table 2 By-stratum estimates of risk (i.e. the probability of exceeding a reference harvest rate, $\breve{\gamma}_a$, at least once during a two year period – calculated using equation 2) associated with the two illustrative management options in Table 1. Colour coding indicates low risk (green <10%), medium risk (orange >10% and <50%), and high risk (red >50%).

Catch limit (t yr^{-1})		155,000						620,000					
	alpha	1%	3%	5%	7%	9%	10%	1%	3%	5%	7%	9%	10%
BS	0.12	0.98	0.56	0.27	0.27	0.09	0.09	1.00	0.98	0.92	0.73	0.67	0.67
EI	0.18	0.75	0.21	0.00	0.00	0.00	0.00	1.00	0.98	0.92	0.73	0.67	0.67
JOIN	0.02	0.61	0.23	0.00	0.00	0.00	0.00	0.86	0.75	0.44	0.23	0.23	0.23
SSIW	0.12	0.77	0.18	0.18	0.18	0.18	0.00	1.00	0.85	0.73	0.49	0.27	0.27
DP	0.23	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
GS	0.23	1.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
PB	0.1	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

The results in **Table 2** also imply that the risk of exceeding a reference harvest rate of 10% is minimal in the Drake Passage and Powell Basin strata. However, this result comes with the strong caveat that these strata each have just one biomass estimate, which provide no information on interannual changes in biomass. Thus extra levels of precaution might be necessary for these strata.

CONCLUSION

Our approach allows evaluation, at the stratum (or management unit) scale, of candidate management options in terms of the probability of the harvest rate remaining below reference levels demonstrated to be consistent with Article II.

There is sufficient information available to use our approach to evaluate any management option for Subarea 48.1 that specifies catch limits at an annual time scale and the spatial scale of the strata (or combinations of strata) illustrated in **Fig. 1**.

Although there is no consensus on what constitutes a safe harvest rate in each stratum our approach can be used to evaluate management options against each other and furnish decision makers with clear information about risk.

REFERENCES

Warwick-Evans, V & Trathan, P.N. (2021) Using the Risk Assessment Framework to spread the catch limit in Subarea 48.1. WG-FSA-2021/16

Constable, A. J. (2011). Lessons from CCAMLR on the implementation of the ecosystem approach to managing fisheries. *Fish and Fisheries*, *12*(2), 138-151.

Hill, S.L., Atkinson, A., Darby, C., Fielding, S., Krafft, B.A., Godø, O.R., Skaret, G., Trathan, P. and Watkins, J., (2016). Is current management of the Antarctic krill fishery in the Atlantic sector of the Southern Ocean precautionary? *CCAMLR Science* 23, 31-51

Watters, G.M., Hinke, J.T. and Reiss, C.S., (2020). Long-term observations from Antarctica demonstrate that mismatched scales of fisheries management and predator-prey interaction lead to erroneous conclusions about precaution. *Scientific Reports*, *10*(1), pp.1-9.