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IS PGK AN APPROPRIATE PERFORMANCE STATISTIC FOR MP PERFORMANCE AND SELECTION?

D.S. Butterworth[1]

SUMMARY

The origins of fishing mortality restriction in PGK (probability of being in the green part of the Kobe plot) are discussed, with their pertinence to the management strategy evaluation (MSE)/management procedure (MP) as distinct from the Best Assessment fisheries management paradigm being questioned. Care must be taken with probabilities in the former paradigm, as they are not comparable to values calculated under the latter. Key recommendations are: 1) refrain from using PGK as a performance target in MSE; especially because it imposes constraints on fishing mortality F which are not required biologically to safeguard the resource, and compromise attaining better total allowable catch (TAC) and industry stability; 2) rather than an F constraint, ensure that the expected trend in resource biomass at the end of the management period considered is reasonably flat; and 3) if a more conservative approach is required, increase the median biomass recovery target, or decrease the period over which that target is to be achieved, rather than adjust a probability level (such as increasing that in PGK), because medians are estimated more robustly than lower percentiles.

RÉSUMÉ

Les origines de la restriction de la mortalité par pêche dans PGK (probabilité de se situer dans le quadrant vert du diagramme de Kobe) sont discutées ainsi que leur pertinence pour l'évaluation de la stratégie de gestion (MSE)/la procédure de gestion (MP), par opposition au paradigme de gestion des pêches de la meilleure évaluation qui est remis en question. Il convient de faire preuve de prudence avec les probabilités du premier paradigme car elles ne sont pas comparables aux valeurs calculées dans le cadre du deuxième. Les principales recommandations sont les suivantes : 1) s'abstenir d'utiliser PGK comme un objectif de performance dans la MSE, notamment car elle impose des limites à la mortalité par pêche F qui ne sont pas requises d'un point de vue biologique pour préserver la ressource, et qui compromettent les chances d'atteindre un meilleur total admissible de captures (TAC) et la stabilité de l'industrie ; 2) plutôt qu'une limite de F, s'assurer que la tendance prévue de la biomasse de la ressource à la fin de la période de gestion à l'étude est raisonnablement plane ; et 3) si une approche plus modérée est requise, augmenter l'objectif de rétablissement de la médiane de la biomasse, ou réduire la période au cours de laquelle cet objectif doit être atteint, plutôt que d'ajuster un niveau de probabilité (comme une augmentation de celui de PGK), car les médianes sont estimées de manière plus robuste que les percentiles inférieurs.

RESUMEN

Se discuten los orígenes de la restricción de la mortalidad por pesca en PGK (la probabilidad de situarse en la parte verde del diagrama de Kobe), cuestionándose su pertinencia para evaluar la estrategia de ordenación (MSE)/el procedimiento de ordenación (MP), a diferencia del paradigma de ordenación pesquera de mejor evaluación. Hay que tener cuidado con las probabilidades en el primer paradigma, ya que no son comparables a los valores calculados en el segundo. Las principales recomendaciones son: 1) abstenerse de utilizar PGK como objetivo de rendimiento en la MSE; especialmente porque impone restricciones sobre la mortalidad por pesca F que no son necesarias biológicamente para salvaguardar el recurso, y compromete la consecución de un total admisible de capturas (TAC) mejor y la estabilidad del sector; 2) en lugar de una restricción de F, garantizar que la tendencia esperada de la biomasa del recurso al final del periodo de ordenación en cuestión sea razonablemente plana; y 3) si se requiere un enfoque más conservador,

[1] Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa

aumentar la mediana del objetivo de recuperación de la biomasa, o disminuir el periodo en el que debe alcanzarse dicho objetivo, en lugar de ajustar un nivel de probabilidad (como aumentar el de PGK), ya que las medianas se estiman con mayor solidez que los percentiles inferiores.

KEYWORDS

Management strategy evaluation; management procedure; operating model; performance; PGK; industrial stability

1. Background

A key component of PGK is fishing mortality, F, and Kobe plots implicitly warn against F values that are greater than F_{msy}. Hence the green part of a Kobe plot reflects fishing mortalities F that are less than F_{msy}.

But why the focus on F? The reasons go back to the last part of the previous century. At that time the greatest threat to sustainability in fisheries was the trend in very many areas of the world of an increase in fishing effort (more fishing vessels). With fishing mortality being considered to be proportional to such effort in most fisheries (purse-seine being an exception), limiting effort became synonymous with restricting F. The specific upper bound of F_{msy} was a particular suggestion of the 1995 UN Fish Stocks Agreement (UN, 1995, see ANNEX II guidelines), which has found its way over time into the Kobe plot. In turn, some countries have implemented a requirement for management of a fishery to respect this bound in their legislation.

However, it is important to appreciate that it is not the level of F that is important for sustainability of fishing (Butterworth, 2008). It is only biomass that matters directly: specifically, one does not want spawning biomass to fall below the level at which the probability of future recruitment success becomes impaired, often referenced as the biomass LRP (Limit Reference Point) – difficult though that might be to determine. It is that poorer recruitment which will reduce the biomass yet lower, and hence jeopardise the achievement of sustainable future catches at a reasonable level.

The PGK concept makes sense in the best assessment (BA) paradigm. There one typically has an estimate of current biomass B relative to B_{msy}, and projects forward under constant catches or a constant F. But it is not sufficient for good management to aim only for the resource to get to B_{msy}. Once there, biomass needs to stay there and not decline, so that the catch must not exceed MSY - or expressed in terms of F, not exceed F_{msy}. Hence the aim to be in the green part of the Kobe plot with $F < F_{msy}$ and $B > B_{msy}$.

2. Moving on to MSE/MPs (Management Strategy Evaluation/Management Procedures)

The MSE/MP paradigm for managing fisheries is quite different from the BA paradigm. Rather than only the short term (say 1-3 years), it focuses on the medium term (typically10-30 years), and it relies on a management control measure (e.g. a *TAC*) being set using a formula (MP) that has a feedback control mechanism as its basis. For that management period there are a number of (partly conflicting) aims, typically: reaching a target resource abundance within the (medium term) management period, avoiding serious depletion of the resource, maximizing the catch achieved and seeking reduced TAC variability in the interests of industrial stability and planning. The MSE paradigm also differs from the BA one in another important way: BA involves forecasting where resource dynamics are unknown and require estimation; in contrast MSE involves testing against models with known dynamics.

It is in this last respect that problems arise with placing a limit on F (at all times in the future). Given recruitment fluctuations, biomass will sometimes vary downwards, and keeping TACs more stable in those circumstances will necessarily result in increases in F. Provided that these are reasonably contained, as is ensured by the simulation testing of the MP beforehand, this is absolutely no concern from a resource safety perspective. Hence, there is no biological need to (aim to) limit F to below F_{msy} at all times. Such a BA paradigm-based approach is superseded in the MSE paradigm. Basically, the MP (quite justifiably) allows F to sometimes exceed F_{msy} to be able to "average over" downward fluctuations in biomass to achieve a more stable TAC and industry – this it is able to do because of its basic feedback mechanism.

But one still needs to deal with the fact that the MP's aim to reach the target biomass is not enough; one needs the resource to stay there and not to decline (on "average", as there will be unavoidable fluctuations because of recruitment variability). Hence, in addition to a performance statistic in the MSE that measures how close the biomass is to its target at the end of the management period, one also needs a further statistic that measures the trend forecast for the biomass at that time to check that this is reasonably flat (and, in particular, not declining).

It is perhaps understandable that the PGK concept has been carried over from the BA paradigm in some fora as managers and stakeholders struggled to come to terms with the new concepts introduced with the move to the MSE paradigm, and hence sought refuge in familiar concepts. But this linkage is flawed, in particular because *F* limitation *per se* is not required under the MSE paradigm. Notably neither the IWC nor the CCSBT, the RFMOs with the longest experience with MSE, refer to *F* in the performance requirements for their MPs. Recently, amongst its objectives for its MSE for Greenland halibut, NAFO changed "low risk of exceeding F_{msy}" from a primary required objective to a desirable secondary objective only, in the light of arguments along the lines of those presented above (NAFO, 2023).

3. Probabilities

So of the two axes in the Kobe plot that define the green Kobe (F/F_{msy} and B/B_{msy}), only the latter has relevance in the MSE paradigm. But what about the P part of PGK: the probability?

Clearly "probability" must play some role in MSE when selecting a MP – given two identical fisheries except for their resource indices (such as biomass surveys) being less precise for the first than the second, the MP for the first would need to be more conservative in terms of catch to maintain the same level of risk to the resource. So there needs to be some consideration of the probability of resource abundance being reduced below some specified threshold.

In the BA paradigm, probability computations are usually straightforward in principle. One has a single model, and evaluates the uncertainty associated with parameter estimation error in the assessment, typically taking only observation error into account. If short-term projections are involved, process error (future recruitment variability and hence uncertainty) may also be factored in. But the situation in MSE is quite different, with a long projection period, and in particular integrating over a (often plausibility weighted) Reference Set of operating models. This renders probability intervals non-comparable with those for the BA paradigm, and typically much wider.

The further problem that then arises is that that Reference Set of operating models tends to change over time, as perceptions of the most important sources of uncertainty change, so that probabilities are not comparable across the MP revisions developed at multi-year intervals. This makes it difficult to defend sticking to a specific risk threshold criterion value, such as the probability of biomass dropping below some threshold or the probability adopted for a PGK criterion, in selecting an MP and its revisions as time proceeds. Another problem for PGK is specifying for what year/years in the management period that probability needs to be achieved. A related problem issue is that PGK measures only whether a threshold has been exceeded, but not the extent; however conventional MSE performance statistics, such as lowest depletion, effectively integrate over time to take that extent into account.

The "what year/years" problem has fairly recently been addressed in the CCSBT (see CCSBT, 2018, Agenda item 5). Their solution rests on the rationale that even though Reference Sets of operating models may change over time, these models should still be "balanced" over a more to less optimistic set of selections (in terms of being within plausible ranges of resource status and productivity). In these circumstances, statistics of distributions which measure their central tendency (e.g. the mean and especially the median) are generally quite robust – much more so than tail probabilities such as the lower 5%ile. If then a more conservative approach to management is sought, rather than select a higher probability threshold, such as a higher 5%ile for biomass recovery or probability level for PGK, instead the median biomass target at the end of the management period is set higher, or alternatively the MP is required to achieve the existing target in a shorter period of time. This has the further advantage of being more readily understood/interpreted by lay stakeholders, compared to changes in probability values.

4. Conclusions

In summary then, key recommendations are:

1) Refrain from using PGK as a performance target in MSE; in particular, it imposes constraints on fishing mortality *F* which are not required biologically to safeguard the resource, and which compromise attaining better TAC and industry stability.
2) In place of an *F* constraint, ensure that the expected trend in resource biomass at the end of the management period considered is reasonably flat.
3) If, say, a more conservative approach is required, achieve that by increasing the median biomass recovery target, or decreasing the period over which it is to be achieved, rather than adjusting some probability level (such as increasing the probability level in PGK).

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