Both a Type 1 shortcut MSE and full feedback MSE were compared for North Sea cod. Relying on the shortcut MSE results alone could have led to a harvest control rule that was not suitably precautionary.

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Shortcut vs. Full MSE: Differences in approach and application

Using a shortcut approach to develop a management strategy evaluation (MSE), a tool used to evaluate harvest strategies, can speed up the process but often provides less robust results.

OVERVIEW

TO ACHIEVE LONG-TERM SUSTAINABILITY and profitability, fisheries are transitioning to management procedures (MPs) to provide effective and science-based management. Also referred to as "harvest strategies," MPs offer a pre-agreed framework for setting fishing opportunities, such as catch or effort limits. Developing this framework depends on extensive input from fisheries managers, in consultation with stakeholders, on each building block of an MP.

Management objectives make up the first building block and define the vision for the future of a fishery. They are often expressed in terms of achieving desired population levels and/or catches—two goals that can be in conflict with one another when trying to maximize catch and fish abundance at the same time. Designing MPs that best achieve all management objectives requires the use of management strategy evaluation (MSE), a computer simulation modelling tool that projects a fishery years into the future under a wide range of scenarios, which effectively accounts for risk and uncertainty. The development of an MSE can be resource-intensive and often requires multi-year commitments from expert scientists. But the upfront investment pays off in the form of a robust MP that contributes to automating management decisions for years to come.

Recognizing the usefulness of the MP approach and MSE, but unwilling or unable to commit the resources needed to develop a full MSE, some scientists are turning to a "shortcut" MSE that relies on a simpler modelling framework. However, potential benefits of a shortcut approach should be weighed against any drawbacks. For instance, the shortcut approach could be completed more quickly, saving time and money, but the results could also be less reliable and useful. What are the differences between shortcut and full MSEs, and, considering their advantages and disadvantages, when is each preferred?

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FULL MSE APPROACH

THE FOUNDATION OF ANY MSE is a set of operating models (OMs). Each OM represents a plausible hypothesis about the future state of the fishery, including, for example, varying assumptions about the biology of the stock (such as growth, reproduction) and anthropogenic influences (such as increased efficiency of fishing due to new technologies). Many MSEs include tens, and sometimes even hundreds, of OMs to reflect the large number of possible scenarios that could occur in the future.

These OMs are compared to real world, historical fisheries data, a step referred to as "conditioning," to eliminate any OMs reflecting implausible scenarios. After this cull, the remaining OMs are subjected to a "closed-loop simulation" to test various candidate MPs (see Figure 1). When projecting the fishery into the future, the OMs generate simulated fisheries data, which are fed into an "observation error model" that adds plausible levels of imprecision and bias to the generated data, as no real-world fisheries data are collected without error.

These data, now dubbed "monitoring data," are used in a so-called "estimation model," which estimates the status of the stock. Next, that information is fed into a candidate harvest control rule (HCR) to determine a management response, such as increases or decreases to catch limits or time-area closures. At the heart of each candidate MP is this HCR, a decision rule that specifies how the harvest is to be managed under different levels of stock status. An alternative to this type of "model-based" HCR is an "empirical" HCR, which uses monitoring data, such as catch per unit effort (CPUE) data or survey data, as a proxy for the stock status to directly trigger the HCR.

Finally, this management response is subjected to implementation error—again to reflect what happens in the real world—since the rule may not be perfectly executed, perhaps due to illegal fishing that leads to additional catches. The output of this implementation error model is then fed back into the OM, restarting the cycle for many years into the future. This testing cycle can be repeated for each candidate management procedure, allowing comparison of the long-term performance of various MPs.

Because the full MSE includes every step in the closed-loop simulation, it is often called "Full Feedback MSE."

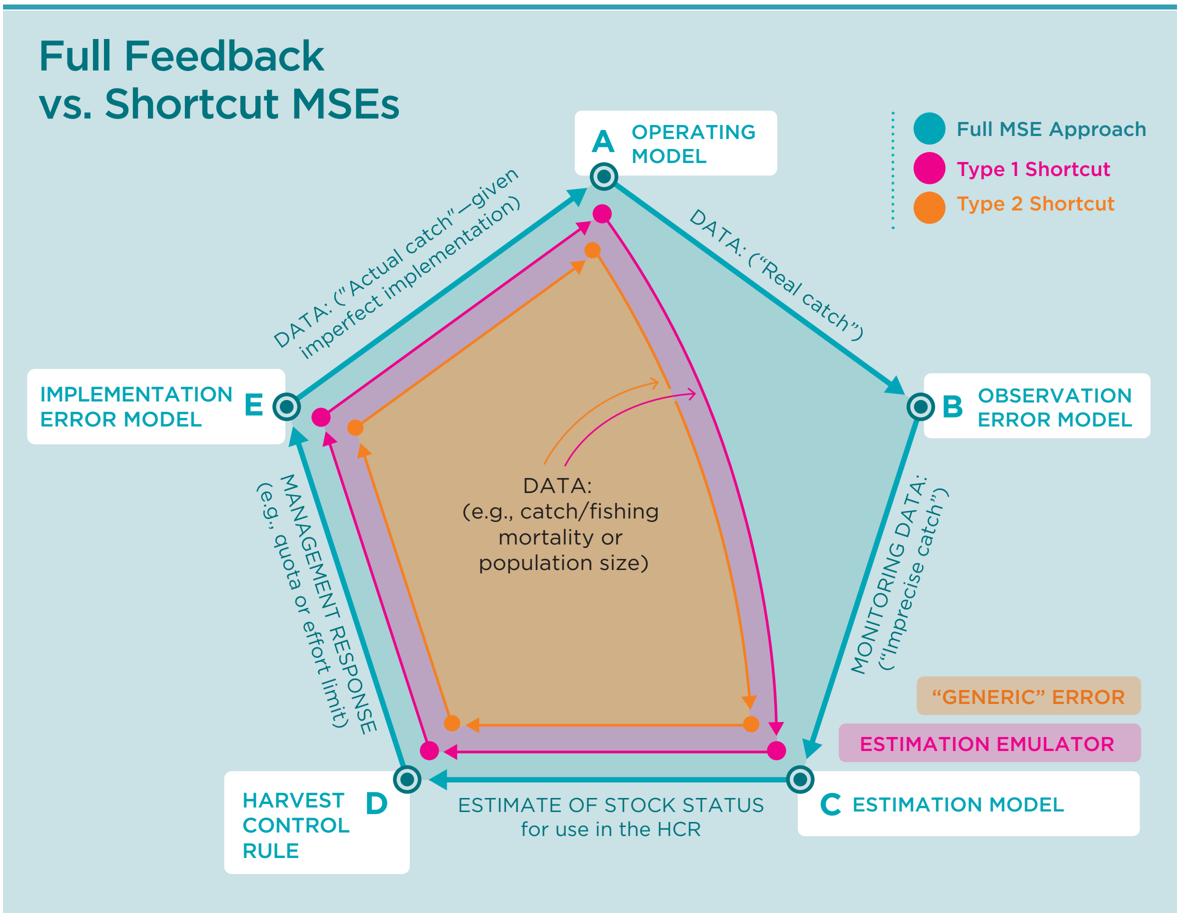

Figure 1. The closed feedback loop for both the full feedback MSE and shortcut MSE approaches is shown. The full approach for a model-based MP is represented by teal arrows that progress through Steps A through E. Two types of the shortcut approach are represented by either pink or orange arrows in steps A, C, D, E, and either the pink box (Type 1) or orange box (Type 2) in step C.

SHORTCUT MSE APPROACH

THE SHORTCUT MSE also subjects OMs and candidate MPs to a closed feedback loop, but it skips some steps. While a full MSE tests model-based MPs by manipulating the generated fishery data through an observation error model and estimation model, the shortcut approach bypasses both steps and replaces them with an "estimation emulator." This emulator adds patterns of error ("noise") to the data coming out of the OMs and produces a simplified estimate of stock status. Then the shortcut MSE runs the HCR based on these data.

There are two main ways to develop a shortcut MSE: A Type 1 shortcut MSE specifies monitoring data, an estimation emulator, and the harvest control rule as part of the MP. A Type 2 shortcut MSE only evaluates the HCR, without incorporating monitoring data or the stock status estimator (estimation model/emulator). Instead, bias is introduced into the OM generated fishery data by subjecting it to generic patterns of error from previous stock assessments, which may or may not be associated with the fishery's OM that is being used in the MSE to evaluate the HCR.

The way shortcut MSEs circumvent the observation error model and estimation model can be problematic. The error that is added during a shortcut approach may not adequately reflect the higher levels of imprecision and bias that impact real-world data. Further, the method used in the Type 2 shortcut has an additional disadvantage because the generic error patterns are less scientifically accurate and likely do not encompass the full range of error that could occur in the future, which can compromise the eventual performance of a selected MP. Additionally, shortcut MSEs can only be used to test model-based MPs as empirical MPs do not rely on an estimation model.

Because the shortcut approach cannot consider all of the uncertainties in a fisheries system, the projected performance of a candidate MP could be inaccurate. As a result, any MP implemented on the water may not achieve its management objectives.

RECOMMENDATIONS

WHICH MSE APPROACH IS BEST for a specific fishery may depend on several factors, such as availability of resources and desired timeframes for completion. However, that choice should be made only after all participants in the process—scientists, managers and stakeholders—discuss their advantages and disadvantages early on in the MP development process to reach an informed decision on which approach to apply (see Figure 2). Effective practice suggests that in most situations a full MSE should be the preferred choice because it leads to a more robust MP that is worth the greater up-front investment in its development.

On the other hand, a shortcut MSE could be an option in certain situations, but not as a replacement for a full MSE. Shortcut MSE approaches could be used to scope a fishery ahead of the development of a full MSE. A Type 1 shortcut MSE can test a variety of candidate MPs quickly and could provide a decent approximation of MP performance that accounts for some uncertainties in a fisheries system. Then, the results of this shortcut MSE can be used to refine and narrow the list of candidate MPs that would be tested later under a full MSE, streamlining the full MSE process. This approach would help to reduce the complexity, time, and costs associated with a full MSE. As such, a shortcut could be used in a "hybrid" approach to facilitate a more efficient and expedient development of the full MSE process. In contrast, the Type 2 shortcut approach should be avoided in all situations as the lack of specified monitoring data and estimation model renders any evaluation of a candidate MP unreliable.

SHORTCUT MSE	FULL MSE
EFFICIENCY	
Reduces computational complexity, less resource intensive	Can be more computationally demanding and resource intensive
Can quickly test wide range of candidate MPs and OM variants using relatively fewer resources	Testing many candidate MPs can be more resource intensive, thus resource constraints can limit scope of work, including number of candi-date MPs or OMs
ROBUSTNESS	
Does not test MP used in practice but relies on estimation emulator instead of MP's estimation model, which may incorrectly estimate MP performance	Fully tests MPs using every step of the full feedback loop, including the estimation model that will be implemented in practice
Emulator may not characterize all biases and plausible future scenarios since it uses only uncertainty from past assessments	Can model any plausible future biases and scenarios that may not yet have been observed
The estimation emulator might receive more information than would be obtained through monitoring data, which may incorrectly estimate MP performance and make it conceptually more challenging to test alternate OMs	The MP receives information similar to the monitoring data that will be received in practice
RELIABILITY	
Monitoring data and stock assessment method to be used within the HCR are not specified for Type 2 shortcut MSE	Meets the pre-specification requirements for MP guidelines and MSE best practice

Figure 2. Comparison of the shortcut and full MSE approach, highlighting risks (in red), lesser risks (in orange), and benefits (in green).

CONCLUSION

ONLY A FULL MSE CAN EVALUATE MPs under a wide range of uncertainties and maximize the likelihood that the final MP will successfully achieve its objectives on the water. It accounts for uncertainty within the fishery, stock, and environment better than any other method. If there is a desire to minimize the computational demand that is needed to develop a full MSE, evaluating empirical rather than model-based MPs can reduce the workload.

A hybrid approach that relies on both shortcut and then full feedback MSE could be useful in certain cases, initially helping to reduce the resources and complexity required by a full MSE without sacrificing the benefits of the full approach. When developed using MSE best practice, MPs can transform a fishery, providing long-term stability and sustainability to fish, fishermen, and seafood markets.

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