Management Strategy Evaluation Process

used in the

evaluation of

Atlantic Herring Acceptable Biological Catch Control Rules

February 24, 2017

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New England Fishery Management Council
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INTRODUCTION

The New England Fishery Management Council (Council) is currently developing Amendment 8 to the Atlantic Herring Fishery Management Plan. Through Amendment 8, the Council expects to establish a long-term control rule for specifying acceptable biological catch (ABC) for the Atlantic herring fishery. A control rule is a formulaic approach for establishing an annual catch limit or target fishing level that is based on the best available scientific information. An objective of Amendment 8 is to develop and implement an ABC control rule that manages Atlantic herring within an ecosystem context. A purpose of Amendment 8 is to address the biological needs of the Atlantic herring resource as well as the ecological importance of Atlantic herring to the greater Atlantic region in a manner that is consistent with the requirements and intent of the Magnuson-Stevens Act.

It is expected that after the MSE is complete, the outcomes will help the Council evaluate tradeoffs between ABC control rule objectives and which control rules would most likely meet the goals of Amendment 8 and form the range of alternatives. This is the first application of the MSE approach for a fishery managed by the New England Fishery Management Council, and the first known MSE in the U.S. to use open, public workshops for input.

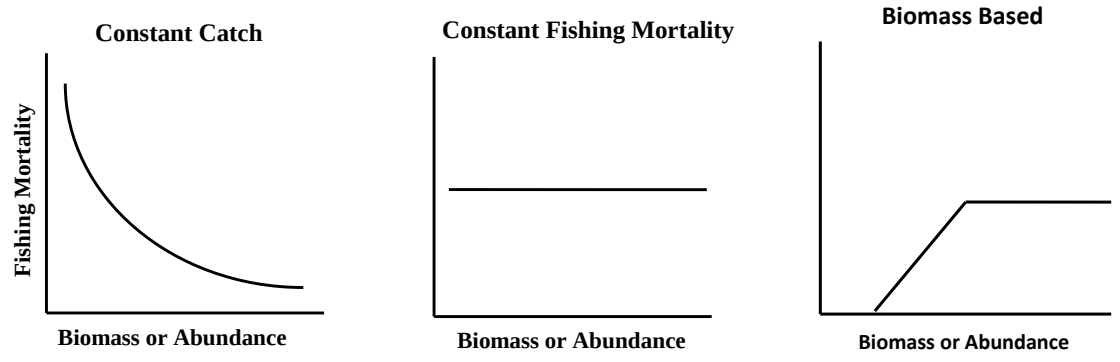
Specifications for the Atlantic herring fishery are currently set through 2018. It is expected that the 2019-2021 specifications will be developed using the control rule adopted through the Amendment 8 process.

This document provides an introduction to ABC control rules, Management Strategy Evaluation (MSE), and the specific process used in this MSE of Atlantic herring ABC control rules.

ABC CONTROL RULES

An Acceptable Biological Catch (ABC) control rule specifies a target amount of catch or a fishing mortality rate that depends on some measure of recent stock abundance. Many control rules exist, and they vary in their ability to achieve fishery objectives, but there are three generic types of control rules (Figure 1).

Figure 1 - Generic types of control rules relating the fishing mortality rate to biomass or abundance



A ‘constant catch’ control rule harvests the same amount of fish regardless of abundance. Consequently, as abundance declines, the fishing mortality rate (i.e., catch divided by abundance) increases, because the fishery is removing a larger proportion of the stock.

A ‘constant fishing mortality’ control rule removes the same fraction of the population regardless of abundance, and consequently catch increases linearly with abundance (e.g., 75% F_{MSY}).

A 'biomass based' control changes the fishing mortality rate depending on abundance, typically with the fishing mortality rate increasing with abundance to some maximum rate. The linear change in fishing mortality can vary in steepness, and fishing mortality does not necessarily need to equal zero at a particular level of abundance.

Many other variations of control rules exist, but these are the basic types. Variations to these basic types can produce a broad range of results. In the U.S., some characteristics of an ABC control are defined by law. For example, ABC cannot have a greater than 50% chance of exceeding the catch associated with F_{MSY} (i.e., the Overfishing Limit (OFL)), and so F_{MSY} should likely serve as an upper bound for any control rule considered. Beyond that, previous research can likely inform decisions about what control rules might be eliminated *a priori* as unlikely to meet fishery objectives.

The ABC control rule currently in place for the Atlantic herring fishery does not fit neatly into any one of these generic types, but combines approaches:

> *Atlantic herring ABC will be specified annually as the catch that is projected to produce a probability of exceeding F_{MSY} in the third year that is less than or equal to 50%.*

Essentially, a fishing mortality rate is applied, and the catch associated with it is set for a three-year period. However, below a certain biomass threshold, a stock rebuilding program would be required, which has no intuitive relationship between biomass and F, because it depends on assumptions that go into determining rebuild time.

MANAGEMENT STRATEGY EVALUATION

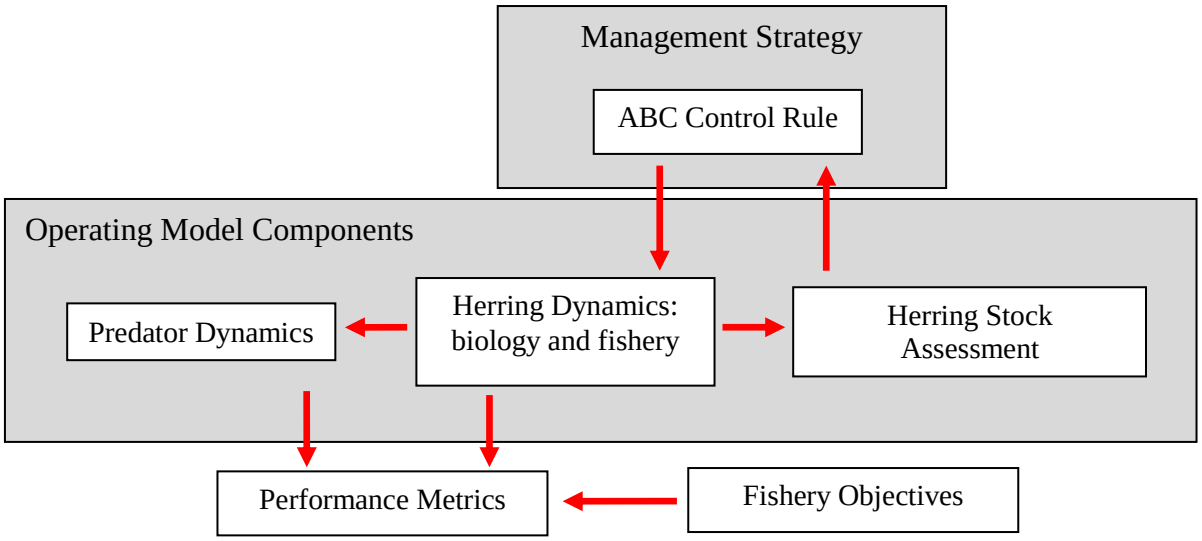
Management Strategy Evaluation (MSE or Management Procedures) is a decision-making process to determine preferred management approaches. MSE involves simulation testing of how various management approaches (e.g., ABC control rules) may perform relative to identified management objectives. MSE can take many forms, but here, the Council is using public workshops to generate stakeholder input on the simulation work.

Of particular importance to the MSE process is identification of fishery objectives and corresponding quantitative performance metrics, and relevant uncertainties (related to the biology, ecosystem, assessment, management, etc.). An example fishery objective might be maintaining enough herring as forage, with a corresponding performance metric of a minimum abundance of herring. Example uncertainties might include those related to stock assessment, fish reproduction (i.e., stock-recruitment), and the strength of predator-prey interactions.

With this information, a simulation is constructed that involves a mathematical representation (i.e., operating model) of the necessary biological aspects of the system, the fishery, stock assessment, and management (e.g., a level of ABC). The operating model should account for the uncertainties identified (Figure 2). In some cases, uncertainty about a process may be so large as to warrant construction of multiple operating models that attempt to bound the plausible range of the given process. For example, the degree to which predator abundance depends on herring abundance might be poorly understood, and so two operating models might be constructed with a high and low degree of predatory dependence, respectively (Figure 3). With each operating model, the performance of the ABC control rules is simulated. Performance metrics are then compared for the control rules under each operating model to evaluate which control rules are more or less robust to the uncertainties.

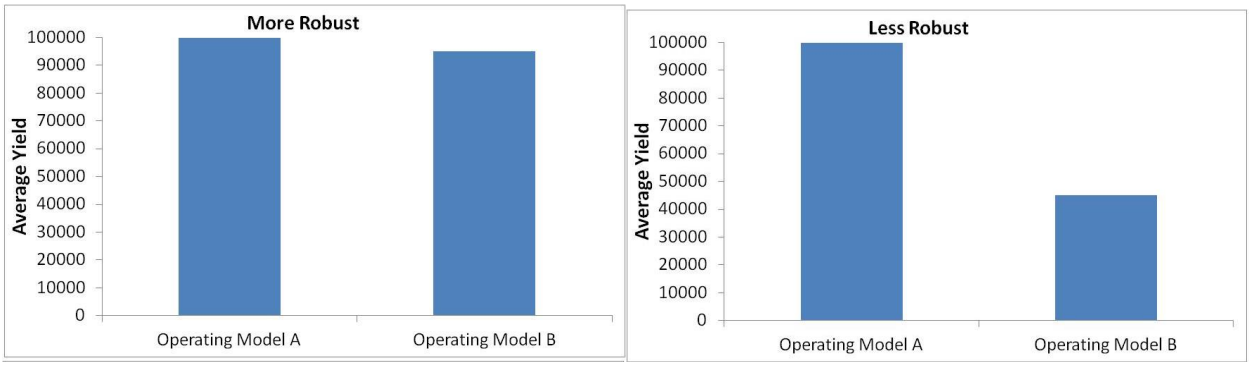
Ideally, a preferred management alternative or range of alternatives is identified through the MSE process that will perform reasonably well for the fishery objectives regardless of the operating model (i.e., regardless of what is happening in reality). Another benefit of the MSE process is improved common understanding of what is or is not well understood about the system, which can help inform research priorities and future refinement of the MSE. In the end, the MSE will only be as useful to the degree to which those involved collaboratively work to create a useful approximation of reality that bounds the major uncertainties.

Figure 2 - Schematic of an operating model for the MSE. In this case, the ABC control rule is the management strategy being evaluated, and potentially many are considered



Source: Adapted from Punt et al. (2014).

Figure 3 - An example performance metric (average yield) demonstrating a more robust control rule and a less robust control rule for two operating models



Atlantic Herring MSE Process

In 2015, the Council initiated, conducted public scoping, and set the goals of Amendment 8 to the Atlantic Herring Fishery Management Plan. In January 2016, the Council approved conducting a Management Strategy Evaluation (MSE) to support the development of alternatives regarding the ABC control rule. The Council aimed to use MSE as a collaborative decision-

making process, involving more upfront public input and technical analysis than usually occur through the amendment development process. MSE is being used here to help determine how a range of control rules may perform relative to potential objectives. The MSE proceeded with four distinct phases. See timeline on page 6. MSEs can take several years to complete. Here, the Council aims to use the ABC control rule adopted through Amendment 8 in developing the fishery specifications for 2019-2021. Thus, this MSE proceeded under more constrained time limits than perhaps is normally the case.

Phase 1 – Identify parameters to be tested

An initial public workshop was held in May 2016 to develop recommendations to the Council for a range of potential objectives of the Atlantic herring ABC control rule, how progress towards these objectives may be measured (i.e., associated performance metrics), and the range of control rules that would undergo testing. In June 2016, upon review of the workshop recommendations and additional input from the Atlantic herring Plan Development Team (PDT), Advisory Panel (AP), and Committee, the Council approved moving forward with the MSE. These bodies did not recommend specific changes to the input provided by the workshop. Although there was not universal support for all of the recommendations, these groups supported evaluation of the full range of concepts.

Phase 2 – Simulation testing

With the fishery objectives, performance metrics and control rules that would undergo testing approved in June 2016, technical work proceeded over the summer. The Northeast Fisheries Science Center (NEFSC) technical team identified, refined, or developed models of Atlantic herring, predators, and fishery economics and tested control rule performance relative to the performance metrics. This work proceeded up until the second public workshop in December 2016.

Phase 3 – Review results, identify additional improvements

The Council convened a second public workshop in December 2016 to review the results of the technical work and to provide continued opportunities for public input. This input was intended to inform both the finalization of this MSE as well as the development of alternatives in Amendment 8. Relative to this MSE, participants were asked to identify what, if any, additional MSE simulation work (or presentation of outcomes) would be informative for establishing a long-term ABC control rule. The workshop identified which of the ideas generated could potentially be accomplished within this current, first MSE and which may be incorporated into future iterations of the MSE with future improvements to data and/or modeling capacity. Relative to the development of alternatives, participants were asked to identify acceptable ranges of performance for various metrics (to help the Council balance tradeoffs) and how the number of control rules simulated could be narrowed into an appropriate range for consideration in Amendment 8.

Phase 4 – Finalize MSE

Based on the input received at the December 2016 workshop, the NEFSC technical team made refinements to the simulations and presentation of outcomes, finalizing a summary of the technical methods and outcomes in February 2017.

USE OF MSE OUTCOMES

Since the December 2016 workshop, the Atlantic Herring PDT, AP, and Committee have met to discuss the preliminary MSE outcomes and the workshop input on identifying acceptable ranges of performance for various metrics and how the number of control rules simulated could be narrowed into an appropriate range for consideration in Amendment 8. These groups will continue to work on developing the range of alternatives, informed by the finalized MSE and outcomes of the peer review on March 13-15, 2017. The Council could potentially approve a range of control rule alternatives for Amendment 8 at its meeting in April 2017.

TIMELINE

The following timeline outlines the Council's development of Amendment 8 to date, including the steps specific to the MSE (in bold).

<table>
<tr><td>2015</td><td>Jan. – Dec.</td><td colspan="4">Amendment 8 initiated; public scoping; review scoping comments; develop amendment goals and objectives</td></tr>
<tr><td rowspan="12">2016</td><td>Jan.</td><td colspan="4">Approve using a MSE in developing amendment alternatives</td></tr>
<tr><td>Feb.</td><td rowspan="4">MSE Phase 1</td><td colspan="3"></td></tr>
<tr><td>Mar.</td><td colspan="3"></td></tr>
<tr><td>Apr.</td><td colspan="3"></td></tr>
<tr><td>May</td><td colspan="3"></td></tr>
<tr><td>Jun.</td><td rowspan="7"></td><td rowspan="7">MSE Phase 2</td><td colspan="2"></td></tr>
<tr><td>Jul.</td><td colspan="2"></td></tr>
<tr><td>Aug.</td><td colspan="2"></td></tr>
<tr><td>Sept.</td><td colspan="2"></td></tr>
<tr><td>Oct.</td><td colspan="2"></td></tr>
<tr><td>Nov.</td><td colspan="2"></td></tr>
<tr><td>Dec.</td><td>MSE Phase 3</td><td rowspan="3">MSE Phase 4</td></tr>
<tr><td rowspan="3">2017</td><td>Jan.</td><td colspan="2" rowspan="2">Discuss preliminary MSE outcomes & workshop input.</td></tr>
<tr><td>Feb.</td></tr>
<tr><td>Mar.</td><td colspan="4">MSE peer review; develop amendment alternatives</td></tr>
<tr><td>Apr.</td><td colspan="4">Potentially approves range of amendment alternatives</td></tr>
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MSE DOCUMENTATION

Additional information about this MSE may be found in the following documents:

- First Workshop of the Atlantic Herring MSE Summary Report, May 16-17, 2016
- Herring PDT, AP, and Committee MSE Recommendations, June 10, 2016
- Second Workshop of the Atlantic Herring MSE Summary Report, December 7-8, 2016
- Atlantic Herring MSE Technical Methods and Outcomes, February 24, 2017

REFERENCES

Punt AE, Butterworth DS, de Moor CL, De Oliveira JAA & Haddon M. (2014). Management strategy evaluation: best practices. *Fish and Fisheries. doi: 10.1111/faf.12104*.