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New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
E.F. "Terry" Stockwell III, *Chairman* | Thomas A. Nies, *Executive Director*

To: Tom Nies, Executive Director
From: Scientific and Statistical Committee
Date: May 29, 2015

Subject: Terms of Reference – Overfishing levels (OFLs) and acceptable biological catch (ABC) recommendations for Atlantic herring.

The SSC met on May 20, 2015 in Revere, Massachusetts, to address the following terms of reference (TORs):

1. OFL and ABC recommendations for Atlantic herring
Review the Atlantic Herring Operational Assessment Report for 2015 (Prepublication Draft) and the work of the Herring PDT and provide the OFL and ABC for each year for fishing years 2016-2018 that will prevent overfishing. (See list of documents for the assessment report and PDT report under Information below).

To address this TOR, the SSC considered the following information:

1.1 Review the Atlantic Herring Operational Assessment Report for 2015, Prepublication Draft, May 7, 2015

1.2 Herring Plan Development Team recommendations for ABC options for 2016-2018 Atlantic herring fishery specifications *(to be distributed)*

1.3 Herring ABC for FY2013-2015 – SSC Memo to Paul Howard, September 21, 2012

2. SSC input on the development of an ecosystem-based control rule for Atlantic herring
Consider the presentation and other information provided by the EBFM PDT and provide advice to the Council, EBFM Committees and PDT on the development of an ecosystem-based control rule for providing future ABC advice for Atlantic herring. The control rule would be implemented under Amendment 8 to the Atlantic Herring FMP.

To address this TOR, the SSC considered the following information:

2.1 Presentation **–** Herring Control Rule Advice (March 30, 2015)

2.2 Differences in diet of Atlantic bluefin tuna at five seasonal feeding grounds on the New England continental shelf (Chase2001)

2.3 Consumption by marine mammals on the Northeast U.S. continental shelf (Smith, et al., 2015)

2.4 Herring ABC Control Rule Alternatives - SSC Memo to Paul Howard, December 10, 2012

OFL and ABC recommendations for Atlantic herring

The SSC received a thorough overview of the operational assessment from Dr. Jon Deroba, and a report on the PDT analyses from Lori Steele. In addition to the catch projection included within the operational assessment report, the PDT included an option based on the same control rule used to set the current specifications. That control rule involves a constant catch approach over fishing years 2016-2018, with the ABC set such that the probability of overfishing does not exceed 50% in any of those years. Based on the projection, probability of overfishing may reach 50% in the third year (2018). That control rule results in an ABC of 111,000mt for 2016, 2017 and 2018, and associated OFLs of 138,000mt in 2016, 117,000mt in 2017, and 111,000mt in 2018. The rationale for this recommendation is as follows:

- A constant catch strategy is the preferred approach of the Council and industry.
- Key attributes of the stock and assessment (SSB, recruitment, F, survey indices, etc.) have not changed significantly since the benchmark assessment, on which the current control rule was based. However, survey indices suggest that the 2011 year class is the second largest in time series and will contribute significantly to the total population abundance and biomass in 2016-2018.
- The most significant change is that the retrospective pattern has become worse in the operational assessment. The assessment implemented a Mohn's rho correction to SSB in an attempt to account for the retrospective pattern, but there is no guarantee that the retrospective pattern will persist in sign and magnitude.
- Although the probability of overfishing reaches 50% in the third year, the probability of the stock becoming overfished is close to 0% in all years.
- The realized catch in the fishery is generally well below the ABC, which reduces the expected risk of overfishing.
- The current ratio of catch to estimated consumption is 1:4, which means that fishing is likely not the largest driver of stock abundance at present, however this does not negate the need to manage the fishing removals on this stock.

The considerations above led the SSC to conclude that ABC should remain relatively constant, or perhaps be reduced modestly. The recommended ABC of 111,000mt, compared with status quo estimate of 114,000mt, achieves that outcome. The SSC notes that the current high biomass of herring, bolstered by two very large year classes, is likely meeting ecosystem goals; however, meeting this goal is by default and not by design, as ecosystem goals are not identified or captured in the current control rule.

SSC input on the development of an ecosystem-based control rule for Atlantic herring

The SSC congratulates the EBFM PDT on the extensive work completed to date to build a scientific foundation for management decisions that consider the ecosystem role of Atlantic herring. The PDT has accomplished the following:

- Compiled and synthesized information on consumption of herring by a range of predators.
- Developed candidate control rules that consider ecosystem function.
- Conducted preliminary analyses of the performance of those control rules through Management Strategy Evaluation (MSE).

- Reviewed a range of more complex models that have the aim to quantify interactions among species.
- Considered a range of important issues that mediate the ecosystem role of herring, including finer scale spatial patterns and dynamics, age- and size-specific predation, and effects of climate change.

The SSC offers advice on further developing the scientific basis for these management decisions along two timelines: steps that can inform the development of Amendment 8 (weeks to months) and steps that can further refine management objectives and measures beyond Amendment 8 (2-5 years). A third timeline to consider might be longer term research that will fill existing gaps in data and models, but the SSC did not address that question.

For the purposes of Amendment 8, the SSC strongly recommends continuing with the MSE work led by Dr. Jon Deroba at NEFSC. The SSC has in the past recommended that MSE become a more central component of the scientific basis for management, and therefore sees this work as a welcome direction. The PDT stressed that the MSE work is preliminary, and therefore the SSC recommends that the first step is to conduct a peer review of the work to date to determine whether it is a sufficient basis for management or to identify modifications needed for it to be ready to inform management, and to solicit recommendations on the most fruitful improvements.

Recognizing that a dedicated peer review of the work is needed, the SSC offers two suggestions for refinement of the MSE that will capture additional ecological reality:

1. Use consumption data to vary natural mortality, analogous to its use in the herring stock assessment.
2. Autocorrelate the stochastic variation in recruitment to simulate climate effects.

Dr. Deroba noted analytical issues that will arise from those suggestions, especially the first, and those concerns could be added to the TORs for a peer review of the work.

The existing MSE does not generate insight into the ecosystem effects of a higher target biomass for herring, e.g., in terms of increased productivity of predators. Addressing that question will require more complex mechanistic models such as those reviewed by the PDT. The PDT suggested that development of those models to a point where they could be useful for management would likely take 2-5 years. The SSC generally agrees with that timeline, although we note that scientific understanding of predator-prey dynamics involving herring are comparably well understood, and therefore models that are useful for management should be able to be developed sooner rather than later.

The SSC suggests that models of intermediate complexity (i.e, “MICE”) will likely be the most appropriate tool to meet the Council’s objectives and will be more scientifically defensible. In contrast with complete food web models, MICE focus on a smaller number of interactions among predators and prey and their environmental drivers. Although this approach introduces risks of unintended consequences due to the interactions that are not considered, those risks will be lower than the single species approaches currently in use. Furthermore, the strength of MICE is that the analyses can focus on the interactions that are of most interest to management and/or those that are best understood scientifically.

Ecosystem based management may involve using multiple models to estimate and project stock biomass. These could range from traditional single-species models to the ecosystem models described above. Using multiple quantitative approaches may provide more robust estimates of population sizes and explicitly consider trade-offs between different components of the ecosystem. The current PDT-SSC-Council process is designed to develop advice from single-species models. We will need to consider how to adapt this process to handle information from multiple models. Furthermore, ecosystem-based management involves goals beyond the standard fishery reference points. Effective ecosystem based management will require explicitly defining these goals.

In addition to application of ecosystem models, the SSC recommends that additional empirical analyses be conducted in order to better understand the effects of changes in the herring stock on predators of interest. The PDT noted that the nutritional value of herring relative to alternative prey species is not equivalent, and future dietary analyses should account for those differences. Furthermore, efforts should be made to link key drivers of the productivity of predator stocks (e.g., growth, reproductive rates, condition, etc.) with attributes of the herring stock. Those empirical analyses will assist the Council with goal-setting, and contribute to modeling the predator-prey interactions.

The PDT also noted that the importance of herring for different predators is likely to vary spatially, and to depend upon age- and size-specific predation rates. The SSC agrees with this conclusion. Therefore, the empirical analyses recommended above should not only include aggregate herring biomass as a predictor variable, but also metrics related to spatial, age and size structure. It is likely that modeling efforts will be limited to aggregate biomass and a stock-wide spatial scale initially, but ongoing efforts should endeavor to incorporate spatial, age and size structure of the herring stock.

Finally, the PDT report highlights an observation from the SSC's previous report to the Council on herring that the estimated high biomass of the stock means ecosystem objectives might be met by current single species scientific and management strategies by default if not by design. That was due to the especially strong 2008 year class which bolstered the stock. This same situation likely still exists due to the comparably strong 2011 year class. However, this might not be the case in the future if another strong cohort does not eventuate, and biomass begins to approach B_{MSY}. Therefore, the SSC strongly urges the Council to set clear goals for ecosystem-based management of herring, analyze and select among control rules attentive to those goals, and support the additional science needed to better understand predator-prey dynamics and refine management strategies accordingly.

Summary of recommendations

1. **ABC for Atlantic herring is 111,000mt for 2016, 2017 and 2018. OFLs for Atlantic herring are 138,000mt for 2016, 117,000mt for 2017, and 111,000mt for 2018.**
2. **Peer review of the preliminary MSE conducted by the PDT and NEFSC should be a high priority, as this presents the greatest potential to analyze ecosystem-based control rules for herring within the timeline of Amendment 8.**
3. **Improved understanding of the ecosystem outcomes of ecosystem-based control rules will best be achieved in the medium term (i.e., 2-5 years) by:**

a. **Use of MICE rather than full food web models in order to focus on the species interactions that are of most interest to management and/or best understood by science.**

b. **Additional empirical analyses that examine the nutritional aspects of alternative prey and effects on key drivers of productivity (e.g., growth, reproductive success, condition), with attention to effects of the spatial, age and size structure of the herring stock.**

4. **The Council should develop clear goals for ecosystem-based management of herring, and analyze and implement management measures to achieve those goals as soon as possible because the high biomass of herring might not be maintained if additional strong cohorts do not emerge. That would mean the current situation in which single species management measures are likely meeting ecosystem-based objectives by default if not by design will no longer be the case.**