SUMMARY REPORT

SECOND WORKSHOP ON ATLANTIC HERRING ACCEPTABLE BIOLOGICAL CATCH CONTROL RULE MANAGEMENT STRATEGY EVALUATION

December 7-8, 2016

Portsmouth, New Hampshire

Report prepared by the

New England Fishery Management Council

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TABLE OF CONTENTS

INTRODUCTION

The New England Fishery Management Council (Council) is currently developing Amendment 8 to the Atlantic Herring Fishery Management Plan (FMP). 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.

In January 2016, the Council approved conducting a Management Strategy Evaluation (MSE) to support the development of alternatives regarding the ABC control rule. MSE is a collaborative decision-making process, involving more upfront public input and technical analysis than the normal amendment development process. The MSE is being used to help determine how a range of control rules may perform relative to potential objectives. 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.

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, and Committee, the Council approved moving forward with the MSE.

The Council convened a second public workshop on December 7-8, 2016 in Portsmouth, New Hampshire to review the results of the MSE technical work and to provide continued opportunities for public input (Appendix I is the workshop agenda). This report summarizes this second workshop and its outcomes.

GOALS

The Council hosted this second workshop to:

1. Develop a common understanding of the outcomes of the MSE technical simulations, which tested the performance of a range of ABC control rules relative to potential objectives, as identified at the May 2016 public workshop and approved by the Council in June.
2. Solicit information from stakeholders on:
    a. Identifying acceptable ranges of performance for various metrics, so that tradeoffs in achieving objectives may be identified.
    b. Narrowing the range of Atlantic herring ABC control rule alternatives to consider in more detail.
    c. What, if any, additional (minor) MSE simulation work would be informative for establishing a long-term ABC control rule.
3. Provide an opportunity for stakeholders of the Atlantic herring fishery to have greater input than typically possible at Council meetings, in an environment that supports constructive and open dialogue between users of the resource, scientific experts, fishery managers, and other interested members of the public.

ORGANIZERS AND FACILITATORS

The workshop was organized by a steering committee comprised of Council members and staff of the Council, Northeast Fisheries Science Center (NEFSC), and the Greater Atlantic Regional Fisheries Office (GARFO; Appendix II). Dr. Brian Irwin served as the primary workshop facilitator. Dr. Irwin is an Assistant Unit Leader at the Georgia Cooperative Fish and Wildlife Research Unit and an adjunct faculty member of the Warnell School of Forestry and Natural Resources at the University of Georgia. Small-group discussions were facilitated by Dr. Madeleine Hall-Arber of the Massachusetts Institute of Technology Sea Grant College Program and independent consultants Jessica Joyce and Laura Singer.

ATTENDEES

The workshop drew diverse participation of 65 individuals, including: herring fishermen and industry representatives; lobstermen; commercial, party/charter and private angler fishermen of tuna, groundfish, and striped bass fisheries; fishing community and environmental non-profit organization staff; scientists; whale-watch businesses; federal and state agencies; Council members; and Herring Advisory Panel members (Table 1). Of the 65 participants, 76% attended for both days and 49% had attended the first workshop. These participants were supported by the facilitators, steering committee members, Council staff, and Herring Plan Development Team members, 18 other individuals in all (Appendix II lists all 83 attendees). The workshop presentations and large group discussions were broadcast via webinar (in listen-only mode), and about 12 people viewed the webinar remotely each day.

Table 1 - Demographics of workshop attendees

All Workshop Attendees		**Workshop Participants***	
Council	10 (12%)	Herring fishery	12 (18%)
Advisory Panel	12 (14%)	Lobster fishery	3 (5%)
Facilitators	4 (5%)	Other fisheries	16 (25%)
Staff/PDT	14 (17%)	Environmental NGO	8 (12%)
Others	43 (52%)	State/federal	8 (12%)
Total	**83 (100%)**	Scientists/other	18 (28%)
		Total	**65 (100%)**
*Excludes facilitators, staff, and PDT members.			

PRESENTATIONS - INTRODUCTION TO MANAGEMENT STRATEGY EVALUATION

Dr. John Quinn (Council Chairman) welcomed participants to the workshop, indicating that this is the first MSE for a fishery managed by the Council, but it is a process that has been used in managing many other fisheries, and it fits well with the Council's risk policy that was just approved in June that calls for using MSE in evaluating control rules to help balance tradeoffs, identify signal from noise, and ensure that our fisheries are less sensitive to uncertainty. He reminded attendees that workshop outcomes will be vetted through the Herring PDT, Advisors, and Committee before coming to the Council for consideration. He asked Council members to participate in discussions primarily as listeners, allowing this to be a time focused on gathering public input. Finally, he asked that discussions stay focused on the topic at hand: developing potential control rules for setting fishery-wide catch levels.

Dr. Brian Irwin (workshop facilitator) introduced the MSE approach, a process being used in fisheries contexts where systems are complex, multiple objectives exist, and uncertainties remain. In short, the goal of this MSE is to evaluate the anticipated performance of alternative control rules, for setting ABC of Atlantic herring, relative to specified metrics. MSEs often are iterative, but keys steps typically include: 1) identify management objectives and corresponding performance metrics (i.e., how to quantify the degree to which objectives are met), 2) identify potential harvest strategies, 3) develop operating models to simulate or forecast anticipated performance), 4) simulate performance, and 5) report results, which often includes consideration of tradeoffs. Further, a MSE can be revisited in future years, to help understand actual performance of the management strategy (e.g., control rule) that is implemented and consider how to potentially modify it in light of its performance relative fishery objectives and improved modeling capacity.

Dr. Rachel Feeney (workshop coordinator, Council staff member) explained how this MSE is supporting the development of Amendment 8 to the Atlantic Herring FMP and reviewed the amendment timeline. This is the first known MSE in the U.S. that has used public workshops to develop the fishery objectives, performance metrics, and management procedures that will be evaluated, and to review simulation outcomes. The more normal scenario is to engage a small, closed group of stakeholders who are well versed in the language and technicalities of control rules and MSE. Additionally, MSEs typically take several years to develop, but the Council is striving to meet more compressed deadlines, completing the MSE within a year. Work that might develop over the course of several workshops has been fit into two. In the spring of 2017, the Council expects to select the range of control rule alternatives for Amendment 8, with a peer-reviewed MSE final report in hand. She also explained that the issue of localized depletion is also being evaluated in Amendment 8, even if not part of the current iteration of the MSE due to current data and modeling limitations. In April 2016, the Council adopted a localized depletion problem statement and the Herring Committee is actively developing alternatives. The next Committee meeting on that topic will be in February.

PRESENTATIONS - MSE METHODS AND PRELIMINARY RESULTS

Presentations and large group discussions on Day 1 were aimed at explaining the MSE methods and results, particularly how the outcomes of the first workshop were incorporated into constructing models and measuring the performance of many alternative control rules. At the workshop, all the methods were generally presented prior to the results, but are organized here by topic: Atlantic herring, predators, and economics. *Note: methods and results will be detailed in the forthcoming MSE final report.*

Atlantic herring

Dr. Jon Deroba (Northeast Fisheries Science Center) explained how the control rules and performance metrics identified through the first workshop and approved by the Council in June 2016 were evaluated relative to Atlantic herring.

Control rule types evaluated, as identified by the first workshop:

1. Biomass based, with setting catch every year
2. Biomass based, with setting a constant catch every three years
3. Biomass based, with setting a constant catch every five years
4. Biomass based, with setting a constant catch every three years and restricting subsequent changes in catch to within 15%
5. Constant catch

6. Conditional constant catch, with a maximum fishing mortality rate set at half of the rate at maximum sustainable yield ($F = 0.5F_{MSY}$).

Performance metrics for Atlantic herring, as identified by the first workshop:

- Spawning Stock Biomass (SSB) & SSB relative to SSB_{MSY} & $SSB_{unfished}$ (or SSB_0)
- Probability that
  - o SSB < SSB_{MSY} & 0.5 SSB_{MSY} (i.e., probability of being overfished)
  - o SSB < 0.3 SSB_0 & 0.75 SSB_0
  - o $F > F_{MSY}$ (i.e., probability of overfishing)
- Yield and yield relative to MSY
- Interannual yield variation
- Probability that Atlantic herring fishery closes
- Proportion of the herring population that is age-1
- Amount of herring dying due to natural mortality

Multiple age-structured operating models, eight in all, were created to evaluate the effects of the uncertainties identified through the first workshop: herring recruitment (high or low?), natural mortality (high or low?), growth (good or poor?), assessment error/bias (yes or no?). For each of the biomass based control rules, 1,360 variations were tested, and ten variations of the constant catch and conditional constant catch were tested, for a total of 5,460 potential alternatives. Each alternative was evaluated with the eight operating models, totaling 43,680 scenarios. For each scenario, control rule performance was simulated for 150 years and this was repeated for 100 simulations. The performance of each metric was summarized over the last 50 years of each simulation, and reported as the median among simulations.

A broad view of the preliminary simulation outcomes for Atlantic herring was presented (as box plots for several metrics), as a precursor to the afternoon small group discussions on refining the acceptable range of performance for the control rules. The effect of each operating model was evaluated (assessment bias or unbiased; herring production and growth poor or high). Relative to the four unbiased models, control rules simulated with the four models where the assessment was assumed to be biased (i.e., estimated biomass is higher than actual biomass) generally produced lower spawning stock biomass (SSB), less natural mortality, more frequent overfished/overfishing conditions, and similar yield, probability of fishery closures, and proportions of young fish.

The effects of uncertain productivity and growth were examined next. Based on the four operating models that assumed an unbiased assessment, uncertainty in production had more of an effect on predicted outcomes than uncertainty in growth, fairly consistently across most performance metrics. However, both growth and production had minor effects on the ratio of fished to unfished SSB (i.e., $SSB/SSB_{unfished}$), variation in yield, the ratio of yield to Maximum Sustainable Yield (i.e., yield/MSY), and the ratio of yield to natural mortality (i.e., yield/N).

The performance of all the control rules was then presented, and given the number of potential scenarios, performance varied widely. The workshop participants were asked to reconsider the performance metrics and identify any preferred range of performance, to help in narrowing the range of control rules.

Predators

Dr. Sarah Gaichas (NEFSC) explained how the control rules and predator performance metrics identified through the first workshop were evaluated relative to predators of Atlantic herring. Bluefin tuna, common tern, groundfish, and marine mammals were the predators that participants of the first workshop were most interested in. Through this MSE, three predator population models (for bluefin tuna, common tern, and spiny dogfish) were developed, and an existing food web model (for marine mammals) was used to illustrate potential aggregate marine mammal responses to herring perturbations. Predator modeling was designed to compare the relative performance of herring control rules, not to develop full population models accounting for all impacts on the predators. Further, the details of spatial or seasonal herring-predator interactions could not be addressed with currently available data within the timeframe required for Council action. What this MSE identifies is how a predator may react to having different amounts of herring in the ecosystem, based on both the relationship between herring and the predator and how a given control rule performs. The results of the Atlantic herring models for each control rule (e.g., numbers at age, biomass, and weight at age) were used as inputs into the predator models.

The presentation summarized what is known about herring's role as forage by the predator classes: groundfish, marine mammals, humans (the fishery), highly migratory fish (e.g., tuna), and seabirds. Groundfish, consume the largest amount of herring but have moderate to low dependence on herring as prey. The highly migratory species consume relatively low volumes of herring, but are highly dependent on herring (herring size may be more important than abundance in our region). The herring consumption data are on a shelf-wide scale and these estimates were accounted for by increasing natural mortality estimates within the most recent benchmark the stock assessment. For the relationships modeled in this MSE, the focus was on the Northeast shelf generally, and the Gulf of Maine in particular to the extent possible.

Not all of the predator metrics reacted to the control rules, in some cases because of data/model limitations and in other cases there was evidence to support that they would not react.

Bluefin tuna forage throughout the North Atlantic, but occur seasonally in the Gulf of Maine to feed on herring. Tuna feed on herring that are about the same size as taken by the herring fishery. The bluefin tuna model simulates the relationship between herring average weight and tuna growth, because tuna growth may be more impacted by herring weight (quality) than abundance (quantity) in the Gulf of Maine ecosystem (quality; Golet et al. 2015). The model uses parameters from the western Atlantic bluefin tuna stock assessment to be consistent with it. The model also incorporated the relationship between tuna growth and herring average weight for the Gulf of Maine (Golet, et al. 2015).

The performance metrics for bluefin tuna identified through the first workshop are:

- Biomass (numbers, recruitment)
- Biomass relative to B_{MSY}
- Average weight
- Average weight relative to expected weight
- Minimum number of years with good biomass and weight status across simulations
- Average proportion of years with good biomass and weight status across simulations

Of these performance metrics, only those related to tuna average weight varied substantially across all herring operating models. However, the operating model configuration has a much greater effect on tuna condition than the control rules. When herring growth is good, tuna growth is also good.

Common terns forage seasonally near their island breeding colonies in the Gulf of Maine. Terns feed on herring that are much smaller in size than what is taken by the herring fishery. The U.S. Fish and Wildlife Service and other agencies involved in the Gulf of Maine Seabird Working Group contributed data from 1997-2015 to help build the common tern population model (incl. numbers of breeding pairs, fledgling success, and diet data). The model simulates the relationship between herring total biomass and tern reproductive success, to help identify how a herring control rule may impact the ability of tern chicks to successfully fledge. It was noted that many factors influence tern productivity besides diet, such as predation, habitat quality, and severe weather, but there appears to be a positive relationship between herring total biomass and herring in the diet of terns for roughly half of the tern colonies.

The performance metrics identified through the first workshop are:

- Numbers, recruitment
- Productivity (the number of fledglings per nesting pair)
- Population status relative to current numbers
- Minimum number of years across simulations
    - good population status
    - production at or above target (1.0)
    - production at or above threshold (0.8)
- Average proportion of years across simulations of population and production status

Preliminary results show that across all the operating models, two of the general control rule types performed consistently poorly in terms of tern productivity – the biomass based with the 15% change restriction and constant catch.

Groundfish and herring have the most similar match in their total population range, relative the other predators modeled. Of the groundfish species, Atlantic cod and spiny dogfish consume the most herring (about 20% of their diets averaged across 1972-2015), both are well-sampled, and are eating herring in proportion to what is available in the ecosystem. However, the currently low abundance of cod likely masks a relationship between abundance and the importance of herring to its diet. Thus, spiny dogfish was selected for the model.

The groundfish performance metrics identified through the first workshop are:

- Biomass, numbers, recruitment
- Biomass relative to B_{MSY}
- Average weight
- Average weight relative to expected weight
- Minimum number of years with OK biomass (i.e., not overfished, above ½ B_{MSY}) and good weight status across simulations
- Average proportion of years with OK biomass and good weight status across simulations

Preliminary results for spiny dogfish, there is some variation in biomass and weight across the herring control rules, and relatively few control rules performed poorly. As with terns, the biomass based with the 15% change restriction and the constant catch control rules had consistently poor performance relative to the others, particularly with the high herring productivity operating models.

Marine mammals occur seasonally in the Gulf of Maine to feed on herring and other prey. Data to construct a marine mammal population model were not available, though there are diet data available. An existing mass-balance Gulf of Maine food web model, updated with recent marine mammal diet data, was used instead to address potential responses of marine mammals to changes in herring. This model simulates interactions for a variety of predators and prey. Uncertainty in food web model and predator prey interaction parameters was included in the analysis, producing a distribution of outcomes rather than a point estimate. The model can estimate how a change in herring survival impacts the productivity of other forage groups and the predators. Preliminary results show that with increases in herring survival, other forage groups may decline, such that improvements in marine mammal productivity are relatively small and highly uncertain, depending on their relative dependence on herring versus other forage.

Economics

Dr. Min-Yang Lee (NEFSC) explained how the economic objectives identified at the first workshop (maximizing yield and profit for the herring fleet and ensuring herring catch temporal stability) were evaluated using yield, net revenue and stability as performance metrics. Yield for each control rule was an output of the Atlantic herring models. Net revenue was calculated with the equation:

net revenue = (price*yield) – cost

Price was estimated based on 2011-2015 Atlantic herring fishery price data, which shows an inverse relationship between price and landings. Costs were based on fishery observer (i.e., NEFOP) data for 2015 and vary between gear types. The primary gear types for the fishery are purse seine and trawl. For this model, purse seine and trawl yields were assumed to be 30% and 70%, respectively. The final performance metric, stability, was measured as the degree to which net revenue was either stable or streaky for the eight operating models and 5,460 control rules, meaning were there periods of "booms and busts" or were the trends in net revenue fairly steady over time.

PARTICIPANT INPUT – REFINE RANGE OF ACCEPTABLE PERFORMANCE

Within three small groups of diverse stakeholders, participants were presented with an exercise to consider (individually and as a group) the preferred range of performance for up to 12 performance metrics, as identified at the first workshop, and provide a rationale, if willing. This exercise was intended to motivate thinking and discussion about the potential range of outcomes across a large set of candidate control rules, and to set the stage for later consideration of tradeoffs, where it is necessary to evaluate more than one performance metric at a time. Participants were given a handout with each metric framed as a question (see below). Most questions were multiple choice with an "other" response should preferences fall outside those provided. On the handout, participants were asked to identify their stakeholder type and whether they are a Council member. Participants were given time to indicate their personal preferences on the handout, and then the small groups discussed each metric to identify the range of individual responses, ask questions, and understand the rationale of others – providing an opportunity for written and verbal input. Participants could revise their individual responses before submitting them to the facilitators.

Overnight, the facilitators, workshop staff, and technical experts collated the participant input to identify themes to determine if a “preferred” range of performance across the metrics could be identified, which would potentially allow for reducing the amount of control rules needing further consideration. This overnight effort was fairly course, given the narrow timeframe. Here, is a more thorough compilation, completed subsequent to the workshop.

The written input of 38 participants and the oral discussions of the entire body of workshop participants are summarized here. There were 41 participants in the three small groups who turned in their handout, including two Council members, one NOAA staff member, and 38 other participants (Table 2), but this summary does not include the written comments of the two Council members or the NOAA staff member, though their input was within the range identified by others.

Table 2 - Demographics of written commenters of the Day 1 small group discussions

Stakeholder Type			**Council member?**	
Herring fishery (all gear types, industry reps)		10 (24%)	Yes	2 (5%)
Other fishery (lobster, tuna, groundfish)		9 (22%)	No	39 (95%)
Environmental NGO		6 (15%)		
Other	State	2 (5%)		
	University	5 (12%)		
	Whale watch industry	1 (2%)		
	Other	3 (7%)		
Not specified		4 (10%)		
NOAA		1 (2%)		
Total		**41 (100%)**		

Note that these responses were solicited as initial reactions to the presentation of a large amount of simulation results, requested with the intent of facilitating further discussions and informing evaluation of different control rules. Thus, these responses may or may not differ from what participants may consider their recommendations for actual management targets.

Question 1 – What is an acceptable amount of Atlantic herring yield (catch)?

Of the 38 participants with written input, 22 provided a quantitative response to the question. Responses varied widely between 50,000-160,000 mt, averaging almost 95,000 mt (Table 3). The herring fishery members, on average, gave higher responses (115,000 mt) than others. Eleven participants did not provide a number, but had a written comment, and five did not respond. The groups were generally uncomfortable with selecting a preferred yield, independent of herring biomass or ecosystem health indicators. This observation may reflect that participants had begun considering tradeoffs, even though this particular exercise was organized around individual performance metrics. Most commented that yield should be tied to stock status, not be a fixed number. Some participants, particularly those who did not provide a numerical value, felt that maintaining a certain yield is less important than maintaining a biomass above a threshold that leaves sufficient herring for forage needs of predators. Some who supported a yield similar to the status quo reasoned that the bait market needs about 100,000 mt per year and felt that fishing at recent levels has been sustainable and sufficiently accounts for uncertainty. For reference, current yield is about 100,000 mt.

Table 3 - What is an acceptable amount of Atlantic herring yield (catch; mt; 22 respondents)?

	Stakeholder type					
	All (n=22)	**Herring fishery (n=9)**	**Other fishery (n=6)**	**ENGO (n=1)**	**All others (n=4)**	**Not indicated (n=2)**
Maximum	**160,000**	160,000	125,000	100,000	100,000	100,000
Median	**100,000**	100,000	50,000	100,000	90,000	75,000
Average	**94,864**	115,000	72,000	100,000	90,000	75,000
Minimum	**50,000**	60,000	50,000	100,000	80,000	50,000

Question 2 – What is an acceptable percentage of Atlantic herring MSY that is harvested?

Of the 38 participants, 34 provided a quantitative response to the question. Responses varied widely, from under 10% to 100% (Figure 1). The range of responses was higher for herring fishery participants (25-100%) than for environmental non-profit (ENGO) participants (10-75%). Four participants provided no number but had a written comment. Some commented that harvest should not be set at 100% MSY, unless predators are explicitly addressed in the process. The assessment accounts for predators in terms of estimated amounts, but not necessarily their need – however, it was noted that predator need is unknown. Those who gave a low percent response generally felt that it would better account for the needs of predators and for uncertainty. There was also concern about the uncertainty in historical data. Some felt that managing to MSY is inappropriate under ecosystem-based management and in a changing climate. Those giving a higher response felt greater confidence in the current stock assessment and were less concerned about continuing near status quo management. For reference, nearly 100% of MSY is currently allowed to be harvested.

Question 3 – What is an acceptable amount of year-to-year change in yield (i.e., yield stability; e.g., 0% = no change)?

Of the 38 participants, 31 provided a quantitative response to the question. Most responses were 10% or less, but a few indicated that over 50% was acceptable (Figure 2). There was not a strong trend in the responses by stakeholder type. Six participants did not provide a number, but had a written comment, and one did not respond. Most responses were 10%, indicating a need to keep a stable and predictable supply of herring for the market. Some felt that stability is good, so long as there is not a risk to the biomass or ecosystem. Some who favored a high percentage (≥50%) felt that any fishery should be able to be closed if needed, or that other biological or ecological factors are more important that yield stability. Those providing no numerical percentage (n=6) indicated that they were either insufficiently knowledgeable or that ecosystem considerations should be prioritized over maintaining fishery stability. Some felt the allowable change should dynamic, more per year if the resource is healthy and less if the resource is in poor condition. For reference, there is currently about a 25% variation from average yield.

Question 4 – What is and acceptable percentage of unfished Spawning Stock Biomass to maintain for Atlantic herring (i.e., proportion of SSB_0)?

Of the 38 participants, 31 provided a quantitative response to the question. Most responses were 75%, but ranged from 25-90% (Figure 3). There was not a strong trend in the responses by stakeholder type. Six participants did not provide a percentage but had a written comment, and one did not respond. Most responses were 75% and indicated a desire to stay near the status quo level and/or be consistent with scientific literature. For nine participants, B_0 is a more appropriate performance metric than SSB; they felt that using B_0 better considers the need to maintain juveniles, and is supported by scientific literature. Those participants support maintaining at least 75% B_0. For reference, SSB is currently about 74% of SSB_0.

Question 5a - What is an acceptable probability that Atlantic herring SSB becomes overfished (i.e., falls below half of SSB at MSY)?

Of the 38 participants, 35 provided a quantitative response to the question. Most responses were 10% or less, and the ENGO participants all responded 0% (Figure 4). Three participants did not respond. Most responses indicated a desire to be risk averse for this important forage species. Those answering 50%, including most of the herring fishery participants, indicated that the status quo seems to be working and/or a desire to be consistent with the legal threshold. For reference, Atlantic herring is currently not considered to be overfished.

Question 5b - What is an acceptable probability that Atlantic herring SSB is below 30% unfished SSB?

Of the 38 participants, 29 provided a quantitative response to the question. Most responses were 10% or less (Figure 5). Four participants did not provide a percentage but had a written comment, and five did not respond. Most respondents indicated a desire to be risk averse for this important forage species. Those indicating 50% or greater did not provide a rationale. For reference, Atlantic herring is currently not considered to be overfished.

Question 5c - What is an acceptable probability that Atlantic herring SSB is below 75% unfished SSB?

Of the 38 participants, 28 provided a quantitative response to the question. Five participants did not provide a percentage but had a written comment, and five did not respond (Figure 6). Most responses were 10% or less and indicated a desire to be risk averse for this important forage species. Many indicated that the management target should be about 75% of SSB_0, but there was variation in the willingness to accept risk around that target. Some indicated that a better metric would be 75% B_0. For reference, Atlantic herring is currently not considered to be overfished.

Question 6 - What is an acceptable probability that Atlantic herring overfishing occurs (i.e., Atlantic herring fishing mortality exceeds the fishing mortality rate (F) at MSY)?

Of the 38 participants, 37 provided a quantitative response to the question. One participant did not respond (Figure 7). Most responses were 10% or less and indicated a desire to be risk averse for this important forage species. Others who responded in the 25-50% range felt comfortable being closer to the legal limit (50%) and the status quo (recently ranged between 35-50%).

Question 7 - What is an acceptable probability that the Atlantic herring fishery must close (i.e., have ABC = 0)?

Of the 38 participants, 33 provided a quantitative response to the question. Three participants did not provide a percentage but had a written comment, and two did not respond (Figure 8). Most responses were 10% or less and indicated that proper management should preclude a need to close the fishery and that closing the fishery would be detrimental to industry business planning and create political pressure to suspend or revise the control rule. Others responding 50% or greater, or who did not provide a specific percentage, indicated that, while closures are not acceptable, maintaining a target biomass (e.g., $B>40\%$ of B_0) is more important than the need to prevent fishery closures. For reference, the current probability of closure is 0%.

Question 8 - What is an acceptable probability that bluefin tuna average weight is at or above long term average?

Of the 38 participants, 32 provided a quantitative response to the question. Three participants did not provide a percentage but had a written comment, and three did not respond. Most responses were in the 75-90% range, indicating a desire to maintain large tuna (Figure 9). Many questioned if a herring harvest control rule could influence tuna weight. For reference, bluefin are currently just below their long-term average weight.

Question 9 - What is an acceptable probability that Common tern population (nesting pairs) is at or above current population size?

Of the 38 participants, 27 provided a quantitative response to the question. Three participants did not provide a percentage but had a written comment, and eight did not respond. Most responses were in the 90-100% range, indicating that terns are an essential part of the ecosystem, and that the population is already below historic levels (Figure 10). Many respondents felt that a herring control rule may have little impact on the tern population; some felt that this metric would not be very informative. Some nonrespondents felt unqualified to answer the question.

Question 10 - What is an acceptable probability that Common tern productivity is at or above the target of 1.0 fledglings/nesting pair?

Of the 38 participants, 27 provided a quantitative response to the question. Three participants did not provide a percentage but had a written comment, and eight did not respond. Most responses were in the 90-100% range, indicating that terns are an essential part of the ecosystem, and that the population is already below historic levels (Figure 11). Many respondents felt that a herring control rule may have little impact on the tern population; some felt that this metric would not be very informative, or that there are other important factors to tern success unrelated to herring. Some nonrespondents felt unqualified to answer the question. For reference, tern production is currently 0.8 on average.

Question 11 - What is an acceptable probability that Common tern productivity is at or above the threshold of 0.80 fledglings/nesting pair?

Of the 38 participants, 25 provided a quantitative response to the question. Five participants did not provide a percentage but had a written comment, and eight did not respond. Most responses were in the 90-100% range, indicating that terns are an essential part of the ecosystem, and that the population is already below historic levels (Figure 12). Many respondents felt that a herring control rule may have little impact on the tern population; some felt that this metric would not be very informative, or that there are other important factors to tern success unrelated to herring. Some nonrespondents felt unqualified to answer the question. For reference, tern production is currently 0.8 on average.

Question 12 - What is an acceptable probability that groundfish biomass is at or above the overfished threshold (i.e., is above half of SSB at MSY)?

Of the 38 participants, 31 provided a quantitative response to the question. Two participants did not provide a percentage but had a written comment, and five did not respond. Most responses were in the 90-100% range, indicating that groundfish are an essential part of the ecosystem, and overfishing should be avoided (Figure 13). Some non-respondents felt that a herring control rule may have little impact on groundfish populations if they are opportunistic feeders; and that this metric may be irrelevant. Some nonrespondents felt unqualified to answer the question. For reference, of the 20 groundfish stocks, about seven are currently considered to be not overfished (NEFMC 2016).

Figures for Questions 2-12 of the Day 1 small group discussions

Note: In each figure, total responses is greater than total respondents, as some respondents indicated more than one response.

LEGEND:

- Herring Fishery
- Other Fishery
- ENGO
- Other
- Not Indicated

Figure 1 (Q2) - What is an acceptable percentage of Atlantic herring MSY that is harvested (34 respondents)?

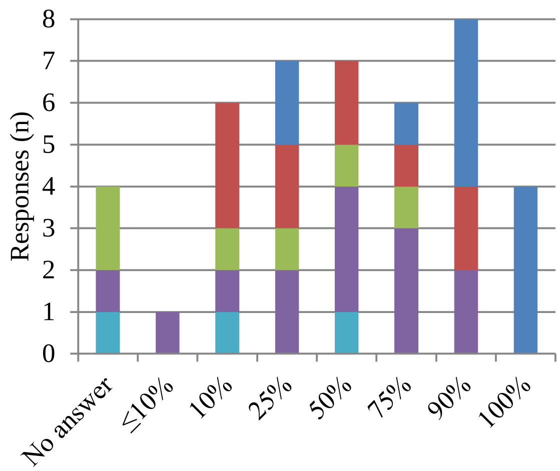


Figure 2 (Q3) - What is an acceptable amount of year-to-year change in yield (i.e., yield stability; e.g., 0% = no change; 31 respondents)?

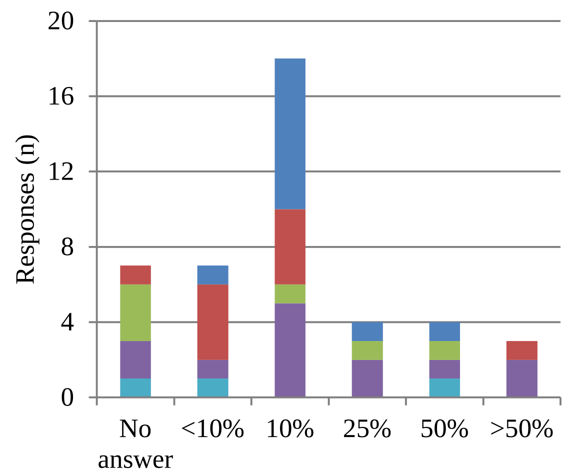


Figure 3 (Q4) - What percentage of unfished Spawning Stock Biomass is acceptable to maintain for Atlantic herring (i.e., proportion of SSB_0; 31 respondents)?

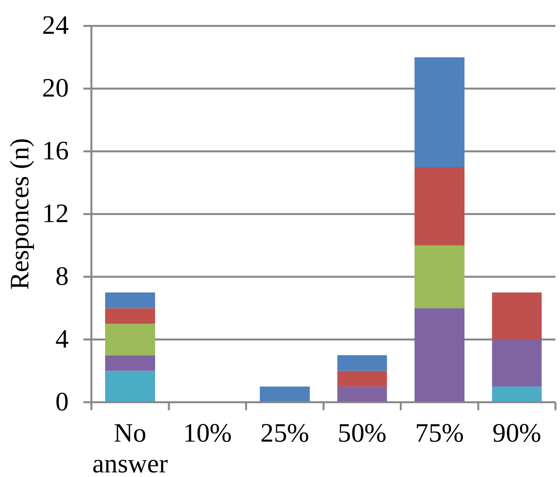


Figure 4 (Q5a) - What is an acceptable probability that Atlantic herring SSB becomes overfished (i.e., falls below half of SSB at MSY; 35 respondents)?

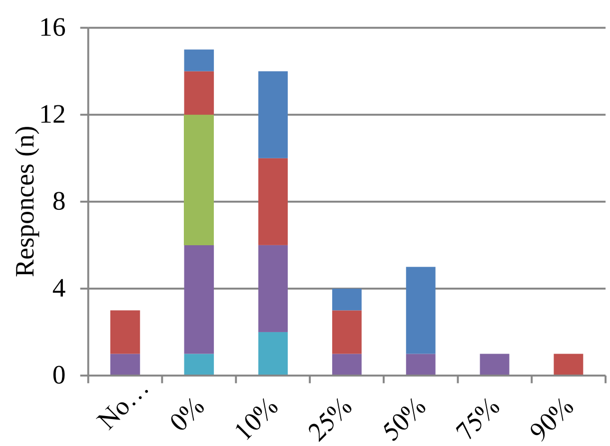


Figure 5 (Q5b) - What is an acceptable probability that Atlantic herring SSB is below 30% unfished SSB (29 respondents)?

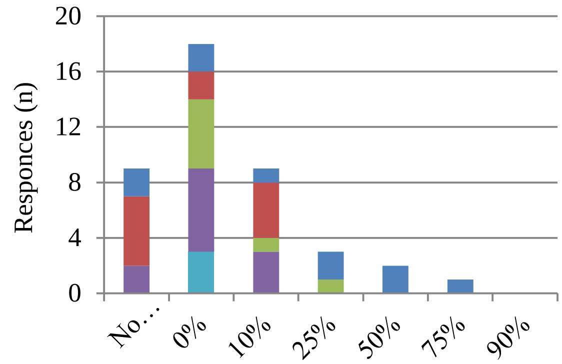


Figure 6 (Q5c) - What is an acceptable probability that Atlantic herring SSB is below 75% unfished SSB (28 respondents)?

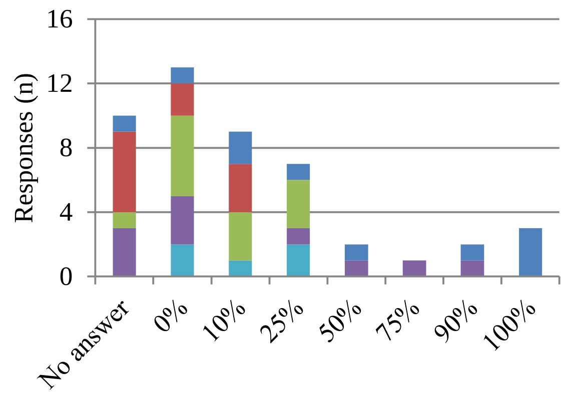


Figure 7 (Q6) - What is an acceptable probability that Atlantic herring overfishing occurs (i.e., Atlantic herring fishing mortality exceeds the fishing mortality rate (F) at MSY; 37 respondents)?

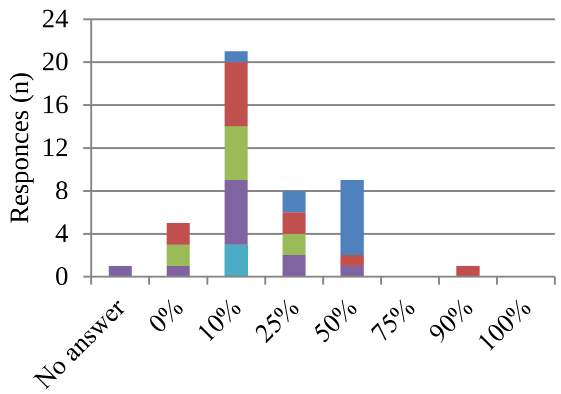


Figure 8 (Q7) - What is an acceptable probability that the Atlantic herring fishery must close (i.e., have ABC = 0; 33 respondents)?

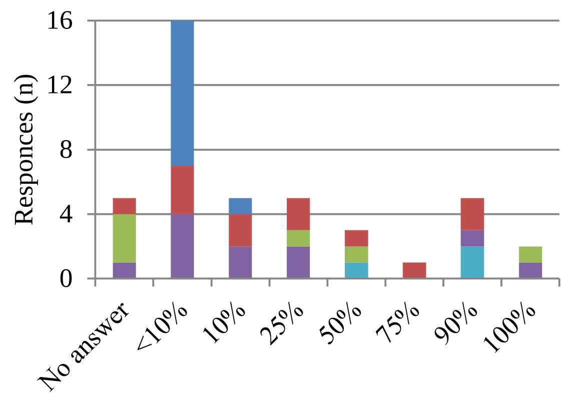


Figure 9 (Q8) - What is an acceptable probability that bluefin tuna average weight is at or above long term average (32 respondents)?

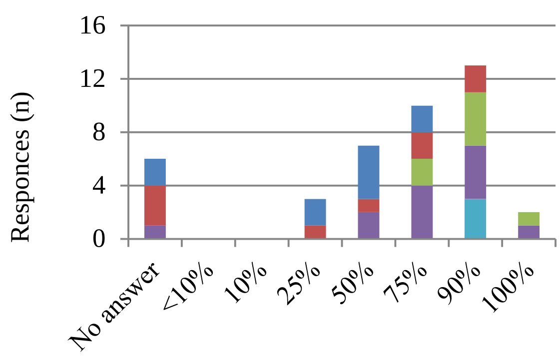


Figure 10 (Q9) - What is an acceptable probability that Common tern population (nesting pairs) is at or above current population size (27 respondents)?

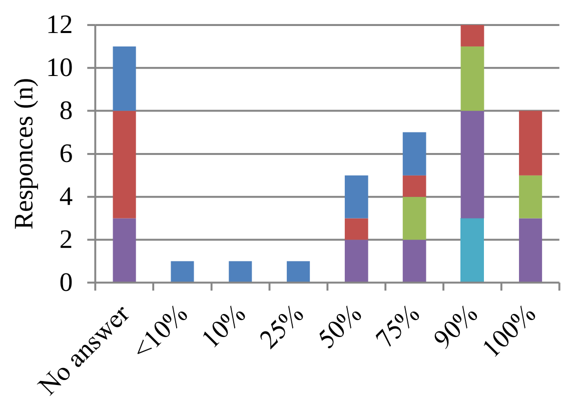


Figure 11 (Q10) - What is an acceptable probability that Common tern productivity is at or above the target of 1.0 fledglings/nesting pair (27 respondents)?

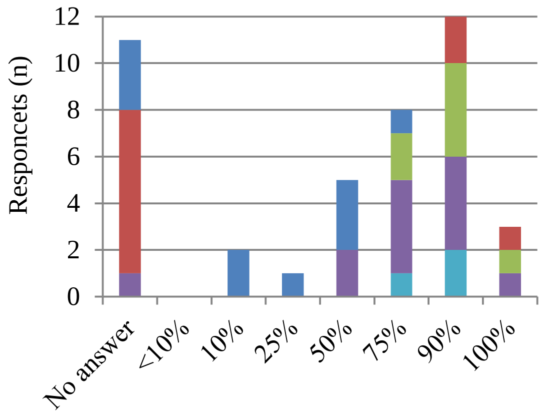


Figure 12 (Q11) - What is an acceptable probability that Common tern productivity is at or above the threshold of 0.80 fledglings/nesting pair (25 respondents)?

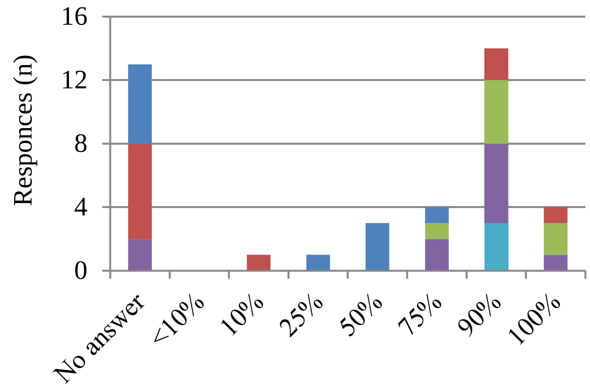
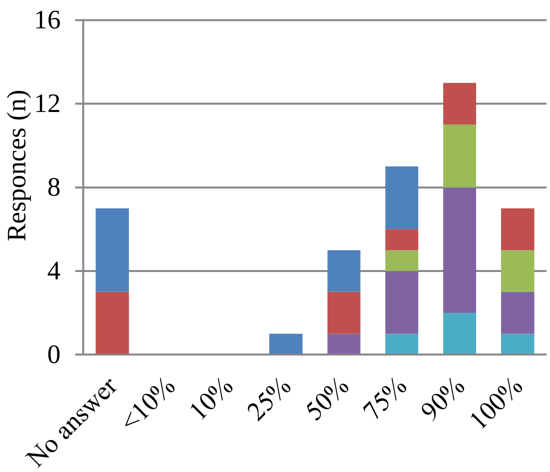


Figure 13 (Q12) - What is an acceptable probability that groundfish biomass is at or above the overfished threshold (i.e., is above half of SSB at MSY; 31 respondents)?



PRESENTATIONS – REFINE CONTROL RULES AND MSE

Introduction to tradeoffs

On Day 2, Dr. Deroba explained how narrowing the range of control rules involves a balance of tradeoffs, that to gain more of metric A, some of metric B needs to be given up. He introduced the topic by using the analogy of selecting airline tickets, which involves balancing criteria such as travel duration, cost, and arrival and departure times.

Meeting the range of performance identified

Dr. Deroba and Dr. Gaichas explained how the participant input from the first day can be used to narrow the range of alternatives, showing x-y plots of control rule performance relative to the performance metrics (e.g., yield vs. stability in yield). For example, most respondents (to the written handout) would like to have the year-to-year change in Atlantic herring yield be 10% or less (Figure 2). However, it may not be possible to achieve low variation in yield and high yield relative to MSY simultaneously. Participants were then asked to provide additional input on tradeoffs such as this.

Robustness to operating models

Dr. Deroba presented some results that compare the performance of operating models, particularly the effects whether an assessment is biased. When the assessment is biased (thinking there is more fish than there actually is), there is more herring yield attained than is sustainable, so the population abundance lowers (e.g., greater probability of the stock becoming overfished). For the dogfish models, outcomes were more sensitive to herring production than whether the assessment is biased.

PARTICIPANT INPUT - REFINE CONTROL RULES

Within three small groups of diverse stakeholders (people were sorted into different groups from those of the first day), participants were asked to discuss the performance of control rules relative to the metrics and the tradeoffs that may be necessary to balance. Participants were given a handout with several x-y plots of control rule performance relative to the performance metrics (the same plots that had been presented). On the handout, participants were asked to identify their stakeholder type and whether they are a Council member. Participants were given time to indicate their personal preferences on the handout, and then the small groups had a discussion of each plot to identify the range of individual responses, ask questions, and understand the rationale of others. Participants could revise their individual responses before submitting them to the facilitators.

Over the lunch break, the facilitators, workshop staff, and technical experts briefly collated the participant input to identify themes. Dr. Irwin then presented a summary of the input to the large group and facilitated a discussion to confirm the key points and solicit additional input. What follows is a more thorough compilation, completed subsequent to the workshop. The themes from the written input of 31 participants and the oral discussions of the entire body of workshop participants are summarized here. In this case, the written input of the two Council member respondents are not removed, because 14 (45%) of respondents did not indicate whether they are a Council member and the responses of the two are within the range of other responses.

Table 4 - Demographics of written commenters of the Day 2 small group discussions

Stakeholder Type		**Council member?**	
Herring fishery (all gear types, industry reps)	5 (16%)	Yes	2 (6%)
Other fishery (lobster, tuna, groundfish)	1 (3%)	No	15 (48%)
Environmental NGO	8 (26%)	Not specified	14 (45%)
University	3 (10%)		
Not specified	14 (45%)		
Total	**31 (100%)**		

Tradeoffs

It was particularly challenging for the workshop participants, in small groups or plenary, to identify their individual preferences for how to balance tradeoffs. Thus, the groups were not able to discuss in detail what the individuals would be willing to give up specifically – or come to a group consensus. Generally, preferences for individual performance metrics were consistent with the input provided on the first day.

Control Rules

Despite differences of opinion in the appropriate range of control rule performance for specific metrics, there was broad agreement about the six general types of control rules:

1. Biomass based, with setting catch every year

There was substantial support for this approach, as it would be responsive to the latest information on environmental and fishery conditions, though it was acknowledged that having a full stock assessment for Atlantic herring on an annual basis is unlikely. Participants questioned if the Council and NMFS had the resources to develop and implement specifications each year. Alternatively, if the current three-year specifications process could incorporate annual information (or projections), that might be the preferable approach.

2. Biomass based, with setting a constant catch every three years

It was generally agreed that this may be the best general approach, as it seems to provide the best performance across a variety of metrics (e.g., most stability, most yield). Participants also thought this approach would be the most feasible, due to logistical concerns about setting specifications every year or every five years.

3. Biomass based, with setting a constant catch every five years

Though a biomass-based approach was generally preferable over constant catch, there was concern that this approach did not perform well across multiple performance metrics. It was considered that five years was too long to go between responding to information updates (i.e., too risky).

4. Biomass based, with setting a constant catch every three years and restricting subsequent changes in catch to within 15%

Though a biomass-based approach was generally preferable over constant catch, there was concern that this approach did not perform well across multiple performance metrics. It was considered that only being able to adjust catch levels by 15% may not be sufficiently responsive to changes in the ecosystem (i.e., too risky).

5. Constant catch

There was concern that this approach did not perform well across multiple performance metrics. It was considered that having to maintain a certain catch level may not be sufficiently responsive to changes in the ecosystem (i.e., too risky).

6. Conditional constant catch, with a maximum fishing mortality rate set at half of the rate at maximum sustainable yield ($F = 0.5F_{MSY}$).

There was concern that this approach did not perform well across multiple performance metrics. It was considered that having to maintain a certain catch level set at half of the rate at MSY may not be sufficiently responsive to changes in the ecosystem (i.e., too risky).

PARTICIPANT INPUT - IDEAS FOR ADDITIONAL MSE WORK

Several ideas were raised throughout the workshop, orally and in writing, for additional work that could be done before the MSE is completed. These ideas are sorted here by those that may or may not be possible to complete within this iteration of the MSE (over the next few months), as noted at the workshop. However, as MSEs are intended to be iterative, ideas beyond the scope of what is currently possible are included here, to help inform improvements in data and technical capacities. These ideas should not necessarily be viewed as the consensus of workshop participants.

Ideas to potentially include in the current MSE

Atlantic Herring

- Provide plots that overlap the results of the "high" and "low" herring production models to identify how specific control rules would perform under both scenarios.
- Evaluate the variability of SSB as a performance metric, expressed as probability of falling below a specified biomass threshold (e.g., 40% of SSB).
- Evaluate, as a performance metric, the probability that the herring biomass falls below 75% of B_0.
- Evaluate, as a performance metric, how often a control rule enters an overfished situation. The simulations assume the control rule is followed even when the stock is overfished, but under current law, when a stock is overfished, a F_{target} is required that will rebuild the stock within a specific time period – so the control rule must change under that scenario. For this reason, actual performance will not be as reflected by the MSE results.
- The results have been presented by control rule type. Could the results also be presented by which control rules have their F_{target} at F_{MSY} or $0.75F_{MSY}$, or relative to variable reference points for forage species?
- To help evaluate risk, develop additional plots such as the frequency that biomass is >75% of SSB and <40% of B_0 for all predators. This would help understand the effects of not allowing fishing when SSB is <40% of B_0.
- Clearly identify any control rules that could result in illegal scenarios (e.g., consistently resulted in overfished conditions).
- Clarify that the most aggressive control rule analyzed had F at F_{MSY}, implying a 50% probability of overfishing all the time.
- Index results to the maximum productive age of herring, rather than just herring SSB. Check the percentage of the SSB that is at its maximum productive age and lipid content.

- Show the relationship between B_{MSY} and B_0 (over the range 0 to 4 x B_{MSY}) for both productivity models.
- Clarify the likelihood that a bias exists with an accepted/peer reviewed stock assessment.
- Add a time series of the historical biomass of herring and the performance of the models in the forecasting, future states of nature relative to the history. What do the catches look like under a B_0 or B_{MSY} estimate? What do the models look like?
- Identify MSY on the plots.

Predators

- Plot the likelihood that predators would fall below 75% of SSB or B_0.

Economics

- Evaluate a best and worst case scenario for costs, rather than use one year of cost data (here, 2015). Perhaps use years of particularly high and low costs to bound the range of results.
- Include examining near-term economic impacts.
- Add more economic metrics, such as real impacts on quota and impacts on the lobster and recreational fisheries.

General

- Results should include some measure of near-term performance. In many cases, the transition period may be dramatic and should be included in tradeoff analysis.
- Later in the process, when there are fewer control rule alternatives, show how individual control rules function for multiple metrics and operating models.

<u>Ideas to potentially include in the future</u>

Atlantic herring

- Create a herring model that is dynamic between high and low production over the time series. Simulate control rule performance with it.
- Simulate control rules purposely using the wrong values for reference points, perhaps using the perfect information (as current), but with values from wrong operating models. This may preclude a need to model bias/error in F or B_{MSY} reference points.
- Evaluate sliding shaped (convex or concave) control rules.

Predators

- Develop a model specific for marine mammals to use in future MSEs.
- Evaluate seabird performance metrics that are less confounded by non-herring related issues (e.g., not as influenced by predation, weather, etc.). For example, growth rate is more directly linked to herring consumption and some limited data exist.
- Evaluate the impacts on other seabirds besides the common tern.

Spatial Scales

- Develop a control rule that takes into account ecosystem needs at finer scales than the Atlantic herring stock area (Gulf of Maine to Cape Hatteras, North Carolina).
- Create two separate SSB metrics, one for Area 1A and one for Areas 1B, 2 and 3.

The workshop facilitator, technical experts, Council members and staff reiterated what was explained at the first workshop, that, while there would be value in incorporating finer scale spatial aspects to the simulations, the models are not sufficiently developed to do so during the current iteration of the MSE (i.e., with simulation testing scheduled to wrap up within the next few months). However, the Northeast Fisheries Science Center is actively working to improve modeling capacity. While input was welcomed on how the data and models may be improved, the workshop was primarily focused on developing input to shape the current MSE. Additionally, the Council has opted, thus far, to focus Amendment 8 on developing ABC control rules; the Council would need to expand this action to consider sub-ACL control rules, or could do so through a future action. Finally, the Council is currently addressing localized depletion concerns by developing other management alternatives (e.g., time/area closures) in Amendment 8. Participants were encouraged to attend the upcoming Herring Committee meeting that will focus on localized depletion, likely in February 2017.

Participant Input - Ideas for Future Research

Several ideas for future research were raised throughout the workshop and are included in Table 5, which notes those that are currently included in the Council's draft *Research Priorities and Data Needs for 2017-2021*.

Table 5 - Ideas for future research

Atlantic Herring
Monitor lipid content; this could inform gamete health.
Identify the timing and location of offshore spawning.
Better define stock components.*
Understand drivers of growth rates to determine why growth is relatively low currently. Is the rate density dependent? Are there insufficient food sources?
Understand the effects of changing water temperature on herring growth/survival.*
Predators
Develop more systematic marine mammal population data collection systems.
Create a marine mammal population model that is informed by data and could be useful in future MSE work. The three main marine mammal predators of interest are humpback and minke whales and gray seals.
Improve consumption data overall, to not only understand diet composition but the importance of specific prey to predator diets.*
Ecosystem
Understand the structural dynamics of the forage base (herring and others) to help identify herring's role in maintaining the resilience of the forage base (e.g., sustain energy transfer through the system).*
Understand the role of menhaden in the ecosystem.*
* Currently included on the Council's draft *Research Priorities and Data Needs for 2017-2021*.

Workshop Evaluation

Workshop attendees were asked to fill out an evaluation form. To date, 19 forms have been received. Table 6 includes responses to the ten closed-ended questions. On a scale of one to five, with one being "strongly disagree" and five being "strongly agree," the respondents, on average, generally agreed that they were well-informed about the workshop, had sufficient background materials, and that the presenters and facilitators were well prepared and clear. They also agreed that there was sufficient opportunity for input and that a workshop is an effective forum to give input in the Council process. The lowest responses were between "neutral" and "agree" to the questions of whether the workshop's goals were met and whether it lived up to expectations. The highest response, between "agree" to "strongly agree" was that that there was sufficient opportunity for input. These responses are similar to the evaluation of the first workshop.

Table 6 - Workshop evaluation questions

Question	Average Response
1. I was well-informed about the workshop and its goals/objectives.	3.9
2. The background material provided was sufficient to feel prepared for the workshop.	3.8
3. The facilitators and presenters were well-prepared.	4.2
4. The presentations were clear and made technical information understandable.	4.1
5. I had sufficient opportunity to provide input.	4.5
6. The workshop's goals/objectives have been accomplished.	3.2
7. The workshop lived up to my expectations.	3.4
8. In general, a workshop is an effective forum to give input in the Council process.	4.1
9. The workshop helped me learn what is/isn't well understood about herring in the ecosystem.	3.7
10. I have a better appreciation for the tradeoffs that need to be made when managing the herring resource and how uncertainty influences the management options.	3.7
Response codes: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree	

Next Steps after Workshop

Workshop outcomes are being reviewed by the Herring Plan Development Team, Herring Advisory Panel, Herring Committee, and Council. After the MSE is complete, the final report will be peer reviewed. It is expected that the workshop outcomes and MSE report 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.

References

Golet WJ, Record NR, Lehuta S, Lutcavage ME, Galuardi B, Cooper AB & Pershing AJ. (2015). The paradox of the pelagics: why bluefin tuna can go hungry in a sea of plenty. *Marine Ecology Progress Series. 527*: 181-192.

NEFMC. (2016). *Framework Adjustment 55 to the Northeast Multispecies Fishery Management Plan*. Newburyport, MA: New England Fishery Management Council in consultation with the National Marine Fisheries Service. 396 p.

APPENDIX I - WORKSHOP AGENDA

Wednesday December 7, Day 1	
8:00 AM	**Doors open**
9:00	**Opening remarks** • Council Chairman's welcome – *John Quinn* • Presentation: MSE introduction – *Brian Irwin* • Presentation: MSE process overview – *Rachel Feeney* • Setting the workshop's stage – *Brian Irwin*
9:25	**MSE methods Session 1 – explaining models** • Presentation: Herring operating models and control rules – *Jon Deroba* • Presentation: Predator models – *Sarah Gaichas* *(with time to answer clarifying questions and identify discussion questions)*
10:30	**Break**
10:50	**MSE methods Session 2 – understanding models** • Large group discussion of identified questions – *Brian Irwin*
11:20	**MSE methods Session 3 – explaining and understanding output metrics** • Presentation: Herring output metrics – *Jon Deroba* • Presentation: Economic output metrics – *Min-Yang Lee* *(with time to answer clarifying questions, open discussion at end)*
12:00 PM	**Lunch** *(facilitators/staff consolidate discussion topics)*
1:00	**MSE results - using metrics and models to generate a range of performance** • Presentation: Herring metrics and models – *Jon Deroba* • Presentation: Predator output metrics – *Sarah Gaichas* *(with time to answer clarifying questions, open discussion at end)* • Charge to small groups – *Brian Irwin*
3:00	**Break**
3:10	**Small group discussions - refine range of acceptable performance**
4:30	**Closing remarks** • Recap Day 1; overnight tasks; Day 2 goals – *Brian Irwin*
4:40	**Adjourn** *(facilitators/staff consolidate discussion outcomes; analysts conduct additional work)*

Thursday December 8, Day 2	
8:30 AM	**Doors open**
9:00	**Opening remarks** • Review Day 1; charge for Day 2 – *Brian Irwin*
9:15	**Report out from Day 1 small group discussions** • One consolidated summary – *Brian Irwin*
9:30	**Refine control rules Session 1 – exploring the possibilities** • Presentation: Introduction to tradeoffs – *Jon Deroba* • Presentation: Meeting the range of performance identified – *Jon Deroba* *(with time to answer clarifying questions, open discussion at end)* • Charge to small groups – *Brian Irwin*
11:00	**Break**
11:10	**Refine control rules Session 2 - small group discussions**
12:30 PM	**Lunch** *(facilitators/staff consolidate discussion outcomes)*
2:00	**Refine control rules Session 3 – finalizing workshop input** • Small groups report out, one consolidated summary – *Brian Irwin*
2:45	**Refining the Atlantic herring MSE** • Large group discussion – *Brian Irwin* o MSE process to ensure understanding o Additional input before the MSE is finished o Ideas for research that may improve future MSEs or reduce uncertainty • Presentation: Revisit robustness to operating models – *Jon Deroba*
3:45	**Closing remarks** • Additional work – *Jon Deroba* o Confirm ideas for any additional work before finishing the MSE o Identify what could be accomplished within the next few days/weeks • Review timeline/next steps – *Rachel Feeney* • Recap workshop/conclude – *Brian Irwin*
4:15	**Adjourn** *(turn in evaluation forms)*

Appendix II - Workshop Attendees

Primary Facilitator
Brian Irwin

Small-Group Facilitators
Madeleine Hall-Arber
Jessica Joyce
Laura Singer

Steering Committee
Deirdre Boelke (PDT)
Jon Deroba (PDT)
Rachel Feeney (PDT)
Sarah Gaichas
Mark Gibson (Council)
Peter Kendall (Council)
Carrie Nordeen (PDT)

Staff Assistants
Andy Applegate
Chris Kellogg
Tom Nies

Other Council
Vincent Balzano
Doug Grout
Peter Hughes
Matthew McKenzie
Cate O'Keefe
John Pappalardo
John Quinn
Terry Stockwell

Herring Advisory Panel
John-Paul Bilodeau
Doug Feeney
Richard Huntley
Zach Klyver
Meghan Lapp
Brendan Mitchell
Peter Moore
Gerry O'Neill
James Rhule
Don Swanson
Chris Weiner

Other Herring PDT
Tim Cardiasmenos
Matthew Cieri
Micah Dean
Marianne Ferguson
Min-Yang Lee
Renee Zobel

Other Attendees
Karen Alexander
Irit Altman
Ashleen Benson
Martha Brewer
Mike Brewer
Michael Blanchard
Morgan Callahan
William Chaprales
Kaycee Coleman
Elizabeth Craig
Gavin Fay
Don Frei
Erica Fuller
Shaun Gehan
Walt Golet
Pam Lyons Gromen
Bill Harford
Ben Haskell
Megan Herzog
Jeff Kaelin
Lisa Kerr
Aaron Kornbluth
Bill Leavenworth
Ben Martens
Patrice McCarron
Peter Murphy
Patrick Paquette
Ralph Pratt
Ryan Raber
Alison Rieser
Larry Rich
Glenn Robbins
Shaun Rocket
Joe Roman
Rich Ruais
Susan Schubel
Paula Shannon
Peter Shelly
Micah Tower
Tim Tower
Emily Tucker
Linda Welch
Gregg Wells
Ritchie White

APPENDIX III – MATERIALS PROVIDED IN ADVANCE

The following materials were provided to the public in advance of the workshop, available on the Council's website (www.nefmc.org)

1. Cover memo with charge to attendees (Tom Nies)
2. Agenda
3. Workshop overview
4. Presentation slides
    A. MSE introduction (Brian Irwin)
    B. MSE process overview (Rachel Feeney)
    C. Herring operating models and control rules (Jon Deroba)
    D. Predator models (Sarah Gaichas)
    E. Herring output metrics (Jon Deroba)
    F. Economic output metrics (Min-Yang Lee)
    G. Herring metrics and models (Deroba)
    H. Predator output metrics (Gaichas)
    I. Introduction to tradeoffs (Deroba)
5. Workshop background
6. Final report from the May 2016 public workshop on the Atlantic herring MSE
7. Recommendations for the MSE, as approved by the Council in June 2016.
8. NEFMC Risk Policy
9. Punt AE (2015). Strategic management decision-making in a complex world: quantifying, understanding, and using trade-offs. *ICES Journal of Marine Science. published online November 13, 2015*: 12.

APPENDIX III - GLOSSARY

Acceptable Biological Catch (ABC). The maximum catch that is recommended for harvest, consistent with meeting the biological objectives of the management plan. The MSA interpretation of ABC includes consideration of biological uncertainty (stock structure, stock mixing, other biological/ecological issues), and recommendations for ABC should come from the NEFMC SSC. ABC can equal but never exceed the OFL.

OFL – Scientific Uncertainty = ABC (Determined by SSC)

ABC Control Rule. The specified approach to setting the ABC for a stock or stock complex as a function of scientific uncertainty in the estimate of OFL and any other scientific uncertainty. The ABC control rule will consider uncertainty in factors such as stock assessment issues, retrospective patterns, predator-prey issues, and projection results. The ABC control rule will be specified and may be modified based on guidance from the SSC during the specifications process. Modifications to the ABC control rule can be implemented through specifications or framework adjustments to the Herring FMP (in addition to future amendments), as appropriate.

Age Frequency or Age Structure. A breakdown of the different age groups of a kind of fish in a population or sample.

Annual Catch Limit (ACL). A stockwide ACL accounts for both scientific uncertainty (through the specification of ABC) and management uncertainty (through the specification of the stockwide ACL and buffer between ABC and the ACL). The ACL is the annual catch level specified such that the risk of exceeding the ABC is consistent with the management program. The ACL can equal but never exceed the ABC. ACL should be set lower than the ABC as necessary due to uncertainty over the effectiveness of management measures. The stockwide Atlantic herring ACL equates to the U.S. optimum yield (OY) for the Atlantic herring fishery and serves as the level of catch that determines whether accountability measures (AMs) become effective. The AM for the stockwide ACL, total fishery closure at 95%, reduces the risk of overfishing.

ABC – Management Uncertainty = Stockwide ACL = OY

Fishing mortality (F). A measurement of the rate of removal of fish from a population caused by fishing. This is usually expressed as an instantaneous rate (F) and is the rate at which fish are harvested at any given point in a year. Instantaneous fishing mortality rates can be either fully recruited or biomass weighted. Fishing mortality can also be expressed as an exploitation rate or less commonly, as a conditional rate of fishing mortality (m, fraction of fish removed during the year if no other competing sources of mortality occurred. Lower case m should not be confused with upper case M, the instantaneous rate of natural mortality).

F_{MSY}. a fishing mortality rate that would produce MSY when the stock biomass is sufficient for producing MSY on a continuing basis.

Maximum Sustainable Yield (MSY). The largest average catch that can be taken continuously (sustained) from a stock under average environmental conditions.

Natural mortality (N). A measurement of the rate of death from all causes other than fishing such as predation, disease, starvation, and pollution. Commonly expressed as an instantaneous rate (M). The rate of natural mortality varies from species to species, but is assumed to be M=0.2 for the five critical stocks. The natural mortality rate can also be expressed as a conditional rate (termed n and not additive with competing sources of mortality such as fishing) or as annual expectation of natural death (termed v and additive with other annual expectations of death).

Optimum Yield (OY). the amount of fish which A) will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and C) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery.

Overfished. A conditioned defined when stock biomass is below the minimum biomass threshold and the probability of successful spawning production is low.

Overfishing. A level or rate of fishing mortality that jeopardizes the long-term capacity of a stock or stock complex to produce MSY on a continuing basis.

Overfishing Limit (OFL). The catch that results from applying the maximum fishing mortality threshold to a current or projected estimate of stock size. When the stock is not overfished and overfishing is not occurring, this is usually F_{MSY} or its proxy.

$$\mathbf{OFL \geq ABC \geq ACL}$$

Spawning Stock Biomass (SSB). The total weight of fish in a stock that sexually mature, i.e., are old enough to reproduce.

Stock. A grouping of fish usually based on genetic relationship, geographic distribution and movement patterns. A region may have more than one stock of a species (for example, Gulf of Maine cod and Georges Bank cod). A species, subspecies, geographical grouping, or other category of fish capable of management as a unit.

Stock assessment. Determining the number (abundance/biomass) and status (life-history characteristics, including age distribution, natural mortality rate, age at maturity, fecundity as a function of age) of individuals in a stock

Total mortality (Z). The rate of mortality from all sources (fishing, natural, pollution) Total mortality can be expressed as an instantaneous rate (called Z and equal to F + M) or Annual rate (called A and calculated as the ratio of total deaths in a year divided by number alive at the beginning of the year)

APPENDIX IV - ACRONYMS

ABC	Acceptable Biological Catch
ACL	Annual Catch Limit
AM	Accountability Measure
B_{MSY}	Biomass at Maximum Sustainable Yield
B_0	unfished Biomass
FMP	Fishery Management Plan
F_{MSY}	Fishing mortality rate at Maximum Sustainable Yield
GARFO	Greater Atlantic Regional Fisheries Office
GOM	Gulf of Maine
MSE	Management Strategy Evaluation
MSFMCA	Magnuson-Stevens Fishery Conservation and Management Act
NEFOP	Northeast Fisheries Observer Program
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
OFL	Overfishing Limit
OY	Optimum Yield
PDT	Plan Development Team
SSB_0	unfished Spawning Stock Biomass
SSC	Scientific and Statistical Committee