Report from the
RISK POLICY WORKING GROUP

Risk Policy Road Map

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1.0 INTRODUCTION

The ***Risk Policy Working Group*** (RPWG) was originally formed by the New England Fishery Management Council as the *ABC Control Rule Working Grou*p, but the name change to *Risk Policy Working Group* more accurately reflects the working group's tasking, i.e., to assist the Council with developing a risk policy, which addresses risk and uncertainty across all levels of fisheries management, not just in the ABC Control Rule. The RPWG met several times during 2013, 2014, and 2015, to develop a Risk Policy (approved by the Council in November 2014) and discuss the steps necessary to implement/operationalize the Risk Policy in all Council-managed FMPs. This document serves as the RPWG's Road Map and includes the RPWG's recommendations for next steps to implement the Council's Risk Policy Statement.

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Acronyms

ABC	Acceptable Biological Catch
ACL	Annual Catch Limit
ACT	Annual Catch Target
AM	Accountability Measure
HCR	Harvest Control Rule
OY	Optimum Yield
RPWG	Risk Policy Working Group

2.0 RISK POLICY STATEMENT

The ***Risk Policy Statement*** is a high-level, broad articulation of the Council's general policy with respect to risk and uncertainty for setting ABCs, ACLs, and other management measures. It complements ABC control rules and ACL-setting by articulating the bounds of how risk tolerant or risk averse a Council's management approach is, given certain criteria. The Risk Policy is intended to inform and work in conjunction with a Council's application of an ABC control rule (CR) and a harvest control rule (HCR) in each FMP. Though informed by scientific advice from the SSC, the Council's risk tolerance is ultimately a policy decision, which is articulated in the Council's *Risk Policy Statement*. The elements of the Risk Policy Statement can be applied through the ABC CRs, HCRs, and management procedures for individual stocks in each FMP.

The three purposes identified in the Risk Policy Statement affirm the Council's intent to address risk and uncertainty across ***all aspects of fisheries management*** by articulating a risk policy not only just for those entities involved in specifying ABC and related harvest levels (i.e., the Council and its subordinate bodies), but also for NOAA Fisheries (NMFS) in cases when it may implement in-season management measures/adjustments (as authorized) or when conducting rule-making independently from the Council, and for the Northeast Fisheries Science Center when performing analyses for Council-managed stocks in the future. The four strategic approaches in the Risk Policy Statement articulate the policy to which the Council's harvest control rules and ABC control rules should adhere.

At its November 2014 meeting, the Council formally adopted the Risk Policy Statement provided below (shaded text).

NEFMC RISK POLICY

Recognizing that all fishery management is based on uncertain information and that all implementation is imperfect, it is the policy of the New England Fishery Management Council (Council) to weigh the risk of overfishing relative to the greatest expected overall net benefits to the Nation.

The purpose of the New England Fishery Management Council's Risk Policy is to:

1. Provide guidance to the Council and its subordinate bodies on taking account of risk and uncertainty in Fishery Management Plans and specification-setting;
2. Communicate the priorities and preferences of the Council regarding risk and uncertainty to NOAA Fisheries; and
3. Make fishery management more transparent, understandable, and predictable while better achieving FMP objectives in the face of uncertain information and imperfect implementation.

This risk policy will be supported by the following strategic approaches:

1. The Council's risk policy will take account of both the probability of an undesirable outcome and the negative impact of the outcome. The probability of outcomes that have a long-term negative impact on ecosystem function should be low.
2. The cumulative effects of addressing risk at all levels of the fishery management process (e.g., estimation of OFL, ABC, ACL, ACT, and setting accountability measures) will be taken into account.
3. Harvest control rules and management procedures will consider stability in the face of uncertain information and inherent variability in ecosystems.
4. Implementation of the policy will be analysis-based, using methods commensurate with the importance of short and long-term tradeoffs between conservation, ecosystem roles, and social and economic benefits. The analysis should evaluate harvest control rules and management procedures with a view towards extracting signal from noise so that management and fisheries are less sensitive to uncertainty. This should allow for a dynamic process of implementation and review, and modification when warranted.

Discussion

The Council's Risk Policy Statement provides a foundation for more explicit risk-based decision making by identifying social, economic, and ecological objectives that the Council should aim to achieve in all FMPs:

Evaluation of management decisions should consider the probability of an outcome as well as its severity. There may be flexibility to allow for short-term tradeoffs, but the risk of long-term or chronic overfishing should be low.

The risk of overfishing and impacting overall net benefits to the Nation are determined by the cumulative impacts of decisions that range from assessment modelling to estimating reference points, developing ABC control rules, specifying ACLs, ACTs, and all other elements of the management procedure. Focusing a risk-based decision for any one of these elements of the management procedure in isolation is inadequate to address the objectives of the Risk Policy. Net benefits to nation are further discussed with respect to the Risk Policy Statement in Section 2.1.

Stability is intended to avoid abrupt shifts in fisheries management, to the extent possible, to provide for more stable stocks and more stable fisheries. Standards for performance measures for stability should be determined on a case-by-case basis. The concept of stability, as it applies to the Council's Risk Policy, is further discussed in Section 2.2.

Analysis of management procedures should account for the complex nature of the system and include both positive and negative feedbacks. This can be addressed through management strategy evaluation or other similar analytical approaches that allow for tradeoffs to be evaluated with respect to the risk of overfishing and net benefits to the Nation. Analytical models should include several performance measures with respect to conservation, and, to the extent possible, economic and social performance indicators. Evaluation of management procedures is further discussed in Section 2.3.

2.1 NET BENEFITS TO THE NATION

The Council (with technical support from the PDT and input from the Committee/Advisory Panel) should identify the factors that affect net benefits to the Nation for each stock/fishery, taking account of the impacts on benefits from other stocks and fisheries. Fishing activity frequently interacts with multiple stocks/fisheries. Decision making should consider the full extent of impacts on the fishery in question and others affected by that decision, in order to maximize the net benefits to the Nation. Risks to these factors should also be identified and measured to the extent possible. When making management decisions, the risk of overfishing the resource should be evaluated against the tradeoffs affecting the total net benefits to the Nation from all fisheries in the region.

Fishery benefits are inclusive of the social, economic, and cultural benefits that rely on productive fish stocks. Furthermore, sustaining benefits to the Nation – including food, jobs, recreation, and intrinsic values – is dependent on productive marine ecosystems. **Net benefits to the Nation should be interpreted broadly and inclusive of benefits derived from not only the target species/fishery in question, but also from the bycatch species, habitat, the ecosystem, and other benefits that may accrue from managing fisheries.** This broad interpretation is consistent with the MSA discussion of *optimum yield and overall benefit to the Nation*:

Optimum yield is defined in the MSA as *the amount of fish which 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; that is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and, in the case of an overfished fishery, that provides for rebuilding to a level consistent with producing the MSY in such fishery.* Given this the focus of optimum yield is not only on an amount of fish that is caught, but also how those fish are utilized and how they are caught. Additionally, the optimum yield reinforces the need to consider the long-term sustainability of the marine ecosystems. Therefore, if outcomes are evaluated by yield only, then the "greatest overall benefits" to the Nation may not have been fully considered.

The factors that need to be taken into account in determining the greatest benefit to the Nation are addressed in more detail in several of the MSA's ten National Standards. The guidelines to *National Standard 1* state that:

Determining the greatest benefit to the Nation. In determining the greatest benefit to the Nation, the values that should be weighed and receive serious attention when considering the economic, social, or ecological factors used in reducing MSY to obtain OY are:

(A) The benefits of food production are derived from providing seafood to consumers; maintaining an economically viable fishery together with its attendant contributions to the national, regional, and local economies; and utilizing the capacity of the Nation's fishery resources to meet nutritional needs.
(B) The benefits of recreational opportunities reflect the quality of both the recreational fishing experience and non-consumptive fishery uses such as ecotourism, fish watching, and recreational diving. Benefits also include the contribution of recreational fishing to the national, regional, and local economies and food supplies.

(C) The benefits of protection afforded to marine ecosystems are those resulting from maintaining viable populations (including those of unexploited species), maintaining adequate forage for all components of the ecosystem, maintaining evolutionary and ecological processes (e.g., disturbance regimes, hydrological processes, nutrient cycles), maintaining the evolutionary potential of species and ecosystems, and accommodating human use.

Further guidance on net benefits to the Nation is provided in National Standards 8 and 9 and Executive Order 12866.

2.2 STABILITY

Stability in the Risk Policy Statement refers explicitly to *stability within the management system*, i.e., the ability to tailor the management system to respond to real change versus noise/variability. Consideration of stability in fisheries management involves evaluating the trade-offs of minimizing variability while achieving the greatest overall net benefits to the Nation.[1]

The RPWG acknowledges that stability may be defined in other ways depending on context. For example, stability within stocks is concerned with the extent of variation in stock biomass. Stability within fisheries is concerned with the minimization of variation in the management system, e.g. annual catch specifications for the fishery. Both types of stability can also serve as important metrics to evaluate the long-term performance of management procedures against the Risk Policy and may be identified as a goal/objective for an individual FMP. These metrics can be identified, measured, and tracked over time on a stock/fishery basis.

The concept of stability as it applies to the Risk Policy Statement (in the management system) is aimed at extracting signal from noise (or minimizing impacts from errors). The RPWG acknowledges that ecosystems are inherently dynamic and are never expected to be stable. The inherent variability in the system is likely due, in part, to measurement error. While accepting this inherent variability, promoting stability will avoid abrupt shifts in fisheries management, which may ultimately provide for more stable stocks and more stable fisheries. By avoiding abrupt shifts in fisheries management, damage caused by errors/variability can be reduced, as the system should be able to absorb a normal amount of random variability.

The strategic approach proposed in the Risk Policy Statement states that harvest control rules and management procedures will consider stability in the face of uncertain information and variability within fisheries systems. As the Risk Policy is applied, stability should be achieved as management procedures (HCRs, ABC CRs, and other measures) can be structured to become less sensitive and less reactive to changes that may be due to natural variability and estimation error.

PDTs can provide guidance on an acceptable level of fluctuation for individual stocks/fisheries that would be expected for a well-managed fishery given the inherent variability (based on

[1] Proposed changes to the National Standard Guidelines support the concept and use of stability in fisheries management (http://www.fisheries.noaa.gov/sfa/laws_policies/national_standards/index.html).

population dynamics for the stock and the fishery objectives). This could be used to evaluate performance of future actions. Metrics that monitor variability from year to year, e.g. in quotas, should be developed.

There are several regional examples to illustrate how the management system can consider stability in the face of uncertain information.

1. The MAFMC SSC recently recommended specifications that considered stability in the summer flounder fishery. Quota reductions were spread over multiple years to mitigate economic impacts on industry and to allow time for more data to be collected/evaluated in year 2 to reduce potential for errors.

2. Georges Bank (GB) haddock designated to Eastern Georges Bank is jointly managed with Canada. The stock has experienced large fluctuations primarily due to large recruitment events; the 2013 cohort has been estimated to be very large and was down-weighted by the SSC. In recommending catch advice, the SSC considered the size of year classes, stock status (GB haddock is well above B_{MSY}), and the impacts of overestimation.

A number of examples exist for both Councils where specifications have been smoothed over a short time period to help improve stability for industry business plans as opposed to following any large increases or decreases as suggested by assessments, e.g. herring, tilefish.

2.3 EVALUATION OF MANAGEMENT PROCEDURES

An important element of the risk policy is that harvest control rules and management procedures be developed in a way that they can be formally evaluated in the context of uncertainty and designed to extract signal from noise. The evaluation of control rules and management procedures could range from a qualitative analysis of fishery performance to a more formal management strategy evaluation, which would require more time, resources, and data quality.

A fishery performance report could be prepared with input from the AP and analysis from the PDT that would describe the current status of the fishery. By providing a framework for these documents that is consistent with the Risk Policy, these fishery performance reports, along with the Risk Policy Matrix (Appendix I), could support decision-making. Some recent examples include the fishery performance report for whiting (NEFMC, 2014), dogfish, and Groundfish performance report (Murphy et al., 2014).

Management strategy evaluation (MSE) is a more formal and lengthy method to formally evaluate HCRs and management procedures that can provide a more thorough analysis where needed and where resources exist. Generally, MSE is a formally-accepted procedure to provide management advice (ex., ABC) where the inputs and methods are pre-specified. Baseline work for MSE is done through collaboration with stakeholders. In addition, other similar multi-criteria methods (ex., Optimal Control techniques) may be available in the future to evaluate the short-term and long-term trade-offs associated with various risk tolerance levels, the value of net benefits, and potentially other goals such as achieving greater stability in the fishery.

3.0 IMPLEMENTING THE COUNCIL'S RISK POLICY – NEXT STEPS

As part of the 2015 management priorities, the Council identified the RPWG's work to review FMP risk policies for consistency with overall policy. In response to the direction from the Council, the RPWG considered various approaches to providing guidance to the Council regarding the risk policy. During RPWG discussions it became clear that most FMPs did not contain risk policies and rather than approaching this on an FMP by FMP basis a more appropriate approach was to prepare a guidance document that lays out the process for the technical work to be done in each FMP in compliance with the policy. The composition of the RPWG does not support FMP specific recommendations. The RPWG acknowledges that these are recommendations for a longer term approach and there is not an expectation that the Council will universally adopt these guidelines within a certain timeframe.

Many steps to operationalize the Council's Risk Policy over the long-term should be taken at the technical/analytical level. Ultimately, implementing analytical approaches like management strategy evaluation (MSE) must begin at the data collection/stock assessment level. In New England, this task largely falls on the NEFSC; their involvement in this process is essential for success.

As efforts by NMFS and the NEFSC continue to build the foundation to support <u>*risk management*</u> across all fisheries, additional steps can be taken in the short-term to operationalize the Risk Policy through the technical groups responsible for developing analysis to support the Council's decision-making (Plan Development Teams, PDTs). The RPWG recommendations for operationalizing the Risk Policy are focused on *process engineering*, i.e., how to design a process within the current system to generate the data and analyses needed to support risk-based decision-making. The RPWG recommends the following steps be taken over the next several years.

STEP 1. Document the Current Management Procedures.

(PDTs, with Committee and AP Input)

The first step that the technical teams should take is to document the current management procedures in order to clearly understand baseline conditions with respect to risks, uncertainty, and net benefits to the Nation for the stock/fishery in question. To support this need, the RPWG has developed a ***Risk Policy Matrix*** (Appendix I).

The ***Risk Policy Matrix*** was developed to provide a summary of the conditions of each stock/fishery and identify major uncertainties, ecosystem considerations, and interactions with other fisheries to support the risk management process. This document, along with the fishery performance reports, can serve as a tool to help the PDTs identify risks and help the Council weigh them to communicate preferences to the SSC. Over time, providing information about risks, uncertainty, consequences, and net benefits to the Nation to the SSC in a standardized format for all stocks/fisheries will improve consistency and clarity in the ABC-setting process.

The Matrix should be a living document, maintained by Council staff and updated when a stock assessment is conducted, and/or when new specifications for a fishery are considered by the

Council. The focus of the matrix is identifying baseline conditions for a stock/fishery; the matrix should not represent a "wish list" of the information or conditions that are desired if more/better information could be available.

When filling out the Risk Policy Matrix, specific consideration should be given to the risks associated with overfishing the stock in question. This is consistent with the first sentence of the Risk Policy – to weigh the risks of overfishing the resource relative to the greatest expected overall net benefits to the Nation. The impacts on the fishery, the ecosystem, and other impacts that can be measured with available data should be identified in the Risk Policy Matrix as the consequences of managing the risks of overfishing the resource. The consequences are important to identify in the matrix because they provide the Council a basis for evaluating net benefits to the Nation and comparing alternative management approaches based on the severity of consequences.

While there may continue to be refinements to the Risk Policy Matrix, the intent is to provide a relatively standardized format for communicating baseline conditions with respect to risk, uncertainty, and the management procedure to the SSC for ABC-setting and to the Council for risk-based decision-making. The Matrix will help the PDTs provide a standardized format to communicate risk and uncertainty. Depending on the relevant timeline for a PDT, this could be addressed over the next 1-3 years, and then the process could be revisited.

The RPWG expects that significant progress towards this step could be achieved across all Council-managed FMPs within 1-3 years.

STEP 2. Evaluate How the Current Management Procedures ***Analyze and Manage Risk*.**

(PDTs, with Input from Committee)

Once the Risk Policy Matrix has been completed, the PDTs (with input from the Committee, as necessary) should consider the information in the Matrix to identify the elements of the management procedure that have the most significant implications on net benefits to the Nation. Once these factors are identified, the PDTs should assess the impacts of those factors on fishery performance and the probability of the undesirable outcomes. The Council should identify tradeoffs to consider with respect to net benefits to the Nation. This should be initiated as part of the specifications process and should be considered by the Council for application to future management actions. The RPWG expects that significant progress towards this step could be achieved across all Council-managed FMPs within 1-3 years.

When developing specifications, a fishery performance report should be developed by the PDT in conjunction with the AP and provided to the SSC for discussion. The report would include catch and landings statistics, performance of accountability measures, market and fishery information (with input from the AP), and status of the resource, and other metrics, as applicable.

STEP 3. Conduct a MSE for a *Candidate* Fishery.

(NMFS/NEFSC, or other scientific person/entity, with Council and PDT)

Moving to MSE will require transition time because of the significant time and resources needed during its initial development. It is not expected that the management system can immediately support MSE across all fisheries. The RPWG considered what stocks currently managed by the Council may serve as a good candidate species to conduct a MSE as soon as possible, assuming that resources are available to do so. The RPWG recommended that the Council identify an appropriate fishery for an MSE, and with assistance from NEFSC, provide guidance on how this could be completed, i.e. under the annual priorities discussion, the Council could include a MSE task on either the Atlantic herring or Sea scallop FMPs as outlined below. This would be aided by funding, where possible, for contract work, which would augment the expertise available to complete the MSE. The species' Committee, PDT, and AP should be involved in design of MSE with respect to the performance measures to be modeled and sources of uncertainty.

A current possibility for MSE analysis within New England fisheries involves the impact of windowpane flounder ACLs, and associated AMs, on the scallop fishery. The windowpane flounder AM was recently triggered and is limiting effort by the scallop fishery. The scallop PDT could simulate the impacts on the fishery of the various alternatives for AMs for windowpane flounder in terms of the overall benefits to the scallop fishery, e.g. what is the most prudent form of AM given the uncertainty about fishing mortality on windowpane flounder. The PDT could examine how to design AMs that perform better in the face of uncertainty about stock status by evaluating foregone yield, etc.

Atlantic Herring	**Sea Scallops**
MSE – ABC Control Rule/Harvest Control Rule	MSE – Harvest Strategy (Area Rotation vs. Others)
Amendment 8 to the Atlantic Herring FMP recently initiated to develop ABC control rule, address herring's role in ecosystem, and address localized depletion	Scallop MSE could be explored independently of a management action
Low/medium value, relatively data rich but significant assessment uncertainty	High value, data rich – spend the limited resources on a high value fishery
Forage/ecosystem aspects of Atlantic herring management would be interesting to explore in MSE	Spatial aspects of scallop fishery management would be interesting to explore in MSE
Goals/objectives not clearly identified	Elements of operating model more clearly defined than herring
Foundation exists and groundwork has been laid – SSC recommended further development of Jon's preliminary MSE work on Am 8	
	Uncertainties are mostly with management (versus science)

Given the scale of the task, this would likely be a long-term priority. If resources are available to support this step, the RPWG expects that the NEFSC, with input and support from the Council, could move forward with conducting a priority MSE for this species within the next few years.

STEP 4. Revisit/Re-evaluate the Risk Policy in 3-5 Years.

(Council, PDTs, Risk Policy Working Group)

Operationalizing the Risk Policy will take the support of the Council, Council staff, NMFS, and the Science Centers.

Once the Council reviews the Risk Policy Roadmap, the PDTs and technical groups can begin taking the first steps to operationalize the Risk Policy and better ensuring that all Council-managed FMPs are consistent with the Risk Policy. The RPWG understands that this transition will take time and does not expect that any steps outlined in this Roadmap would become strict Council policies or rules by which the PDTs and other technical groups must adhere. Rather, the RPWG recommends annual check-in with the working group to see how things are going. Updates about developments at the Science Center and challenges that the PDTs are facing.

- There should be some oversight of the roadmap over time. (Exec. Committee/Working Group once/year? Council staff support for Risk Policy Matrix – touch base with PDT chairs as they work through it)
- Council Staff - Managing PDT work and challenges that the PDT faces as they work through Steps 1 and 2.
- Discuss how to get Council buy in – education and communication about risk-based decision making and MSE. Recommendation for a regional workshop (RPWG – to be discussed by the RPWG)
- Council and NMFS should consider funding (where possible) for contract work to support MSE
- The RPWG recommends a re-evaluation of the risk policy after 3-5 years.

4.0 MSE DEFINED

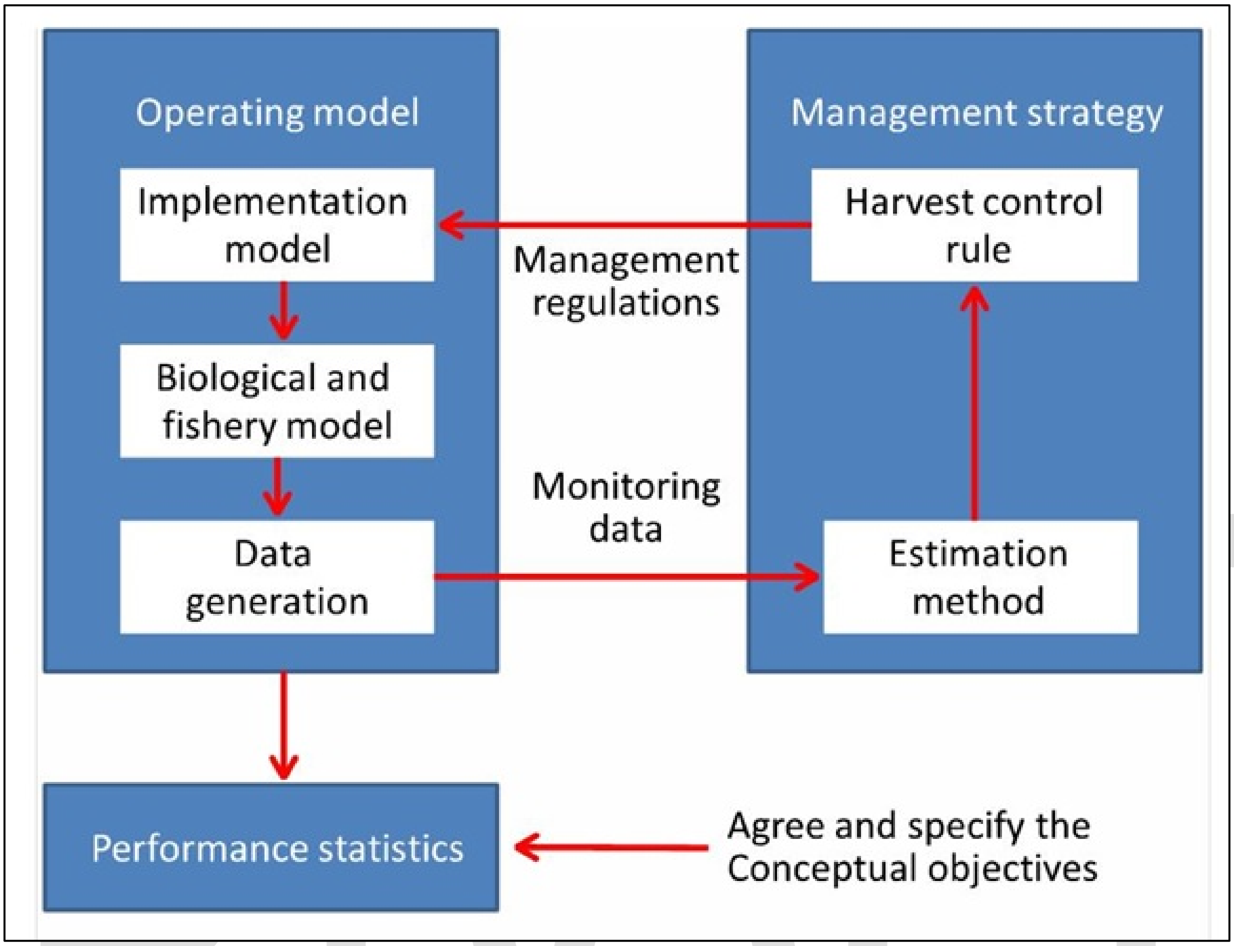
Management strategy evaluation (MSE) is the evaluation of management strategies using simulation and a feedback loop (*simulation testing decision-making*). It is widely considered to be the most appropriate way to evaluate the trade-offs achieved by alternative management strategies and to assess the consequences of uncertainty for achieving management goals. MSE can examine outcomes of multiple parameters changing, perhaps even with cross-correlations. This allows for the examination of more complex uncertainties than the typically used method of projections, which can only handle single parameter changes. MSE can help to quantify the impacts of uncertainty associated with management strategies adopted at present, and to identify the ‘realizable’ performance which can be achieved given the quality of the data available and the types of uncertainties which are inherent in the system being managed (Punt et. al, 2014). While decision-makers (i.e., the Council) identify the desirable outcomes that any management procedure should aim to achieve, the technical analyses (i.e., the MSE) can inform the decision-makers on the feasible ranges of trade-offs. This approach allows for explicit identification and consideration of multiple objectives, risks, and tradeoffs.

MSE allows for much more complex management frameworks to be evaluated. MSE simulates the assessment process and how that process plays out to future outcomes. MSE deals with multiple sources of uncertainty at once and allows for a wide range of different models to be considered. This approach allows for the evaluation of all outputs resulting in a decision that considers all of the possibilities within the range in multiple dimensions. The feedback loop between the management strategy and the operating model(s) is a fundamental aspect of MSE and is the particular feature that distinguishes MSE from simple risk assessment where the implications of unchanging management regulations (ex., constant quota) are evaluated by use of projections. Simple risk assessment can overestimate risk by failing to take into account management reactions to the information provided by future data (the feedback loop). Conducting a MSE is not the same as conducting projections from a stock assessment, although a stock assessment may form the basis for the operating model(s) which are central to the MSE. Specifically, MSE takes feedback control into account, that is it takes account of the collection and use of future data on the status of the managed system (Figure 1, from Punt et al, 2014).

The definition of MSE can be interpreted rather broadly, and the application of MSE should not be limited in any way by semantics. According to Smith (1994), the key elements of a MSE framework are:

- **Multiple Objectives**. This is almost always the case in fisheries management. The National Standards of the Magnuson-Stevens Act (MSA) inherently create a system with multiple objectives.
- **Uncertainty exists and can be characterized**. There are multiple levels of uncertainty and variability in fisheries management.
- **Stakeholder Involvement**. Stakeholders must be involved in the MSE process, from identifying the objectives to providing input to refine other scientific questions. One of the most challenging parts of the MSE process is obtaining stakeholder input in an objective manner.
- **Tradeoffs are Evaluated**. Performance indicators are refined and tested, but not for optimality in any single factor.

Figure 1 Conceptual Overview of Management Strategy Evaluation (MSE)



Source: Punt et al. 2014. Management strategy evaluation: best practices. Fish and Fisheries. DOI:10.1111/faf.12104.

Benefits of MSE

As described above, MSE allows for a thorough evaluation of risk with the added benefit of a feedback loop (Figure 1). MSE provides a clear framework that outlines the data to be used and the estimation method. This can help to streamline the overall process by reducing the number of meetings and timeframe required to complete a task, which can also increase the amount of time available for other research needs (Butterworth, 2007). MSE can identify which parameters a system is most sensitive to. The design of MSE allows all stakeholders to make informed decisions on the tradeoffs between longer term stability and interannual variability in a stock. MSE can be performed on various scales; if limited information is currently available, smaller evaluations could be conducted. It allows for multiple plausible perceptions about the state of nature to be considered.

Stakeholder Input

Stakeholders help ID and quantify objectives (desired outcomes) at the policy level. They also shape the scope of the operating model and how broadly the issue should be viewed. The MSE structure is not based on one model but rather a number of models that encompass all of the possible alternatives and outcomes. The current system allows for stakeholder input at the policy level (i.e. scoping, AP, Committee, Council meetings) but limits their role in scientific uncertainty considerations. Stakeholder involvement increases buy-in and increases the range of plausible alternatives that may be considered.

4.1 MSE BEST PRACTICES

Punt et. al (2014) discuss the following best practices for MSE (see APPENDIX II) for a summary of all MSE best practices guidelines):

- **Establishing objectives and performance statistics.** When establishing objectives and performance statistics, any conceptual objectives should be translated into clear, operational objectives. These can then be used to construct an operating model, from which performance statistics can be calculated. The statistics used should be easily understood by all stakeholders. It is essential for all parties to understand the tradeoffs that typically arise between different components of a fishery (e.g. commercial versus recreational). A firm understanding would help each party select acceptable tradeoffs.
- **Selecting uncertainties to consider and selecting operating model parameters.** For every MSE, a range of uncertainties needs to be considered. These typically fall under the following categories: process uncertainty, parameter uncertainty, model uncertainty, errors when conducting assessments, and outcome uncertainty. However, individual factors will vary for every fishery. Each uncertainty should be explicitly addressed within the MSE. A suitable approach is to run scenarios of plausible hypotheses (i.e. ‘reference trials’) and scenarios or unlikely hypotheses (‘robustness trials’) then compare the outcomes. This acts as a performance evaluation on the management strategy. The incorporation of a standard set of factors could help ensure that a well-rounded MSE is being performed.
- **Identifying candidate management strategies which could realistically be considered for implementation.** The management strategy selected should be based on policies agreed to by decision-makers. However, alternative management strategies should be evaluated to better understand the strategies identified by decision makers. These strategies could be model-based or empirical, or a mixture of the two. Ideally all management strategies being tested would be fully run as if it was being applied.
- **Simulating the application of each management strategy for each operating model.** Care should be taken when running simulations to minimize the chance of errors from the coding itself. The strategy should only use data that is available and all assumptions should be outlined in advance.
- **Presenting results and selecting a management strategy.** Multiple strategies should be provided to help decision-makers address tradeoffs. This step highlights the importance of stakeholder involvement throughout the entire MSE development process. The basis of management strategy selection should be as simple as possible. The explanation of the possible strategies should be as transparent as possible with the feasibilities of the various hypotheses adequately reported.

4.2 MSE CASE STUDIES

There is a large body of available literature regarding MSE and case studies discussing the application of MSE to address fisheries management issues. A literature review of MSE case studies provides an overview of the broad application of MSE in fisheries management. (Follow-up with NEFSC still to be done). A few notable case studies are included in the reference list; a brief summary of the MSE for southern Bluefin tuna fishery is described below as one example that can be referenced for more information.

Management Strategy Evaluation for the Southern Bluefin Tuna Fishery (Hillary et al., 2015). The Southern Bluefin tuna stock has been at historically low levels in recent years. Even with a commercial moratorium predictions indicated an imminent collapse with minimal chance of recovery. To avoid such a moratorium an adaptive rebuilding strategy was adopted by the Commission. The Commission developed their management procedure by approving a set of monitoring data and a procedure for analyzing that data to be input to a harvest control rule which specifies the recommended level of catch or effort. This was a 10 year process. The countries involved were the stakeholders and provided input on objectives. The MSE was parameterized with respect to rebuilding target, the target year for completion, and the probability of reaching the target. The fishery is managed using a TAC and the committee constrained how much the TAC would be allowed to change. The assessment group designed an operating model based on stock dynamics and sources of uncertainty, which included strategies to address those uncertainties. Major sources of uncertainties included the shape and slope of the stock-recruit curve. The Commission subjected a range of management procedures to extensive simulation testing before selecting a procedure that 'combined elements of the two best performing candidates.' The simulation projection drew probabilistically from 1000 models, all of which were possible outcomes based on the parameters. A model was run to determine what the population would look like in the future, a stock assessment model was applied. A management strategy was applied followed by another modeling of the population and another stock assessment. This process resulted in an operating model and procedure to be followed. The TAC was then evaluated based on what parameters were observable. The chosen management procedure allows for the continued rebuilding while allowing continued harvest. Harvest levels are adjusted every three years to meet rebuilding targets.

5.0 REFERENCES

Atlantic King Mackerel Fishery Stakeholder Workgroup (AKMFSW). 2008. A vision for the king mackerel fishery. UMCES[CBL] 08-127. http://consensus.fsu.edu/pfs/PDFS/Stakeholder_Final_Report.pdf

Butterworth, D.S. 2007. Why a management procedure approach? Some positives and negatives. ICES Journal of Marine Science. 64: 613 – 617.

Hillary, R.M., Preece, A. L., Davies, C. R., Kurota, H., Sakai, O., Itoh, T., Parma, A. M., Butterworth, D. S., Ianelli, J. and Branch, T. A. 2015. A scientific alternative to moratoria for rebuilding depleted international tuna stocks. Fish and Fisheries. doi: 10.1111/faf.12121. http://www.fisheriesforum.org/topic-pages/mse-library

Martell, S., Leaman, B., and Stewart, I. 2013. Developments in the management strategy evaluation process, fisheries objectives, and implications for harvest policy and decision making. http://www.iphc.int/publications/rara/2013/rara2013_15_2013mse.pdf

Murphy T, Kitts A, Records D, Demarest C, Caless D, Walden J, Benjamin S. 2014. 2012 Final Report on the Performance of the Northeast Multispecies (Groundfish) Fishery (May 2012 – April 2013. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-01; 111 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

New England Fishery Management Council (NEFMC). 2014. Stock Assessment and Fishery Evaluation (SAFE) Report for Fishing Year 2013 – Small-Mesh Multispecies. http://s3.amazonaws.com/nefmc.org/SAFE-Report-for-Fishing-Year-2013.pdf

Punt, A.E., Butterworth, D.S., de Moor, C.L., De Oliveira, J.A.A., and Haddon, M. 2014. Management strategy evaluation: best practices. Fish and Fisheries. doi: 10.1111/faf.12104

Smith, A.D.M. 1994. Management strategy evaluation – The light on the hill. In: Population dynamics for Fisheries Management, Australian Society for Fish Biology Workshop Proceedings, Perth 24-25 August 1993 (ed. D.A. Hancock). Australian Society for Fish Biology, Perth, pp. 249 - 253.

Wiedenmann, J. 2015. Application of data-poor harvest control rules to Atlantic Mackerel. Report to the Mid Atlantic Fishery Management Council. http://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/55356f9de4b0b85613f76b3c/1429565341859/Mackerel_ABC_reportOpt.pdf

Wiedenmann, J. and Wilberg, M. 2014. Final report: Evaluation of management and regulatory options for the summer flounder recreational fishery. [UMCES] CBL 2014-006. http://www.fisheriesforum.org/topic-pages/mse-library

Report from the
RISK POLICY WORKING GROUP

Risk Policy Road Map

Appendix I
Risk Policy Matrix Template

NEW ENGLAND
FISHERY MANAGEMENT COUNCIL

New England Fishery Management Council
50 Water Street
Newburyport, MA 01950

FMP	**XXX**	**Complete this table with information about current conditions for the stock/fishery based on the most recent assessment and round of fishery specifications. This is an inventory of current conditions - not a "wish list." Information provided in the cells should relate specifically to evaluating the risks to the resource and net benefits to the Nation, with consideration/acknowledgement of consequences to the fishery, ecosystem, and other consequences.*
STOCK(S)	**XXX**	
LAST ASSESSMENT	**Assessment/Meeting, Year**	

Assessment Model, Terminal Year	**Description of Assessment Model**	**Overfishing? Overfished?**	**In Rebuilding Program?**	**OFL**	**ABC/ABC CR**	**ACL**	**ACT**
Name of most recent model used in assessment and terminal year of data	General description of assessment model	Most recent F/B status determinations	Yes/No; Year x of y (if yes)	OFL definition/formula and most recent specification (x lbs, year)	ABC and ABC CR/formula and most recent specification (x lbs, year)	Most recent (year) fishery ACL(s), sub-ACL(s)	Most recent (year) ACTs, if applicable

	MSY/OY	**AMs**	**Discards**	**State Waters**
***Summarize major fisheries management issues/challenges here, in a few words.**	MSY/OY definitions/formulas and most recent specifications (values, year)	Briefly summarize accountability measures in FMP	Summarize how discards are treated for stock assessment and quota monito	Summarize state waters catch and how it is treated for stock assessment

			ring	and quota monito ring

Availability of Biological and Assessment Data	*Used in Assessment:* ID biological data used in assessment (time period) *Other Biological Data:* ID other biological data that may be available but not used in assessment ID any significant biological/stock data elements that are missing
Recent Performance Against Harvest Control Rule	*For the most recent three years-* Summarize utilization of available yield (% of total ACL harvested) Summarize how control rule affected the stock? Has stock status and/or fishing mortality changed (improved/declined)?
Current Management Program	Briefly summarize major elements of current management program; include summary of Federal and State management, as appropriate
Catch, Revenues, and Variability	*For the most recent three years-* Provide average catch, revenues; Characterize trends and variability *over 10 to 15 years*, depending on data availability, using avg., min. and max. values.
Data - Vessels, Permits, Dealers, Processors, Employment	*For the most recent three years* - Number of vessels by permit and/or gear (and % of active/inactive), and percentage of catch taken by each category; Briefly summarize shoreside components- number of active dealers, processors/plants; ID and summarize any available employment information; Characterize trends and variability *over 10 to 15 years*, depending on data availability, using avg., min. and max. values.
% Food, % Recreational	*For the most recent three years* - Information about percentage landed/sold for food/recreational; Also include general summary of markets and ID any major factors that influence/change market conditions (ex., availability of other product)

Fishing Communities	*ID Top Fishing Communities for last 3-5 years based on:* (RQ) = Revenue of that species in a port/total revenue fishery-wide; and (LQ) = Revenue of that species in a port/total revenue in that port. Characterize trends.*Identify any vulnerable communities that may incur significant economic risk from resource decline*
Other Economic/Social Factors	Identify any other economies/industries that may be dependent on the resource (other than directed fishery); Describe the potential impacts of variability and size composition of resource/catch on market share and prices.
Major Sources of Scientific Uncertainty	Summarize the sources of uncertainty identified in the stock assessment; Identify/summarize other sources of scientific uncertainty
Major Sources of Management Uncertainty	Summarize the sources of management uncertainty that were explicitly accounted for during last round of fishery specifications; Identify and summarize any new/additional sources of management uncertainty
How is the probability of overfishing addressed?	What is the process and/or formula used to specify catch levels to prevent overfishing? How was the probability of overfishing addressed during the last round of fishery specifications?
What is the consequence of overfishing?	Given the current status of the stock (biomass), what are the short-term impacts of overfishing? What are the long-term impacts of overfishing the stock (if it were to continue)?
How are expected net benefits to the Nation currently measured/evaluated?	What tools/data are currently available to measure and evaluate net benefits to the Nation? How were net benefits to the Nation evaluated during the last round of fishery specifications?
Interactions with Other Fisheries/Stocks, Bycatch Issues	Describe most significant interactions with other fisheries/stocks, including stocks for which there may be catch/bycatch caps or sub-ACLs; Identify any overlapping fisheries with significant interactions

Ecosystem Considerations: Trophic Interactions	Describe any important trophic interactions related to the role of the stock in the ecosystem; Summarize important predator-prey interactions Discuss trends/variability over the last 10-15 years, and identify any new related data/analyses
Ecosystem Considerations: Habitat	ID habitat sensitivity/vulnerability issues for the stock; Describe any recent changes to important habitat for stock and/or changes to fisheries that impact stock habitat; Discuss trends/variability over the last 10-15 years, and identify any new related data/analyses
Ecosystem Considerations: Climate	Does the stock exhibit strong response to temperature? Has climate change affected the distribution of the stock? Discuss trends/variability over the last 10-15 years, and identify any new related data/analyses
Other Important Considerations/Notes	Discuss any other important considerations for evaluating risk to the resource and net benefits to the Nation.

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Risk Policy Road Map

Appendix II
Summary of Best Practices

New England Fishery Management Council
50 Water Street
Newburyport, MA 01950

Table 1 Summary of Best Practices Guidelines (Punt et. al, 2014)

Selection of objectives and performance metrics

- Involve decision-makers and stakeholders (e.g. using workshops) throughout the process to ensure the performance statistics capture the management objectives and are understandable.
- At a minimum, report statistics related to average catches, variation in catches and the impact on stock size.

Selection of uncertainties

- Consider a range of uncertainties, which is sufficiently broad that new information collected after the management strategy is implemented should generally reduce rather than increase this range.
- Include trials for each potential source of uncertainty (unless there is clear evidence that the source does not apply) and for the factors considered in Table 3.
- Consider the need for spatial structure, multiple stocks, predator-prey interactions and environmental drivers on system dynamics; modelling the last by imposing trends on the parameters of the operating model is often sufficient to understand its implications.
- Include predation effects using minimum realistic models and examine the potential for technical interactions amongst major fished species, especially in multispecies fisheries.
- Divide the trials into 'reference' and 'robustness' sets.
- Use Bayesian posterior distributions to capture the parameter uncertainty for each trial if possible.

Identification of candidate management strategies

- This should be the primary responsibility of the stakeholders/decision–makers, but with guidance from the analysts given the limitations of the management strategy evaluation (MSE). Care needs to be taken that the management strategy can be implemented in practice.
- Evaluate the entire management strategy. In cases in which the management strategy is complex, this may be impossible computationally, in which case a simplification of the assessment method is needed – the nature of the simplification should be based on simulation analyses.

Simulation of the application of the management strategy

- Check that operating model and management strategy are consistent with reality; projections into the future should generate quantities, such as past assessment errors and levels of variability in biomass and recruitment, on the same scales as those estimated to have occurred in the past.
- Conduct tests of the software, for example using 'perfect' data before conducting actual analyses.
- Base recommendations for management actions in management strategies only on data which would (with near certainty) actually be available.
- Document any assumptions regarding parameters assumed known when applying the management strategy.

Presentation of results and selection of a management strategy

- Develop a process, so that the decision-makers understand the results of the MSE and the range of trade-offs which are available to them.
- Use effective graphical summaries which are developed collaboratively with the stakeholders.
- Identify whether there are 'performance standards' which must be satisfied to eliminate some possible management strategies immediately and hence simplify the final decision process.
- Select a method for assigning a plausibility rank to each trial and take these ranks into account when making a final selection among candidate management strategies.

Other

- Include 'Exceptional Circumstances' provisions which specify the situations under which a management strategy's recommendations may be over-ridden.
- Include a schedule for when formal reviews of the implemented management strategy will take place.