OVERFISHING REFERENCE POINTS AND UNCERTAINTY BUFFERS

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Scientists, fishery managers and fishermen from throughout New England and far beyond contributed to a workshop focused on reviewing a range of overfishing and rebuilding reference points as well as uncertainty buffers. The workshop was hosted by The Massachusetts Marine Fisheries Institute as the second in a series that forms an end-to-end review of groundfish stock assessments and management. The strengths and weaknesses of alternative reference point approaches and the costs and benefits of uncertainty buffers were considered to identify best practices. Conclusions and recommendations were formed for application to the scientific basis of managing the New England groundfish fishery on the topics of legal constraints, Maximum Sustainable Yield (MSY) reference points, proxy reference points, defining overfishing limits and rebuilding targets, scientific and policy decision making process, current uncertainty buffers, risk-based catch limits and management procedures[1].

Legal Contraints

- Workshop participants recognized that many of the challenges faced with New England groundfish result from mandates of the Magnuson-Stevens Fishery Conservation and Management Act and the interpretation of the Act in National Standard guidelines:
- The requirement for MSY reference points is mandated in the Act.
    - The Act defines "overfishing" as "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" or fishing mortality greater than F_{MSY}.
    - The Act requires Annual Catch Limits (ACLs) so that "overfishing does not occur in the fishery, including measures to ensure accountability."
    - The Act requires rebuilding of "overfished" stocks to the stock size that can produce MSY (B_{MSY}), typically in 10 years.
- National Standard 1 includes both optimum yield and preventing overfishing, but "underfishing" (i.e., not achieving optimum yield) is not considered nearly as much as overfishing in the National Standard 1 guidelines.
    - The guidelines define "overfished" as a stock size that is less than a minimum threshold, regardless of whether the low stock size results from overfishing or not.
    - The mixed-species nature of the groundfish fishery cannot be effectively addressed by the management procedure specified in the guidelines. The "mixed-stock exemption" in the guidelines is not effective in practice.
    - The current implementation of the Act and guidelines is not flexible enough to respond to apparent changes in groundfish productivity, increased predation and competition, and climate change.
    - Alternative management procedures may perform better for achieving the objectives of the Act than the system of Acceptable Biological Catch (ABC) and Annual Catch Limits (ACLs) in National Standard 1 guidelines.

[1] *Representatives from National Marine Fisheries Service Northeast Regional Office and Northeast Fisheries Science Center participated in this workshop. This does not constitute an endorsement of the recommendations of the workshop.*

Maximum Sustainable Yield (MSY) Reference Points

- Although MSY reference points are mandated in the Magnuson Act definitions of optimum yield, overfishing and overfished, productivity of fish stocks and components of productivity (recruitment, growth, natural mortality, selectivity) vary over time as a function of the environment and stock density. A variety of scientifically valid approaches to estimating MSY reference points have different information requirements, assumptions, strengths and weaknesses, and produce different values of MSY, F_{MSY} or B_{MSY}. Therefore, there is no single value of MSY, F_{MSY} or B_{MSY} for any stock, and therefore no single definition of overfishing limits or rebuilding targets.
- Age-based estimates of MSY reference points (F_{MSY} and B_{MSY}) consider information on demographics, but require a well-estimated stock-recruit relationship, typically only include density-dependence in the reproductive rate (e.g., recruits/spawning biomass), and are sensitive to assumptions about natural mortality at age and associated changes over time.
- Biomass-based estimates of MSY reference points from surplus production models consider density dependence in aggregate production (and implicitly all components of production), but require an informative exploitation history and stock development history to accurately estimate absolute B_{MSY}, and they do not explicitly account for demographics and changes in demographic parameters over time.
- National Standard 1 guidelines allow for F_{MSY} and B_{MSY} proxies to define overfishing limits and rebuilding targets.
    - $F_{40\%}$ (the fishing mortality that conserves 40% of the maximum spawning biomass per recruit) is a common proxy that is expected to have nearly as much long-term yield as F_{MSY}, and does not require a stock-recruit relationship or an informative exploitation history. However, the short-term yield associated with $F_{40\%}$ may be considerably different than the yield associated with F_{MSY}, rebuilding targets associated with $F_{40\%}$ may be substantially different than B_{MSY}. $F_{40\%}$ does not consider density dependence in productivity, and is sensitive to assumptions about natural mortality at age and associated changes over time. Biomass reference points derived from $F_{40\%}$ require a recruitment assumption.
    - $F_{40\%}$ may be more appropriate as a target (e.g., as applied to North Pacific groundfish) than an overfishing limit.
    - Without an informative series of stock and recruitment and an understanding of the stock-recruit relationship, the appropriate % of maximum spawning potential that accurately approximates F_{MSY} is unknown. For example the relative performance of $F_{20\%}$, $F_{30\%}$ or $F_{40\%}$ as proxies for F_{MSY} are unknown.
    - Replacement-based reference points (e.g., F_{med}) may be sustainable, but are not necessarily accurate approximations of F_{MSY}, because they are constrained by the exploitation history and resulting range of stock sizes in the stock-recruit series.

Overfishing Limits and Rebuilding Targets

- There are costly consequences to inaccurate estimates of overfishing limits (F_{MSY} or F_{MSY} proxies). Management decisions based on overestimated overfishing limits will tend to deplete stocks toward an overfished state. Management decisions based on underestimated overfishing limits will forego yield of the target stock and possibly forego yield of co-occurring stocks and increase discards of the target stock.
- A wide range of approaches to estimating MSY reference points, including age-based MSY and biomass dynamics, and appropriate proxies should be attempted.

- Performance of all candidate reference points for avoiding depletion and achieving optimum yield should be simulation tested for the specific applications.
- The full range of plausible estimates should be considered for stock status determination and projection of catch associated with overfishing or rebuilding (e.g., in the form of a consequence table as considered in SAW55 Gulf of Maine cod working group).
- Ecological information, understanding of the exploitation history and changes in environmental conditions should be considered to determine plausibility.
- Scientific recommendations of catch associated with overfishing or rebuilding should consider the full range of plausible approaches.

Science and Policy Process for Risk-Based Catch Limits

- Scientists should make scientific decisions and managers should make policy decisions, but reference points and uncertainty buffers often have scientific and policy aspects.
- An active and iterative feedback loop between science and management will help to coordinate scientific and policy decisions.
- The Fishery Management Council should clearly define objectives to scientists, including factors to consider in optimum yield (e.g., social, economic, ecological) and risk tolerance in the short-term and long-term.
- Scientists should effectively communicate the basis of a catch recommendation (without jargon), including plausible scenarios considered in the determination of the recommendation, and their relative plausibility.

Current Uncertainty Buffers

- The basis for the current Acceptable Biological Catch (ABC) control rule for New England groundfish (the lesser of 75%F_{MSY} proxy or $F_{rebuild}$) is based on National Standard 1 guidelines for stocks that have not rebuilt as planned.
- The existing ABC control rule is not performance-based or tailored to New England groundfish objectives or properties.
- The existing control rule conforms to National Standard 1 guidelines, but is not consistent with principles of a precautionary approach:
    - The uncertainty buffer is not a function of relative uncertainty (i.e., does not increase as uncertainty increases).
    - There is no uncertainty buffer for $F_{rebuild}$.
- The existing ABC control rule has been generally ineffective for avoiding overfishing (in that the subsequent estimate of fishing mortality is greater than the F_{MSY} proxy), mostly due to scientific uncertainty (e.g., retrospective inconsistency of stock assessments, changes in natural mortality). This evaluation relies on the accuracy of the accepted stock assessment.
- Considering the full range of plausible models and consequences may perform better.

Risk-Based Catch Limits

- The retrospective inconsistencies experienced for some groundfish stocks complicate an explicit risk-based approach to uncertainty buffers for those stocks.
- In addition to the current emphasis on risk of overfishing, other biological, ecological, economic and social factors should be considered in risk assessments.

- Risk assessments should include consequences of undesirable outcomes as well as preferences for avoiding those outcomes.
- Socio-economic analysis is as important as stock assessment for determining optimum yield, but investments are needed in socio-economic data, data collection programs and expertise.

Management Procedures

- A range of alternative management procedures should be considered, including simpler data-driven procedures (catch, surveys, and relative exploitation ratios).
- Performance of the entire system (monitoring, assessment, reference points, projections, peer-review process, role of SSC, ABC control rules and accountability measures) should be evaluated for all candidate management procedures.
- Existing limitations in budgets and human resources should be considered in performance evaluations.
- Developing a management procedure process for an example stock would help to develop the procedural aspects of applying the procedure in the existing legal system.
- Eventually, the mixed-stock nature of the groundfish fishery and technical interactions needs to be considered in performance evaluations.
- Transitions to alternative management procedures will likely require a re-programming existing science and management system components or increased funding.

A more detailed workshop report will be provided as a part of the integrated end-to-end review of groundfish stock assessments and management.