



## Term of Reference 6: Stock Integration of Ecosystem Factors and Climate Change into Stock Assessments

### Summary

Under this term of reference, we briefly review NEFSC programs relevant to ecosystem and climate observation, research, and modeling that can be incorporated into stock assessments. We cannot exhaustively review all of the data collection, research programs, and models potentially contributing ecosystem and climate data to stock assessments because every branch and program of the NEFSC is involved in this process. Instead, we highlight synthetic ecosystem and climate products and key research which have been incorporated in recent fish stock assessments. This document summarizes the synthetic products and provides links to full documentation for reviewers.

In our presentation to reviewers, we first review key characteristics of the Northeast shelf large marine ecosystem. We then ask three questions: do we have the data to integrate ecosystem and climate factors in stock assessment, do we have the analytical tools to do so, and do we have an effective process for this integration? During the course of the presentation, we highlight the successes, challenges, and potential solutions associated with integrating ecosystem and climate factors into stock assessment fishery management advice.

There are many successes to highlight under TOR 6. NEFSC has a unique (among NMFS science centers) and outstanding history of ecosystem monitoring, data collection, and research. Examples of the ecosystem monitoring work and synthetic products include ecosystem advisories, ecosystem status reports, a climate webpage, papers, ecosystem models, and more. We also briefly review the extensive food habits database housed at NEFSC and the Food Web Dynamics program which was externally reviewed (positively) in 2009. The NEFSC ecosystem modeling enterprise has also been reviewed positively by the Center for Independent Experts in 2011. In addition, we show several recent examples of this information being integrated and improving stock assessment performance and advice (e.g., butterflyfish, herring, yellowtail flounder). NEFSC ecosystem and climate scientists, along with stock assessment scientists, economists, and social scientists, are involved in fishery management council and ocean planning processes. Finally, a collaborative project between NEFSC ecosystem and stock assessment scientists to develop a pilot multispecies assessment for Georges Bank is in progress.

Despite these many successes, climate and ecosystem science is inherently complex and challenging, and there are specific challenges facing NEFSC. First, climate change is altering ecosystems in this region at a rapid rate; this issue is increasingly important for stock assessment and resource management here. Climate change impacts vary within the northeast shelf ecosystem and will impact resources differently. For example, ocean acidification is a long-term, gradual change, and research underway now may be able to provide advice for management in the future. Fish growth and condition also may be affected by climate change which will require adjustments to biological parameters in stock assessments but few alterations to management. In contrast, species range shifts, which are observed now, raise questions regarding stock areas, stock identification, and spatial management; these questions are more immediate. In general the consequences of climate change are difficult to predict at the scale relevant to natural resource management; increased monitoring in time and space may be necessary. Ecological factors relevant to stock assessment such as predation, disease, competition, and habitat quality are already complex and only partially understood, and they may also interact with climate change in the region to produce previously unobserved conditions.

In addition to the scientific challenges inherent in climate and ecosystem integration into assessments, there are more practical challenges. Budget issues affecting NOAA in general and NEFSC specifically have resulted in recent cuts to ecosystem observation surveys and ecosystem research programs. The stock assessment production and review system is already running at full (or perhaps over) capacity at NEFSC such that integration of ecosystem and climate factors is difficult, as they add data, models, analytical work, and review to an already complex and time-consuming process. Finally, research is necessary to determine best practices for altering catch advice and management reference points based on ecosystem and climate factors.

Some potential solutions to the challenges facing NEFSC with respect to climate and ecosystem factors have been identified. First, continued monitoring of climate and ecological indicators is critical as the system continues to change; therefore, continuing existing ecosystem observation and research programs is necessary. Second, further integration of climate/ecosystem and stock assessment scientists working on both stock assessments and research will improve integration of all necessary factors into management advice. Finally, there is much potential to explore alternative analytical methods and management reference points within projects like the multispecies assessment study for Georges Bank which will employ extensive simulation testing and management strategy evaluation methods. Results of this project may suggest how to streamline assessment workloads by addressing multiple species within an ecoregion at once, how to address structural uncertainty with multi-model inference, and whether simpler indicator-based management procedures might perform as well or better than current single species reference points. Further down the road, studies like this could address spatial issues, migration, and other technical aspects of assessment.