Discussion Document 3

Provision of EPU Catch Advice Using Ecosystem and Multispecies Models

Successful transition from conventional single species management approaches to Ecosystem-based Fishery Management will depend on establishing an effective conceptual and analytical framework for the provision of scientific advice to managers. An overarching goal of EBFM is to protect ecosystem structure and function to ensure the sustainable flow of a key ecosystem service. Preserving the resilience properties of exploited marine ecosystems is the most effective way to protect the human communities that depend on fishery resources. Principal elements of the approach include:

1. Establish a transparent connection between single species and ecosystem based advice using multispecies assessment models as a natural bridge,
2. Adopt a Management Strategy Evaluation approach to test assessment models and candidate management procedures
3. Incorporate consideration of climate forcing in assessment models
4. Develop alternative assessment models spanning a spectrum of complexity to evaluate model uncertainty. Apply formal strategies of multimodel inference
5. Evaluate uncertainty and risk under different harvesting scenarios
6. Evaluate tradeoffs in a bioeconomic context.

Although we will use different modeling approaches than the current single-species management framework now in place, the approach is designed to provide Annual Catch Limit advice to managers to meet existing requirements

Data streams feeding into this process encompass fishery-dependent (both ecological and social-economic) sources, fishery-independent surveys, food habits data to identify and quantify biotic interactions among species, and oceanographic and climate data to track external forcing mechanisms (Figure 1). We will complement model-based estimation tools with indicator-based approaches. To further enhance communication with stakeholders we will employ data and model visualization tools to aid in the interpretation of multispecies model outputs.

The core analytical elements of the process involve development and testing of a set of multispecies assessment models, indicators, social-economic modules linked to the assessment models, and forecast models developed outside the assessment model framework to complement predictions made using these assessments. The interplay between the operating models and the other analytical elements of the approach is envisioned as an iterative process (Figure 1). The analysis includes risk analyses accounting for key uncertainties and will incorporate candidate management procedures. The process culminates in the provision of Annual Catch Limit advice for individual stocks to meet existing requirements under current management approaches.

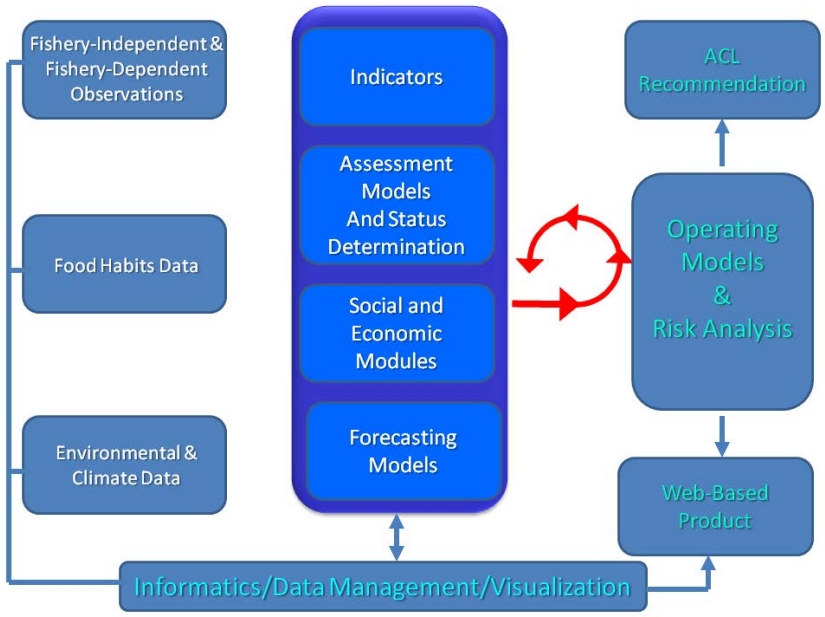

Figure 1. Key structural elements of the multispecies analysis to be used in EBFM in the region.

Our overall approach entails the use of three different assessment model types encompassing simple multispecies production models applied both to individual species and to defined functional groups, multispecies delay-difference models that implicitly accommodate simple demographic structure (again for individual species and functional groups), and a complex multispecies statistical catch-at-age model applied to individual species (Figure 2). Single species analogues of these models are familiar to resource managers in the region and we have deliberately attempted to frame our approach in a way that trades on this familiarity. Multiple estimation techniques including maximum likelihood, state-space, genetic algorithm and Bayesian methods will be applied to the production models in both aggregated and disaggregated forms to assess aspects of estimation uncertainty. We will apply a multispecies production model framework designed to encompass a number of different functional forms, model structures, and estimation techniques.

The consideration of functional groups as a focal point for management is specifically intended to directly address the issue of complexity. Legitimate concerns over the potential for greatly increased complexity and data requirements for EBFM deserve careful attention. Our examination of the potential utility of management centered on higher levels of ecological organization is an attempt to reduce overall complexity while taking advantage of the potential for greater stability and predictability at the functional group level. We will attempt to complement the multispecies models with ecosystem-level models designed to address the production potential of the system under changing environmental/climate conditions. We will also examine the performance of nonparametric non-linear time series models as forecasting tools and compare these forecasts with those derived from the parametric assessment models.

A key issue in assessment and management of the New England fisheries is the centrality of the mixed-species nature of the fishery. We define our functional groups as species that are caught

together and share basic ecological characteristics (similarity in life history attributes, body size, etc.). Our interest in testing the performance of assessment models based on functional groups defined in this way centers both on their importance as key structural elements of the system and recognition that we cannot fully control the fishing mortality rates on the individual species comprising these mixed-species assemblages. These species, *inter alia*, share similar histories of exploitation and environmental forcing. Simulation tests will be made to assess the performance of the functional group models against models in which the species identity of all components is retained to see if they offer any advantage in assessing mixed-species fisheries. If the functional group approach is adopted, it will be necessary to ensure that constraints are placed on removals of the individual species comprising the assemblage. We envision testing the performance of management procedures in which an overall cap or 'Ceiling' on the removals from a functional group is set. A set of constraints will then be established on catches of individual species such that none will drop below a 'Floor' or minimum biomass constraints (an alternative would be to specify an upper limit to the exploitation rate on each species). The sum of the catches of all species within a functional group cannot exceed the specified Ceiling level.

Economic modules link to the assessment models to produce revenue streams and measures of profitability. They are being developed for direct use in tradeoff analysis. For the economic module we are also employing an empirical multispecies portfolio model approach to assess risk. We are developing forecast models using new methods in nonlinear time series analysis to complement the assessment models.

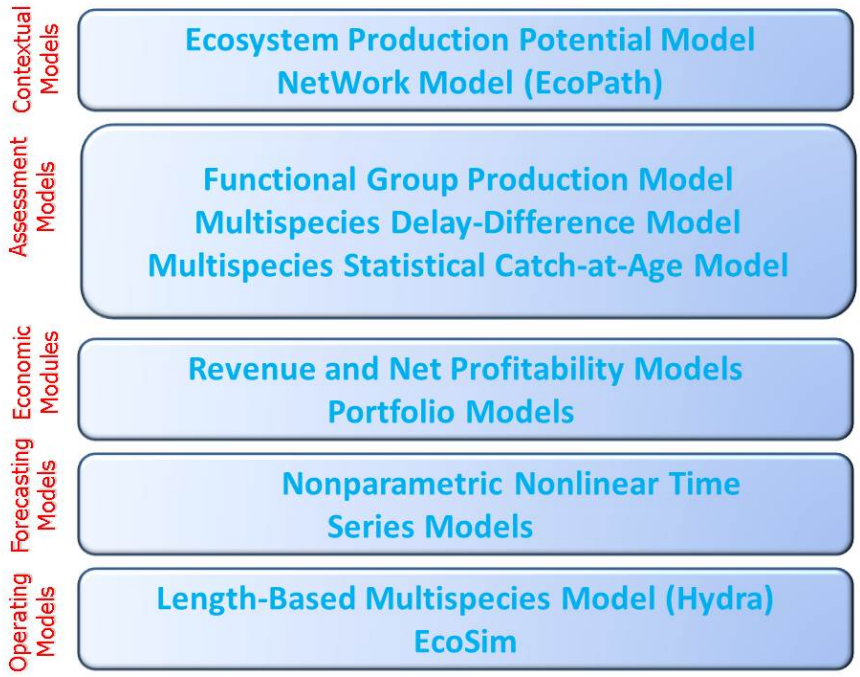

Figure 2. Modeling elements to be employed in the prototype multispecies bio-economic model for Georges Bank.