Background material for presentation on Focus on Modeling and Forecasting

Kerim Aydin

Multispecies and ecosystem modeling work at the Alaska Fisheries Science Center can be organized by type and by ecosystem. The eastern Bering Sea sub-region has seen the most modeling work performed, with a full suite of model types. These types include Regional Oceanographic Modeling (ROMS), enhanced single-species assessments, technical interaction models (single-species assessment modeled linked by non-independent fishing fleets to explore fishing policy changes), food web models with large numbers of compartments, climate-enhanced multispecies stock assessment models, and a spatial model for key Bering Sea species (FEAST). Under development are size-spectrum models and qualitative network models.

For the Bering Sea, these models represent a "suite" that can be used for multi-model inference; in particular, as part of the FATE, SAAM, and S&T jointly funded ACLIM project, these models are being driven by a set of IPCC climate scenarios (whole-earth model atmospheric model predictions) to perform multi-model predictions and management strategy evaluations driven by the IPCC results. These results will be communicated to management as a direct part of the Bering Fisheries Ecosystem Plan and the Regional Climate Science strategy.

A specific model in active use for management purposes is the Bering 10K ROMS model, a $10km^2$-scale model for the eastern Bering Sea with 10 vertical depth layers, and including an NPZ component. This model, a collaboration between AFSC and PMEL, was developed for the NPRB/NSF Bering Sea Project and is currently a key part of the region's Integrated Ecosystem Assessment (IEA) work. Key developments of this model include improved ice dynamics and ice plankton dynamics critical for modeling the Bering Sea. Products of this model include a 40-year hindcast (1971-2012) for model validation, 9-month forecasts driven by NOAA CFS seasonal atmospheric forecasts, and long-term (2040-2100) forecasts forced by IPCC model results. 9-month forecasts are presented to management annually as part of the Ecosystem Assessment process. Long-term forecasts are being used for the Bering Sea Rapid Climate Assessment as well as for driving biological models discussed above.

A multispecies assessment model (CEATTLE) links the stock assessments of three key Bering Sea species – walleye pollock, Pacific cod, and arrowtooth flounder – by using 30+ years of groundfish diet data to link predation rates to mortality. This model uses bioenergetics growth and habitat-based predation overlap and so includes modeled impacts of temperature. The results of this model will be presented as an "alternate" stock assessment model in upcoming single-species stock assessments. For climate projections, the recruitment estimates of the assessment model are fit to a stock/recruit curve that includes climate covariates from the ROMS model; best fit covariates were fit from the ROMS model hindcast to use in future projections.

The FEAST model (Forage and Euphausiid Abundance in Space and Time) is a 2D, gridded, daily-scale multispecies length-based foraging, bioenergetics movement, and recruitment model for post-larval forage and predatory fish. It runs within the Bering10K-ROMS framework, with fish as state variables being tracked as 2D biological tracers. Fish numbers, condition factor and caloric density are driven by inputs of prey availability, depth-averaged temperature, and water movement (i.e. advection) from the Bering10K-ROMS-BESTNPZ model. The depth-averaged temperature is used in temperature-dependent functions for prey-consumption and metabolism. FEAST obtains daily estimated dry weight of euphausiids, small copepods, large copepods, and benthic infauna from the BESTNPZ and produces daily mortality rates for prey, which can be fed back into the BESTNPZ model as biomass consumed by fish for each zooplankton species and benthic infauna.This results in a two-way coupled modeling structure between plankton and fish. The FEAST model predicts the productivity and distribution of forage and and predators for investigating climate responses of the ecosystem and developing spatial-based management strategy evaluations. Of particular interest is the predictions of forage fields for determining the response of forage-sensitive predators such as fur seals.

Ecopath/Ecosim models have been used in the context of the Ecosystem Assessment since 2005; models have been created and maintained for the eastern Bering Sea, Gulf of Alaska, Aleutian Islands, and the Chukchi Sea (high Arctic). For the Bering Sea and Gulf of Alaska, they are the basis of guild-level analysis of productivity patterns produced for the ecosystem Report Cards annually presented to the Council. They have been used in natural mortality estimation for groundfish stocks, and in investigating cumulative impacts of fishing policies (TOR 5). The Alaska Center, in collaboration with the NEFSC, is also developing a set of statistical tools in R for validating food web model dynamics parameters (model fitting) especially focused on fitting to diet data collections.

Models are included and communicated in the management processes in several ways (TORs 6-7). The 9-month forecasts (EBS) and annual outputs of guild productivity based on survey biomasses (EBS, GOA, AI) are produced for ecosystem Report Cards and ecosystem assessment within the Ecosystem Considerations report. Also, selected ecosystem indicators from the Ecosystem Considerations are being evaluated for robustness under different climate forecasts. For the 9-month forecast, results are compared for the hindcast period for validation before inclusion. Guild biomass outputs were selected for the EBS and GOA Report Cards by teams of experts for the both regions (indicator selection process). Report Cards are reviewed annually by the Plan Teams and the SSC. Beginning in 2016, the CEATTLE model will be included and reviewed as part of the walleye pollock stock assessment. Models and MSE scenarios included in the ACLIM project will be done in collaboration with the regional councils and stakeholders.