NPFMC SSC Workshop on Multispecies and Ecosystem Modeling

Rennaissance Madison Hotel, East Room, Seattle, WA
February 9, 2005

Agenda

SECTION I: APPROACHES IMPLEMENTED ON A STOCK ASSESSMENT SCALE

8:00 - 8:30 **Introduction** (SSC Chair, Kerim Aydin)

8:30 - 9:00 **Jim Ianelli and Tom Wilderbuer**. Projection models for N. Pacific groundfish stocks, and needed research for multispecies technical interaction models.

9:00 - 9:15 Discussion

9:15 - 9:45 **Jesus Jurado-Molina and Pat Livingston**. Bering Sea Multispecies Virtual Population Analysis (MSVPA) and Multispecies Statistical Models.

9:45 - 10:00 Discussion

10:00 - 10:30 Break

10:30 - 11:00 **Kerim Aydin and Ivonne Ortiz.** Ecopath results from the Bering Sea/Aleutian Islands, and potential contributions to Stock Assessments.

11:00 - 11:15 Discussion

11:15 - 11:45 **Sarah Gaichas.** Gulf of Alaska Ecosim: retrospective analysis and predictive potential.

11:45 - 12:00 Discussion

12:00 - 1:00 Lunch

SECTION II: STRATEGIES/REFERENCE POINTS AND MULTISPECIES MODELS

1:00 - 1:15 **Franz Mueter**. Maximum productivity estimates for GOA and BSAI groundfish.

1:15 - 1:30 **Martin Dorn**. Extending separable age-structured assessment models to evaluate juvenile mortality trends of GOA walleye pollock.

1:30 - 1:45 **Teresa A'mar**. A Management Strategy Evaluation of the GOA walleye pollock fishery.

1:45 - 3:00 **GENERAL DISCUSSION** of current approaches within the stock assessment process

- can/should these results affect ABCs or TACs?; strategic approaches (MSE, etc.); baselines/indicators (B_0 and OY); predictive potential (all models); data gaps; bioeconomic integration

3:00 - 3:30 Break

SECTION III: DEVELOPING APPROACHES

3:30 - 3:45 **Kray Van Kirk and Terry Quinn.** A multi-species age-structured assessment model with measurement error in catch at age.

3:45 - 4:00 **Doug Kinzey**. Multispecies assessment of 3 stocks with predator-prey interactions in the Aleutians.

4:00 - 4:15 **William Stockhausen**. Multispecies production and marine reserve models.

4:15 - 4:30 **Grant Thompson**. Kalman filter models of multispecies systems.

4:30 - 5:30 **DISCUSS FUTURE PRIORITIES**

Summary of presentations

INTRODUCTION

Multispecies Modeling and Fisheries Management Needs [powerpoint]

Kerim Aydin, AFSC

Dr Aydin explained the design of the workshop, to focus on multispecies and ecosystem models as they can be applied to and useful for fishery management. Different types of multispecies and ecosystem models address bycatch and fishery interactions, the indirect effects of fishing, uncertainty, biological and physical interactions, or contribute ecological information into single species assessments. The workshop topic is timely, considering the goals in the NOAA 5 year strategic and research plans. Multispecies models offer a different perspective of the future compared to single species models. Multispecies and ecosystem models are continuing to develop, and a major purpose of this workshop is to get feedback from fishery managers on how they may best be applied for fishery management.

SECTION I: APPROACHES IMPLEMENTED ON A STOCK ASSESSMENT SCALE

Projection models for North Pacific groundfish stocks: research on multispecies technical interaction models [powerpoint]

James Ianelli and Tom Wildebuer, AFSC

Dr Ianelli presented four models for the workshop. The **standard projection model** is used for each age-structured stock assessment. The model provides projections given alternative fishing mortality rates. Specific enhancements include modifying the model to provide realistic acceptable biological catch (ABC) projections for two years, and providing a graphic user interface. This will improve the facility of the Plan Team and SSC to provide ABC recommendations.

The **multispecies technical interaction model** (MSTIM) is an extension of the standard projection model that accounts for incidental catch in different fisheries. The model was developed in order to evaluate the effects of different management policies. Incidental catch patterns are estimated from observer data regarding species composition by fishery, gear type, and area. The model includes a set of constraints that reflect regulatory requirements and mimic actual TAC-setting strategies. A linear programming approach is used (constrained optimization). The model is limited by the lack of available cost data (only the price of fish determines catch optimization). Also, the bycatch array is non-varying, differing stock recruitment dynamics are limited, and fishery management is presumed to be optimal (within the constraints imposed).

Dr Ianelli also presented **alternative models for predicting multispecies TACs**. The models rely on a historical database of the Council's ABCs and TACs for BSAI groundfish. Simple regression and GAM models are used to predict likely TACs based on the various species ABCs. The model is potentially a useful management tool for the NEPA analysis that accompanies the annual TACs, a draft of which precedes the annual industry TAC negotiations.

Finally, a **management strategy evaluation** for flatfish is intended to evaluate the impacts on flatfish from environmental shifts. The model is similar to the MSTIM, but each projection year involves running a 'new' stock assessment on simulated data. This type of feedback loop is critical for evaluating management strategies. Results are preliminary.

Multispecies Models in the Eastern Bering Sea [powerpoint]

Jesus Jurado-Molina and Patricia A. Livingston, AFSC

Dr Jurado-Molina presented three biological interaction models for the workshop. The **multispecies virtual population analysis** (MSVPA) model is a deterministic model developed originally by ICES. The model produces point estimates of predation mortality based on the suitability of prey biomass and predator-prey information from stomach contents. Estimates of predation mortality from the model are generally higher than the mortality used in single species stock assessments.

The **multispecies forecast** (MSFOR) model is the predictive counterpart of MSVPA. The model uses some of the same inputs as MSVPA, and some outputs from MSVPA.

The **multispecies statistical model** (MSM) is similar to MSVPA but is based on a statistical framework. Because it incorporates process and observation error, it produces a likelihood of predation mortality rather than simply point estimates. Another advantage is that it uses the same tools as single species assessments, so there is a basis to compare them. Still in the development stages, the model only includes limited species at present. The model is tuned to single species assessments, so long-term predictions of spawning stock biomass are similar, but when F rates are changed, the model illustrates the impact of trophic interactions. A potential difficulty with expansion of the model is the number of coefficients that are currently needed for each species.

Ecosystem Modeling: E. Bering Sea, Gulf of Alaska, and Aleutian Islands [powerpoint]

Kerim Aydin, Ivonne Ortiz, and Sarah Gaichas, AFSC

Dr Aydin described the use of Ecopath and, briefly, Ecosim models in Alaska. **Ecopath** models have been developed for the eastern Bering Sea, the Gulf of Alaska, and the Aleutian Islands. Diet and predator-prey information is entered for regions and subregions, from stomach content data. The model works on a mass balance equation, solving linear equations to balance production and consumption. Each data input is graded on an eight point scale, where each category is a qualitative judgment on reliability. End users are able to compare and analyze outcomes based on data quality.

The models result in food webs for the eastern Bering Sea and the Gulf of Alaska. The Aleutian Islands model is still under development. Although the food webs include hundreds of species, most are directly linked to four or five major species.

Although the results of the Ecopath models represent a static snapshot of the food web, they are useful to stock assessments. All of the groundfish stock assessments include a section on the predator-prey interactions of each assessed species. A web-based format is also being developed, which will allow users to see the relative importance of fishing and other predators in contributing to mortality. The model is useful for determining which species interact significantly.

Ecopath models can also be used to test simple hypotheses. For example, Dr Aydin illustrated the disturbance resulting from a ten percent removal of Pacific cod in the Bering Sea, Gulf of Alaska, or Aleutian Islands, which is muted in the first two areas but more pronounced in the Aleutian Islands both among predators and prey of Pacific cod. Such model results could be useful for conducting economic analyses, as well as identifying research areas.

Limitations of the Ecopath model result from data issues of infrequently sampled non-target species, and a poorly understood deep-water food web. The models don't include climate and recruitment drivers, although these could be included.

Ecosim, and its derivative, Elseas, are used to make dynamic assumptions. Dr Aydin suggested that dynamic models may provide a way to build correlation into stock assessment recruitment.

GOA retrospective analysis and predictive potential [powerpoint]

Sarah Gaichas, AFSC

Ms Gaichas presented a retrospective analysis of the GOA conducted with **Elseas, a derivative of Ecosim**. Elseas uses the same algorithms as Ecosim but is more flexible. The model is used to test hypotheses as to what drives species trends in the GOA. The four major species in the GOA are walleye pollock, Pacific cod, Pacific halibut, and arrowtooth flounder. Stock assessment biomass predictions and trawl survey diet information for juveniles and adults are included in the model. Ms Gaichas concludes that fishing influences alone are insufficient to explain the GOA biomass changes, and recruitment is an important driver.

Ms Gaichas also discussed predictive potential and the importance of tying models to the information needs of fishery managers. Single species stock assessment models are capable of quantitative prediction for one to two years out; ecosystem models make qualitative predictions, and an important consideration is how to convey uncertainty. However, ecosystem models can be used to assess fishing scenarios artificially perturbing the base case. For example, to test the effects of fishing hard on arrowtooth flounder, Ms Gaichas compares the model output for 50 years into the future, looking at the change in uncertainty. Results indicate that this scenario would result in the decrease of several other target species.

SECTION II: STRATEGIES/REFERENCE POINTS AND MULTISPECIES MODELS

Maximum productivity estimates for GOA and BSAI groundfish complexes [powerpoint]

Franz Mueter, Joint Institute for the Study of the Atmosphere and the Oceans, University of Washington

Dr Mueter presented an analysis of maximum productivity estimates for the BSAI and GOA groundfish complexes. Dr Mueter suggested several ways of estimating a multispecies maximum sustainable yield (MSY), but used a simple **aggregated surplus production model** for his analysis. The model treats each groundfish complex as a single stock, with biomass and catch summed across species. Dr Mueter's analysis may be useful to determine whether a review of the optimum yield (OY) range specified in the FMPs is necessary. Currently, the OY range is based on an arbitrary and inconsistent reduction in MSY to account for ecosystem considerations, and doesn't explicitly account for multispecies and ecosystem interactions, or uncertainty. The current upper bound of the BSAI OY range is 2 million mt, which from this study, appears to be conservative; for the GOA, the current upper bound of the OY is 0.8 million mt may require further evaluations.

Extending separable structured assessment models to evaluate trends in juvenile mortality of walleye pollock in the GOA [powerpoint]

Martin Dorn, AFSC

Using GOA walleye pollock as a case study, Dr Dorn examined ways to approximate ecosystem processes in a single species model. Many ecosystem effects in multispecies models are expressed at the

population level, as changes in mortality. In view of this, Dr Dorn presented an **extended single species model that accounts for juvenile predation**.

Most predation on GOA pollock is on juvenile fish. By adding new parameters to the model, namely mortality of age-1 fish with a decay coefficient, the model can potentially detect changes in juvenile mortality. When compared with the baseline model, results were similar for estimates of female spawning biomass, but different for year class abundance. This indicates a change in juvenile mortality over time, and may be important as stock assessment may otherwise predict biased estimates of stock size (i.e., higher than actual biomass). This method of extending single species models using mortality parameters, although simple, may also be used to address other ecosystem objectives.

Management Strategy Evaluation: a case study with applications for the Gulf of Alaska pollock fishery [powerpoint]

Teresa A'mar, QERM, University of Washington

Ms A'mar presented an outline for a management strategy evaluation of GOA walleye pollock. Ms A'mar intends to examine the robustness of various single species decision rules to ecosystem and multispecies forcing. Analysis will include the implications of both spatial and temporal stock structure and varying total allowable catches for meeting management objectives.

General Discussion

The SSC discussed the applicability of the various multispecies models for use in setting harvest levels. How close are we to using multispecies models in the Stock Assessment and Fishery Evaluation reports? A distinction was made between setting total allowable catches based on a multispecies model, and using ecological considerations from such models to augment information from single species models. Some of the multispecies models are ready to be used for adding ecosystem context to the single species model results. It was suggested that the first step would be to look at single species model results to determine to what extent individual fisheries are performing poorly, and if the addition of multi-species consideration might improve upon single-species assessments. At the same time, we should continue with system-level analysis to discover whether we should be concerned with further adjusting single species TACs.

SECTION III: DEVELOPING APPROACHES

Multispecies Assessment Models for Fisheries Management [powerpoint]

Terrance J. Quinn II and Kray F. Van Kirk, SFOS, UAF, Juneau, and Jeremy S. Collie, GSO, URI, Narragansett

Dr Quinn described a Sea Grant project to develop a new **multispecies, age-structured assessment model**. The model incorporates predator-prey calculations for determining natural mortality by age. The model is to be tested across GOA, Georges Bank, and North Sea species groups. The model includes a series of predator consumption equations based on simple parameters.

Mr Van Kirk explained that for the GOA, the project is using twenty years (1981-2001) of Alaska Fisheries Science Center stomach data to examine predation changes over time. The focus is on three species: Pacific cod, arrowtooth flounder, and walleye pollock. The model will use a predator-prey preference coefficient, and a predator-prey ratio per age class combination.

Multispecies Assessment of three stocks with predator-prey interactions in the Aleutians [powerpoint]

Douglas Kinzey and Andre Punt, School of Aquatic and Fishery Sciences, University of Washington

Mr Kinzey described a **multispecies assessment of three stocks with predator-prey interactions in the Aleutian Islands**. The project has expanded single species models of pollock, Atka mackerel, and Pacific cod to include predator-prey interactions in the Aleutian Islands, and will compare results to single species assessments from 1978 to 2003.

Modeling Marine Reserves [powerpoint]

William (Buck) T. Stockhausen, AFSC

Mr Stockhausen presented an analysis of **modeling multispecies marine reserves using spatially-explicit life history models**. Mr Stockhausen described an example in the Caribbean that he will be using to develop similar guidelines for marine reserves for Alaska rockfish.

In order to evaluate marine reserves for spiny lobster in Exuma Sound, Bahamas, Mr Stockhausen used spatially-explicit full life history models of the benthic and pelagic stages of the larvae and adult lobsters. The location and size of marine reserves should consider physical oceanographic patterns, and larval, juvenile, and adult dispersal patterns. Mr Stockhausen also addressed effects of marine reserves on fishing mortality and fishing effort.

Kalman Filter Models of Multispecies Systems: A Tale of Two Studies [powerpoint]

Grant Thompson, AFSC

Dr Thompson presented two studies using Kalman filter models of multispecies systems. The first **study evaluates single species versus multispecies models** in the context of managing for maximum sustainable yield (MSY). The key question addressed was: is it true that we must be overharvesting because we use single species models? Dr Thompson designed a hypothetical example to test the two types of models. The analysis concluded that the single species model was precautionary in some ways, but not in others. The study highlighted that in practice, multispecies models do not model all species but focus on a subset of the food web representing key species; given that, it is unclear whether single species models, albeit flawed, are worse.

The second is a **study of a Bayesian assessment of ecological risk** resulting from a press perturbation such as a 'constant catch' harvest policy. Using a hypothetical example, Dr Thompson presented a risk profile for four species. Such an assessment could allow managers to evaluate maximum acceptable decreases in species abundance.

SSC DISCUSSION OF FUTURE PRIORITIES

The SSC posed a number of suggestions for future directions in multispecies and ecosystem modeling. Some of these are captured below:

- How can these models be used to assess impacts on non-target species or marine mammals, and what data needs are required for such uses? Is there a need to incorporate spatial as well as abundance components of non-targets?
- How can the economic aspect of species tradeoffs be brought into these models (i.e., some species have more value than others)?

- How might models allow us to determine which management actions are likely to lead to undesirable ecosystem states? This would be useful for management analysis.
- Comparisons among outputs from different model types are encouraged.
- Many of the models are focusing on predation effects rather than climate effects; both effects should be addressed.