Project #: B71

Title:
Integrate economic-ecological models of pollock and cod

Principal Investigator(s) and Recipient Organization(s):

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$ 409,126 (UW); 69,500 (AFSC)

Report Period:
1 April 2009 through 30 September 2009

Report Date:
7 December 2009

Lead Author of Report:
Michael Dalton

Proposed timeline and milestones within report period:

- Attended relevant PI and EMC meetings:
  - June 2009 Modelers Workshop (w/presentation)
  - August 2009 FISH-Modelers meeting (w/presentation)
- Prepared NPRB semi-annual report

Project Summary:

- Develop and embed economic models for pollock and cod to drive commercial fishing in FEAST
- *BSIERP Hypothesis 5: Climate-ocean conditions will change and thus affect the abundance and distribution of commercial and subsistence fisheries*

Progress Summary:

- Presented Bioeconomic model to embed in FEAST
- Attended relevant PI and EMC meetings (see above)

Lessons learned and project adjustments:

Coupling of the ROMS-NPZ-FEAST models is behind schedule and as a consequence so is work on this project. At the end of this reporting period, the spatial resolution of the bioeconomic model needed to support FEAST had not been determined, and thus, the project objectives were not entirely clear. In particular, the observer data for pollock discussed at the June 2009 modelers meeting had not been used to drive spatial removals in a FEAST hindcast simulation, and in particular, these data were not available to use in this project. Development of the bioeconomic model will be delayed until a spatial time series of removals, based on observer data calibrated to official catch statistics from the region, become available (see the addendum to this report for details). A post-doc will be hired in January 2010 and most components of this project are expected to be back on the original schedule by March 2010. However, the timeline for project objectives scheduled in March 2010 and beyond are subject to FEAST progress in generating data to conduct the MSE.

Integration activity:
Dalton presented the FEAST bioeconomic modeling framework at June 2009 modelers meeting and the August 2009 FISH-modelers meeting.

Education and Outreach:
As an invited speaker at PICES 2009, Dalton presented the BSIERP modeling framework and SRES A2 and B2 scenario results of an energy-balanced global economic model that gives fuel prices and world food demand.

2009-2012 Tasks, Assignments, Timeline (updated to reflect current expectations)

What	*Who*	*Start (2009)*	*Other key dates*
Post-doc hire	PIs (Dalton, Punt, Aydin)	February 2009	Appointment begins January 2010
Code and documentation for economic models	Dalton	April 2009	Document ready for miniworkshop July 2009
Estimation and testing of economic models	Post-doc	January 2010	DELAYED until July 2010
Integration of economic models with FEAST	Post-doc	January 2010	Initial report on model integration by March 2010
Review FEAST integration and MSE coordination	PIs, Post-doc	February 2010	FEAST data generation for MSE March 2010?
Economic analysis of FEAST/MSE outcomes	Post-doc	April 2010	Economic analysis of outcomes by July 2010
Model Workshop I	PIs, Post-doc		July 2010
Draft publication on model integration	PIs, Post-doc	July 2010	Review by September 2010
Economic scenario development and model implementation	PIs, Post-doc	September 2010	Scenario implementation by January 2011
Scenario analysis	Post-doc	January 2011	Draft document due June 2011
Model Workshop II: Review results of scenario analysis	PIs, Post-doc		July 2011
Publication on scenario analysis	PIs, Post-doc	July 2011	Finalized by October 2011

November 2009 follow-up email from Mike Dalton to Francis Wiese regarding spatial scale and alternative FEAST bioeconomic models discussed at the June 2009 modelers meeting:

The bioeconomic model that I proposed for FEAST is quite flexible in its spatio-temporal resolution (e.g., in a single-area the continuous time limit of the model is a type of Brownian motion so in general it's Brownian motion on a lattice). So it's really a question of determining the level of resolution that the catch data will support. I won't say much about temporal resolution here but the same principles apply. For now, let's assume an A and B season in each year. A general comment is that the catch data won't resolve to10x10km grid so at some point we will need a downscaling procedure to go from the level of resolution that we think is supported by the catch data (i.e., observer data for pollock) to the ROMS-NPZ-FEAST grid.

The catch data obviously become sparser at finer spatio-temporal resolutions which becomes a major problem in model estimation because time series at finer scales often have zero values in many areas or time periods and the zero values are usually autocorrelated, making things even worse. The problem here is that disturbance terms are correlated with regressors thus violating one of the basic assumptions of the regression model which then leads to biased estimates.

If we use a subset of the fishing blocks where the most fishing occurs then we may be able to circumvent the zero-values problem through spatial aggregation (which Alan and I have been doing). Another approach would be to use an unbiased simulated maximum likelihood procedure, which we have available to us and can use, but the tradeoff is that type of approach is developed only for scalar time series which would place strong restrictions on the spatio-temporal relationships among grid cells. A third approach would consider a full range of spatio-temporal relationships but parameterizing these relationships goes up on the order of N^2 (essentially a matrix of interaction terms) which probably won't be practical if the number of spatial areas exceeds a number like 10 or 20.

At the June meeting, we discussed these 3 approaches (statistical fishing blocks, restricted model w/maximum spatial resolution, unrestricted model with limited spatial resolution). While we didn't settle on one as "best", it is important to note that all 3 come from the same family of dynamic models. The general idea here is maintain flexibility because it isn't at all clear which one will be best suited for FEAST.

We also spent a lot of time at the June meeting looking at Jim Ianelli's maps of observed catch over time. My recollection is that the distribution of catch had a number of distinct maxima that persisted in time. The "regions" around each maximum could encompass multiple fishing blocks. Since observer data do not need to be organized by the fishing blocks, the idea behind using 12 or so "regions" would be to identify a dozen or so areas with a distinct maximum, look at local bathymetric or other geographical features to determine if there was a natural way of bounding or characterizing these, and then, use these regions to organize the observer data. The observer data organized in these regions would then be used in the 3rd approach described above (unrestricted model w/limited spatial resolution). I suspect that Ivonne thought this "regional" approach was the most interesting and was potentially richer than the other 2 because it could include additional geographical information.

December 2009 Updated plan for the FEAST bioeconomic model:
James Murphy (SAFS PhD candidate) has been hired to begin assisting with this work in January 2010 (50% basis through winter quarter when he defends his thesis; expected 100% post-doc in spring 2010).

Instead of embedding in FEAST, the bioeconomic model will be linked directly with the MSE model, to be coupled with FEAST at a future date.

From the meeting of BSIERP FEAST, MSE, and economic modelers at AFSC in November 2009, it was clear that observer data for pollock going back to 1991, and calibrated to catch totals from the region, may not be as readily available as believed after the modelers meeting in June 2009. However there was consensus among the meeting participants that identical data should be used as input in FEAST, MSE, and the two economic models. Therefore, a fresh retrieval of observer data will be made and these will be adjusted to match pollock catch totals from the NMFS Alaska regional office for each year 1991-2009.

At the November 2009 modelers meeting, it still was not clear whether FEAST would aggregate or average observer-based catch over multiple 10km^2 grid cells, but it was clear that Haynie's model would operate on a much coarser spatial scale than FEAST (e.g., aggregated to fishing blocks to avoid technical problems associated with zero values). To avoid or at least minimize the use of an ad-hoc downscaling procedure, the FEAST modelers expressed a clear preference for a bioeconomic model of pollock removals that will match the spatial and temporal resolution of FEAST (i.e., daily time-step and 10km^2 grid). Only one of the 3 possible approaches for the FEAST bieconomic model described in the addendum above would meet this criterion. This one approach, based on a censored regression model to handle the ubiquitous zero values involved with maximizing spatial-temporal resolution, will be the one implemented starting in January 2010.

The likelihood functions for a spatial and dynamic Tobit model will be programmed in Fortran and R. Observer data on pollock catch from 1991- through the present will be resolved to 10km^2 cells on a daily time step. Each grid cell will be associated with its own time series of daily pollock catch. The series of each cell will probably contain many zero values indicating days with zero catch in that cell. A likelihood function based on the Tobit model for censored regressions will handle these zero values, which can severely bias the results of an ordinary regression. Therefore, each grid cell in the dataset will be associated with its own likelihood function and these will be maximized separately, and not jointly as a system. In the type of dynamic model that will be used, maximum likelihood estimation equation by equation gives consistent estimates but estimating the equations together as a system can be more efficient.

However, the potentially large number of grid cells with any pollock catch over the entire series (guessed to be between 5-10 thousand but could be as high as 20 thousand cells) necessitates that some simplifying assumptions be imposed on the regression model:

A1. Spatial autocorrelation is contemporaneous and catch dynamics of each cell are adequately represented by past values of catch in that cell and possibly other system-wide (and uncensored) variables such as prices or climate conditions.

A2. The dynamic regression equation for each cell is conditional on lagged values of the observed value of the censored variable and not on the unobserved value. The latter alternative requires simulated maximum likelihood estimation which is not practical here because of the computational overhead attributed to the large number of grid cells.

A3. Model error terms are multivariate normal and can exhibit contemporaneous correlation with other variables but serial autocorrelation is excluded.

The upshot of these three assumptions is that each likelihood function will contain contemporaneous variables from neighboring grid cells and lagged values (of multiple orders: e.g., previous days, same day previous year) plus lagged and current values of system-wide variables of interest such as the price of different pollock products (e.g., fillet, surimi, roe). The implementation of assumption A3 may require that the model include a high-order of lagged variables. There are standard statistical procedures to determine lag-length and tests to verify the normality assumption.

Note that variables representing the spatial distribution of the pollock stock will probably not be available in the first version of the spatial-dynamic Tobit model. These variables will be added when the simulated daily abundance of pollock is available for each grid cell from FEAST. If the FEAST modelers decide to average observer catch over multiple grid cells or choose another scheme, then the same resolution will be configured in the Tobit model described here.