Bering Sea Integrated Ecosystem Research Project: Format for Semiannual Progress Reports

Project #: B70

Title: Forage/euphausiid abundance in space and time

Principal Investigator(s) and Recipient Organization(s):
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Contract Period and Amount of Funding:
April 1, 2008 to September 30, 2011.
$506,716

Report Period:
April 1, 2009 to September 30, 2009.

Report Date:
September 30, 2009

Lead Author of Report:
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Proposed timeline and milestones within report period:

i) Incorporation of 2008 field data	Jan-July 2009
ii) Mini-workshop (vertically integrated models)	July 2009
iii) High resolution ensemble runs	July 2009-July 2010
iv) Ongoing incorporation of field data	July 2009-July 2010
v) Low-resolution/retrospective runs for Management strategy evaluation	Jan-July 2009

Project Summary: We will implement a spatially-explicit forage fish/Pollock 3-D model based within ROMS, which communicates directly with the NPZ model (M.5) and allows for behaviors such as aggregation at fronts. This approach allows for depletion of primary and secondary production by all higher trophic levels, hence a simultaneous treatment of both top-down and bottom-up effects in the ensemble runs with euphausiids and pollock as the key interface between controlling mechanisms. The scale for the grid is 10km and covers the Bering Sea shelf. The FEAST model will have several sub-components, developed separately and finally integrated. The components include: Forage species (spatial distribution of prey fields), Cod/ATF/Salmon (pollock predators modeled within FEAST), Bird/mammal (forage fields and forage success) and Economic (spatial fishing choice model).

Progress Summary:

i) **Incorporation of 2008 field data**: Most data collected in 2008 has been incorporated in the analysis of retrospective data used to establish growth curve parameters, length-weight relationships for pollock, cod and arrowtooth flounder, and amount of non modeled prey consumed. Data sources include all databases related to the bottom trawls surveys, summer acoustic/midwater trawl surveys for pollock and fish food habits data from AFSC retrospective sources as well as from project B.61. In addition, we have been exploring spatial patterns in prey consumption and warm/cold temperature comparisons for arrowtooth and cod. The BASIS and acoustic surveys conducted by AFSC/NOAA for 2008 need to be incorporated and 2008 data has not yet being incorporated in the analysis to set year-location specific initial conditions for biomass and length distribution of walleye pollock, Pacific cod and arrowtooth flounder. This analysis has been focused on initial conditions for years 1999 and 2004, once all the criteria and methods have

been worked out they can be applied to any other year. We are no longer adding mortality in FEAST from jellyfish on fish. The recommendation for its inclusion followed the observation of large quantities of jellyfish with small fish in their stomachs during the 2008 BASIS survey. However it was later noted that no measurements were taken on jellyfish stomach contents and the algorithm to estimate jellyfish abundance from acoustic data is still under development. Figure 1 shows zooplankton biomass and consumption by pollock as estimated during 1999 by the 1D version of FEAST. Figure 2 shows the distribution of pollock by length classes in 1999 and 2004 used to estimate initial conditions of pollock distribution to start off the 3D version of FEAST.

ii) **Mini-workshop (vertically integrated models):** The mini workshop took place June 1-3, 2009 and was attended by all modelers involved in the vertically integrated model as well as Will Satterthwaite who is working on the behavioral model and Jim Ianelli, working on management strategy evaluation. The workshop provided the opportunity to present a detailed explanation and update on each model, discuss best approach to continue on model advance, collaboration across modeling groups to get data, model inputs and learn new software and coding details. During the workshop we were also able to run the 1D version of ROMS/NPZ/FEAST in parallel on the 88 processors. The mini-workshop concluded with the agenda for the next six months for the vertically integrated model, a summary of performance metrics for each model component and a list of potential outputs of interest for the database. A full report of the workshop activities was provided to the Ecosystem Modeling Committee and NPRB.

iii) **High resolution ensemble runs:** We are putting together the full 3D code using the latest ROMS-NPZ and FEAST runs. Updates in the ROMS model (changes in equations/codes) conflicted with the FEAST code and are still being resolved, we expect to have a functional fully coupled 3D version working by the October PI meeting at Girdwood with at least the 1999 run and be able to provide full runtime estimates. During the mini-workshop it was decided to first have one year hindcasts for 1999 (a cold year) and 2004 (a warm year), and then try to have a multiple year simulation with the set of years yet to be determined depending on ROMS latest runs and available data. The selection of suitable climate models for ensemble runs is almost finalized (Nick Bond), however the specific climate models and climate scenarios to run forecasts have not been selected/discussed yet). **As of 9/24/09, the 3D full model is running on the AFSC Cluster. We are currently conducting speed and basic output tests.**

iv) **Ongoing incorporation of field data:** We attended the Fish Group meeting and discussed some of the ways in which the field data could be incorporated into FEAST, particularly with respect to movement and vertical distribution of pollock. We have started the spatiotemporal analysis of length and age data in fisheries removals to estimate initial conditions for the 1D and 3D models in January 1999 and January 2004, we are also hoping to incorporate some of the results in the field data analysis to improve fish horizontal initial distribution –particularly that of eggs, larvae and age zeros. Our current functional 1D version has a fixed value for mortality "other than zooplankton predation" in the NPZ portion, and a fixed consumption rate for fish in the FEAST portion. These current values cause a mismatch: there is either too much pollock consumption, or not enough euphausiid production. We are currently working on 1) how best to split the "other than zooplankton mortality" into "fish predation and other sources of mortality", and on 2) how to improve our estimate of fish consumption. Although some ways on how to resolve this mismatch were proposed at the Fish Group meeting, we hope to have a larger discussion at Girdwood with observational biologists and get their input on how best to resolve the mismatch.

v) **Low-resolution / retrospective runs for management strategy evaluation:** A low resolution version of FEAST was explored earlier this year, but during the mini-workshop it was decided that time was best invested in refining the 1D version of ROMS-NPZ-FEAST and putting together the full 3D version. These versions of the ROMS-NPZ have been updated with the latest versions of each corresponding model and have the capability of two way feedback with FEAST set on a daily time step. They still have three species only: walleye pollock, Pacific cod and arrowtooth flounder although both cod and arrowtooth are currently treated with a biomass of zero. The 1D version does show pollock >10cm (age

1+) growing at expected rates and timing and is now running with ROMS outputs (as opposed to analytical curves or time-location specific data).

Lessons learned and project adjustments:

While feedback from the acoustics surveys highlighted the relevance of jellyfish biomass and potentially high predation on fish, (changing FEAST set-up where predation mortality only went from FEAST to the NPZ component -fish eating zooplankton) we later learned that no quantitative estimates of stomach contents/ composition were taken. Furthermore, with the algorithm to estimate jellyfish abundance from acoustic data still under development our ability to incorporate this into FEAST in the short term is very limited. For the moment, we have decided to postpone this revision to the model until better jellyfish abundance data is available.

During the mini-workshop we decided to split the benthic infauna box in the NPZ model into two boxes: benthic infauna and benthic epifauna to improve how model captures cod-benthos dynamics in FEAST. This modification will not show on this first version of the 1D or 3D versions, but we would expect to incorporate it when cod and arrowtooth are added.

We found developing any functional version of a fully coupled ROMS-NPZ-FEAST is very time consuming, and results should be highly informative given the effort involved. Thus we decided to keep developing the 1D and high resolution 3D versions of FEAST and stop developing the coarse resolution 3D version.

Increasing the frequency of our meetings from every two weeks to weekly meetings has facilitated our progress on the joint NPZ-FEAST calibration and clarification of technical details as they come up.

Integration activity: We have maintained active communication both with modelers and field researchers. On the modeling side, we found the mini-workshop to improve overall understanding of all components of the vertically integrated model. We have continued working very closely with Al Hermann and Georgina Gibson by holding weekly meetings, mainly to discuss parameter values, estimates of the ROMS-NPZ-FEAST 1-D version, and set up tasks to have the 3D version working. As of early September we have involved Elizabeth Moffitt (MSE postdoc) in some of these discussions. With regards to competing models we have included Jim Ianelli and Andre Punt (MSE project) as well as Marc Mangel and Will Satterthwaite (Behavioral model) in all major discussions, mini-workshop and model updates to ensure FEAST and MSE have compatible data outputs, catch reconstruction assumptions in hindcasts; and ensure FEAST and the Behavioral model have compatible data outputs. As for integration with field biologists, our major exchange occurred during the Fish Group meeting in June, when all modelers presented brief updated summaries of their corresponding model and attended the presentations of preliminary findings of fish projects. During this meeting we discussed how some of these results could be incorporated into FEAST (e.g. in movement or vertical distribution). We have maintained close consultation with Patrick Ressler, discussing overlaps of pollock and euphausiids. In particular, we look forward to discussing with the field biologists at Girdwood how best to approach the mismatch we currently have between fish consumption and euphausiid production. We hope this discussion will provide some consensus on what the model assumptions/ best parameter values should be, or a preferred method on how to guide the selection process. We also hope to get some feedback on the performance metrics we have proposed (this was proposed during the mini-workshop as a goal for the Fish Meeting but we somehow focused on the pollock/euphausiid mismatch and didn't address the performance measures directly).

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Education and Outreach:
We presented both a talk and a poster at the GLOBEC meeting in Victoria (June 22-26, 2009), as well a talk at ESSAS in Seattle June 17-19, 2003. The talks provided an overview of some background information used in FEAST, model principles and assumptions as well as challenges and current status. The poster provided an overview of FEAST and the vertically integrated modeling, as well as some of the spatial/ temporal patterns in diets and distribution of walleye pollock in the Bering Sea.

Next year's Work plan (not part of the 5 page target length):

BSIERP B70, Forage/euphausiid abundance in space and time, Kerim Aydin, Kerim.Aydin@noaa.gov, (206)526-4225

2009-2012 Tasks, Assignments, Timeline

What	*Who*	*Start (2009)*	*Other key dates*
Review and report links between hypotheses and models	Aydin	March 2008	
FEAST initial programming integration	Aydin, Ortiz, Hermann	July 2008	
Mini-workshop (vertically integrated models)	Aydin, Ortiz, Punt, BEST	July 2008	
Incorporation of available retrospective data	Ortiz	July-Dec 2008	
Coupled model first transect/low res runs	Aydin, Ortiz, Hermann	Jan 2009	
Initial NPZ/FEAST sensitivity analysis showing sensitive parameters for field research	Aydin, Ortiz, Hermann, BEST	Jan 2009	
Presentation/workshop with field researchers	Aydin, Ortiz, Hermann, BEST	Oct 08, Jan 09	
Incorporation of 2008 field data	Ortiz	Jan-July 2009	
Mini-workshop (vertically integrated models)	Aydin, Ortiz, Hermann, BEST	July 2009	
High resolution ensemble runs	Aydin, Ortiz, Hermann, BEST	July 09–July 10	
Ongoing incorporation of field data	Ortiz	July 09–July 10	
Low-resolution/retrospective runs for Management strategy evaluation	Aydin, Punt, Ortiz	July 09–July 10	
Results of field work incorporation, presentation of "new hypotheses" for testing in 2010 field season	Aydin, Ortiz	Jan 2010	

MODEL WORKSHOP I, initial integration of multiple models ("parallel" models), driven by management analyses of needs	Aydin, Ortiz, Punt, Hermann, BEST	July 2010	
Scenario examination using ensemble runs, focusing on future scenarios, including for humans, birds and marine mammals, final evaluations of "uncertainty" in projections, comparisons with parallel models	Ortiz, Aydin, Punt, Hermann, BEST	July 2010-July 2011:	
Hypothesis evaluation workshop (evaluation of primary field "hypotheses" from the results of the models, and final field season (hypothesis testing season) begin "final publication" on combined model and data syntheses of "Bering Sea Structure and Function")	Aydin, Ortiz, Hermann, BEST	January 2011	
MODEL WORKSHOP II on results of management strategy evaluation, recommendation of a "prediction strategy" for future use of these models and field work, especially within an ongoing NPFMC management context.	Punt, Ortiz, Aydin	July 2011	
Completion of publications, final reports	Aydin, Ortiz, Punt, Hermann, BEST	Sept. 2011	

Publications:

We expect the vertically-integrated sequence to include two "publication sets" (July 2010, July 2011 submission). These "publication sets" are envisioned as special volumes of peer-reviewed journals, along with accompanying "glossy and web versions" (developed with NPRB/BSIERP outreach assistance) for public access to results. The first publication set will focus on the models themselves (technical details) while the second will focus on management uses of the models.

A third publication set, integrating "our understanding and predictions for the Bering Sea ecosystem" may be lead from either the modeling or the field side, and will focus on the evaluation of the "core hypotheses" for Bering Sea structure and function (results of Jan 2011 workshop?). Additional publications are expected as individual results are completed, but are not explicitly scheduled.

Results are expected to be presented to the NPFMC Council (Plan Teams, SSC, and public) beginning in Fall 2009, thereafter following an annual presentation schedule (Aydin, lead) deemed appropriate by the Council.

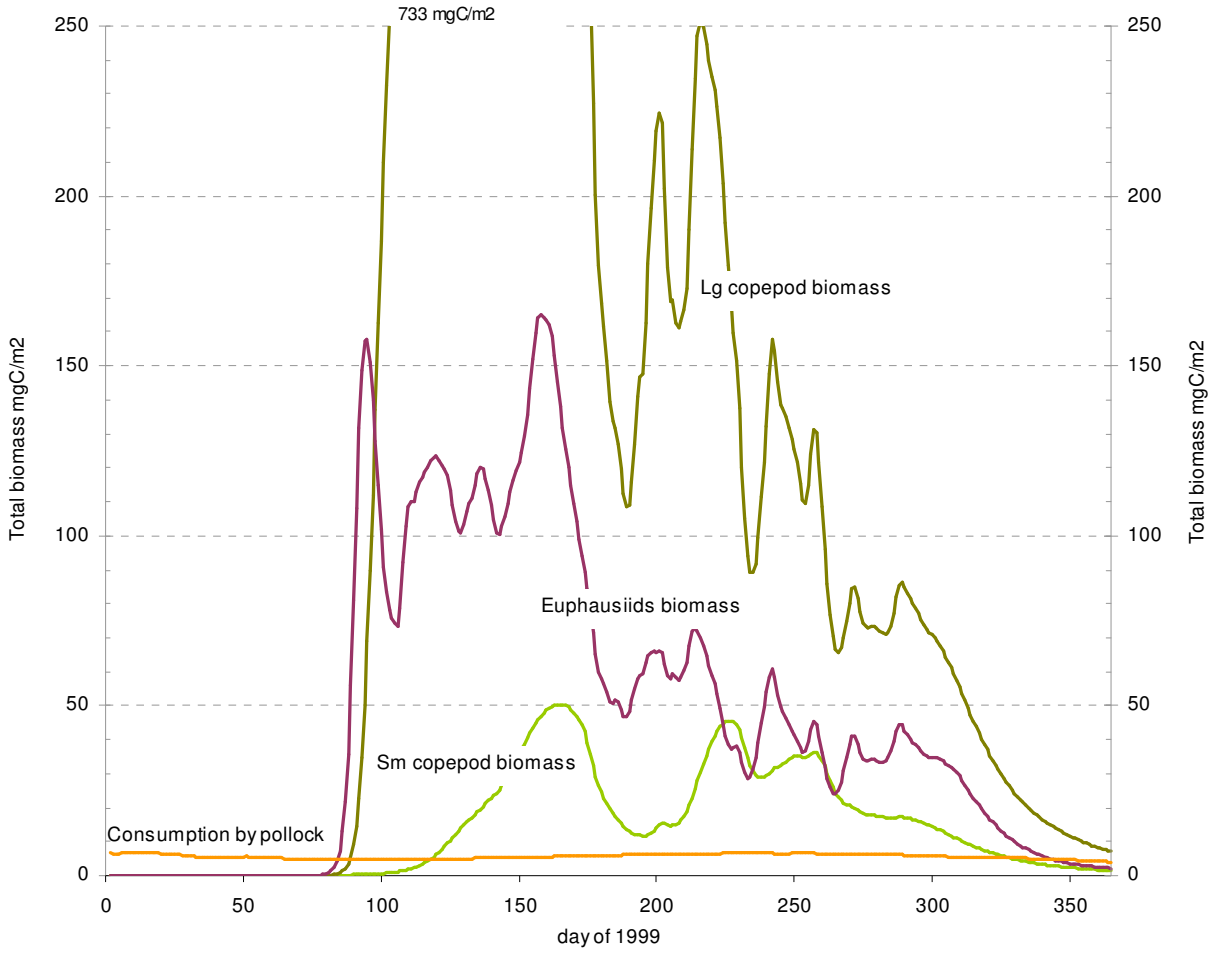

Figure 1. Biomass (mgC/m^2) of large and small copepods and euphausiids compared to consumption of zooplankton by all pollock at mooring M2 (SE Bering Sea) as estimated by 1D version of FEAST

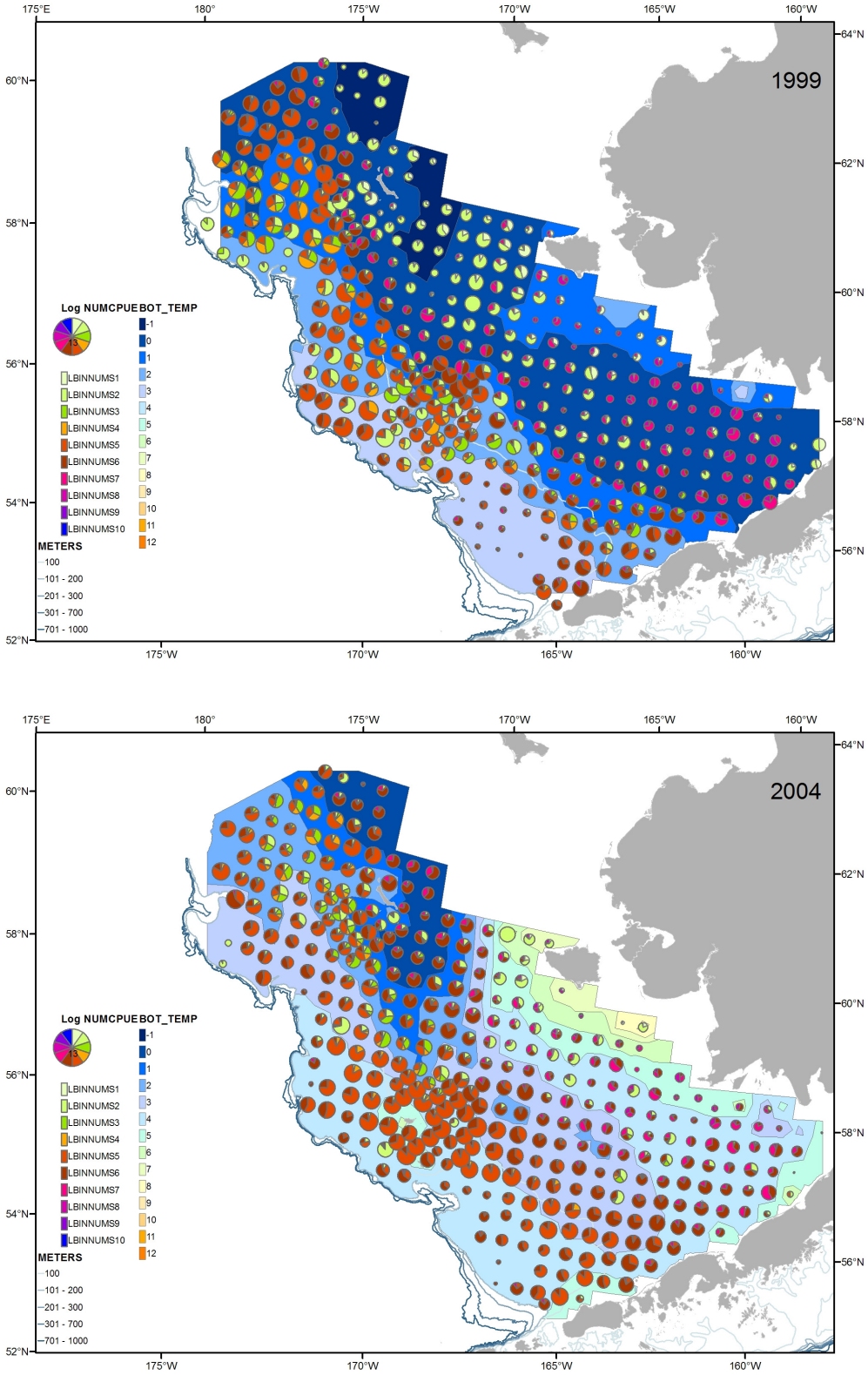

Figure 2. Summer length composition in 10 cm length categories from the bottom trawl survey during a cold year, 1999 (top), and warm year, 2004 (bottom); data are used to estimate initial conditions of pollock distribution of length classes in the one year runs of the 3D version of FEAST.