

North Pacific Research Board Semiannual Progress Reports
Project # 607

Title: Modeling study on the response of lower trophic level production to climate

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Project Summary:

The most prominent climate trends resulting from global climate warming in the southeastern Bering Sea, reduced sea ice cover and rising seawater temperature, have profound impacts on lower trophic level production and fishery production. Some explanatory hypotheses relating sea ice variability to marine ecosystems have been proposed, such as the Oscillating Control Hypothesis (OCH, Hunt et al. 2002), but have not been studied through a coupled ice-ocean ecosystem model yet. This study aims to establish a coupled ice-ocean ecosystem model including both pelagic and sea ice habitats, based on the existing pelagic ecosystem model (Jin et al. 2006b) for the Bering Sea and the ice-ocean ecosystem model (Jin et al. 2006a) for offshore Barrow. We will conduct sensitivity studies of the impact of physical and biological process variations on primary production, nutrient cycling, phytoplankton species composition, and carbon export to benthos. We will provide recommendations on how, when and which observations should be made to ensure effective improvement in understanding of the Bering Sea ecosystem. Historical observations from the NOAA mooring site M2 are being used to construct a multi-year (1958-2005) model run. The long time series of biogeochemical model results will be used to elucidate the lower trophic level productivity response to climate changes.

Progress Summary:

During the first half year of 2007, we published a manuscript in the March issue of *Geophysical Research Letters*:

Jin, M., C. Deal, J. Wang, V. Alexander, R. Gradinger, S. Saitoh, T. Iida, Z. Wan, and P. Stabeno 2007. **Ice-associated phytoplankton blooms in the southeastern Bering Sea.** *Geophysical Research Letters*, 34, L06612, doi:10.1029/2006GL028849.

This paper introduced a newly developed ice-ocean ecosystem model of the southeast Bering Sea which correctly reproduced the ice-associated phytoplankton blooms observed in 1997 and 1999. The model suggests that blooms, seeded by algae released from melting sea ice, can thrive if melting and resulting low-salinity stratification at the surface are not followed by wind-driven mixing. The high biological productivity of the southeastern Bering Sea shelf is modulated by seasonal sea ice cover. The bloom's timing and magnitude, as well as species shifts associated with fluctuating ice margins coupled with gradual ecosystem changes associated with global warming, can dramatically alter the Bering Sea ecosystem. A news report of the paper can be found on the AGU Journal Highlights (http://www.agu.org/sci_soc/jh/2007-04-16.html).

On the basis of the above model development and research conclusions, we further conducted model runs from 1970 to present to validate the long-term model performance and investigate the linkage of the lower trophic level production to decadal climate effects on the regional ecosystem and fishery production. The model results were validated with various observed data available: remote sensing data (sea surface Chl-a, 1997-present, and temperature from 1995-present), PROBES data (temperature, salinity, and Chl-a, 1980-1981) and PMEL/NOAA Mooring 2 data (temperature, salinity, and fluorometer etc., 1995-present). The model results showed changes of bloom patterns after the 1976/77 regime shift. Statistical relationships were sought among the model results (monthly and seasonal primary production, mixed-layer depth, temperature etc.), climate index (PDO winter, summer, annual index; AO index) and fishery catches (annual mean weight of catch per unit effort (WTCPUE) in several regions of the eastern Bering Sea). A graduate student was hired to work on the statistics this summer. A manuscript on the broad model validation and statistical research was in preparation.

Jin was invited to Advances in Marine Ecosystem Modelling Research (AMEMR) workshop, Plymouth, UK, Feb 5-9. A presentation was given titled as 'Sea ice modulation on primary production in the polar and subpolar regions'.

Jin and Deal attended the Brussels, Belgium, SOLAS-sponsored CODiM workshop (Comparison of Oceanic Dimethylsulfide Models) in December 2006, and the results of ecosystem model comparison were presented at the European Geophysical Union (EGU) meeting in Vienna, Austria this April. A joint manuscript by the meeting participants is in preparation. Title is: A first appraisal of ocean DMS models and prospects for their use in climate models.

Outreach and education:

- A graduate student is hired to work on statistics of the model variables, climate index and fishery catch data in summer 2007.
- Jin, Deal and Lee (in Korea) will chair a session in the 2008 Ocean Science Meeting in Orlando on March 2-7. Session title is "Ecosystem in sea ice influenced areas: observations and modeling studies" (Session statement will appear on AGU web site soon)

Updates of our project web site: <http://www.frontier.iarc.uaf.edu/nprb2006/>