PROJECT SUMMARY

NGOMEX 2006: Improving the accuracy of hypoxia models for the northern Gulf of Mexico

Investigators: Dubravko Justić and Brian Fry
Institution: Coastal Ecology Institute, Louisiana State University, Baton Rouge, Louisiana
Project Period: May 1, 2006 - April 30, 2009
Project Cost: $599,440

Problem: Large-scale hypoxia in the northern Gulf of Mexico, recently affecting a record area of 22,000 km^2, overlaps with habitat and fishing grounds of commercially important fish and shrimp species. In 2001, the Mississippi River Watershed/Gulf of Mexico Hypoxia Task Force set a goal to reduce the 5-year running average of the Gulf's hypoxic zone to less than 5,000 km^2 by the year 2015. The proposed action plan suggested that a 30% reduction in nitrogen load is needed to reach the goal. Although there is a general consensus among scientists that large-scale reductions in the nitrogen flux of the Mississippi River would eventually lead to a decrease in areal extent and severity of hypoxia, the degree of nutrient reduction needed to produce temporal or spatial diminishment in the hypoxic zone cannot be determined from the existing models. This is largely due to poor model parameterization arising from (1) the lack of detailed understanding of the partitioning of oxygen and dynamics amongst the key biological and physical processes, and, (2) the excessive use of default model parameters, i.e., parameters that were not independently verified by field studies in the region. Thus, in spite of the considerable monitoring and modeling efforts carried out since 1985, imprecise field oxygen (O) and carbon (C) budgets strongly limit the accuracy of model forecasts and hindcasts about timing and extent of hypoxia. These problems are routinely detected in diagnostic box and 1-D model simulations and will not be resolved by just adopting larger 3-D models.

Objectives and approach: The main objective is to develop and calibrate an advanced process-based hypoxia module for the Louisiana shelf that would be suitable for coupling to a 3-D hydrodynamic model. The module will advance hypoxia modeling by incorporating experimental results to (1) estimate the importance of benthic and epibenthic oxygen production, (2) partition the total oxygen uptake in the Gulf's hypoxic zone into water-column and benthic respiration, and (3) estimate the relative forcings of biology and physics as controls of hypoxia in relatively stagnant bottom waters.

Proposed work uses a multiple-budget, cross-checking approach to partition the dynamics of O_2 and DIC (dissolved inorganic carbon) amongst the key biological and physical processes. Budgets are based on conventional O and C concentration measurements, but also on O and C isotopic measurements. This multiple-budget approach allows new and robust estimates of photosynthesis (P) and respiration (R) rates across the Louisiana shelf, elucidating the basic biological controls of hypoxia development and persistence. Physical controls of hypoxia will be inferred from differences between bottle incubations and whole-system field studies.

Relevance: This proposed research will improve our understanding of oxygen and carbon cycling, reduce errors in model parameterization, and enhance the overall validity of hypoxia models. The hypoxia module resulting from this research should greatly enhance efforts to predict the spatial and temporal extent of hypoxia over the Louisiana continental shelf. Likewise, future management of hypoxia may hinge on developing an accurate hypoxia module.