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Modeling Approaches for Assessment of Biological Responses to Nutrients in Estuaries

W. Nelson[3], P. Eldridge[3], M. Murrell[2], J. Hagy[2], R. Devereux [2], E. Dettmann[1], J. Kaldy[3], J. Latimer[1],
T. DeWitt[3], C. Brown[3], B. Boese[3], D. Young[3], D. Keith[1]
National Health and Environmental Effects Research Laboratory, Atlantic[1], Gulf [2], and Western[3] Ecology Divisions

LTG 1 Poster 5

Science Questions

Long Term Goal 1: Provide the approaches and methods to develop and apply nutrient criteria that will support designated uses for aquatic systems

What are the quantitative and causal relationships between varying levels of nutrients and the biological response of aquatic ecosystems and the resulting services such systems provide?

How Research Addresses the Water Quality MYP Goals

Current EPA guidance on establishing quantitative nutrient criteria is based principally on nutrient levels and the assumption that criteria levels will be protective of estuarine resources. The NHEERL modeling approaches will allow assessment of whether proposed quantitative nutrient standards are likely to be protective of coastal resources.

Research Objective

Provide the models of load-response relationships for 1) Submerged Aquatic Vegetation (SAV), 2) Food Web and 3) Hypoxia endpoints required to develop improved numeric, nutrient criteria.

Research Approaches

1) Develop numerical seagrass stress-response models for eelgrass (*Zostera marina*) and for turtlegrass (*Thalassia testudinum*)

2) Develop empirical and network optimization models to identify the response of a range of food web indicators to nutrient loads

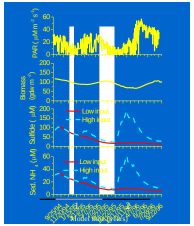
3) Quantify ecosystem processes that control hypoxia, including physical transport, sediment metabolism and plankton metabolism

Research Results – 1) SAV

Model Output: SAV response to Texas brown tide

- Blooms did not impact SAV biomass
- High organic load scenario increased sediment sulfide
- Sulfide did not reach toxic threshold

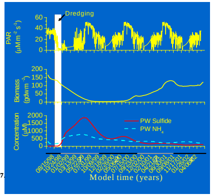
Eldridge et al. (2004) Estuaries 27(4):923-937.



Model Output: Seagrass Response to Dredging

- Impacted biomass
- Persistent toxic sulfide conditions

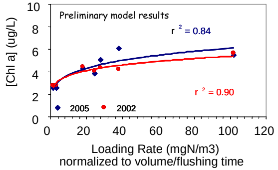
Eldridge et al. (2004) Estuaries 27(4):923-937.



The SAV stress response models utilize inputs of light, nutrient levels, and other environmental variables and provides output for plant biomass, together with sediment geochemical variables.

Models can be applied to examine effects of multiple stressors including nutrients, brown tides (top graph), or dredging (lower graph).

Research Results – 2) Food Web

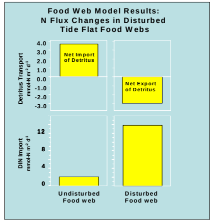


Empirical models: Define regional responses of food web indicators such as CHL *a*, SAV, benthos to increasing nutrient loads (see poster LTG1-04 for details),

Predicts: disturbed food web exported detritus to other estuarine habitats

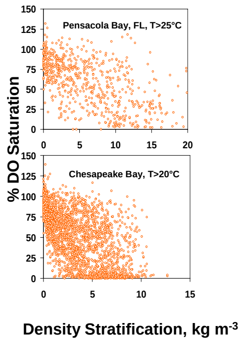
Predicts: Disturbed food web needs imported DIN to support productivity

(DIN – Dissolved Inorganic Nitrogen)



Estuarine Food Web Network Optimization models: Developed through stable isotope measurements and use of inverse analysis techniques, adds ecosystem functional indicators to structural indicators of food web perturbation by nutrients.

Research Results – 3) Hypoxia



Density stratification of the water column is a critical factor in the development of hypoxia in estuaries. Higher density stratification is expected to result in a higher probability of low % oxygen saturation. More than 22,000 observations of bottom O_2, density stratification and other important variables were compiled from more than 50 estuaries to examine this relationship.

Research Conclusions & Future Directions – 1) SAV

Models are now being validated for nutrient effects with field data and/or laboratory mesocosm experiments in the Northwest, Northeast and Gulf regions. Phase II models will be spatially explicit and predict SAV population characteristics such as distribution extent.

Research Conclusions & Future Directions - 2) Food Web

Increases in nutrient loads relate to increases in phytoplankton levels (CHL *a*): shown for NE estuaries.
Food web models have demonstrated that habitat disturbance alters N flux: next step is to calibrate model responses to predict effects on food webs of increased nutrient loads.

Research Conclusions & Future Directions – 3) Hypoxia

Physical factors could explain approximately 50% of the variability in bottom O_2. Ongoing work is examining how factors related to nutrient enrichment may explain some of the remaining uncertainty, thereby helping to quantify risk of hypoxia due to nutrient enrichment in the physically diverse environments of estuaries.

Interactions with Customers

Great Lakes Ecological Indicators Project
Long Island Sound Study Management Council
Science & Technology Advisory Committee
EPA Office of Water
National Nutrient Coordinators
National Nutrient Implementation Workgroup
National Estuaries Nutrient Criteria Workgroup
NOAA
National Eutrophication Update Team
National Classification Team
US Army Corps of Engineers (ACE) Galveston Office
States
NH Estuarine Nutrient Criteria
CT Eelgrass Steering Committee
RI TMDL Program
TX Interagency Coordination Team
WA Dept. of Natural Resources

How Research Contributes to Outcomes

Seagrass stress-response model will be used to evaluate proposed nutrient criteria in Yaquina Bay, OR as part of case study for OW development of nutrient criteria.

Nitrogen load-eelgrass response models will be used by the state of CT as part of weight of evidence to determine critical nitrogen loading limits protective of eelgrass habitat designated uses.

RI, NH exploring use of load-response models to determine critical loads protective of estuarine habitats.

US ACE used seagrass stress-response model to determine dredge spoil placement guidelines in Laguna Madres TX.