Hypoxia Forecast Models in Coastal Waters used to Inform Nutrient Management

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National Centers for Coastal Ocean Science

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Nutrient Pollution Can Lead to Hypoxia

Nutrient Pollution $\downarrow$

Algal Blooms $\downarrow$

Bacterial Decay $\downarrow$

Oxygen Depletion (Hypoxia) $\downarrow$

Fish and shellfish mortality, habitat loss, reproductive stress, population reductions
Scenario Forecast Models

Predictive models used to:

- inform management goal-setting,
- monitor progress of management actions, and
- evaluate the effectiveness of alternative management scenarios

Model ensemble suggests a 35 - 45% reduction in N loads to meet Gulf Hypoxia Action Plan Goal

Scavia et al
Legislatively Mandated Hypoxia Programs

- Coastal Hypoxia Research Program (CHRP)
- Northern Gulf of Mexico Ecosystems and Hypoxia Assessment Program (NGOMEX)
  - Develop the capability to predict hypoxia in response to anthropogenic and climatic stress, and to evaluate the ecological, economic, and social impacts;
  - Provide results and modeling tools to coastal managers to assess alternative strategies for preventing, controlling, or mitigating the impacts of hypoxia on coastal ecosystems.
Sources of Nutrient Pollution Vary by Region

Gulf of Mexico

% Contribution to Nitrogen Pollution

Greatest source: Agriculture

Source: Alexander et al. (2008)
Sources of Nutrient Pollution Vary by Region

Narragansett Bay

% Contribution to Nitrogen Pollution

Greatest Source: Urban areas

Atmospheric

Agriculture

Urban/Suburban

Source: Nixon et al. (2008), Moore et al. (2004)
Narragansett Bay

**Lead PI:** Dan Codiga/Candace Oviatt (URI)

**Partners:** Brown U; U Conn; VIMS; RI DEM; Narr Bay Estuary Program, RI Rivers, Bays, & Watersheds Coordination Team; EPA

**Models:**
- Empirical hindcast/forecast statistical
- ROMS Hydrodynamic
- Bio/Phys Ecological GEM (Gross Exchange Matrix)
- Ecological OBM (Officer Box Model)

**Management Need:**
- In 2003, an intensive hypoxia event in NB prompted a new state law to impose N limits on wastewater treatment facilities;
- Models used to evaluate effectiveness of N reductions in mitigating hypoxia and its ecological impacts, and to inform future nutrient reduction targets.

Source: Warren Prell (Brown U)
Lake Erie

Lead PI: Don Scavia (U. Mich)
ECOFOR Program

Partners: Heidelberg U; NOAA; W Mich U; LimnoTech; Purdue; Ohio St; E2 Inc

Models:
- Statistical models
- Hydrodynamic - SWAT (Soil & Water Assessment Tool)
- DLBRM (Distributed Large Basin Runoff Model)
- Several ecological models

Management Need:
- Inform regulators of phosphorus reduction targets needed for hypoxia mitigation;
- Model forecasts used by Lake Erie fisheries managers to guide fisheries policies in response to anticipated hypoxia impacts.
Green Bay

Lead PI: Val Klump (U. Wisconsin – Milwaukee)

Partners: UW-Green Bay; UW-Madison Ctr Climate Res; Wisc Initiative on Climate Change Impacts; GB Metropolitan Sewerage District; WDNR; EPA; USGS

Models:
• FVCOM Hydrodynamic coupled to biogeochemical model
• SWAT Watershed
• Downscaled global climate models

Management Need:
• Models assessing effectiveness of current P reduction BMPs, and providing guidance for future nutrient reduction targets taking into account watershed land use and climate change.
Chesapeake Bay & Delaware Inland Bays

**Lead PI:** Mike Kemp (U. Maryland Center for Environmental Sciences)

**Partners:** U Del; Dalhousie U

**Models:**
- Multivariate regression models
- Statistical models
- ROMS hydrodynamic coupled to RCA biogeochemical model
- Sediment Flux Model (SFM)
- 3D Habitat Volume Model

**Management Need:**
- Determining quantitative relationship between nutrient reductions and hypoxia volume;
- Informing future nutrient reduction targets
Sources of Nutrients Delivered to Gulf

**Sources**
- Corn and soybean crops
- Other crops
- Pasture and range
- Urban and population-related sources
- Atmospheric deposition
- Natural land

**Total Phosphorus**
- Yield (kg km\(^{-2}\) yr\(^{-1}\))
- Color scale: < 0.1, 0.1 to 1, 1 to 10, 10 to 50, 50 to 100, > 100

**Total Nitrogen**
- Yield (kg km\(^{-2}\) yr\(^{-1}\))
- Color scale: < 1, 1 to 10, 10 to 100, 100 to 500, 500 to 1000, > 1000

Extent of Bottom-Water Hypoxia (DO < 2 mg L\(^{-1}\))
late July 2011 and late July 2012

Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, and
R.E. Turner, Louisiana State University; funding from NOAA, CSCOR, NGOMEX09
Gulf Hypoxic Zone Monitoring

Maximum annual areal extent of hypoxic zone – metric to assess progress toward Hypoxia Task Force Action Plan Goal

From Nancy Rabalais (LUMCON)
Scenario Forecast Models

Lead PIs: Nancy Rabalais (LUMCON); Steve DiMarco (Texas A&M)

Partners: Dalhousie U; VIMS; LSU; U Mich; Coastal Carolina U

Models:
• Statistical Regression
• FVCOM Hydrodynamic
• ROMS Hydrodynamic coupled to biogeochemical

Management Need:
• inform hypoxic zone and nutrient reduction goal-setting;
• Evaluate the effectiveness of alternative nutrient reduction scenarios to inform adaptive management strategy
NOAA’s Ecological Forecasting Roadmap

Users and Stakeholders: identification of needs and iteration on forecast products throughout all processes
Questions

Photo credit: Nancy Rabalais (LUMCON)