Green Bay Ecosystem Model: Development & Prelim Calibration w/Management Implications

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Why Model?

• Incorporates fundamental physics, chemistry, and biology from research on Green Bay.

• Integrates observations from many types of sampling programs. Fills in spatial and temporal gaps. Brings “life” to stationary grab sample data.

• Identifies key processes and cause-effect relationships

• Deals with complex interactions. Powerful hypothesis testing tool.

• Helps project how system will respond under possible future outcomes (e.g. load reductions)

• Makes you look smart
Modeling Framework: GBEM

Loads and Forcing Functions

Hydrodynamic - EFDC

Hydrodynamics

Temperature

Sediment Transport

A2EM

Water Column

Nutrients

Oxygen, Phyto & Zoo

Dreissenid

Cladophora*

Sediment

Nutrients, SOD, Diagenesis

Initial Conditions
Phosphorus Cycling in GBEM

Dissolved Organic Phosphorus (RDOP/LDOP) → Mineralization → Soluble Reactive Phosphorus (SRP)

Particulate Organic Phosphorus (RPOP/LPOP) → Hydrolysis → Dissolved Organic Phosphorus (RDOP/LDOP)

Soluble Reactive Phosphorus (SRP) → Algal P → Particulate Inorganic P (sorbed to NVSS)

Mineralization → Soluble Reactive Phosphorus (SRP)

Water Column

Diagenesis of POP

Sediment Bed

Depletion

Growth

Deposition

$V_s$, $V_r$
- 4,000 horizontal cells
- Up to 10 vertical layers
- 25,300 simulation cells
- 200 m to 2 km length
- Avg of 500 m length
Forcings

- **Hydrodynamic model**
  - Exchange driven by a separate Lake Michigan model
  - Atmospheric inputs from Green Bay meteorological station

- **Tributary**
  - Flows transfer from hydrodynamic model
  - Nutrient and ion concentrations for Fox River from NEW Water monitoring program and USGS River monitoring
  - Other tribs sourced from USGS Menominee River data
TP Load

![Bar chart showing annual TP load from 2011 to 2013 for different regions: Fox, Menominee, Oconto, Peshtigo, Duck, and GBMSD. The chart indicates a decrease in TP load from 2011 to 2013.]
TP Load

Annual TP Load Distribution (metric tons)

- Fox: 630.7 metric tons
- Menominee: 70.6 metric tons
- Oconto: 39.4 metric tons
- Peshtigo: 39.4 metric tons
- Duck: 12.2 metric tons
- GBMSD: 6.1 metric tons
Calibration Datasets

“It takes a village...”

• NEW Water
  • Continuous monitoring near Entrance Light, ~30 min intervals
    Temp, oxygen, conductivity
  • Grab samples at 12-18 sites, biweekly
    Phosphorus, nitrogen, suspended solids, Chl-a, secchi

• UWM
  • Continuous monitoring, GLOS buoy, ~30 minute intervals
    Temp, oxygen, conductivity, turbidity, temp profile
  • Sonde profiles at 20-30 sites, monthly
    Temp, oxygen, conductivity, turbidity
Miles: 14.00, Pool 1 (I=37, J=80, K=10)  Stations: 1701, 1702, 1703, 60, 60

Average DO (mg/L)

2011

Date/Time

Outer (60)

Outer (65)

Outer (72)
WinModel® Overview

- **Multiple sub-models**
- **Temporal aggregation**
- **Animate through time/space**
- **Spatial & temporal profile plots**
- **Compare multiple scenarios or variables**
- **View different spatial profiles**
- **Interactive GIS visualization**
- **Monitoring data by source / program**
- **Export results to Excel, graphics to Word**
- 4,000 horizontal cells
- Up to 10 vertical layers
- 25,300 simulation cells
- 200 m to 2 km length
- Avg of 500 m length
Center “slice” down axis of Green Bay

Aug 2, 2011

Aug 8, 2011
Dissolved Oxygen, bottom water layer (mg/L)

- < 1.00000
- 1.00000 - 2.0000
- 2.0000 - 3.0000
- 3.0000 - 4.0000
- 4.0000 - 5.0000
- 5.0000 - 6.0000
- 6.0000 - 7.0000
- 7.0000 - 8.0000
- 8.0000 - 9.0000
- >= 9.0000

Date: 08/02/2011
Dissolved Oxygen (bottom) (mg/L)

Date:
07/01/2011
Management Implications

- Example Management Scenarios (P, N, and C conc.)
  - 25% Tributary reduction
  - 50% Tributary reduction
  - 75% Tributary reduction
  - 100% Tributary reduction
  - 25% Tributary increase
  - 2 deg C temp increase
  - 50% Tributary reduction w/ 50% sediment reduction

- Direct link from tributary concentrations to in-lake end points
- Helps to differentiate key processes and response times
Miles: 4.00, Pool 1 (I=19, J=30, K=1)  Stations: 26, 26

2011

Total Phosphorus (mg-P/L)

- RCA (Baseline)
- RCA (S1-25% Load Reduction)
- RCA (S2-50% Load Reduction)
- RCA (S3-75% Load Reduction)
- RCA (S4-100% Load Reduction)
Miles: 4.00, Pool 1 (I=19, J=30, K=1)  Stations: 26, 26

Chlorophyll-a (µg/L)

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<thead>
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<th>Date/Time</th>
<th>RCA (Baseline)</th>
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<th>RCA (S3-75% Load Reduction)</th>
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Miles: 15.00, Pool 1 (I=40, J=86, K=10)  Stations: 63, 63

Dissolved Oxygen (mg/L)

2011

Apr  May  Jun  Jul  Aug  Sep  Oct  Nov

RCA (Baseline)  RCA (S1-25% Load Reduction)  RCA (S2-50% Load Reduction)  RCA (S3-75% Load Reduction)  RCA (S4-100% Load Reduction)
WinModel-MAT Interface

A2EM/RCA Water Quality Modeling Framework

- Build Scenario
- Visualize Mass Balance
- Visualize MAT
- Visualize Scenarios
- Model: RCA
- Project: GBHYP
- Data Folder (click to change): 'D:\data\XO\LTI_Projects\GBHYP\WinModel'
- About WinModel
- Exit
Annual Metric Comparison Between Scenarios

WinModel.NET Management Analysis Tool

Annual Metrics  Metric Comparison  Statistics (Chart)  Load Distribution  Summary Table  Calculation  Zone Map  Exit

Select Scenarios
- Baseline
- S1-25% Load Reduction
- S2-50% Load Reduction
- S3-75% Load Reduction
- S4-100% Load Reduction
- S5-25% Load Increase
- S6-2C Temp Increase
- S7-50% Load and Sed Red

Selections
- Metric: Chlorophyll-a: summer avg (ug/l)
- Location/Zone: Inner Bay

Annual Metric Comparison

- Baseline
- S1-25% Load Reduction
- S2-50% Load Reduction
- S3-75% Load Reduction
- S4-100% Load Reduction
- S5-25% Load Increase
- S6-2C Temp Increase
- S7-50% Load and Sed Red

Chlorophyll-a: summer avg (ug/l)

Criterion

- 2010
- 2011
- 2012
- 2013
- 2014
1:1 Comparison Between Separate Metrics
User-Define Statistics (Aggregation/Time Period)

Average of May - August Model Output

- Baseline
- S2-50% Load Reduction
- S3-75% Load Reduction