Ecopath with Ecosim: Ecotracer

Biogeochemical processes and fish dynamics in food web models

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EwE Ecotracer

• Part of the Ecopath with Ecosim (EwE) approach and software system
• Ecotracer is integrated with the three major EwE modules (Ecopath, Ecosim, Ecospace)
• Can use reference data for tuning (in time and space)
Ecopath flow accounting

Ecotracer adds:

- Environment (time-varying)
- Immigrants
- Decay
- Excretion
Ecotracer input

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial conc. (t/km²)</th>
<th>Conc. in immigrating biomass (t/t)</th>
<th>Direct absorption rate (t/t/t/year)</th>
<th>Decay rate (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>0.100</td>
<td></td>
<td></td>
<td>0.000</td>
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<tr>
<td>Striped bass YOY</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Striped bass resident</td>
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<tr>
<td>Striped bass migratory</td>
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<tr>
<td>Bluefish YOY</td>
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<td>0.000</td>
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<tr>
<td>Bluefish adult</td>
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<td>0.000</td>
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</tr>
<tr>
<td>Weakfish YOY</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Weakfish Adult</td>
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<td>Atl. croaker</td>
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<tr>
<td>Other in/epi fauna</td>
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<td>0.000</td>
<td>0.010</td>
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<td>0.003</td>
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<tr>
<td>SAV</td>
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<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td>Phytoplankton</td>
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<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
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<td>Detritus</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.200</td>
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</table>
**Introduction**

Mercury introduced to the environment is readily incorporated into the food chain, becoming concentrated in fish at the highest levels of the food chain. Industry and automotive emissions have substantially increased mercury inputs to the environment and as a result many governmental organizations have taken regulatory action, enacting policies to reduce mercury pollution and advising certain sectors of the population to decrease consumption of seafood. However, the extent of increase in many locations is not well known. Thus, this study attempts to discern trends in mercury pollution of the Chesapeake Bay and to date the timing of major pollution events.

**Data Analysis and Discussion**

Sedimentation rates were applied to the cores after careful consideration of the location, water depth, and peak lead concentration in the cores. The peak lead concentration is a good indicator of 1972, the year that the use of leaded gasoline was banned, and consequently the peak year for lead emissions to the atmosphere. The sedimentation rates determined by Colman et al take this into account. The resolution of the cores reflect the different sedimentation rates for the cores: 0.1 cm/yr for core B and 0.7 cm/yr for core A. Core A shows a peak in concentration in the early 1960s with a general decrease in concentration since this time. Current values are about 35% less than the peak value. The core depth was insufficient to allow determination of inputs prior to 1950. Core B shows a better long-term trend but lacks resolution for the recent period. Core B shows that levels in the pre-industrial period were relatively constant but that current inputs are at least a factor of two higher than these pre-industrial values. Inputs increased dramatically in the early 20th Century.

Future work in the coming months will include Lead-210 and pollen stratigraphy dating to determine the actual sedimentation rate. Spatial and temporal differences in sedimentation rates in an estuary like the Chesapeake Bay make dating a core particularly difficult, and several different methods need often be applied to gain any confidence in the dating.

**Methods**

To examine the historical inputs, this study used two sediment cores taken from the Chesapeake Bay using a box corer. For mercury analysis, these samples were freeze dried and analyzed using the DMA-80 Mercury Analyzer (pictured below) to determine the mercury concentration at each depth. Dates were determined using sedimentation rates determined in a previous study (Colman et al, 2000). Sedimentation rates are spatially variant in the Chesapeake Bay, so the rate applied was one taken from a very similar location in the Colman study.

- **Core A**
- **Core B**

<table>
<thead>
<tr>
<th>Core</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Water Depth</th>
<th>Applied Sedimentation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>39° 34' N</td>
<td>76° 30' W</td>
<td>10 meters</td>
<td>0.1 cm/yr</td>
</tr>
<tr>
<td>B</td>
<td>39° 23.9' N</td>
<td>76° 50' W</td>
<td>10 meters</td>
<td>0.7 cm/yr</td>
</tr>
</tbody>
</table>

**Conclusions**

This study confirms what has been seen in many similar studies in the United States: an increase in mercury pollution with the industrialization of the coasts in the early 19th century, and a decrease in mercury pollution with the Clean Air and Water Act of 1972. This study also shows one curious trend - an increase in mercury concentration in the sediments at the beginning of this century.

**Acknowledgments**

I would like to acknowledge and thank the following for all their help and guidance through this research: Dr. Robert Mason, Dr. Eun-Hee Kim, Prentiss Balcolm, Dr. Moshe Gai, Dr. Leo Weissman and Genivieve Bernier.
CB Hg-loading: Tristan Kading

[Graph showing mercury concentration over time for Core A]

[Map indicating Core A and other locations]
$$y = 0.000000461151971x^5 - 0.004640244866876x^4 + 18.674012460293300x^3 - 37,570.355086074100000x^2 + 37,788,947.800964300000000x - 15,201,520,023.941900000000000$$
Hg (MeHg) data from Chesapeake tidal waters
Ecosim: parallel accounting for persistent pollutants
Ecotracer

Stripped bass migratory

SS = 320.657
Time series weight = 20.761
Chesapeake Bay: Where’s the MeHg?
What impacts MeHg level?

Predict MeHg levels for all components

Predict impact of policy measure
Concentration in space

One application (so far) where Ecotracer has been fitted to spatial reference data
Dioxin-loading: Global model
Predicted Dioxin:
Approaching steady state
Dioxin: Observed vs. Predicted
Dioxin: Predicted/Observed
Ecotracer applications


Ecotracer implementation

• EwE5
  – Initial version implemented

• EwE6
  – Currently not included
  – Expecting to implement in cooperation with Finnish Institute of Marine Science and NOAA Chesapeake Bay by early 2008
  – Time series handling added
  – Lipophilic handling