EPA’s ECOLOGICAL TOOLS FOR INTEGRATED WATERSHED MANAGEMENT

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Introduction

Watershed management is becoming more holistic and comprehensive

Managers are interested in relating landscape processes to aquatic endpoints

The U.S. EPA has developed useful quantitative tools for Integrated Watershed Management
EPA’s Aquatic Ecology Tools

CADDIS (http://www.epa.gov/caddis/)
- a decision support system for diagnosing causes of biological impairment

BASS (http://www.epa.gov/ceampubl/fchain/bass/index.htm)
- a model that simulates the population and bioaccumulation dynamics of age-structured fish communities

AQUATOX (http://www.epa.gov/waterscience/models/aquatox/)
- a simulation model that predicts the fate of pollutants and their effects on the aquatic ecosystem (streams, lakes, estuaries)
The Stressor Identification process within its broader management context

Stressor Identification

1. Define the Case
2. List Candidate Causes
3. Evaluate Data from the Case
4. Evaluate Data from Elsewhere
5. Identify Probable Cause

Decision-maker and Stakeholder Involvement

As Necessary: Acquire Data and Iterate Process

Identify and Apportion Sources

Management Action:
Eliminate or Control Sources, Monitor Results

Biological Condition Restored or Protected
Candidate Causes

Stressors that could be responsible for causing the biological impairment that you are investigating

<table>
<thead>
<tr>
<th>Common Candidate Causes</th>
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<tbody>
<tr>
<td>CC.1. Metals</td>
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<tr>
<td>CC.2. Sediments</td>
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<tr>
<td>CC.3. Nutrients</td>
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<tr>
<td>CC.4. Dissolved Oxygen</td>
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<tr>
<td>CC.5. Temperature</td>
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<tr>
<td>CC.6. Ionic Strength</td>
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<tr>
<td>CC.7. Flow Alteration</td>
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<tr>
<td>CC.8. Unspecified Toxic Chemicals</td>
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</table>
CADDIS provides access to statistical tools and aids for interpretation.
Simple conceptual model diagram for IONIC STRENGTH
Developed 7/2007 by Kate Schofield & Rick Ziegler
Using Conceptual Models

CADDIS helps you compare evidence to identify the best explanation for the cause of biological impairments.
Bioaccumulation and Aquatic System Simulator (BASS)

Introduction

Bioaccumulation and Aquatic System Simulator (BASS) is a model that simulates the population and bioaccumulation dynamics of age-structured fish communities. Although BASS was specifically developed to investigate the bioaccumulation of chemical pollutants within a community or ecosystem context, it can also be used to explore population and community dynamics of fish assemblages that are exposed to a variety of nonchemical stressors such as altered thermal regimes associated with hydrological alterations or industrial activities, commercial or sports fisheries, and introductions of non-native or exotic fish species.

The ability to predict accurately the bioaccumulation of chemicals in fish has become an essential component in assessing the ecological and human health risks of chemical pollutants. Accurate bioaccumulation estimates are needed not only to predict realistic dietary exposures to humans and piscivorous wildlife but also to assess more accurately potential ecological risks to fish assemblages themselves. Although the bioaccumulation of many chemicals in fish can often be predicted accurately using simple bioaccumulation factors (BAFs) and measured or predicted chemical water concentrations, such calculations frequently fail to predict accurately concentrations of extremely hydrophobic chemicals and metals such as mercury that are often the chemicals of greatest concern. Process-based models like BASS that simulate the toxicokinetic, physiological, and ecological processes of fish can overcome many of the limitations associated with the use BAF approaches.
BASS Simulation Modes

- **FGETS** – cohort growth and bioaccumulation dynamics

- **Leslie matrix projection** – cohort growth, bioaccumulation, and population dynamics where cohort ‘mortality’ is modeled as a lumped self-thinning process

- **Full community** – cohort growth, bioaccumulation, and population dynamics where cohort ‘mortalities’ are explicitly modeled as predation, physiological death, and dispersal
Simulated Biomass in BASS

Trout Run, Hardy County, WV

Balls Creek, Wayne County, PA
BASS Output: Largemouth BASS PCB Bioaccumulation in Twelve Mile Creek, SC
BASS Output: Largemouth Bass Methyl Mercury Bioaccumulation in Everglades

Average C[ppm] of Methylmercury in Largemouth_Bass

Length Classes
- Class 1: 0 < length [cm] ≤ 17.631
- Class 2: 17.631 < length [cm] ≤ 35.262
- Class 3: 35.262 < length [cm] ≤ 52.893

Time (days)
AQUATOX Model

AQUATOX

U.S. Environmental Protection Agency

Linking water quality and aquatic life

AQUATOX is a simulation model for aquatic systems. AQUATOX predicts the fate of various pollutants, such as nutrients and organic chemicals, and their effects on the ecosystem, including fish, invertebrates, and aquatic plants. This model is a valuable tool for ecologists, biologists, water quality modelers, and anyone involved in performing ecological risk assessments for aquatic ecosystems.

Release 2.1 of AQUATOX is now available. Release 2.1 has enhanced scientific capabilities to better simulate the fate of nutrients and toxic organics and their effects on aquatic ecosystems.

Download the model and support documents:
- What’s new in release 2.1?
- Basic Information
- What does AQUATOX do?
- Potential applications to water management
- Unique features & operations
- Order CDs & documents
- Training - live classes and downloadable lectures
AQUATOX Ecosystem Components

- phytoplankton
- zooplankton
- forage fish
- macrophyte
- detritivore
- periphyton
- detritus
- zoobenthos
- piscivore
Inorganic Sediment

Nutrients (NO₃, NH₃, PO₄)

Organic toxicant

Detritus (suspended, particulate, dissolved, sedimented)

Oxygen

Plants Phytoplankton Attached algae Macrophytes

Animals Invertebrates (spp) Fish (spp)

Environmental loadings

Decomposition

Partitioning

Bioaccumulation

Death

Biochemical Oxygen Demand

Settling, resuspension

Light extinction

Photosynthesis Respiration

Respiration

Ingestion

Outflow

Environmental loadings

Decomposition

Partitioning

Bioaccumulation

Death

Biochemical Oxygen Demand

Settling, resuspension

Light extinction

Photosynthesis Respiration

Respiration

Ingestion

Outflow
Main Screen

AQUATOX: Study Information
Version 2.61

Study Name: CORALVILLE LAKE, IA

Model Run Status:
- Perturbed Run: No Results Attached
- Control Run: No Ctrl. Results Attached

Data Operations:
- Initial Conds.
- Chemical
- Site
- Setup
- Notes

Program Operations:
- Perturbed
- Control
- Output
- Export Results
- Export Control

State and Driving Variables In Study:
- Dissolved org. tox 1: [Dieldrin]
- Total Ammonia as N
- Nitrate as N
- Total Soluble P
- Carbon dioxide
- Oxygen
- Tot. Susp. Solids
- Refrac. sed. detritus
- Labile sed. detritus
- Susp. and dissolved detritus
- Buried refrac. detritus
- Buried labile detritus
- Diatoms1: [Cyclotella nana]
- Greens1: [Greens]
- BI-green1: [Anabaena]
- OtherAlg1: [Dinoflagellate]
- SedFeeder1: [Chironomid]
- SedFeeder2: [Tubifex tubifex]
- SuspFeeder1: [Daphnia]
- SuspFeeder2: [Rotifer, Brachionus]
- PredInv1: [Chaoborus]
- LFeeser Fields [Bluegill]

Edit With Wizard

Use Wizard
Bass & bluegill eliminated within first year due to Dieldrin

Buffalofish show steady increase
Conclusions

• Three EPA aquatic ecology tools can be useful in watershed management

• CADDIS allows for diagnosis of impairment
  – Can support TMDLs

• BASS most useful for toxic chemicals, esp. Hg

• AQUATOX most useful for multiple stressors
  – Good for combined effects of toxics and nutrients
Acknowledgements

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Although this work was reviewed by EPA and approved for presentation, it may not necessarily reflect official Agency policy.