The USGS Upper Delaware Decision Support System (DSS) for Ecological Flows

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Tool to Support Management

- Evaluate how different flow scenarios affect instream habitat for biota
- Incorporate a suite of taxa
- User-friendly, updateable, etc.
Tool to Support Management

Flow Release Model (OASIS)

Habitat Suitability Criteria (HSCs)

Temperature & Other Parameters

Flow-Specific Estimates of Habitat

Equation: $T_c = k + a_1 f + a_2 T + a_3 f + a_4 W + a_5 + a_6 (Q - Q_1) + a_7 Y_1$
Current Decision Support System

Upper Delaware

Bovee et al. 2007

A Decision Support Framework for Water Management in the Upper Delaware River

By Karl O. Bovee, Terry J. Waddle, John Babbitt, and Judy Burris

Open-File Report 2007-1172

U.S. Department of the Interior
U.S. Geological Survey
Current Decision Support System

- 11 reaches
- 4 species
- 2 fish guilds
- Integrates:
  - OASIS estimates
  - Temperature
  - User defined parameters
  - Habitat curves

Bovee et al. 2007

Master Spreadsheet

West Branch (2)  East Branch (3)  Main stem (3)  Neversink (3)

Bovee et al. 2007
Current Decision Support System

- **Platform:** Excel
- **Output:**
  - Summary stats available by flow scenario

![Image of tables showing resource data](image-url)

**Figure 11.** Expanded view of the scoring summary page, showing details of the scores and metrics for biological resources and spills in the DRDSS.
Improving Management of Ecological Water Needs - Objectives

- Add 2010 hydrodynamic modeling data for three main stem reaches & extend time coverage
- Update habitat suitability criteria for biota and include additional species
- Extend meteorological data and test temperature model
- Develop an improved DSS platform
- Extend coverage – from dams to Trenton NJ
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2010 data

- 2010 high resolution bathymetry – 3 main stem reaches
2010 data

2-D hydrodynamic models

Pixel-scale output
2010 data

- Better hydrodynamic model estimates for sedentary taxa/life stages
Extend time coverage of DSS

- Incorporate OASIS model outputs over range of time (1928 – 2006)
- Add FFMP
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Revised Habitat Suitability Curves (HSC)

- Bovee et al. 2007: Delphi technique
  - Questionnaire to experts

<table>
<thead>
<tr>
<th>Target Organism</th>
<th>Depth Range (m)</th>
<th>Velocity Range (m/s)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown trout adult</td>
<td>0.3–100</td>
<td>0.0–1.0</td>
<td></td>
</tr>
<tr>
<td>Brown trout juvenile</td>
<td>0.2–0.8</td>
<td>0.0–0.7</td>
<td></td>
</tr>
<tr>
<td>Brown trout spawning</td>
<td>0.2–0.6</td>
<td>0.3–0.81</td>
<td></td>
</tr>
<tr>
<td>Brown trout incubation</td>
<td>0.2–1.0</td>
<td>0.15–1.2</td>
<td></td>
</tr>
<tr>
<td>Rainbow trout adult</td>
<td>0.3–100</td>
<td>0.0–1.2</td>
<td></td>
</tr>
<tr>
<td>Rainbow trout juvenile</td>
<td>0.2–1.0</td>
<td>0.0–0.8</td>
<td></td>
</tr>
<tr>
<td>American shad spawning</td>
<td>0.3–3.0</td>
<td>0.2–0.7</td>
<td></td>
</tr>
<tr>
<td>American shad juvenile</td>
<td>0.25–1.6</td>
<td>0.0–0.6</td>
<td></td>
</tr>
<tr>
<td>Shallow-fast guild</td>
<td>0.05–0.3</td>
<td>0.3–1.2</td>
<td></td>
</tr>
<tr>
<td>Shallow-slow guild</td>
<td>0.05–0.3</td>
<td>0.0–0.3</td>
<td></td>
</tr>
</tbody>
</table>

- USGS NARL approach: Literature review
  - Other species? (e.g., American eel, bridal shiner, sea lamprey, etc.)
Literature Review methods

• Use defined “key search terms” in several major search engines
  • E.g., ISI Web of Knowledge, Google Scholar, USGS Digital Desktop Library
• Primary literature (no grey literature)
• Preference: articles reporting fish density AND environmental variables (depth, velocity, temperature)
• Second: articles reporting average environmental variables where fish present (no density data)
Example: Rainbow Trout

- Search Engine = Web of Knowledge
- Topic = *Oncorhynchus mykiss*
- Topic = Depth
- 188 Results
  - Reviewed 56 Articles
  - Used ~20

1. Title: Archival and acoustic tags reveal the post-spawning migrations, diving behavior, and thermal habitat of hatchery-origin Sacramento River steelhead kels (*Oncorhynchus mykiss*)
   - Author(s): Too, Steven L. H.; Sandstrom, Phil T.; Chapman, Eric D.; et al.
   - Source: ENVIRONMENTAL BIOLOGY OF FISHES Volume: 90 Issue: 3 Pages: 177-187 DOI: 10.1007/s10641-011-9938-4 Published: FEB 2013
   - Find It @ USGS [ (a) View abstract ]

2. Title: Deep RNA Sequencing of the Skeletal Muscle Transcriptome in Swimming Fish
   - Author(s): Palstra, Aryan P.; Beltran, Sergio; Burgenhout, Eric; et al.
   - Source: PLoS ONE Volume: 8 Issue: 1 Article Number: e53171 DOI: 10.1371/journal.pone.0053171 Published: JAN 2013
   - Find It @ USGS [ (a) View abstract ]

3. Title: A hydrodynamic investigation of brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) redd selection at the riffle scale
   - Author(s): Marshburn, M. A.; Annable, Yv. K.; Power, M.; et al.
   - Source: RIVER RESEARCH AND APPLICATIONS Volume: 28 Issue: 5 Pages: 659-673 DOI: 10.1002rra.1478 Published: JUN 2012
   - Find It @ USGS [ (a) View abstract ]

- Similar for each additional search engine
- Other search terms: habitat suitability, rainbow trout, flow, etc.
Current progress on trout

- Brown Trout (depth and velocity)
  - Adult, juvenile, spawning
  - Total Number of Articles = 33; 309 observations
    - 20 from Studies Conducted in Europe
    - 12 from Studies Conducted in North America
    - 1 from Studies Conducted in Australia

- Rainbow Trout (depth and velocity)
  - Adult, juvenile
  - Total Number of Articles = 29; 89 observations
    - 1 from Studies Conducted in Europe
    - 27 from Studies Conducted in North America
    - 1 from Studies Conducted in Asia
Brown trout HSC

Adult Brown Trout

Juvenile Brown Trout

Spawning Brown Trout

Proportion of observations

Depth (m)

Velocity (m/s)
NARL curves vs. Bovee et al. 2007

0.3 m → 100 m

Proportion of observations

Depth (m)

0.0 0.5 1.0 1.5 2.0

0.0 0.1 0.2 0.3 0.4

Adult Brown Trout

0 m/s → 1 m/s

Proportion of observations

Velocity (m/s)

0.0 0.2 0.4 0.6 0.8

0.00 0.05 0.10 0.15 0.20 0.25 0.30
Dwarf wedgemussel

- Limited published literature on habitat use of mussels in general
- Used USGS NARL field, laboratory, and modeling data to build HSC – idea of **Persistent Habitat**

**Field measurements**
- 2007-2009 Delaware mainstem & tributaries

**Depth preference studies, NARL**
- 2010-2011 Delaware tributaries

**Hydrodynamic modeling results**
- Maloney et al. 2012

![Field measurements](image1)
![Depth preference studies](image2)
![Hydrodynamic modeling results](image3)
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Climate Data & Temperature Model

- **Extend meteorological data**
  - Currently used station limited to 1994
  - Timeline to match OASIS
  - Use other stations to extend by proxy

- **Test temperature model**
  - SNTEMP and Multivariate models
  - Construct models with part of data, test with recent data
  - Deploy additional temp loggers

- **NEED:** Reservoir release amounts and temperatures, spillover estimates
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Improved DSS Platform - History

- Original Delaware DSS (Excel)
- SMART River (Trinity River)
- Yakima River DSS (hard coded)
- Revised Delaware DSS (User Friendly, spatially referenced GUI)
Improved DSS Platform

Key Features:

- User friendly, transferable GUI
- Enables user to manually modify the habitat suitability criteria/curves
- Spatial representation of input data (e.g., hydrodynamic variables) and calculated available habitat
- Allows user to select time period of interest
Selection of key species.

Habitat suitability criteria can be modified.

Color coded habitat maps for each scenario.

Daily average amount of available habitat over period of interest.

Geographic Information System (GIS) functionality.

Habitat GIS functionality.

Map of site location.

Equation for displayed habitat suitability maps.

Display of hydrograph for all scenarios.

Hydroperiod of interest.

Amount of available habitat by scenario by date.

Color coded habitat maps for each scenario.

Daily average amount of available habitat over period of interest.
Putting it all Together

Flow Release Model (OASIS)

Temperature & Other Parameters

Synthesis Tool (DSS)

Habitat Suitability Criteria (HSCs)

Flow-Specific Estimates of Habitat

Environmental variable

Tolerance limits

Response

Optimum

\[ T = k + a_1T_1 + a_2T_2 + a_3W + a_4Q + a_5(Q-Q_0) + a_6T_0 \]
Where do we Stand?

- Automate data import from OASIS (2012)
- Extend temporal coverage of DSS and add 2010 hydrodynamic modeling data (2012)
- Develop a more user-friendly, transferable DSS platform (beta version Jan 2013)
- Revise and incorporate revised habitat suitability criteria (ongoing, 2013/14)
- Add persistent habitat metric to DSS (2013/14)
- Test temperature model and add to DSS (2013/14???)

**Workshop on DSS – mid-April in conjunction with SEF meeting**
Extend Aerial Coverage — 2014 & beyond

Temperature

• 13 stations
• 37 stream gages
• Deployed 60 HOBO loggers

Bathymetry

• RTK GPS & side-scan sonar
• Hyperspectral imagery

2D Modeling

• Experimental LiDAR

DSS
Thank you

Upcoming possible “hands on” demonstration of the DSS in 2013

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