Delta Ecosystem Diagnosis & Treatment: A Tool for Restoration Planning

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What is Delta-EDT?

• Definition: A spatial habitat assessment model focused on population performance of delta smelt
• Purpose: Guide restoration of habitat in the delta
• Value: Evaluation of habitat relative to delta smelt life history tactics
• Approach
  – Integrate knowledge
  – Develop scientific hypotheses
  – Assess limiting factors
  – Support adaptive management
• Delta EDT is NOT:
  – A hydrological model (though it uses hydrologic data)
  – A particle tracking model (though it uses PTM output)
  – A time series model (though it evaluates habitat through time)
  – A statistical model (though it does have variation)
  – An HSI model (though they have traits in common)
Delta-EDT Components

- Biology: Species Description
- Life History Trajectories
- Environment: Environmental Description
- Species-Habitat Rules
- Performance Estimate
- Diagnosis

http://edt.codeplex.com/
Delta-EDT Environment-Spatial/Temporal Structure

• Built on DSM2 reaches
  – Reach-node network
  – “Pixel” of environmental picture

• Monthly time-step
  – Characterization of conditions over a month
1-Year life history used (for now)

Habitat along each trajectory evaluated using Beverton-Holt population metrics

- **Capacity** (fish) ➔ quantity of suitable habitat + **Food**

- **Productivity** (returns/spawner) is density-independent survival ➔ quality of habitat

- Population BH function disaggregated to life stages

- Each trajectory has unique capacity and productivity reflecting habitat conditions ➔ **Life History Diversity**
Habitat is Evaluated Across Numerous Life History Trajectories

Integration across trajectories ➔ Population performance
Trajectory Performance
Delta-EDT Information Structure

Input Data

**Habitat Quality Attributes**
1. Dissolved Oxygen
2. Diel Variation
3. Fish Species Introductions
4. Misc. Toxins
5. Predation Risk
6. Temperature: Daily Minimum
7. Temperature: Daily Maximum
8. Total Suspended Solids
9. Flow Velocity
10. Salinity
11. Entrainment
12. Zooplankton
13. Water clarity

**Habitat Quantity Attribute**
1. Shallow Flats
2. Deep subtidal
3. Flooded wetlands
4. Intertidal mudflat
5. Shallow subtidal
6. Tidal brackish
7. Tidal freshwater
8. Wetted fringe
9. Width
10. Channel length

**Survival Factors**
1. Competition
2. Flow
3. Food
4. Habitat diversity
5. Obstructions
6. Oxygen
7. Pathogens
8. Predation
9. Sediment load
10. Temperature
11. Entrainment
12. Salinity
13. Key Habitat

**Life stage-Habitat Rules**
Construction of Food Rule

- Zooplankton
- Water Clarity
- Competition (clams)
- Nutrients
- Other

Food Index

Food Density

Productivity

Capacity

Graphs showing relationships between food density and other factors.
Species-Habitat Rule: Maximum Temperature

Nobriga, 2007

Daily Maximum Temperature (DSM2)

Bennett, 2005

Rule & Hypothesis for Life Stage
PRELIMINARY APPLICATION
Delta-EDT compares scenarios to diagnose conditions

Impairment of biological potential due to habitat change

- Capacity (habitat quantity)
- Productivity (habitat quality)
- Abundance (habitat potential)
- Life history diversity
Diagnostic splicing in Delta EDT

\[ \Delta P_r = \frac{(P_{splice} - P_{current})}{P_{current}} \]

\[ \Delta P_{r4} = \frac{418 - 327}{327} = 28\% \]

\[ \Delta P_{r7} = \frac{523 - 327}{327} = 60\% \]

Conclusion: Relaxing constraints in Reach 7 had greater effect on population performance than did Reach 4

Splicing can address
- Productivity
- Capacity
- Neq
- Life History Diversity

Of
- Populations
- Reaches
- Attributes
- Life stages
## 20 Year Population Performance EBC1

### Scenario Comparison

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Current</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>4.5</td>
<td>14.6</td>
</tr>
<tr>
<td>Capacity</td>
<td>285,330</td>
<td>16,676,808</td>
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<tr>
<td>NeQ</td>
<td>221,373</td>
<td>15,798,582</td>
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<tr>
<td>Life history diversity</td>
<td>4.9%</td>
<td>97%</td>
</tr>
</tbody>
</table>

### Graph Description

- **Spawners** vs **Recruits**
- Line colors and markers indicate different scenarios and reference values:
  - Blue: Replacement
  - Purple dashed: Current Productivity
  - Orange: Current Recruits per Spawner
  - Black: Current Capacity
  - Light purple dashed: Reference Productivity
  - Black dashed: Reference Capacity
  - Orange: Reference Recruits per Spawner
  - Red: Current NeQ
  - Green: Reference NeQ

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# Limiting Factors Diagnosis

<table>
<thead>
<tr>
<th>LSSequenceName</th>
<th>Competition</th>
<th>Flow</th>
<th>Oxygen</th>
<th>Predation</th>
<th>Salinity</th>
<th>Sediment load</th>
<th>Temperature</th>
<th>Withdrawals</th>
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<tbody>
<tr>
<td>0-Spawners/Mature (1)</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>1-Eggs</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>2-Larvae (yolk-sac)</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>3-Larvae (feeding)</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>4-Post-Larvae</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>5-Juveniles</td>
<td>7%</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
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<tr>
<td>6-First Year Rearing</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>7-First Year Migrant Prespawner</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>8-First Year Holding Prespawner</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
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<table>
<thead>
<tr>
<th>LSSequenceName</th>
<th>Average of Change in Capacity</th>
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<tbody>
<tr>
<td>0-Spawners/Mature (1)</td>
<td>0%</td>
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<tr>
<td>1-Eggs</td>
<td>21%</td>
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<td>2-Larvae (yolk-sac)</td>
<td>30%</td>
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<tr>
<td>3-Larvae (feeding)</td>
<td>45%</td>
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<tr>
<td>4-Post-Larvae</td>
<td>14%</td>
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<tr>
<td>5-Juveniles</td>
<td>22%</td>
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<tr>
<td>6-First Year Rearing</td>
<td>11%</td>
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<tr>
<td>7-First Year Migrant Prespawner</td>
<td>4%</td>
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<tr>
<td>8-First Year Holding Prespawner</td>
<td>81%</td>
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Reach Loss of Neq

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<tr>
<th>Location</th>
<th>Total</th>
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<tr>
<td>Suisun Bay-259</td>
<td>93%</td>
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<tr>
<td>Sacramento River-46</td>
<td>91%</td>
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<tr>
<td>Sacramento River-201</td>
<td>90%</td>
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<tr>
<td>Grizzly Bay-256</td>
<td>90%</td>
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<tr>
<td>Broad Slough-214</td>
<td>87%</td>
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<tr>
<td>Napa River-285</td>
<td>83%</td>
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<tr>
<td>Grizzly Bay-252</td>
<td>82%</td>
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<tr>
<td>Middle River-135</td>
<td>79%</td>
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<tr>
<td>San Joaquin River-55</td>
<td>78%</td>
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<tr>
<td>Sherman Lake-203</td>
<td>78%</td>
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<tr>
<td>Whiskey Slough-94</td>
<td>73%</td>
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<td>Grizzly Bay-253</td>
<td>72%</td>
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<tr>
<td>San Joaquin River-59</td>
<td>72%</td>
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<td>Grizzly Bay-257</td>
<td>71%</td>
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<tr>
<td>Burns Cutoff-97</td>
<td>70%</td>
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<tr>
<td>Old River-179</td>
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<tr>
<td>Sacramento River-19</td>
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<td>San Joaquin River-92</td>
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<tr>
<td>Grizzly Bay-235A</td>
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<td>Mayberry Slough-204</td>
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<td>Liberty Cut-1</td>
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<td>Victoria Canal-131</td>
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<td>False River-63</td>
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<td>San Joaquin River-207</td>
<td>59%</td>
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<tr>
<td>San Joaquin River-91</td>
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<tr>
<td>Elk Slough-18</td>
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<tr>
<td>Fourteenmile Slough-76</td>
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<tr>
<td>Sevenmile Slough-54</td>
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<td>San Joaquin River-99</td>
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<td>Grizzly Bay-220</td>
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<td>Broad Slough-217</td>
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<td>Potato Slough-49</td>
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<td>North Mokelumne River-30</td>
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<td>Steamboat Slough-12</td>
<td>51%</td>
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<tr>
<td>Georgiana Slough-29</td>
<td>50%</td>
</tr>
</tbody>
</table>
Development of Delta-EDT

• Work to date ➔ working model with provisional parameterization
• Next steps
  – Peer review—This is where you come in!
  – Test the model by evaluating habitat conditions and alternatives
  – Refine and make available
• We invite you all to work with us to develop Delta-EDT as a useful tool for delta habitat restoration
  – Collaboration
  – Peer review
• Applications
  – Limiting factors analysis—what do we restore?
  – Identification of restoration priorities—where do we restore?
  – Habitat status & trends reporting—how are we doing over time?
  – Adaptive management—how does our working hypothesis change over time?
Acknowledgements

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