The underpinnings of integrating ecological risk assessment with the Endangered Species Act

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Overview

• Section 7 of the Endangered Species Act
• Application of Ecological Risk Assessment
• Steelhead Example
• Summary
Where might ecological risk assessment fit into a biological opinion?

- **Description of Proposed Action**: Answers who, what, where, when, how, how long, how often, etc.
- **Status of Species and/or Description of Designated Critical Habitat**: Life history and ecological attributes; reproduction, numbers, and distribution
- **Environmental Baseline**: Existing ecosystem condition from past, current, and future multiple stressors
- **Effects of the Action**: Ecological risk assessment: problem formulation, risk analysis, risk characterization
- **Cumulative Effects**: Addresses non-federal activities that occur in the action area which are reasonably certain to occur
- **Conclusion**: Does action jeopardize the continued existence of ESU? Does action adversely modify or destroy designated critical habitat?
Biological organization and ESA determinations

"TAKE"  "Likely to Adversely Affect"

"Jeopardize the continued existence of"

Endangered Species Act

Conservation biology

Conservation biology

molecular biology

down arrow

biochemistry

down arrow

cellular physiology

down arrow

systems physiology

down arrow

behavior

down arrow

individual animal

down arrow

population

down arrow

species / ESU

down arrow

community
Translation of individual effects to populations

**Sub-lethal effect(s)**
- Acetylcholinesterase inhibition and disruption of olfactory function

**Habitat effect(s)**
- Reduction in prey availability

**Lethal effect**
- Mortality from mixture toxicity

**Behavioral impact**
- Reduced feeding and growth
- Reduced body size

**Population level consequence(s):**
- Abundance, productivity, spatial structure, diversity

Life history specific population models
Middle Columbia River Steelhead

Oncorhynchus mykiss

Note: return spawners
Listed as Threatened in 1999
16 populations
Critical Habitat designated in 2005
Population viability affected

Common stressors:
- Habitat blockages
- Hatchery influences
- Land use impacts
- Harvest

Chemical contaminants:
- Pesticides
- PAHs
- Heavy metals
Yakima River Basin

A Conceptual Model for Columbia River Steelhead and Pesticides
Use and registration of formulated pesticide products, degradates, metabolites, and tank mixtures

Pesticide use patterns; transport, fate, persistence, and concentration in steelhead habitat, co-occurrence of environmental mixtures

Steelhead distribution

Habitat distribution

Exposure profile

Best available science regarding the effects of pesticides on steelhead and their habitat

Individual steelhead response

Habitat response

Response profile

Effects on individual steelhead

Effects on habitat

Impacts on 16 steelhead populations

Impacts on steelhead ESU
Yakima baseline conditions

• **Physical stressors**
  – Water quantity
  – Asynchronous flow regimes
  – Elevated water temperatures (thermal barriers)
  – Migratory challenges and blockages (dams, culverts, diversions)

• **Chemical stressors**
  – Pesticides
  – Legacy compounds (DDT, DDE TMDL)
  – Heavy metals
  – Elevated nutrients (low dissolved oxygen and eutrophication)

• **Biotic stressors**
  – Non-indigenous, piscivorous predators
  – Pathogenic bacteria
  – Fishing
Exposure Profile:

Pesticide use patterns; transport, fate, persistence, and concentration in steelhead habitat, co-occurrence of environmental mixtures

Steelhead distribution

Habitat distribution

Exposure profile
Steelhead Distribution and Cropping Patterns in Yakima Basin

1. 2. /}

©

Metolachlor detections (ppb) 2004 General Crops

2004 General Crops

Prepared by the Washington State Department of Agriculture

March 8, 2005
Life History Temporal Distribution of Yakima Summer Run Steelhead

K. Gullet, NOAA Fisheries
Best available science regarding the effects of pesticides on steelhead and their habitat

Individual steelhead response

Habitat response

Response profile
<table>
<thead>
<tr>
<th>Assessment Endpoints</th>
<th>Assessment Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile growth</td>
<td>Foraging behavior</td>
</tr>
<tr>
<td></td>
<td>Growth rate</td>
</tr>
<tr>
<td></td>
<td>Condition index</td>
</tr>
<tr>
<td>Reproduction</td>
<td>Courtship behavior</td>
</tr>
<tr>
<td></td>
<td>Number of eggs produced</td>
</tr>
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<td></td>
<td>Fertilization success</td>
</tr>
<tr>
<td>Early development</td>
<td>Gastrulation</td>
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<td>Organogenesis</td>
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<td></td>
<td>Hatching success</td>
</tr>
<tr>
<td>Smoltification</td>
<td>Ion exchange (<em>i.e.</em> gill Na(^+)/K(^+) ATPase activity)</td>
</tr>
<tr>
<td></td>
<td>Blood hormone (<em>i.e.</em> thyroxin)</td>
</tr>
<tr>
<td></td>
<td>Salinity tolerance</td>
</tr>
<tr>
<td>Disease-induced mortality</td>
<td>Immunocompetence</td>
</tr>
<tr>
<td></td>
<td>Pathogen prevalence in tissues</td>
</tr>
<tr>
<td></td>
<td>Histopathology</td>
</tr>
<tr>
<td>Migration or distribution</td>
<td>Use of juvenile rearing habitats</td>
</tr>
<tr>
<td></td>
<td>Adult homing behavior</td>
</tr>
<tr>
<td></td>
<td>Selection of spawning sites</td>
</tr>
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</table>
Mixture toxicity of organophosphate insecticides: Acetylcholinesterase inhibition

<table>
<thead>
<tr>
<th>Binary Mixtures</th>
<th>Predicted</th>
<th>Observed</th>
<th>Lethality</th>
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<tbody>
<tr>
<td>malathion + diazinon</td>
<td>additive</td>
<td>synergistic</td>
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<table>
<thead>
<tr>
<th>ppb (ug/l)</th>
<th>toxicity thresholds</th>
<th>EC50 units</th>
<th>exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Insecticide</td>
<td>LC50</td>
<td>LC50 /20</td>
<td>LC50 /2.27</td>
</tr>
<tr>
<td>diazinon</td>
<td>913.9</td>
<td>45.7</td>
<td>404.4</td>
</tr>
<tr>
<td>chlorpyrifos</td>
<td>80.2</td>
<td>4.0</td>
<td>35.3</td>
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<tr>
<td>malathion</td>
<td>118.8</td>
<td>5.9</td>
<td>52.6</td>
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</tbody>
</table>

a=NY apples, pears scenario, b= OR apples, c= OR apples

Laetz et al. in preparation
Risk Characterization

Effects on individual steelhead
- Impacts on 16 steelhead populations
  - Impacts on steelhead ESU

Effects on habitat
Health of Yakima Steelhead Populations

- Moderate risk in each VSP category across ESU
- Greatest risk to Abundance
- Long term negative trend in 11 of 12 steelhead production areas
- Continued low number of natural steelhead returns to Yakima (<10% of recovery target)
- Biological Review Team divided between “likely to become endangered in the foreseeable future” and “not in danger of extinction or likely to become endangered in the foreseeable future”
Linking behavior impairment to population level effects: Population model

Spromberg et al., in preparation
Summary

- Species effects from pesticides can be assessed using current Ecological Risk Assessment techniques.
- Sub-lethal effects to individuals can lead to population level consequences.
- Pesticide effects should be linked to viable salmonid population attributes such as abundance and productivity.
Acknowledgement

Bridget Moran  WA State Department of Agriculture
Jim Cowles  WA State Department of Agriculture
Julann Spromberg  NOAA’s NW Fisheries Science Center
David Baldwin  NOAA’s NW Fisheries Science Center
Thank you
Assessing Population Status:

Viable Salmonid Population Concept*

• Abundance
• Productivity
• Spatial Structure
• Diversity

Pesticide effects to lotic habitats
Designated Critical Habitat
Primary Constituent Elements (PCE)

<table>
<thead>
<tr>
<th>Habitat Component</th>
<th>For each listed ESU:</th>
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<tr>
<td>1) Spawning and juvenile rearing areas</td>
<td>1) spawning gravel; 2) <strong>water quality</strong>; 3) water quantity; 4) water temp.; 5) <strong>food</strong>; 6) <strong>riparian veg</strong>.; 7) access</td>
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<td>2) Juvenile migration corridors</td>
<td>1) substrate; 2) <strong>water quality</strong>; 3) water quantity; 4) water temp.; 5) water velocity; 6) cover/shelter; 7) <strong>food</strong>; 8) <strong>riparian veg</strong>.; 9) space; 10) safe passage</td>
</tr>
<tr>
<td>3) Areas for growth and development to adulthood</td>
<td>Ocean areas – not identified</td>
</tr>
<tr>
<td>4) Adult migration corridors</td>
<td>1) substrate; 2) <strong>water quality</strong>; 3) water quantity; 4) water temp.; 5) water velocity; 6) cover/shelter; 7) <strong>riparian veg</strong>.; 8) space; 9) safe passage</td>
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Insecticide | EC50 | 0.5 EC50 | 0.2 EC50 | 0.05 EC50 | LC50 | 1/20 LC50 | LC50/2.27 | Peak Field Concs. | Peak EECs |
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<tr>
<td>diazinon</td>
<td>147.5</td>
<td>73.8</td>
<td>29.5</td>
<td>7.4</td>
<td>913.9</td>
<td>45.7</td>
<td>404.4</td>
<td>0.14</td>
<td>25.1a</td>
</tr>
<tr>
<td>chlorpyrifos</td>
<td>2.0</td>
<td>1.0</td>
<td>0.4</td>
<td>0.1</td>
<td>80.2</td>
<td>4.01</td>
<td>35.3</td>
<td>0.48</td>
<td>9.2b</td>
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<tr>
<td>malathion</td>
<td>74.3</td>
<td>na 37.2</td>
<td>14.9</td>
<td>3.7</td>
<td>118.8</td>
<td>5.94</td>
<td>52.6</td>
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