This presentation is for informational use and may not reflect views shared by the Department of Pesticide Regulation.
Spatial and Temporal Quantification of Pesticide Loadings to the Sacramento River, San Joaquin River, and Bay-Delta to Guide Risk Assessment for Sensitive Species

Gerco Hoogeweg
Debra Denton
Marty Williams
Rich Breuer

Key Objectives

- Identify the potential spatial and temporal co-occurrence of 40 pesticides with 12 threatened and endangered species to guide future risk assessments
- Provide further knowledge of the fate and transport of pesticides in the study area
- Provide further knowledge of species presence/life cycle in the study area
- Identify and rank areas of highest potential risk to prioritize future initiatives

Study Area

Sacramento River
27,000 sq mi (69,930 km²)

Bay-Delta Estuary
4,500 sq mi (11,691 km²)

San Joaquin River
32,000 sq mi (83,000 km²)

Project Team

Funded by CA Bay-Delta Science Program (CALFED)

DWR
UC Davis
Waterborne Environmental
US EPA Region 9
CPR
CVRWQCB
NOAA-NMFS
TDC Environmental
USDA-ARS
USDA-NRCS
USGS
Cramer Fish Sciences
The magic hat (pulling it together)

- Pesticide Loadings
  1. Runoff from fields
  2. Drift from spray
  3. Discharges from rice paddies
  4. Runoff from urban settings

- Species of Interest
  1. Ecotoxicological benchmarks
  2. Life history assessment
  3. Species distribution

- Watershed Characteristics
  1. Landscape patterns
  2. Soils
  3. Climate Conditions

- Water Quality Monitoring
  1. Species Distributions
  2. Pesticide Loadings
  3. Hotspots
  4. Areas of Concern
  5. Recommendations

- Spatial-Temporal Co-occurrence
  1. Species Distributions
  2. Pesticide Loadings
  3. Hotspots

- Visualizations

Species List

- Chinook Salmon (*Oncorhynchus tshawytscha*)
  - Sacramento River winter run
  - Central Valley spring run
  - Central Valley fall/late fall run
  - Central Valley steelhead (*O. mykiss*)

- Southern North American Green Sturgeon (*Acipenser medirostris*)

- Delta Smelt (*Hypomesus transpacificus*)

- Striped Bass (*Morone saxatilis*)

- San Francisco Longfin Smelt (*Spirinchus thaleichthys*)

- Threadfin Shad (*Dorosoma petenense*)

- California Red-legged Frog (*Rana draytonii*)

- California Freshwater Shrimp (*Syncaris pacifica*)

Species Life Cycle / Species Distribution

- Fall Run Chinook Salmon

<table>
<thead>
<tr>
<th>Species Distribution (by month)</th>
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<td>Presence of Central Valley Steelhead</td>
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- Special to allow or restrict: *Restricted* or *Allow*

- Total Barriers:
  - Road Barriers
  - Water Barriers

- Special to allow or restrict:
  - Restricted
  - Allow

Species Distribution (by month)
### Pesticide List

- (s)-Metolachlor Herbicide
- Abamectin Insecticide
- Bifenthrin Insecticide
- Bromacil Herbicide
- Captan Fungicide
- Carbaryl Insecticide
- Chlomazone Herbicide
- Chlorpyrifos Insecticide
- Copper Sulphate Fungicide
- Copper Hydroxide Fungicide
- Cyfluthrin Insecticide
- Cyhalofop-butyl Herbicide
- Cypermethrin Insecticide
- Deltamethrin Insecticide
- Diazinon Insecticide
- Dimethoate Insecticide
- Diuron Herbicide
- Esfenvalerate Insecticide
- Hexazinone Herbicide
- Imidacloprid Insecticide
- Indosarcarb Insecticide
- Lambda cyhalothrin Insecticide
- Malathion Insecticide
- Mancozeb Fungicide
- Maneb Fungicide
- Methomyl Insecticide
- Naled Insecticide
- Oxyfluorfen Herbicide
- Paraquat dichloride Herbicide
- Permethrin Insecticide
- Propargite Insecticide
- Pyrazosulfuron Fungicide
- Salmazine Herbicide
- Tri fluorothrin Herbicide
- Ziram Fungicide
- Thiodan Insecticide
- Thimet Insecticide

### Pesticide Applications

- California Pesticide Use Reporting (PUR) database
  - PLSS section level data for agricultural applications
  - Date, rate, method (air/ground) area treated, pesticide, and crop
  - County level data for urban applications
  - Month and application site
  - Home owner use is not included

### Urban Pesticide Use

- Non-professional Landscape
- PCO Homeowner Structural
- PCO Recreational Areas
- County Health Vector Control

### Context

Agricultural use is "known"
Urban use is "NOT known"
Urban Use Studies

Challenge–Where was it applied?

Challenge–A Changing Landscape

Role of Modeling

Urban growth

 daylight.

 Role of Modeling

- Estimate potential pesticide loadings into nearby water bodies considering important factors in chemical fate and transport:
  - Application location, date, rate, method
  - Pesticide mobility / persistence
  - Site conditions – crop (land use), irrigation, soil properties, weather
Models

- Agricultural modeling
  - Pesticide Root Zone Model (PRZM)
  - Adapted for furrow irrigation runoff
  - Edge-of-field mass
- Rice modeling
  - Rice water quality model (RICEWQ)
  - Water management /release
- Urban modeling
  - Pervious and impervious areas with PRZM
  - Pyrethroid "Kd" calibrated to hard surface washoff studies
  - Drift estimates

Role of Monitoring Data

- Monitoring results from federal, state, and regional monitoring programs
- "Real" concentrations esp. larger water bodies

Results

- Total mass loading
  - Drift 4.98%
  - Erosion 4.43%
  - Rice 4.34%
  - Runoff 86.22%
  - Urban 0.03%

Urban Conclusions

- Annual predicted runoff losses were <0.1% of applied a.i.
  - Study area as a whole, all years, all pyrethroids
  - Varies with individual areas, years, and chemicals
- Applications to impervious areas were predicted to be the primary source of pyrethroid runoff
- Very little loss from pervious areas
- Higher losses associated with rainy season compared to irrigation season
Spatial Distribution of Urban Pyrethroid “Loads”

Co-occurrence
- What is co-occurring?
  - Species of concern
  - Pesticides in surface water
- Requirement for co-occurrence
  - Same location (PLSS section level)
  - Same time (monthly)
- Goal is to develop an scalable index that takes into account available species and pesticide information

Questions to consider when developing a Co-occurrence Index
- RQ ≥ 1
- What if two pesticides have RQ ≥ 1 on the same day?
- Do we consider all events where RQ ≥ 1?
- Do we need to consider additive/cumulative effects?
- Consider Indirect effects?
- Is species presence as important as richness?
- Do we know which pesticide affects which species?
- What time period do we consider?
- Do we need to consider sublethal effects?
- Can we calculate a fraction of events exceeding the benchmarks?
- Are we doing a absolute or relative ranking?
- Can we kill the same fish or shrimp twice?

Co-occurrence Index
- Indicator days - day that one or more pesticides exceed the toxicity threshold
  - On monthly basis compute the number of indicator days within a PLSS
  - Determine the percentile points from all PLSS (10th, 20th, ... 90th, 100th)
- Species richness – the number of species present in a given area
  - On a monthly basis compute the number of species present within a PLSS
  - Determine the percentile points from all PLSS (10th, 20th, ... 90th, 100th)
- Flexible and scalable to the questions be asked
Indicator Days

Distribution of Indicator Days for randomly selected PLSS Sections

Species Richness / Indicator Days

Multi-dimensional Index

No potential co-occurrence

Increased potential co-occurrence

No co-occurrence
**Multi-dimensional Index**

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What does 73 mean?

73 means that at least 70% of the species are present and the top 70 percentile of the indicator events. Emphasis would be on the species.

What does 37 mean?

37 means that top 70 percentile of the indicator events are considered and at least 30% of the species are present. Emphasis would be on the pesticides.

**Results Processing**

- Compare concentrations with benchmarks
- Pesticide mass loading
- Aquatic habitat concentration
- Benchmark: No concern
- Species: Spatial & temporal co-occurrence
- Monitoring: No concern
- Determine co-occurrence
- Are there monitoring stations present downstream?
- Need additional study
- Co-occurrence predictions do not indicate adverse effects

**Implementation**

- Q: Show all areas with at least half the species present and 50th percentile indicator events for the month of July?

**Caveats based on data limitations and uncertainty**

- PUR precision / accuracy
- Pesticide properties
- Field-specific characteristics
- Hydrography
- Hydrology / hydraulics
- Species distributions
- Dissipation processes not represented
- Standardized assumptions

Co-occurrence predictions do not indicate adverse effects.
Use of Results

- Relative risk
- Prioritize research
- Where to focus refined risk assessments
- Support future monitoring programs
  (strategic locations, sampling frequency)
- Aid in developing plans to improve ecosystem quality and water quality (e.g., BMPs, hydrologic operations)

Next steps

- Where to house data?
- Development of GIS user interface?
- Data mining
  - Causal assessment
  - BMP assessments
  - Other “what-if” scenarios
- Refine data gaps and areas of uncertainty
  - Upgrade components
  - Extend species further upstream
  - Link to routing models
- Foundation for other initiatives
  - Address additional pesticides and/or other constituents
- Future trends
  - climate change
  - land use change
  - Link with population models
- Program specific needs

Data and Framework Retained for Future Analysis

- GIS products
  - Species of concern maps – by species by month
  - Land use changes
  - Mass loadings – by pesticide by source by day
  - Indicator days – by pesticide by day
  - Etc
- Model ready input
  - Cropping parameters
  - Soil properties
  - Weather data
  - Pesticide properties
  - Etc.

Questions?
Urban Approach

- Bifenthrin, cypermethrin, and cyfluthrin
  - Highest urban uses (DPR-PUR) and most often contributing to toxicity (Moran, 2010)
- Permethrin
  - Highest urban use (DPR-PUR)
- Professional pest control operator (PCO) use from PUR
  - Structural, landscape, other (right-of-way, uncultivated non-ag, turf/sod)
- Homeowner use
  - Bifenthrin only - assume 0.25 x PCO use (Moran, 2010)
Contact Information

Rich Breuer, CDWR at 916-376-9694 rich@water.ca.gov
Debra Denton, USEPA Region 9 at 916-341-5520 denton.debra@epa.gov

Gerco Hoogeweg, Waterborne Environmental Inc. hoogewegg@waterborne-env.com
Marty Williams, Waterborne Environmental Inc. williamsm@waterborne-env.com

To download report and see overview of project:
http://www.waterborne-env.com/projects_featured.asp