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

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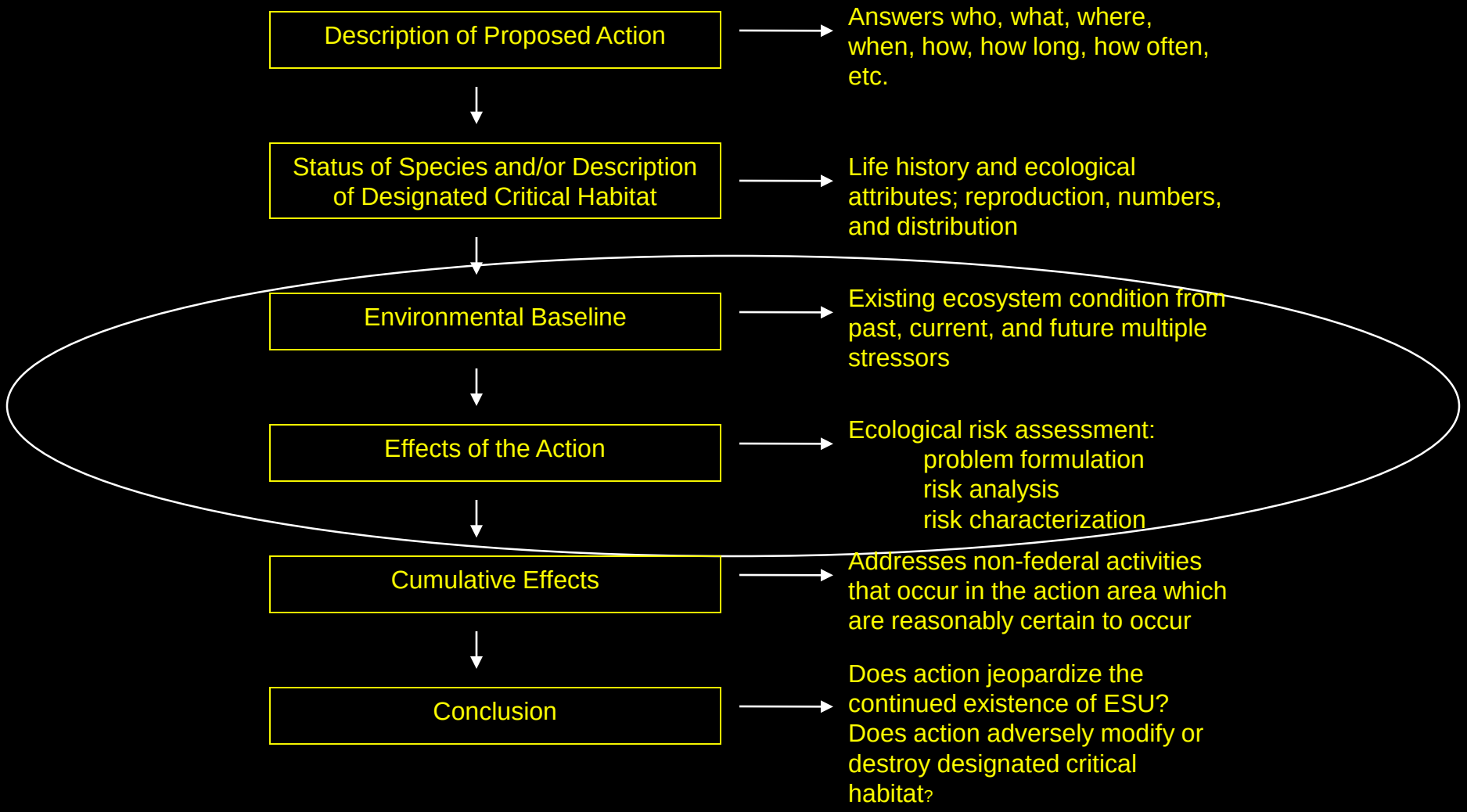
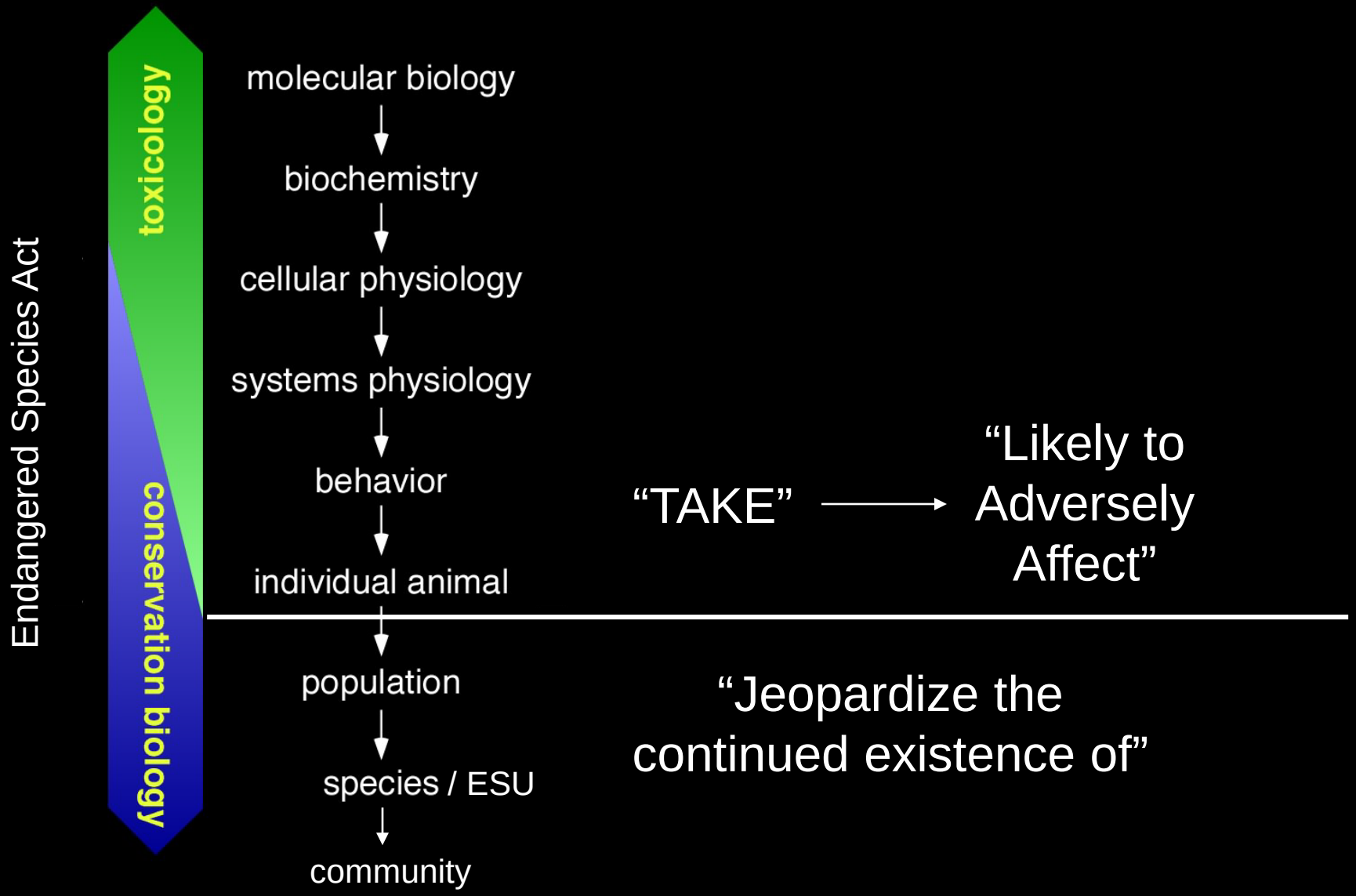
Overview

- 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?



Biological organization and ESA determinations



Translation of individual effects to populations

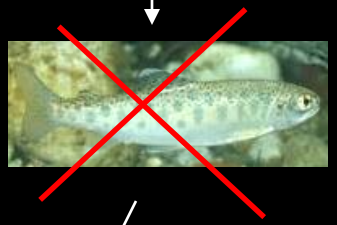
Sub-lethal effect(s)

Acetylcholinesterase inhibition and disruption of olfactory function

Behavioral impact

Lethal effect

Mortality from mixture toxicity



Habitat effect(s)

Reduction in prey availability

Reduced feeding and growth

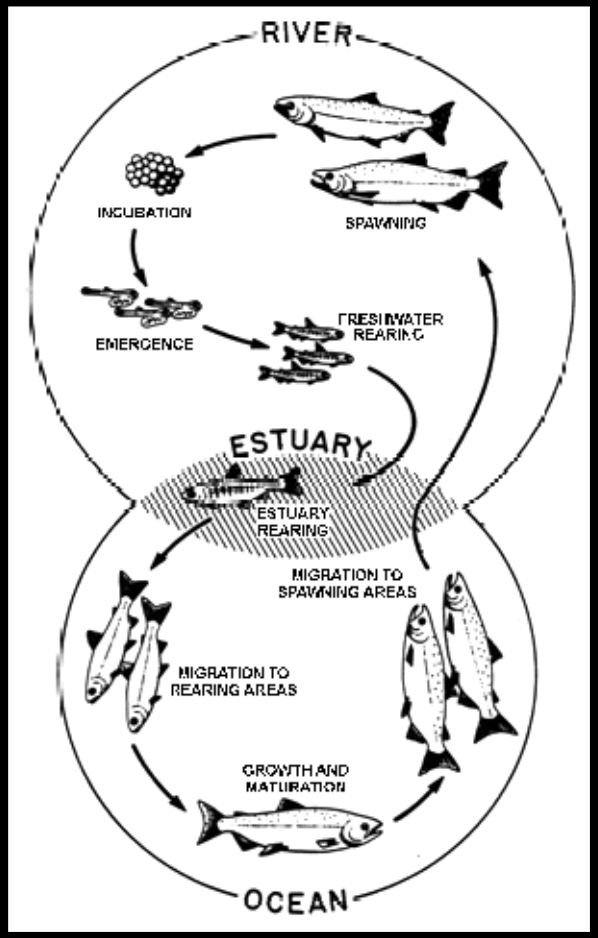
Reduced body size

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

life history specific population models

Middle Columbia River Steelhead

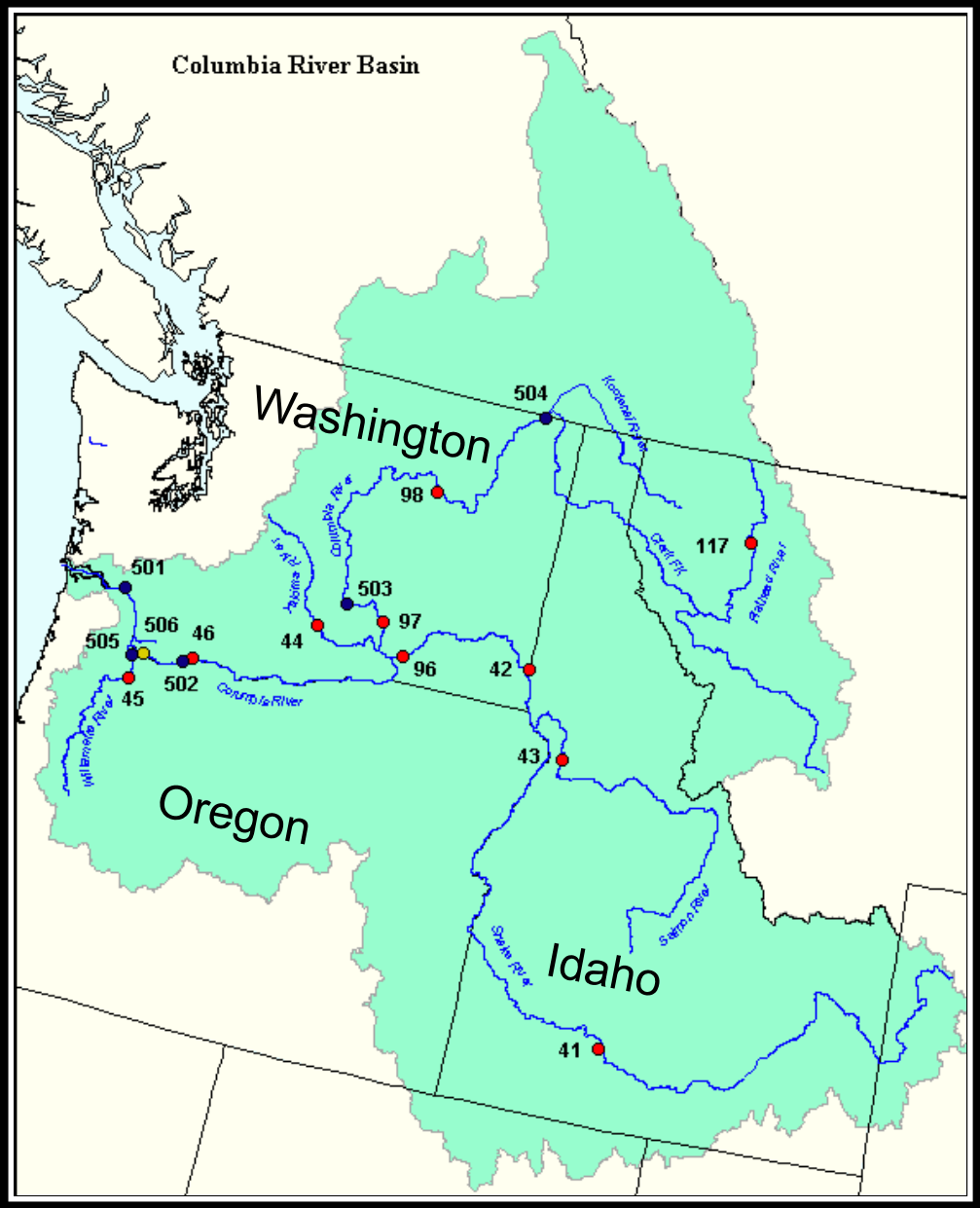
Oncorhynchus mykiss



Note: return spawners


Columbia River Basin
Canada
Continental United States
Mexico
Hurricanes

Columbia River Basin



- Listed as Threatened in 1999
- 16 populations
- Critical Habitat designated in 2005
- Population viability affected

Common stressors:

Habitat blockages

Hatchery influences

Land use impacts

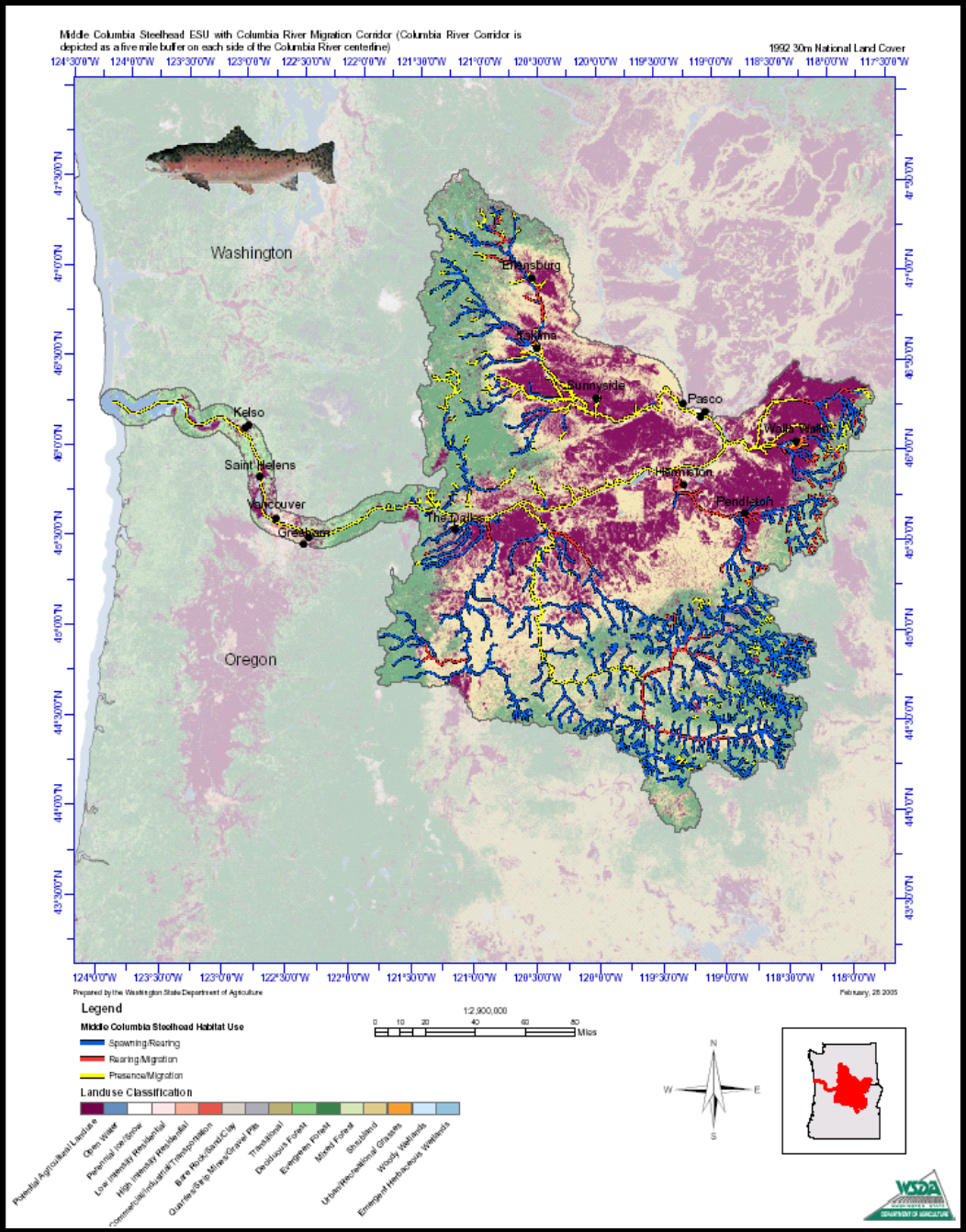
Harvest

Chemical contaminants:

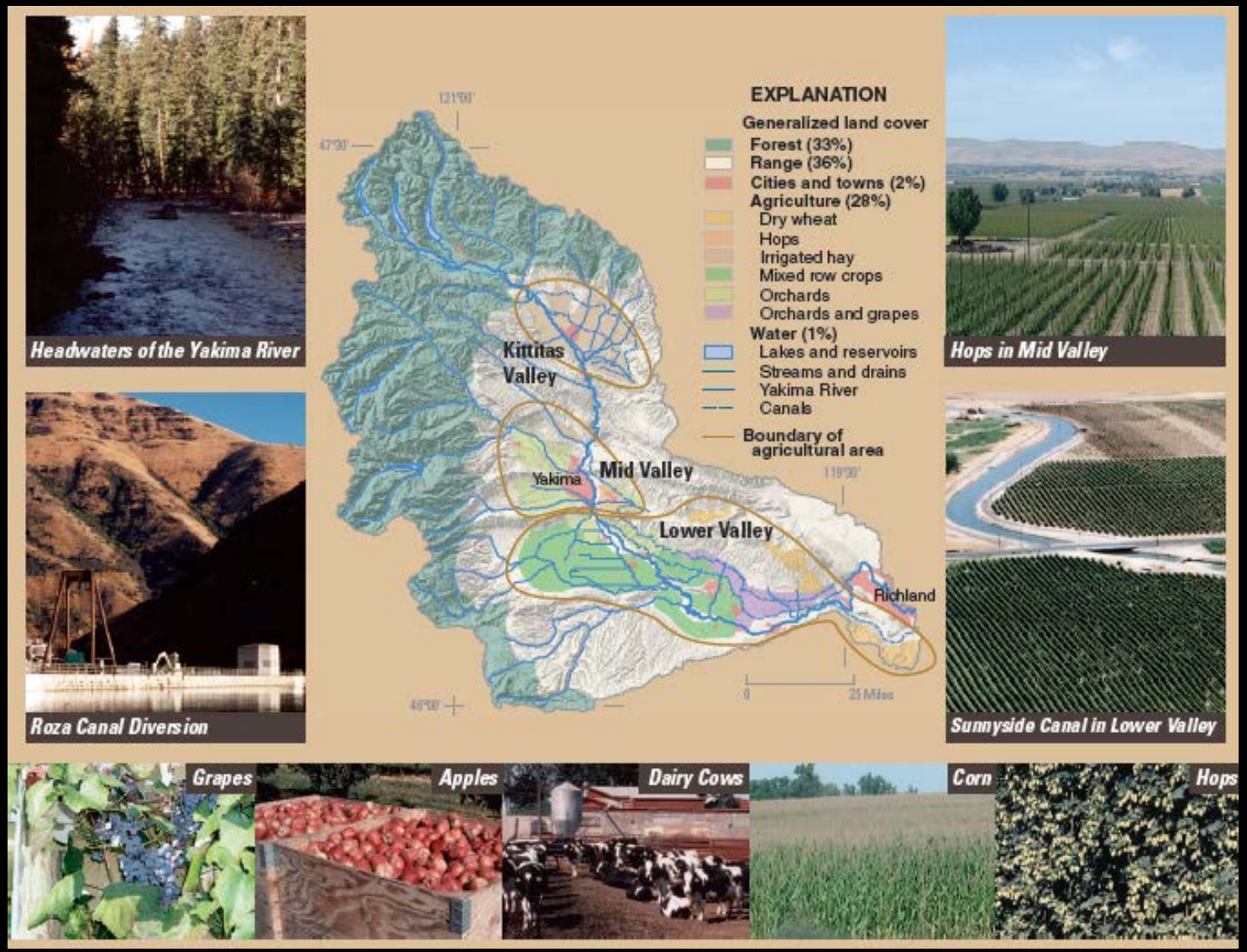
Pesticides

PAHs

Heavy metals

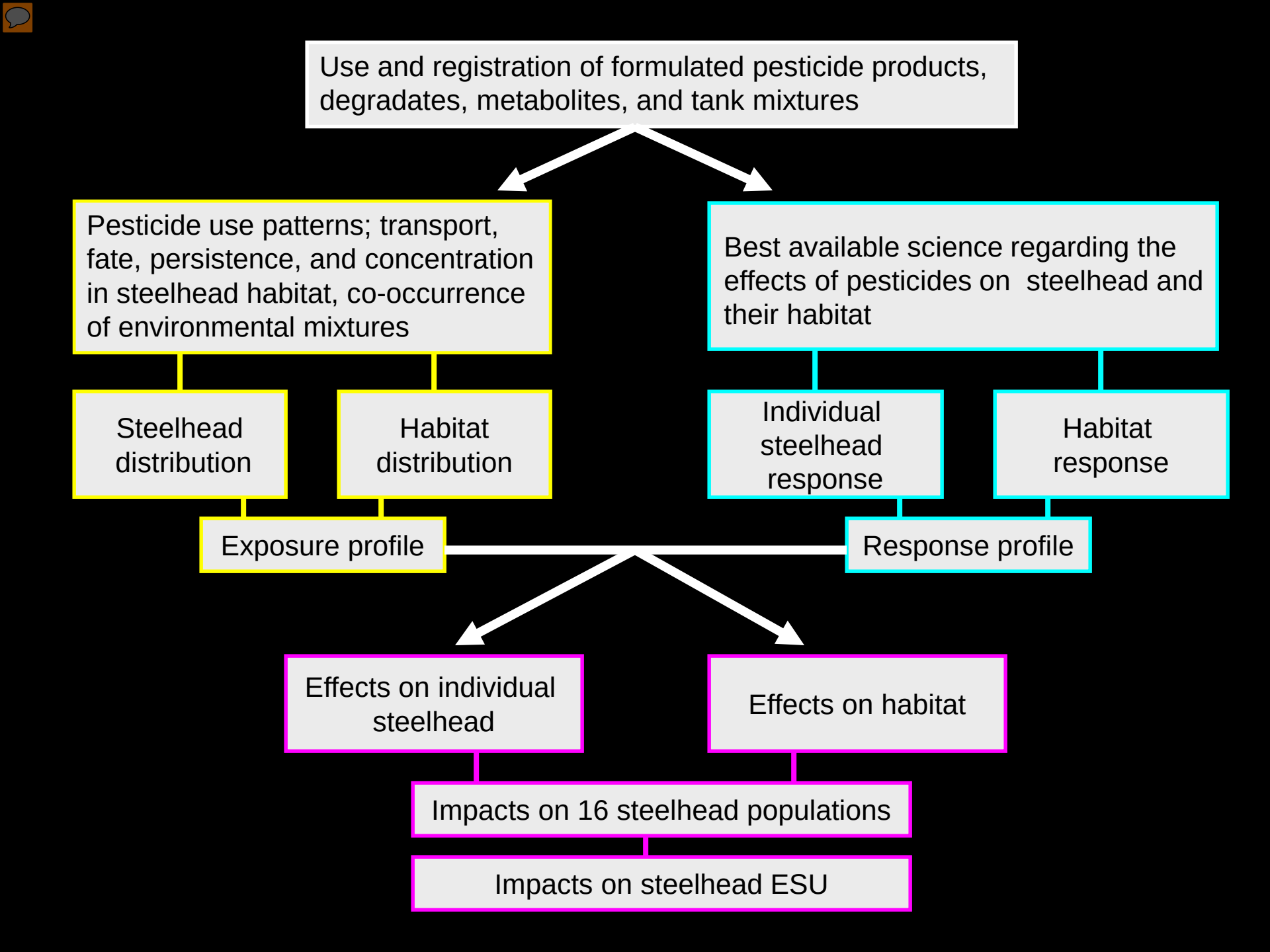


Yakima River Basin



Fuhrer GJ, Morace JL, Johnson HM, Rinella JF, Ebbert JC, Embrey SS, WaiteIR, Carpenter KD, Wise DR, Hughes CA. 2004. Water Quality in the Yakima River Basin, WA, 1999-2000: US Geological Survey Circular 1237, 34 p. Figure 1.

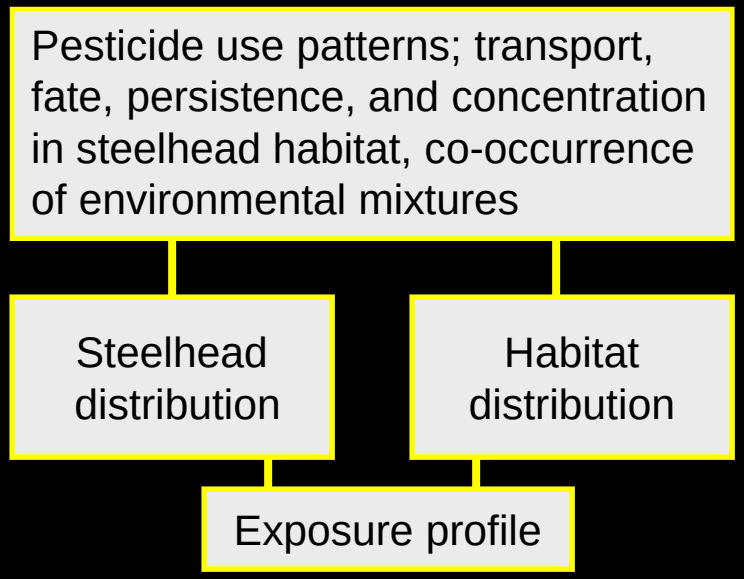
A Conceptual Model for Columbia River Steelhead and Pesticides


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
Best available science regarding the effects of pesticides on steelhead and their habitat
Steelhead distribution
Habitat distribution
Individual steelhead response
Habitat response
Exposure profile
Response profile
Effects on individual steelhead
Effects on habitat
Impacts on 16 steelhead populations
Impacts on steelhead ESU

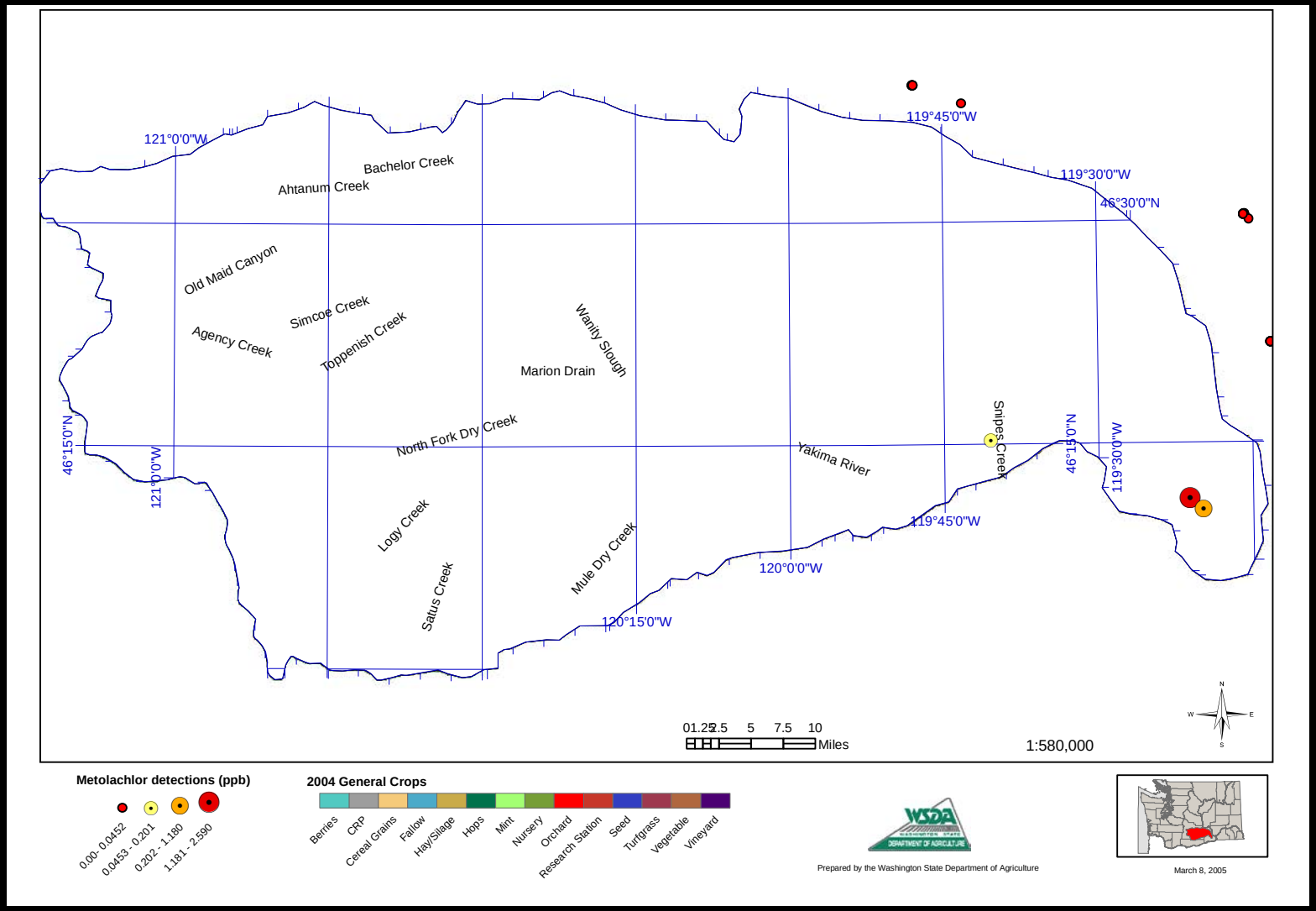
Yakima baseline conditions

- 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, piscivorus predators
  - Pathogenic bacteria
  - Fishing

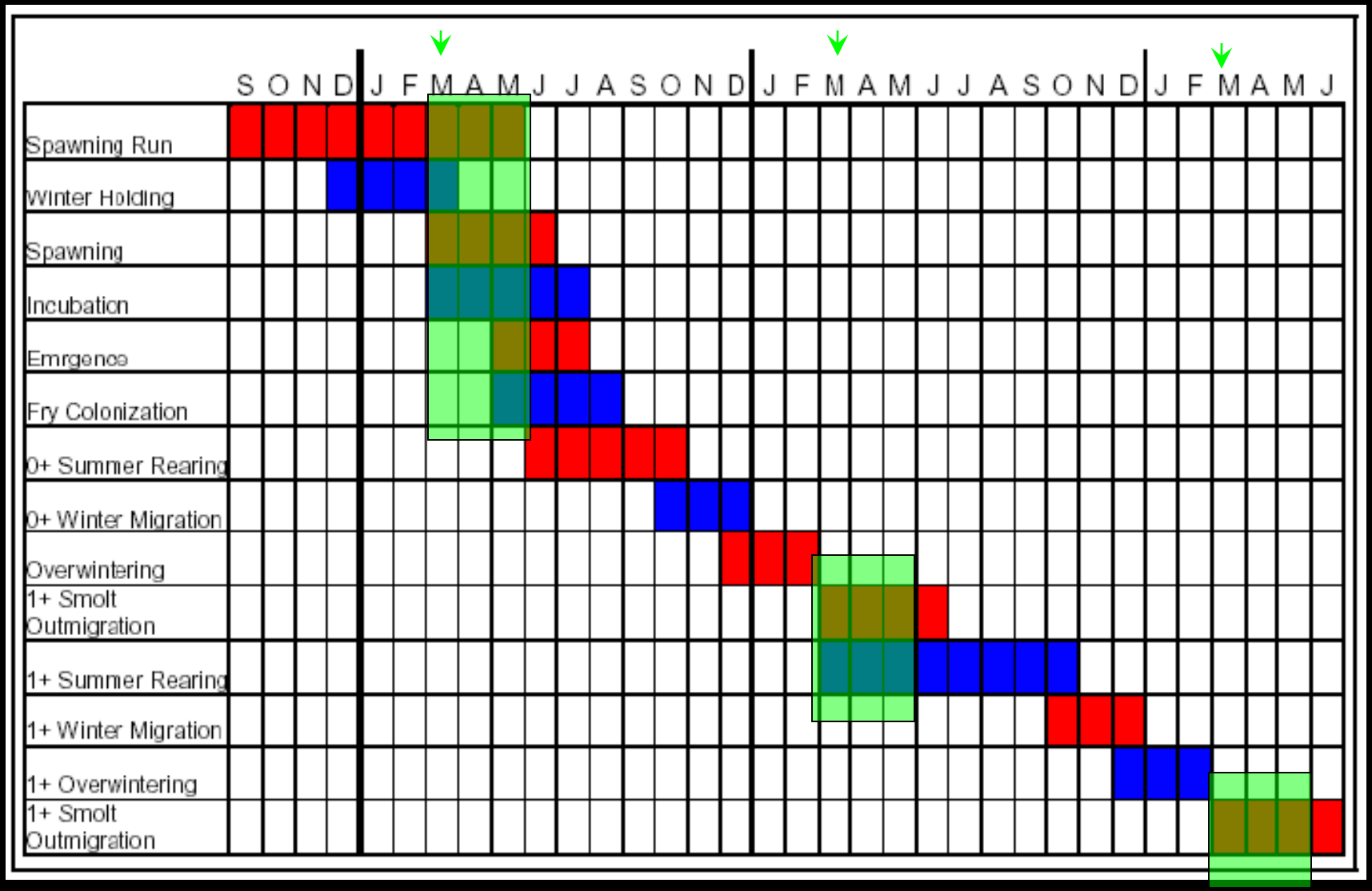
Exposure Profile:



Steelhead Distribution and Cropping Patterns in Yakima Basin

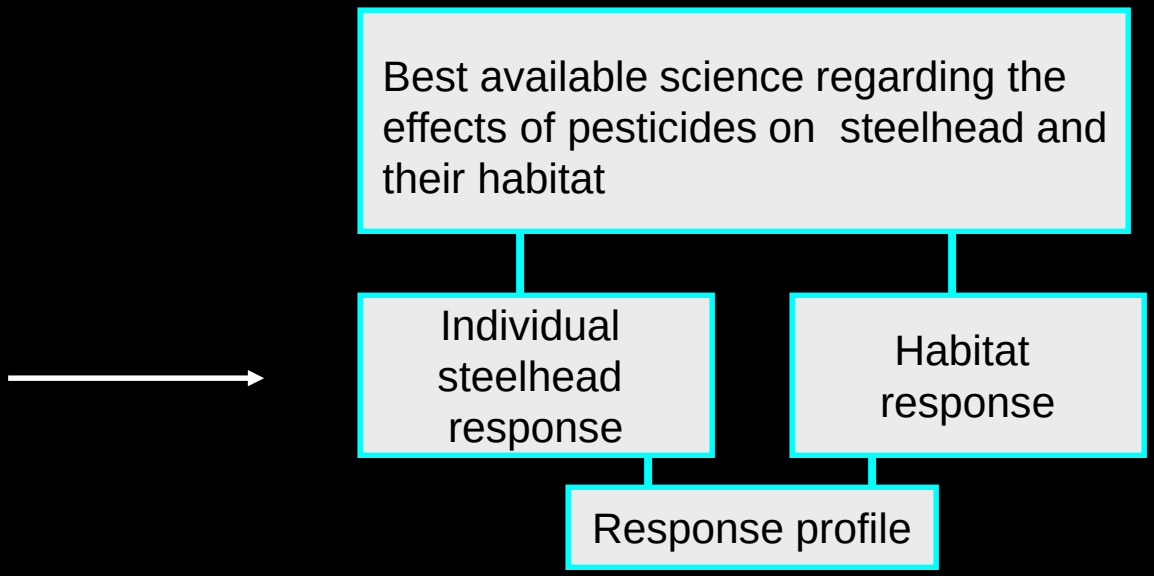


Life History Temporal Distribution of Yakima Summer Run Steelhead



K. Gullett, NOAA Fisheries

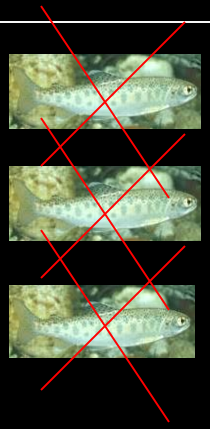
Response Profile



Effects to individual steelhead

Assessment Endpoints	Assessment Measures
Juvenile growth	Foraging behavior Growth rate Condition index
Reproduction	Courtship behavior Number of eggs produced Fertilization success
Early development	Gastrulation Organogenesis Hatching success
Smoltification	Ion exchange (*i.e.* gill Na^+/K^+ ATPase activity) Blood hormone (*i.e.* thyroxin) Salinity tolerance
Disease-induced mortality	Immunocompetence Pathogen prevalence in tissues Histopathology
Migration or distribution	Use of juvenile rearing habitats Adult homing behavior Selection of spawning sites

Mixture toxicity of organophosphate insecticides: Acetylcholinesterase inhibition

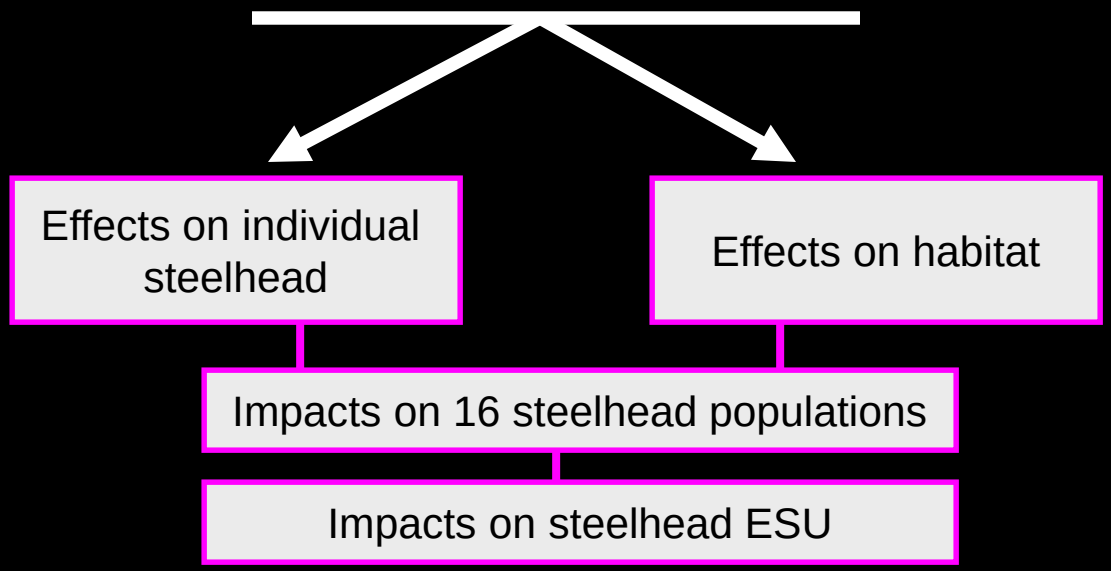
Binary Mixtures	Predicted	Observed	Lethality
malathion + diazinon	additive	synergistic	
malathion + chlorpyrifos	additive	synergistic	
diazinon + chlorpyrifos	additive	synergistic	

ppb (ug/l)	toxicity thresholds				EC50 units			exposure	
					1	0.4	0.1		
Insecticide	LC50	LC50 /20	LC50 /2.27	EC50	0.5 EC50	0.2 EC50	0.05 EC50	Peak Field Concs.	Peak EECs
diazinon	913.9	45.7	404.4	147.5	**73.8**	**29.5**	**7.4**	0.14	25.1[a]
chlorpyrifos	80.2	4.0	35.3	2.0	**1.0**	**0.4**	0.1	0.48	9.2[b]
malathion	118.8	5.9	52.6	74.3	**37.2**	**14.9**	**3.7**	3.05	47.2[c]

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

Laetz *et al*. in preparation

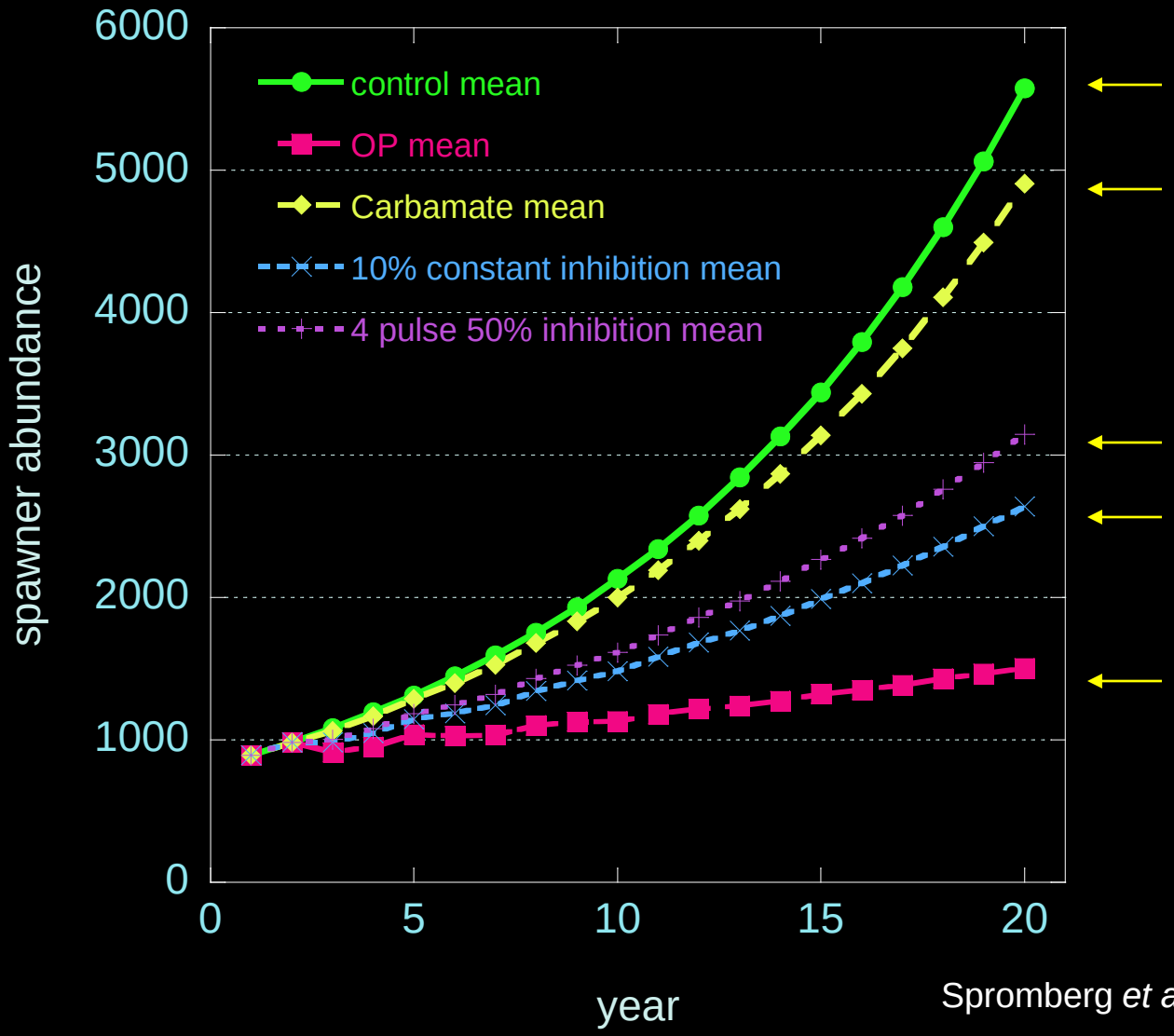
Risk Characterization



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

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David Baldwin	NOAA’s NW Fisheries Science Center

Thank you

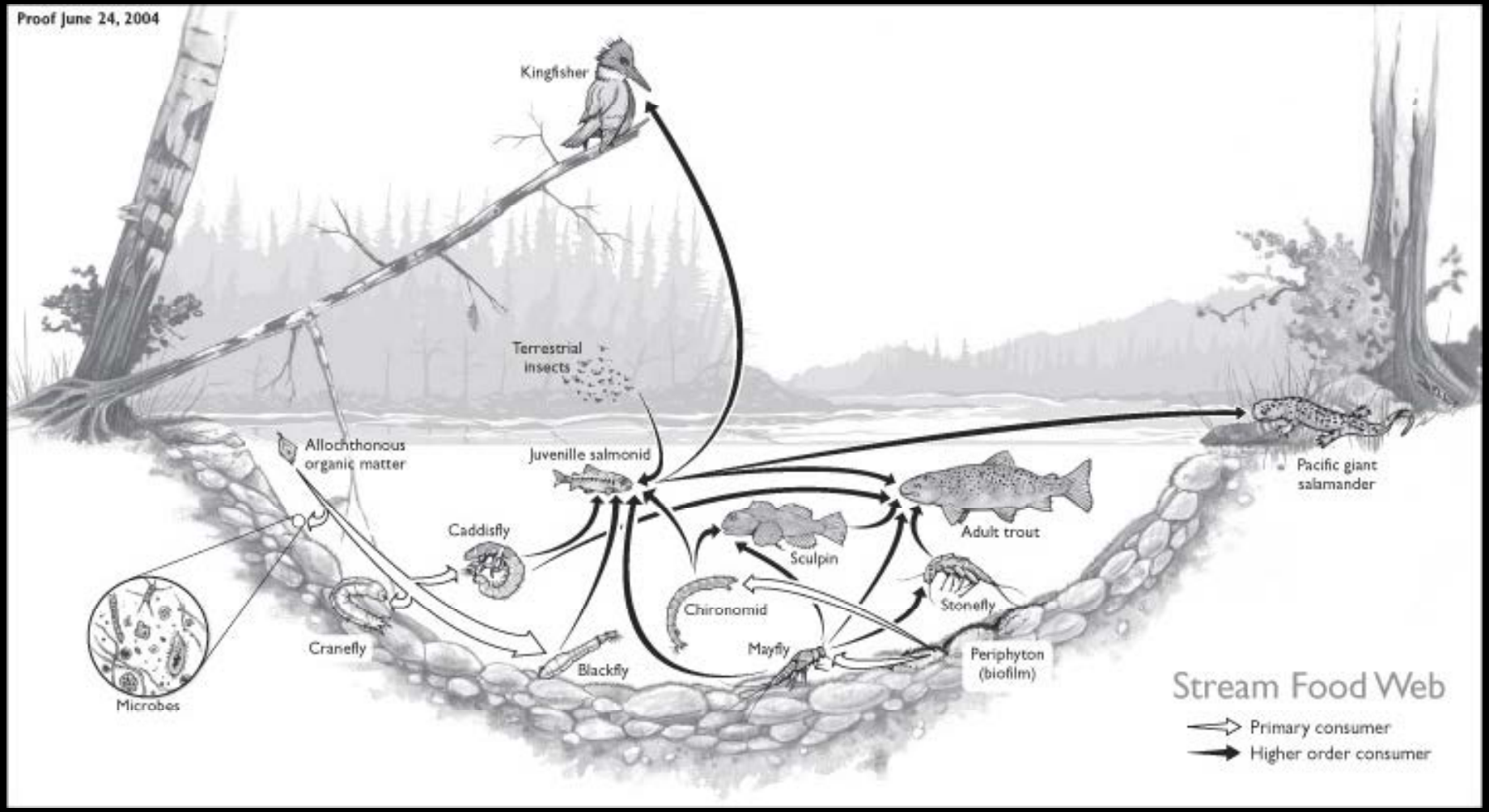
Assessing Population Status:

Viable Salmonid Population Concept*

- Abundance
- Productivity
- Spatial Structure
- Diversity

*McElhany P, Ruckleshaus M, Ford MJ, Wainwright T, Bjorkstedt E. 2000. Viable salmon populations and the recovery of evolutionaruli significant units. US DOC. NOAA Technical memorandum NMFS-NWFSC-42. 156p.

Pesticide effects to lotic habitats



Designated Critical Habitat
Primary Constituent Elements (PCE)

Habitat Component:	For each listed ESU:
1) Spawning and juvenile rearing areas	1)spawning gravel; 2) **water quality**; 3) water quantity; 4) water temp.; 5)**food**; 6) **riparian veg**.; 7) access
2) Juvenile migration corridors	1) substrate; 2) **water quality**; 3) water quantity; 4) water temp.; 5) water velocity; 6) cover/shelter 7) **food**; 8) **riparian veg**.; 9) space; 10) safe passage
3) Areas for growth and development to adulthood	Ocean areas – not identified
4) Adult migration corridors	1) substrate; 2) **water quality**; 3) water quantity; 4) water temp.; 5) water velocity; 6) cover/shelter; 7) **riparian veg**.; 8) space; 9) safe passage

Conceptual model: Translation of individual effects to populations

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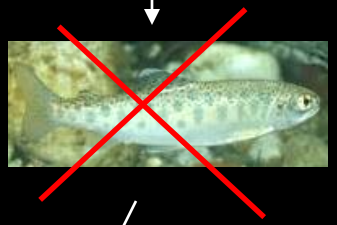
Mortality from mixture toxicity



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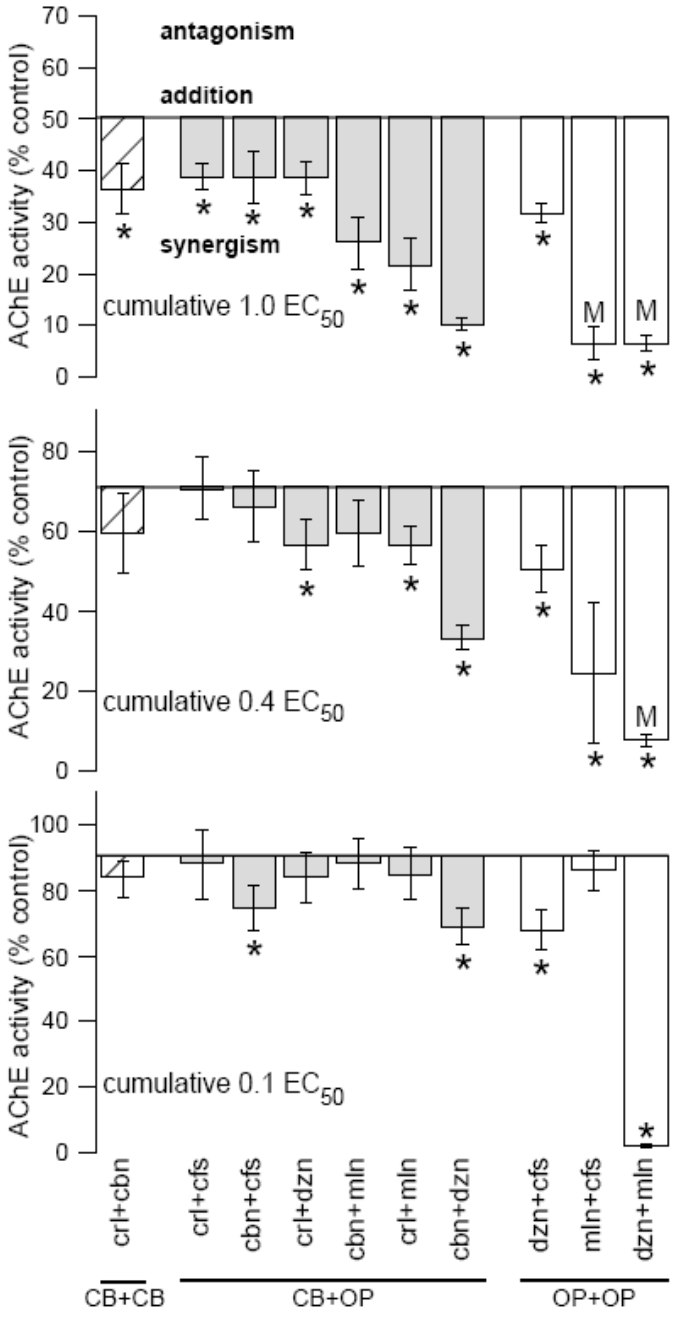
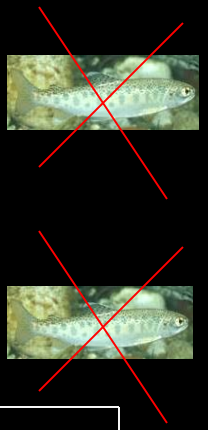

antagonism
addition
synergism
AChE activity (% control)
cumulative 1.0 EC50
cumulative 0.4 EC50
cumulative 0.1 EC50
M
crl+cbn
crl+cfs
cbn+cfs
crl+dzn
cbn+mln
crl+mln
cbn+dzn
dzn+cfs
mln+cfs
dzn+mln
CB+CB
CB+OP
OP+OP

Mixture toxicity of organophosphate insecticides: Acetylcholinesterase inhibition

Binary Mixtures	Predicted	Observed
malathion + diazinon	additive	synergistic
malathion + chlorpyrifos	additive	synergistic
diazinon + chlorpyrifos	additive	synergistic



ug/L (ppb)

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