

Assessing indirect effects to threatened and endangered Pacific salmonids: A case example



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ESA-Listed Pacific NW and California Anadromous Salmonids

28 Evolutionarily Significant Units



Oncorhynchus kisutch



Oncorhynchus keta



Oncorhynchus nerka



Oncorhynchus mykiss

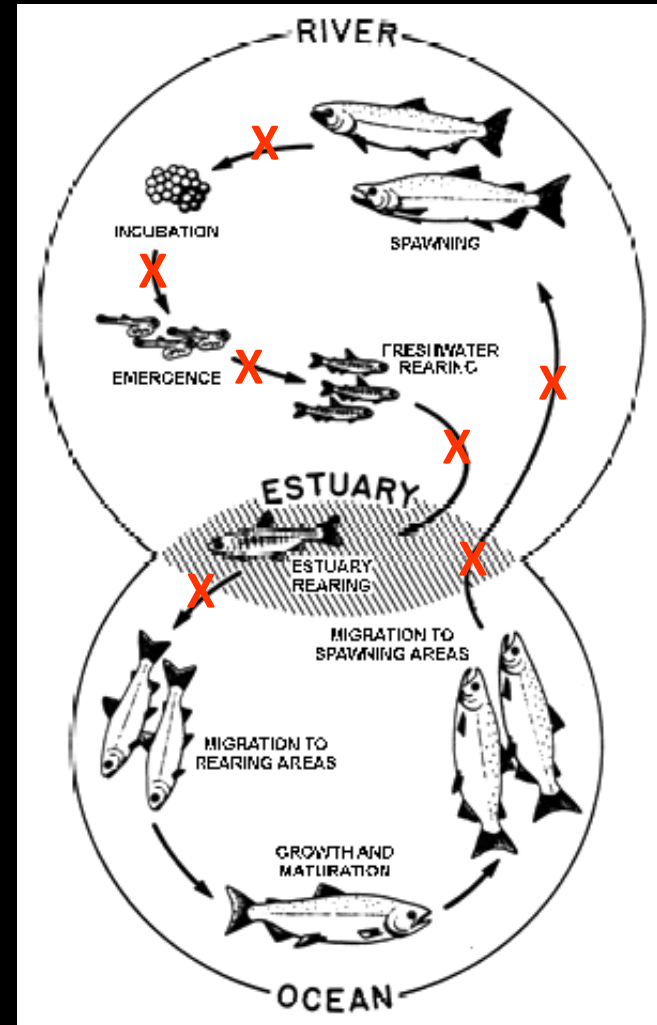


Oncorhynchus tshawytscha



Pacific Salmonids

- Anadromy
- Cultural, ecological, economic importance
- Diverse, multiple life histories
- Geographic specificity
- 58 ESUs – 28 listed as threatened or endangered
- Susceptible to pesticides at multiple life stages
- Diverse habitat use



Pesticides and indirect effects

Insecticides

Effects to salmonid prey

Herbicides

Effects to primary producers
(aquatic and terrestrial);
Indirect effects to salmonid prey

Fungicides

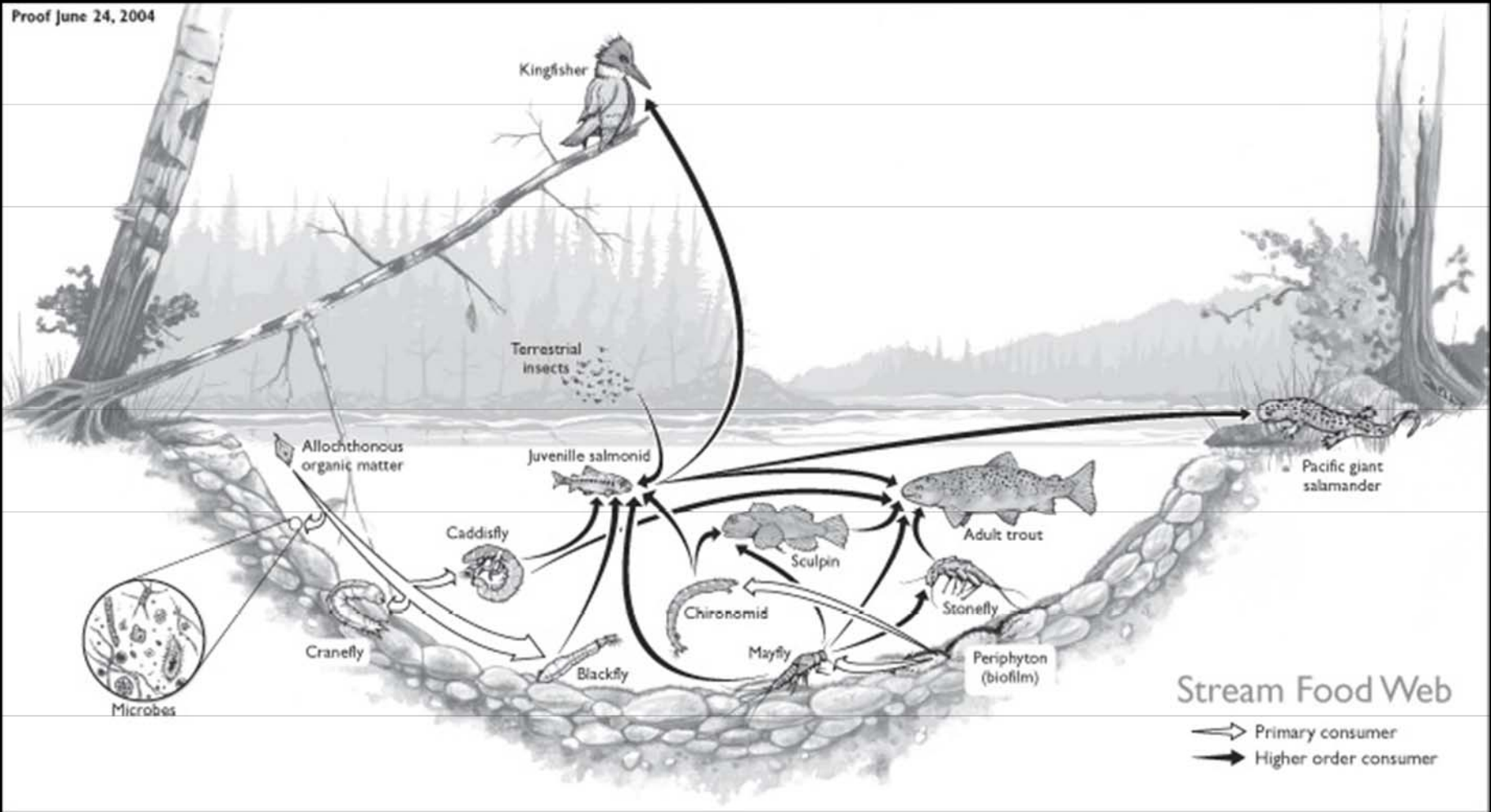
Effects to aquatic microbial
community;
Indirect effects to salmonid prey

Other ingredients

Various effects to aquatic
ecosystems (chemical dependent)

Freshwater salmonid Habitats





Freshwater exposure to insecticides is sufficient to reduce abundances of salmonid prey



Reductions in abundances of salmonid prey lead to reduced juvenile growth and subsequent survival, and impacts populations

Off channel habitats and small streams

- Shallow, low flow aquatic habitats
- Fish rear and seek protection from high velocity flows
- Susceptible to drift and runoff
- Many of these areas are designated critical habitat
- Occur in agricultural- and human-dominated flood plains
- Primary focus of restoration efforts and off-site mitigation



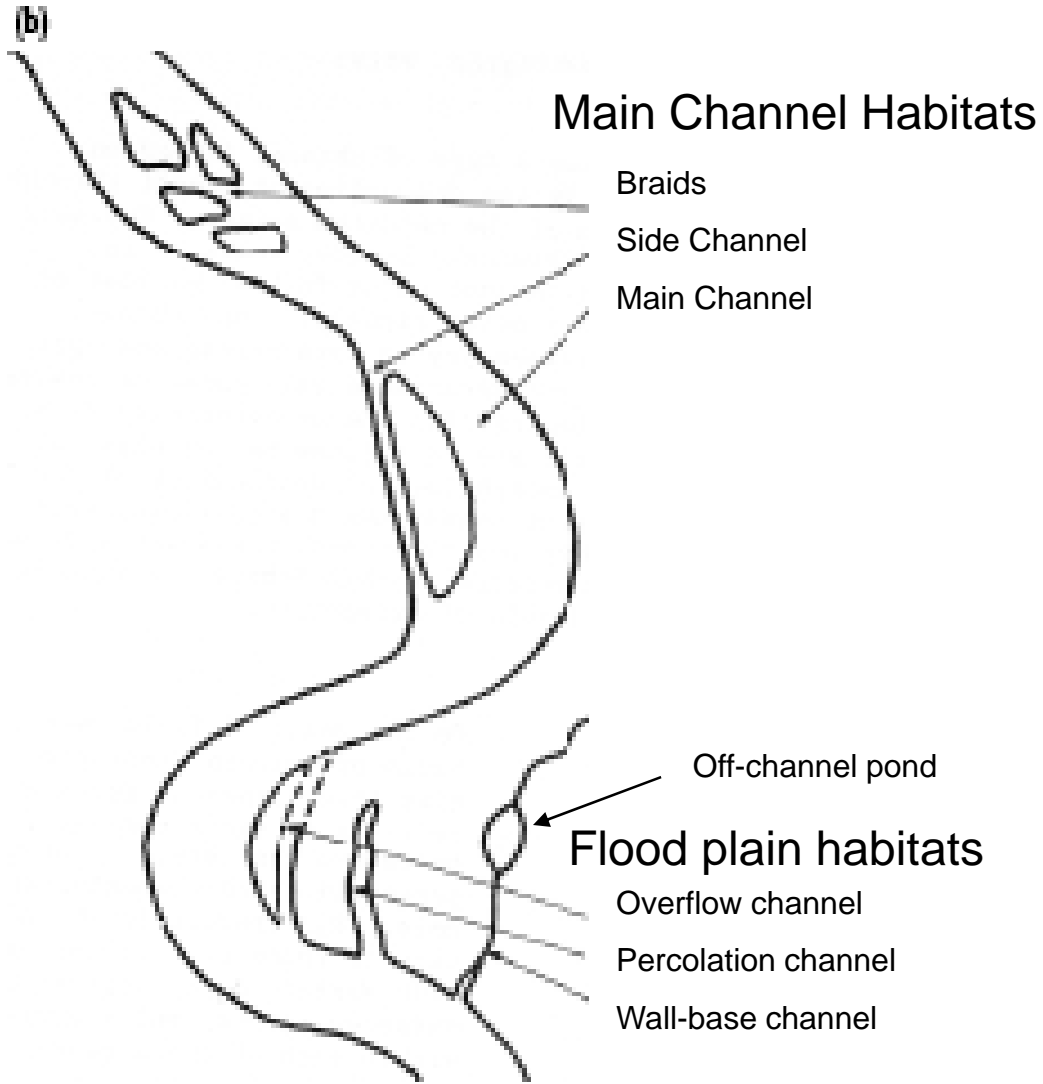
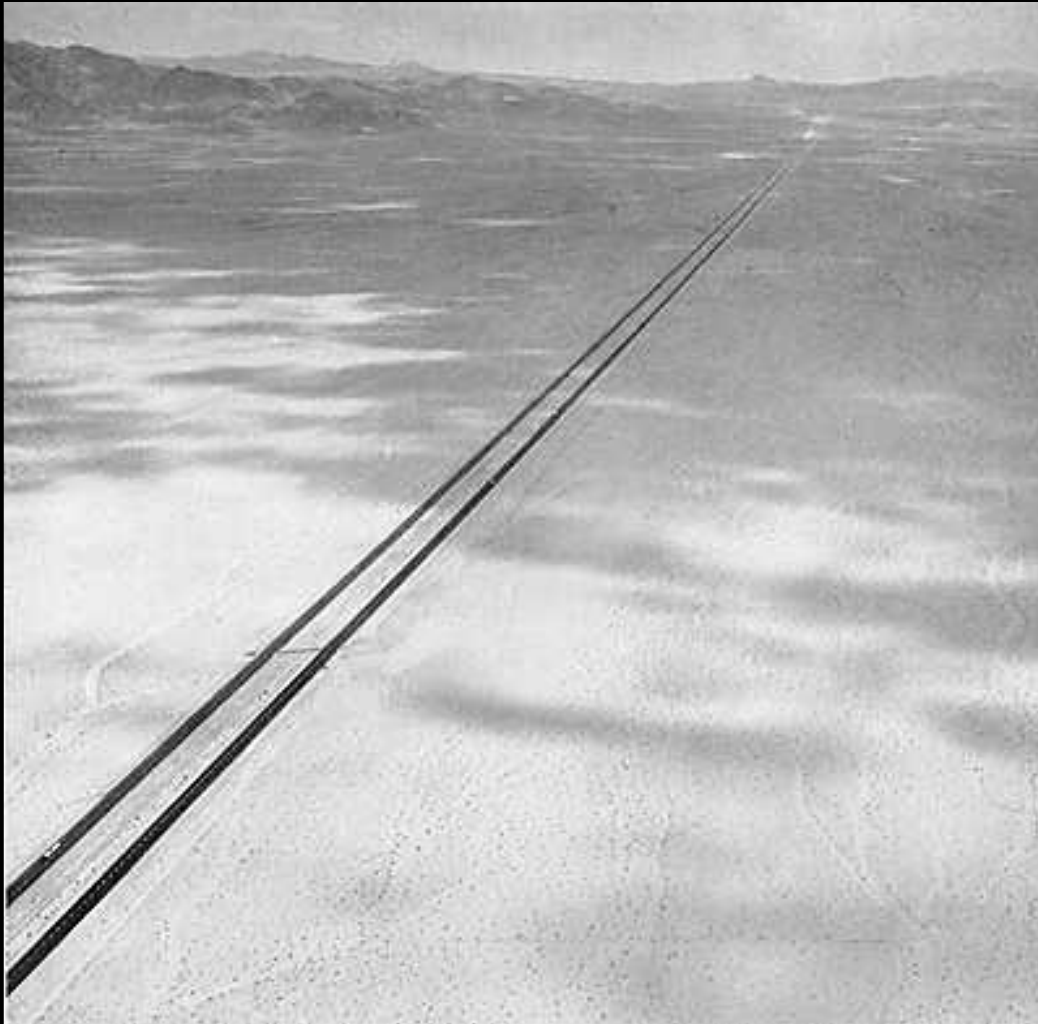
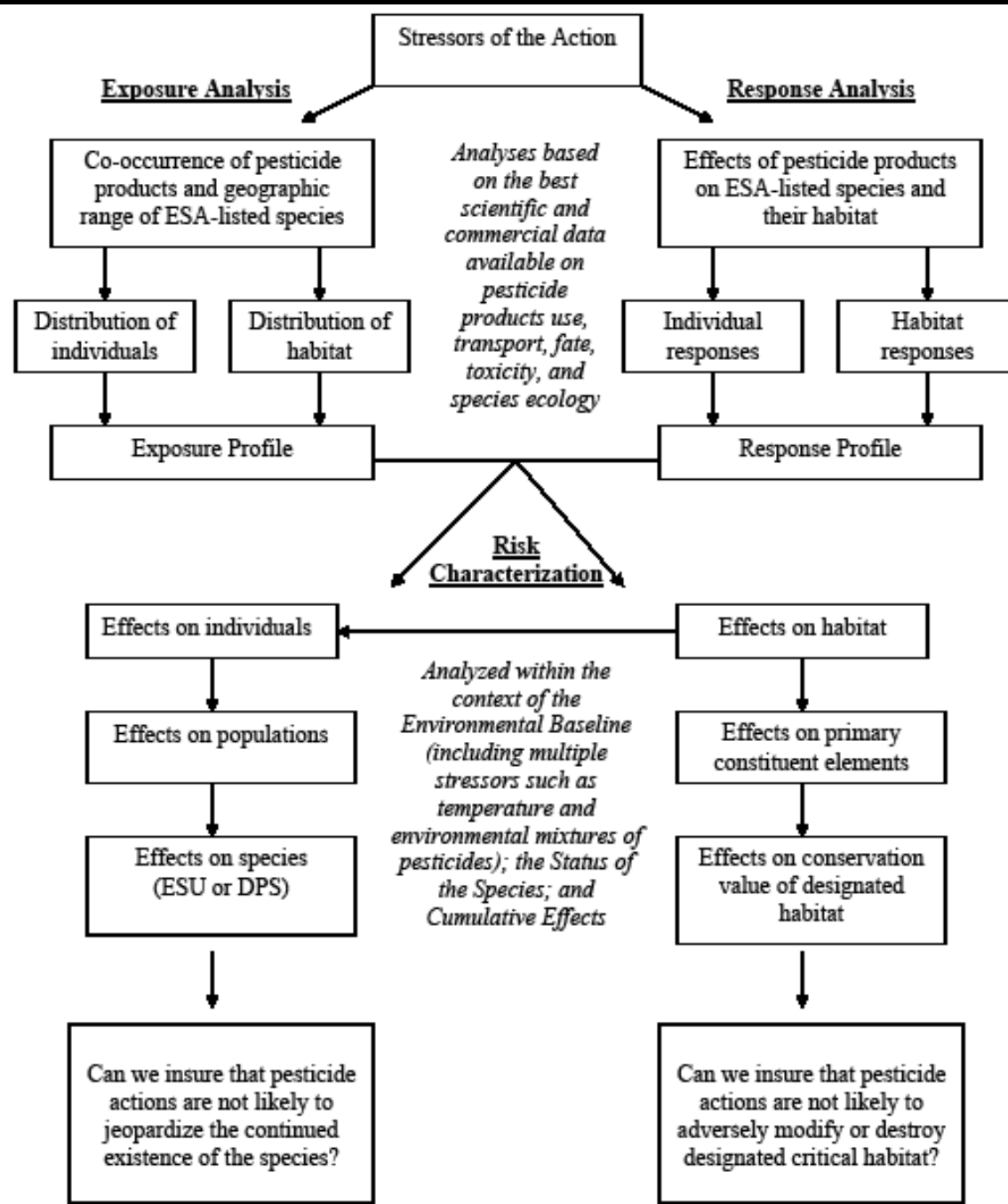


Fig. 2. b. Examples of off channel habitats. Pess et al. 2005.

Indirect effects of pesticides: Two avenues



1. Effects to salmonids from pesticide-induced habitat impairment – Jeopardy analysis
2. Effects to Designated Critical Habitat: Reductions in Primary Constituent Elements (PCE)



Avenue 1 – Jeopardy analysis (habitat)

Effects on habitat

Effects on individuals

Effects on populations

Effects on salmonid species
(ESU/DPS)

Can we insure that
pesticide actions are not
likely to jeopardize the
continue existence of the
species?

Avenue 1 Risk hypothesis: Response of habitat to insecticides

1. Freshwater exposure to insecticides is sufficient to reduce salmonid prey availability and quality.
2. Reductions in prey lead to reduced fitness of individuals i.e., juvenile growth, survival, reduced reproductive success.
3. First year survival of smaller juveniles is reduced which leads to population-level consequences

Salmonid Habitat Assessment Endpoints

| Assessment Endpoints | Assessment Measures |
|-----------------------------|---|
| Prey availability | Acute and chronic toxicity (LC ₅₀) Species abundance (aquatic and terrestrial) Indices of biological integrity (IBIs) |
| Primary productivity | Macro-algal cover Chlorophyll concentration Dissolved oxygen production |
| Habitat structure | Sediment grain size (embeddedness) Shelter availability Large woody debris |
| Riparian function | Plant community composition Allochthonous inputs of organic matter Riparian buffer width |
| Water quality | Temperature Dissolved oxygen concentration Sediment load |

Effects to salmonid populations via reduced juvenile growth

Linking biological scales:

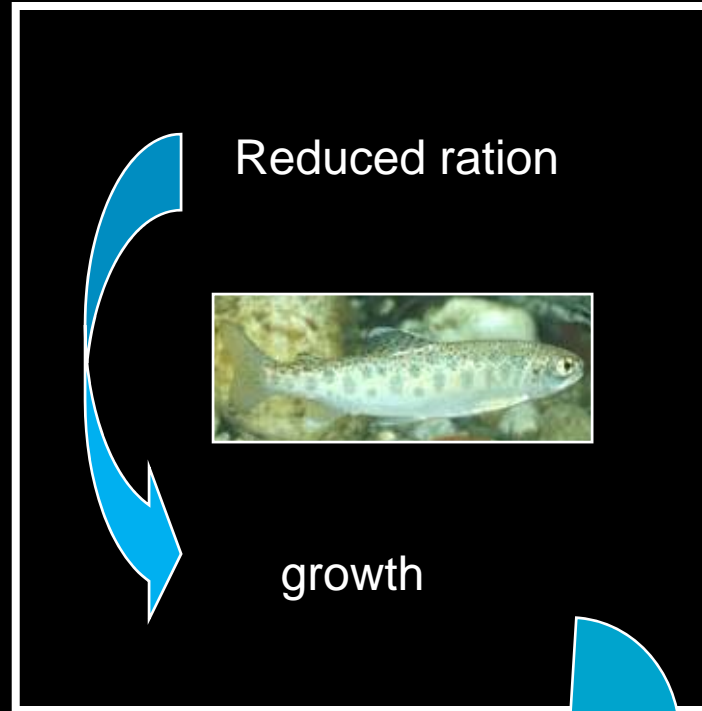
Reduced prey abundance

Reduced size of juveniles

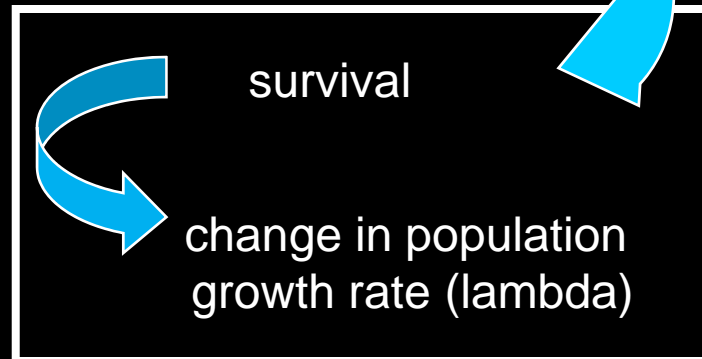
Juvenile survival

Population growth rate

Somatic Growth Model



Population Model



Avenue 2 – Critical habitat analysis

Effects on habitat

Effects on primary
constituent elements

Effects on conservation
value of designated critical
habitat

Can we insure that
pesticide actions are not
likely to adversely modify
or destroy designated
critical habitat?

Risk hypothesis:

Freshwater exposure to
insecticides is sufficient to
reduce abundances of
salmonid prey- an identified
primary constituent element

Avenue 2 - Designated Critical Habitat Salmonid Primary Constituent Elements (PCE)

Habitat component:

For each salmonid species:

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

Examples of habitat attributes that influence a pesticide's toxicity



Water flow and depth

Temperature

pH

Presence of other pesticides

Areas of uncertainty and research needs

- Empirical stressor-response relationships between habitat assessment endpoints and salmonid responses
- Environmental mixtures and pesticide formulations
- Development of ecotoxicological tools to explore species responses to habitat effects

Take Home Message

- Analysis of pesticide-induced habitat effects is required under the Endangered Species Act via two mechanisms
- Salmonid specific risk hypotheses and associated assessment endpoints are critical to ensure ecologically relevant indirect effects are evaluated
- Off-channel habitats are particularly susceptible to pesticides and important as rearing areas to juvenile salmonids

THANK YOU



| Habitat Type | Description | Physical characteristics |
|--------------------------------------|---|---|
| Braid | Shallow channel across mudflat or channel bar | Flow = 10-30 cm/s Depth < 0.5 m Length >a few meters |
| alcove | Area of slack water along the channel margin separated from main channel by stream banks | Aquatic area = variable Drainage are =variable Depth = variable |
| Off-channel pond | Pond located off main channel with connecting channel to river, low to no flow, shallow | variable |
| Terrace tributary | Stream flowing across valley floor to river | variable |
| Upland slough | A slough fed by spring or terrace tributary; has outlet to river | variable |
| Wall base channels | Spring fed ponds and swamps with mud bottoms | variable |
| Small runoff tributary | Small runoff streams with abundant woody debris and gravel substrate | variable |
| Intermittent tributary | Standing water always present but during summer isolated pools are all that remain | variable |
| Ephemeral swamp/ wetlands | Seasonably variable water levels, less than 25 cm depth. Substrate- organic muck blanket, connected during flood events | variable |