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A Preliminary Framework for Assessment of Ecological Risk to Wild Salmon from Large-scale Mining in Bristol Bay, Alaska

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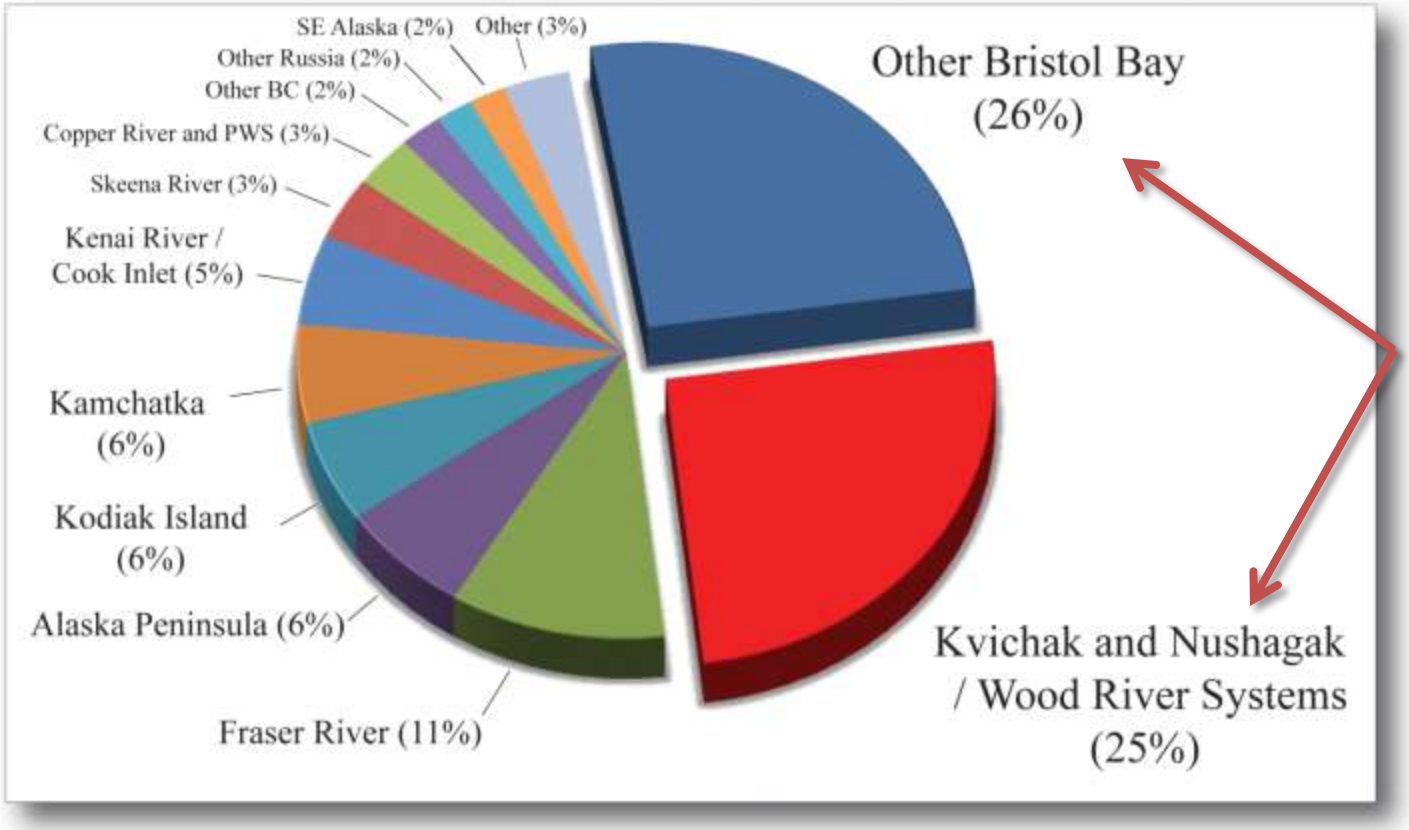
Global Significance:

Bristol Bay produces ~51% of all sockeye salmon on earth



51% of all sockeye salmon come from Bristol Bay

From: Ruggerone et al. 2010. Magnitude and trends in abundance of hatchery and wild pink salmon, chum salmon and sockeye salmon in the North Pacific Ocean. Marine and Coastal Fisheries: Dynamics, Management and Ecosystem Science. (2) 306-328.

and Pinsky et al. 2009. Range-wide selection of catchments for Pacific salmon conservation. Conservation Biology (23) 681-691.

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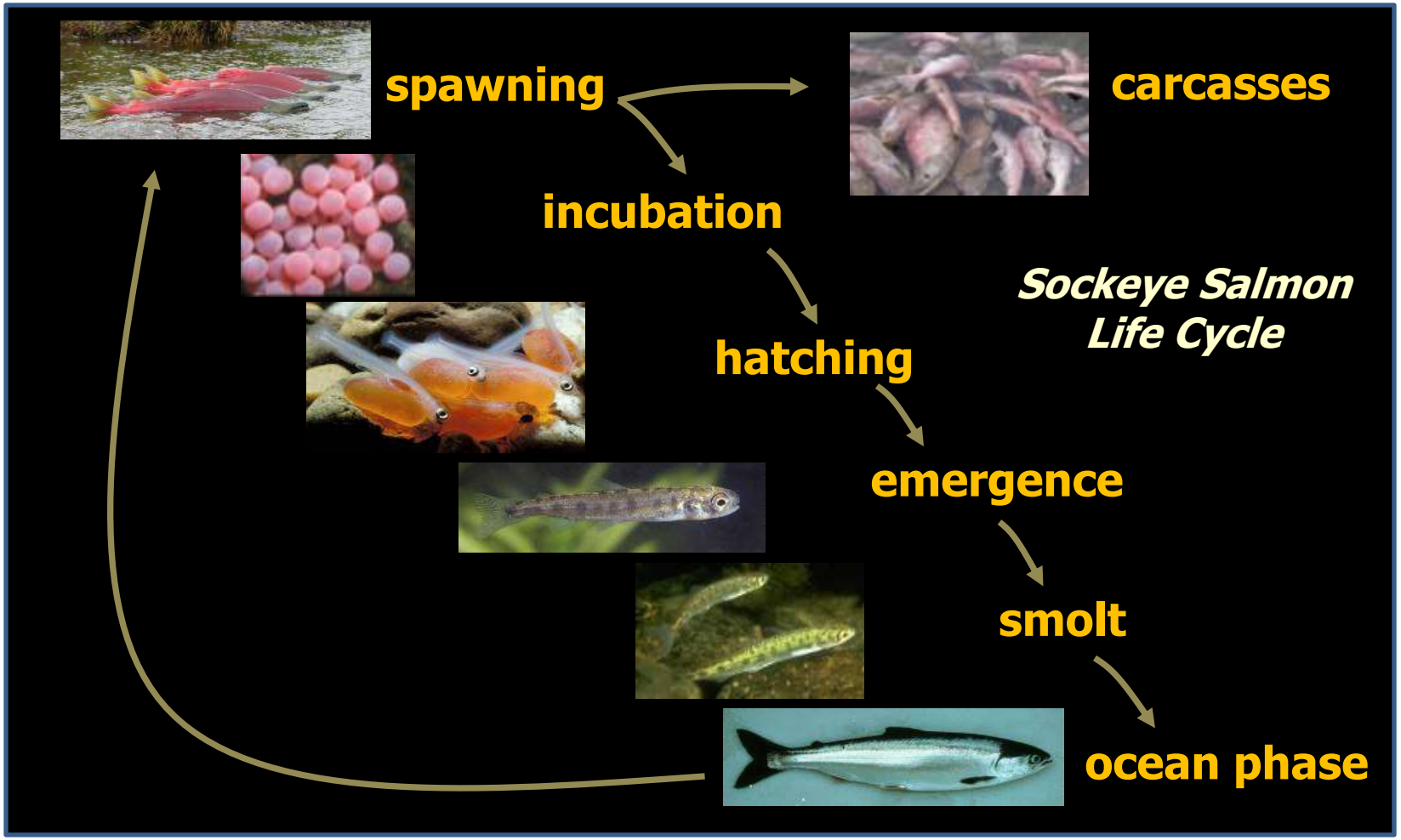
What do salmon need?

- Life history requirements:



From: Dr. Tom Quinn, Univ. of Washington

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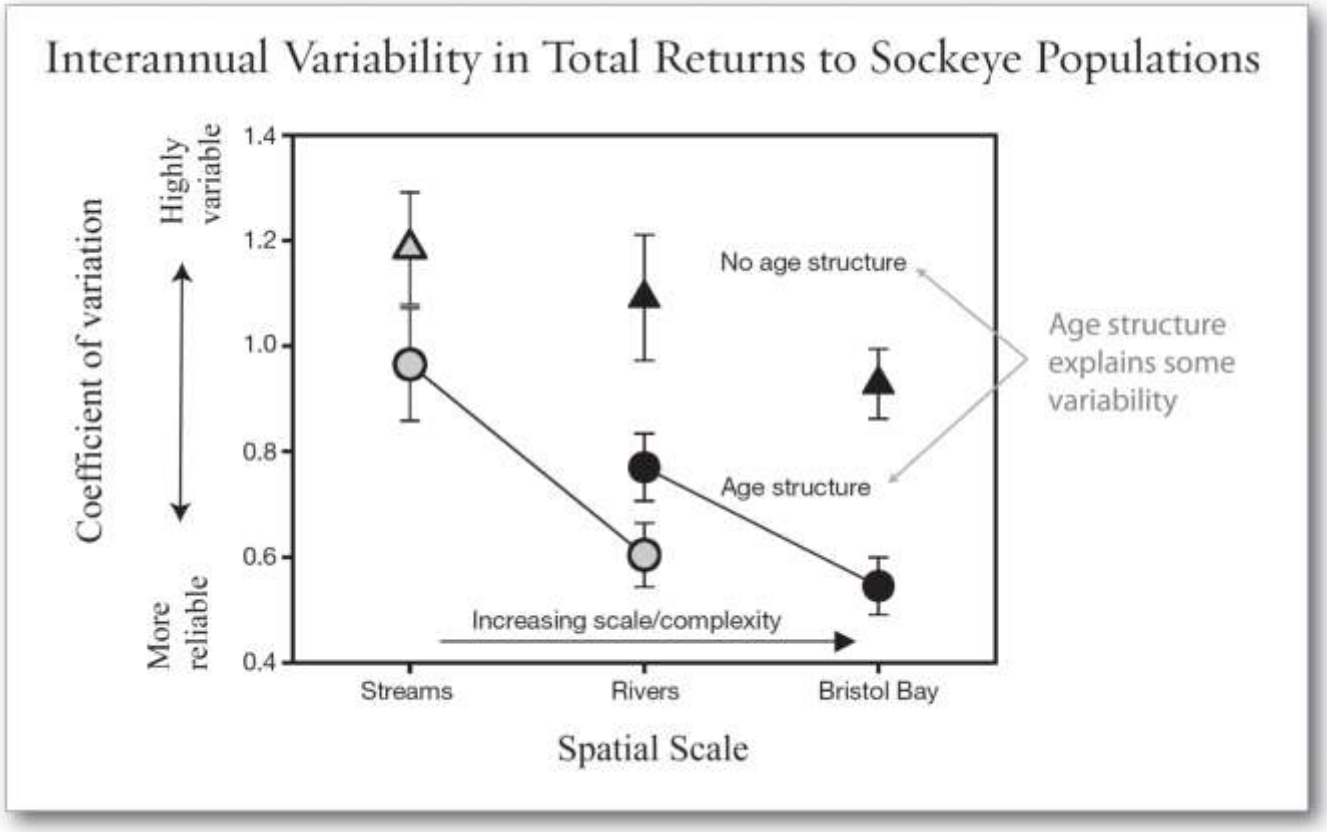
What do salmon need?

- Population diversity and the "portfolio effect"



From: Schindler, et al. 2010. Population stability and the portfolio effect in an exploited species. Nature 635: 609 - 613

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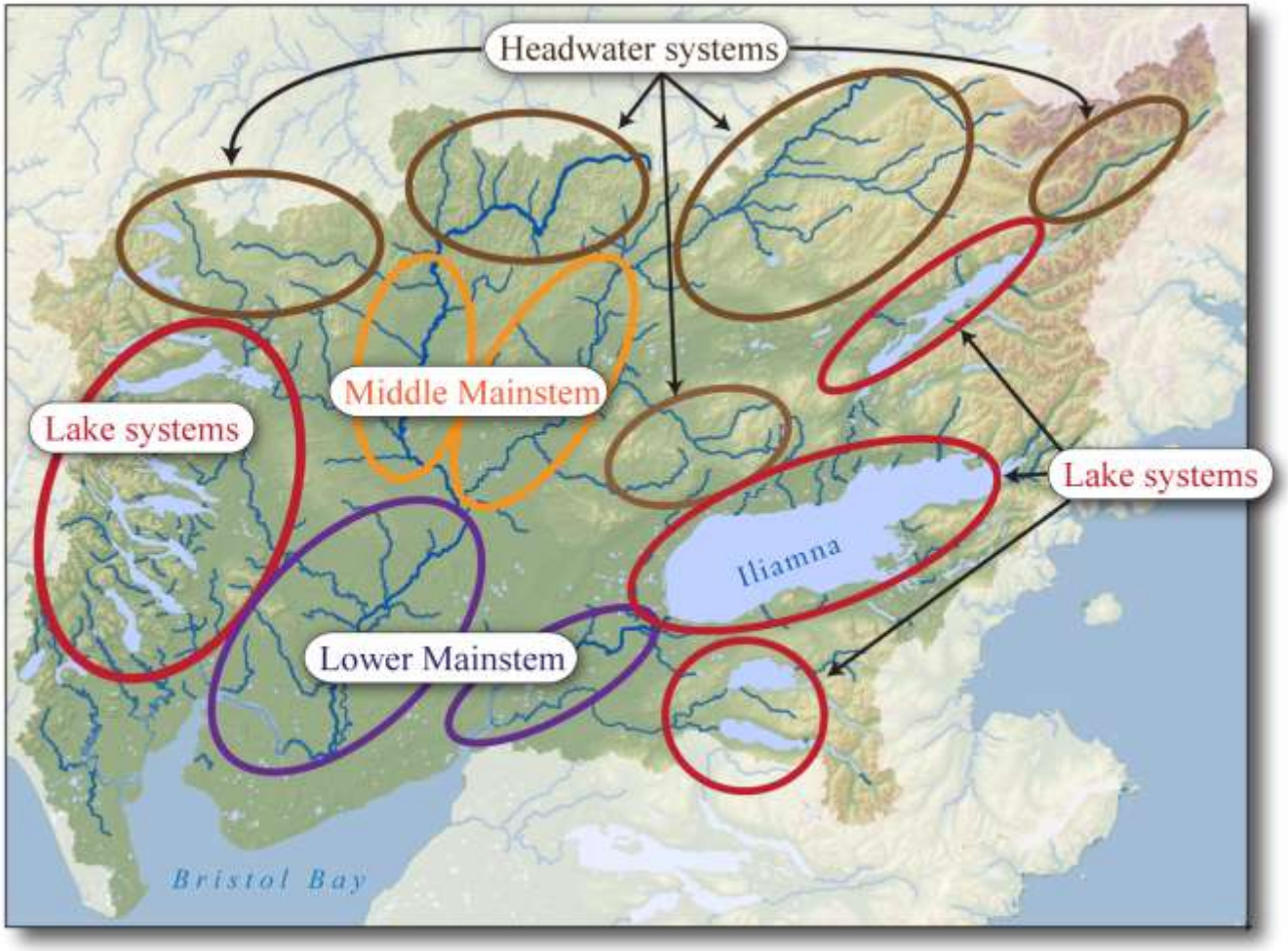

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Ecological Risk Assessment

Methods:

- Large Mine Scenario:
  - Northern Dynasty application for water rights, 2006
- Problem formulation:
  - Physical stressors
  - Chemical stressors
  - Resources at risk
- Characterization of Risk Exposure and Effects
  - Literature review and data analysis
  - Describe impact on biological resources
- Risk characterization:
  - Evaluate potential for adverse effect over time

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Sources of Stress *Risks to key ecological attributes associated with large-scale mining*	Ecological Attributes *Physical and biological functions necessary to maintain viability of each salmon life stage*	Life History Requirements *Life stages representing "links in a chain" are essential for successful conservation of salmon*
		Eggs *(embryonic development)*
		Alevin *(pre-emergence)*
		Fry *(emergence)*
		Parr *(freshwater rearing)*
		Smolt *(out migration)*
		Spawning Adult *(return and spawning)*

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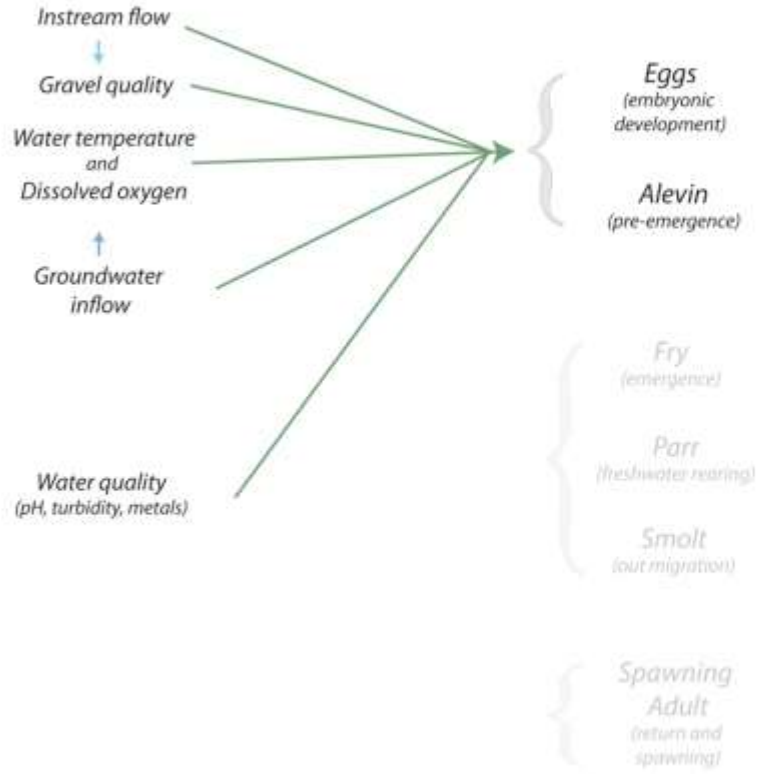
Sources of Stress
Risks to key ecological attributes associated with large-scale mining

Ecological Attributes
Physical and biological functions necessary to maintain viability of each salmon life stage

Life History Requirements
Life stages representing "links in a chain" are essential for successful conservation of salmon



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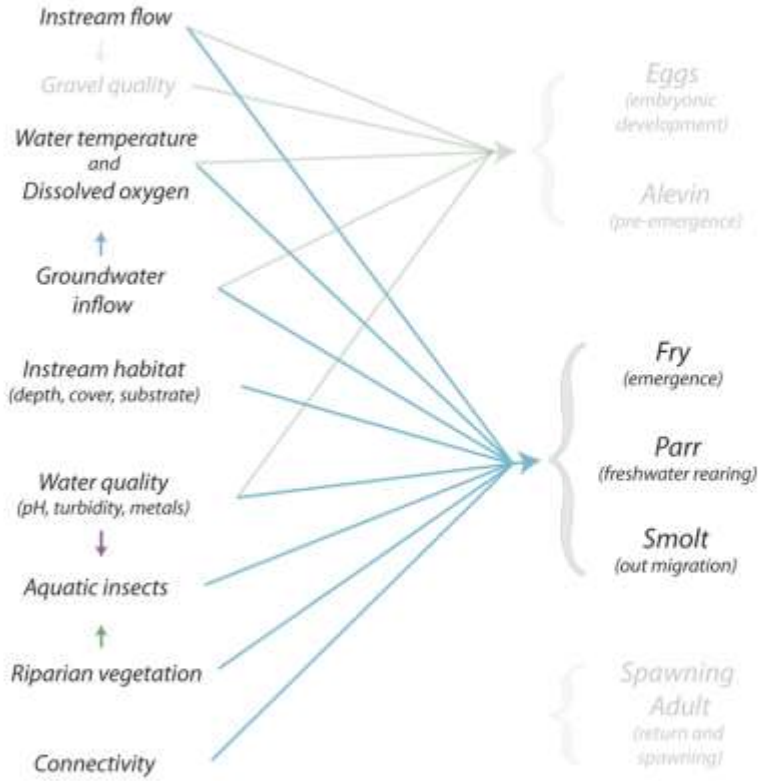

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Sources of Stress

Risks to key ecological attributes associated with large-scale mining

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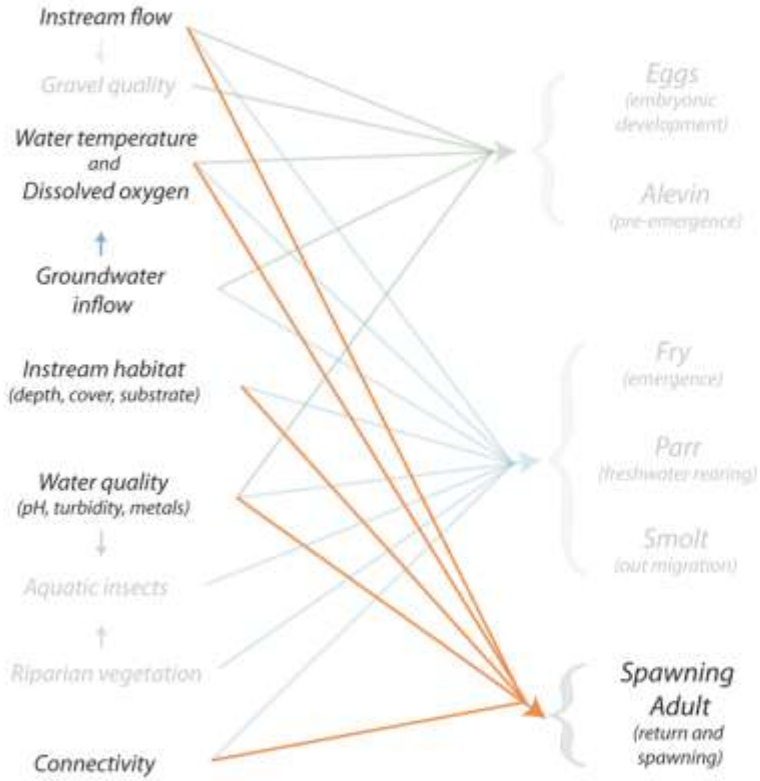

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Sources of Stress
Risks to key ecological attributes associated with large-scale mining

Ecological Attributes
Physical and biological functions necessary to maintain viability of each salmon life stage

Life History Requirements
Life stages representing "links in a chain" are essential for successful conservation of salmon

Flow
- Dewatering / Loss of instream flow

Water Quality
- Large-scale Pollution Events
- Acid Mine Drainage
- Chemical Spills
- Pipeline Spills
- Fugitive Dust

Connectivity
- Road Construction

Instream flow
Gravel quality
Water temperature and Dissolved oxygen
Groundwater inflow
Instream habitat (depth, cover, substrate)
Water quality (pH, turbidity, metals)
Aquatic insects
Riparian vegetation
Connectivity

- *Eggs* (embryonic development)
- *Alevin* (pre-emergence)
- *Fry* (emergence)
- *Parr* (freshwater rearing)
- *Smolt* (out migration)
- *Spawning Adult* (return and spawning)

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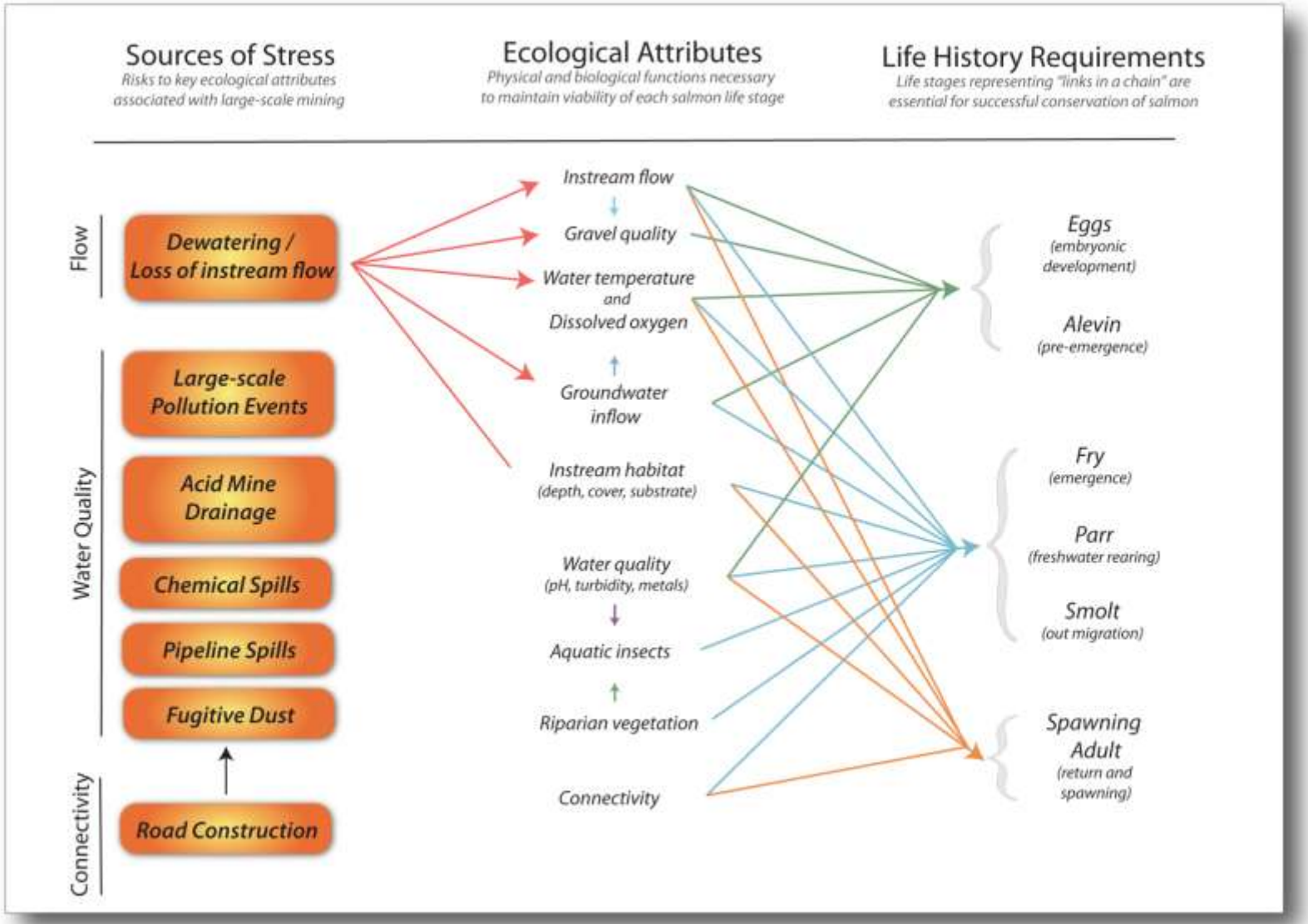

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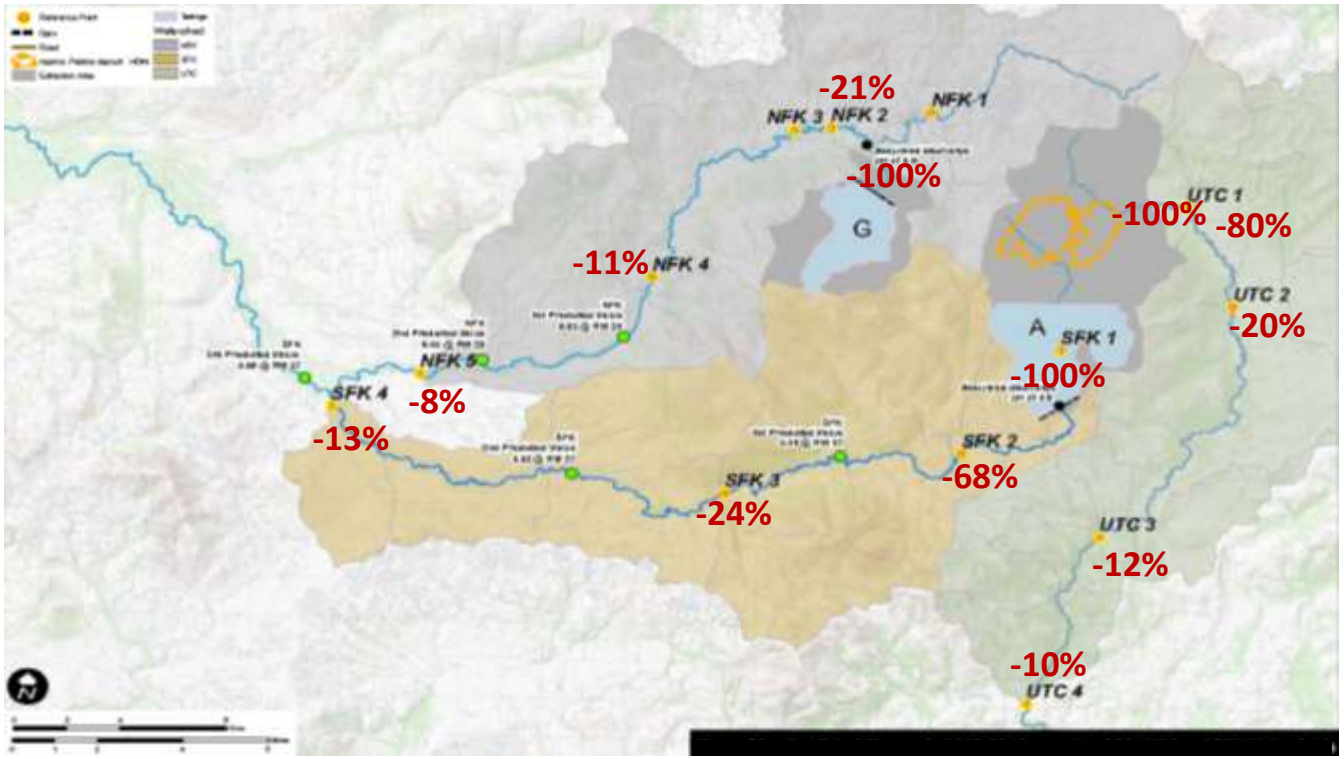
Risk Factor: Loss of Instream flow



Exposure to Risk:
(habitat lost or altered)

- Drainage area lost: 33 miles^2
- All Streams lost: 68 miles
- Salmon streams lost: 14 miles
- Salmon streams with reduced flow: 78 miles

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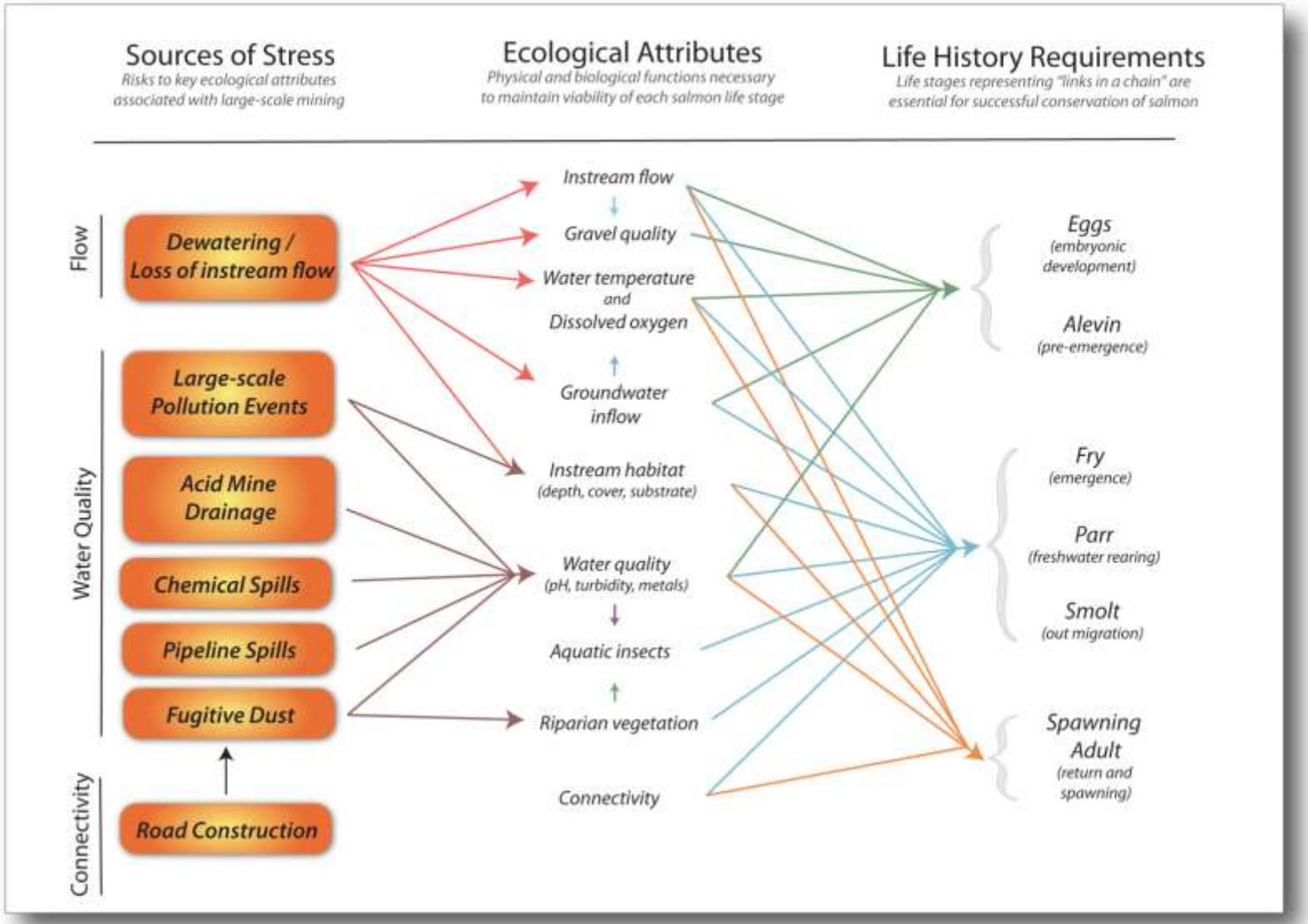

Risk Factors: Water Quality

- **Baseline conditions:**
  - Very clean water (low metals, neutral pH)
  - Low dissolved organics and hardness
  - Low alkalinity

- **Key Concerns:**
  - Copper Toxicity
    - Acute effects (death)
    - Chronic effects (impaired function)
    - Behavioral effects (avoidance)
  - Acid Mine Drainage
    - High likelihood of occurrence, long-term risk
    - Low pH increases toxicity of copper and other metals to fish
  - Large-scale Pollution Events
    - Unknown likelihood
    - Potentially catastrophic effects
    - Distribute acid-generating materials throughout downstream watershed

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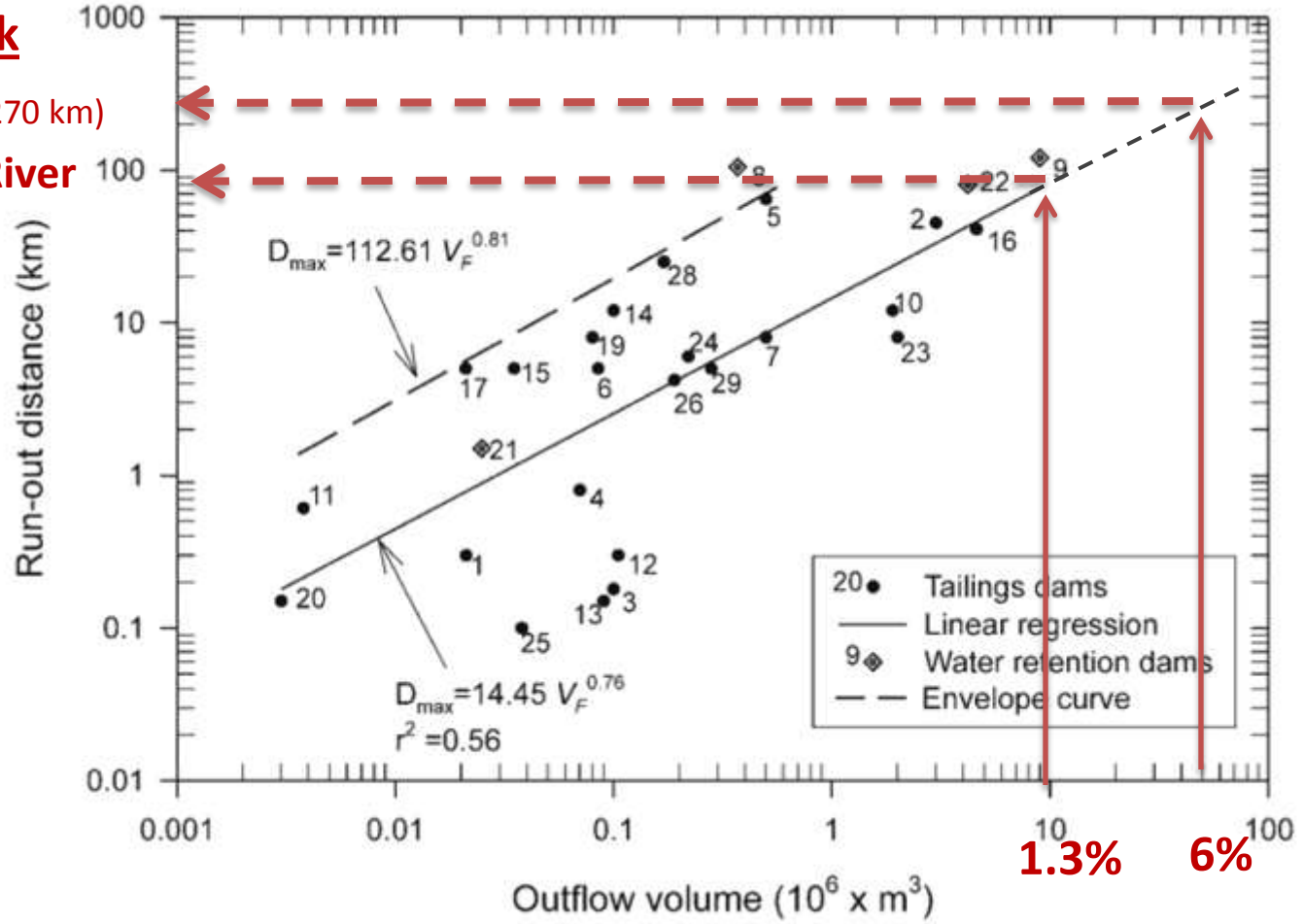
Risk scenario: 2 billion-ton tailings impoundment

Zone of Risk

Bristol Bay (270 km)

Mulchatna River (78 km)



Percent of Capacity

From: Rico, M., G. Benito and A. Díez-Herrero, 2008. Floods from tailings dam failures. J. Hazard. Materials 154:79-87.

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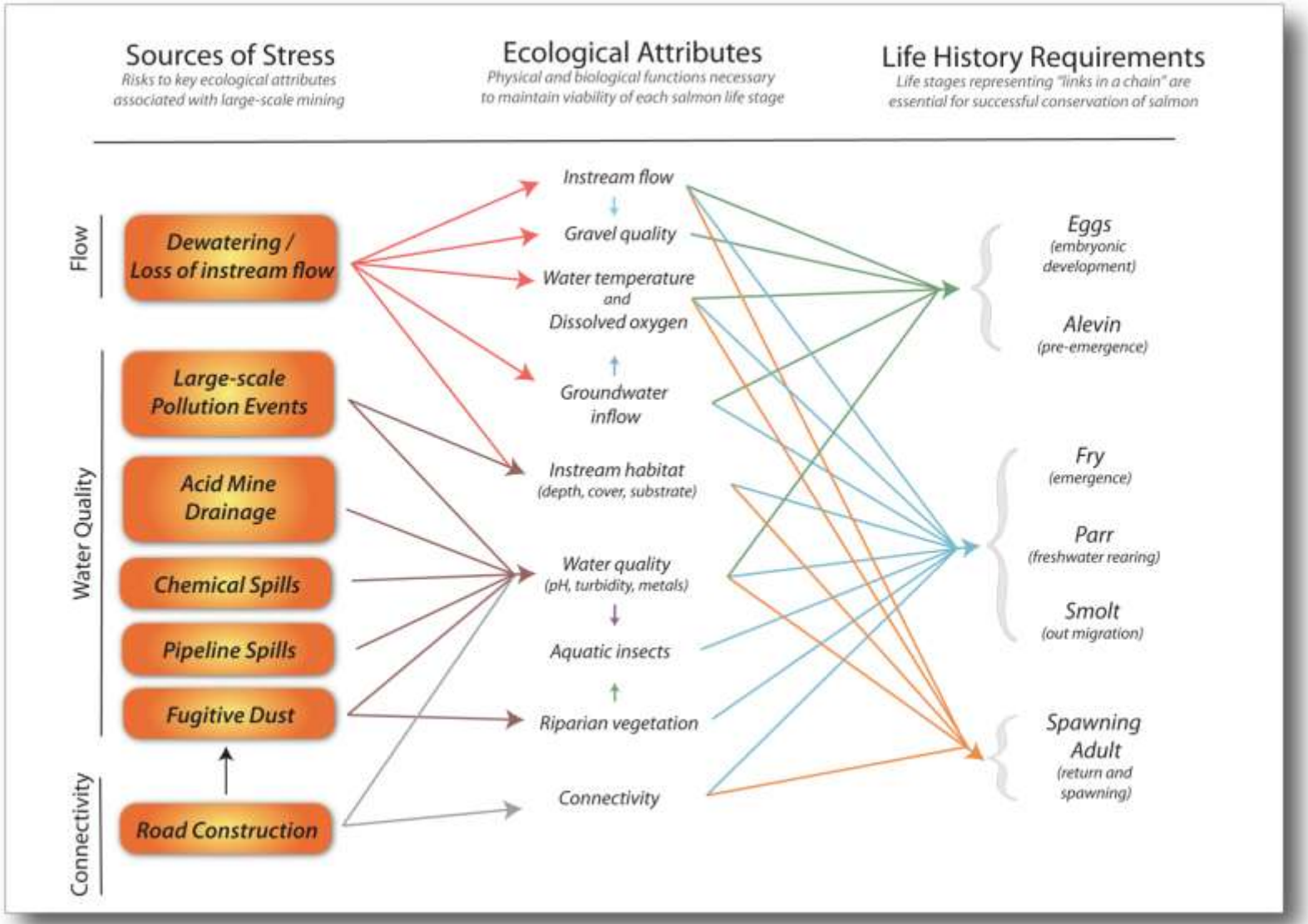

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