Salmon and Climate Change: Preparing for an Uncertain Future

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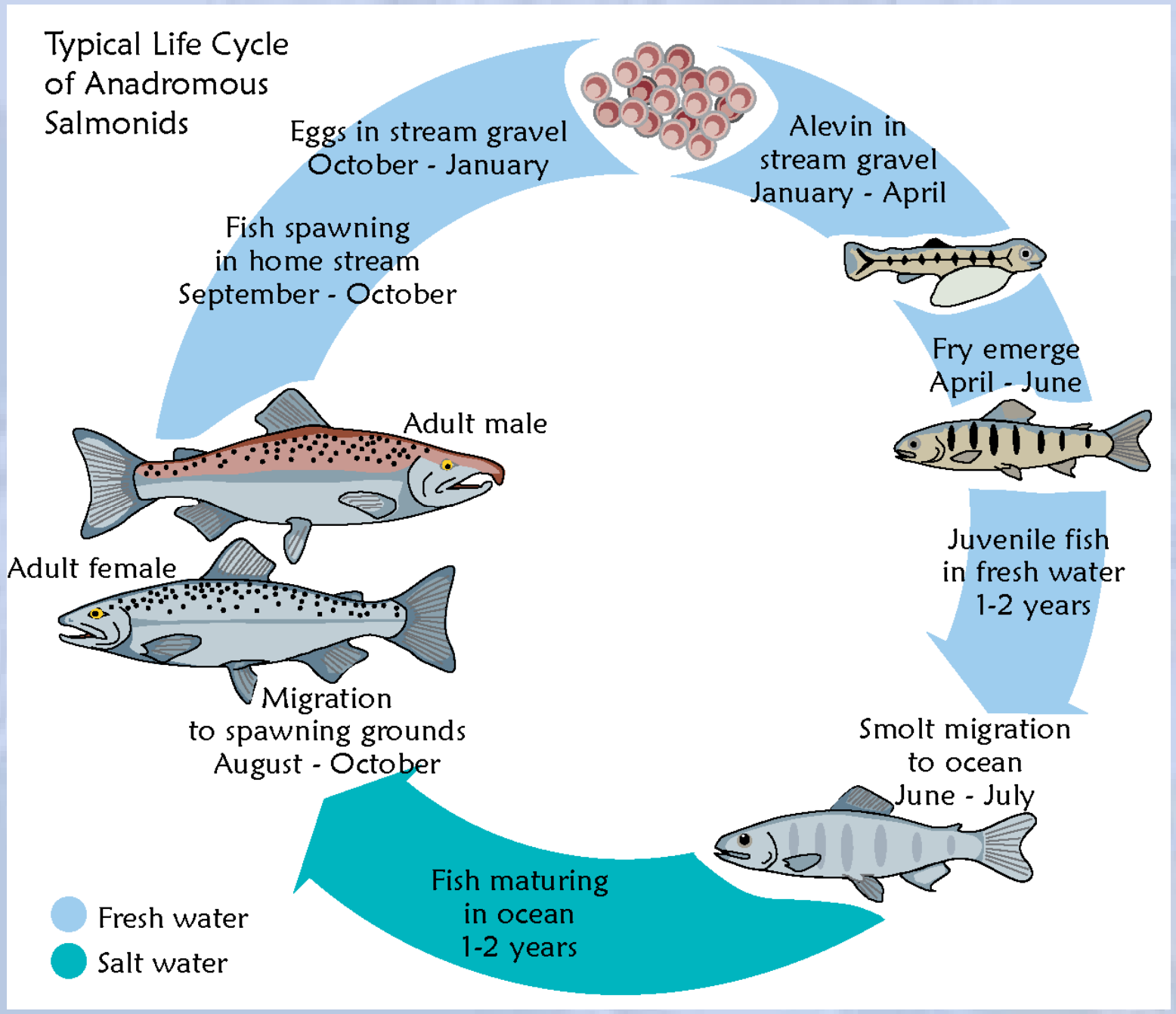
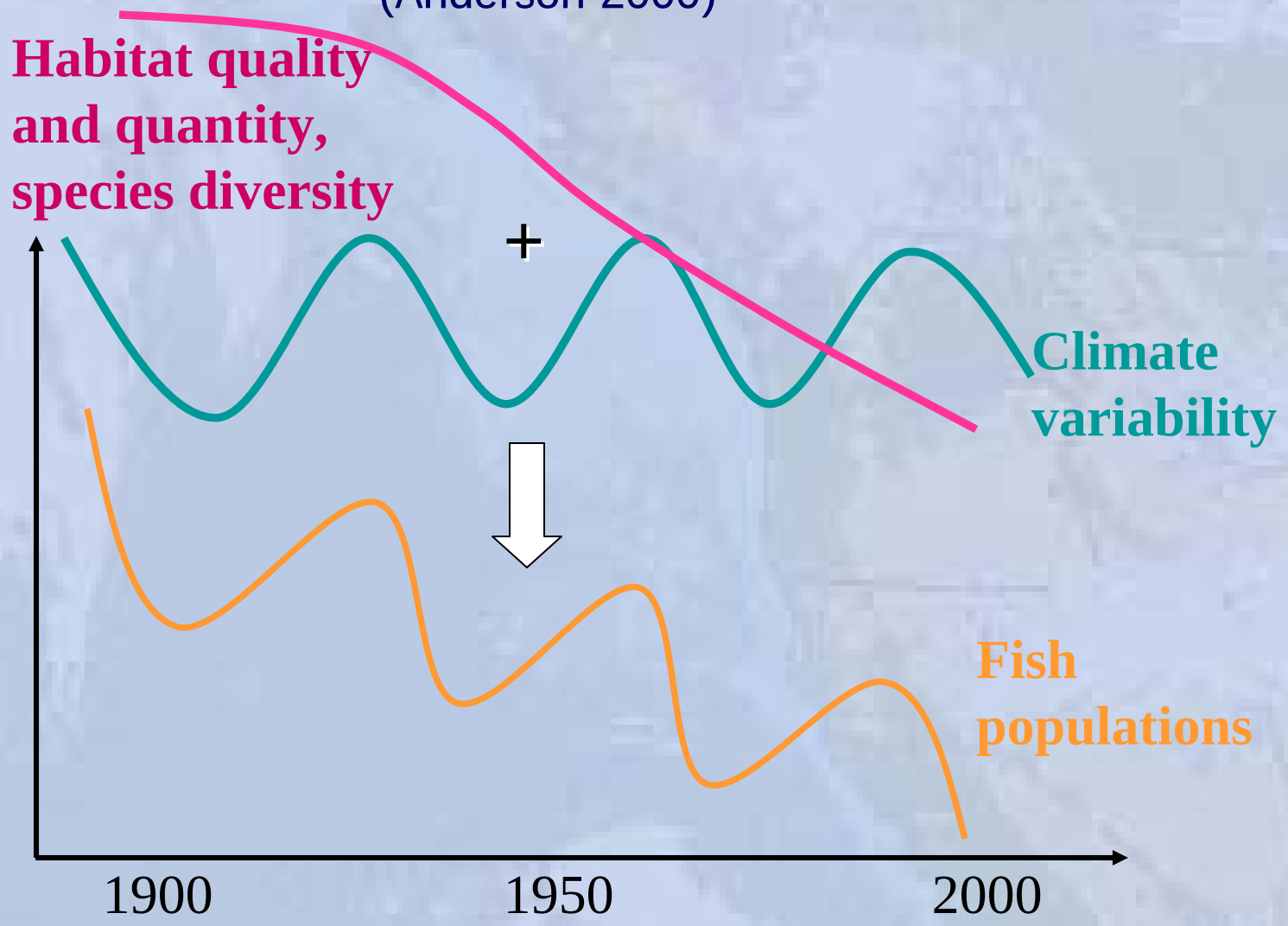

Typical Life Cycle
of Anadromous
Salmonids
Eggs in stream gravel
October - January
Alevin in
stream gravel
January - April
Fry emerge
April - June
Juvenile fish
in fresh water
1-2 years
Smolt migration
to ocean
June - July
Fish maturing
in ocean
1-2 years
Migration
to spawning grounds
August - October
Adult female
Adult male
Fish spawning
in home stream
September - October
Fresh water
Salt water

The climate/habitat ratchet:
cumulative impacts tell the story

(Anderson 2000)



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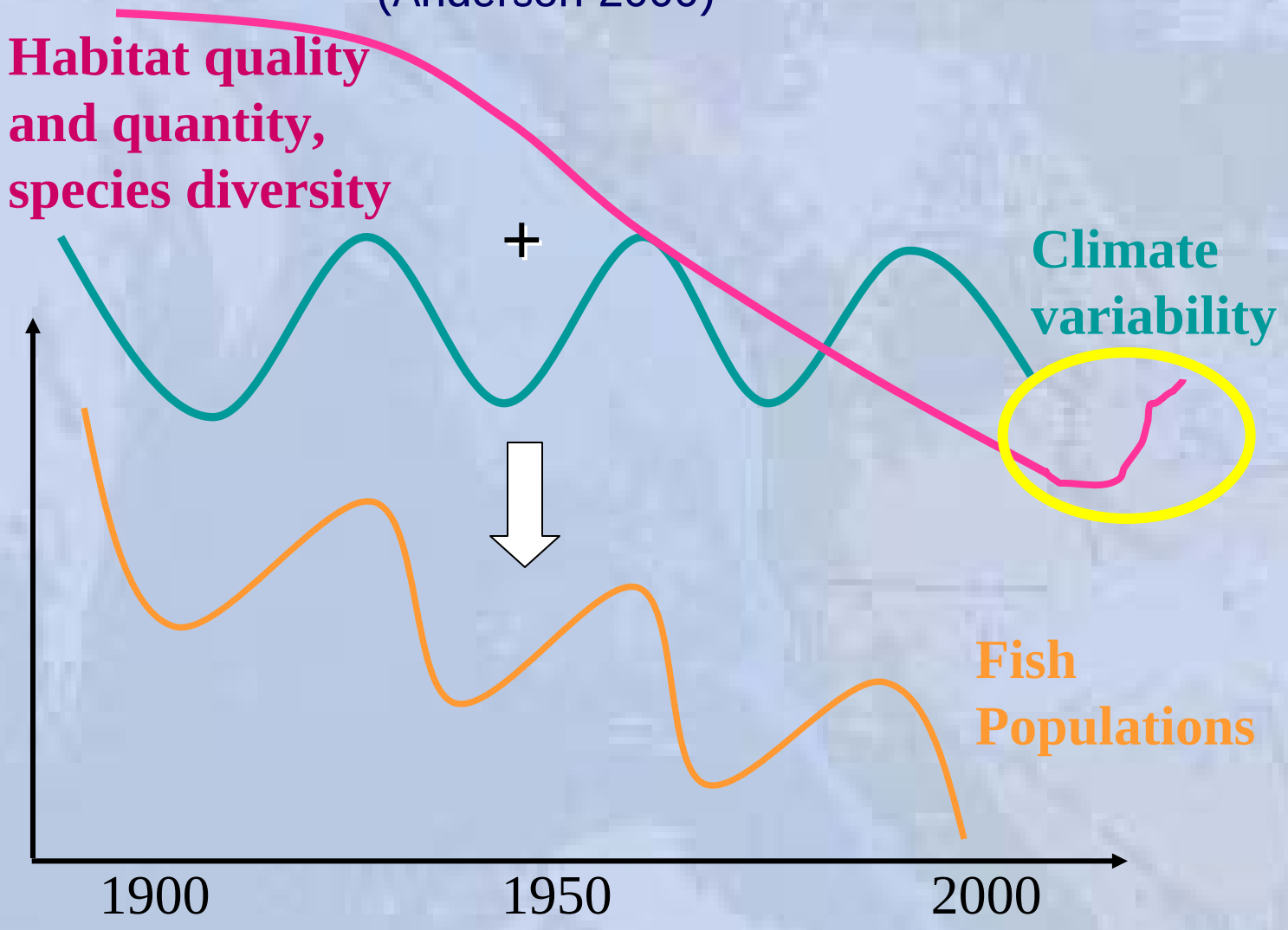
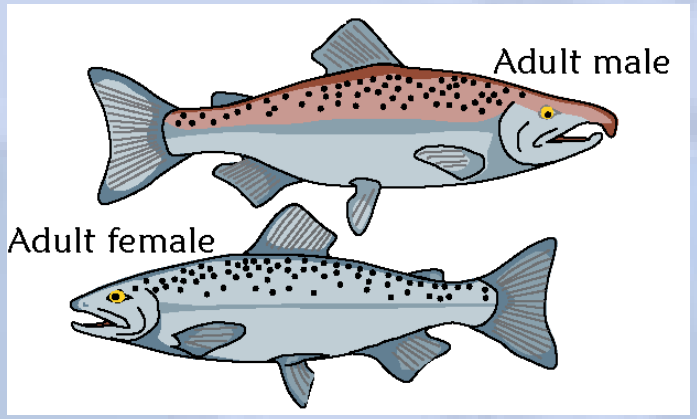


Expected Effects of Climate Change: Ocean

- increased temperatures
- change in timing of upwelling
- decrease in pH
  - reduces carbonates for shell-forming organisms



Adults: Ocean

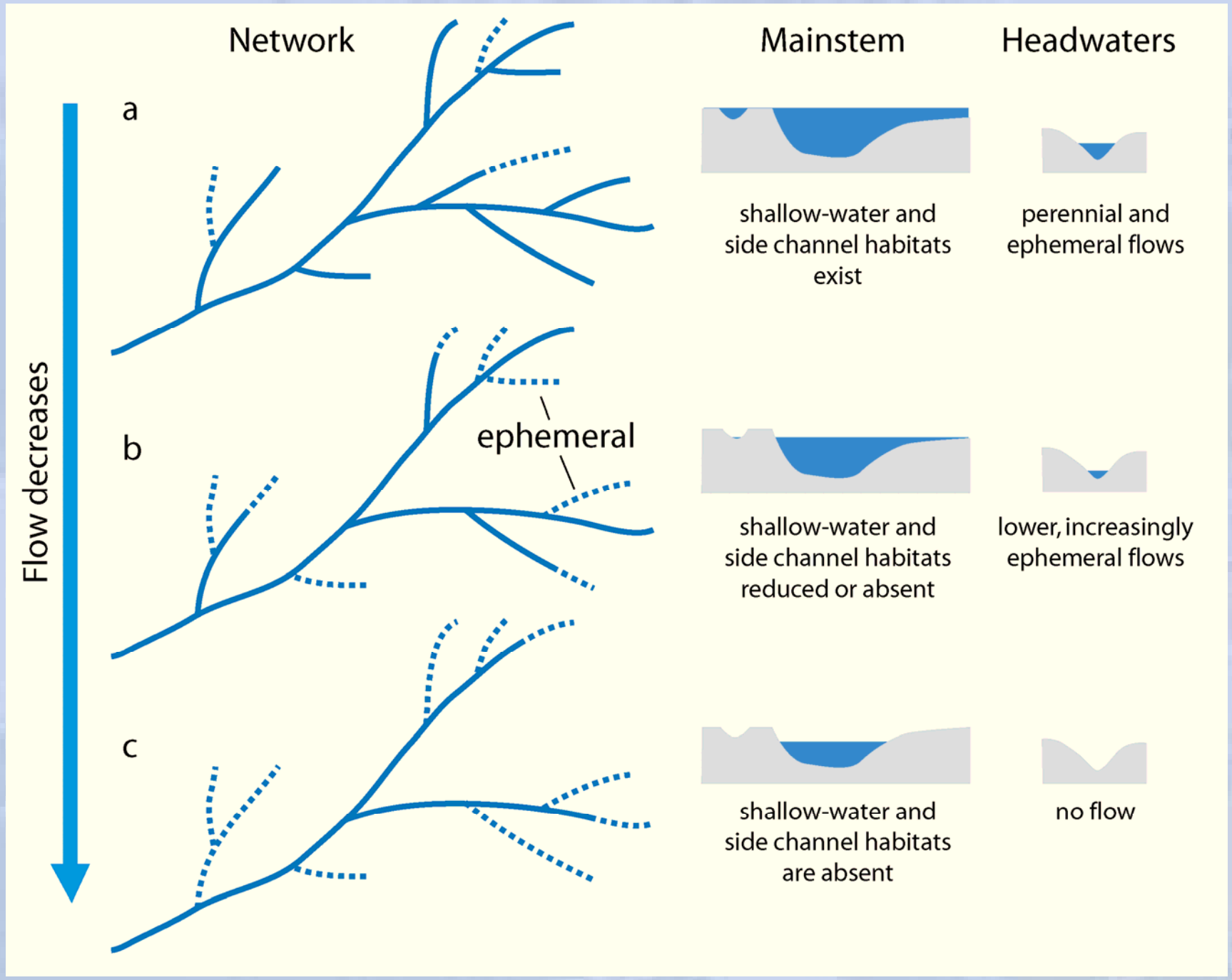
- Water temp ⇧
- Upwelling timing △
- pH ⇩

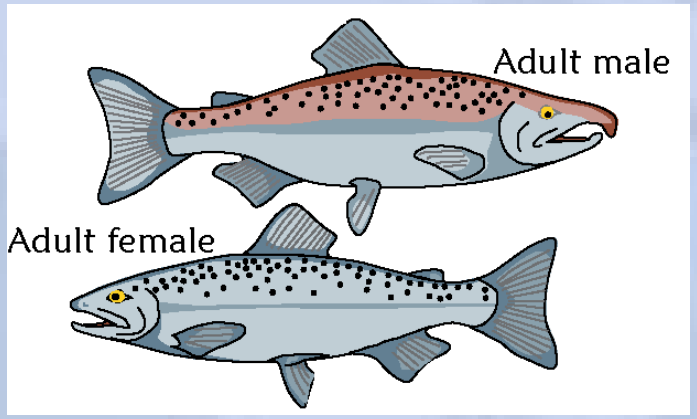
⇒

- decreased growth and survival in marine environment
  - smolts
  - adults

Expected Effects of Climate Change: Freshwater

- Water temperatures
  - higher highs
  - higher lows
- Streamflow
  - peak flows increase (less precip. as snow, more rain)
  - more frequent droughts


Network
Mainstem
Headwaters
Flow decreases
a
shallow-water and side channel habitats exist
perennial and ephemeral flows
b
ephemeral
shallow-water and side channel habitats reduced or absent
lower, increasingly ephemeral flows
c
shallow-water and side channel habitats are absent
no flow

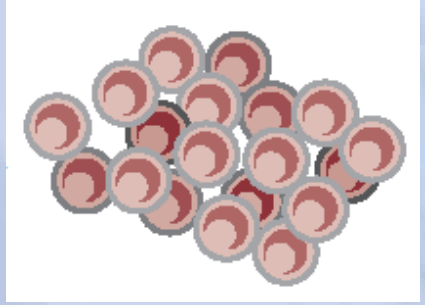


Adults: Freshwater

- Water temp ⇧
- Flows ⇩

⇒

- Increased energetic costs of migration
- Reduced fecundity
- Increased disease susceptibility
- Habitat availability altered (quantity and quality)

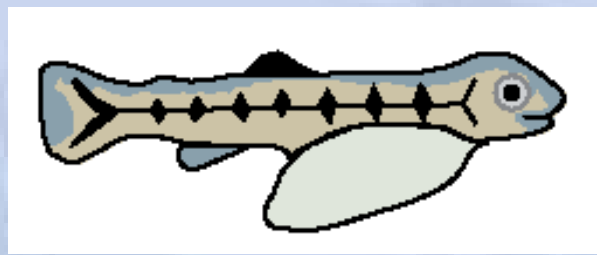


Eggs & Developing Embryos

- Water temp ⇧
- Flows ⇧

⇒

- Increased rate of development
- Increased susceptibility to scour
  - fish that spawn in smaller streams are more susceptible
  - may be confounded by reduced size of adults

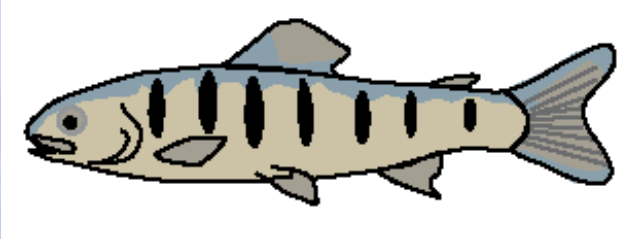


Fry

- Water temp ⇧
- Flows ⇧

⇒

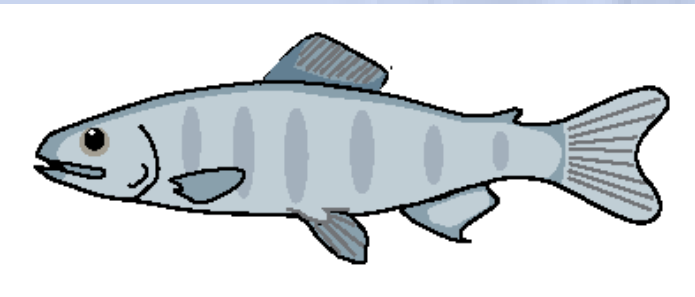
- Positive effects
  - early emergence
  - increased growth rate
  - increased habitat availability
- Negative effects
  - displacement



Juveniles

- water temp ⇧
- flows ⇩

- Change in growth rates -potentially offset by increased growth of fry
- Altered habitat availability
- Increased competition & predation from non-salmonids
- Increased disease susceptibility



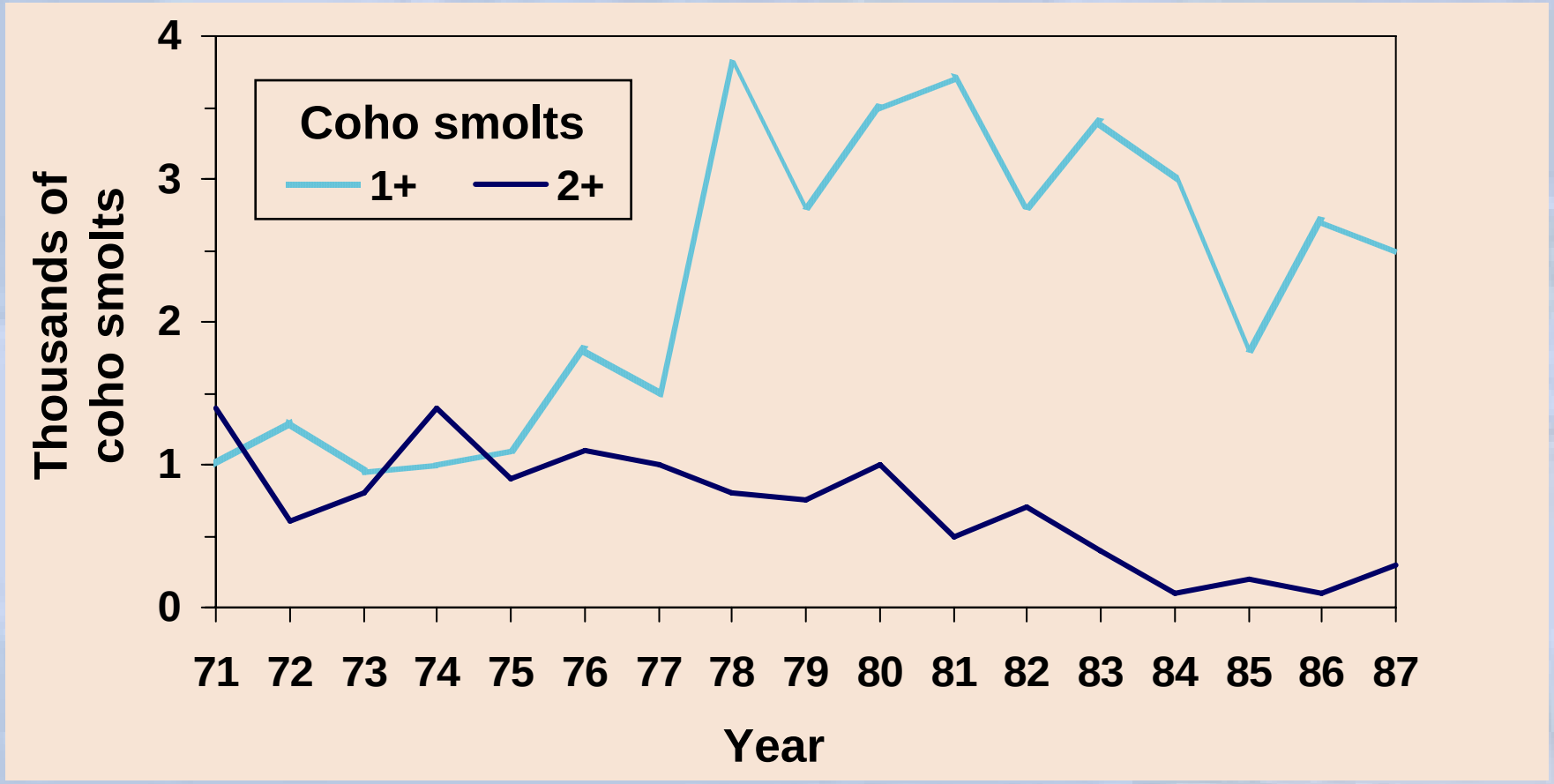
Smolts

- Water temp ⇧
- Flows ⇧

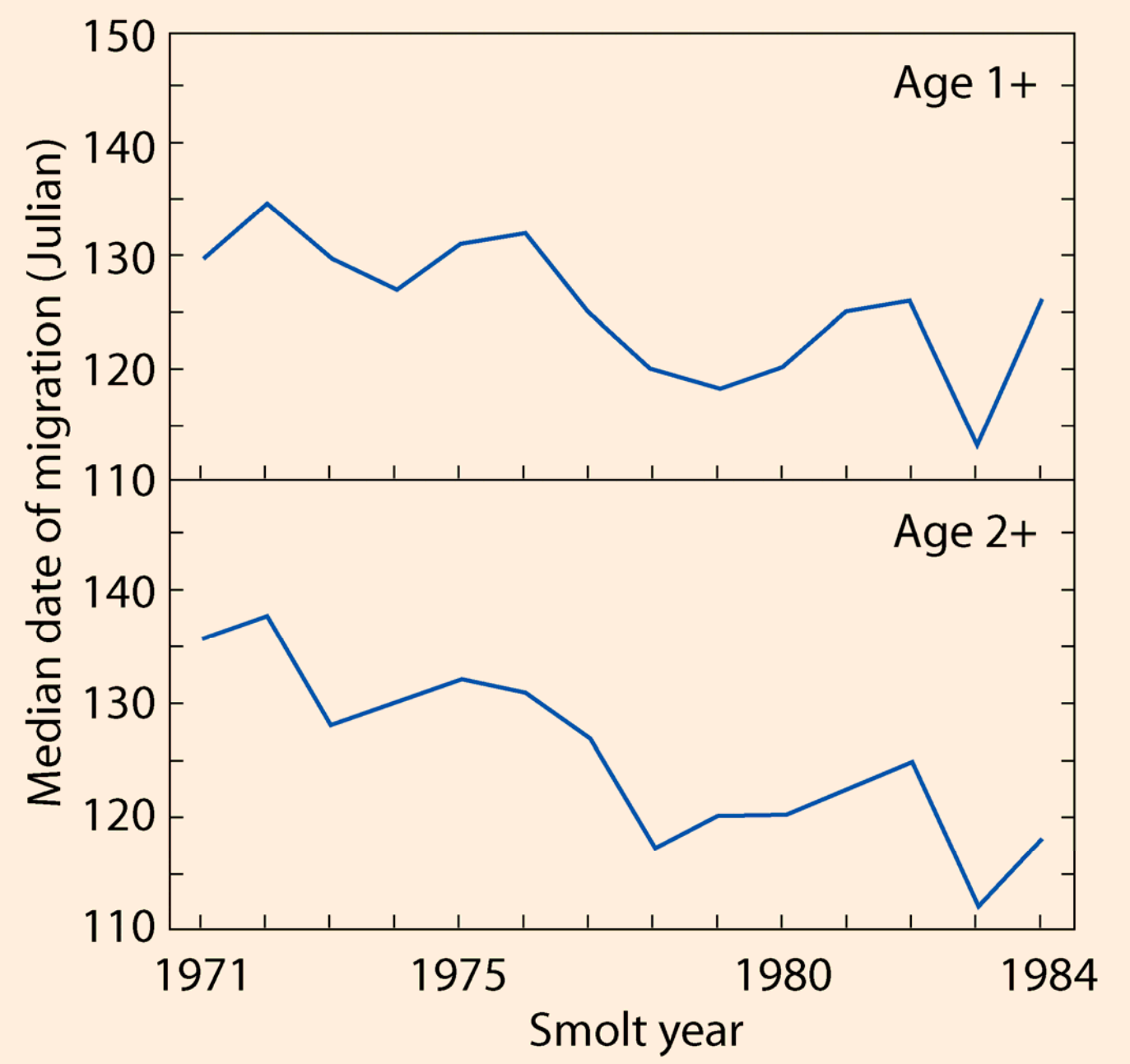
⇒

- Altered time of migration
  - success in ocean depends on presence of favorable estuary/ ocean conditions
- Reduced migratory times
- Continued growth

Numbers of age 1+ and 2+ coho salmon smolts migrating from Carnation Creek, BC, 1971-1987



From: Hartman and Scrivener, 1990. Impacts of forestry practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223



from LB Holtby (1988) Can. J. Fish. Aquat. Sci. 45: 502-515

Vulnerability to Potential Climate Change Effects

Lower → Higher

Winter Steelhead

Summer Steelhead

Fall Chinook (ocean type)

- spawn in larger streams
- life history variation

Spring Chinook (stream type)

Coho Salmon

- rigid life history

Potential of Salmonids to Respond to Climate Change

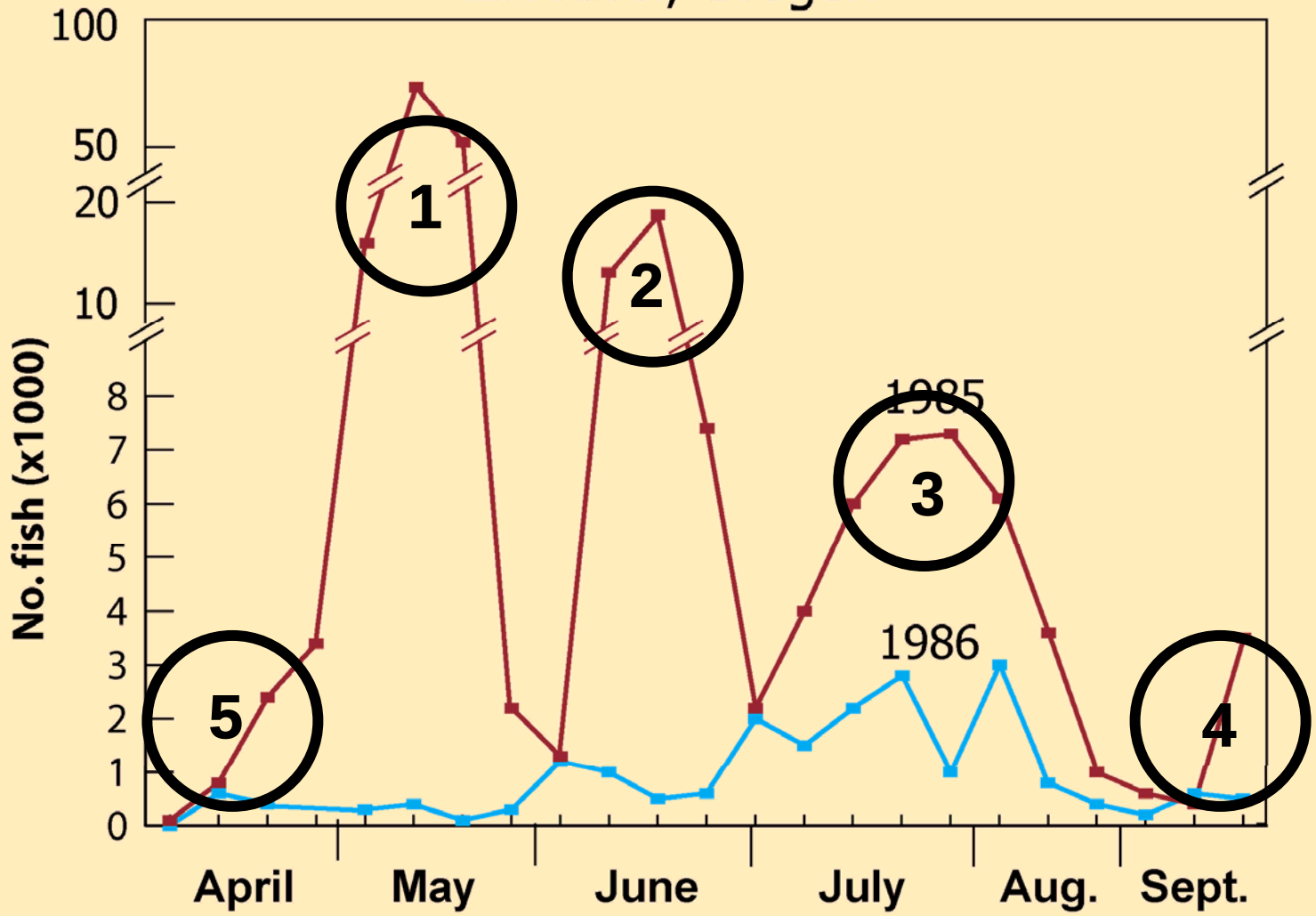
- Life-history & phenotypic variability
  - immediate response
- Genetic adaptability
  - longer-term response

Fall Chinook Salmon Life History Types

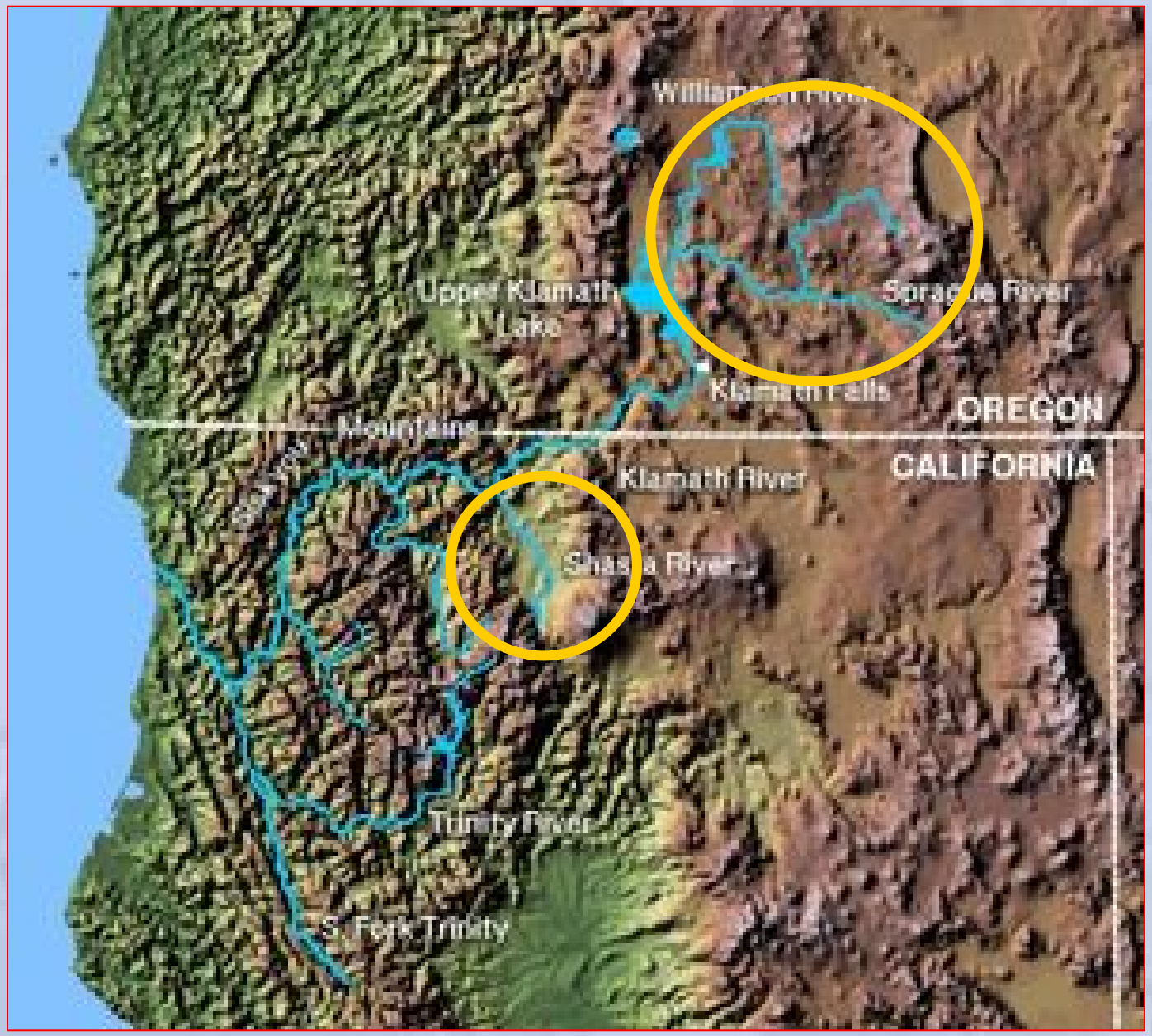
Life History Type	Juvenile Rearing Habitat		
	Tributaries	Mainstem	Estuary
1	brief	brief	brief
2	brief	1-2 mo.	brief
3	brief	1-2 mo.	3-4 mo.
4	5-6 mo.	brief	brief
5	1 y	brief	brief

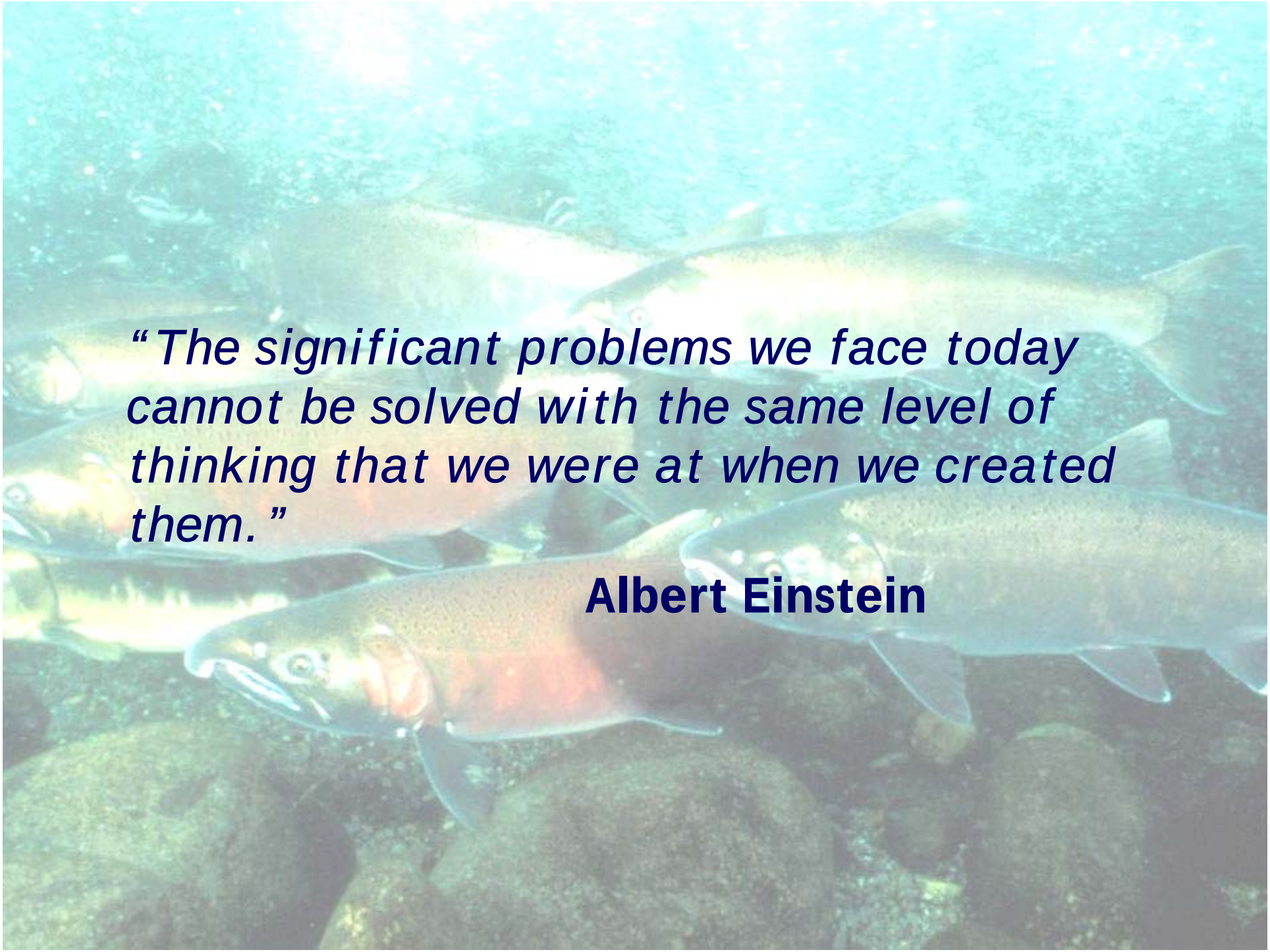
from Reimers (1973)

Juvenile Chinook Salmon Moving Past Humphrey Trap, Elk River, Oregon



Source: G. Reeves, unpublished data


Upper Klamath
Lake
Klamath Falls
OREGON
CALIFORNIA
Klamath River
Trinity River



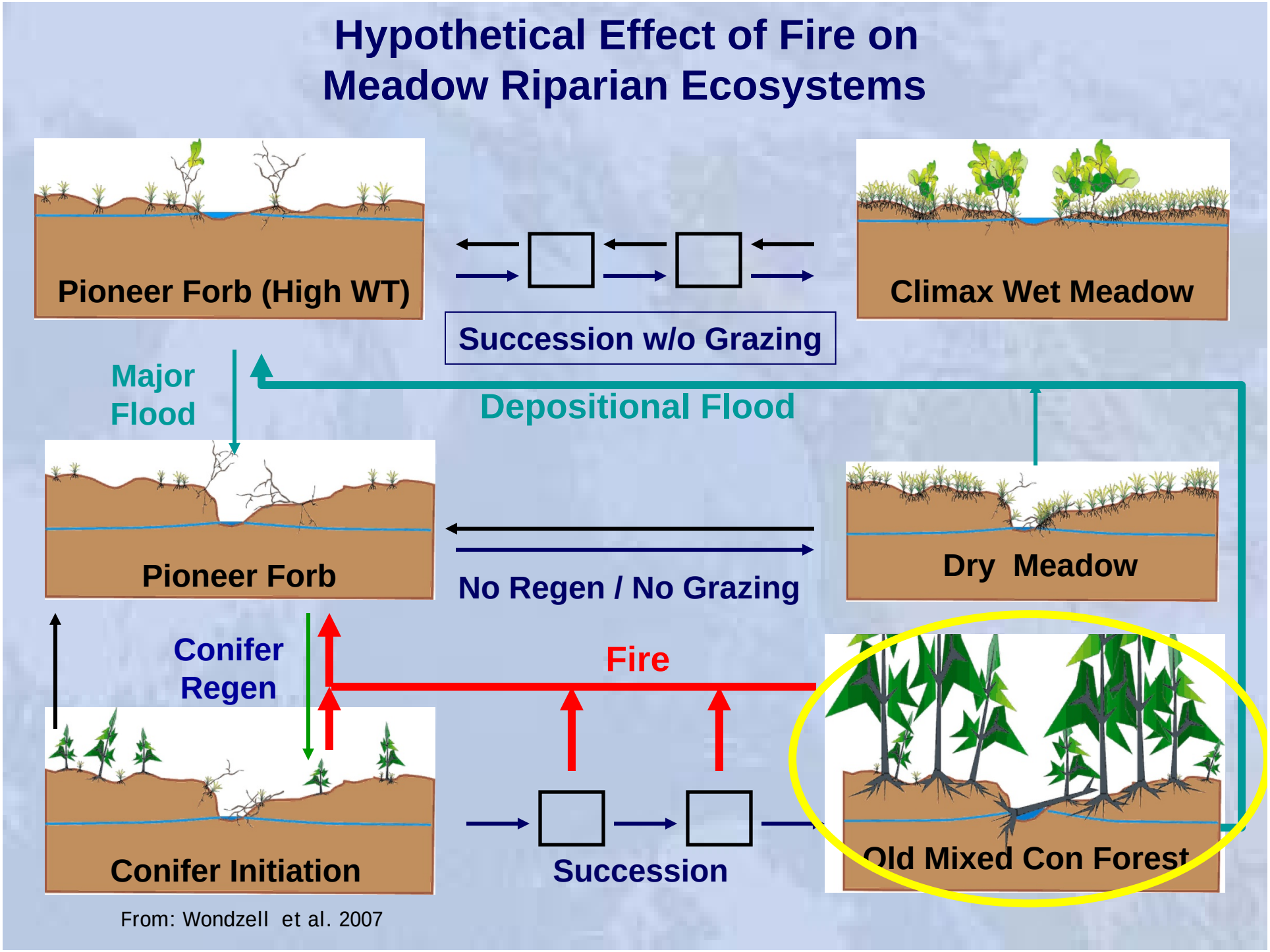
"The significant problems we face today cannot be solved with the same level of thinking that we were at when we created them."

Albert Einstein

Sometimes High Intensity Trauma Happens

L.M. Reid

Hypothetical Effect of Fire on Meadow Riparian Ecosystems



From: Wondzell et al. 2007

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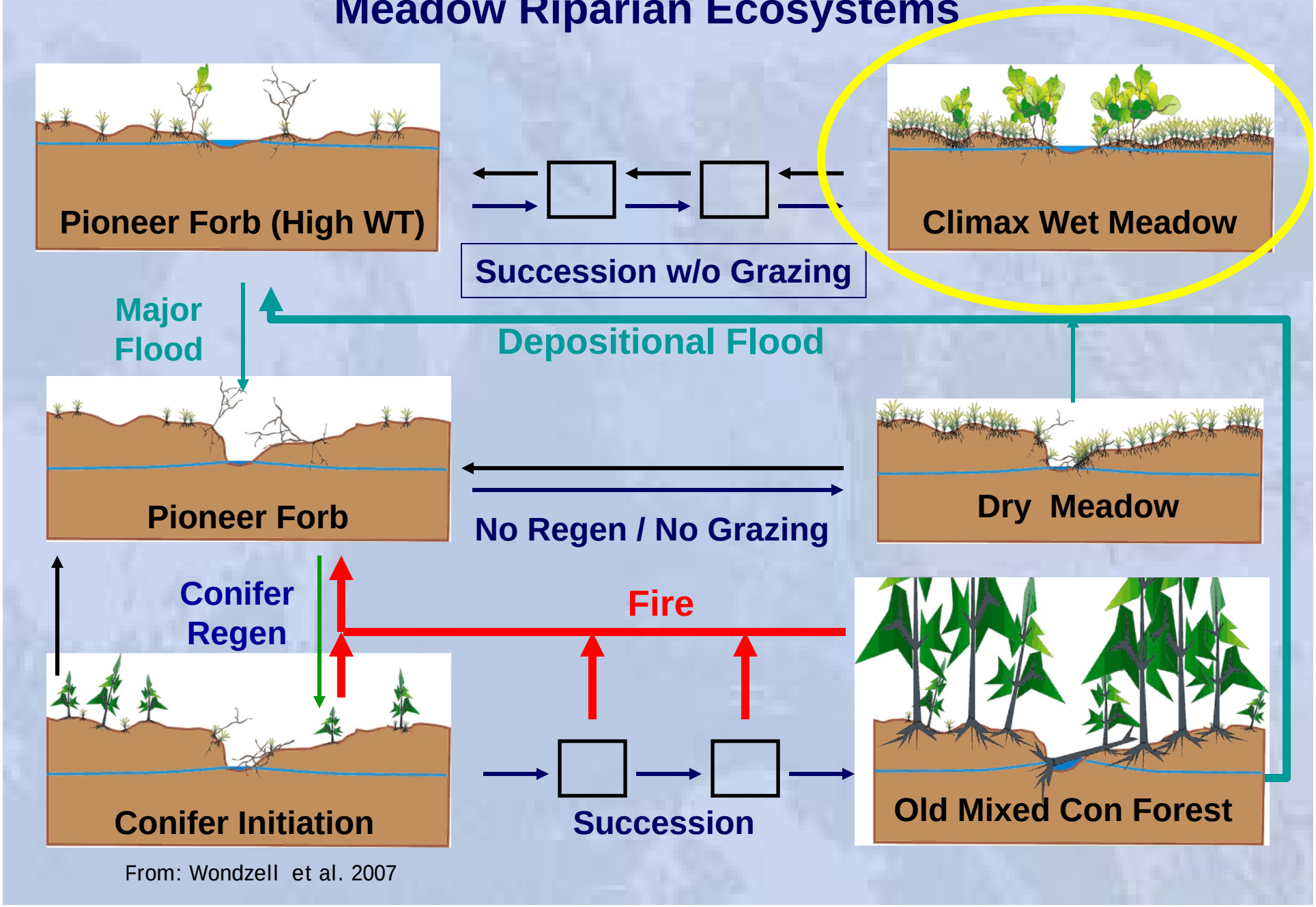

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Summary

- Anadromous and resident salmonids have a large inherent capacity to respond to climate change

Summary

- Need to develop strategic comprehensive region-wide conservation & restoration strategy
  - Protect existing productive basins
  - Initiate restoration efforts in other important basins
    - Focus on ecological processes & habitat diversity

THE SALMON FAMILY TREE