Fish population response to climate change

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Climate

Fish Persistence
Fish Persistence

Habitat

Catastrophic events

Temperature

Climate

Flow

Flow

Fish Persistence
Fish Persistence

Habitat

Catastrophic events

Biotic interactions*

Landscape context

Temperature

Flow

Climate

Flow

Habitat

Catastrophic events

Biotic interactions*
Or (more or less) equivalently:
Temperature and fish

Empirical thermal optima based on distributions

- Brown = Brown trout
- Green = Cutthroat
- Red = Rainbow
- Blue = Brook
Timing: migrations, spawning, incubation

- Changes in migration timing to avoid high temperatures
- Shorter incubation times
- Potential de-synchronization with prey availability

- Traits related to timing are usually very plastic
Flow and fish: low flows

- Less water = fewer fish
- Less water = warmer water
- Reduced access, restricted movement
Flow and fish: high flows

![Graph showing mean flow (cfs) from November to September with peaks in May and July]

![Two fish swimming in clear water]
Flow and fish: high flows
Flow and fish: high flows
Flow and fish: high flows
Catastrophic events

- Warming
- Fires
- Debris Flows
- Higher Stream Temp
- Mortality
Catastrophic events

Impact depends on size and connectivity of habitat patches
Biotic interactions

Flow

Temperature

Cascading effects
Biotic interactions

Flow  Temperature

Cascading effects

Potentially even more important: Disease
The missing evidence

• Few documented cases of population losses due to climate change. Why?

  – Maybe we’re not looking in the right places
  – Maybe changes aren’t gradual, but punctuated
  – Maybe fish are resilient / adapting
  – Maybe we have the wrong model– do we really understand the process?
Adaptation & Evolution

• Most fish are very plastic in behaviors

• Even if you can adapt or evolve, if someone else is better adapted, you still lose

• Need to retain diversity in life history expression and potential for evolution
Study: climate effects on trout

- 9890 sites
- Four species
- GCM predictions of temperature, flow
- Correlation analysis of empirical relations
Empirical fish-climate relations

Also: strong negative biotic interactions on cutthroat trout
Cutthroat current
Cutthroat
2040s
Cutthroat
2080s
Rainbow
2040s
Brown
2080s
The big picture

• Over the next century, we expect to see a shift from cold-water fish to cool-water fish and warm-water fish, except at high elevations.