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

Fish spawning in home stream
September - October

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

Migrating to spawning grounds
August - October

Adult male

Adult female

Fresh water

Salt water
The climate/habitat ratchet: cumulative impacts tell the story

(Habitat quality and quantity, species diversity)

Climate variability

Fish populations

(Anderon 2000)
The climate/habitat ratchet: 
*cumulative impacts tell the story*

(Anderson 2000)

Habitat quality and quantity, species diversity

Climate variability

Fish Populations

1900 1950 2000
Expected Effects of Climate Change: Ocean

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

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

- Water temp ↑
- Upwelling timing △
- pH ↓
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
- shallow-water and side channel habitats exist

Headwaters
- perennial and ephemeral flows

Flow decreases

b
- shallow-water and side channel habitats reduced or absent

b
- lower, increasingly ephemeral flows

c
- shallow-water and side channel habitats are absent

c
- no flow
Adults: Freshwater

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

- 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

Water temp
Flows
Fry

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

Negative effects
- displacement

Water temp

Flows
Juveniles

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

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

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

Vulnerability to Potential Climate Change Effects

Lower

Winter Steelhead

Fall Chinook (ocean type)
- spawn in larger streams
- life history variation

Spring Chinook (stream type)

Higher

Summer Steelhead

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

from Reimers (1973)

<table>
<thead>
<tr>
<th>Life History Type</th>
<th>Juvenile Rearing Habitat</th>
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<tbody>
<tr>
<td></td>
<td>Tributaries</td>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>brief</td>
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<tr>
<td>3</td>
<td>brief</td>
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<tr>
<td>4</td>
<td>5-6 mo.</td>
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<tr>
<td>5</td>
<td>1 y</td>
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</tbody>
</table>
Juvenile Chinook Salmon Moving Past Humphrey Trap, Elk River, Oregon

Source: G. Reeves, unpublished data
“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
Succession w/o Grazing

Major Flood

Hypothetical Effect of Fire on Meadow Riparian Ecosystems

Depositional Flood

No Regen / No Grazing

Conifer Regen

Conifer Initiation

Pioneer Forb

Pioneer Forb (High WT)

Climax Wet Meadow

Dry Meadow

Old Mixed Con Forest

From: Wondzell et al. 2007
Hypothetical Effect of Fire on Meadow Riparian Ecosystems

From: Wondzell et al. 2007
**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

PACIFIC SALMON

20 MILLION YEARS AGO

ANCESTRAL SALMON

EXTINCT

RED SNapper

Sockeye

Trout

Atlantic Salmon

Steelhead

Masu

Pink

CHINOOK

Oncorhynchus

WESTERN TROUT

NAKANISHI

TROLL

RAYS 2003

THE SALMON FAMILY TREE