Restoring salmon habitat for a changing climate

Tim Beechie, Hiroo Imaki, Jen Greene, George Pess, Phil Roni, Peter Kiffney
NW Fisheries Science Center

Alisa Wade-Wilcox
University of California Santa Barbara

Huan Wu, John Kimball, Jack Stanford
University of Montana
Will climate change negate salmon restoration efforts?

- Recovery plans are in place
- Millions of dollars will be spent
- Should we alter habitat restoration plans to accommodate climate change?
Outline

• Predicted climate change effects
• Salmon population vulnerability
• Restoration actions and climate change
• Decision support for climate adaptation
Predicting climate change effects

Global climate simulations

- ½° to 2° resolution (50-250 km)
- 2 emissions scenarios
- 10 climate models

Downscaling & bias correction

- 1/16° - 1/8° (6-12 km)

Air temperature & precipitation

Base flow & runoff

VIC hydrologic model

Daily stream flow & temperature
Model uncertainty

Scott Doney, Woods Hole Oceanographic Institute
Predicted change in low flow

- Change in lowest monthly flow between 1980s and 2080s

Data source: http://www.hydro.washington.edu/2860/report/
Predicted change in high flow

- Change in flow between 1980s and 2080s

Data source: http://www.hydro.washington.edu/2860/report/
Summer rearing sensitivity

- Below threshold: <10°C
- Near threshold: 10-14°C, 14-18°C
- Above threshold: 18-22°C, 22-26°C, 26-30°C, >30°C

What does that mean for salmon?

<table>
<thead>
<tr>
<th>Sep</th>
<th>Dec</th>
<th>Mar</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp</td>
<td>Low flow</td>
<td>Peak flow</td>
<td>Spring melt</td>
</tr>
</tbody>
</table>
What does that mean for salmon?
What does that mean for salmon?

Ocean-type Chinook salmon
What does that mean for salmon?
Flow regime and Chinook life history

Stream-type Chinook

Ocean-type Chinook

Snowmelt

Transitional

Rainfall

Log Monthly Mean Discharge (cfs)

Beechie et al. 2006
Flow regime and Chinook life history

Data source: http://www.hydro.washington.edu/2860/report/
Adapting Restoration for Climate Change
Key questions

- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?
Literature review

• Does the action ameliorate a climate effect?
  – Increased peak flow
  – Decreased low flow
  – Increased stream temperature

• Does the action increase habitat diversity and population resilience?
  – Must increase habitat diversity enough to accommodate additional species or life-history types
Restore riparian areas

Reduce temperature
Increase low flow
Decrease peak flow (or its effect)
Restore riparian areas

- Reduce temperature
- Increase low flow
- Decrease peak flow (or its effect)
Restore flow regimes

- Reduce temperature
- Increase low flow
- Decrease peak flow (or its effect)
Restore flow regimes

Reduce temperature
Increase low flow
Decrease peak flow (or its effect)
Restoring incised channels

- Reduced flows in summer
- Increased temperature
- No refuge from peak flows

Incised channel:
- conversion to sagebrush
- lowered water table
- intermittent streamflow
Restore incised channels

More flow in summer
Lower summer temperature
Added refuge from peak flows

Wet floodplain system:
- sedge meadows
- deep accumulation of sediments
- elevated water table
Restoring incised channels

~3 cm/yr

10-40 cm/yr

Beechie et al. (2008)

Pollock et al. (2007)
Restore incised channels

Reduce temperature
Increase low flow
Decrease peak flow (or its effect)
Restore incised channels

- Reduce temperature
- Increase low flow
- Decrease peak flow (or its effect)
Strategies to increase resilience
Increase habitat diversity

Waples et al. 2008
Increase habitat diversity

Waples et al. 2008
Restore access to diverse habitats

Rainfall/transitional hydrologic regime
Blue

Ocean-type Chinook population
Green

Snowmelt hydrologic regime

Stream-type Chinook population

Waples et al. 2008
Restore access to diverse habitats

Waples et al. 2008

Rainfall/transitional hydrologic regime

Ocean-type Chinook population

Snowmelt hydrologic regime

Stream-type Chinook population
## Restoration actions and climate change

<table>
<thead>
<tr>
<th>Restoration action</th>
<th>Does Project Ameliorate -</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature increase</td>
</tr>
<tr>
<td>Longitudinal connectivity</td>
<td>Y</td>
</tr>
<tr>
<td>Floodplain connectivity</td>
<td>Y</td>
</tr>
<tr>
<td>Restore incised channel</td>
<td>Y</td>
</tr>
<tr>
<td>Restore in-stream flow</td>
<td>Y</td>
</tr>
<tr>
<td>Riparian rehabilitation</td>
<td>Y</td>
</tr>
<tr>
<td>Road removal</td>
<td>M</td>
</tr>
<tr>
<td>Sediment reduction</td>
<td>M</td>
</tr>
<tr>
<td>In-stream habitat</td>
<td>M</td>
</tr>
<tr>
<td>Nutrient enrichment</td>
<td>N</td>
</tr>
</tbody>
</table>
Do climate change predictions alter restoration plans?

- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?
Evaluating a restoration plan

Question 1: What habitats limit salmon recovery?

Question 2: What are local predicted climate effects?

Question 3: Does the plan reduce the effect?

Question 4: Does the plan increase resilience?

Identify habitats limiting recovery

Does climate change alter habitats limiting recovery?

Follow existing plan

Do planned actions likely ameliorate climate effect?

Follow existing plan

Do planned actions increase diversity or resilience?

Unlikely

Likely

Revise restoration plan

Identify actions that address long-term limiting habitats

Re-evaluate restoration plan

Are there alternative actions that ameliorate climate effect?
Summary

- Models predict changes in
  - Low flow
  - Peak flow
  - Temp

- Restoration actions vary in their ability to ameliorate climate change effects
  - Riparian – temp
  - Instream flows – temp & low
  - Channel incision – temp, low & peak flows
Summary

- Some restoration strategies can help increase salmon resilience
  - Restore connectivity
  - Increase habitat diversity (floodplains)
  - Restore flow regimes

- Decision support framework helps evaluate whether to adjust restoration plans or actions for climate change