Chehalis Thermalscape and Thermal Summer Rearing Habitat

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Temperature and salmon

• Temperature of interest especially in face of climate change
• Ectotherms – limited ability to physiologically regulate metabolic processes
• Patterns of distribution, abundance, and community structure track spatial temperature gradients across scales
• Understanding stream temperature is critical for planning restoration or protection and understanding potential impacts under climate change scenarios
NorWeST provides continuous stream temperature predictions

• August stream temperature model
• Spatial Stream Network Model
• Predicts stream temperature over space and time
• NorWeST is modelled at a regional scale
• Predictive power limited by distribution of observations

https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html
Chehalis observations warmer than NorWeST predictions

August Temperature

<table>
<thead>
<tr>
<th>Observed temperature (°C)</th>
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<tbody>
<tr>
<td>15</td>
</tr>
<tr>
<td>17.5</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>22.5</td>
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<table>
<thead>
<tr>
<th>Predicted temperature (°C)</th>
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<tbody>
<tr>
<td>15</td>
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<td>20</td>
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NorWeST observed sites

Adding 100+ observation sites and updating predictions

Chehalis Thermalscape sites
How well does updated temperature model perform?

NorWeST Model

Chehalis Thermalscape

Predicted temperature (°C)

Observed temperature (°C)
NorWeST Model

<table>
<thead>
<tr>
<th>Mean August Stream Temperature (°C)</th>
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<tbody>
<tr>
<td>&lt;8</td>
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<tr>
<td>8-10</td>
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<td>10-12</td>
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<td>12-14</td>
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<td>14-16</td>
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<td>16-18</td>
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<td>18-20</td>
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<td>&gt;20</td>
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Chehalis Thermalscape
Climate change scenarios of stream temperature

• Followed same approach as NorWeST
• Future changes in **August air temperature and stream flow**
• Based on A1B emissions scenario for WA West processing unit from a 10 GCM ensemble relative to 1980s (Mote and Salathé 2010; Hamlet et al. 2013)
  • Mid century = 2040
  • Late century = 2080
2018 Chehalis Thermalscape

2080 Chehalis Thermalscape

2080 NorWeST Model

Mean August Stream Temperature (C)

- Less than 8
- 8-10
- 10-12
- 12-14
- 14-16
- 16-18
- 18-20
- Greater than 20
Conclusions – Chehalis Thermalscape

• Chehalis observations of August temperature warmer than NorWeST predictions
  • >4°C in some locations

• Chehalis Thermalscape provides more robust predictions across Chehalis
  • Provides a more accurate tool for biologists, researchers, restoration practitioners, etc

• Stream temperatures under climate change

• Landscape temperature model – fine scale refugia not captured
Thermal Summer Rearing Habitat

- Juvenile salmon and steelhead density information from 2013-2016
  - 380 km (237 miles) of snorkel surveys (Winkowski et al 2018)

- Generalized Additive Models (GAMs)
  - Fish density ~ August Temperature + Landscape Variables (Canopy, Slope, Precip, Base Flow Index, Valley Width Index)

- Combine salmon density relationships with Chehalis Thermalscape

- Develop spatially continuous thermal summer habitat maps
  - Current and Future scenarios

- Focused on coho, juvenile steelhead, resident trout
  - Species/age classes that use river for entire summer
  - Chinook generally complete outmigration by end of July

- Caveats
  - Does not consider stream accessibility (e.g. barriers, slope)
  - Landscape thermal model does not capture fine scale thermal refugia (e.g. groundwater seeps, hyporheic patches, etc)
Relationship between salmonid density and stream temperature in Chehalis River

**Juvenile Coho Salmon**

- **Thermally Optimal Habitat** = Top 25% fish density index

Graph showing the relationship between fish density index and temperature (C):
- **Fish Density Index**
- **Temperature (C)**
  - **Cold**: 6-12°C
  - **Warm**: 14-24°C

The graph indicates a peak in fish density at temperatures between 14 and 16°C.
2018 Coho thermally optimal habitat

- ~25% of basin
- ~1212 km

Grays Harbor

Olympic Mt Tributaries

Cascade Mt Tributaries

Willapa Hills

- Poor
- Optimal
2040 Coho thermally optimal habitat

- ~6% of basin
- ~305 km

Map indicating locations:

- Olympic Mt Tributaries
- Cascade Mt Tributaries
- Willapa Hills
- Grays Harbor

Legend:

- Red: Poor
- Orange: Optimal
- Blue: Optimal

Image of fish on the right side of the map.
2080
Coho thermally optimal habitat

- ~2% of basin
- ~103 km
2018 to 2080
Coho thermally optimal habitat

• 1100 km net loss
• Thermally optimal habitat shifts to headwaters of Olympic and Cascade tributaries
Discussion

• Updated temperature model provides important information on current and future stream temperature conditions in Chehalis

• Salmon density ~ temperature relationships non linear

• Under climate change, without restoration, minimal thermally optimal habitat by late century

• Thermal habitat shifts under climate change scenarios
  • Headwaters in Olympic and Cascade Mountains important future summer rearing habitat
Acknowledgements

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• Weyerhaeuser, Green Diamond, Rayonier

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