Development and use of NorWeST Temperature Scenarios for Steelhead Assessments

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Funding agencies:
Temperature Affects Distribution & Abundance

Thermal niches differ among species

NorWeST Stream Temperature (S1)

Frequency of Occurrence

Wenger et al. In Review.
Temperature Affects Phenology

**Spawn timing - Chinook salmon**

- Median redd completion date vs. Mean Stream Temperature (C)

**Incubation time - Chinook salmon**

- Incubation time vs. Mean Stream Temperature (C)

**Migration timing - sockeye salmon**

- July stream temp vs. Median redd completion date

**Daily Growth - Arctic grayling**

- Length-at-day vs. Degree-days

References:

- Brannon et al. 2004
- Crozier et al. 2008
- Dion and Hughes 1994
Temperatures are Getting Warmer...

1880-2014 Global Air Temperature Trend

2014 & 2015 Set New Records

Plan on continued warming for decades...
Summer River Temp Trends (1968-2011)
245 sites with >10 year monitoring records

Southern Steelhead
Range = Lots of Temperature Data

>150,000,000 hourly records
>20,000 unique stream sites

>100 agencies
California Temperature Database

Final database
Sites ~ 3,500
Years ~ 10,000

• Database & scenarios online
• More data coming
• Eli Asarian, Rich Fadness
• Refit model in fall

Agency

#1

#2
March 8

#3
End April
Predictive Accuracy of Temperature Model

**Covariate Predictors**

1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km²)
9. Glacier (%)
10. Discharge (m³/s)  
   **USGS gage data**
11. Air Temperature (°C)  
   **RegCM3 NCEP reanalysis**  
   Hostetler et al. 2011

**Mean August Temperature**

\[ r^2 = 0.90; \text{ RMSPE} = 1.0^\circ \text{C} \]

**Observed (°C)**

**Spatial statistical network models**

High-Resolution Stream Climate Scenarios

1-km resolution

>1,000,000 stream kilometers
Website: Distributes Information in Useful Digital Formats (ArcGIS & .pdfs & Excel)

1) GIS shapefiles of stream temperature scenarios

2) GIS shapefiles of stream temperature model prediction precision

3) Temperature data summaries

Google “NorWeST” or go here...

http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml
## 30 Climate Scenarios (Historic & Future)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1_93_11</td>
<td>Historical scenario representing 19 year average August mean stream temperatures for 1993-2011</td>
</tr>
<tr>
<td>S2_02_11</td>
<td>Historical scenario representing 10 year average August mean stream temperatures for 2002-2011</td>
</tr>
<tr>
<td>S3_1993</td>
<td>Historical scenario representing August mean stream temperatures for 1993</td>
</tr>
<tr>
<td>S4_1994</td>
<td>Historical scenario representing August mean stream temperatures for 1994</td>
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<tr>
<td>Etc…</td>
<td></td>
</tr>
<tr>
<td>S23-33</td>
<td>10 Future scenarios…</td>
</tr>
</tbody>
</table>

*Extensive metadata on website*
Temperature Applications

Regulatory temperature standards

Too Hot!
Too cold!

Data access accelerates temperature research

Coordinated Interagency monitoring

Species distribution models & climate assessments
Climate in North Idaho Steelhead Streams

Historic (1993-2011 Average August)

Temperature (°C)

- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution
Climate in North Idaho Steelhead Streams

+1.00°C Stream Temp

1 kilometer resolution
Climate in North Idaho Steelhead Streams

+2.00°C Stream Temp

Temperature (°C)

- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution
Fish Data Can be Used to Define Thermal Habitat Suitability

Stream temperature maps

Regional fish survey databases (n ~ 20,000)

Temperature (°C)

Occurrence probability
Fish Data Can be Used to Define Thermal Habitat Suitability
Steelhead/Rainbow Trout Habitat
Historic (1993-2011 Average August)

Clearwater R.
Lochsa R.
Selway R.
Salmon R.

11°C – 14°C

Optimal
Suboptimal
Suboptimal
Steelhead/Rainbow Trout Habitat

+1.00°C Stream Temp

11°C – 14°C

- Optimal
- Suboptimal
- Suboptimal

Clearwater R.
Locksa R.
Selway R.
Salmon R.
Steelhead/Rainbow Trout Habitat
+2.00°C Stream Temp

Clearwater R.
Lochsa R.
Selway R.
Salmon R.

11°C – 14°C
- Optimal
- Suboptimal
- Suboptimal
Multivariate Models for More Accurate Predictions of Distribution & Abundance

- 13,769 fish survey sites
- 1,420 RBT occurrences

\[ p(\text{RBT occurrence}) = \text{temperature} + \text{reach slope} + \text{stream flow} \]

AUC = 0.8-0.9
\[ r^2 \sim 80-90\% \]
National Hydrography Dataset (NHD)


The “PLUS” part of NHD-Plus: Stream Reach Descriptors

- Elevation
- Slope
- %Landuse
- Precipitation
- 100’s more...

Available at: https://www.researchgate.net/profile/Lizhu_Wang2

Available at: http://www2.epa.gov/national-aquatic-resource-surveys/streamcat
Website for 1-stop Shopping: The National Stream Internet

NSI Resources

- NSI hydrography network (shapefiles)
- Databases of stream reach descriptors
- Databases of stream measurements
- Spatial stream-network models

Idea → Data → Analysis → Information
High-Resolution, Spatial Information for Steelhead Decision Support is Possible

**Fundamental Questions:**

- How much steelhead habitat is in this river network?
- What are the spatial patterns in steelhead densities?
- What are the environmental constraints on fish density?
- Is climate change something to worry about for this population?
- Where should strategic conservation investments be made?