Thermal and habitat suitability for anadromous salmonids in the dammed and inaccessible Upper Mainstem Eel River subbasin in the Eel River Basin

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Cooper 2016

Introduction - Eel River Basin

• Large, diverse stream system
  – ~10,000 river kilometers

• Historically hosted robust run sizes (~1 million) of salmonids
  – Severe declines resulted in federally listing under ESA
    • Chinook California Coastal ESU (threatened)
    • Northern California Steelhead DPS (threatened)

• Managed recovery
Introduction - Eel River Basin

- Potter Valley hydroelectric project
  - Scott Dam (1922) blocks access to ~12% of river km in the Eel River Basin

- Is the blocked **Upper Mainstem Eel River** subbasin important for salmonid recovery?

![Maps of steelhead and chinook](https://via.placeholder.com/150)
1) How much suitable habitat does **Upp. Main.** have relative to other subbasins?
- River km
- Applied qualitative scores of channel type productivity and thermal conditions to estimate amount of suitable habitat
- Expert opinion and GIS-based

2) How many parr and spawners can the **Upp. Main.** hold?
- Number
- Applied Unit Characteristic Method, a capacity estimation model
- Statistical modeling approach based on fish densities and habitat use in Oregon
Methodological Approach 1

For each reach:
1) Accessible?
2) Productive habitat?
3) Thermally suitable?
   ▪ In each month of occupancy
Methodological Approach 1

For 3-4 life stages,
for 3 runs,
for 3 year types,
for each subbasin

For each reach:
1) Accessible?
2) Productive habitat?
3) Thermally suitable?
   ▪ In each month of occupancy

Subbasin: historical population boundaries defined from salmonid biogeographic breaks (Bjorkstedt et al. 2005, Spence et al. 2008)
• **Steelhead**
  - ~5,000 km potentially accessible in Eel Basin
  - 584 km blocked in Upp. Main. (12%)

• **Chinook salmon**
  - ~2,500 km potentially accessible in Eel Basin
  - 144 km blocked in Upp. Main. (6%)
Channel geomorphology types were assigned using channel gradient and catchment area (Flores et al. 2006) – 76% accuracy for their stream system in western U.S.
Expanded a pre-existing spatial stream network (SSN) model
- [https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html](https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html)

Mean monthly stream temperature predictions for ~380,000 stream km in western U.S., across 8 major watershed units
- $r^2 = 0.925$
- Error ~ 1°C
<table>
<thead>
<tr>
<th>Accessibility</th>
<th>Channel productivity</th>
<th>Thermal suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sacramento pikeminnow</td>
<td><a href="http://www.wideopenspaces.com/catch-a-pikeminnow-save-a-salmon-and-get-paid/">www.wideopenspaces.com/catch-a-pikeminnow-save-a-salmon-and-get-paid/</a></td>
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<tr>
<td>– Introduced (ca. 1979) species in Eel River Basin</td>
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<td>– Predator and competitor of juvenile salmonids</td>
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<tr>
<td>– Pikeminnow prefer temps $\geq 18^{\circ}$C, so these are high-risk for juvenile salmonids</td>
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<td></td>
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<tr>
<td>• Steelhead rearing</td>
<td></td>
<td></td>
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<tr>
<td>– Optimal: 10-17$^{\circ}$C</td>
<td></td>
<td></td>
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<tr>
<td>– Suboptimal: 17-23$^{\circ}$C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Lethal: $\geq 23^{\circ}$C</td>
<td></td>
<td></td>
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<td>• Chinook salmon rearing</td>
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<td>– Optimal: 13-$18^{\circ}$C</td>
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Approach 1: Results

How much suitable habitat does Upp. Main. have relative to other subbasins?

**HISTORICAL STATUS**
- Dependent
- Independent
- Independent (currently blocked)

**DAMS**
- Van Arsdale Dam (passable)
- Scott Dam (impassable)

**Steelhead - Winter-run**
1. Upper Main. Eel
2. Middle Fork Eel
3. North Fork Eel
4. Van Duzen
5. South Fork Eel
6. Larabee
7. Dobbyn
8. Lower Main. Eel

**Steelhead - Summer-run**
9. Price
10. Howe
11. Jewett
12. Pipe
13. Kekawaka
14. Chamise
15. Bell Springs
16. Woodman

**Chinook - Fall-run**
17. Outlet
18. Tomki
19. Bucknell
20. Soda
21. Lower Midd. Main. Eel
22. Upper Midd. Main. Eel
24. Lower Eel

Sources: Esri, USGS, NOAA
Results: Incubation

Figure 6. Thermal refuges during the entire extended incubation season that are suitable for steelhead winter-run (top), steelhead summer-run (middle), or Chinook fall-run (bottom). Suitability is broken up by year type (colors in legend) and habitat type (left/right panels). Reaches suitable during drought years are also suitable during average years, and reaches suitable during average years are also suitable during cool years.

- During drought (orange), little ideal habitat for entire season
  - Entire season: early, peak, and late spawners
- But lots of suitable conditions during peak season (not shown)
- Successful spawning for early/late spawners may be precluded during drought years
- **Upp. Main.** similar to Van Duzen, South Fork, and Larabee
• Juveniles rear in a wide range of habitats, so temperature more restricting
• **Higher proportion green -> Good**
• Worse conditions in July & August
Results: Juvenile Rearing

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- Better conditions in cool year
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- Higher proportion green -> Good
- Worse conditions in July & August
- Better conditions in cool year, worse conditions in drought year
• Worse conditions in July & August
• Better conditions in cool year, worse conditions in drought year
• Most reaches not lethal, many suboptimal -> Rearing squeezed in summer
• S. Fork had greatest amount of optimal space in July; second was Upp. Main.
Results: Juvenile Rearing

- Worse conditions in July & August
- Better conditions in cool year, worse conditions in drought year
- Most reaches not lethal, many suboptimal -> Rearing squeezed in summer
- S. Fork had greatest amount of optimal space in July; second was Upp. Main.
- Chinook outmigrate by summer
Summary: Approach 1

- Suitable habitat restricted during summer and drought
  - Fringe spawners and juveniles rearing in summer
- Van Duzen had the highest proportion of suitable habitat for multiple life stages
- Second was the currently dammed Upp. Main.
  - STL: 169-467 km
  - CHK: 51-129 km

Figure 6 from Cooper et al. 2020
Opening access to Upp. Main. would be similar to adding a Van Duzen subbasin to Eel Basin. Upp. Main. could likely sustain anadromous populations, even during drought years.

*How many fish could Upp. Main. sustain??*
1) How much suitable habitat does Upp. Main. have relative to other subbasins?
   - River km
   - Applied qualitative scores of channel type and thermal conditions to estimate amount of suitable habitat
   - Expert opinion and GIS-based

2) How many parr and spawners can the Upp. Main. hold?
   - Number
   - Applied Unit Characteristic Method, a capacity estimation model
   - Statistical modeling approach based on fish densities and habitat use in Oregon
Methodological Approach 2

- Unit Characteristic Method (UCM) to estimate parr capacity (Cramer & Ackerman 2009)
- Multiplies baseline fish density by unit area, then adjusts the density by habitat scalar values based on parameters describing local conditions for each habitat type.

Figure 2 from Cooper 2017
Methodological Approach 2

Baseline fish density
Methodological Approach 2

Baseline fish density

Larger area +
Same habitat ==
More fish
Methodological Approach 2

Baseline fish density  
Larger area + 
Same habitat == 
More fish

Same area + 
Worse habitat == 
Less Fish
Methodological Approach 2

Baseline fish density

Larger area +
Same habitat ==
More fish

Same area +
Worse habitat ==
Less Fish

Same area +
Better habitat ==
More fish
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<th>Baseline Fish Density</th>
<th>Local Conditions</th>
<th>Reach Area</th>
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<td>• Multiplies baseline fish density by unit area, then adjusts the density by habitat scalar values based on parameters describing local conditions for each habitat type</td>
<td>• Baseline fish density -&gt; Oregon</td>
</tr>
<tr>
<td>• Reach area (length x width)</td>
<td>• Modeled wetted width by month from flow gages</td>
<td>• Local conditions (e.g. habitat type, cover, depth, pH, % boulders, temperature)?</td>
</tr>
</tbody>
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Cooper (2017), Cooper et al. (2020)

Extrapolated local conditions based on Reach Type

Assumed that local conditions in Upp. Main. are representative of other subbasins
Results: Parr capacity by month

- **Steelhead:** August
- **Chinook salmon:** May
Results: Parr capacity – STL

- **Steelhead**
  - Removed reaches conducive to pikeminnow
  - 11.5% of the parr capacity in **Upp. Main.**
  - Similar to the Van Duzen

- **Adjusted**

- **Raw**
  - Not adjusted for pikeminnow
  - 5.8% of parr capacity in the **Upp. Main.**
  - Similar to the North Fork
Results: Parr capacity – CHK

- **Chinook salmon**
- **Adjusted**
  - Removed reaches conducive to pikeminnow
  - 1.4% of the parr capacity in **Upp. Main**.
- **Raw**
  - Not adjusted for pikeminnow
  - Same because temperature throughout Eel Basin too cool for pikeminnow in May
Results: Spawner capacity

- To convert from parr to spawner capacity:

- **Steelhead**
  - Parr-adult survival model
    - 28% survival
  - Ocean survival models
    - 1.5%
    - 13%
    - 20%

- **Chinook salmon**
  - Parr-adult survival model
    - 76% survival
  - Ocean survival models
    - 1.5%
    - 3.0%
    - 4.0%
Results: Spawner capacity

- STL: 256-5,370
- CHK: 1,242-3,314
Results: Spawner capacity

This study:
STL: 256-5,370
CHK: 1,242-3,314
Conclusions

• **Upp. Main.** harbors a large amount of thermally suitable, productive habitat types
  – Cool-water refuge during summer, drought
  – **Upp. Main.** similar to Van Duzen

• Capacity estimates are wide, but generally overlap with other estimates

• **Upp. Main.** could sustain populations of anadromous salmonids