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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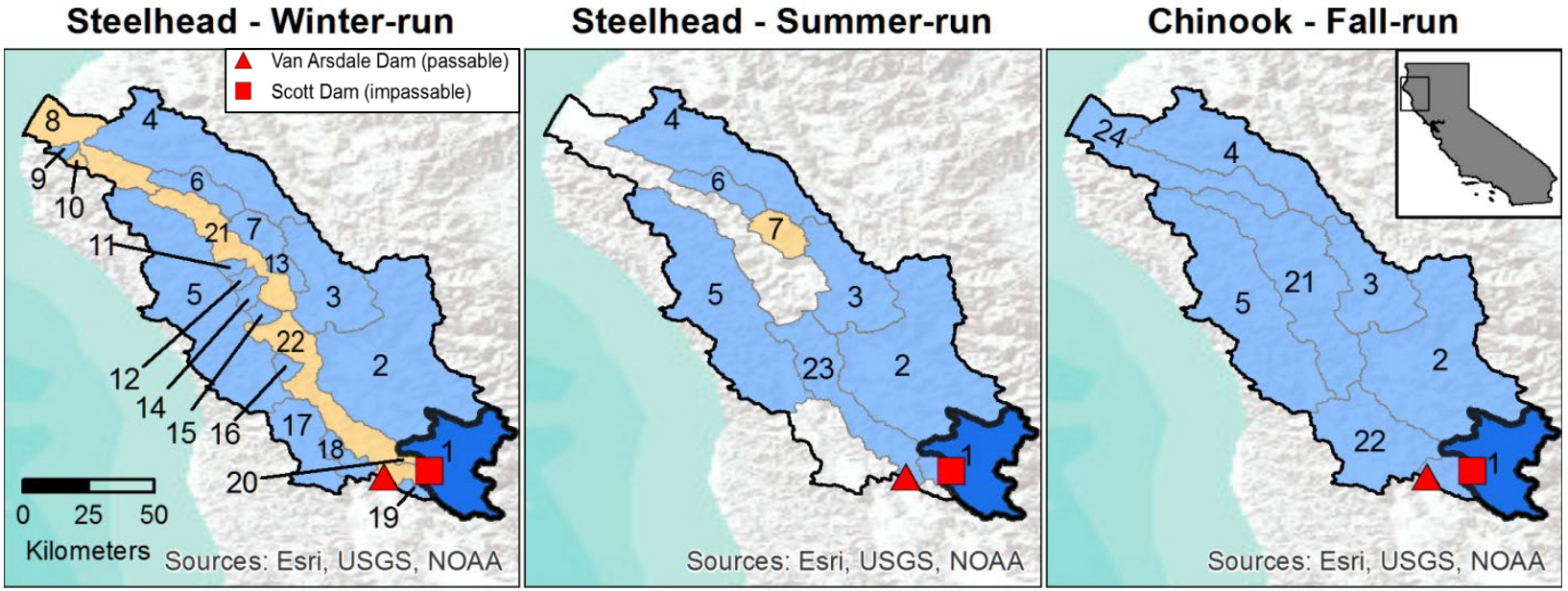
Introduction - Eel River Basin

- 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

Cooper 2016

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?**

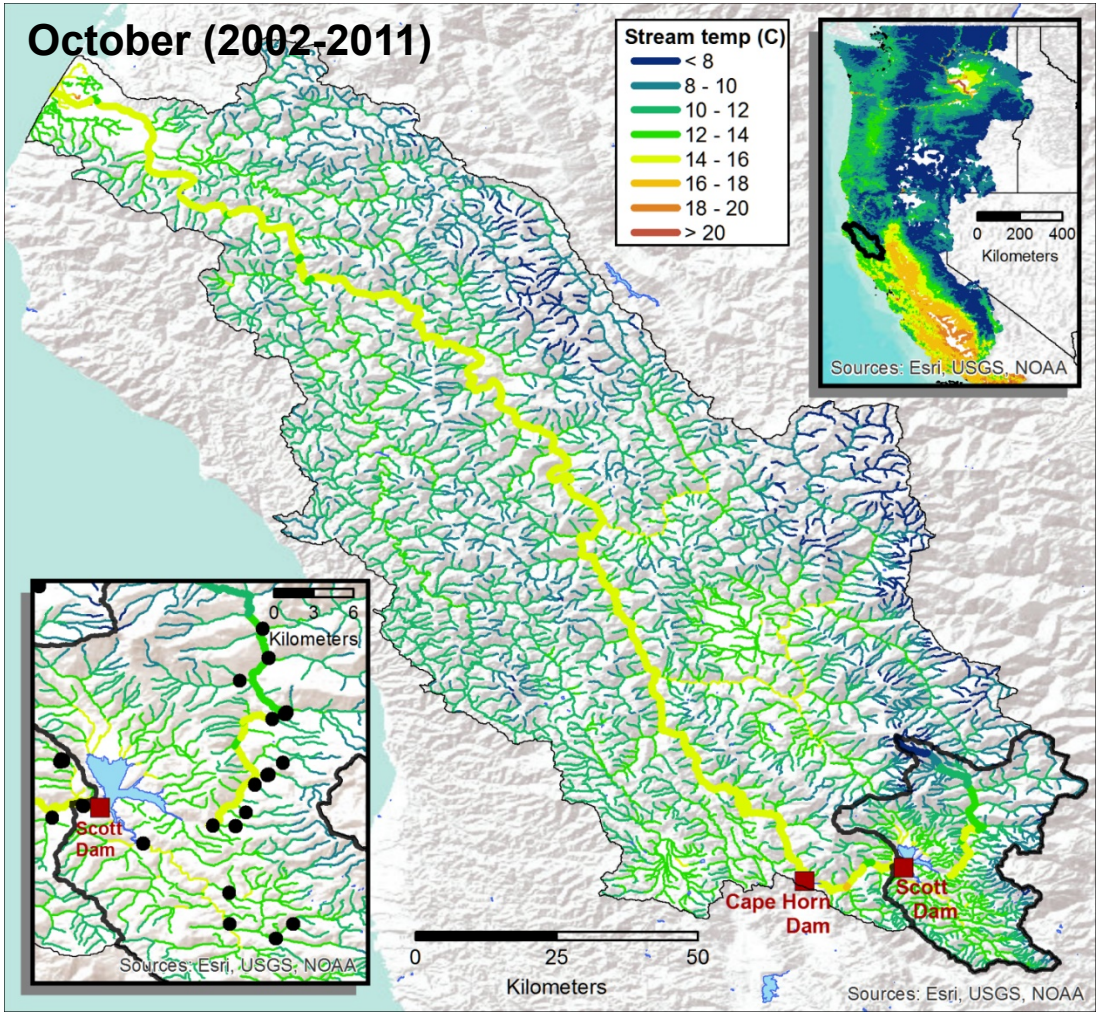


Approaches

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

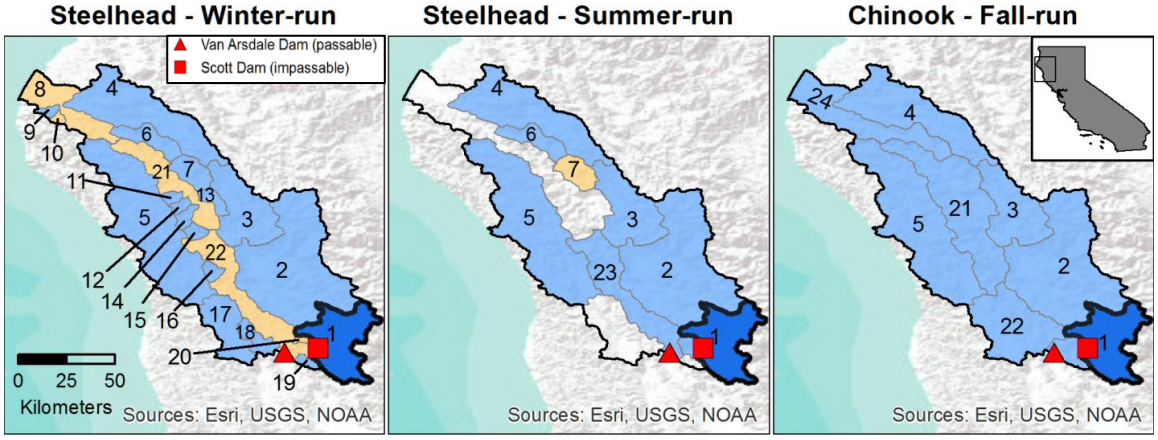


For each reach:

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



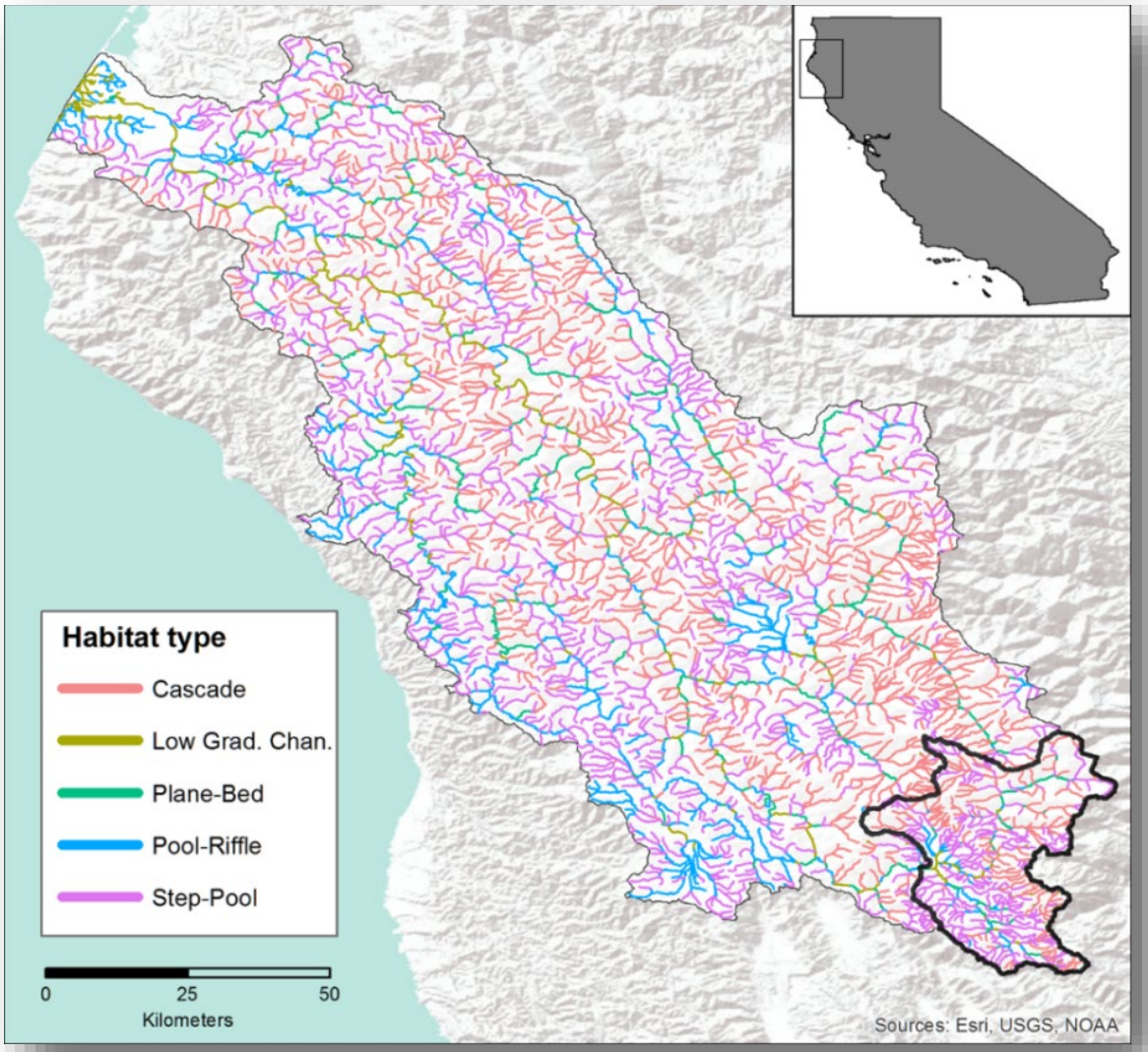
Subbasin: historical population boundaries defined from salmonid biogeographic breaks (Bjorkstedt et al. 2005, Spence et al. 2008)

For each reach:

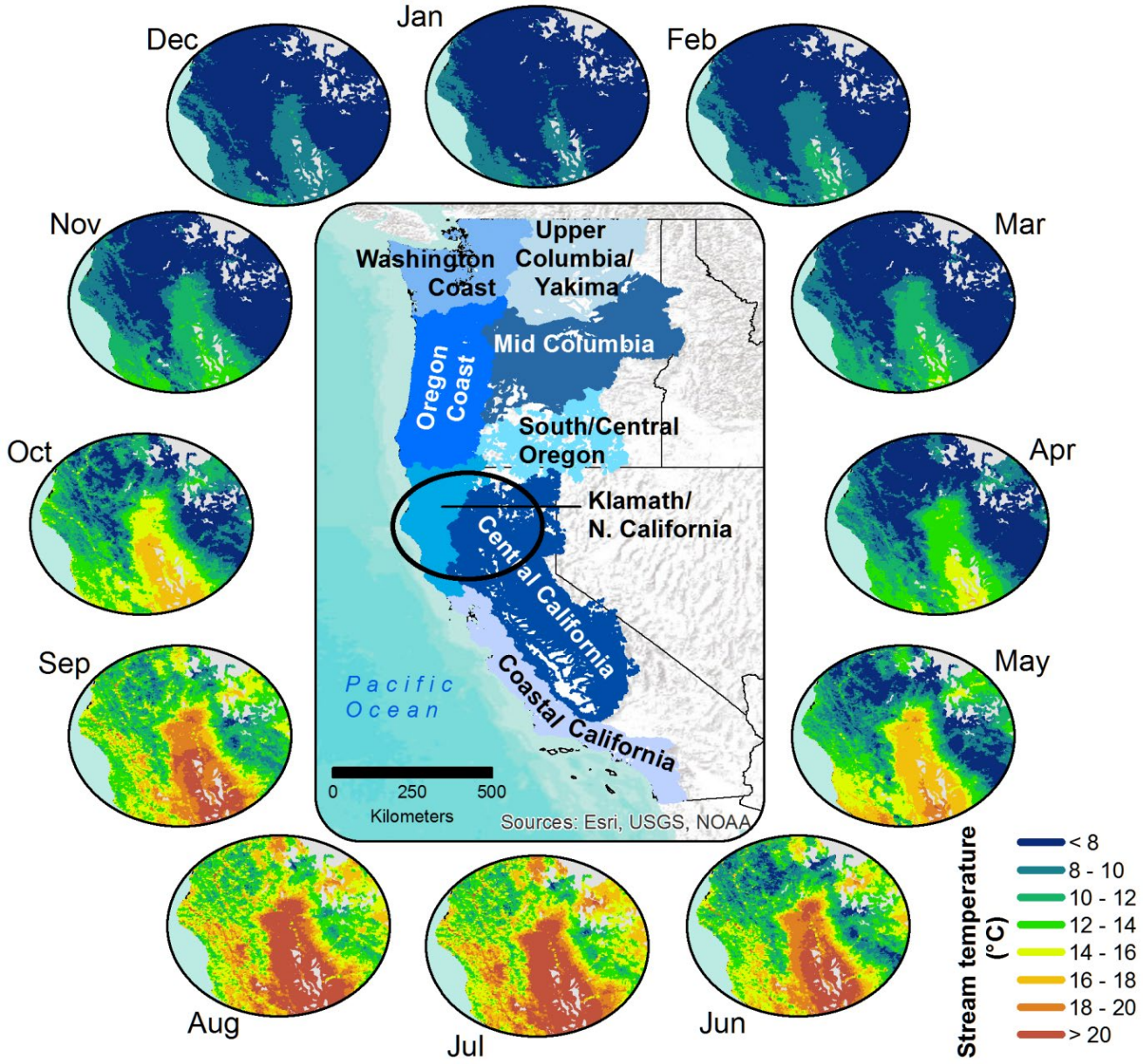
1) Accessible?
2) Productive habitat?
3) Thermally suitable?
   - In each month of occupancy

- 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.



Accessibility | Channel productivity | Thermal suitability



- Expanded a pre-existing spatial stream network (SSN) model
  - 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

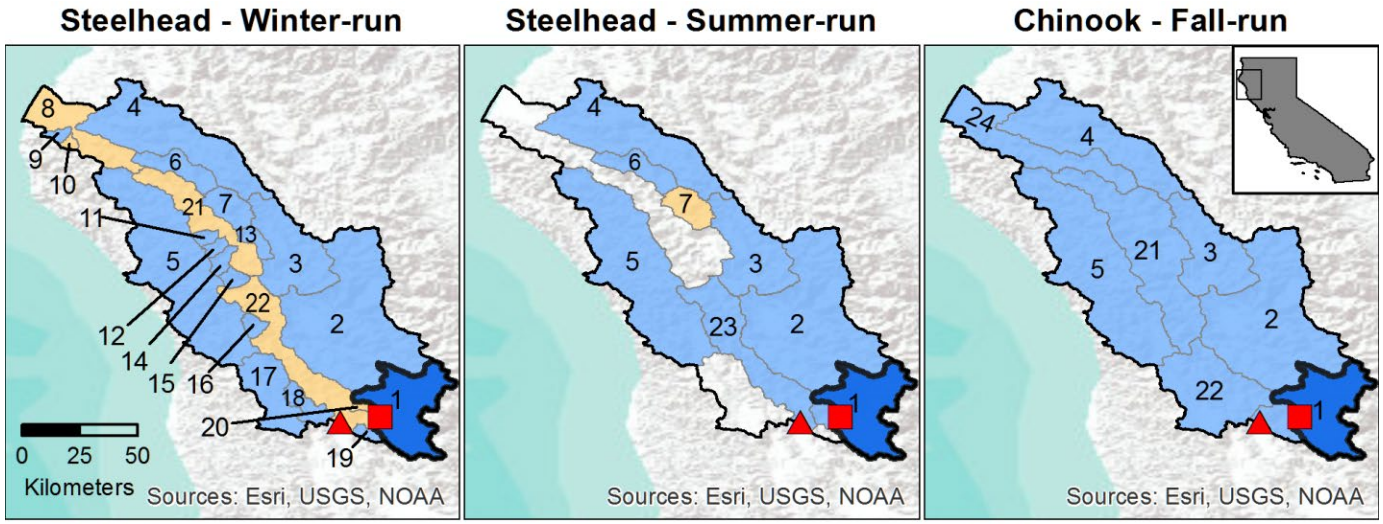
- Sacramento pikeminnow
  - Introduced (ca. 1979) species in Eel River Basin
  - Predator and competitor of juvenile salmonids
  - **Pikeminnow prefer temps ≥ 18°C, so these are high-risk for juvenile salmonids**

www.wideopenspaces.com/ catch-a-pikeminnow-save-a-salmon-and-get-paid/

- Steelhead rearing
  - Optimal: 10-17°C
  - Suboptimal: 17-23°C
  - Lethal: ≥ 23°C
- Chinook salmon rearing
  - Optimal: 13-18°C
  - Suboptimal: 18-24°C
  - Lethal: ≥ 24°C

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)

POPULATION

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
9. Price
10. Howe
11. Jewett
12. Pipe
13. Kekawaka
14. Chamise
15. Bell Springs
16. Woodman
17. Outlet
18. Tomki
19. Bucknell
20. Soda
21. Lower Midd. Main. Eel
22. Upper Midd. Main. Eel
23. Upper Midd. Main.
24. Lower Eel

Results: Incubation

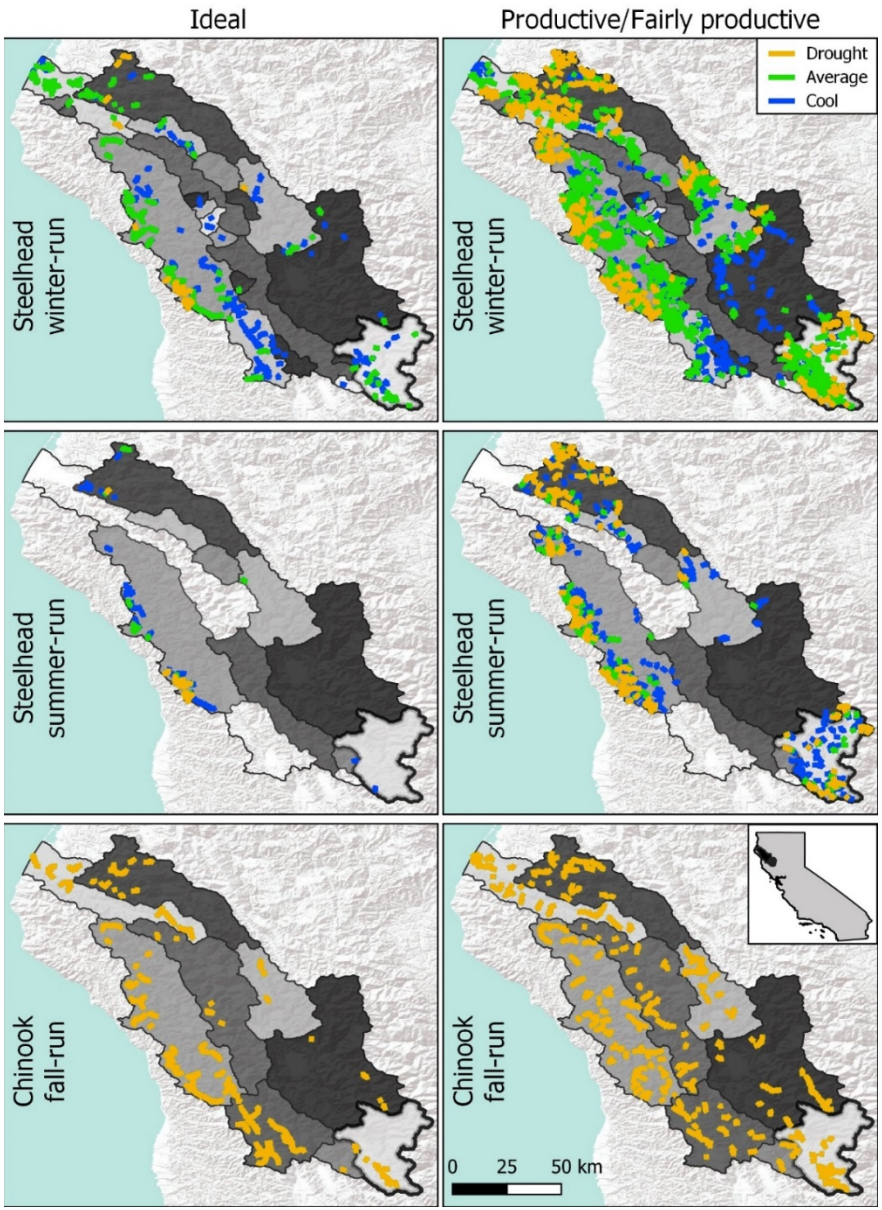
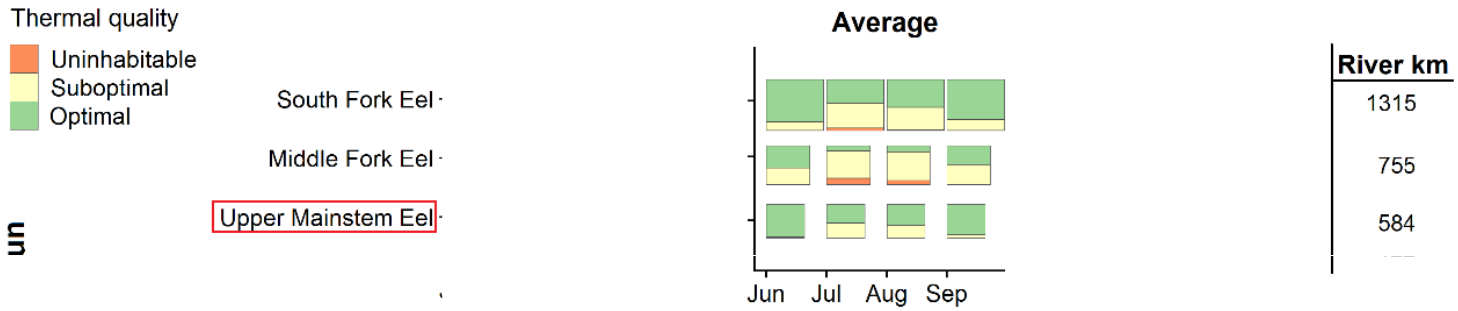


Figure 6. Thermal refuges during the entire extended incubation season that are suitable for steelhead winter-run (top), steelhead summer-run (middle), or Chinook fall-run (bottom). Suitability is broken up by year type (colors in legend) and habitat type (left/right panels). Reaches suitable during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

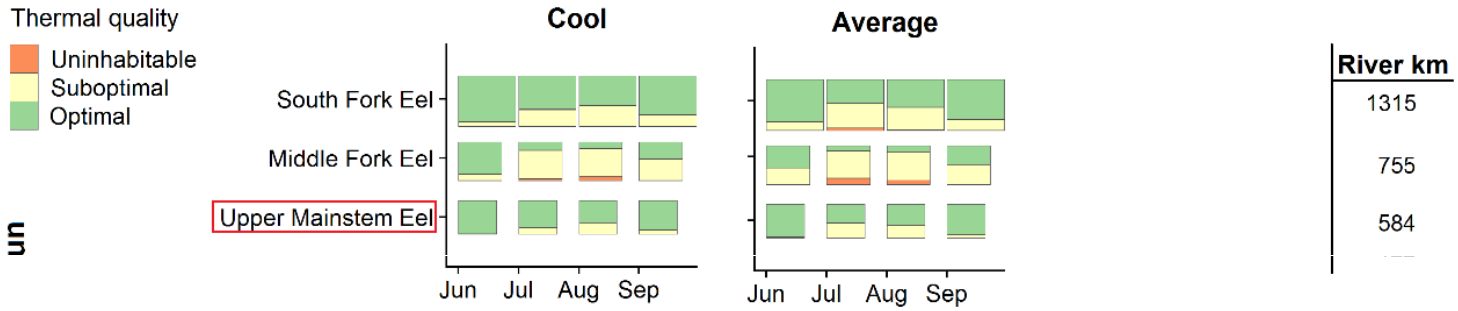
- During drought (orange), little ideal habitat for entire season
  - Entire season: early, peak, and late spawners
- But lots of suitable conditions during peak season (not shown)
- Successful spawning for early/late spawners may be precluded during drought years
- **Upp. Main.** similar to Van Duzen, South Fork, and Larabee

Results: Juvenile Rearing



- 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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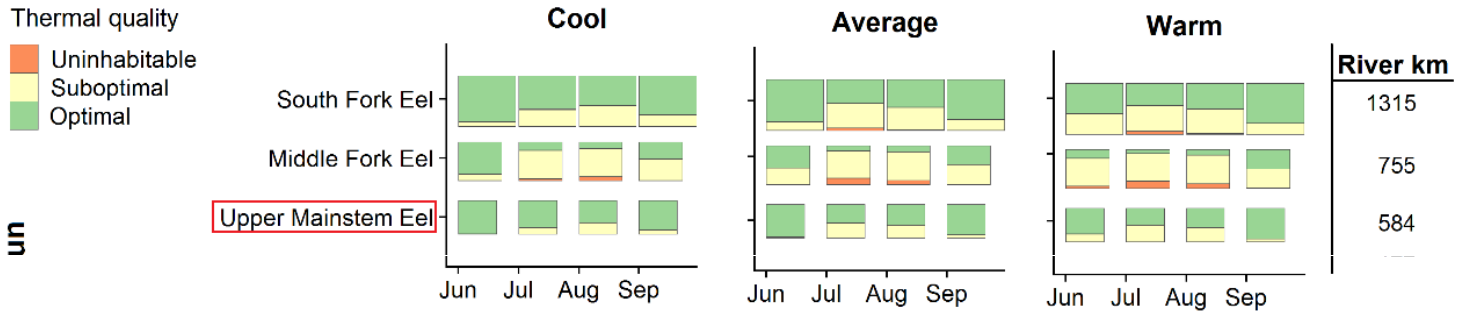

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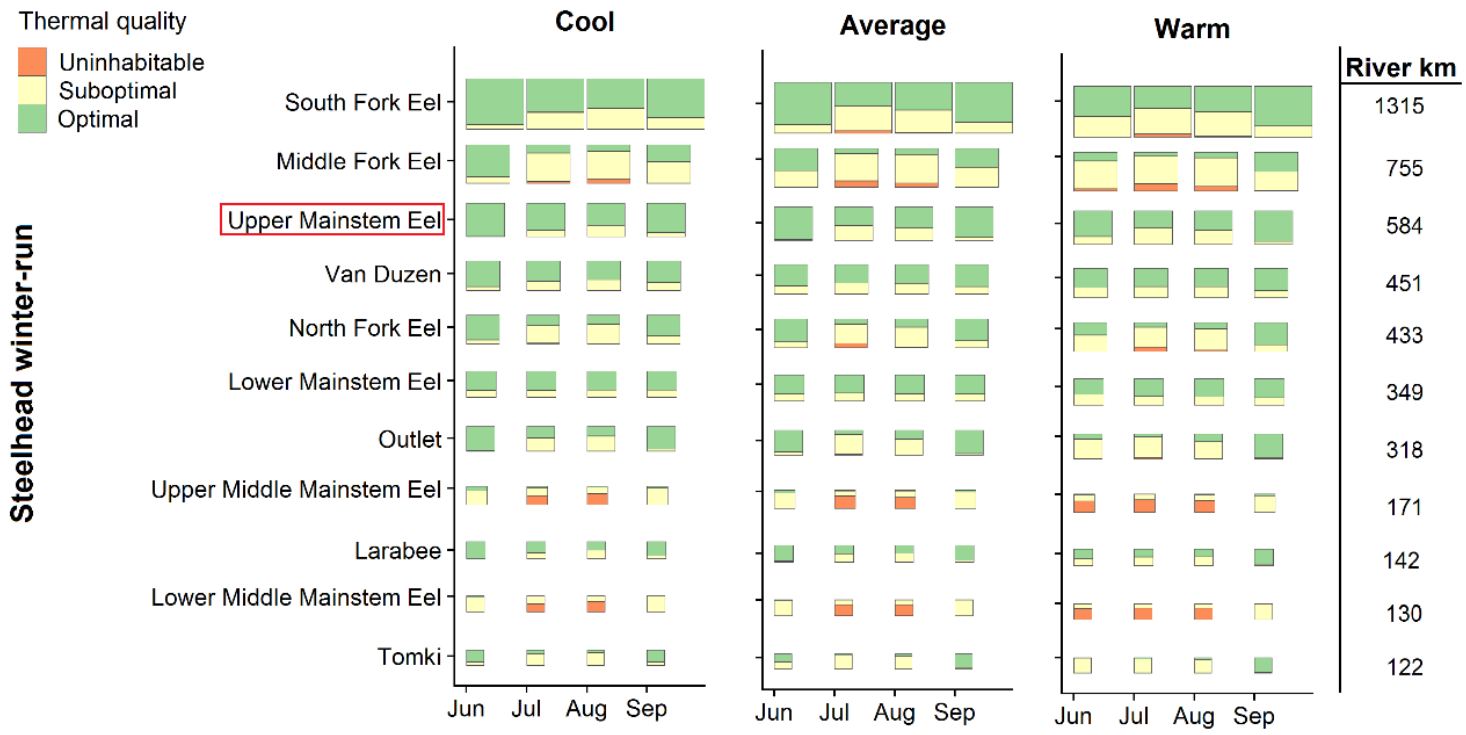
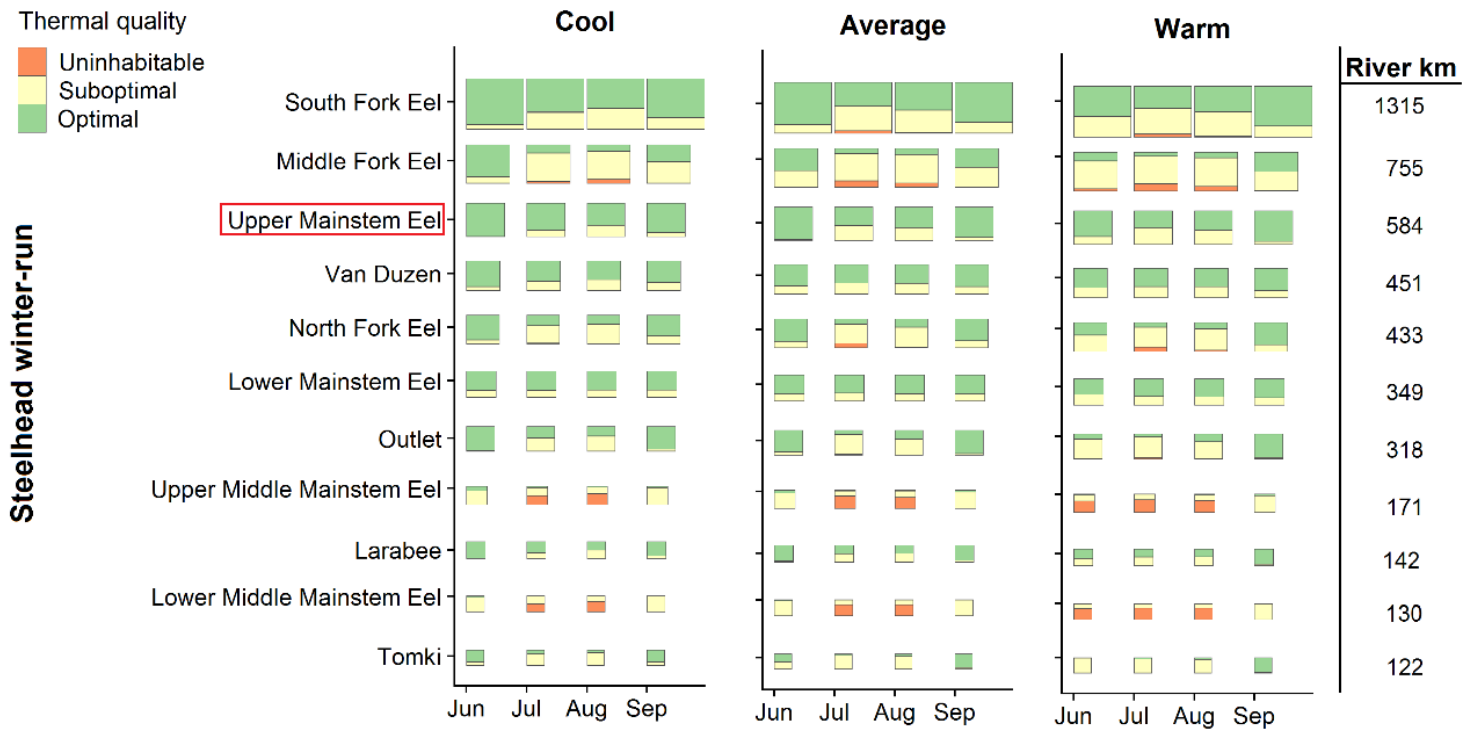


- Worse conditions in July & August
- Better conditions in cool year, worse conditions in drought year
- Most reaches not lethal, many suboptimal -> Rearing squeezed in summer
- S. Fork had greatest amount of optimal space in July; **second was Upp. Main.**

Results: Juvenile Rearing



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- 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

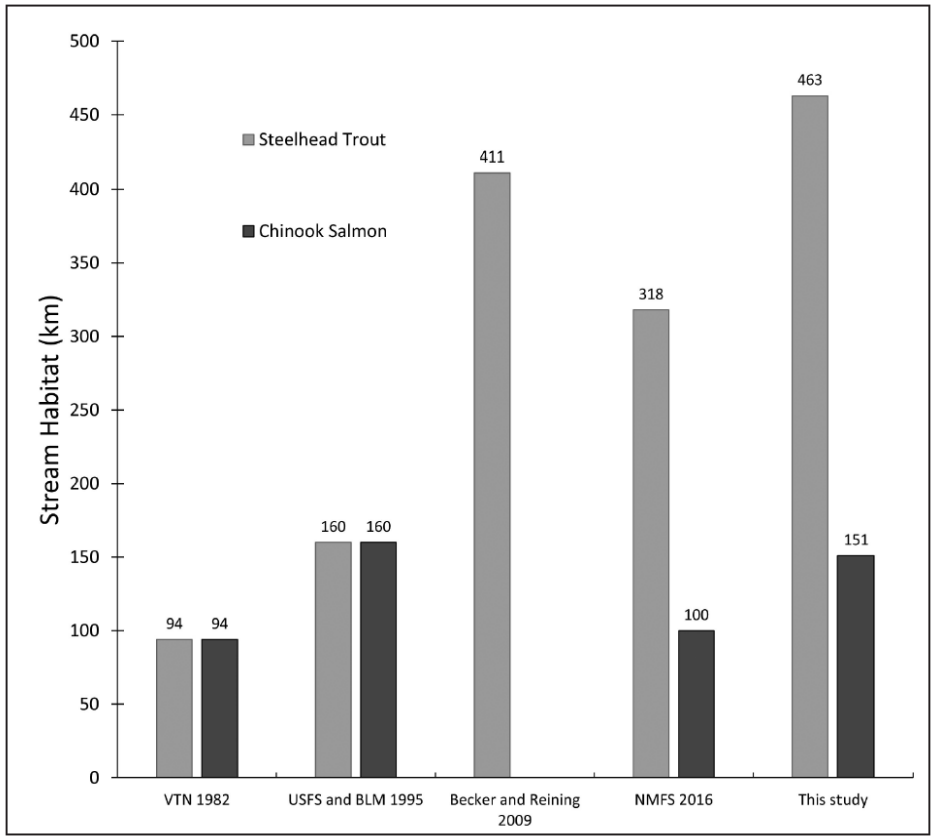
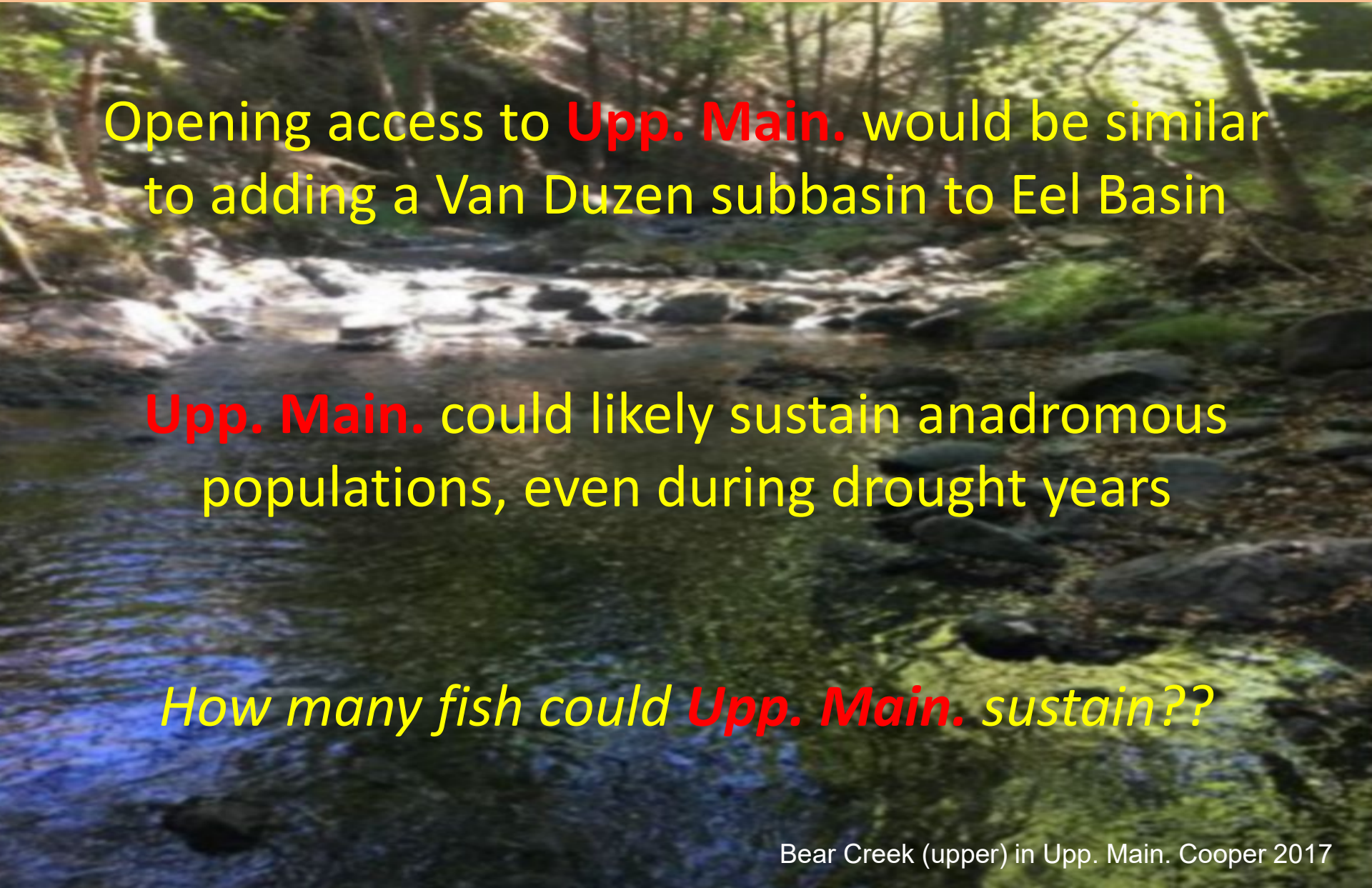


Figure 6. Quantified stream habitat (km) for steelhead trout and Chinook salmon upstream of Scott Dam from four other sources and this study (Cooper et al.).

Figure 6 from Cooper et al. 2020

Summary: Approach 1



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??*

Bear Creek (upper) in Upp. Main. Cooper 2017

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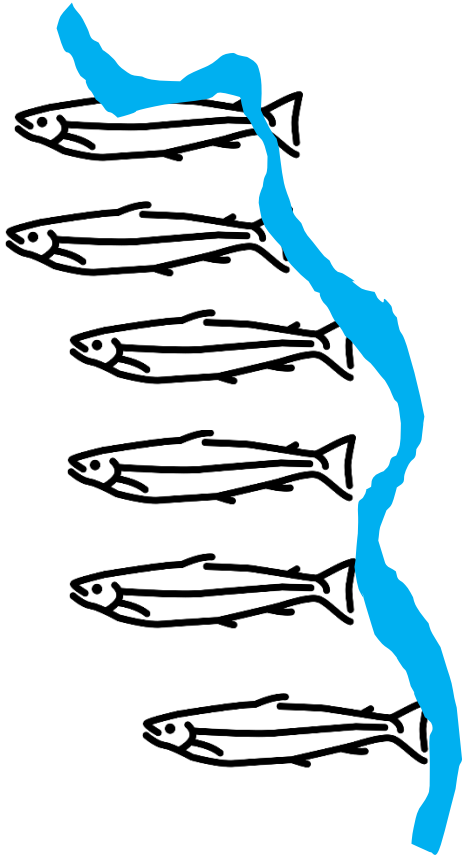
Methodological Approach 2



Baseline fish density

- 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

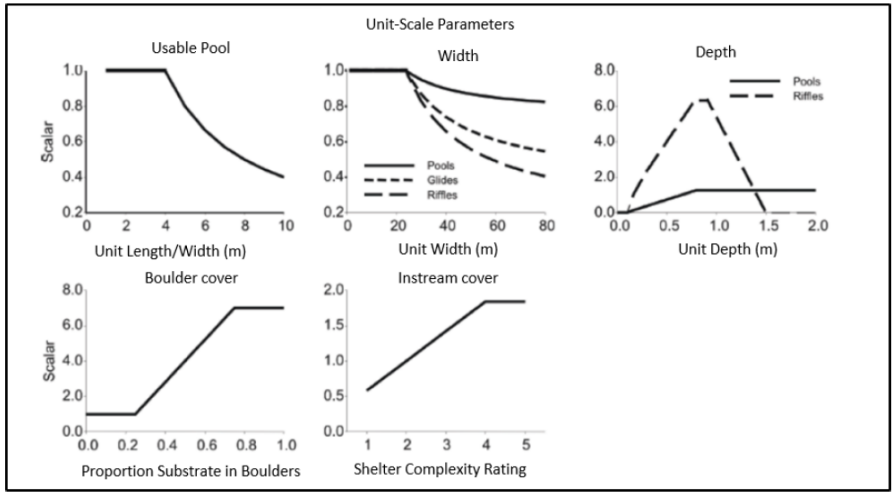
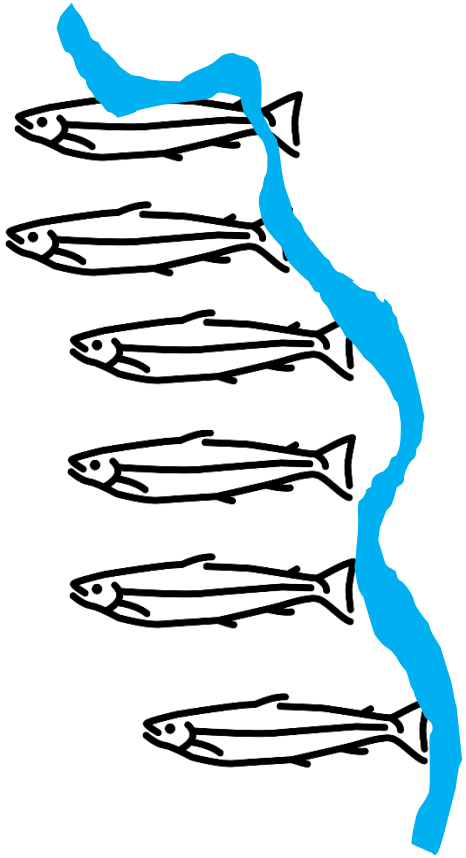


Figure 2. Habitat-parr density relationships used in unit-scale adjustments for the UCM. The y-axis represents habitat parameters in scalar values. These scalars are multiplied by parr/m^2, which adjusts the overall parr density. The Usable Pool and Width curves are used in the unit area parameter. Note that some scalar values can be greater than one. (from Cramer and Ackerman, 2009b).

Figure 2 from Cooper 2017

Methodological Approach 2



Baseline fish density

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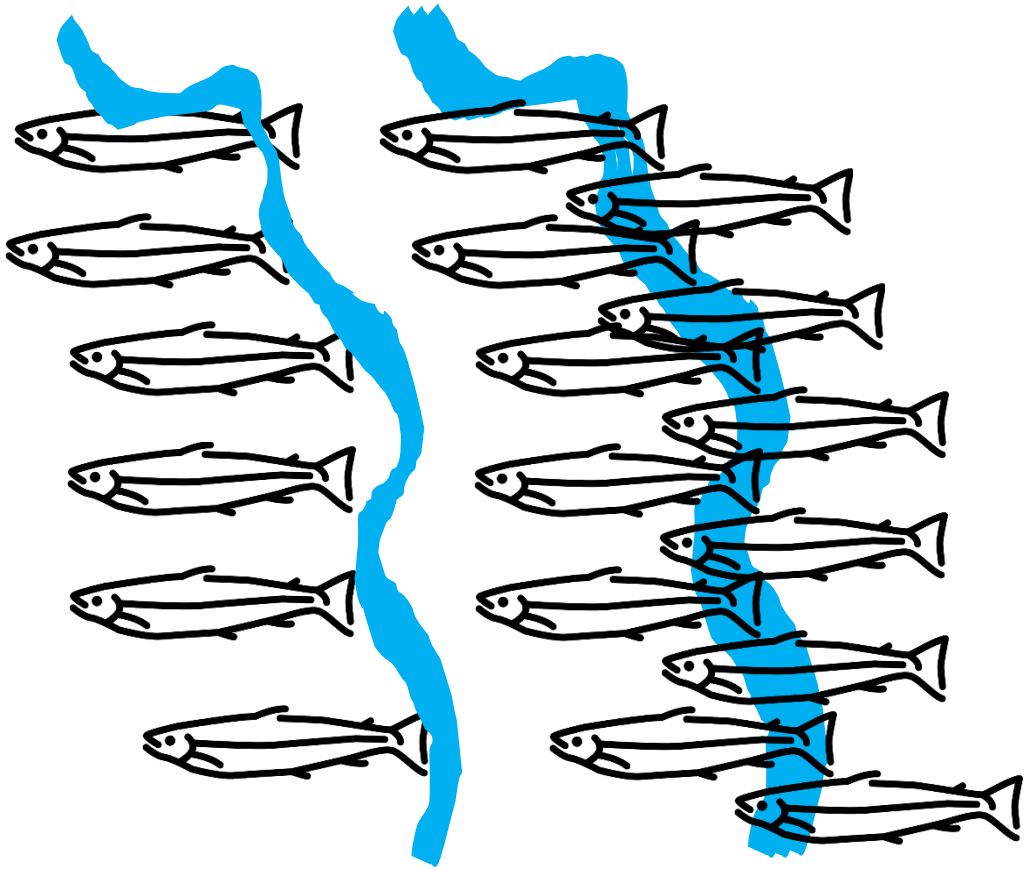
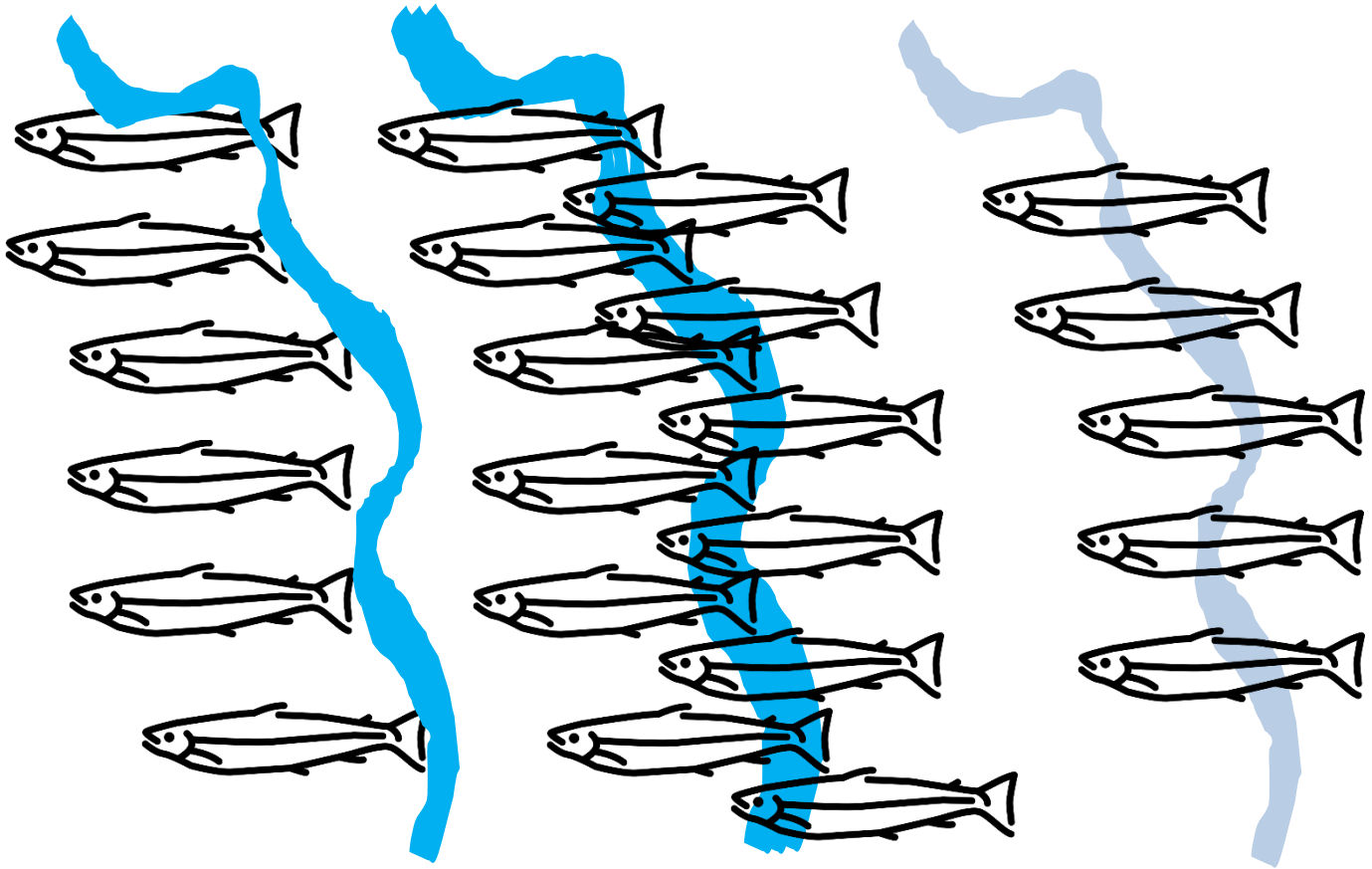


Baseline fish density

Larger area +
Same habitat ==
More fish

Methodological Approach 2

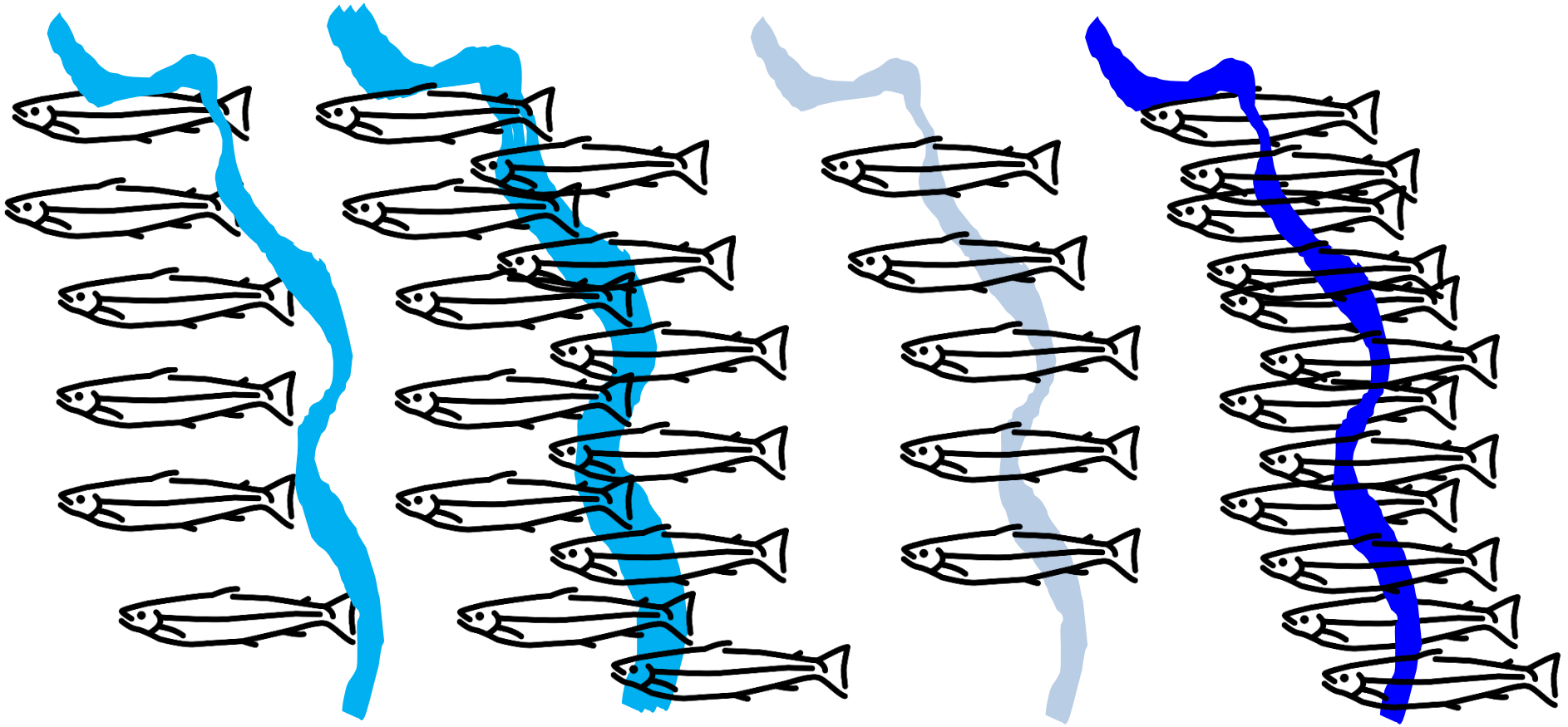


Baseline fish density

Larger area +
Same habitat ==
More fish

Same area +
Worse habitat ==
Less Fish

Methodological Approach 2



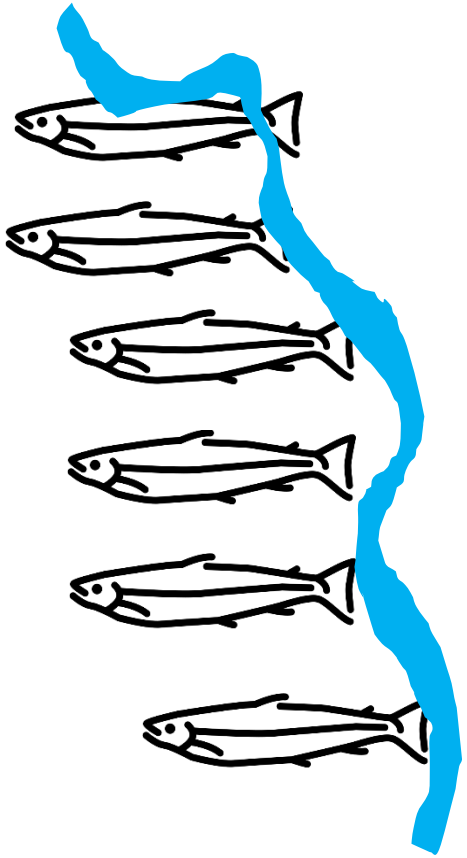
Baseline fish density

Larger area +
Same habitat ==
More fish

Same area +
Worse habitat ==
Less Fish

Same area +
Better habitat ==
More fish

Baseline Fish Density	Local Conditions	Reach Area



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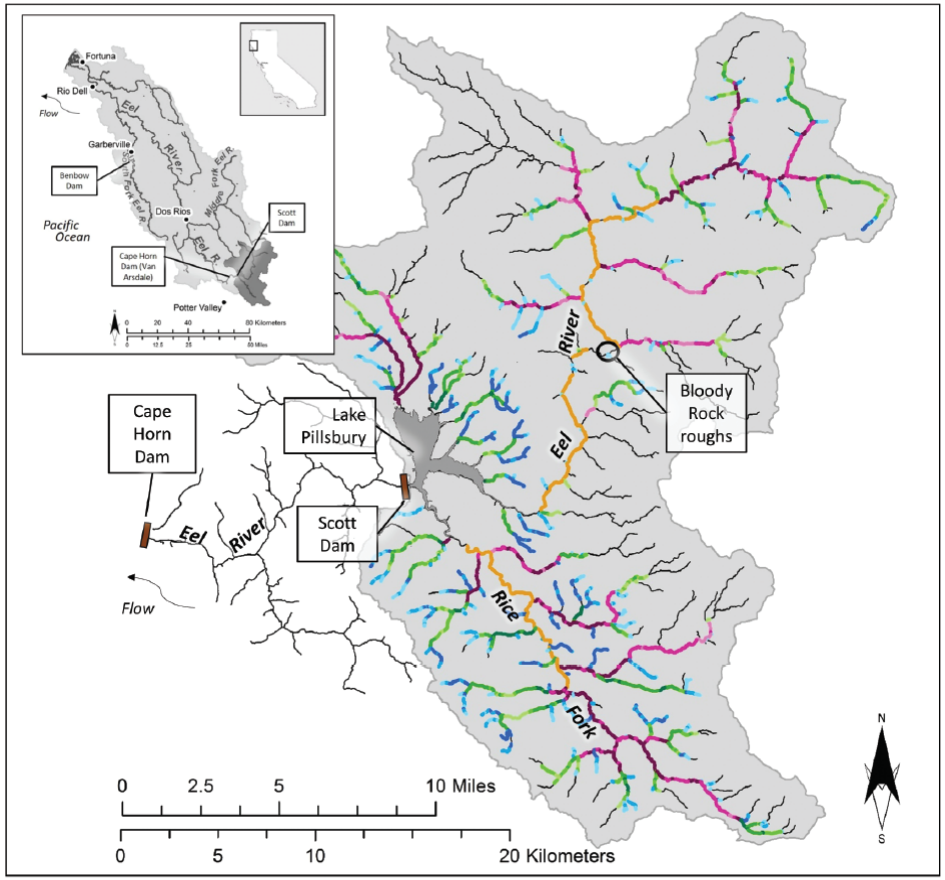
- Baseline fish density -> Oregon
- Reach area (length x width)
  - Modeled wetted width by month from flow gages
- Local conditions (e.g. habitat type, cover, depth, pH, % boulders, temperature)?



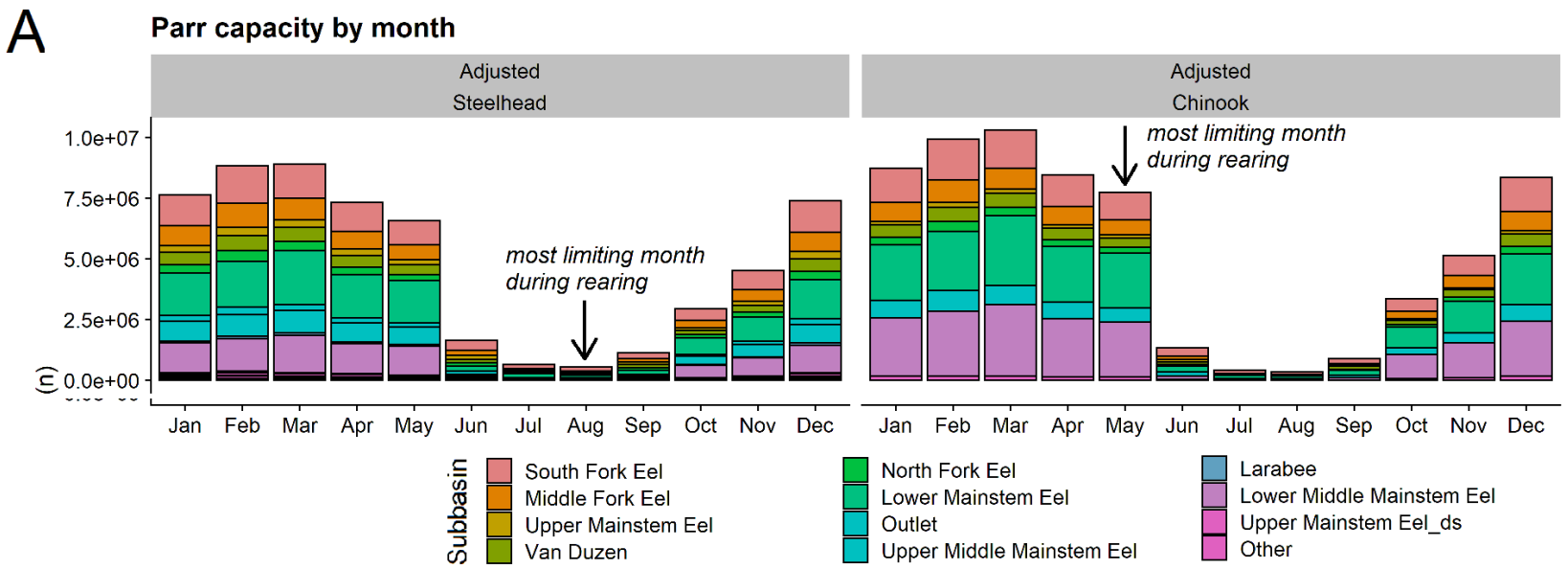
Drainage Area	0 - 2 km²			2 - 10 km²				10 – 100 km²			> 100 km²
Slope	0 – 2%	2 – 7%	7 – 12%	0 – 2%	2 – 7%	7 – 12%	> 12%	0 – 2%	2 – 7%	7 – 12%	0 – 2%
RT	2.1	3.1	4.1	1.2	2.2	3.2	4.2	1.3	2.3	3.3	1.4

Figure 2. Study area streams were classified and coded into Reach Types (RT) by categories of drainage area (color) and slope (steeper slopes in lighter shades) for data collection and extrapolation. Bloody Rock roughs is a partial barrier and thin black streams upstream of Scott Dam are inaccessible to anadromous salmonids.

Figure 2 from Cooper et al. 2020

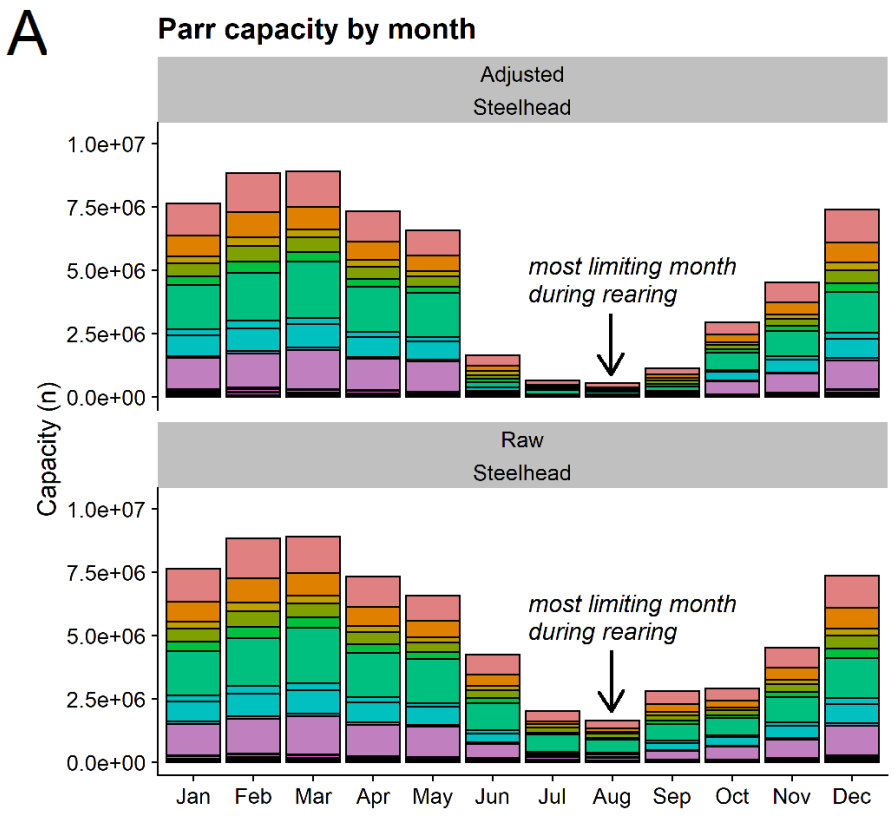
- Cooper (2017), Cooper et al. (2020)
- Extrapolated local conditions based on Reach Type
- **Assumed that local conditions in Upp. Main. are representative of other subbasins**

Results: Parr capacity by month



- Steelhead: August
- Chinook salmon: May

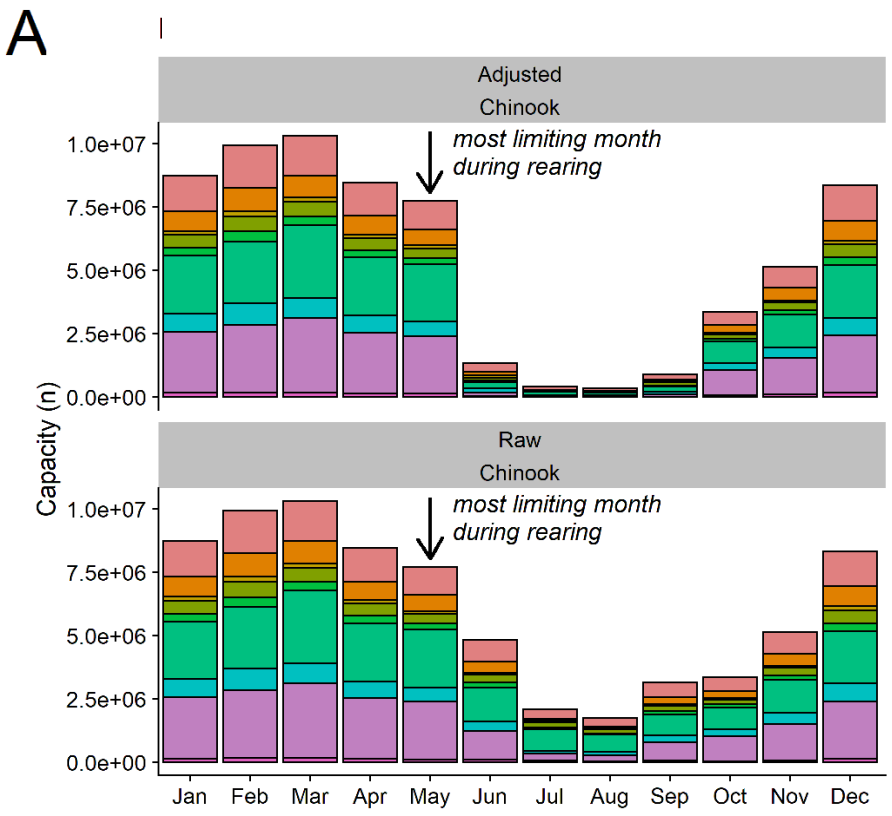
Results: Parr capacity – STL



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



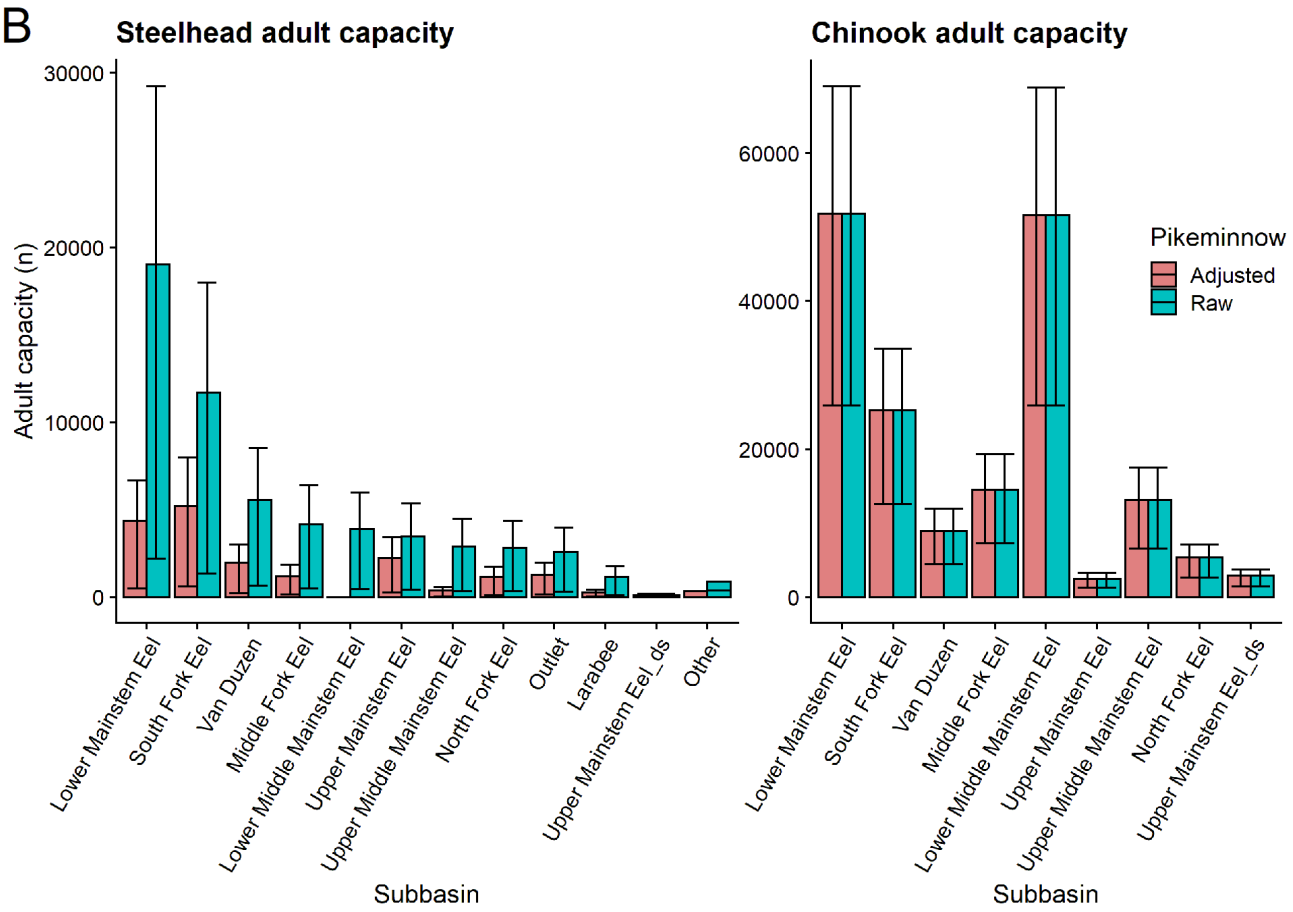
Results: Spawner capacity

- 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

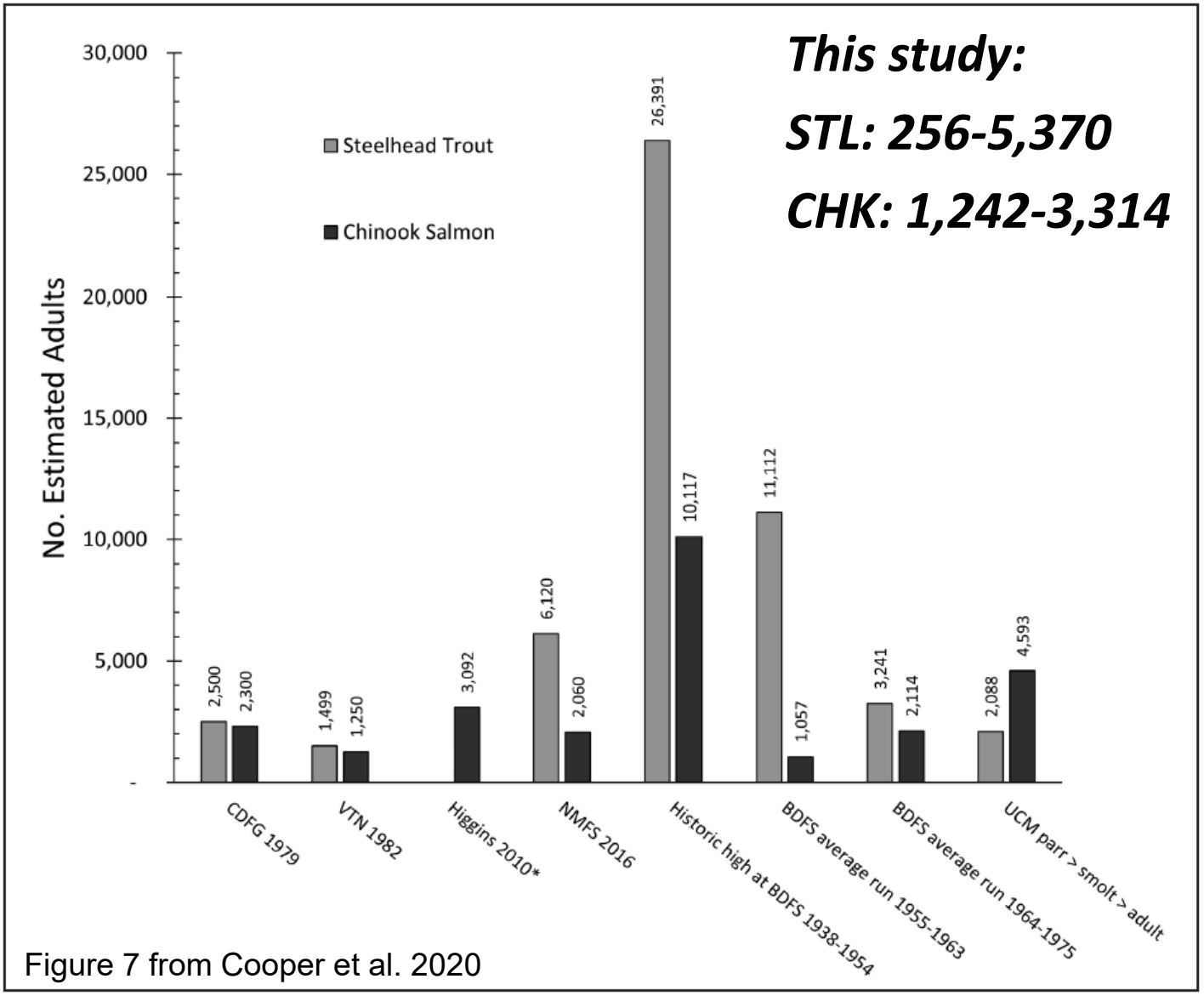


Figure 7 from Cooper et al. 2020

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

Cooper 2016