Investigating the Relation Between Streamflow and Habitat for Rearing and Spawning Spring Chinook in the McKenzie and North Santiam Rivers, Oregon

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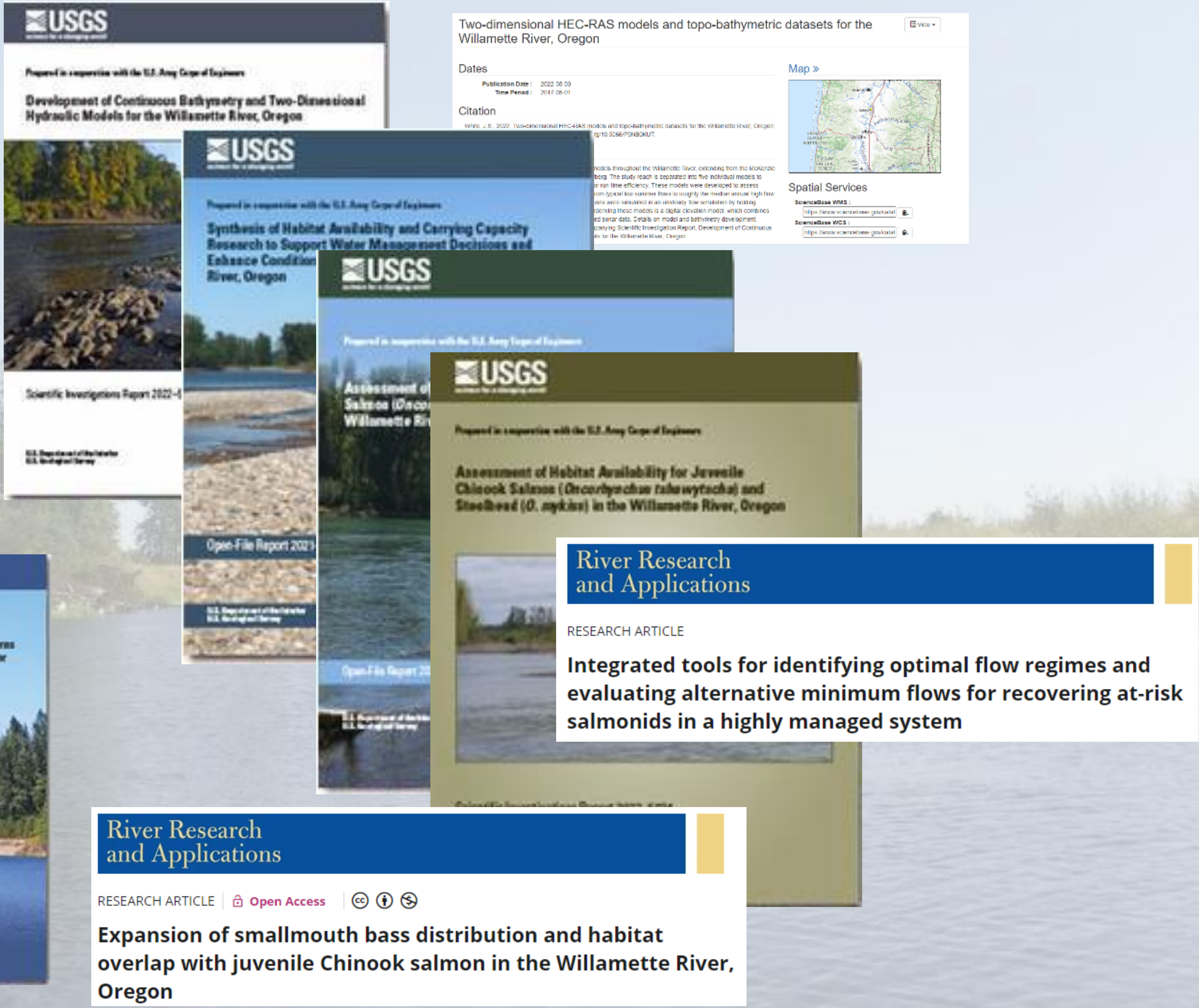
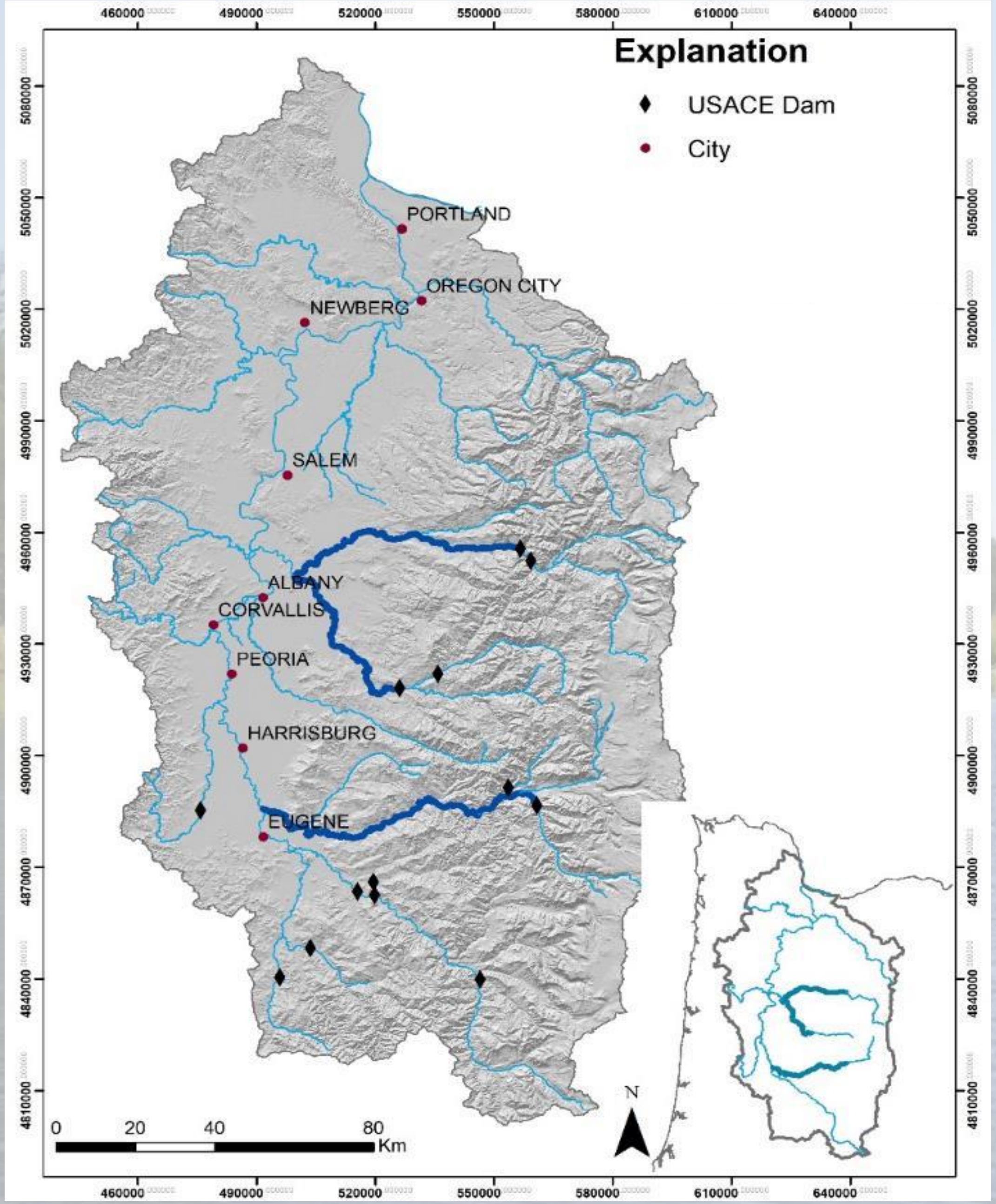
Willamette Fisheries Science Review
April 3, 2024
Corvallis, Oregon

Background

Mainstem Willamette River studies

- Bathymetric lidar & sonar
- Hydraulic models
- Habitat modeling literature review
- Chinook habitat use assessment
- Chinook/steelhead habitat models
- Temperature models
- Movement/growth/survival models
- Smallmouth bass models

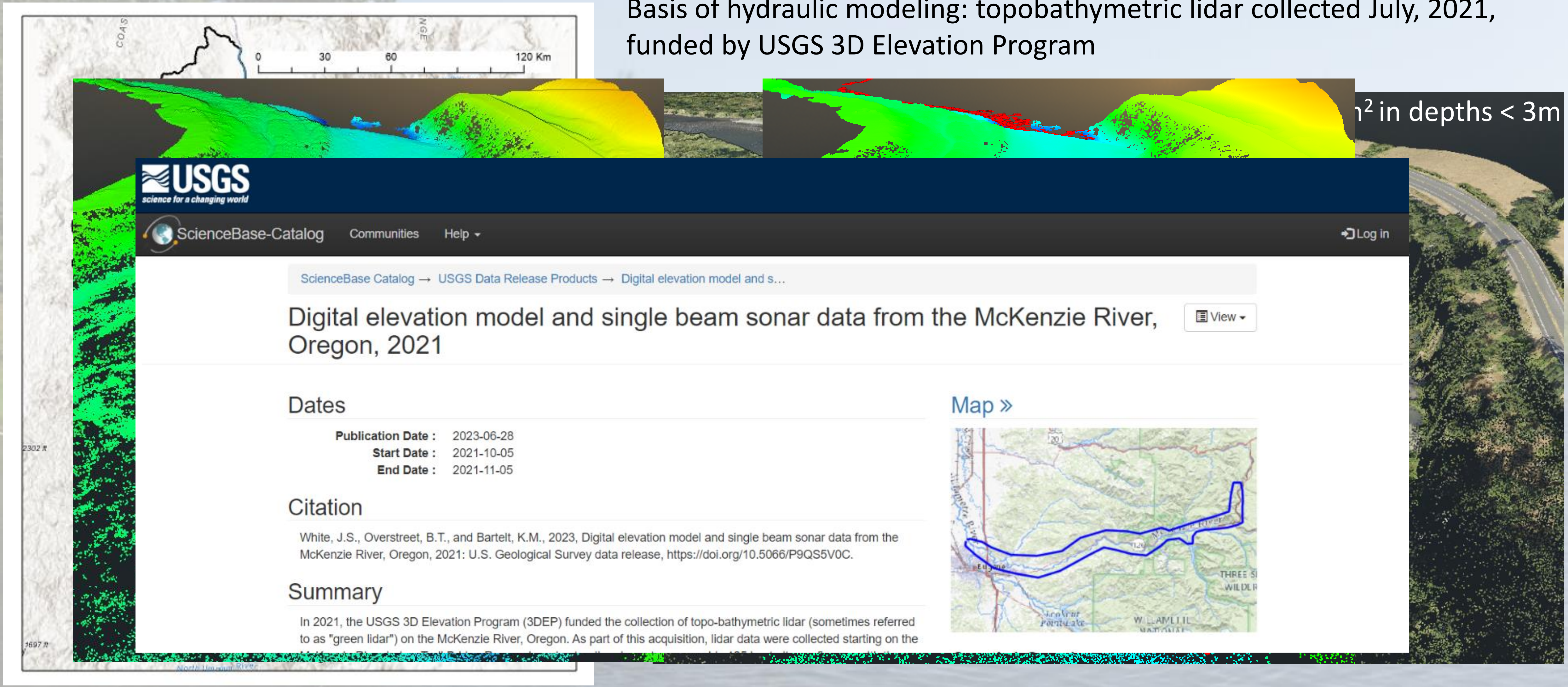



Explanation
USACE Dam
City
PORTLAND
OREGON CITY
NEWBERG
SALEM
ALBANY
CORVALLIS
PEORIA
HARRISBURG
EUGENE
0 20 40 80 Km
N
460000 490000 520000 550000 580000 610000 640000
5080000 5050000 5020000 4990000 4960000 4930000 4900000 4870000 4840000 4810000

USGS

Hydraulic Modeling

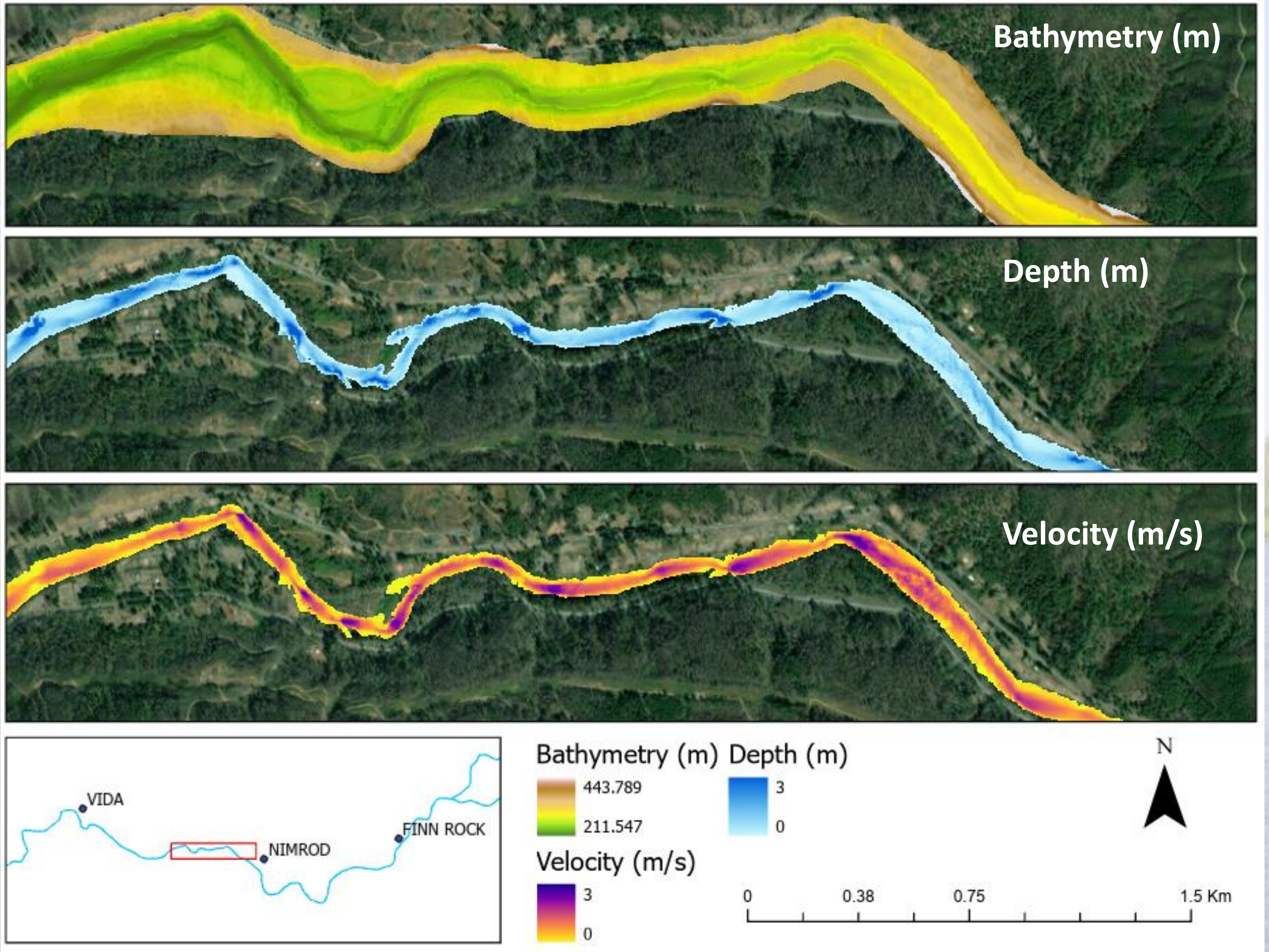
Basis of hydraulic modeling: topobathymetric lidar collected July, 2021, funded by USGS 3D Elevation Program



White et al., 2023

Juvenile Habitat Modeling

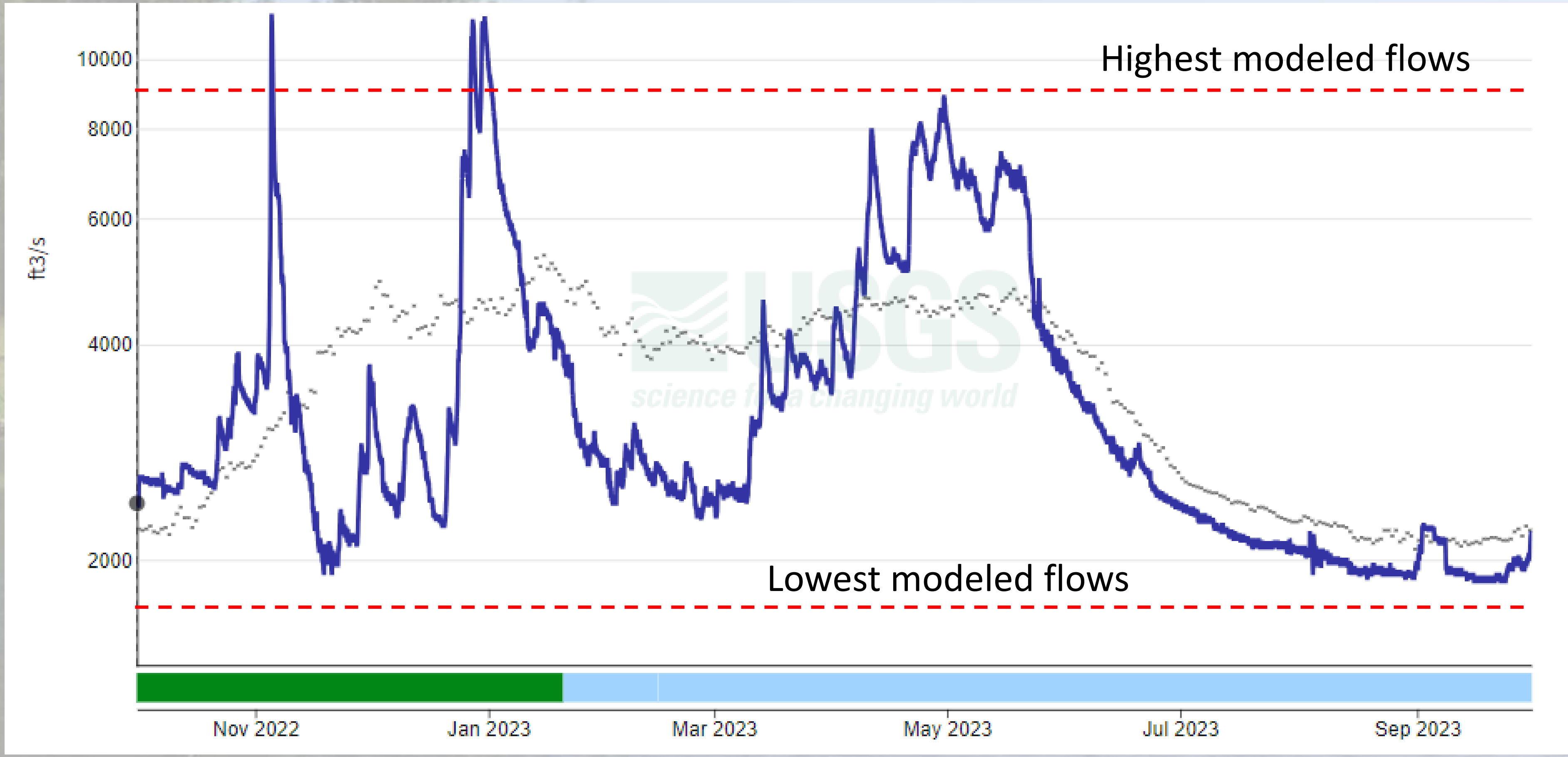
Hydraulic modeling results at low flow (1600 $ft^3/2$)



Preliminary data, do not cite

Juvenile Habitat Modeling

Water Year 2023 flows at Vida (14162500)



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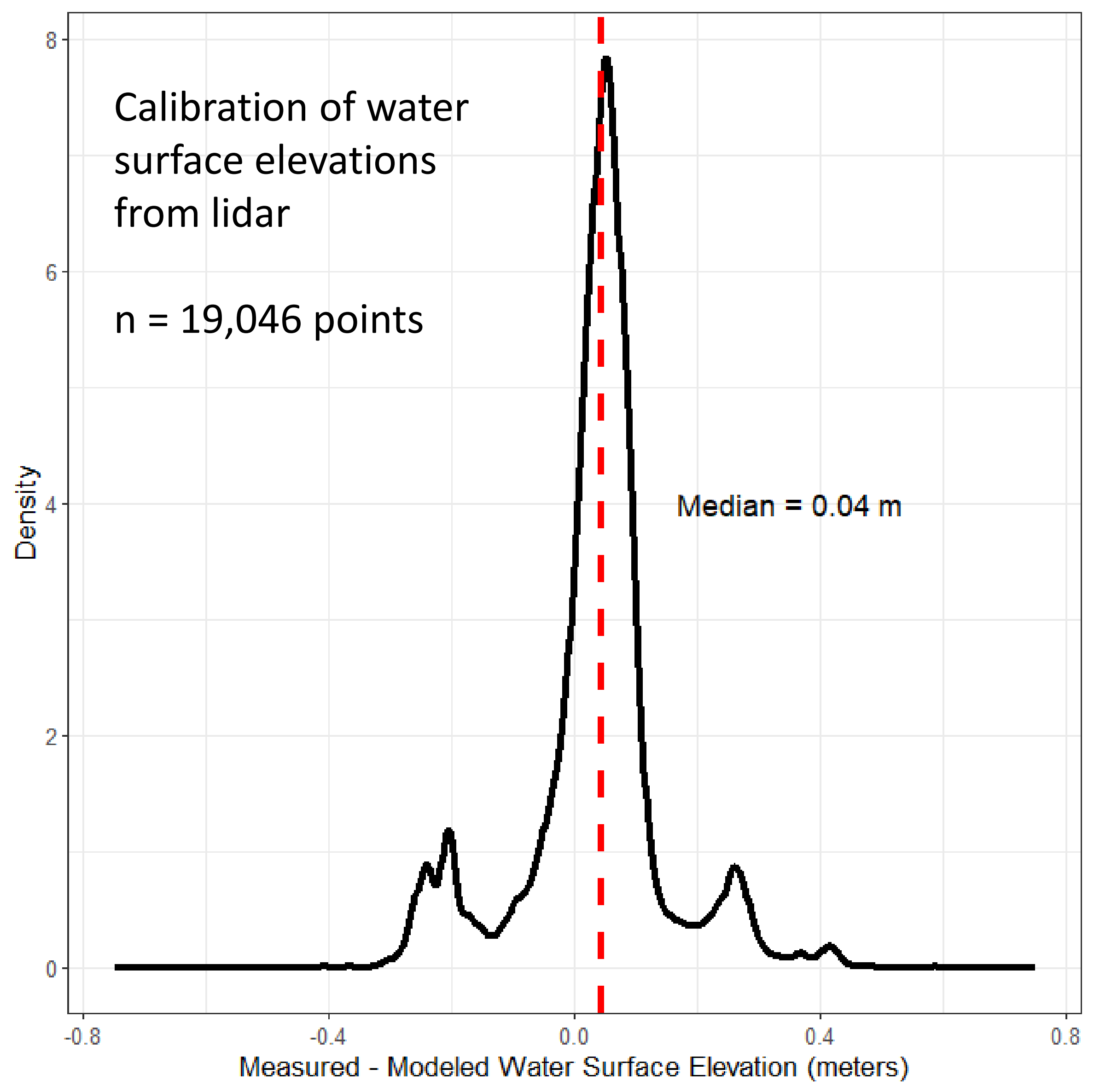

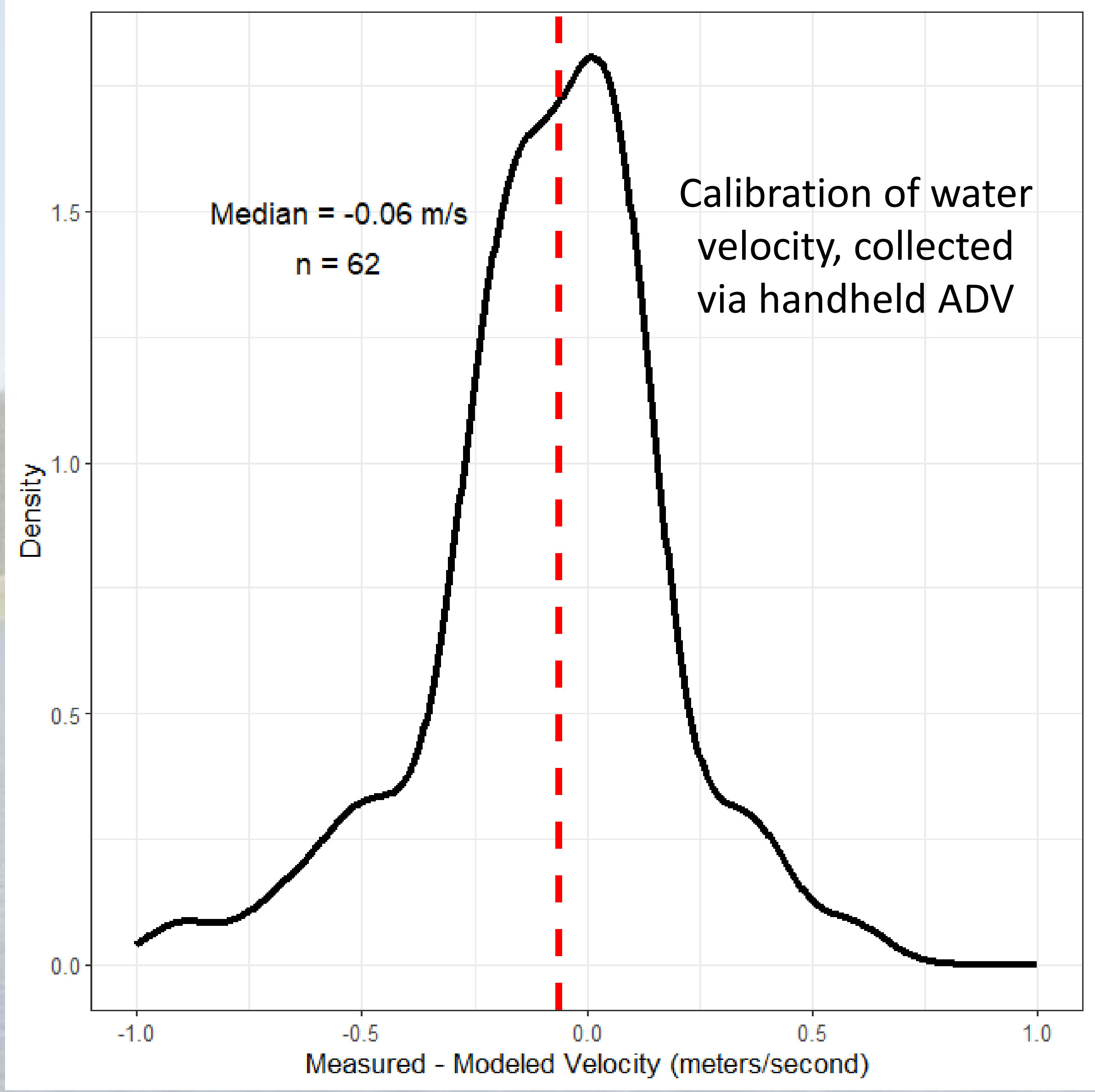

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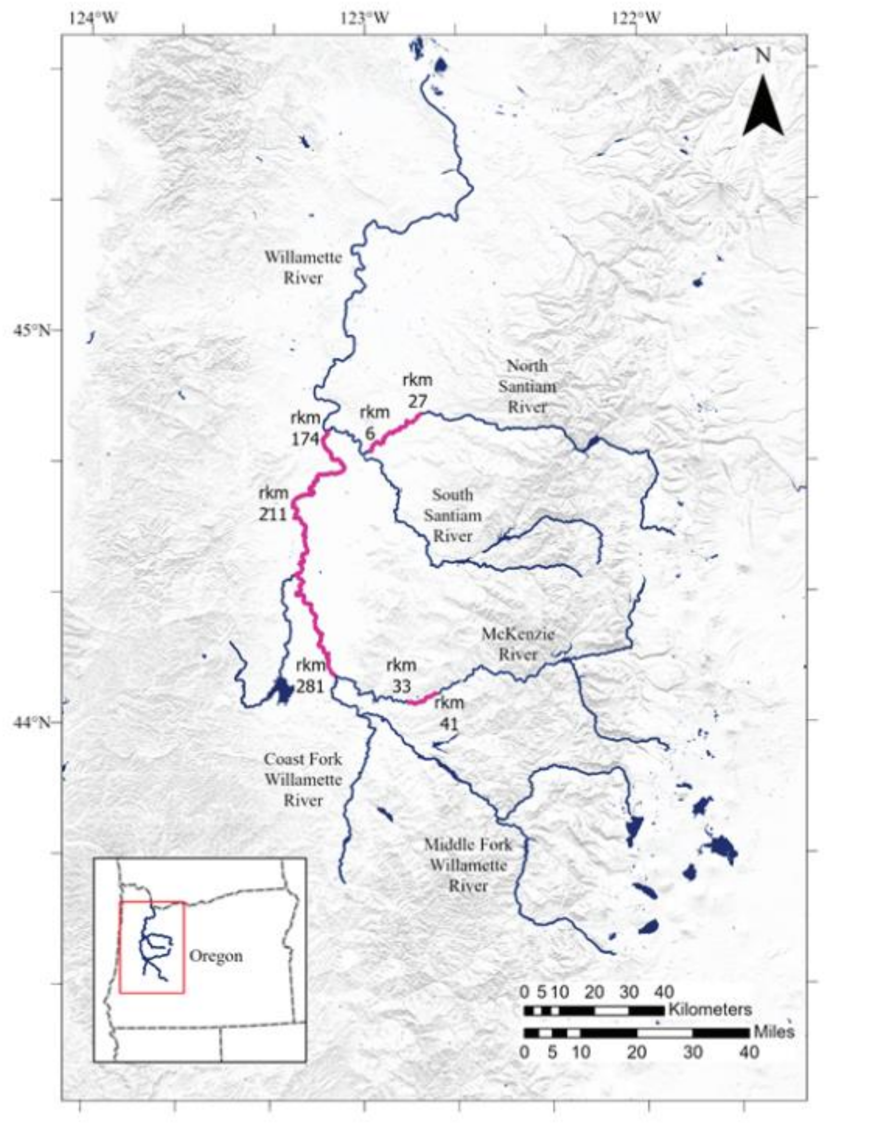
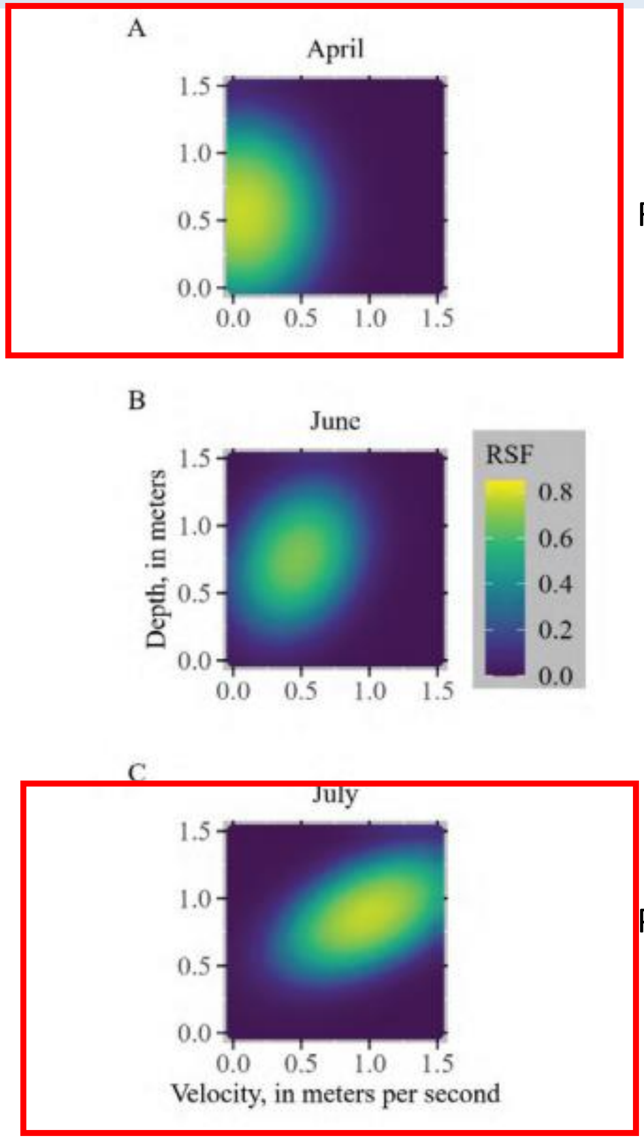


Figure 1. Map showing reaches (pink shading) where habitat sampling occurred during April–July 2020 and 2021 on the mainstem Willamette, Santiam, and McKenzie Rivers.



Fry

Parr

Figure 10. Estimated presence probability from the resource selection function (RSF) for juvenile Chinook (*Oncorhynchus tshawytscha*) salmon based on water velocity and water depth.

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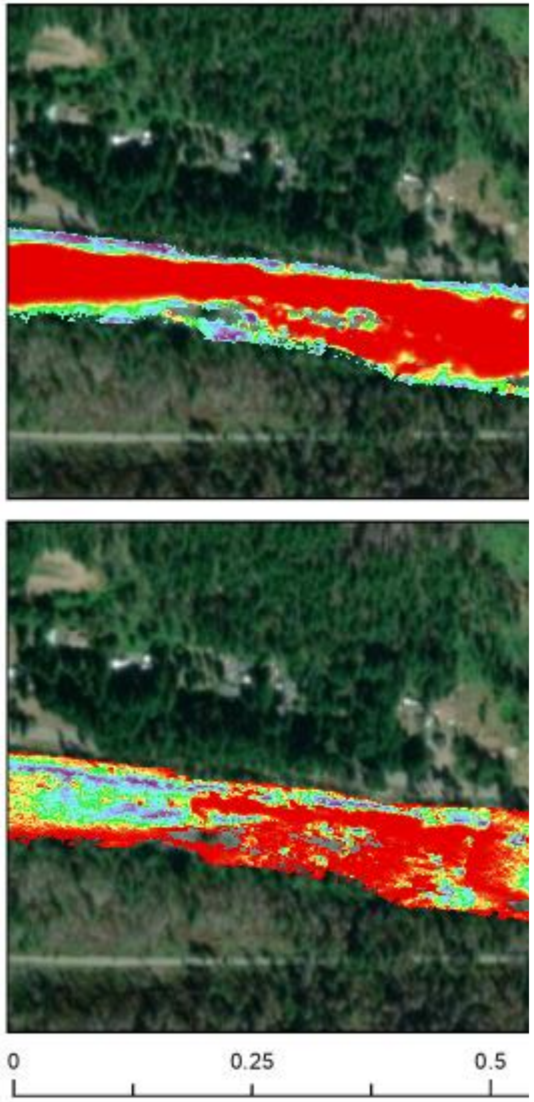
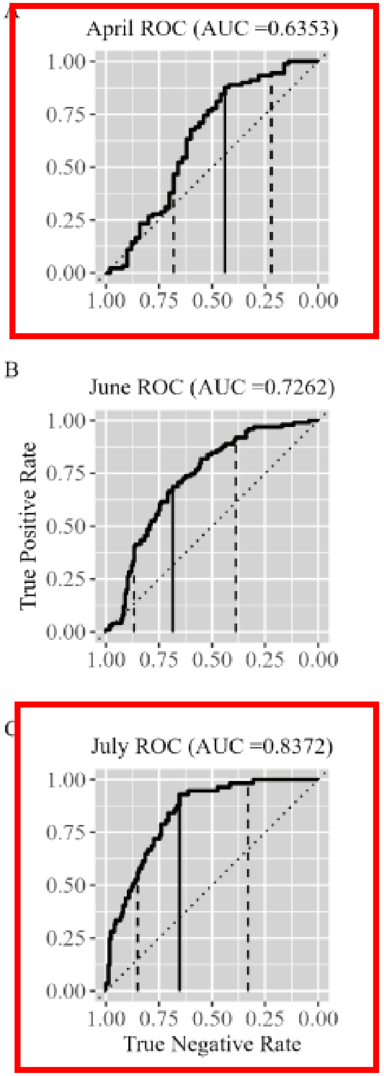
Figures from Hansen and others, 2023

Juvenile Habitat Modeling

Chinook Fry

Chinook Parr





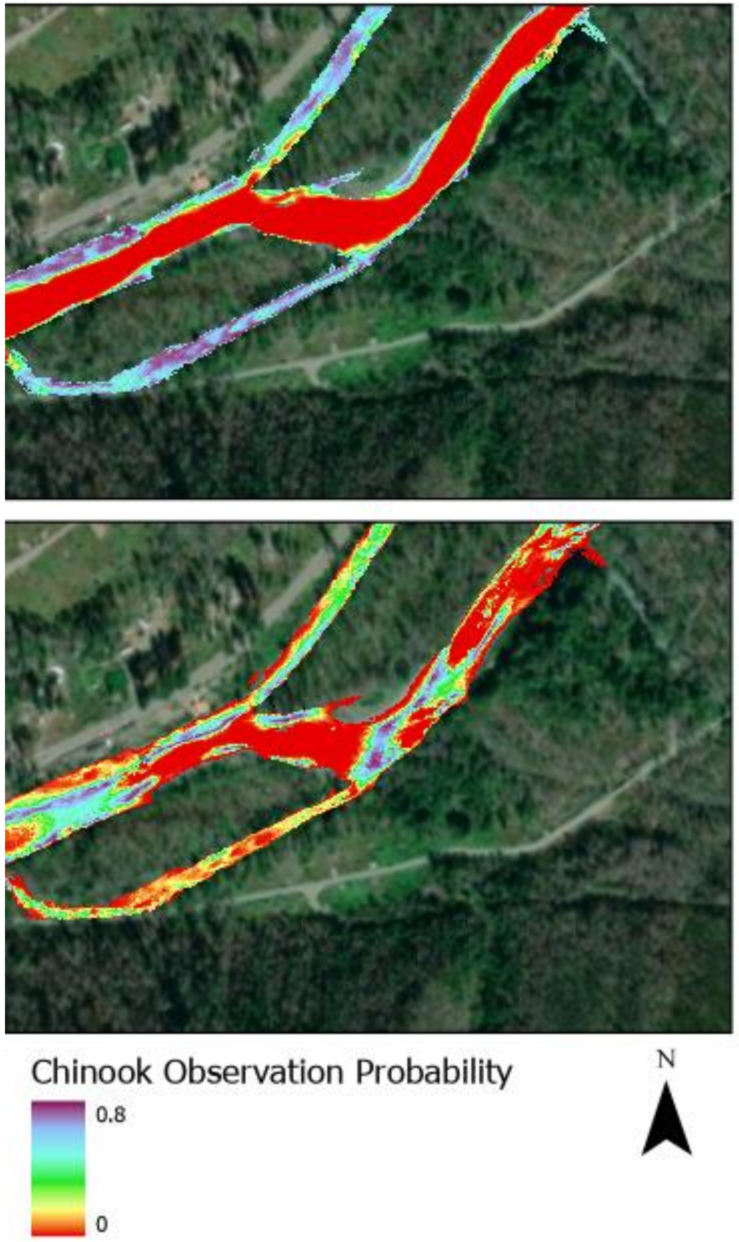


Figure 11. Receiver operating characteristic (ROC) curve (bold solid line) with Narrow (left vertical dashed line), Median (vertical solid line), and Broad (right vertical dashed line) category thresholds for selected models. Area under the curve (AUC) is an indication of model performance. For comparison perfect chance (the flip of a coin has an

Hansen et al., 2023

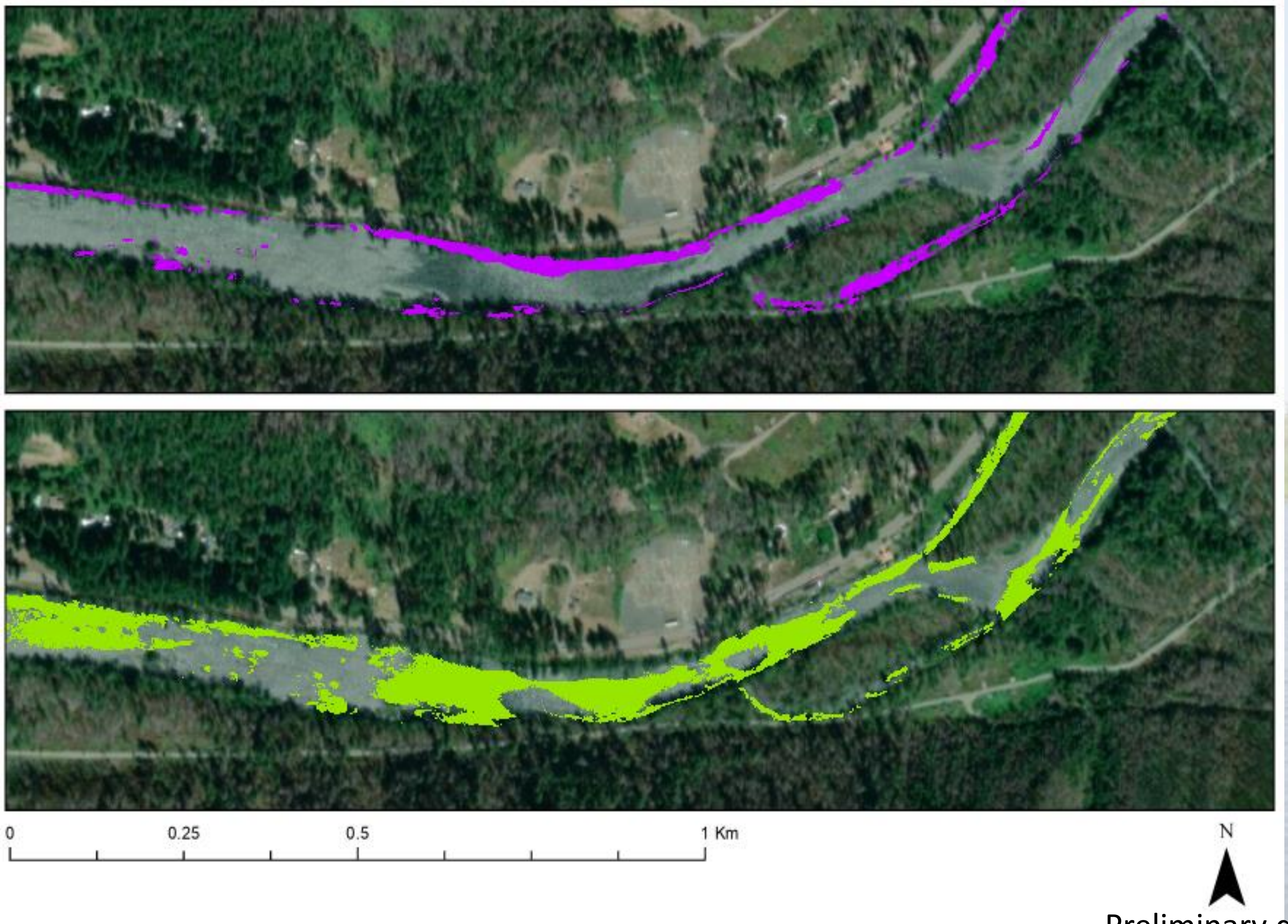
USGS

Preliminary data, do not cite

Juvenile Habitat Modeling

Chinook Fry
“median”
threshold

Chinook Parr
“median”
threshold



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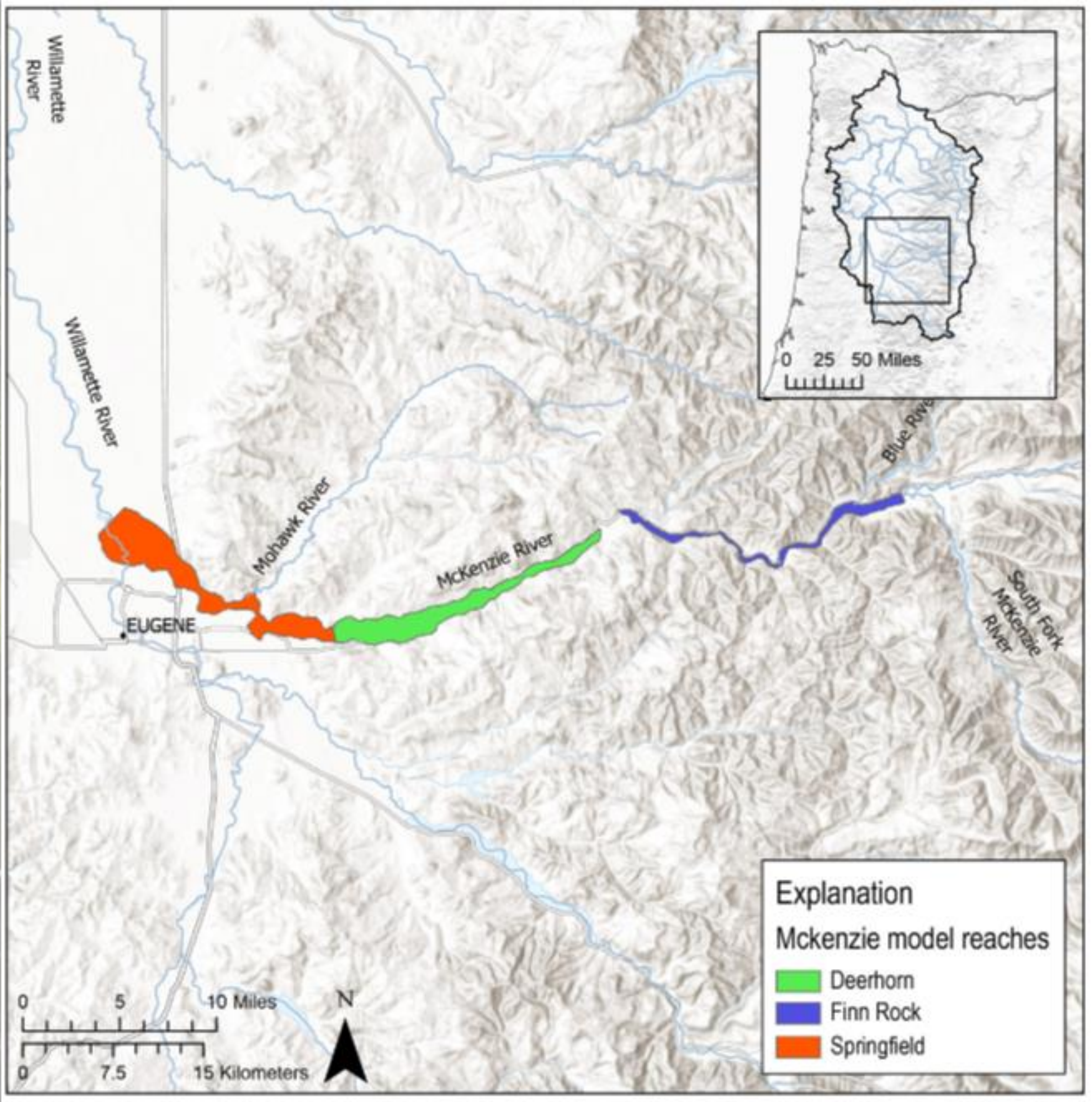

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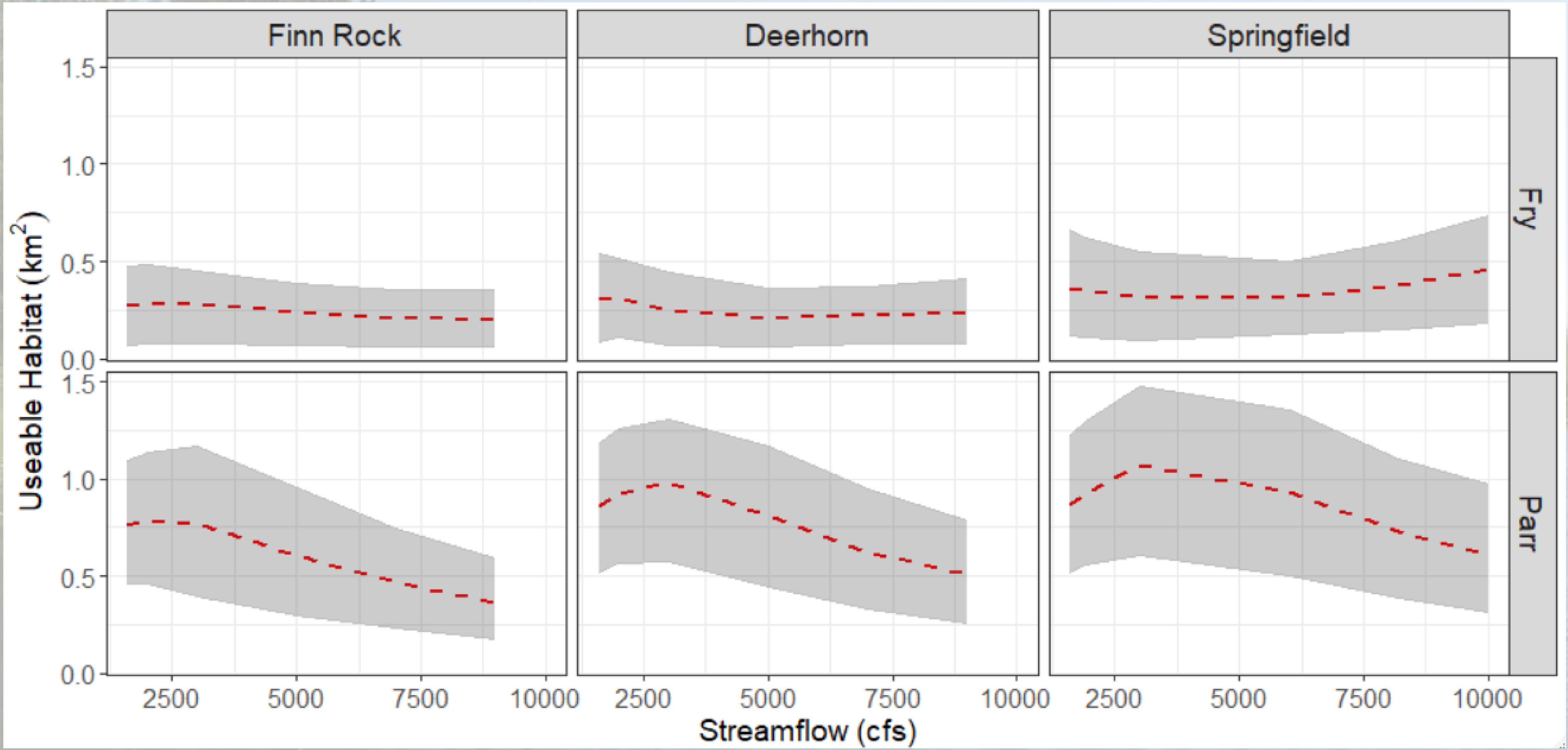

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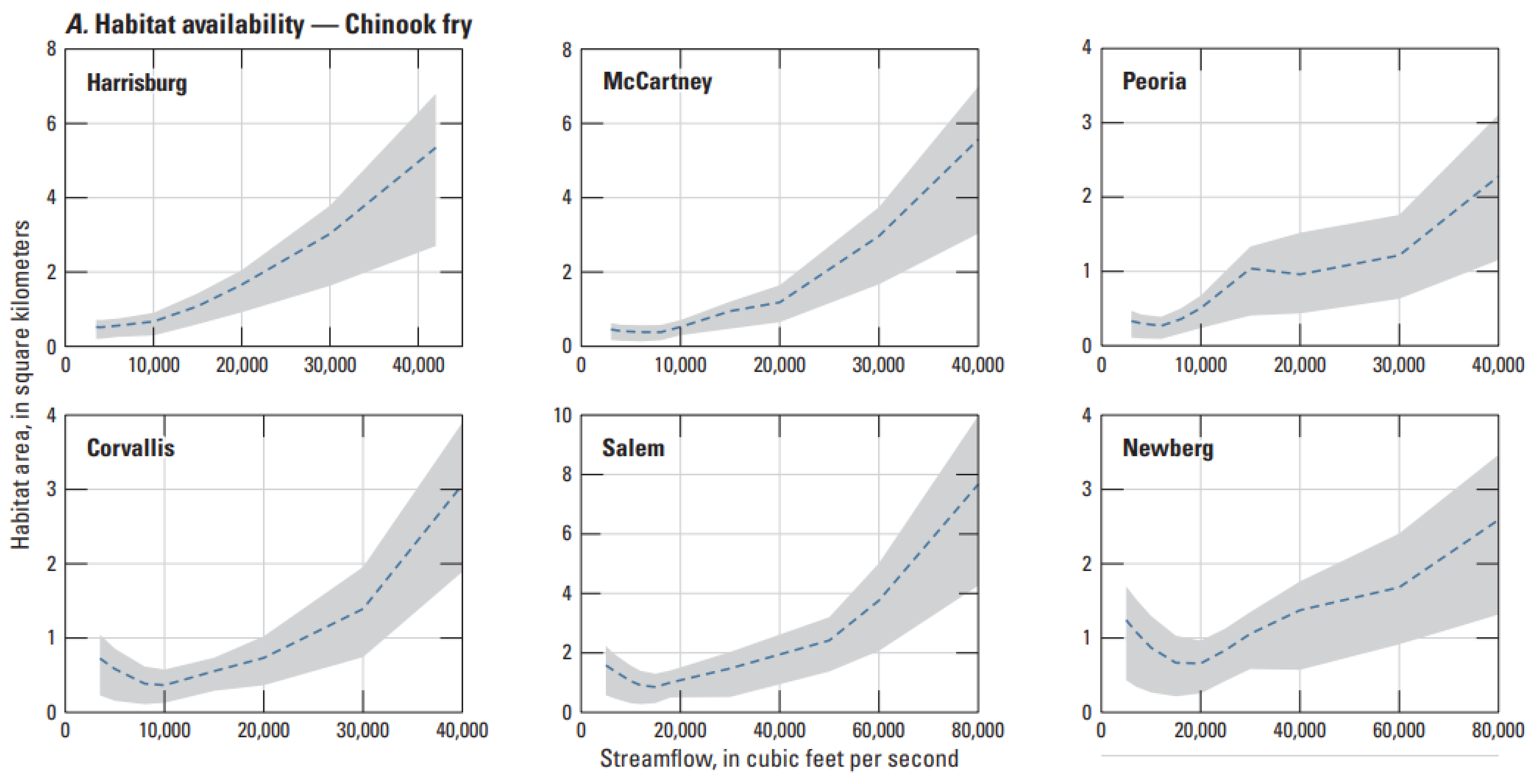

Figure from White and others, 2022

Spawning Habitat Modeling

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6	Isaak et al 2007	Salmon River basin	Middle Fork Salmor	Spring Chinook	m	0.289	0.2139	0.3641	0.166	0.493							cm	3.7	2.701	4.699	1.76	6.4	Ranges are SD. Metrics based on 'habitat patches' identified by locations of redds from 1994-2005. Substrate measur
7	McHugh and Budy 2004	Salmon River basin	Elk Creek	Spring Chinook	m	0.17	0.14	0.19	0.12	0.21	m/s	0.42	0.3	0.48	0.19	0.71	cm	4.9	4.6	5.8	3	7.7	Ranges are upper and lower quartiles from box plot. Substrate measurement is D84.
8	McHugh and Budy 2004	Salmon River basin	Sulphur Creek	Spring Chinook	m	0.29	0.24	0.32	0.13	0.33	m/s	0.33	0.32	0.38	0.27	0.54	cm	6.3	4.1	6.8	3.8	8	Ranges are upper and lower quartiles from box plot. Substrate measurement is D84.
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10	Burner 1951	Cowlitz River basin,	Ohanapecosh River	Spring Chinook	m	0.2286			0.0762	0.508													Info from table on page 101
11	Burner 1951	Wenatchee River ba	Nason Creek	Spring Chinook	m	0.2159			0.1016	0.3556	m/s	0.6096			0.1524	1.0668							Info from table on page 101. Velocity reported as 'cubic feet a second', possibly intended to by ft/s?
12	Knudsen et al 2004	Yakima River Basin,	Upper Yakima River	Spring Chinook	m	0.5			0.32	0.78	m/s	0.8			0.4	1.35							Values interpreted from Figure 2 for in-river redds.
13	Hughes and Murdoch 201	Chiwawa River, WA	Chiwawa River	Spring Chinook	m		0.28	0.44															Depth range includes highest/lowest upper and lower 95% confidence intervals from Fig. 5 Redd depth. Study took de
14	Cepello et al 2009	Feather River, CA	Feather River	Spring Chinook	m	0.6706	0.4877	0.8534	0.061	1.1887	m/s	0.762	0.381	0.8992	0.061	1.524							Based on habitat suitablity index developed by this study. High and low ranges determined by 'preferred range' in st
15	Moir and Pasternack 200	Lower Yuba River, C	Lower Yuba River	Spring Chinook	m		0.39	0.79			m/s		0.45	1.32			cm				3.22	7.4	Depth and velocity ranges include lowest and highest mean depth for habitat sections that contained redds from Ta
16	Dudley et al 2022	Unspecified		Spring Chinook							m/s	0.5		1.2									Figure 6 and supplemental material S16 have information on Spring Chinook from other studies. This study has Wint
17	Bjorn and Rieser 1991	Unspecified		Spring Chinook	m				0.24		m/s				0.3	0.91	cm				1.3	10.2	Both Reiser and Bjornn publications have same data sources and values. Substrate measurement is general range s
18	Reiser and Bjornn 1979	Unspecified		Spring Chinook	m				0.24		m/s				0.3	0.91	cm				1.3	10.2	Both Reiser and Bjornn publications have same data sources and values. Substrate measurement is general range s
19	Hampton 1988	Trinity River basin, CA		Spring and Fall Chir	m	0.4572	0.1524	0.8534	0.0305	1.8288	m/s	0.9144	0.3048	1.7374	0.1524	1.7678							Based on habitat preference criteria developed by this study. Low and high ranges determined by 0.5 or higher prefer
20	Raleigh et al 1986	Unspecified		Chinook unspecifie	m		0.2	7			m/s		0.27	0.9	0.23	1.2	cm	4.2			0.3	15	Velocity ranges are based on Habitat Suitablity index. Depth is implied to be mainly limited by lower end, and are ju
21	Geist and Dauble 1998	Columbia River	Upper	Fall Chinook	m				0.6	4.5													Values from Table 2
22	Geist and Dauble 1998	Columbia River	Near Wells Dam	Fall Chinook	m		5.3	7.2	1.6	9.6	m/s	0.9			0.4	1.2							Values from Table 2
23	Geist and Dauble 1998	Columbia River	Hanford Reach	Fall Chinook	m	1.4			1.2	2.6	m/s				0.4	2							Values from Table 2
24	Geist and Dauble 1998	Columbia River	Hanford Reach	Fall Chinook	m		1.8	7.6	0.3	9							cm		10	20	5	30	Values from Table 2
25	Geist and Dauble 1998	Columbia River	Not specified	Fall Chinook	m				0.2	2	m/s				0.8	1.1	cm				2.5	15	Values from Table 2
26	Geist and Dauble 1998	Columbia River trib	Snake River	Fall Chinook	m				1	2	m/s				0.5	1.2	cm				2.5	15	Values from Table 2
27	Geist and Dauble 1998	Columbia River trib	Snake River	Fall Chinook	m	2.8			0.2	6.5	m/s	1.1			0.4	2.1							Values from Table 2
28	Geist and Dauble 1998	Columbia River trib	Snake River	Fall Chinook	m				4.6	7.9	m/s				0.3	0.4							Values from Table 2
29	Geist and Dauble 1998	Columbia River trib	Kalama River	Fall Chinook	m	0.4					m/s	0.6											Values from Table 2
30	Geist and Dauble 1998	Columbia River trib	Toutle River	Fall Chinook	m	0.3					m/s	0.4											Values from Table 2
31	Geist and Dauble 1998	Other river systems	Campbell River, BC	Fall Chinook	m	0.6			0.3	0.8	m/s	0.6			0.4	0.8							Values from Table 2
32	Geist and Dauble 1998	Other river systems	Nechako River, BC	Fall Chinook							m/s				0.15	1							Values from Table 2
33	Geist and Dauble 1998	Other river systems	Oregon streams	Fall Chinook	m	0.4					m/s	0.5											Values from Table 2
34	Geist and Dauble 1998	Other river systems	Unspecified	Fall Chinook													cm				1.3	10.2	Values from Table 2
35	Groves and Chandler 199	Snake River, ID	Snake River	Fall Chinook	m	2	1	4.5	0.5	6.5	m/s	1.25	1	1.5	0.5	2.25	cm		2.6	7.5	0.6	15	Values interpreted from Figures 4, 5, and 7
36	Riebe et al 2014	Shasta River, CA	Shasta River	Fall Chinook													cm	7	4.5	10			D50 for Chinook interpreted from Figure 5
37																							

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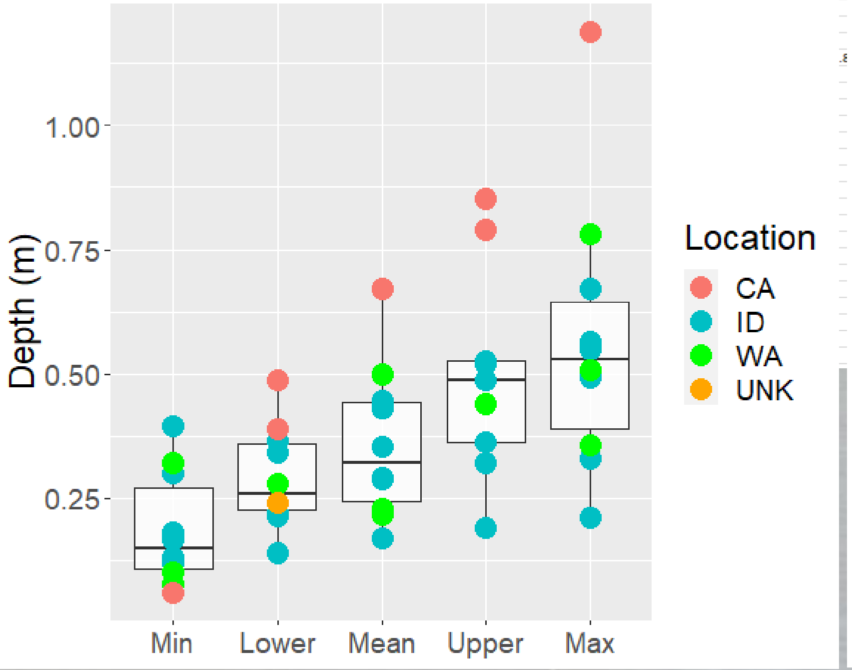

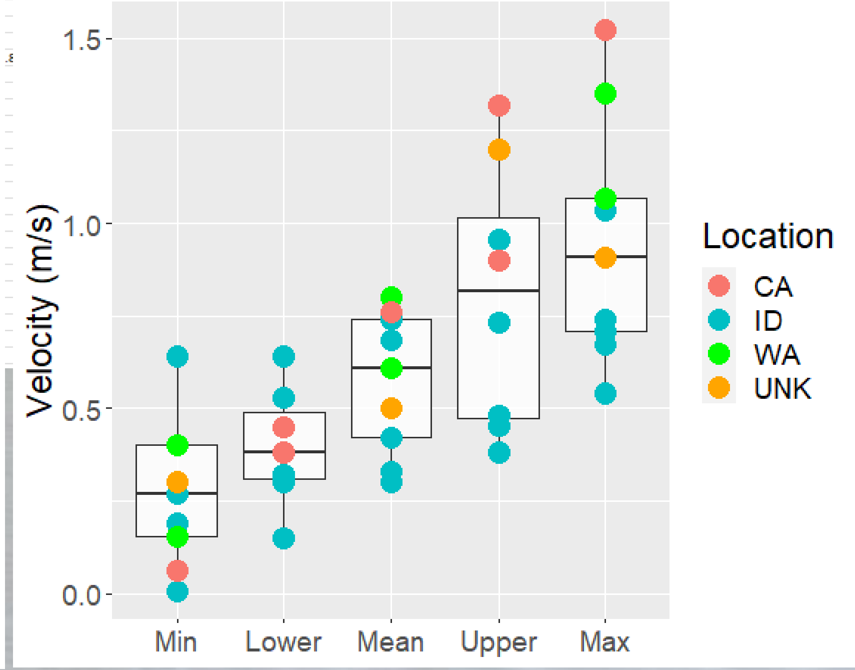

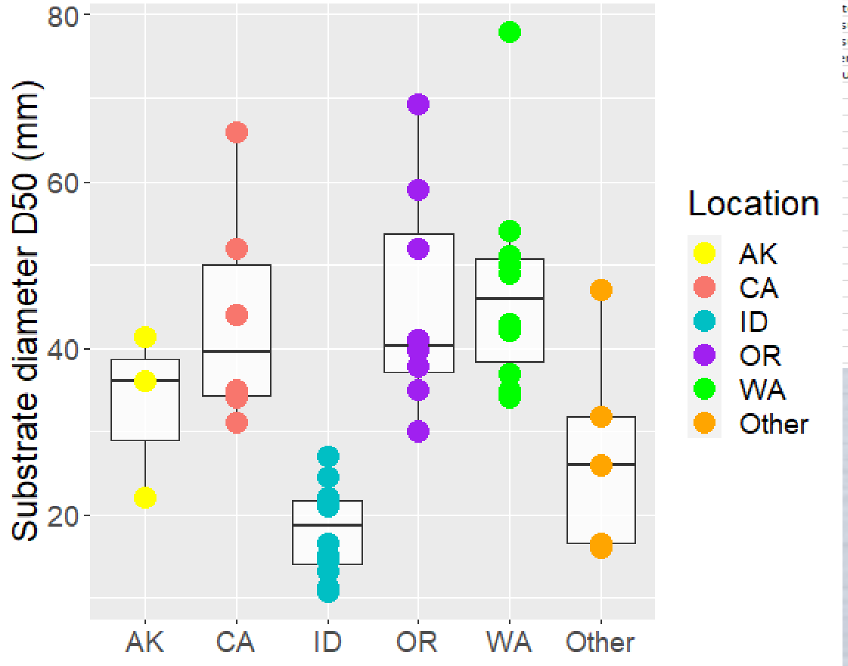

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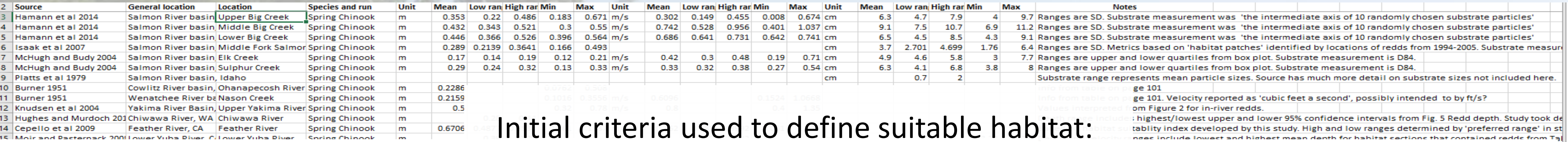

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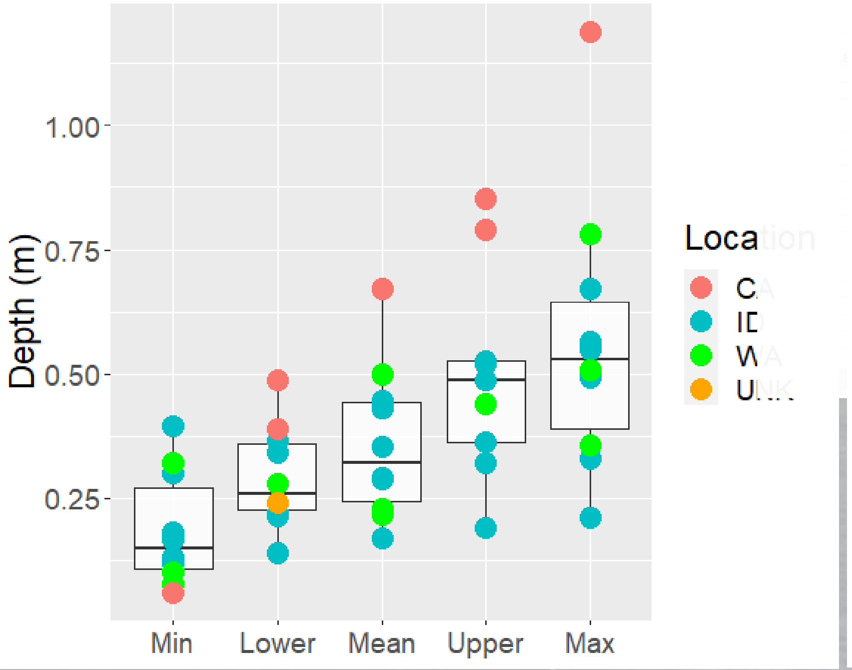
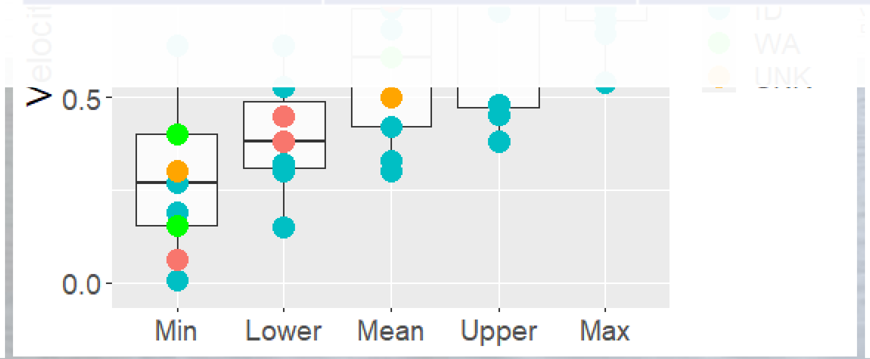
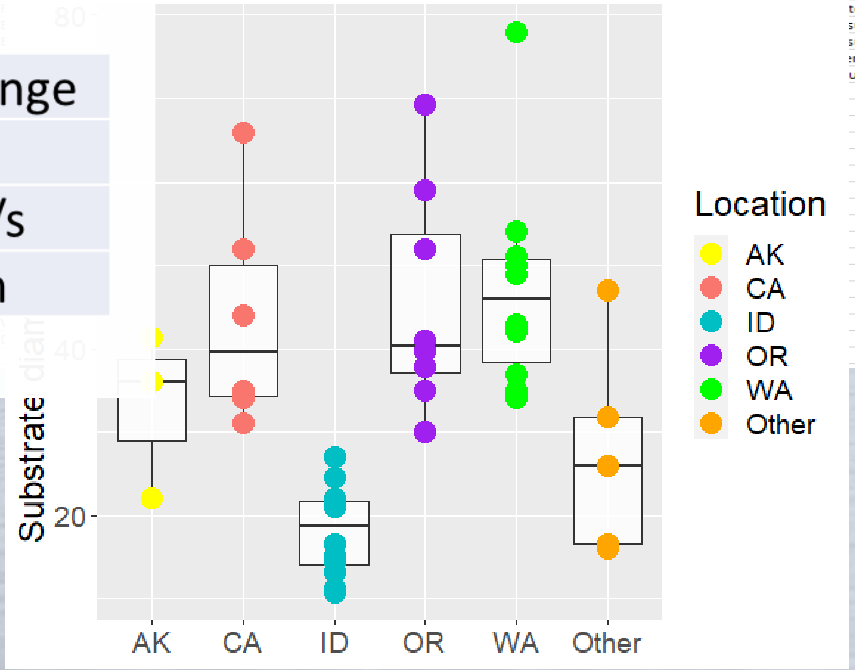
Initial criteria used to define suitable habitat:

Metric	Wide range	Narrow range
Depth	0.1-Inf m	0.2-0.8 m
Velocity	0.05-1.8 m/s	0.3-1.3 m/s
Substrate	1.3-11.2 cm	1.7-5.9 cm

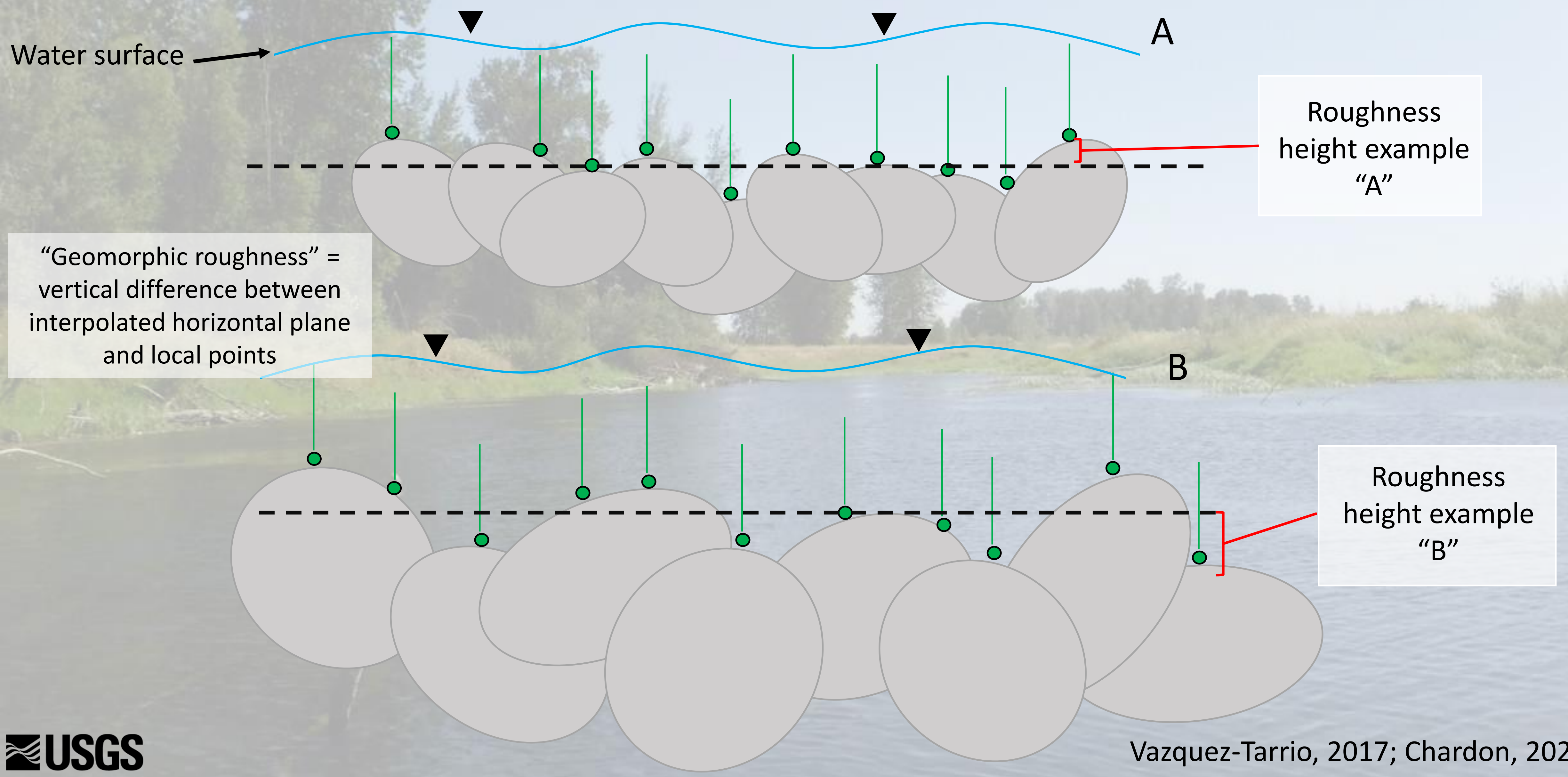






Preliminary data, do not cite

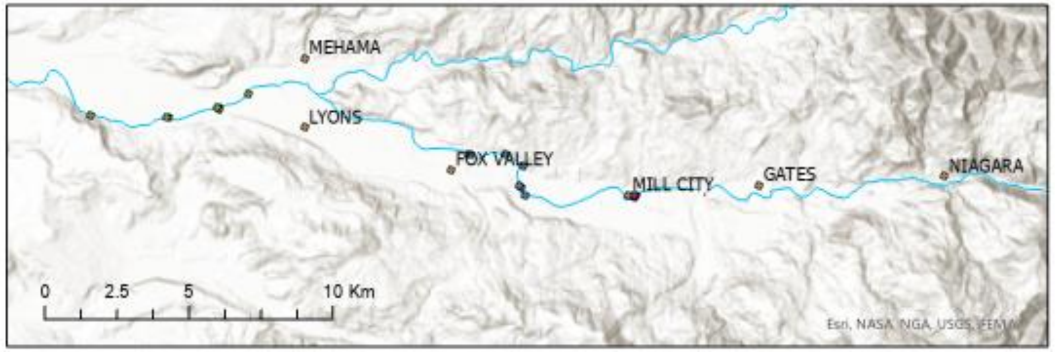
Developing grain-size datasets



USGS

Vazquez-Tarrio, 2017; Chardon, 2020

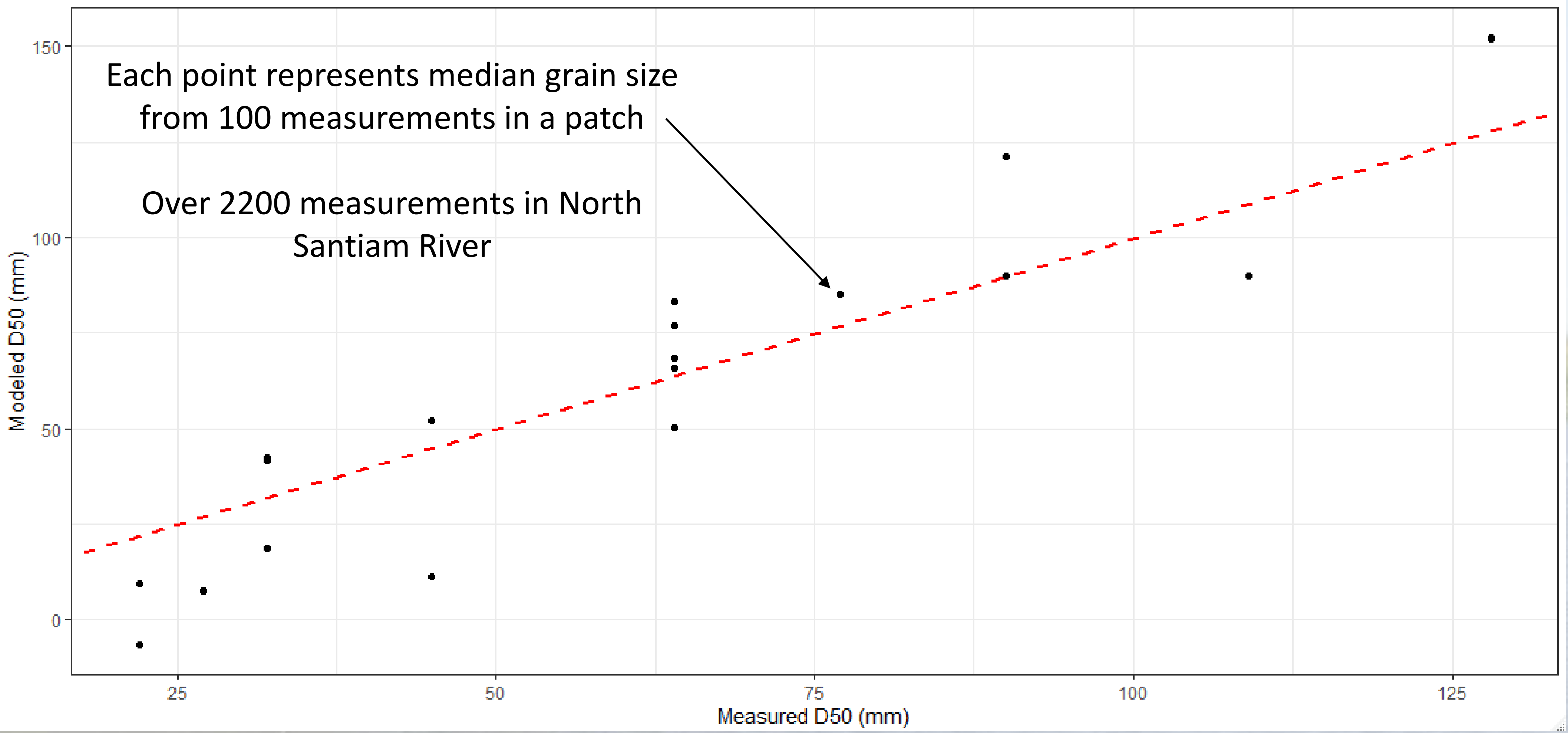
Linking grainsize to roughness



Preliminary data, do not cite

Linking grainsize to roughness

North Santiam River



$R^2 = 0.73$

RMSE = 18 mm

PBIAS = 12%

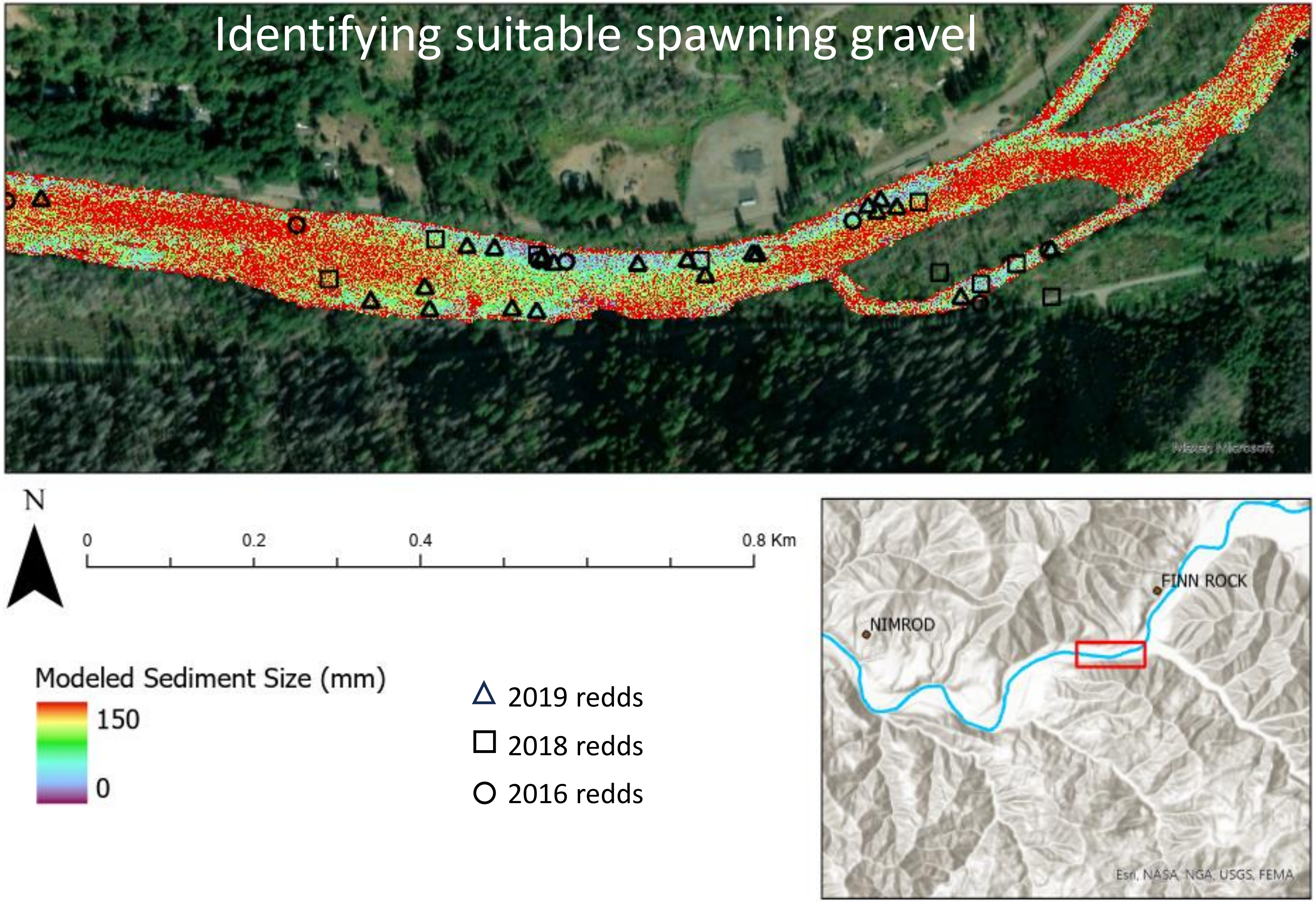
USGS

Preliminary data, do not cite

Identifying suitable spawning gravel

Quick note on spawning data....

- Location of GPS point not always taken directly over redd
- Not using survey-grade GPS
- Potential for geomorphic change between redd survey and lidar/pebble counts



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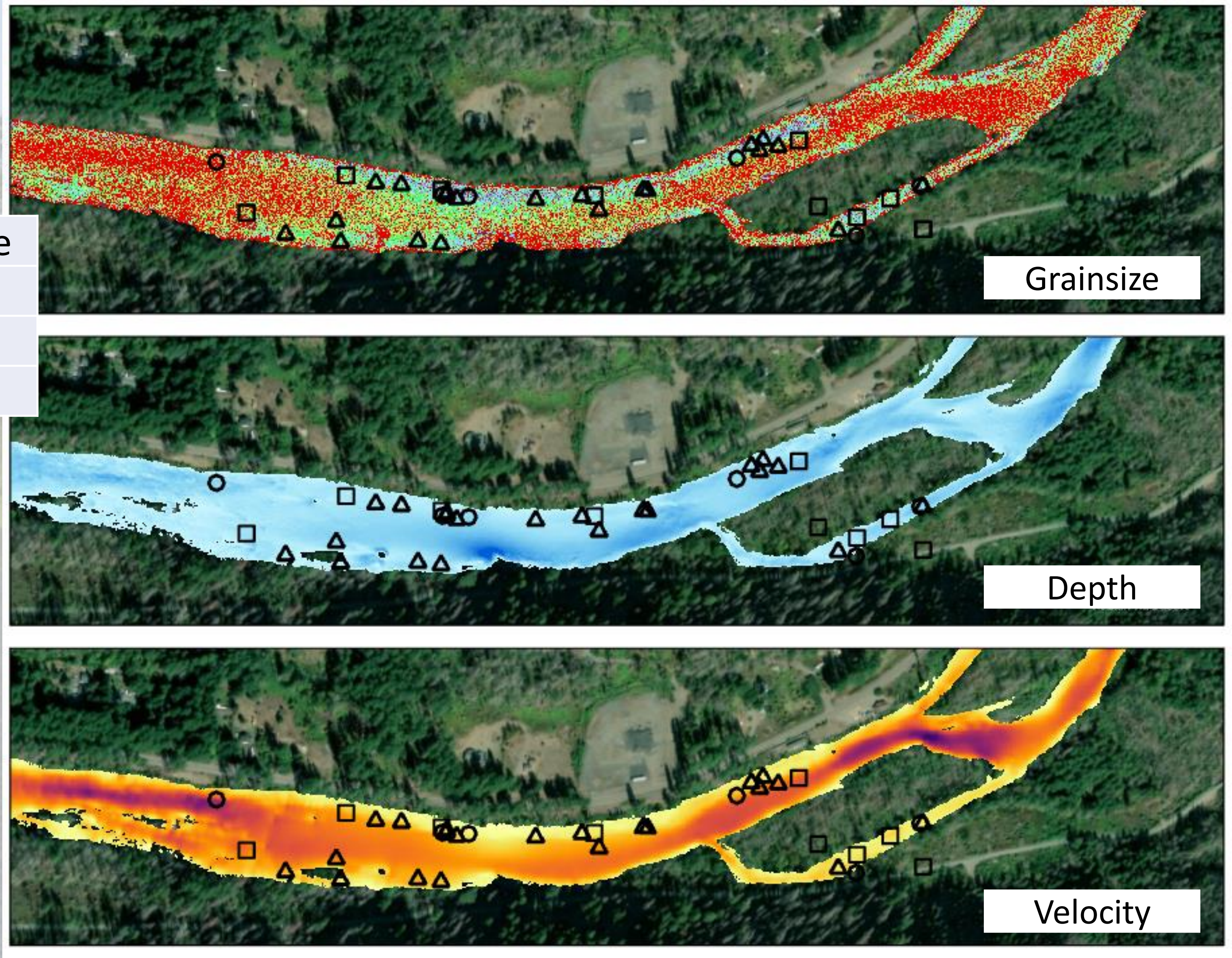
Preliminary data, do not cite

Spawning Habitat Modeling

Metric	Wide range	Narrow range
Depth	0.1-Inf m	0.2-0.8 m
Velocity	0.05-1.8 m/s	0.3-1.3 m/s
Substrate	1.3-11.2 cm	1.7-5.9 cm



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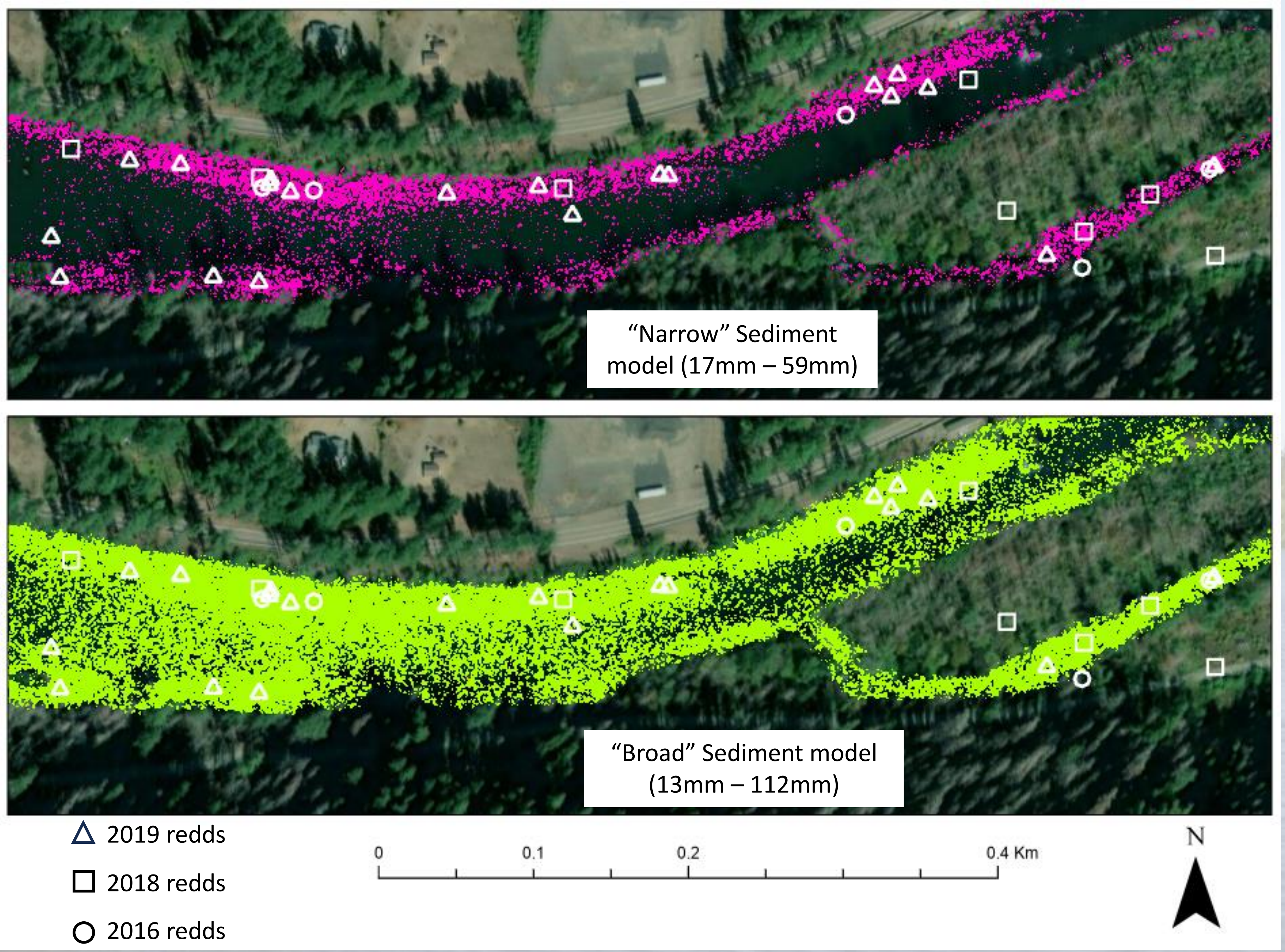
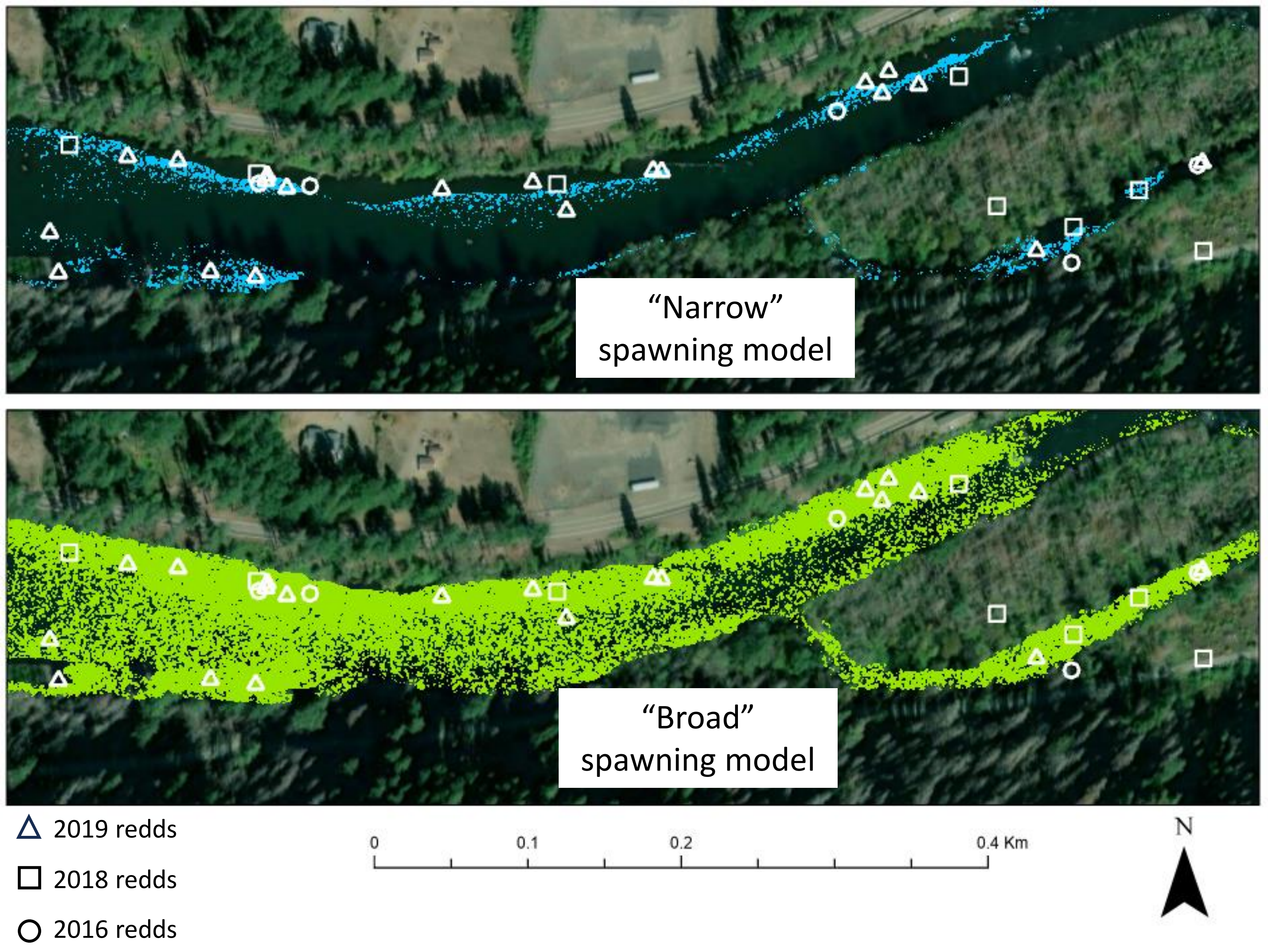
Sediment Suitability Model



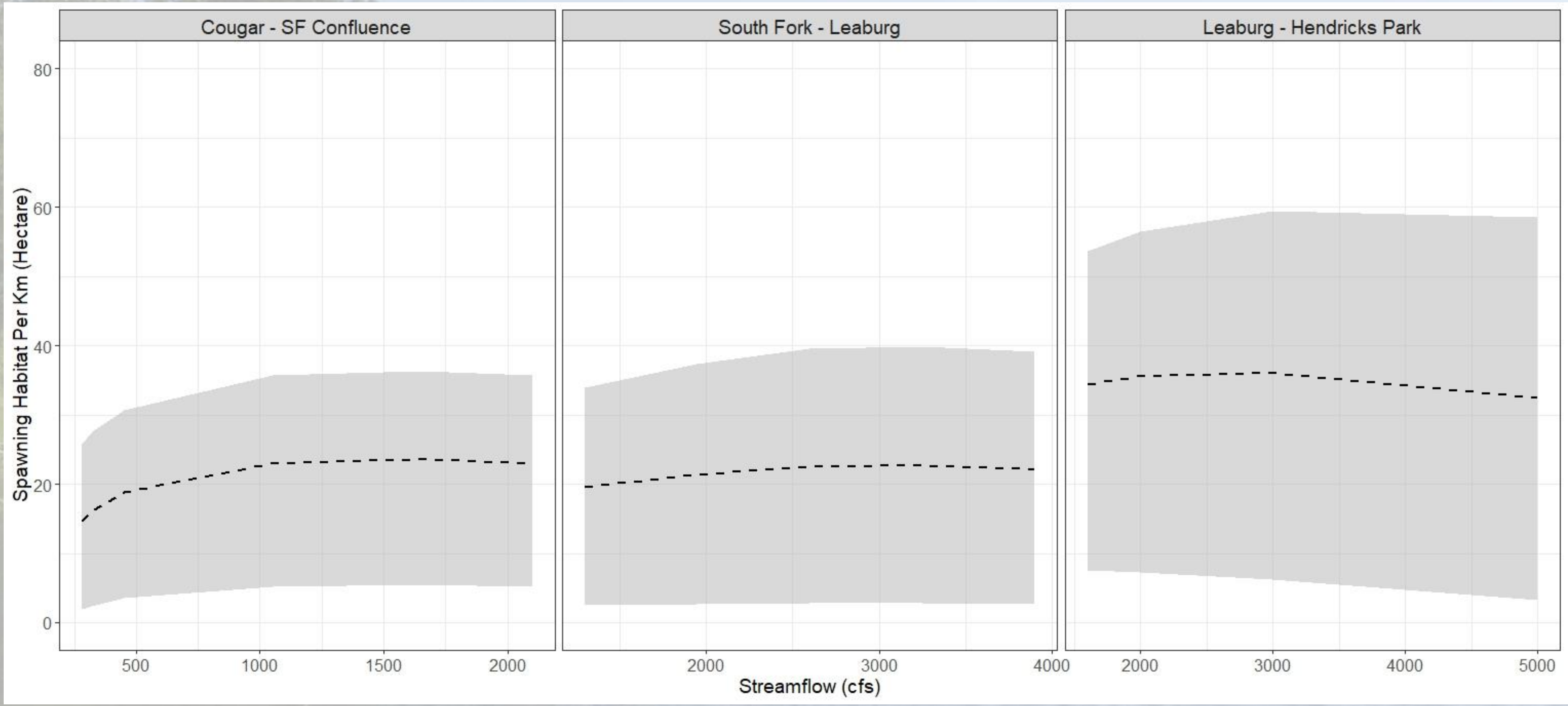
Preliminary data, do not cite

Full Spawning Suitability Model



Preliminary data, do not cite

Spawning habitat availability during typical September flows

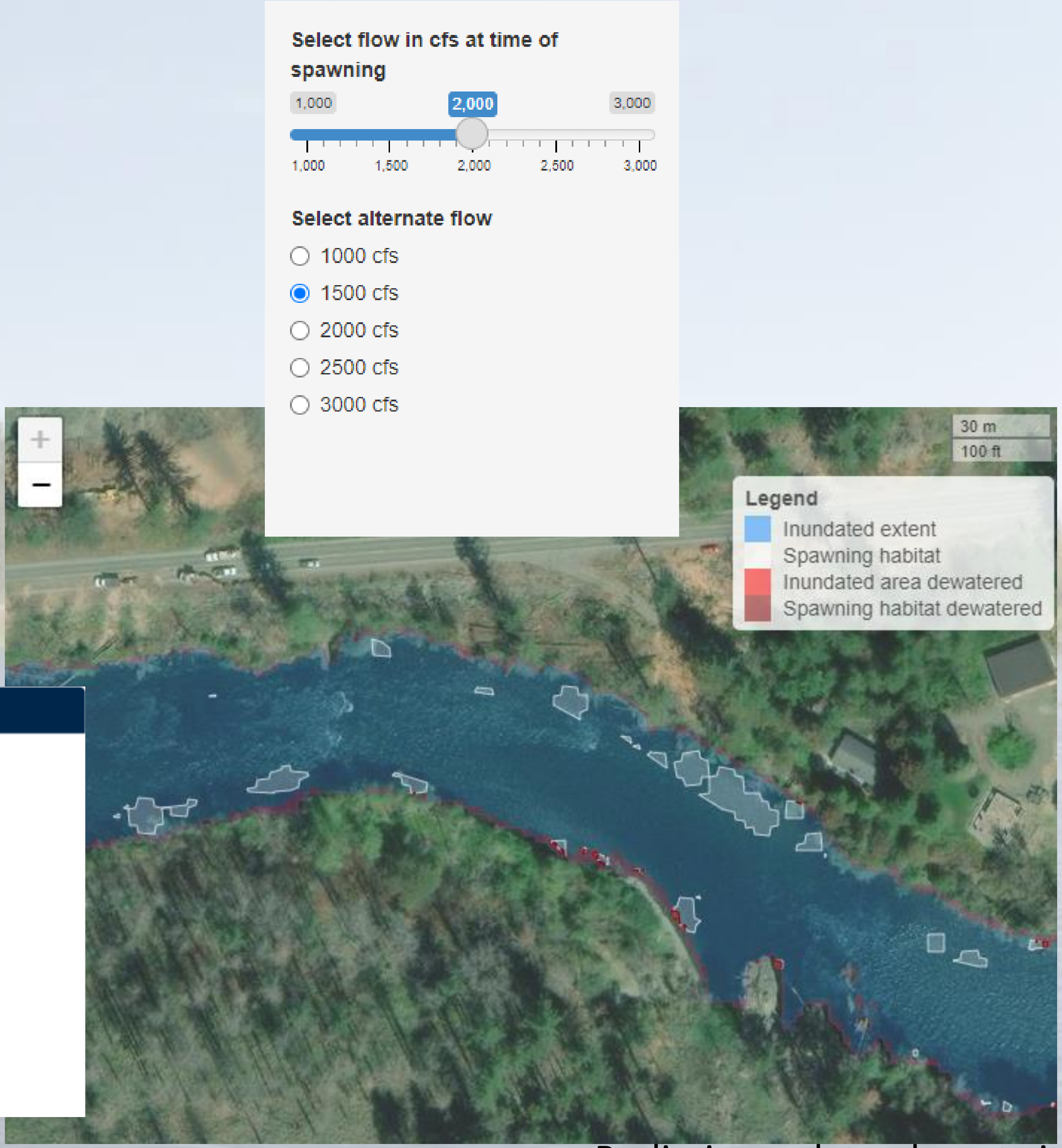


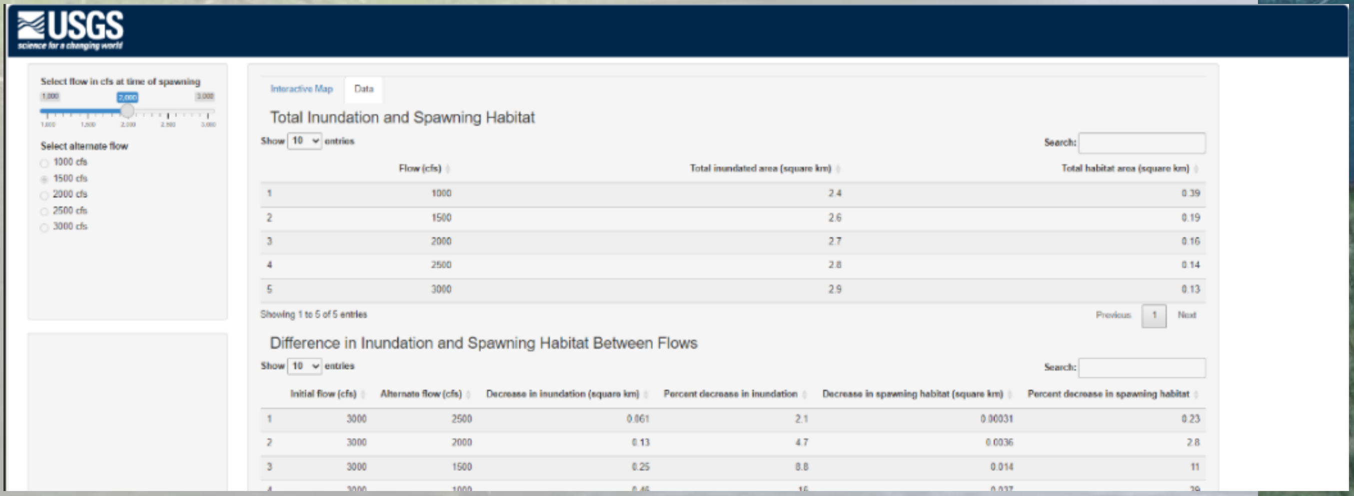
USGS

Preliminary data, do not cite

Dewatering tool

- Preliminary, proof of concept web app
- Shows inundated extent and spawning habitat at a range of typical spawning flows
- User can select two different flows and view the change in wetted area and spawning habitat between flows





Preliminary data, do not cite

Summary

Juvenile habitat

- Fry and parr models show fairly different habitat use between life stages
  - Parr slightly more sensitive to changes in streamflow
- Juvenile habitat in McKenzie and N. Santiam Rivers generally less sensitive to changes in streamflow compared to the mainstem Willamette River

Spawning

- Method to simulate sediment and spawning habitat appears to capture observed conditions reasonably well
- Suitable sediment is most limiting factor to available spawning habitat
- Spawning habitat generally not sensitive to changes in streamflow
  - No “optimal” streamflow, but interannual changes in streamflow likely still important to redd dewatering
  - Tool will provide real time information for flow managers

Questions

McKenzie bathymetry :
White, J.S., Overstreet, B.T., and Bartelt, K.M., 2023, Digital elevation model and single beam sonar data from the McKenzie River, Oregon, 2021: U.S. Geological Survey data release, https://doi.org/10.5066/P9QS5V0C.

Willamette models/bathymetry:
White, J.S., 2022, Two-dimensional HEC-RAS models and topo-bathymetric datasets for the Willamette River, Oregon: U.S. Geological Survey data release, https://doi.org/10.5066/P9NB0KUT.

White, J.S., Gordon, G.W., and Overstreet, B.T., 2019, Single-beam Echosounder Bathymetry of the Willamette River, Oregon 2015-2018: U.S. Geological Survey data release, https://doi.org/10.5066/P92TTY4R .

Reports

Habitat Use:
Hansen, G.S., Perry, R.W., Kock, T.J., White, J.S., Haner, P.V., Plumb, J.M., and Wallick, J.R., 2023, Assessment of habitat use by juvenile Chinook salmon (Oncorhynchus tshawytscha) in the Willamette River Basin, 2020–21: U.S. Geological Survey Open-File Report 2023–1001, 20 p., https://doi.org/10.3133/ofr20231001.

Habitat Models:
White, J.S., Peterson, J.T., Stratton Garvin, L.E., Kock, T.J., and Wallick, J.R., 2022, Assessment of habitat availability for juvenile Chinook salmon (Oncorhynchus tshawytscha) and steelhead (O. mykiss) i the Willamette River, Oregon: U.S. Geological Survey Scientific Investigations Report 2022–5034, 44 p., https://doi.org/10.3133/sir20225034.

Hydraulic Models:
White, J.S., and Wallick, J.R., 2022, Development of continuous bathymetry and two-dimensional hydraulic models for the Willamette River, Oregon: U.S. Geological Survey Scientific Investigations Report 2022–5025, 67 p., https://doi.org/10.3133/sir20225025.

Habitat review:
Kock, T.J., Perry, R.W., Hansen, G.S., White, J., Stratton Garvin, L., and Wallick, J.R., 2021, Synthesis of habitat availability and carrying capacity research to support water management decisions and enhance conditions for Pacific salmon in the Willamette River, Oregon: U.S. Geological Survey Open-File Report 2021–1114, 24 p., https://doi.org/10.3133/ofr20211114.

Smallmouth models:
White, J. S., Kock, T. J., Penaluna, B. E., Gregory, S., Williams, J., & Wildman, R. (2023). Expansion of smallmouth bass distribution and habitat overlap with juvenile Chinook salmon in the Willamette River, Oregon. *River Research and Applications*, 1–13. https://doi.org/10.1002/rra.4228

Growth, Movement, Survival Models:
Peterson, J. T., Pease, J. E., Whitman, L., White, J., Stratton-Garvin, L.,Rounds, S., & Wallick, R. (2022). Integrated tools for identifying optimal flow regimes and evaluating alternative minimum flows for recovering at-risk salmonids in a highly managed system. River Research andApplications,38(2), 293–308. https://doi.org/10.1002/rra.3903

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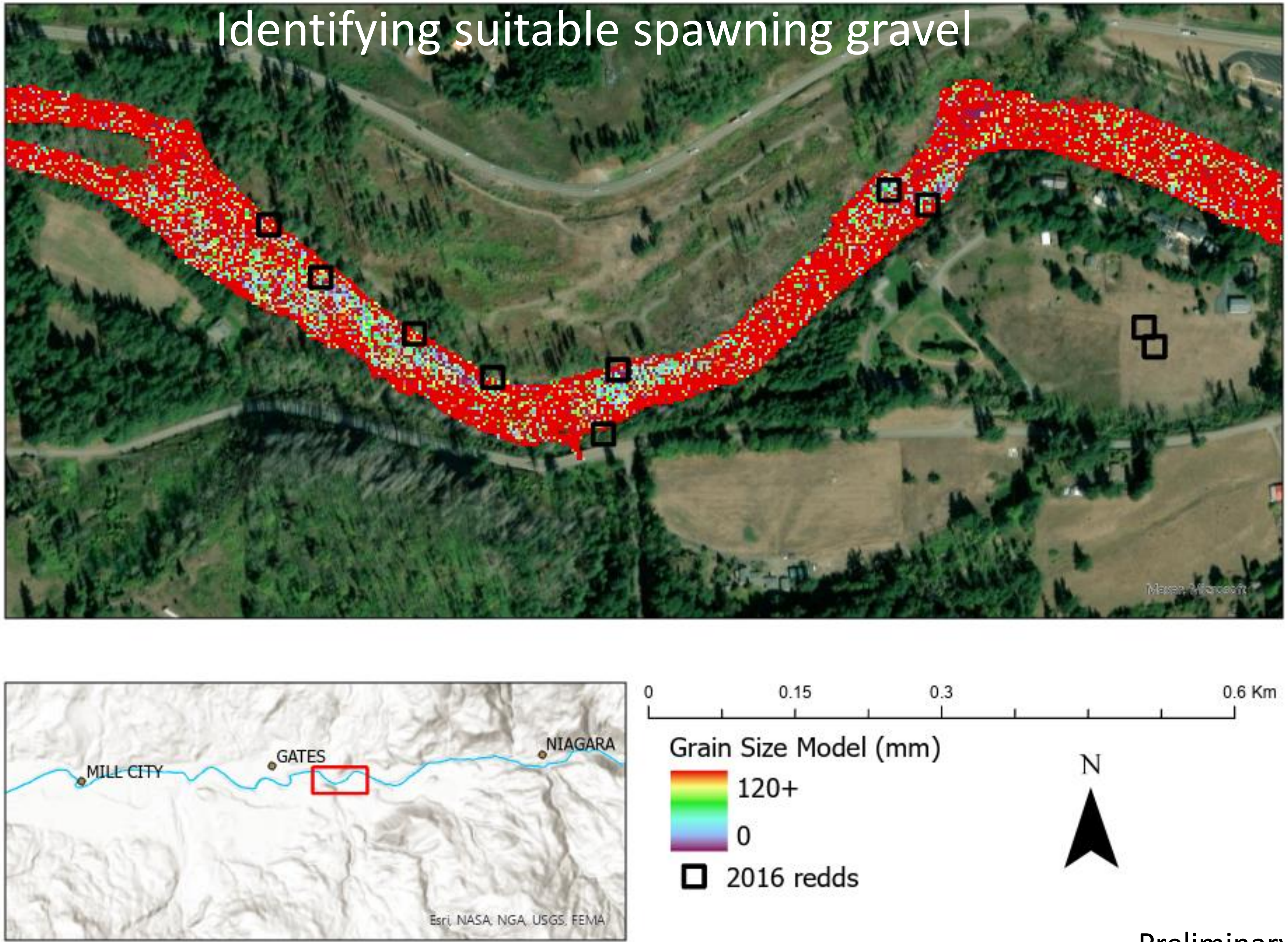
Identifying suitable spawning gravel



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