Water Quality and Ecosystem Processing in the Middle Rio Grande: Integrating New Data from the Southern Reach for a Comprehensive Perspective

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Department of Biology, University of New Mexico, Albuquerque, New Mexico, USA

Talk Outline

1) WQ data in the MRG and RGSM conservation

2) Introduction to the MRG water quality network

3) Compare and contrast: a) the impacts of disturbances, b) stream metabolism, and c) habitat suitability, at northern and southern sites in the MRG

The Importance of Water Quality for the MRGESCP

***Middle Rio Grande Endangered Species Collaborative Program Long-Term Plan for Science & Adaptive Management*" program objectives:**

Science Objectives, Strategies, and Panel Recommendations

A-2b) Identify factors that influence life history traits (e.g., water availability, food resources, water temperature). Seven life history traits: size at birth; growth pattern; age and size at maturity; number, size and sex ratio of offspring; age- and size-specific reproductive investments; age- and size-specific mortality schedules; length of life.

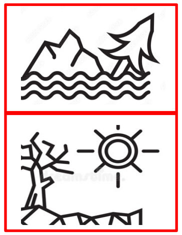
A-3) Determine the relationships between base flow, habitat suitability, and survival and recruitment of RGSM in the MRG.

A-4) Evaluate suitable environmental flow (i.e., timing, duration and magnitude of spring hydrograph), given system constraints and opportunities, needed to cue spawning and recruitment for the RGSM population. Describe management and river conditions by reach.

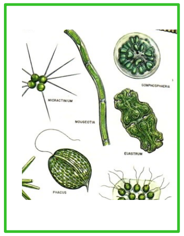
G-1) Support efforts to enhance the operational flexibility of water managers to support species. Provide monitoring data to support the environmental assessment process to establish the conservation storage pool.

The Importance of Water Quality for RGSM Conservation

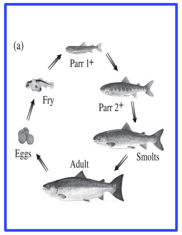
1) Disturbances that impact survival and recruitment



2) Algal resources important for RGSM diet

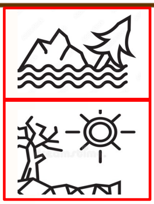


3) Environmental controls on life history traits/habitat suitability



Disturbance Studies:

Disturbances that impact survival and recruitment



Wildfire (continuous sampling)

Ball, G., Regier, P., González-Pinzón, R., Reale, J., & Van Horn, D. J. 2021. Wildfires increasingly impact western US fluvial networks. Nature Communications. 12: 2484.

Dahm, C. N., Candelaria-Ley, R., Reale, C. S., Reale, J. K., and Van Horn, D. J. 2015. Extreme water quality degradation following a catastrophic forest fire. Freshwater Biology. 60: 2584-2599.

Reale, J. K., Van Horn, D. J., Condon, K.E., and Dahm, C. N. 2015. The effects of catastrophic wildfire on water quality along the river continuum. Freshwater Science. 34:1426-1442

Reale, J. K., Archdeacon, T. P., Van Horn, D. J., Gonzales, E. J., Dudley, R. K., Turner, T. F., & Dahm, C. N. 2021. Differential effects of a catastrophic wildfire on downstream fish assemblages in an aridland river. Aquatic Ecology. 55: 483-500.

Stormwater (discrete and continuous sampling)

Regier, P. J., González-Pinzón, R., Van Horn, D. J., Reale, J. K., Nichols, J., & Khandewal, A. 2020. Water quality impacts of urban and non-urban arid-land runoff on the Rio Grande. Science of The Total Environment. 729: 138443.

Wise, J. L., D. J. Van Horn, A. F. Diefendorf, P. J. Regier, T. V. Lowell, and C. N. Dahm. 2019. Dissolved organic matter dynamics in storm water runoff in a dryland urban region. Journal of Arid Environments 165: 55-63.

Flooding (continuous sampling)

Reale, J. K., Archdeacon, T. P., Van Horn, D. J., Gonzales, E. J., Dudley, R. K., Turner, T. F., & Dahm, C. N. 2021. Differential effects of a catastrophic wildfire on downstream fish assemblages in an aridland river. Aquatic Ecology. 55, 483-500.

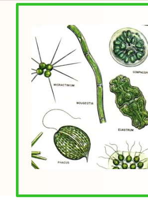
Shafer, B., Van Horn, D.J., Reale, J.K., Gonzalez-Pinzón, R., Bixby, R., Stone, M.C. In preparation. The impacts of large-scale climate patterns and localized disturbance events on whole stream metabolism in an aridland river. TBD.

Drought (discrete and continuous sampling)

Van Horn, D. J., Reale, J. K., & Archdeacon, T. P. 2022. Water quality in three potential drought refuges in an arid-land river: assessing habitat suitability for at-risk fish species. Knowledge & Management of Aquatic Ecosystems. 423: 7.

Underlined = entire MRG
No underline no italics = just Northern MRG
Italics = just southern MRG

Metabolism Studies:
Algal resources important for RGSM diet



Whole Stream Metabolism (continuous sampling)

Shafer, B., Van Horn, D.J., Reale, J.K., Gonzalez-Pinzón, R., Bixby, R., Stone, M.C. In preparation. Seasonal and interannual variability in stream metabolism along an aridland river. TBD.

Shafer, B., Van Horn, D.J., Reale, J.K., Gonzalez-Pinzón, R., Bixby, R., Stone, M.C. In preparation. The impacts of large-scale climate patterns and localized disturbance events on whole stream metabolism in an aridland river. TBD.

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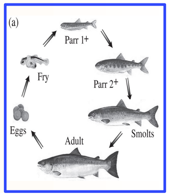
Baseline Water Quality Studies:
Environmental controls on life history traits



Ions (discrete sampling)

Anderholm, S. K., Radell, M. J., & Richey, S. F. (1995). Water-quality assessment of the Rio Grande Valley study unit, Colorado, New Mexico, and Texas: analysis of selected nutrient, suspended-sediment, and pesticide data (Vol. 94, No. 4061). US Department of the Interior, US Geological Survey.

Healy, D. F. (1997). Water-quality Assessment of the Rio Grande Valley, Colorado, New Mexico, and Texas: Summary and Analysis of Water-quality Data for the Basic-fixed-site Network, 1993-95 (Vol. 97, No. 4212). US Department of the Interior, US Geological Survey.

Passell, H. D., Dahm, C. N., & Bedrick, E. J. (2005). Nutrient and organic carbon trends and patterns in the upper Rio Grande, 1975–1999. Science of the Total Environment, 345(1-3), 239-260.

Nutrients (discrete sampling)

Mortensen, J. G., González-Pinzón, R., Dahm, C. N., Wang, J., Zeglin, L. H., & Van Horn, D. J. (2016). Advancing the food-energy–water nexus: closing nutrient loops in arid river corridors. Environmental science & technology, 50(16), 8485-8496.

Oelsner, G. P., Brooks, P. D., & Hogan, J. F. (2007). Nitrogen Sources and Sinks Within the Middle Rio Grande, New Mexico 1. JAWRA Journal of the American Water Resources Association, 43(4), 850-863.

Temperature (continuous but short duration sampling)

Reale, J.K., Segura, M.V., Stomp. J. In preparation. High-frequency water temperature data collection within the inundated floodplain of the Middle Rio Grande during the 2019 snowmelt pulse. Submitted to MRGESCP.

Reale, J.K. 2014. Continuous water temperature monitoring on the Middle Rio Grande during the 2014 snowmelt pulse. Submitted to MRGESCP.

Valdez, R.A., Haggerty, G.M., Richard, K. and Klobucar, D., 2019. Managed spring runoff to improve nursery floodplain habitat for endangered Rio Grande silvery minnow. Ecohydrology. 127: e2134.

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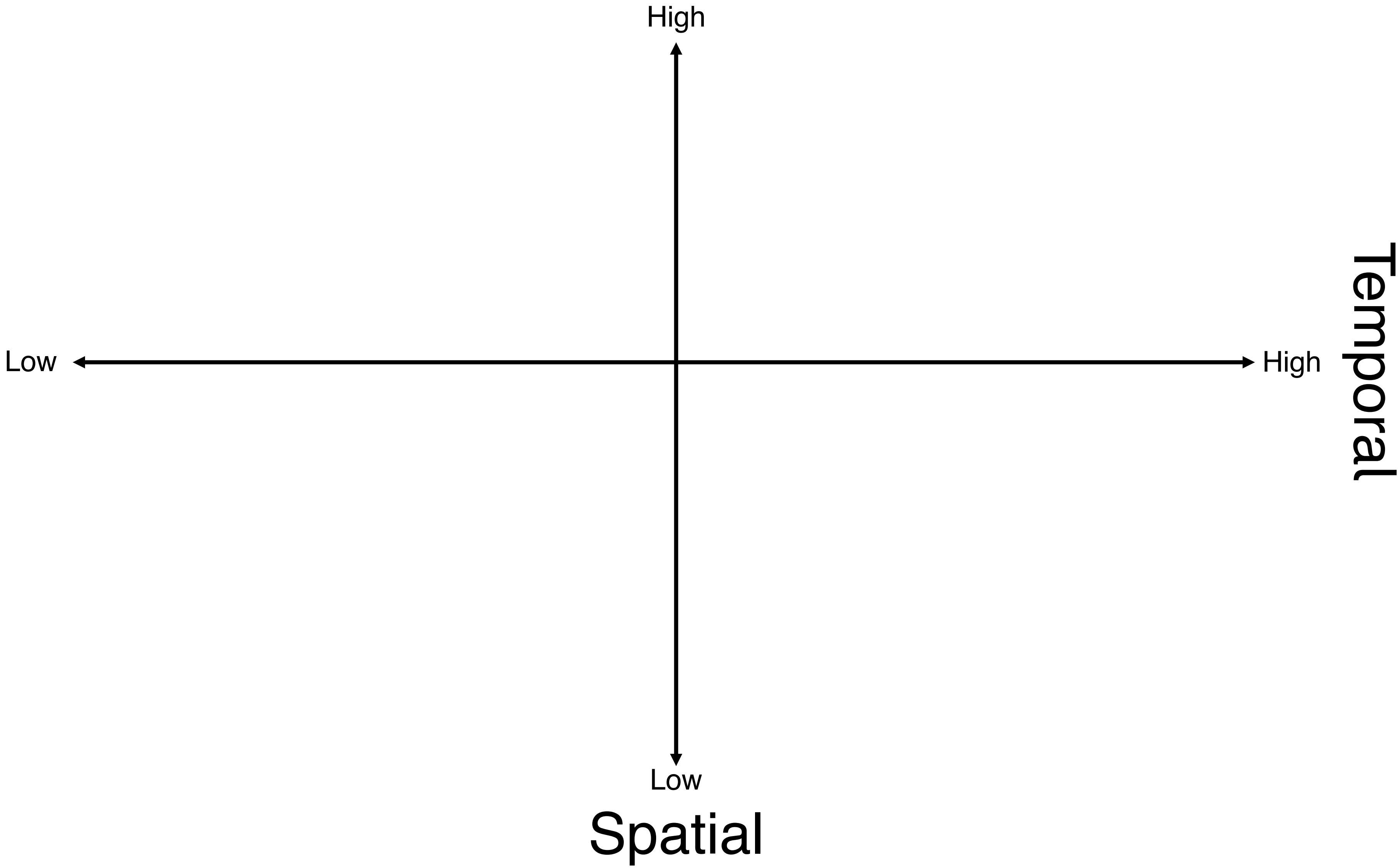
Available Data



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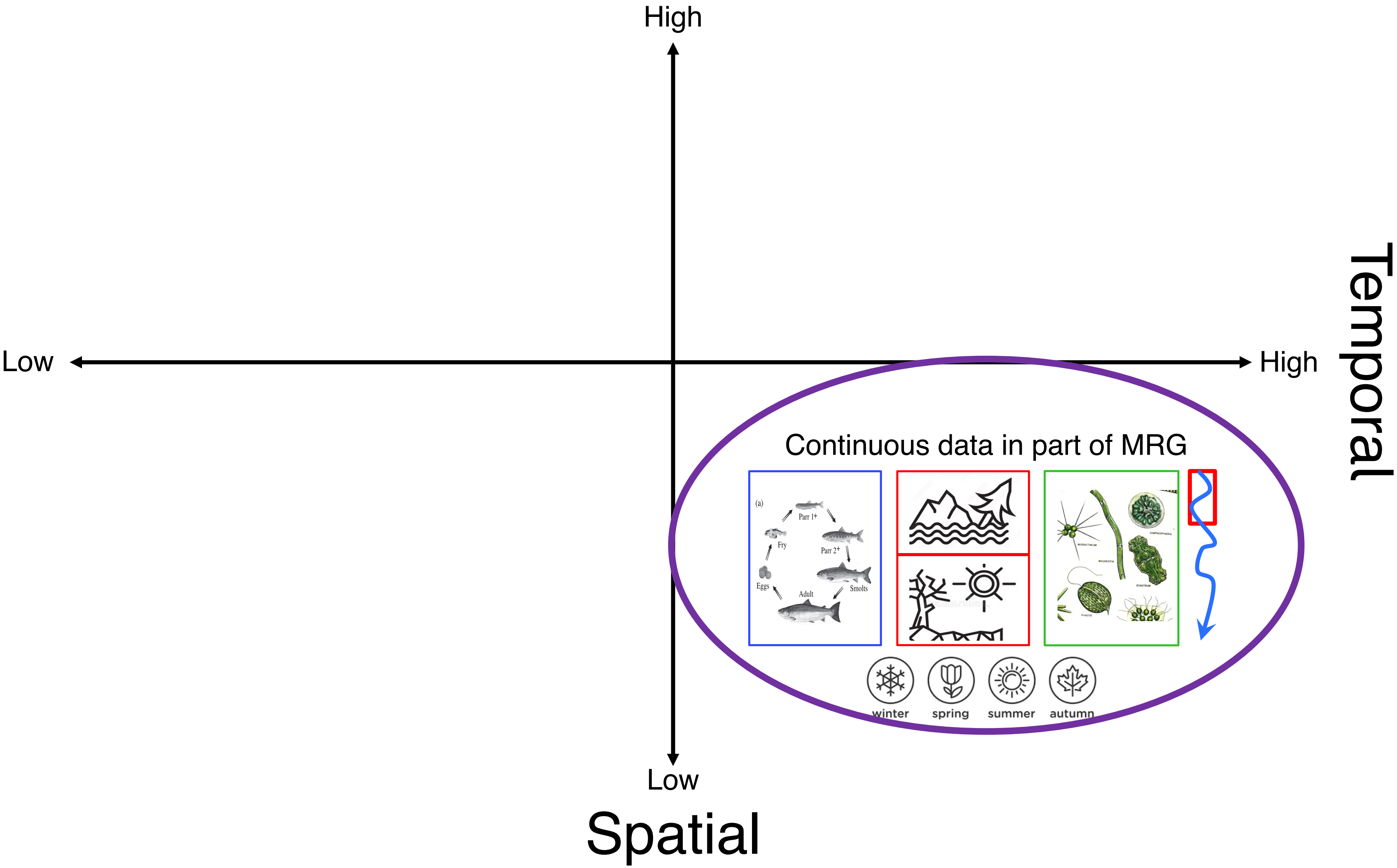

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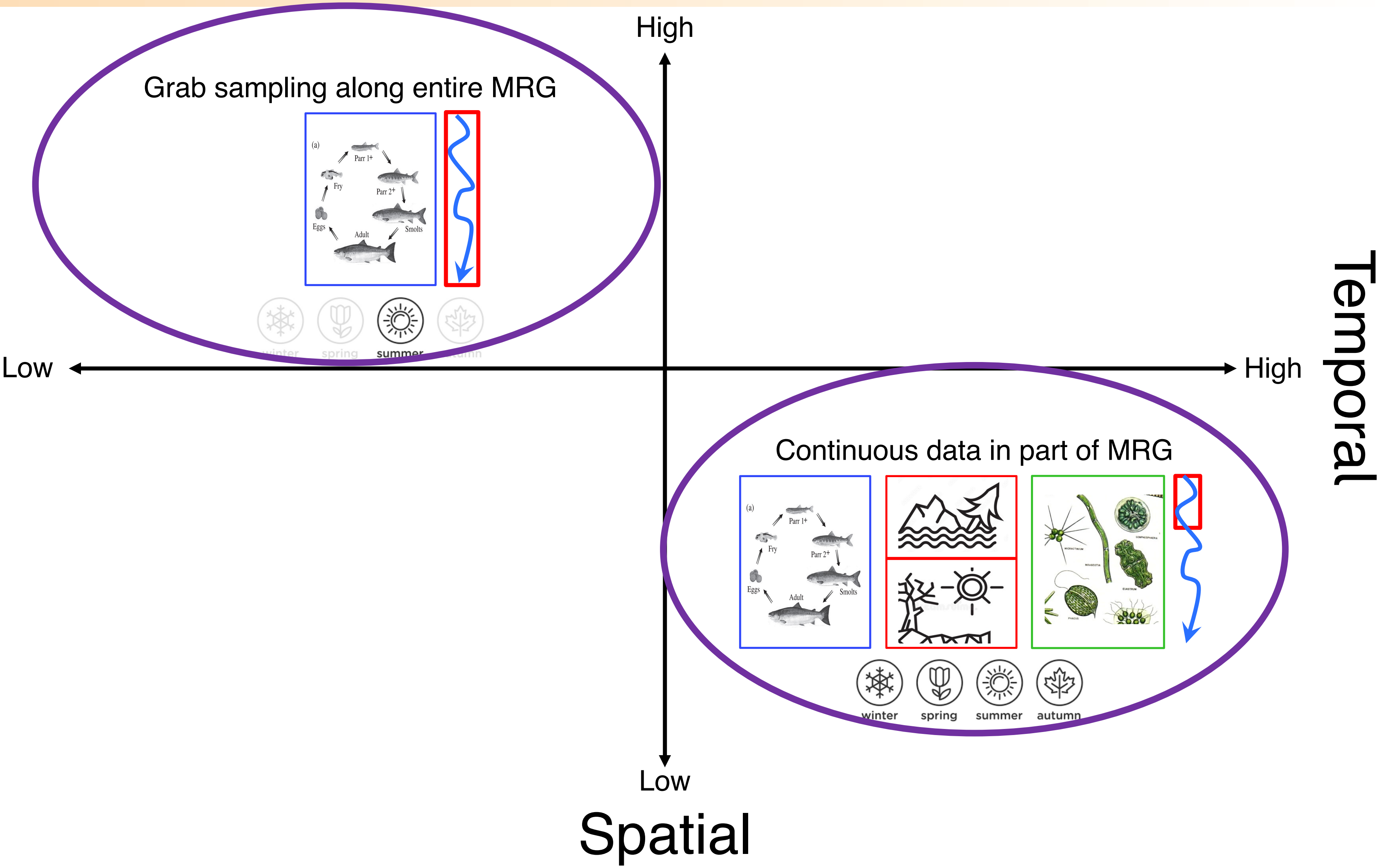
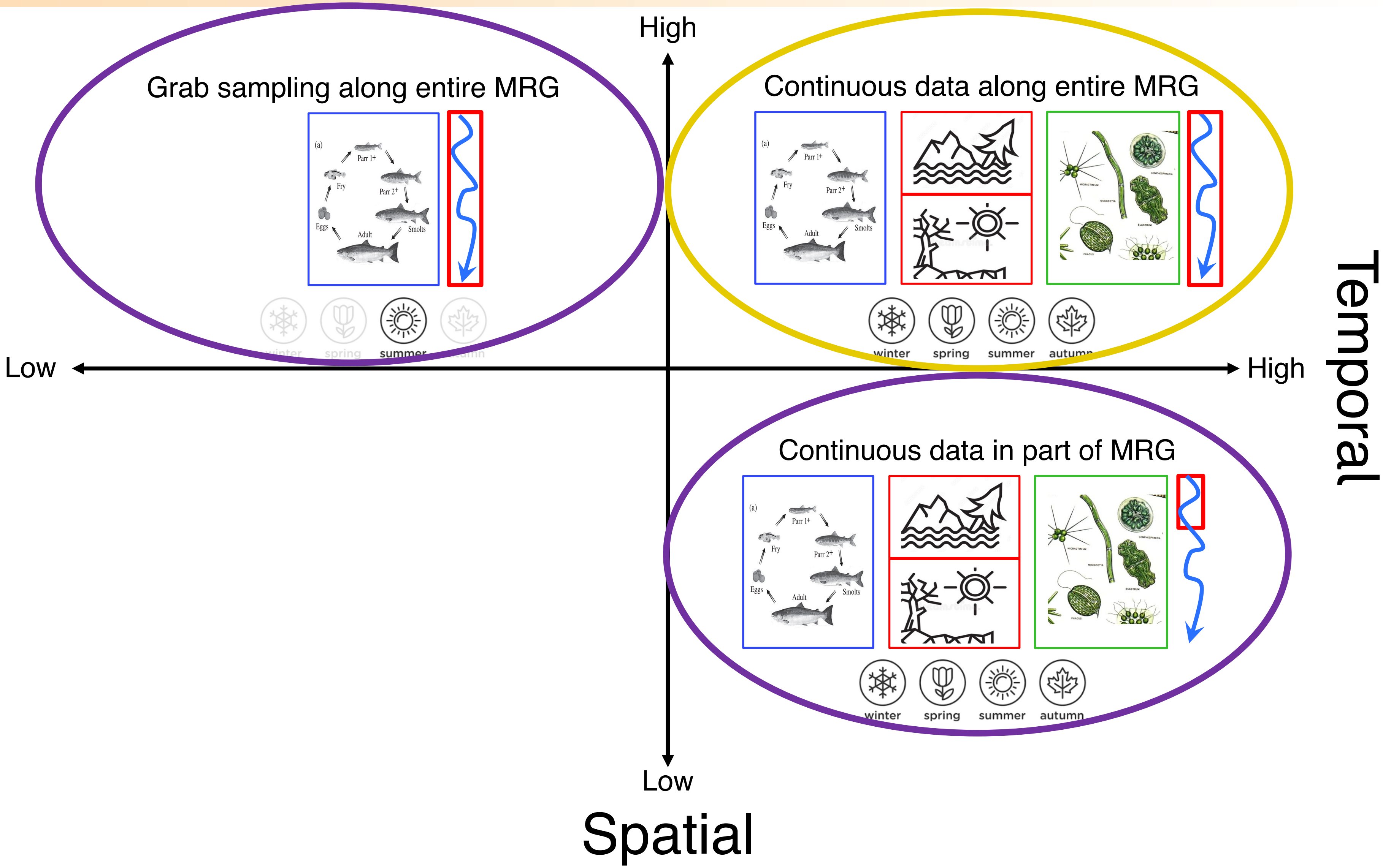


Ideal Data



High
Grab sampling along entire MRG
(a)
Parr 1+
Fry
Parr 2+
Eggs
Smolts
Adult
summer
Continuous data along entire MRG
winter
spring
summer
autumn
Low
High
Temporal
Continuous data in part of MRG
winter
spring
summer
autumn
Low
Spatial

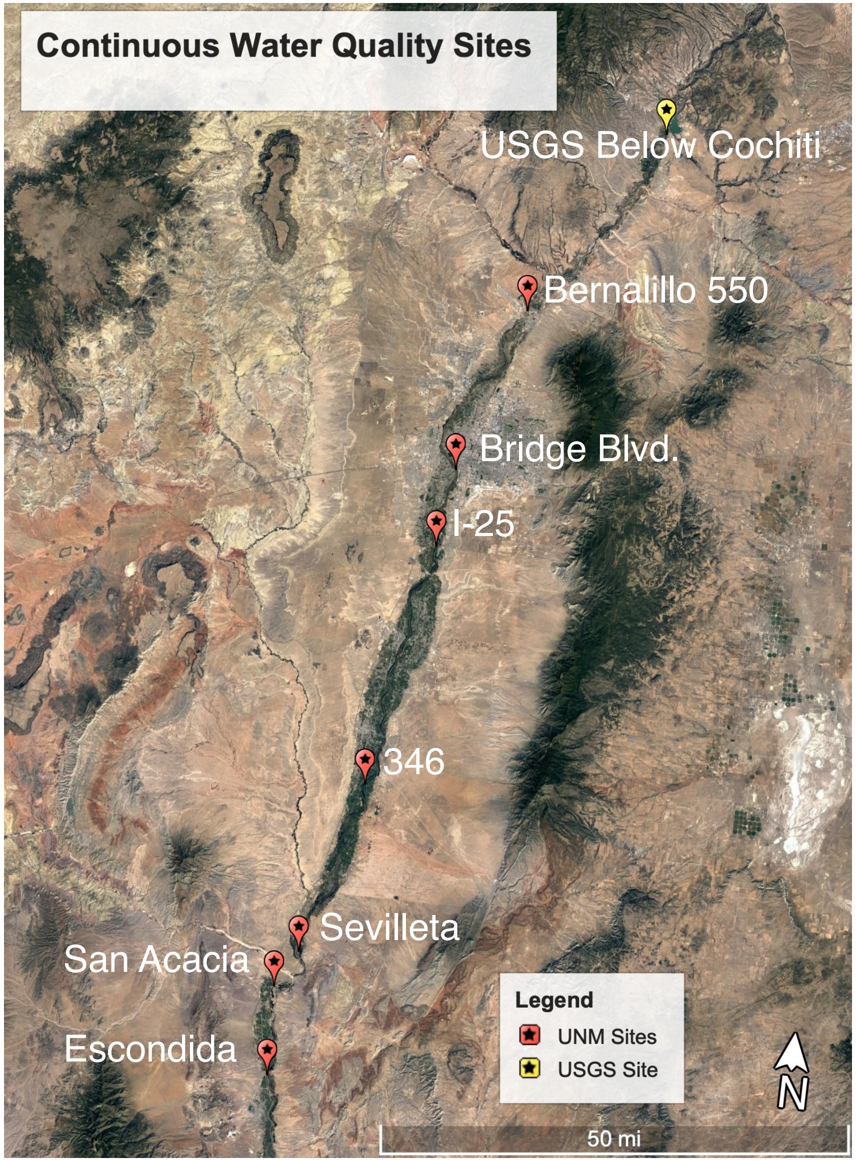
USACE/ISC - Water Quality Monitoring Network for the Middle Rio Grande

History: 2006 – Present

Goal: Assess temporal and spatial water quality trends in the Middle Rio Grande (MRG)

Methods: Continuous water quality collection at four sites in the Abq. reach of the MRG since 2006,three sites added above Cochiti Reservoir in 2012, two southern sites added on the Sevilleta and at Escondida in 2021, two additional southern sites (Hwy 346, and San Acacia) in 2023.

Study Sites



Continuous Water Quality Sites
USGS Below Cochiti
Bernalillo 550
Bridge Blvd.
I-25
346
Sevilleta
San Acacia
Escondida
Legend
UNM Sites
USGS Site
N
50 mi

exo

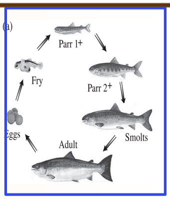
Study Sites

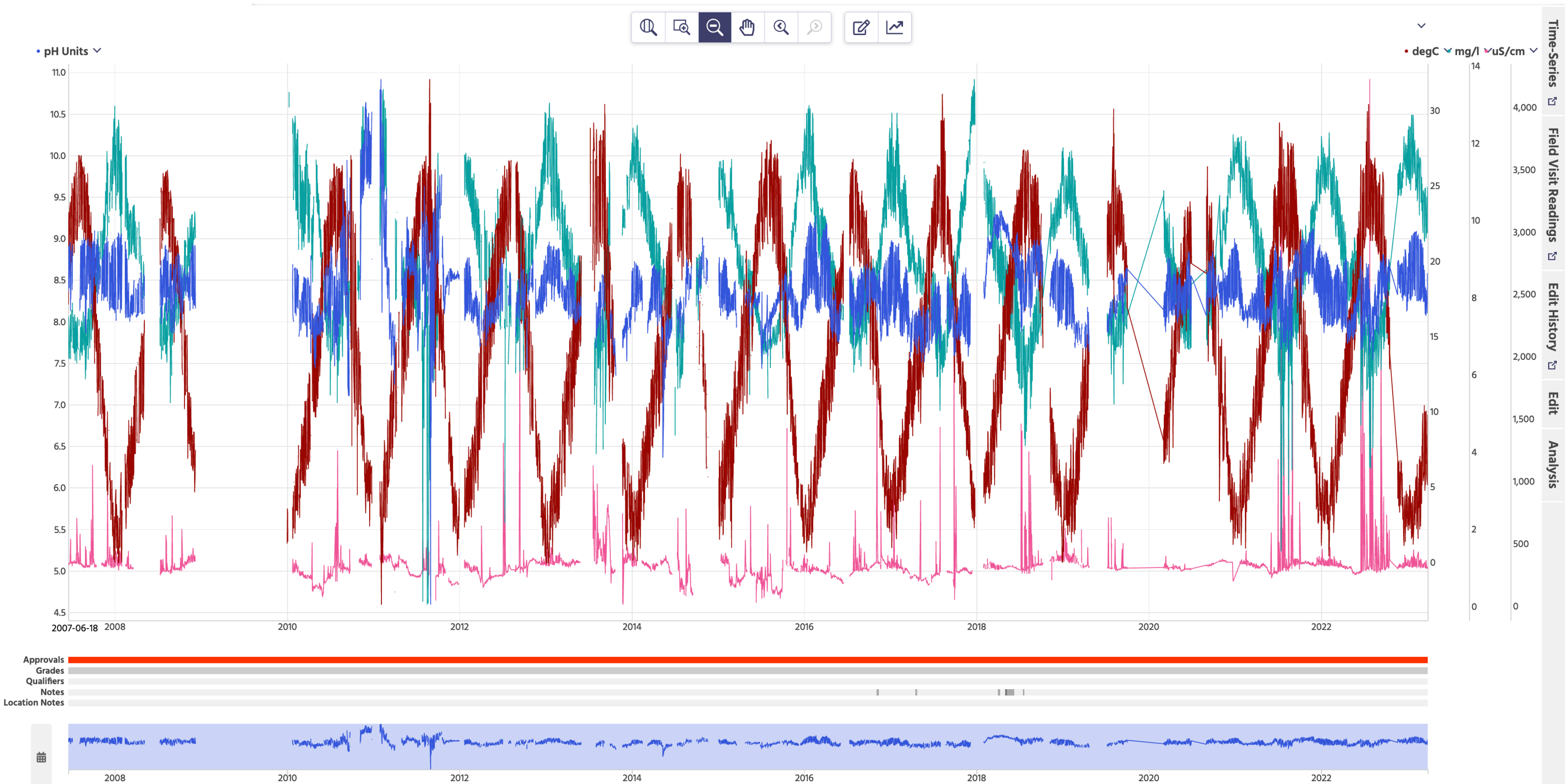
Study Sites

Study Sites

Study Sites

Available Data





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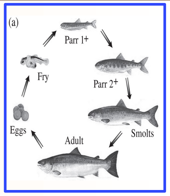


Upper Rio Grande

1) Above Abiquiu: 2020-Present
2) Below Abiquiu: 2020-Present
3) Lyden: 2012-2019
4) Chamita: 2012-2019
5) Buckman: 2018-Present
6) Above Cochiti: 2012-2017

Middle Rio Grande

Angostura Reach

1) Bernalillo-550: 2007-Present
2) Alameda: 2006-2019
3) Bridge/Rio Bravo: 2006-Present
4) I-25: 2006-Present

Isleta Reach

1) 346: 2023-Present
2) Sevilleta NWP: 2021-Present

San Acacia Reach

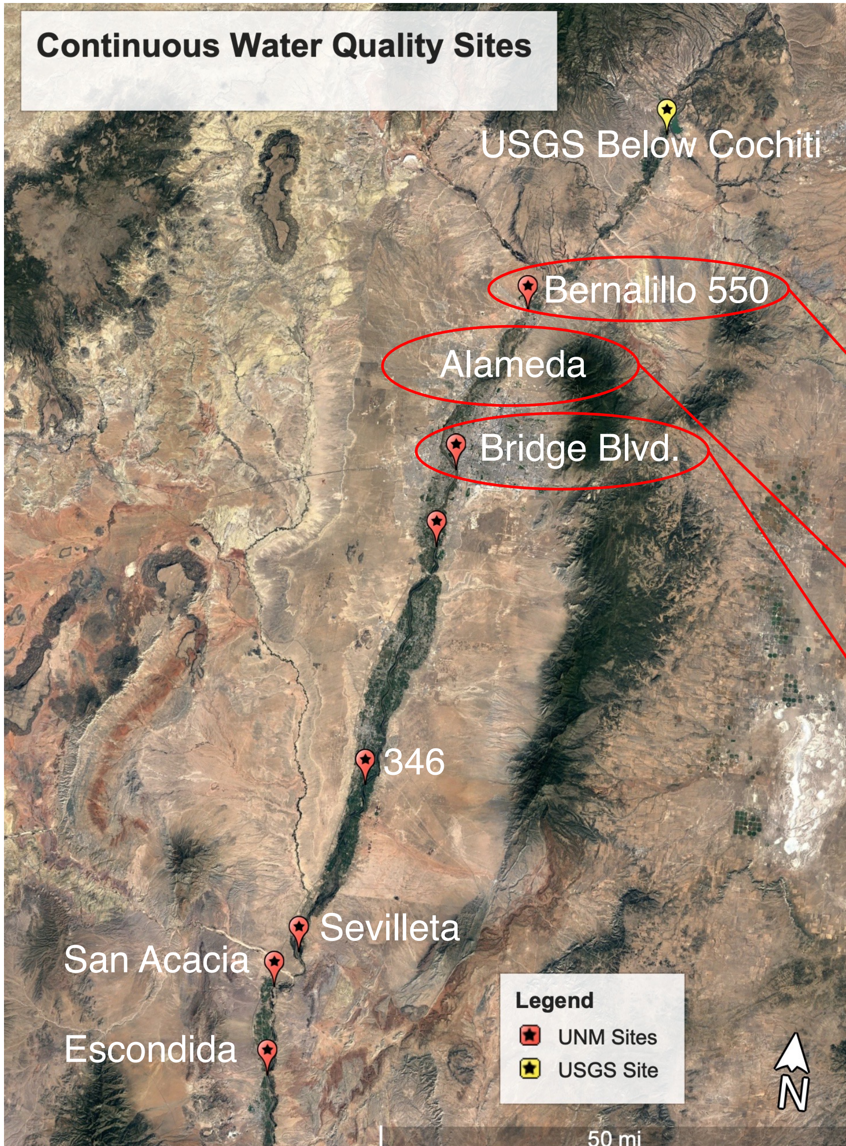
1) SADD: 2023-Present
2) Escondida: 2021-Present

Data Collection in the Southern MRG

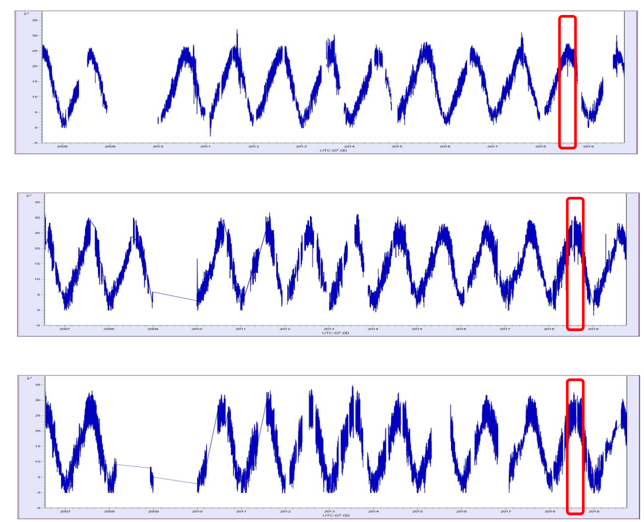
Data Collection in the Southern MRG

Data Collection in the Southern MRG

Disturbances that impact survival and recruitment: Stormwater



RQ1: How do storms impact WQ in the northern MRG?



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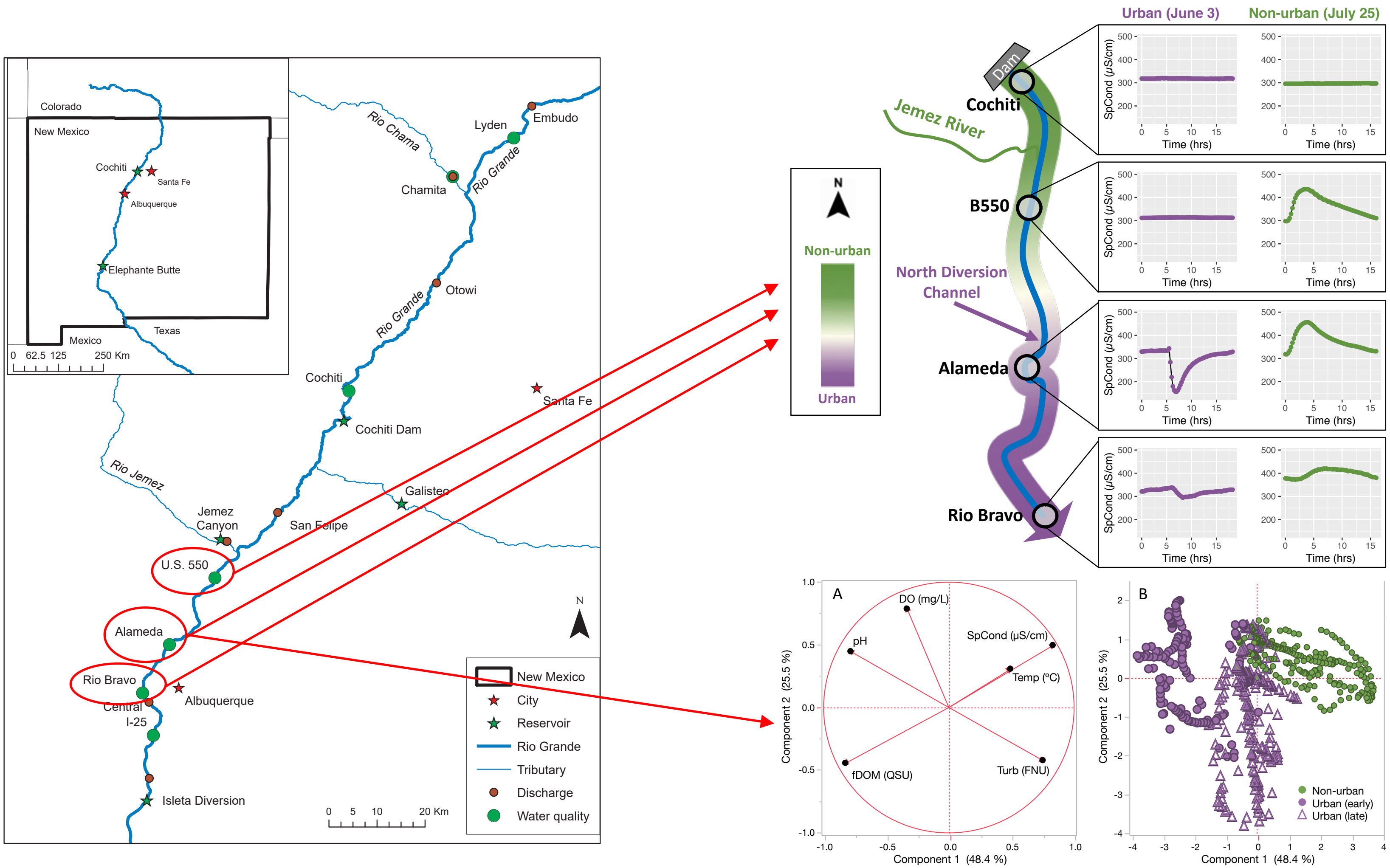

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Disturbances that impact survival and recruitment: Stormwater

Table 1
Storm event hydrology and water quality measured at Alameda.

Date (m/d/yy)	Type	Physical properties				Biogeochemical properties		
		Direct runoff[a]	∂-SpCond	∂-Temp	∂-Turbidity	∂-DO	∂-pH	∂-fDOM[b]
5/21/18	Urban	230.70	−202.83	−10.70	529.36	2.58	0.25	–
6/3/18	Urban	153.57	−186.70	4.87	200.10	−4.65	–	265.63
6/16/18	Urban	210.19	−238.93	3.51	213.65	−5.65	–	300.43
7/30/18	Urban	344.70	−262.52	−10.49	2115.26	−2.42	0.92	161.79
8/1/18	Urban	182.14	−207.80	3.02	−4774.73	−2.97	0.40	80.21
8/2/18	Urban	87.31	−98.25	1.62	−2065.46	−4.46	0.41	61.28
8/17/18	Urban	33.40	−52.80	1.56	40.81	−1.29	−0.21	109.00
8/22/18	Urban	218.48	−181.00	1.70	10,516.27	−1.94	−0.33	139.24
9/19/18	Urban	76.31	−125.63	7.09	105.91	−1.91	−0.48	149.40
10/30/18	Urban	49.20	−106.20	−0.88	64.10	−1.14	−0.27	70.54
7/25/18	Non-urban	209.41	139.90	−4.12	7628.05	−0.67	–	–
8/1/18	Non-urban	61.26	269.27	4.28	11,040.62	−3.02	−0.43	–
8/11/18	Non-urban	106.79	967.15	3.02	8099.33	−1.80	−0.16	–
8/18/18	Non-urban	68.62	695.50	4.69	7895.76	−1.77	−0.42	–
10/15/18	Non-urban	41.29	1218.65	1.58	8881.19	−0.35	−0.18	–
	Average urban	150.59	−162.20	1.33	712.88	−2.94	0.06	148.61
	Average non-urban	97.47	658.09	1.89	8708.99	−1.52	−0.30	–

[a] Reported as direct runoff excluding baseflow, in thousands of m^3.
[b] fDOM data were collected but not reported for non-urban events in Table 1 due to poor data quality.

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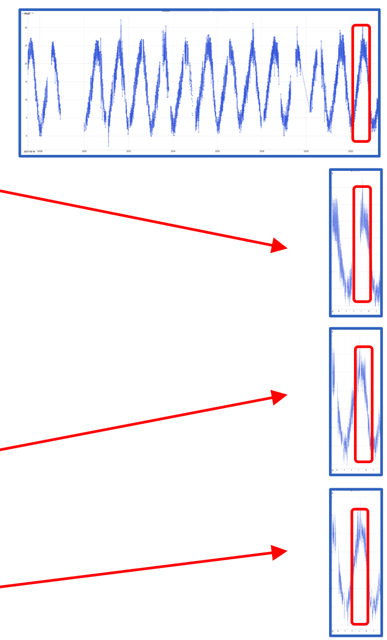
Disturbances that impact survival and recruitment: Stormwater

Downstream propagation???

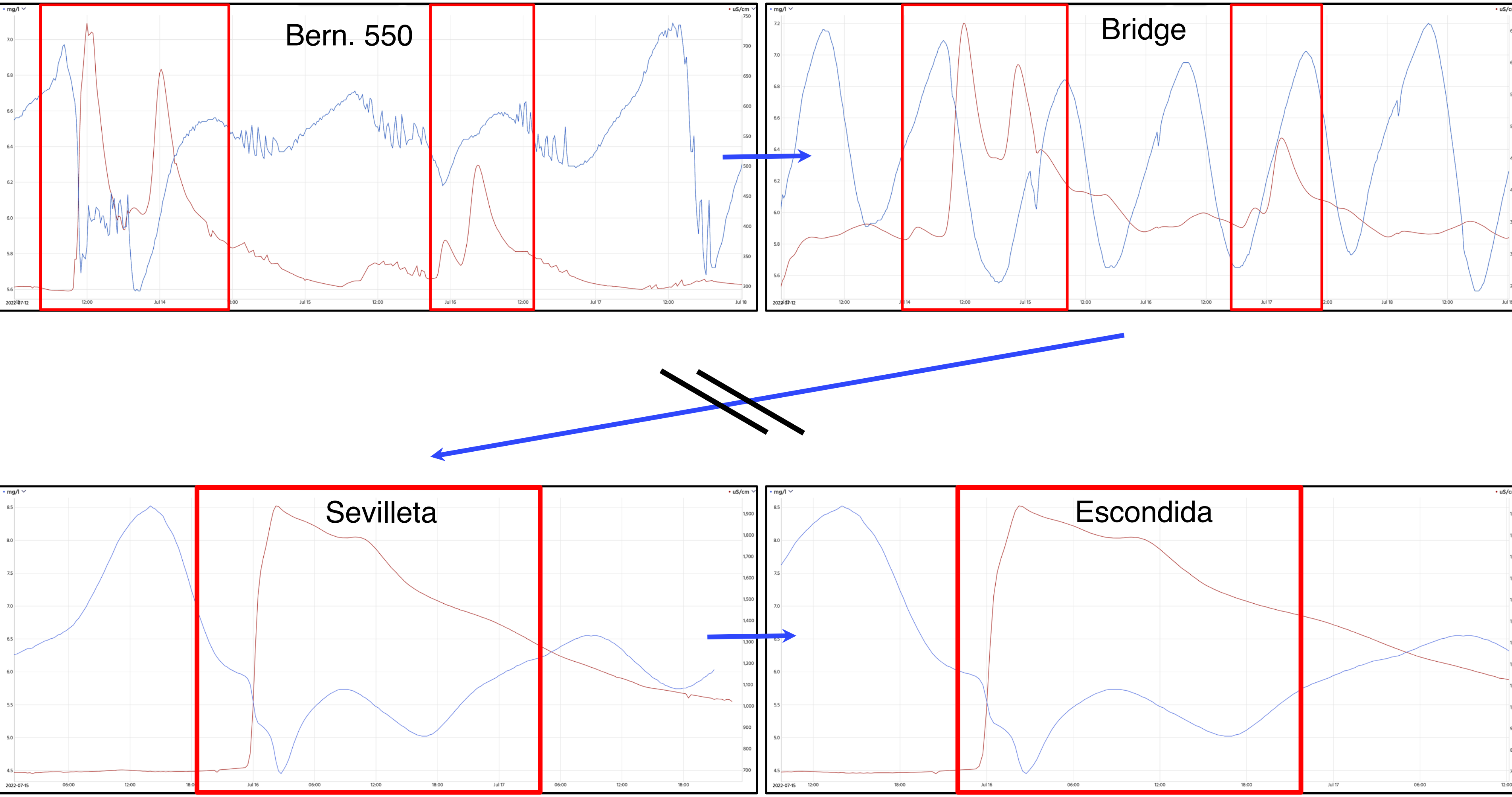
Southern tributaries???

Disturbances that impact survival and recruitment: Stormwater

RQ2: Do storm impacts from the northern MRG propagate to the southern MRG?



Disturbances that impact survival and recruitment: Stormwater



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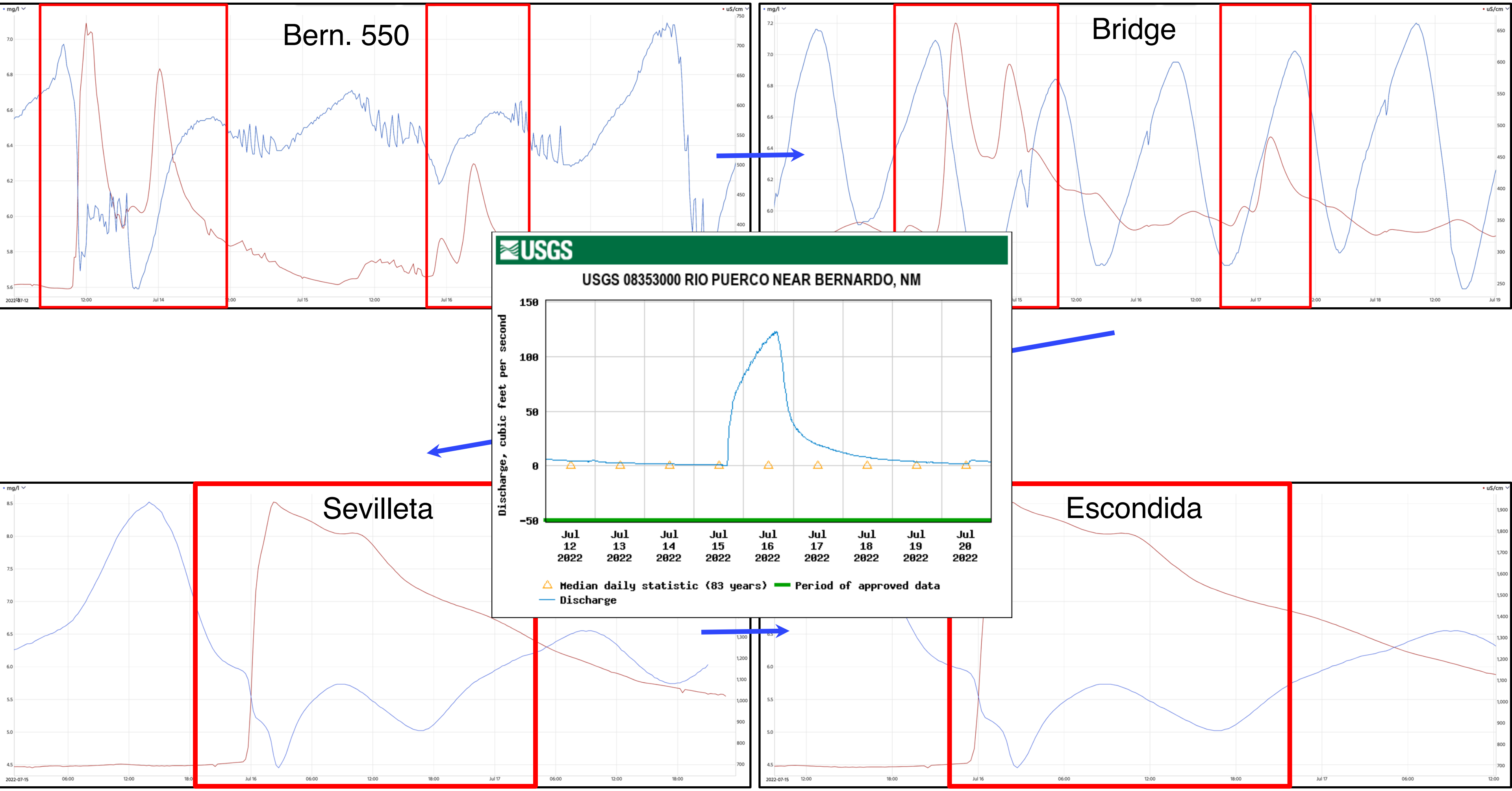
Disturbances that impact survival and recruitment: Stormwater



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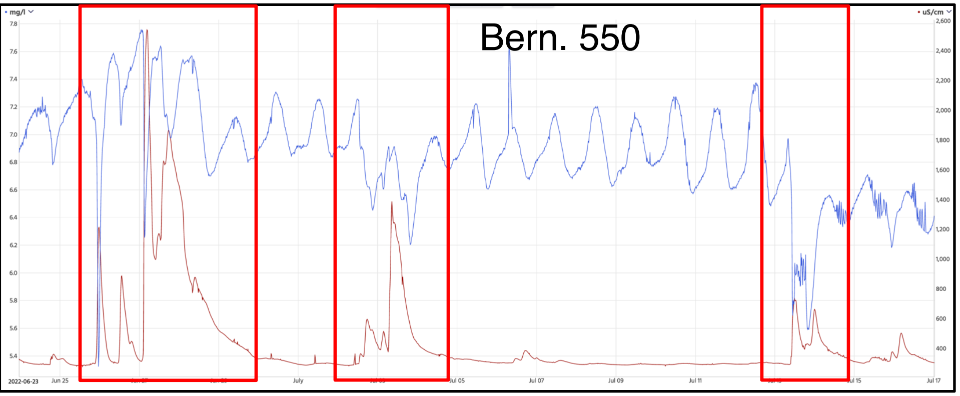
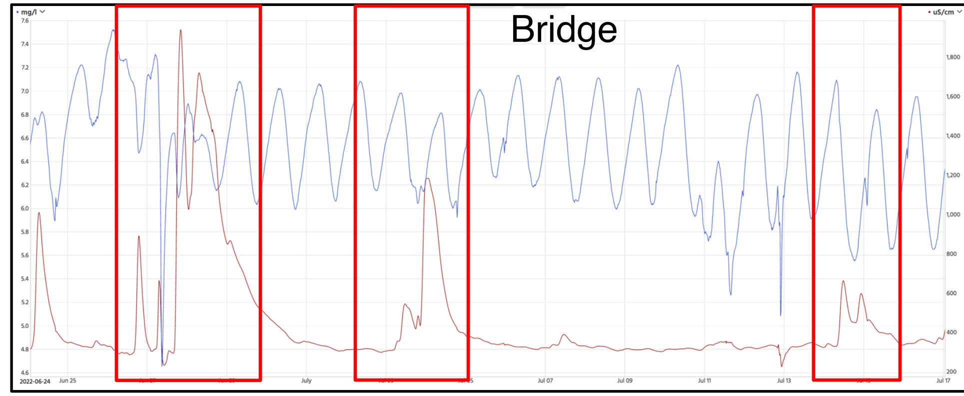
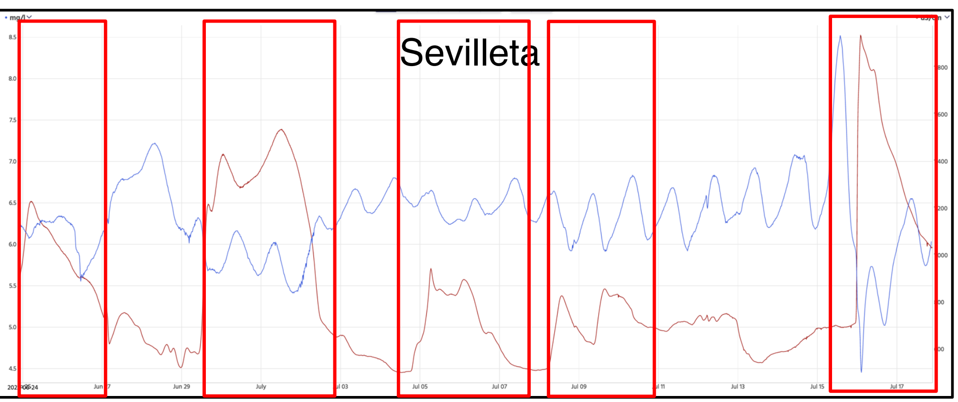
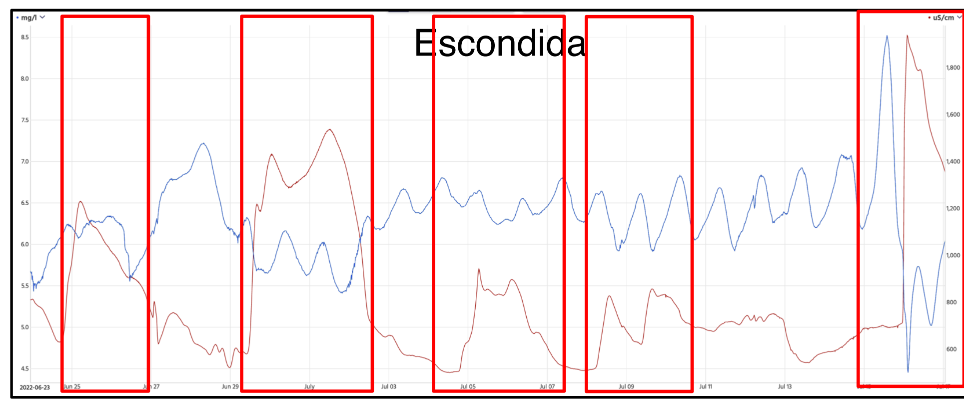
Disturbances that impact survival and recruitment: Stormwater









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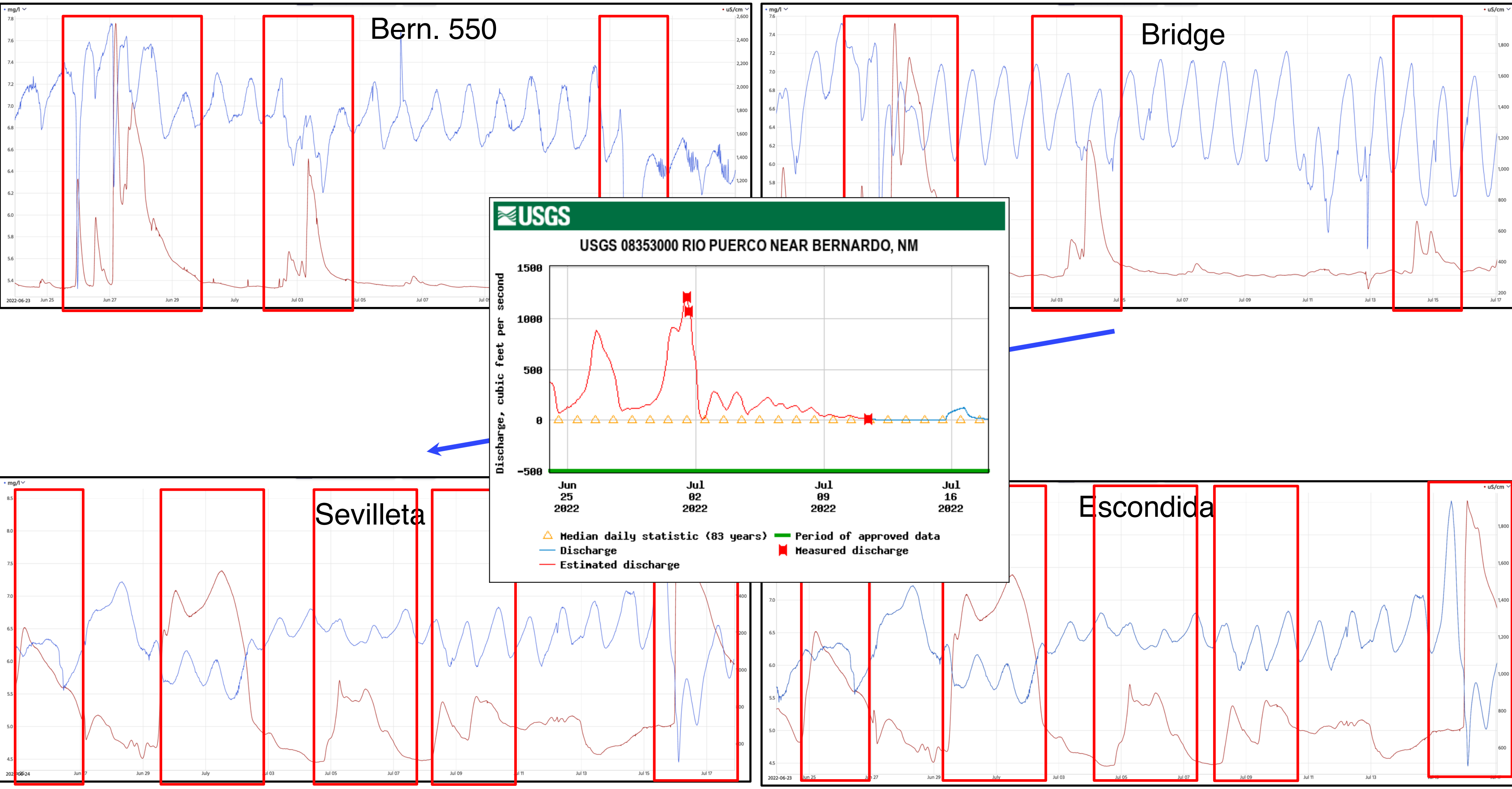
Disturbances that impact survival and recruitment: Stormwater



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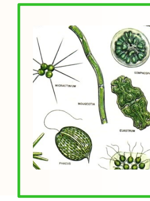
Disturbances that impact survival and recruitment: Conclusions

1) Urban and non-urban storm events have distinct and potentially large impacts on MRG water quality

2) The northern and southern reaches of the MRG appear to have varying disturbance regimes with respect to storm impacts likely driven by local tributary inputs

3) Dissolved oxygen appears to be differentially impacted at northern and southern

Algal resources important for RGSM diet: Modeling Metabolism

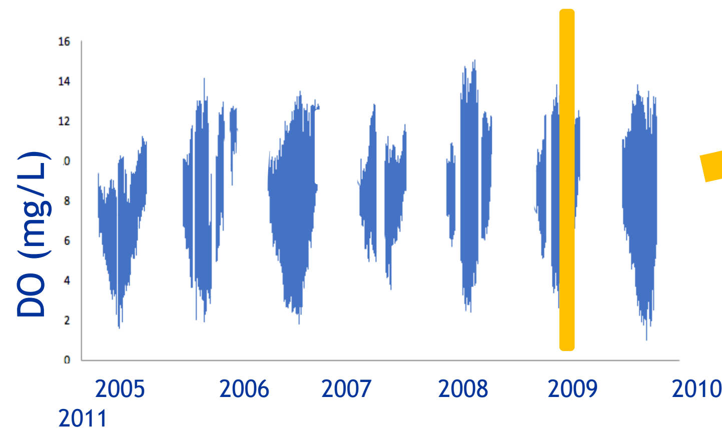


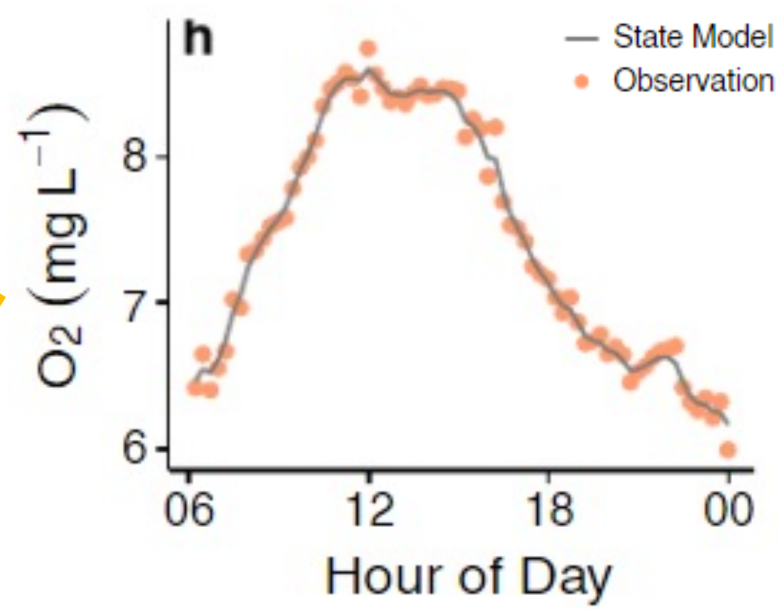
- Instantaneous (subdaily) dissolved oxygen (DO) is modeled to estimate GPP, ER, K

USGS-R / **streamMetabolizer** Public

Governing Equation:

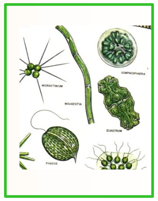
$$\frac{dO_2}{dt} = GPP + ER + K(O_2sat - O_2)$$

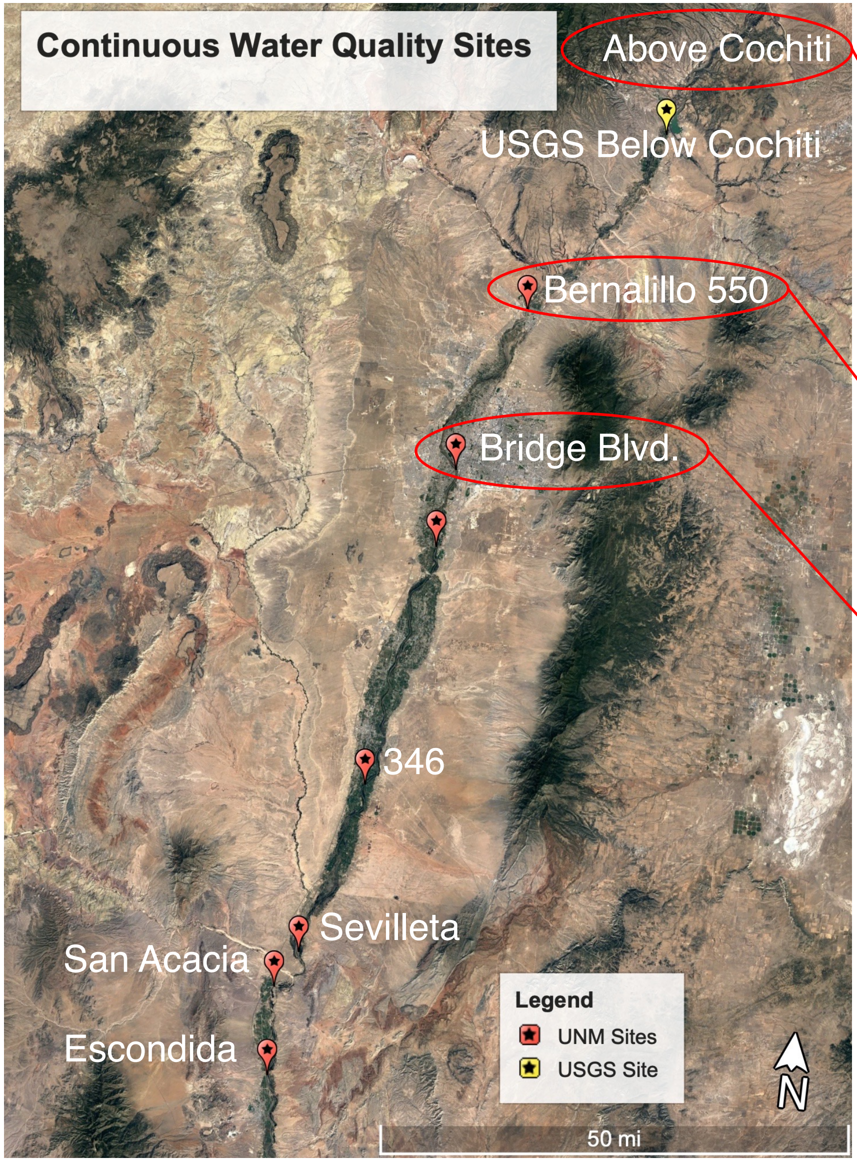




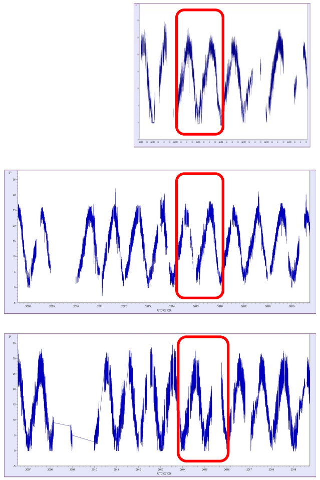
Appling et al. 2018

Algal resources important for RGSM diet



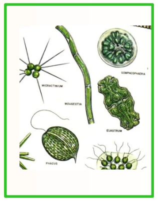


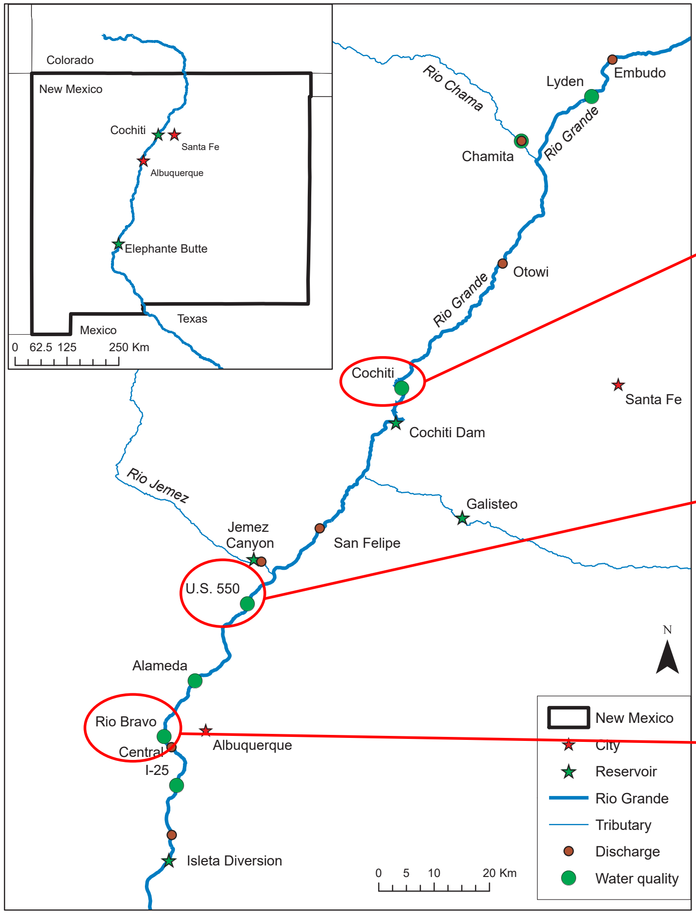
RQ3: How does GPP vary spatially in the northern MRG?

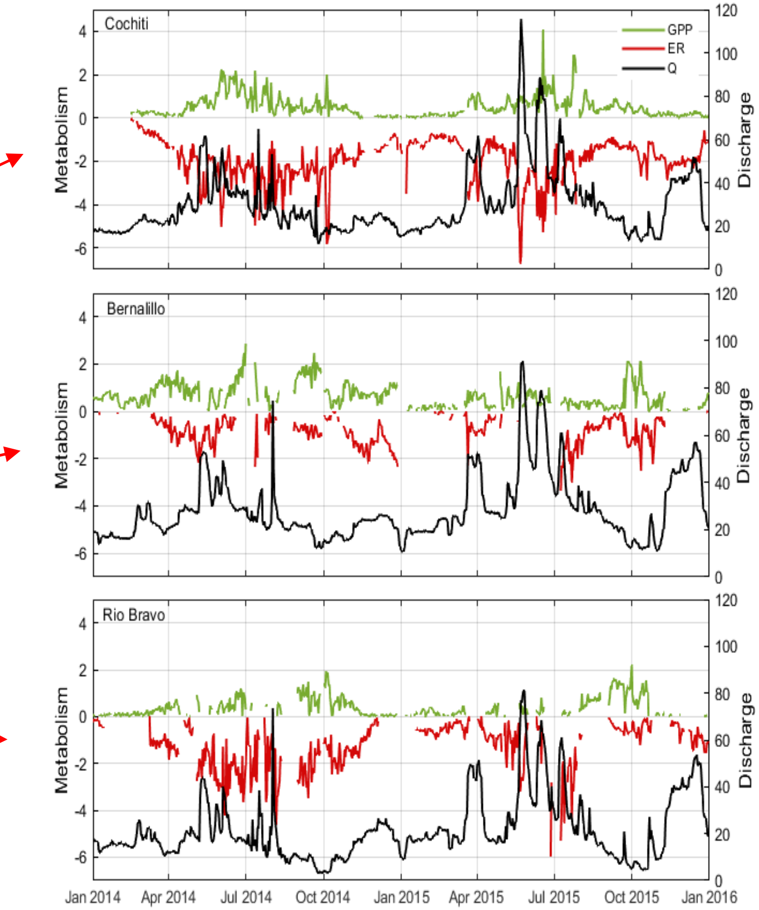


Summers et. al. in prep.

Algal resources important for RGSM diet

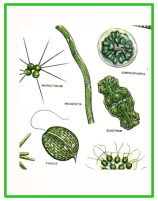


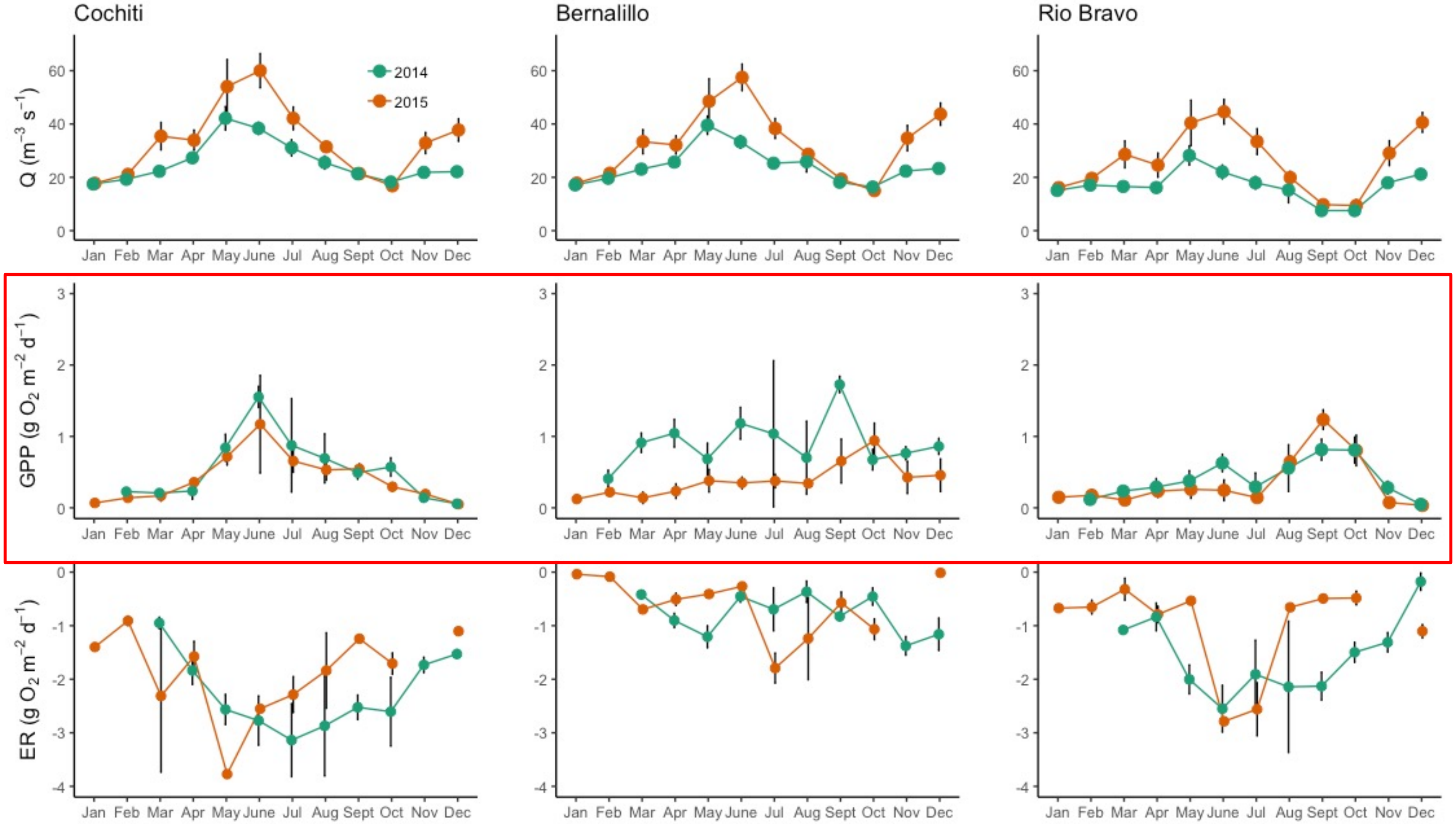




Summers et. al. in prep.

Algal resources important for RGSM diet





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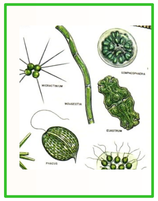
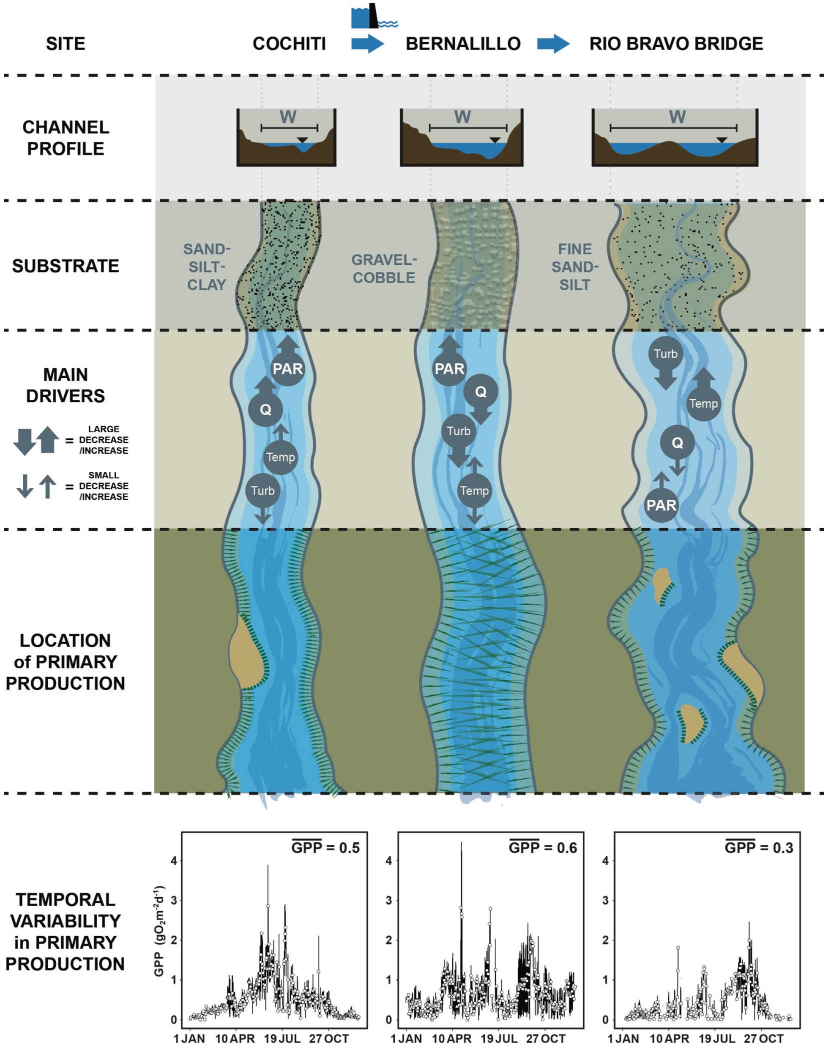
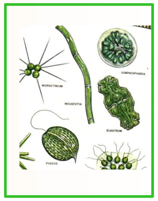
Algal resources important for RGSM diet

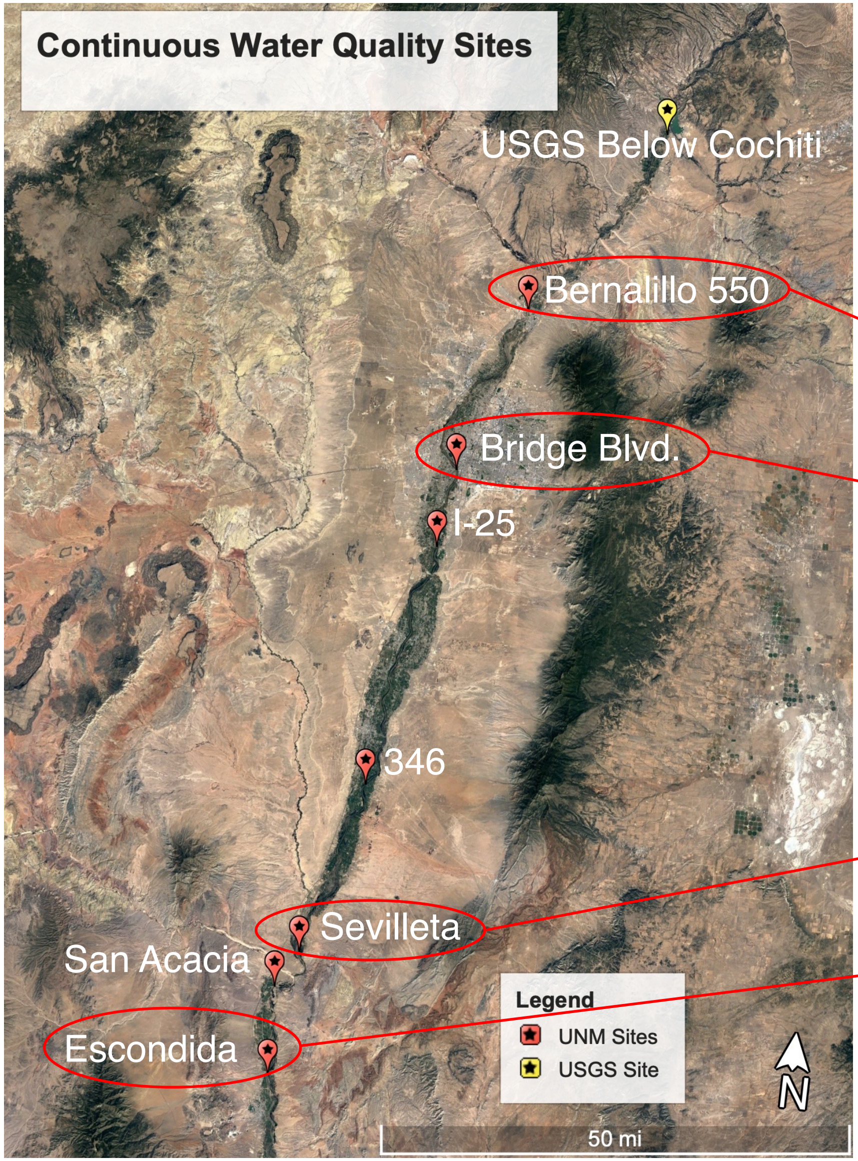




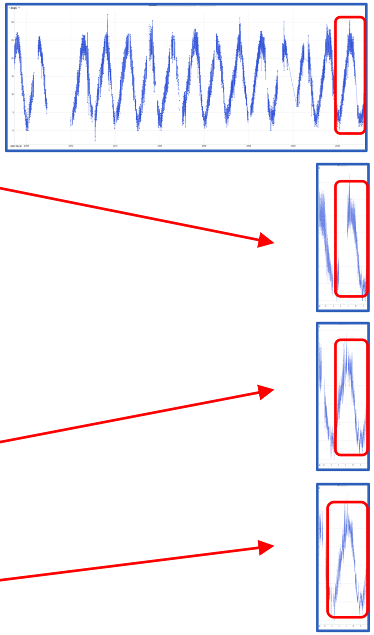
Summers et. al. in prep.

Algal resources important for RGSM diet: GPP along the MRG

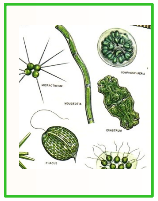




RQ4: How does GPP vary longitudinally in the MRG?



Algal resources important for RGSM diet



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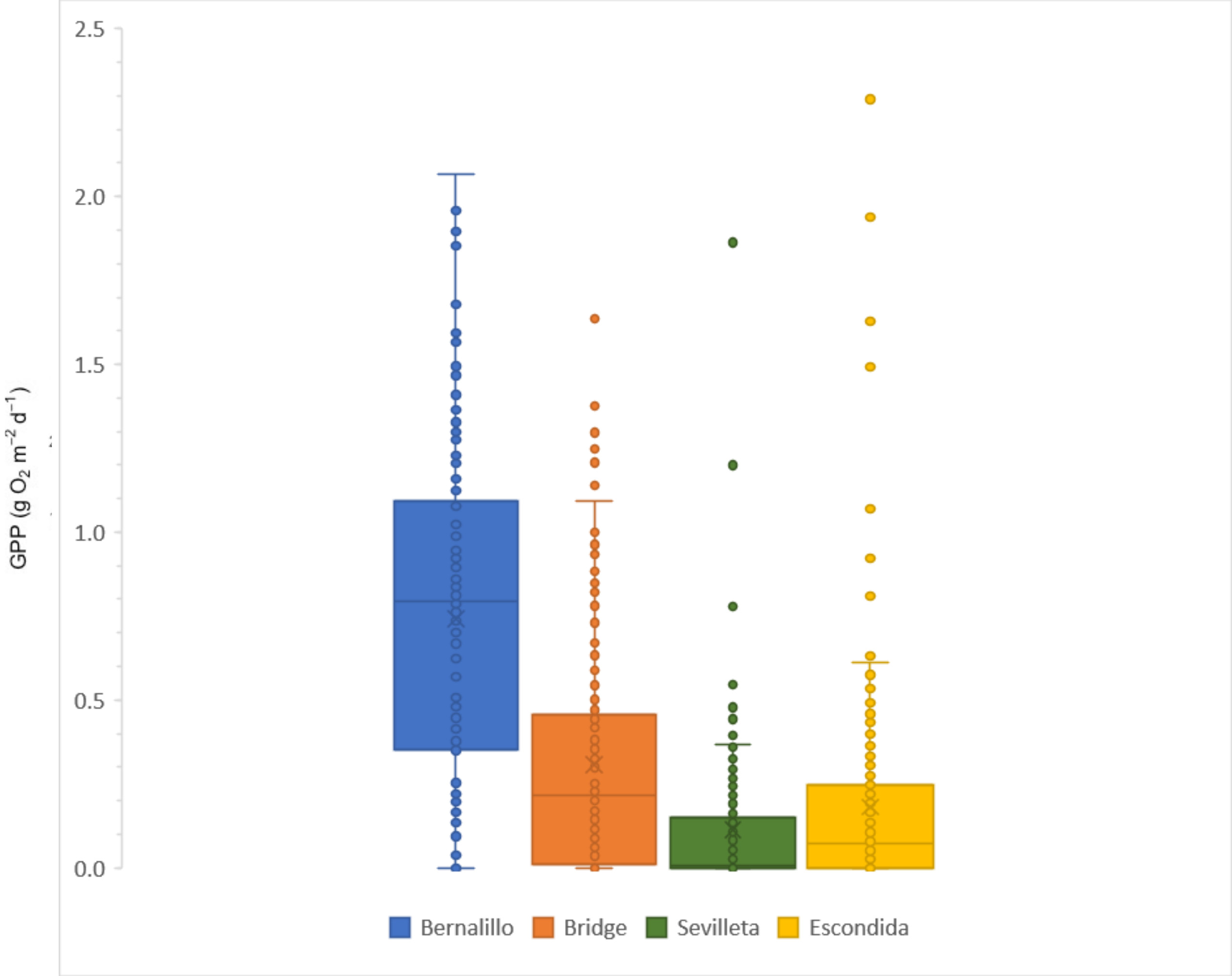
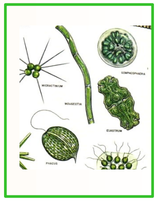
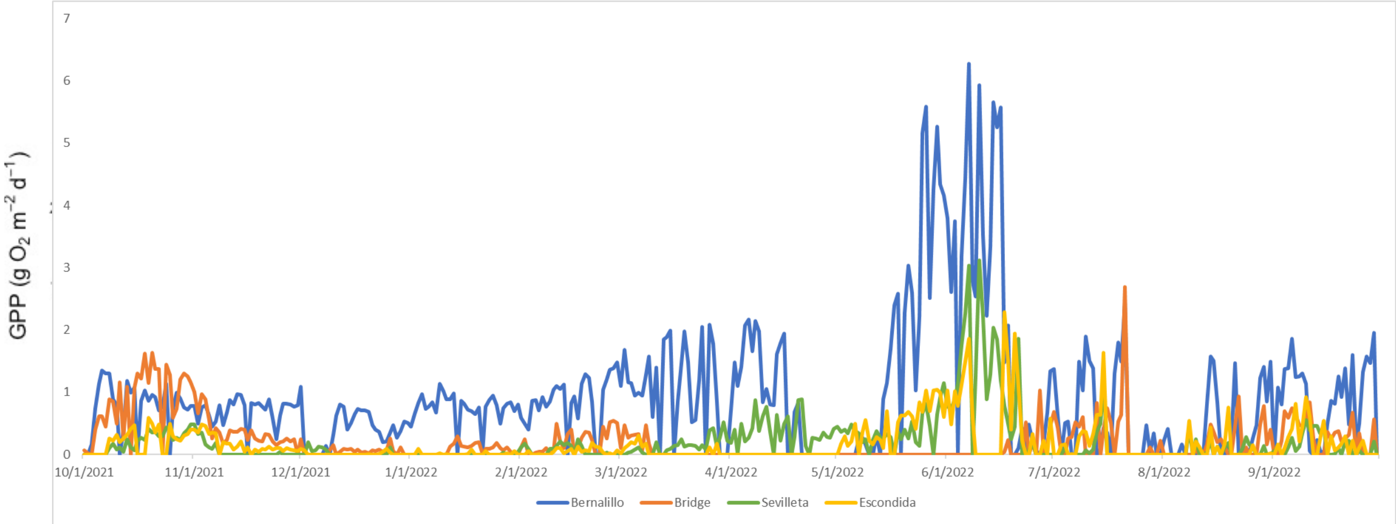
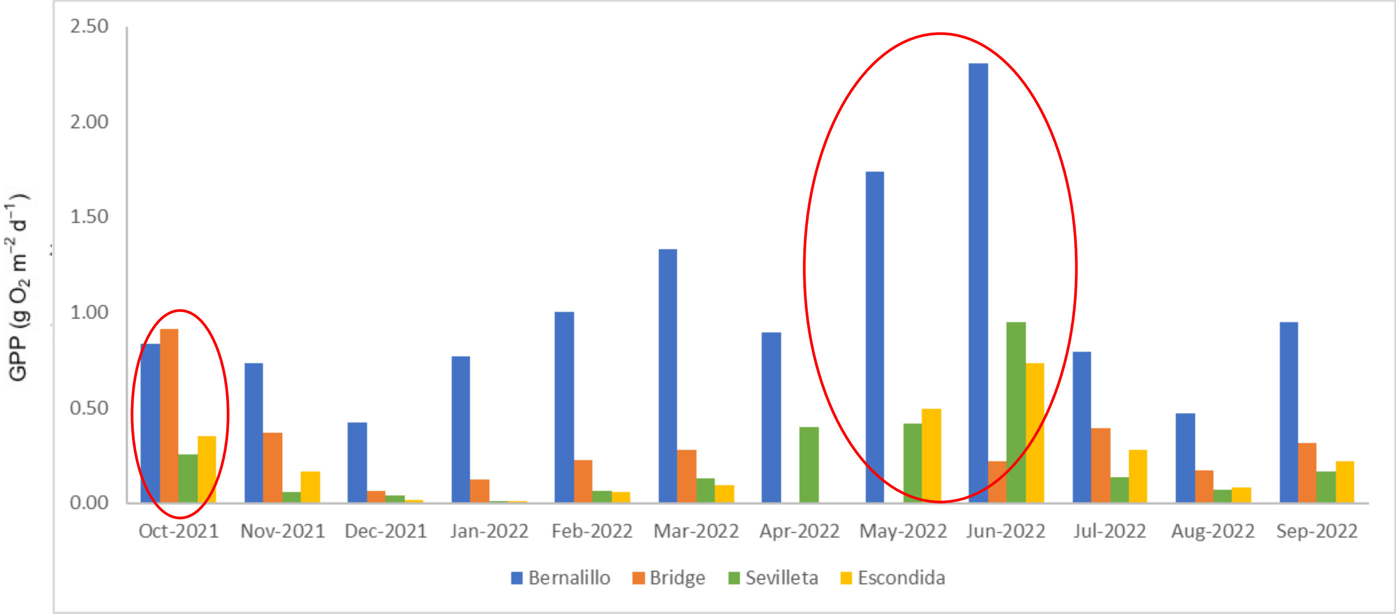


Algal resources important for RGSM diet







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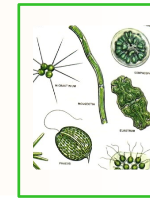
Algal resources important for RGSM diet: Conclusions

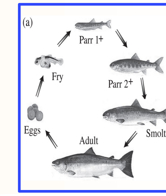


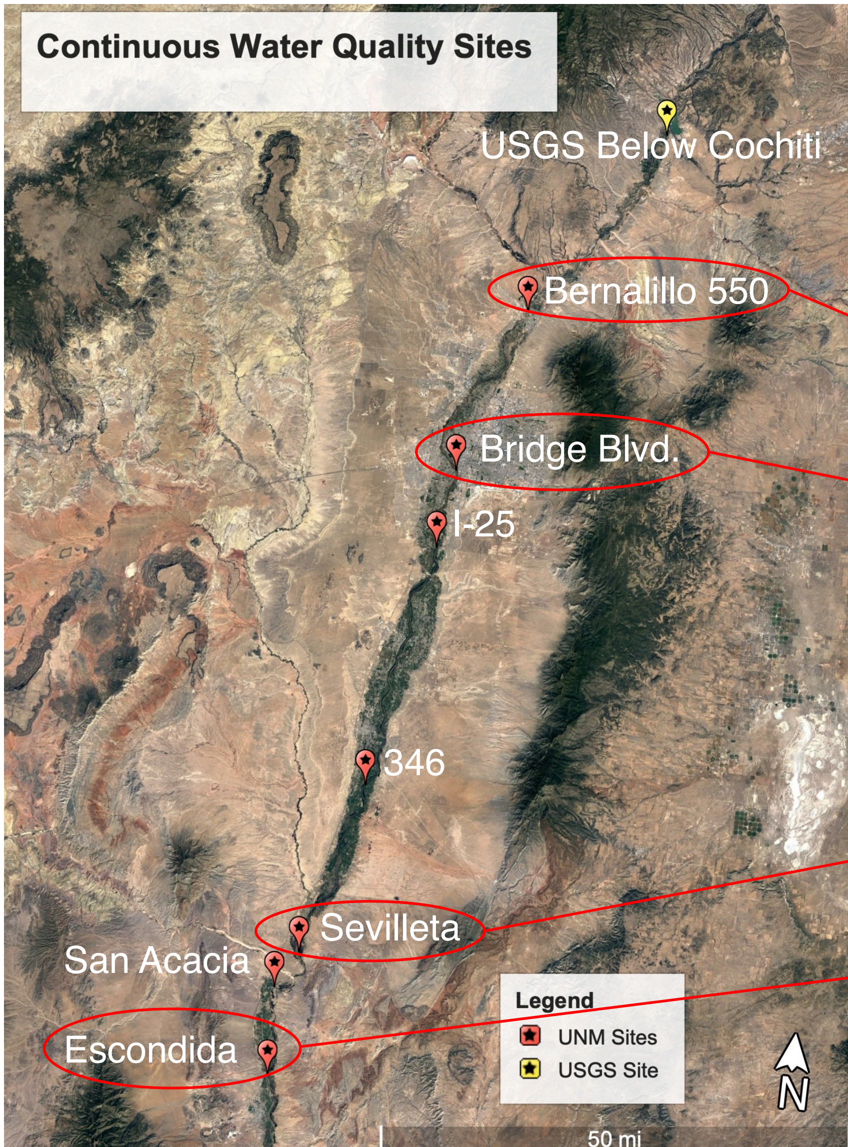
1) Overall GPP declines in the downstream direction in the MRG

2) Seasonally, GPP peaks most commonly in late spring/early summer when PAR is elevated and Q is low, but before monsoon storms increase turbidity

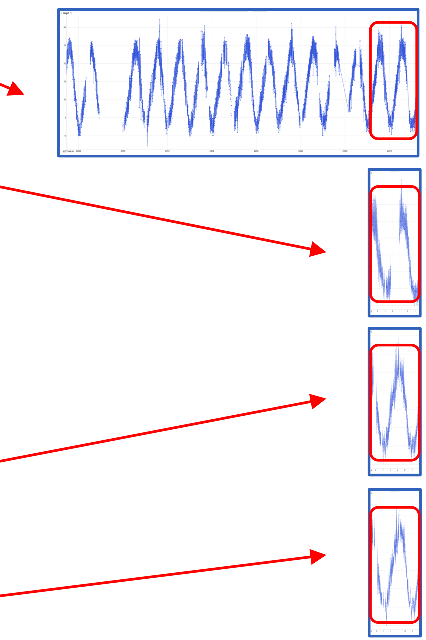
3) At some sites GPP peaks during fall when flows and turbidity are low but PAR is still relatively high

Environmental controls on survival/recruitment: Temperature and DO exceedances N to S

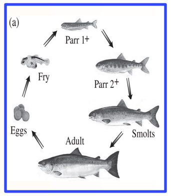


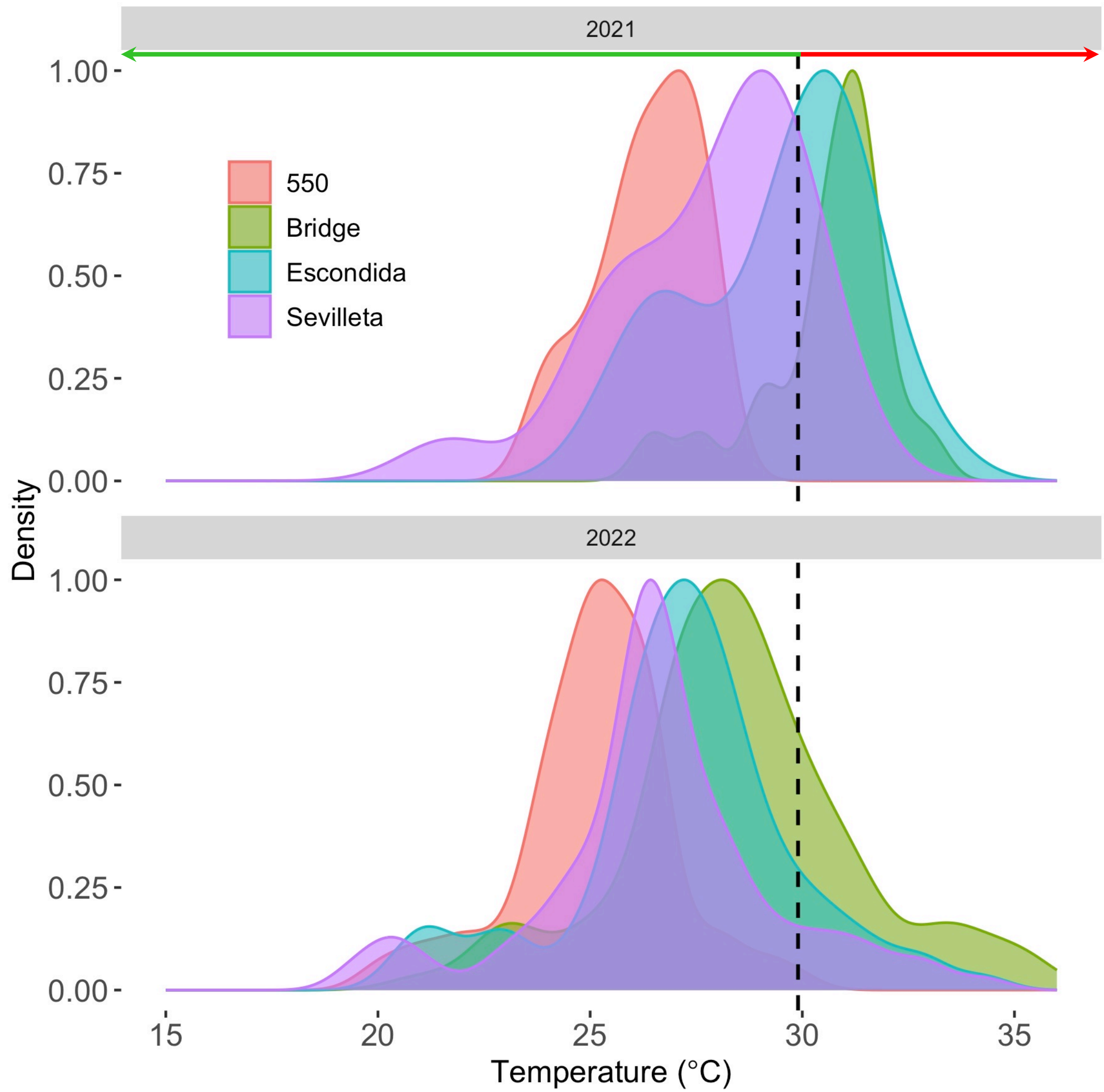


RQ5: How do basic water quality parameters impact habitability in the MRG?



Environmental controls on survival/recruitment: Temperature and DO exceedances N to S





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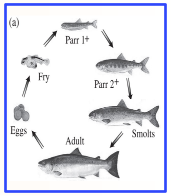
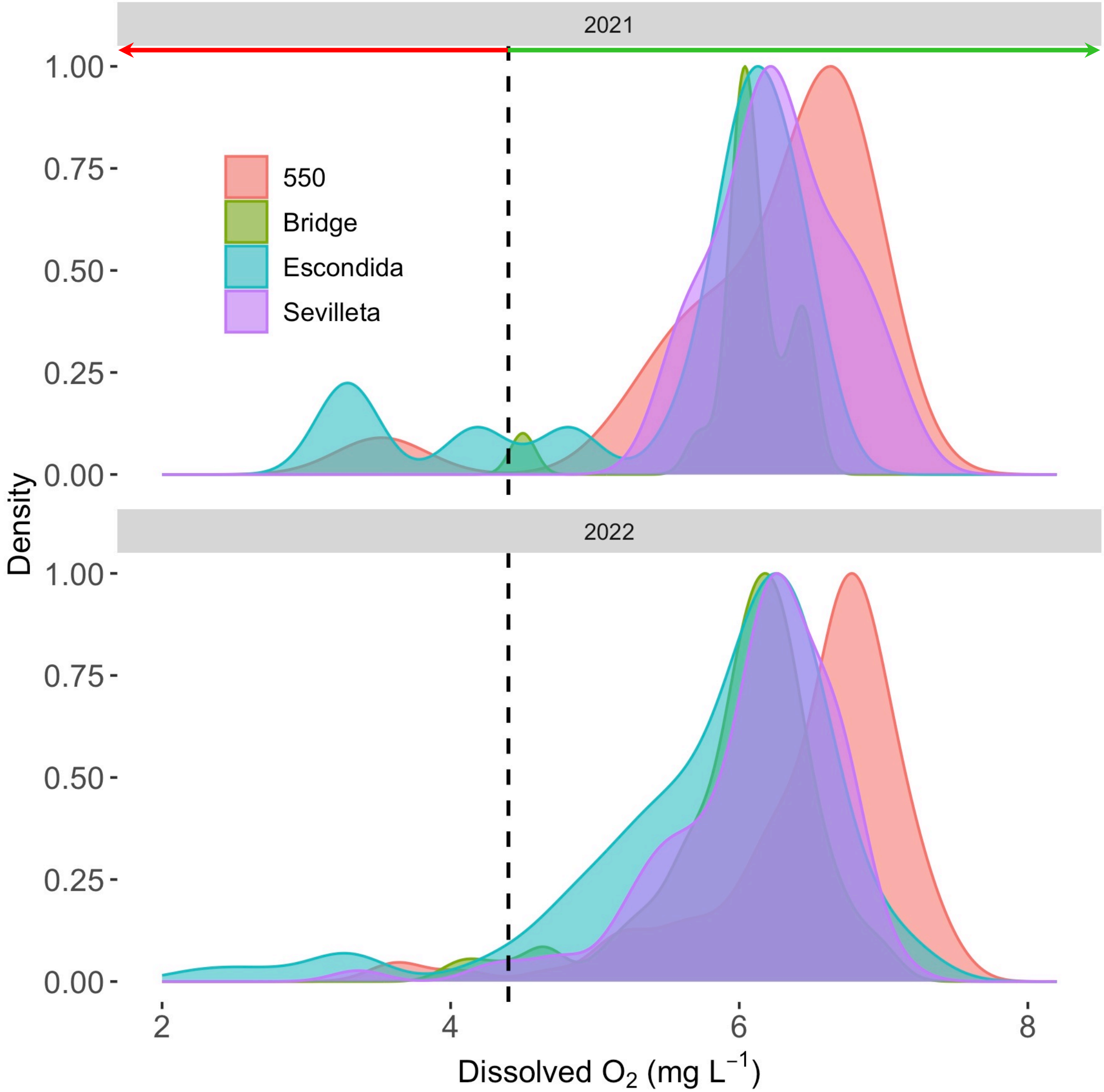
Environmental controls on survival/recruitment: Temperature and DO exceedances N to S





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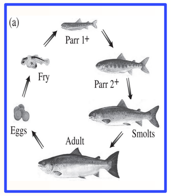
Environmental controls on survival/recruitment: Conclusions



1) The northern MRG site consistently has the highest water quality (temp., DO)

2) Max-daily temp. values at the Bridge and Escondida sites often exceed the NALL for the RGSM

3) DO values rarely drop below the NALC at any site and Bridge, Sevilleta, and Escondida have similar min-daily DO profiles

Conclusions

- Water quality in the MRG is highly dynamic, both spatially and temporally
- There appears to be a disconnect between the northern and southern MRG with respect to storm related disturbance regimes
- Algal productivity declines from the north to south in the MRG and is highest at most sites during early summer months; however, some sites experience a peak during fall
- While temperature and dissolved oxygen vary between sites, southern sites do not necessarily have degraded quality as compared to more northern sites

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New Mexico EPSCoR

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