Science and Habitat Restoration Work Group Meeting

May 14, 2019

Meeting Materials:

Meeting Agenda

Meeting Minutes

Rio Grande Silvery Minnow Population Monitoring During 2018 [report, not included]

Insights From Long-Term, High Frequency, Water Quality Monitoring in the Middle Rio Grande [presentation]

Rio Grande Silvery Minnow Population Monitoring (1993-2018) [presentation]

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Science and Habitat Restoration Work Group (ScW/HR)

May 14, 2019
10:00 PM – 12:00 PM

WEST Offices
8500 Menaul Blvd NE; 3rd Floor

Call-In Information: 712-451-0011; Code 141544#

Meeting Agenda

10:00 – 10:10	**Welcome, Introductions, and Agenda Review** ➢ **Decision**: Approval of May 14, 2019 meeting agenda	*Ashley Tanner*
10:10 – 10:20	**Review of March 12, 2019 ScW/HR Meeting** • Review Action Items ➢ **Decision**: Approval of March 14, 2019 meeting minutes	*Ashley Tanner*
10:20 – 10:25	**Announcements/Updates on State Water Initiatives**	*Julie Dickey*
10:25-11:30	**Annual RGSM Population Monitoring Presentation**	*Rob Dudley (ASIR)*
11:30-11:35	**Break**	
11:35-11:55	**SOW Updates and Project Description Review** ➢ **Action Item**: Review SWFL Surveys project description ➢ **Decision**: Approval of SWFL Surveys project description to be sent to the EC and further developed.	*Ashley Tanner*
11:55 – 12:00	**Additional Items and Next Meeting Date**	*Ashley Tanner*
12:00	**Adjourn**	

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Science and Habitat Restoration Work Group (ScW/HR)
Meeting Minutes

May 14, 2019
10:00 PM – 12:00 PM

Location: WEST Offices, 8500 Menaul Blvd NE; 3rd Floor

Decisions:

- ✓ The ScW/HR approved the May 14, 2019 meeting agenda.
- ✓ The ScW/HR approved the March 12, 2019 meeting minutes with no changes.
- ✓ The ScW/HR approved the SWFL Surveys project description to be sent to the EC for approval, and subsequently developed into a full SOW.

Action Items:

WHO	ACTION ITEM	BY WHEN
Chad McKenna and Grace Haggerty	Send Doodle poll for late May, habitat restoration-focused float trip to ScW/HR members	May 17th
All participants	Send suggestions for stops to be made during the habitat restoration field trips to Chad McKenna	May 24th
Chad McKenna and Grace Haggerty	Send information, including suggested gear, for the June 11th habitat restoration field trip (via vans)	May 28th
Clint Smith, Lori Walton, Vicky Ryan, Ashley Tanner	Convene small group to develop the SWFL Surveys SOW	June 2019

Next Meeting: TBD

Meeting Minutes

Welcome, Introductions, and Agenda Review
Ashley Tanner, Deputy Science Coordinator with Western EcoSystems Technology, Inc. (WEST), opened the meeting and reviewed the proposed meeting agenda.

> ➢ **DECISION:** The ScW/HR approved the May 14, 2019 meeting agenda with no changes.

Review of March 12, 2019 ScW/HR Meeting
Ashley T. reviewed the status of Action items from the March 12, 2019 meeting:

- Scope of Work (SOW) descriptions for project numbers 20, 41, and 77 were brought to the Executive Committee (EC) in March; all three were approved for development into full SOWs by the ScW/HR.
- Project #87 was moved forward to the Population Monitoring Work Group (PMWG) and the description was subsequently approved by the EC for further SOW development by the PMWG.
- Project descriptions were also sent to Brian Hobbs, Bureau of Reclamation (Reclamation); Brian H. is pursing funding for the Yellow-billed Cuckoo genetics project (#66) as a grant. YBCU genetic samples will be sourced from different universities starting in the near future.

  > ➢ **DECISION:** The ScW/HR approved the March 12, 2019 meeting minutes with no changes.

Annual Rio Grande Silvery Minnow (RGSM) Population Monitoring Presentation
Rob Dudley, American Southwest Ichthyological Researchers, LLC (ASIR), presented the results of the annual RGSM population monitoring efforts (coauthors Steve Platania, ASIR, and Gary White, Colorado State University).

During the presentation, Rob D. made the following points in response to questions from the ScW/HR:

- Adults are sampled before larval fish.
- When there is flooding, sampling begins upstream and continues downstream until quotas are met
- The population estimation study was funded by the Collaborative Program/Reclamation in the 2000s for six years. While Rob D. did not know for certain why the study ended, he noted that the trends for population estimation are similar to those of population monitoring.
- RGSM are capable of spawning within a year of hatching, but reproduction is not likely to occur until the age of one year.
- During years when overbanking occurs, sampling occurs along the margins/transitional zone; isolated regions are not sampled.
- There was a sharp drop in the rank abundance of RGSM in 2018. Contributing factors may have included the lack of spring runoff or spring runoff flashed, subsequently trapping fish.
- A long-term flow/inundation model would be useful in analysis of inundation sites.

SOW Updates and Project Description Review

Ashley T. discussed the background of the Southwestern Willow Flycatcher (SWFL) Surveys in the Belen Reach (handout provided). Beginning in 2019, SWFL presence/absence surveys in the Belen Reach were no longer be part of the annual SWFL surveying efforts in the MRG due to lack of funding. She asked the ScW/HR group if there was interest in developing a SOW to conduct surveys within this reach to provide continuity of valuable species distribution information.

Recommendations for involvement in developing the SOW included U.S. Fish and Wildlife Service (USFWS), Reclamation, and the Middle Rio Grande Conservancy District (MRGCD). Ashley T. suggested that Audubon be in the loop as well. There was a suggestion to add SWFL surveys in the Angostura reach as well. In consideration of cost, it was agreed that surveys in the Angostura reach could be an optional task in the SOW.

- **DECISION:** The ScW/HR approved the SWFL Surveys project description to be sent to the EC for approval, and subsequently developed into a full SOW by a small group including Clint Smith, Lori Walton, Vicky Ryan, and Ashley T.
- **ACTION:** Convene small group to develop the SWFL Surveys SOW

Additional Items and Next Meeting Date

Chad McKenna, GeoSystems Analysis (GSA), provided an update on the geodatabase of habitat restoration projects. He is working to integrate missing sites and is waiting on a few agencies to provide data. In the following week, he will merge what data has been provided and update attribute layers as much as possible. There are tentative plans for a workshop for interested participants in the Collaborative Program and the U.S. Geological Survey (USGS) in mid-June to solicit feedback on the database.

Chad M. also indicated that he and Grace H. from NMISC have been planning some field trips to visit habitat restoration sites, given the high flows this year. Chad M. offered to be the point of contact for these trips.

- A van trip on June 11th could incorporate different habitat restoration themes at various stops within the Albuquerque Reach, Sevilleta National Wildlife Refuge, and San Acacia Reach, including integrated discussions of long-term maintenance and monitoring.
- A float trip through the Albuquerque Reach could be scheduled for late May (gear can be provided).

    - **ACTION:** Send Doodle poll for late May, habitat restoration-focused float trip to ScW/HR members
    - **ACTION:** Send suggestions for stops to be made during the habitat restoration field trips to Chad McKenna
    - **ACTION:** Send information, including suggested gear, for the June 11th habitat restoration field trip (via vans)

Ashley T. notified the work group that the ScW/HR is not likely to meet during the summer field season, but there will be small group meetings. Ashley T. will send a doodle poll when SOWs are ready for discussion. Otherwise, contact Ashley T. if the need for a meeting is identified.

Meeting Participants

Participant	Organization
Jen Bachus	U.S. Bureau of Reclamation
Adam Barkalow	American Southwest Ichthyological Researchers, LLC
Robert Dudley	American Southwest Ichthyological Researchers, LLC
Kim Fike	Bosque Ecosystem Monitoring Project
Lynette Giesen	U.S. Army Corps of Engineers
Grace Haggerty	New Mexico Interstate Stream Commission
Alison Hutson	New Mexico Interstate Stream Commission
Joel Lusk	U.S. Fish and Wildlife Service
Kathy Lang	City of Albuquerque BioPark
Chad McKenna	GeoSystems Analysis, Inc.
Kate Mendoza	Albuquerque Bernalillo County Water Utility Authority
Matthew Peterson	City of Albuquerque Open Space
Dana Price	U. S. Army Corps of Engineers
Justin Reale	U. S. Army Corps of Engineers
Rich Valdez	SWCA Environmental Consultants
Janet Armstead	Western EcoSystems Technology, Inc.
Debbie Lee	Western EcoSystems Technology, Inc.
Ashley Tanner	Western EcoSystems Technology, Inc.

Insights from Long-term, High Frequency, Water Quality Monitoring in the MRG

May 14th, 2019 MRGESA Collaborative Program

David J. Van Horn, Clifford N. Dahm - Department of Biology;
University of New Mexico, USA

US Army Corps of Engineers ®

THE UNIVERSITY *of* NEW MEXICO

Talk Outline

1) Previous water quality sampling studies in the MRG
2) Introduction to the instruments and field sites
3) Introduction to the data
4) Three water quality stories:
    a. Forest fire impacts
    b. Urban versus non-urban stormwater impacts
    c. Whole stream metabolism

Previous Water Quality Studies in the MRG

WATER-QUALITY ASSESSMENT OF THE RIO GRANDE VALLEY STUDY UNIT, COLORADO, NEW MEXICO, AND TEXAS--ANALYSIS OF SELECTED NUTRIENT, SUSPENDED-SEDIMENT, AND PESTICIDE DATA

By S.K. Anderholm, M.J. Radell, and S.F. Richey

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

By Denis F. Healy

Nutrient and organic carbon trends and patterns in the upper Rio Grande, 1975–1999

Howard D. Passell[a,*], Clifford N. Dahm[b], Edward J. Bedrick[c]

Science of the Total Environment

An International Journal for Scientific Research into the Environment and its Relationship with Humankind

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NITROGEN SOURCES AND SINKS WITHIN THE MIDDLE RIO GRANDE, NEW MEXICO[1]

Gretchen P. Oelsner, Paul D. Brooks, and James F. Hogan[2]

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

AMERICAN WATER RESOURCES ASSOCIATION

USACE - Continuous Water Quality Monitoring Network for the Middle Rio Grande

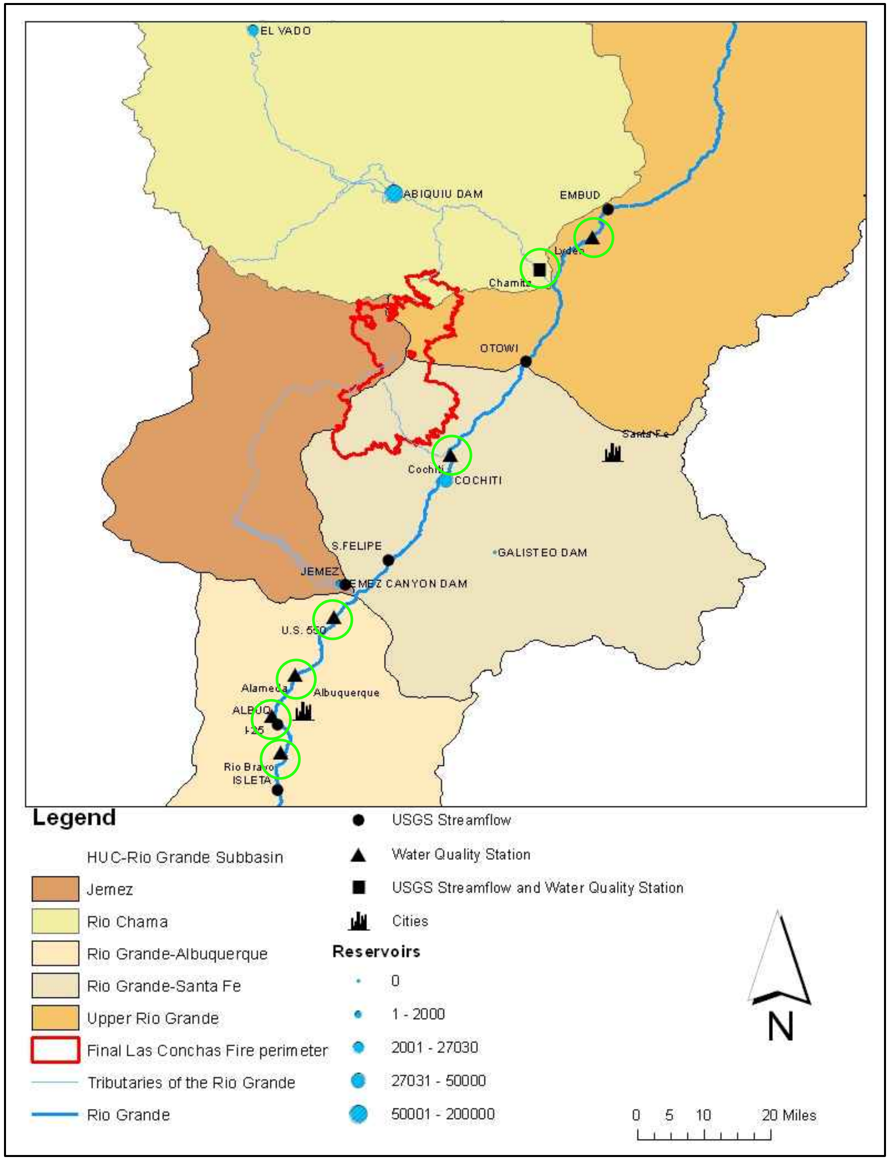
History: 2006 – Present

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

Methods: Continuous water quality collection in the Abq. reach of the MRG since 2006,three sites added above Cochiti Reservoir in 2012.

Continuous Water Quality Instrumentation

Study Sites


EL VADO
ABIQUIU DAM
EMBUD
Chamita
OTOWI
Santa Fe
COCHITI
S.FELIPE
GALISTEO DAM
JEMEZ
JEMEZ CANYON DAM
Alameda
Albuquerque
Rio Bravo
ISLETA
Legend
HUC-Rio Grande Subbasin
Jemez
Rio Chama
Rio Grande-Albuquerque
Rio Grande-Santa Fe
Upper Rio Grande
Final Las Conchas Fire perimeter
Tributaries of the Rio Grande
Rio Grande
USGS Streamflow
Water Quality Station
USGS Streamflow and Water Quality Station
Cities
Reservoirs
0
1 - 2000
2001 - 27030
27031 - 50000
50001 - 200000
N
0 5 10 20 Miles

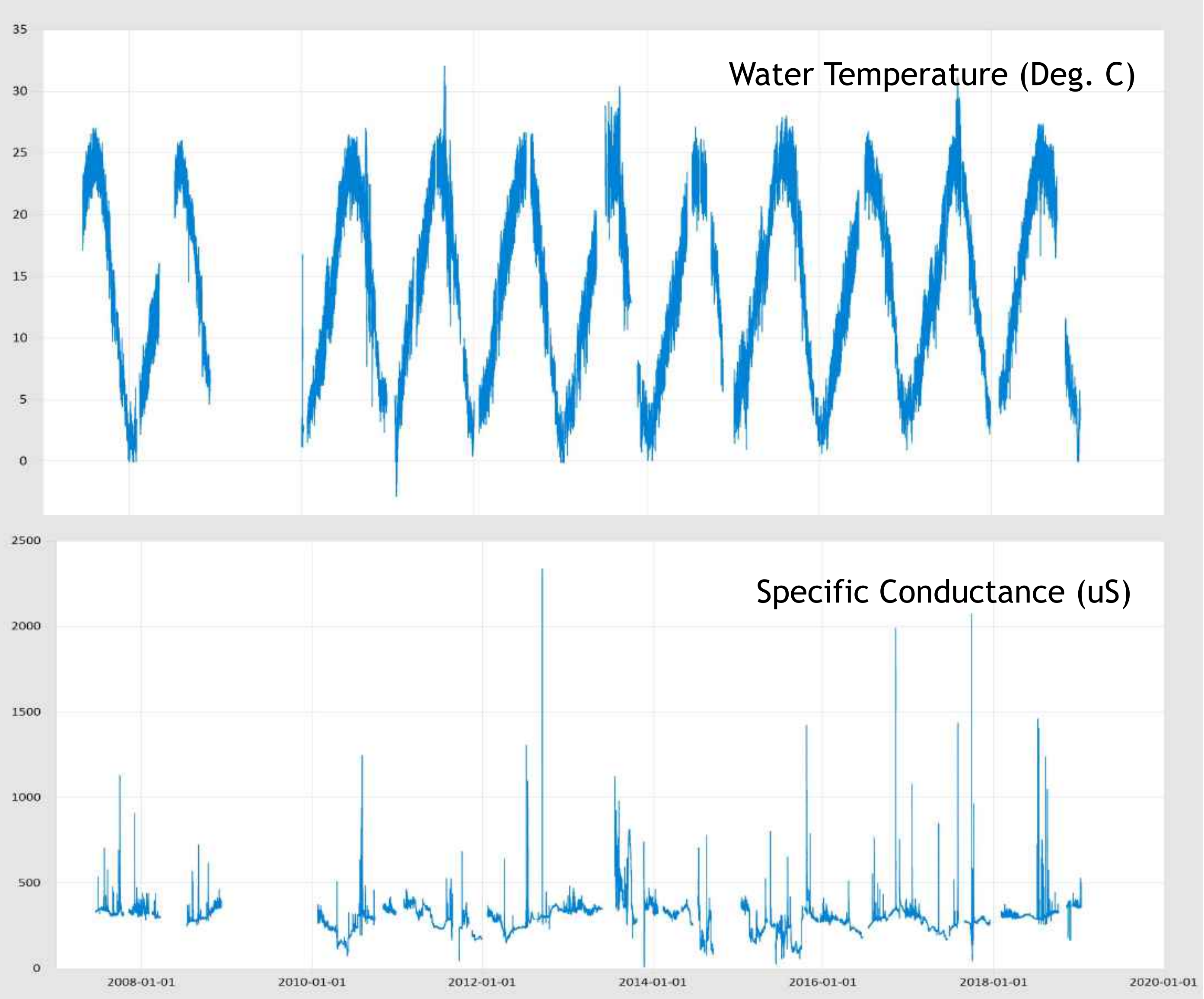
Study Sites

Study Sites

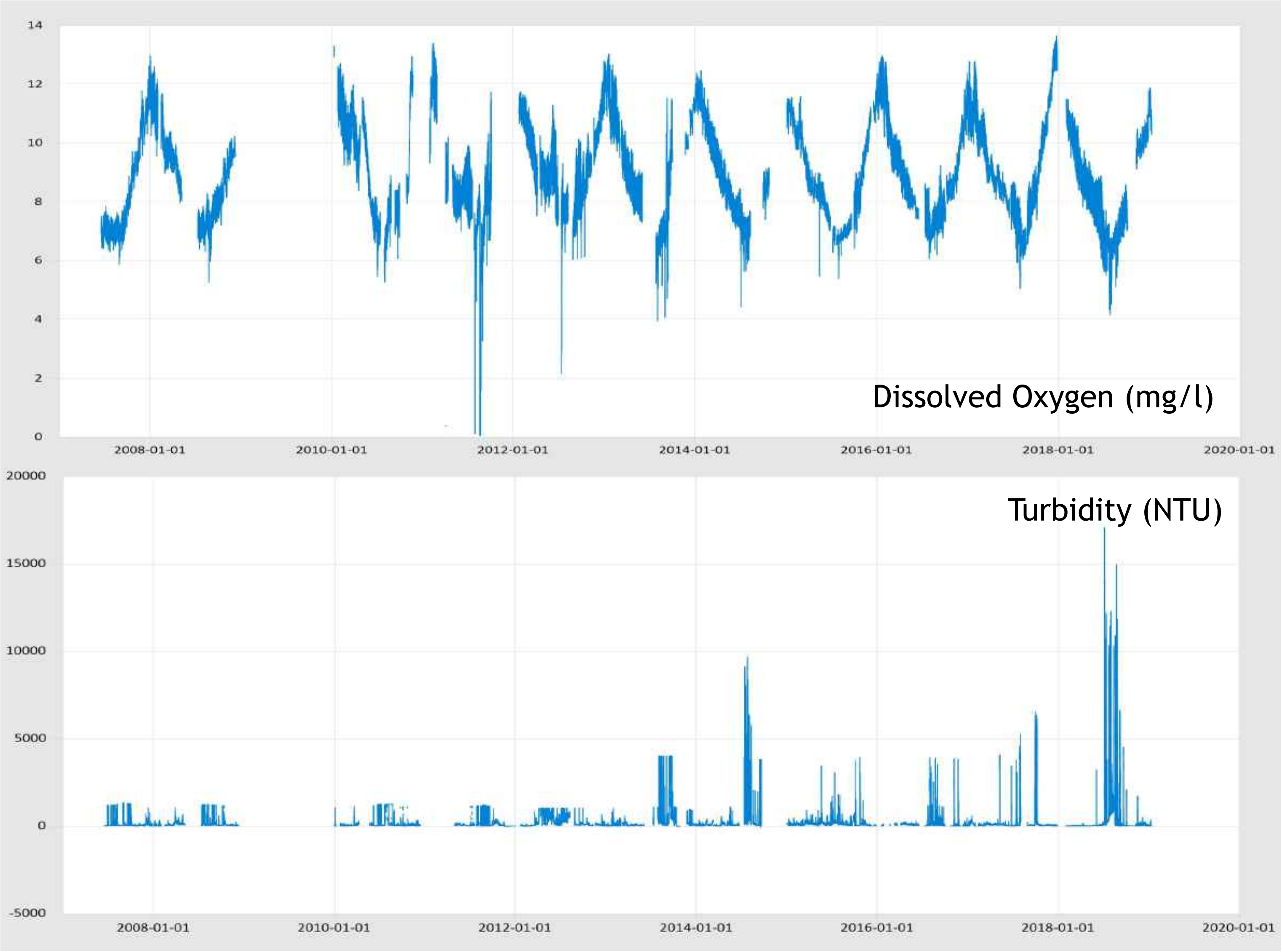
Study Sites

Study Sites

Data – Bernalillo 550

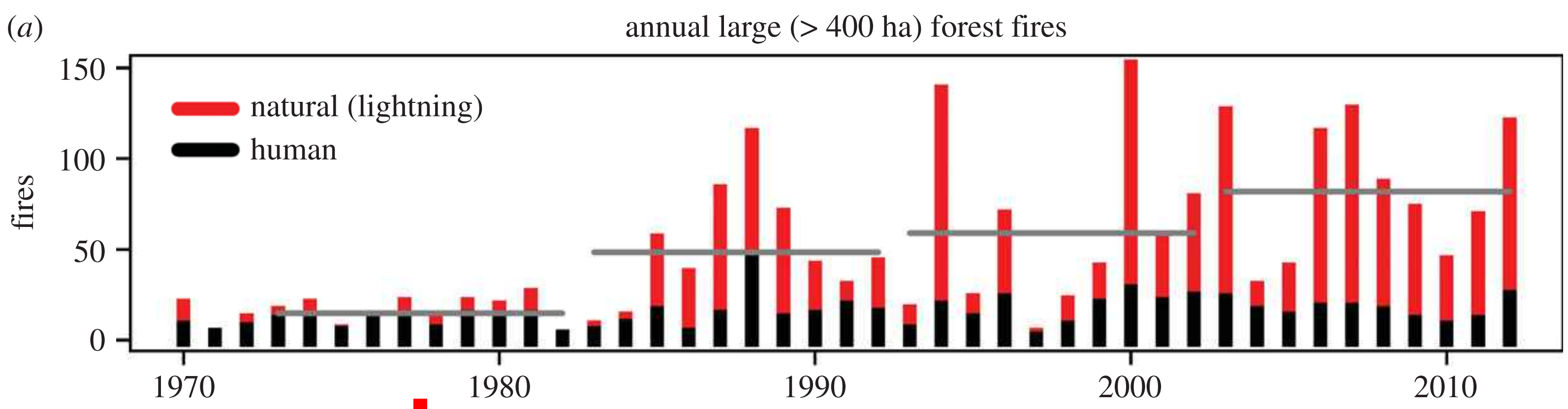


Data – Bernalillo 550

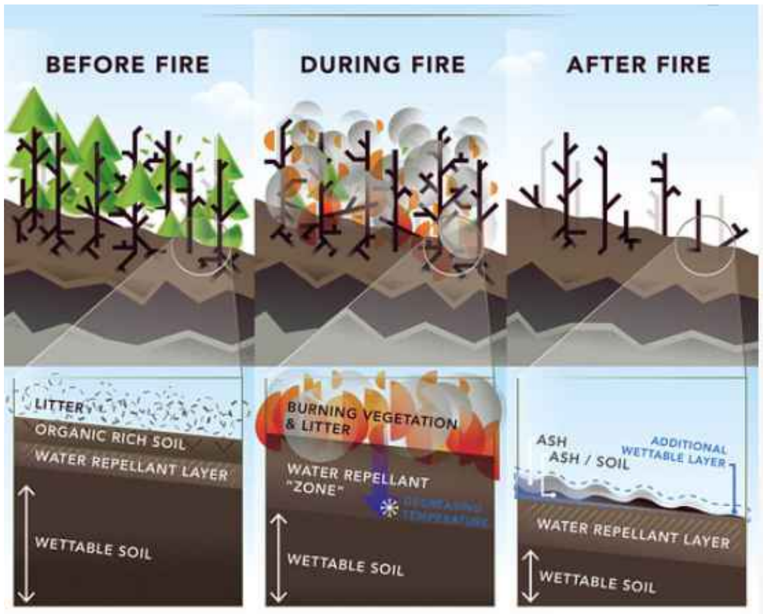


Wildfire Impacts to WQ in the MRG

Wildfire Background



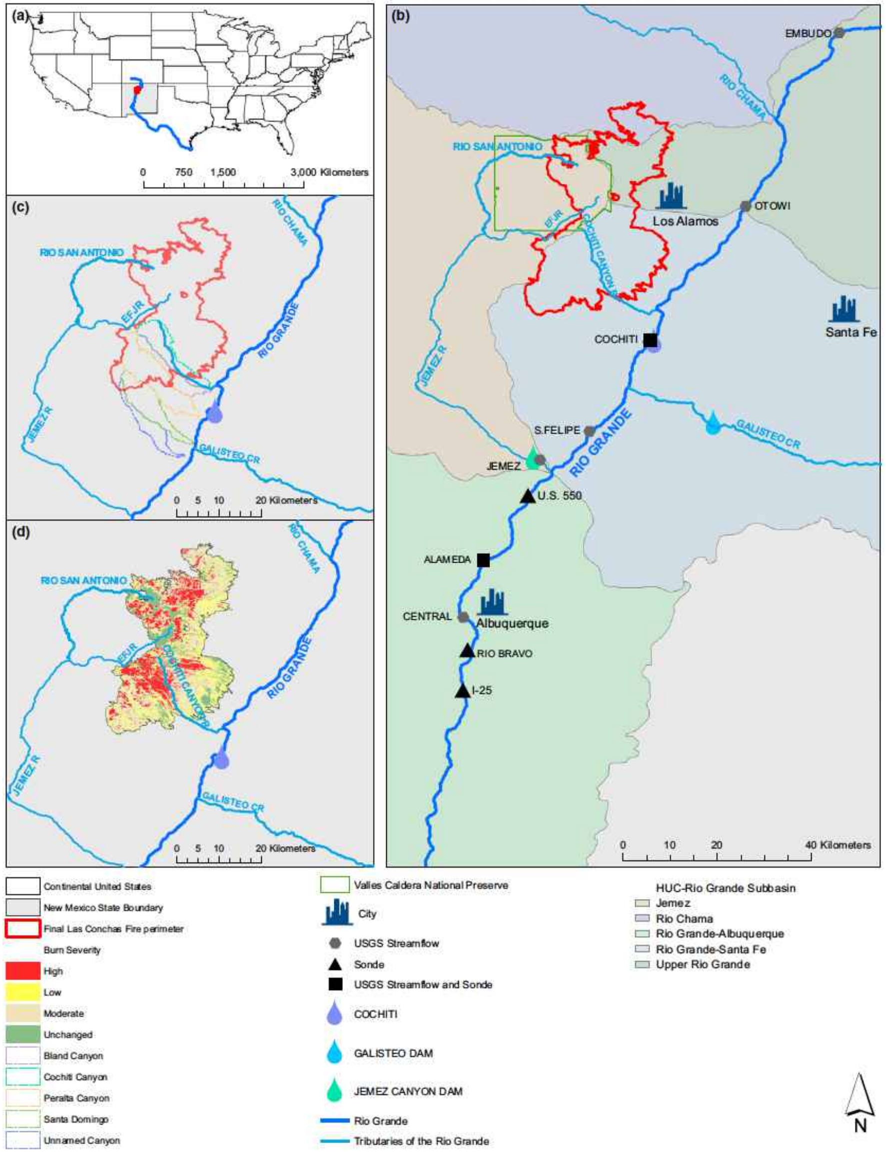
Westerling et al. 2016



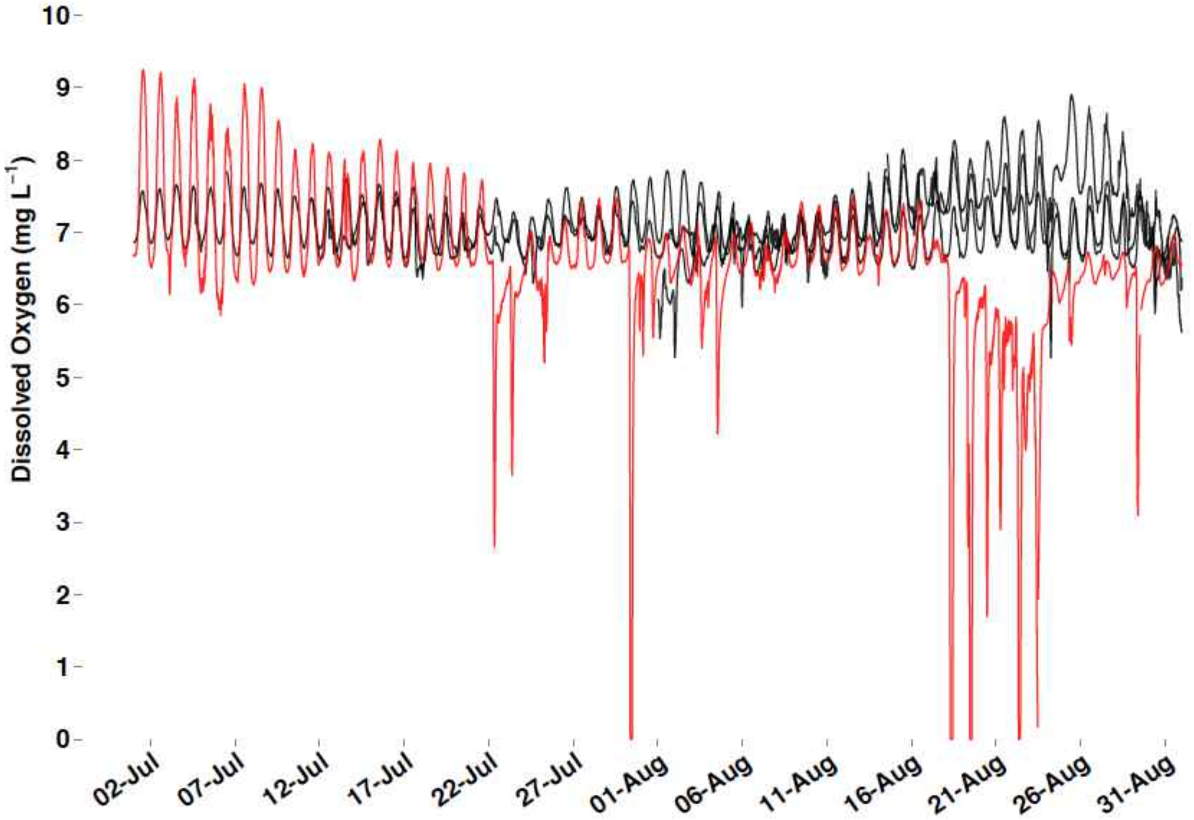
Las Conchas Fire –2011

Cochiti Canyon Video

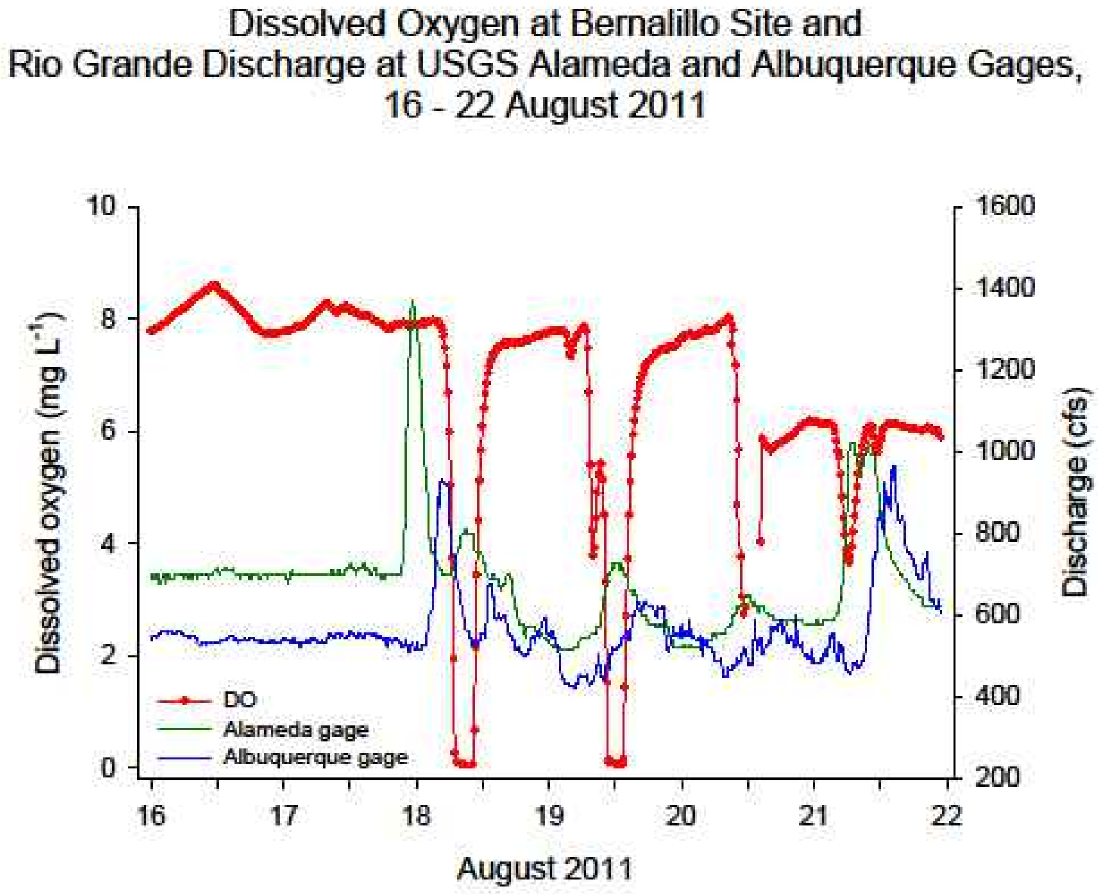
Study Design



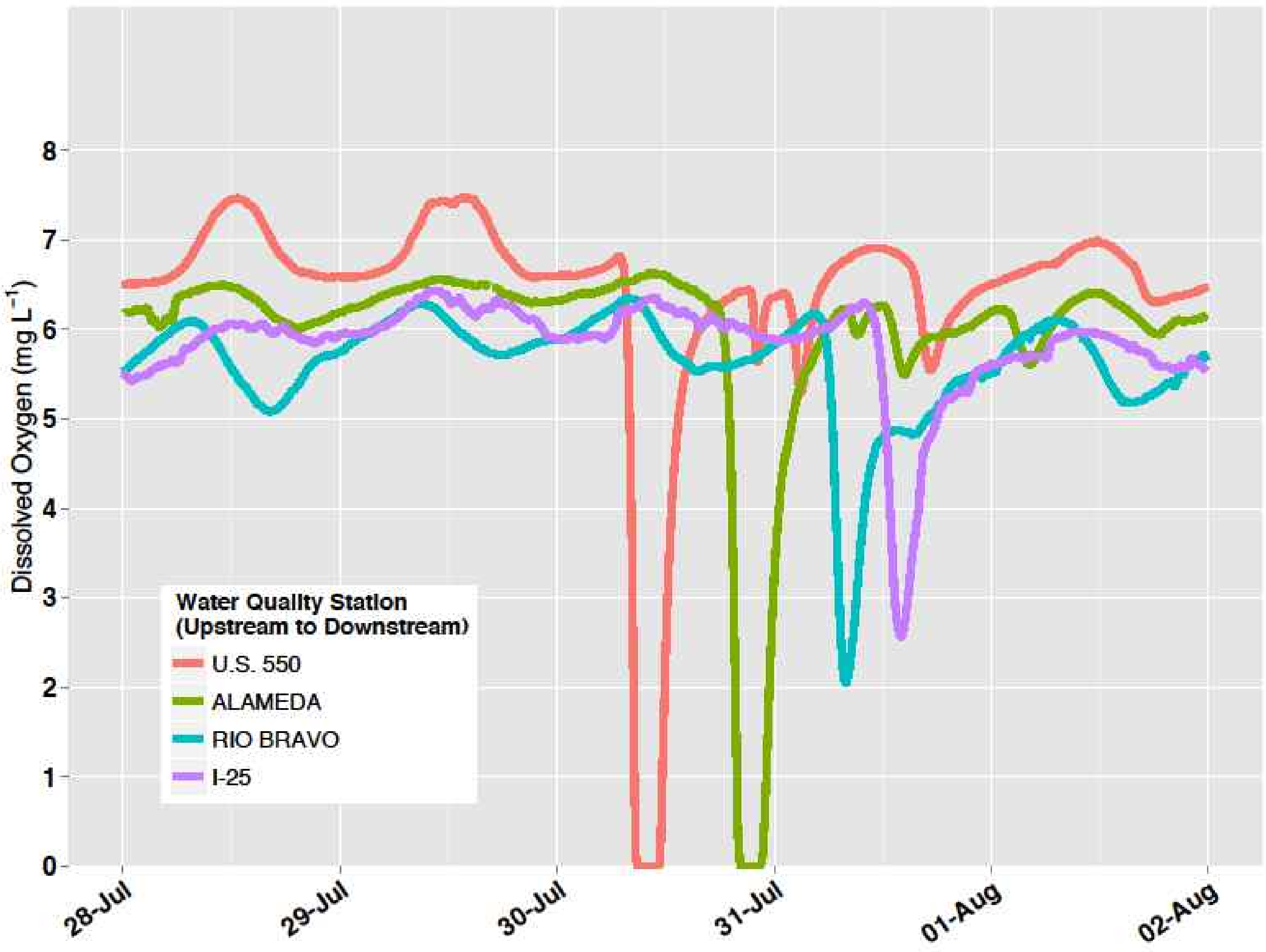
Post Fire DO - 2011



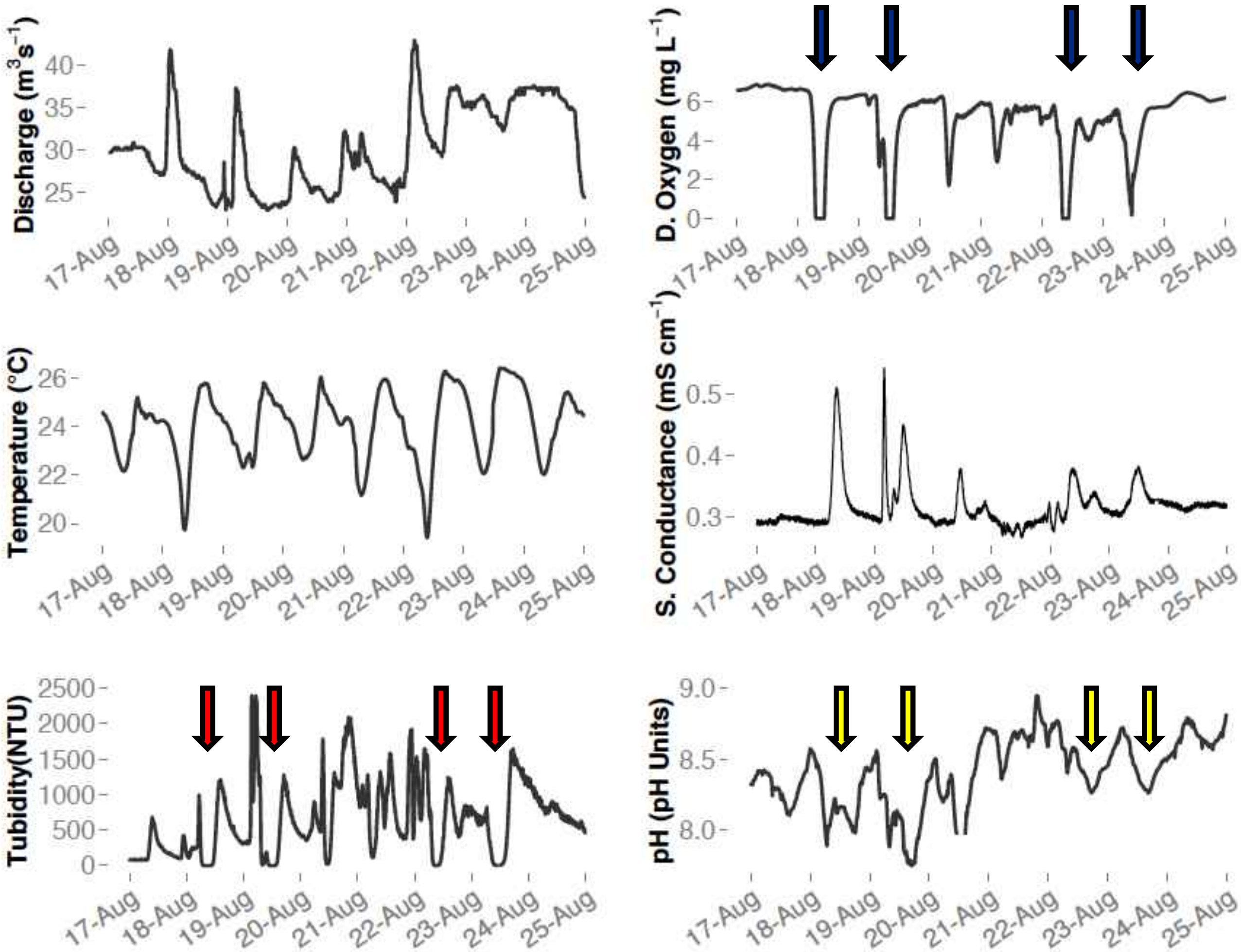
Post Fire DO - 2011



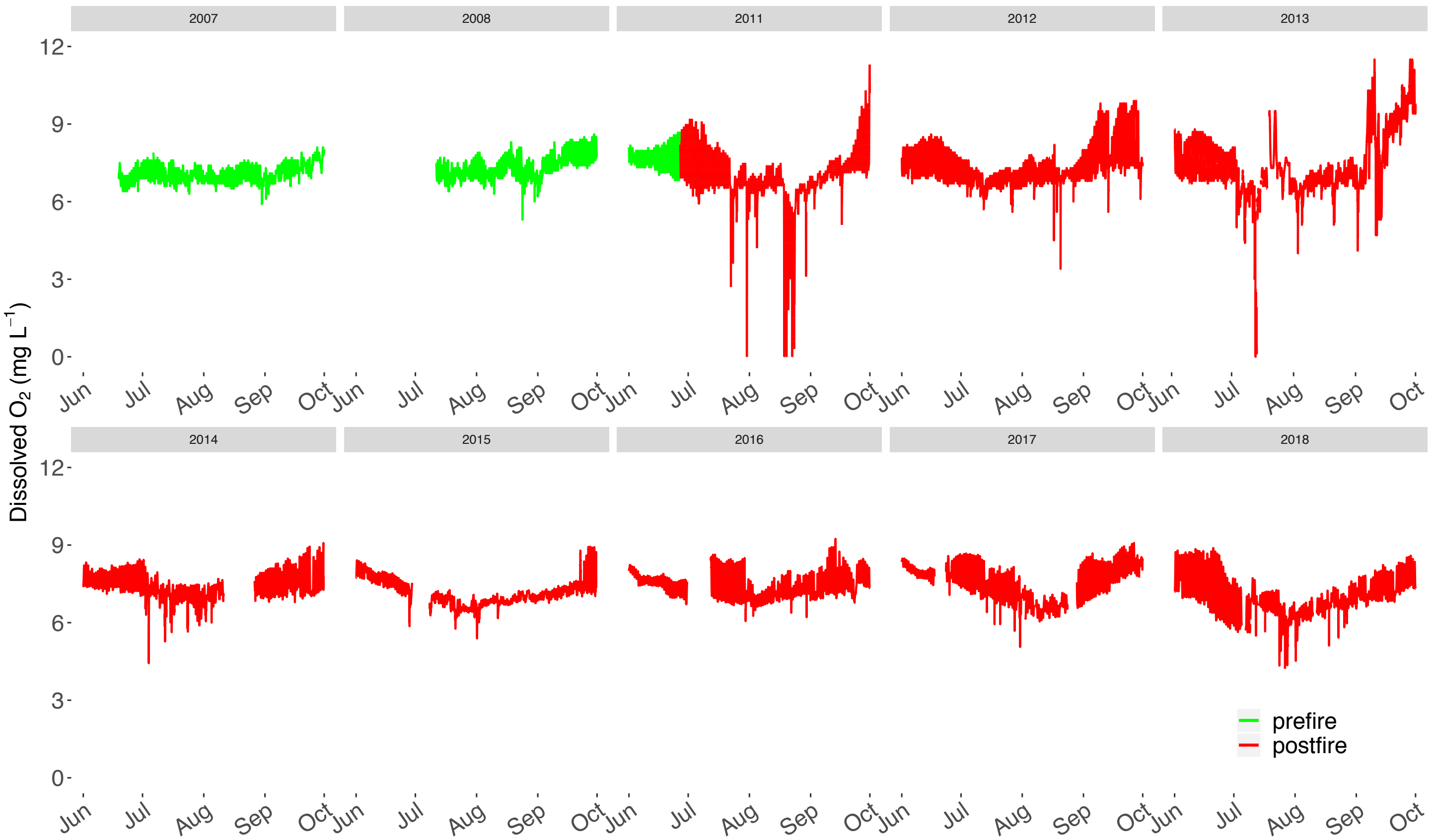
Post Fire DO - 2011



Post Fire WQ - 2011



Post Fire DO Recovery - 2007 to 2018



Wildfire WQ Implications for MRG Biota

Severe water quality excursions

- Prior to the Las Conchas fire DO in the MRG rarely declined below 6 mg/l
- Following the fire, numerous DO sags down to 0 mg/l
- The LC50 for DO for the MRG Silvery Minnow is ~0.8mg/l, and most of the mortality occurs within the first 3-8 hours
- Impacts occur at distant, downstream locations, impacted large reaches of the river, and are persistent for at least three years post-fire

Freshwater Biology
Freshwater Biology (2015) doi:10.1111/fwb.12548

Extreme water quality degradation following a catastrophic forest fire

CLIFFORD N. DAHM*, ROXANNE I. CANDELARIA-LEY*, CHELSEA S. REALE†, JUSTIN K. REALE* AND DAVID J. VAN HORN*
*Department of Biology, University of New Mexico, Albuquerque, NM, U.S.A.
†Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM, U.S.A.

FIRE ECOLOGY

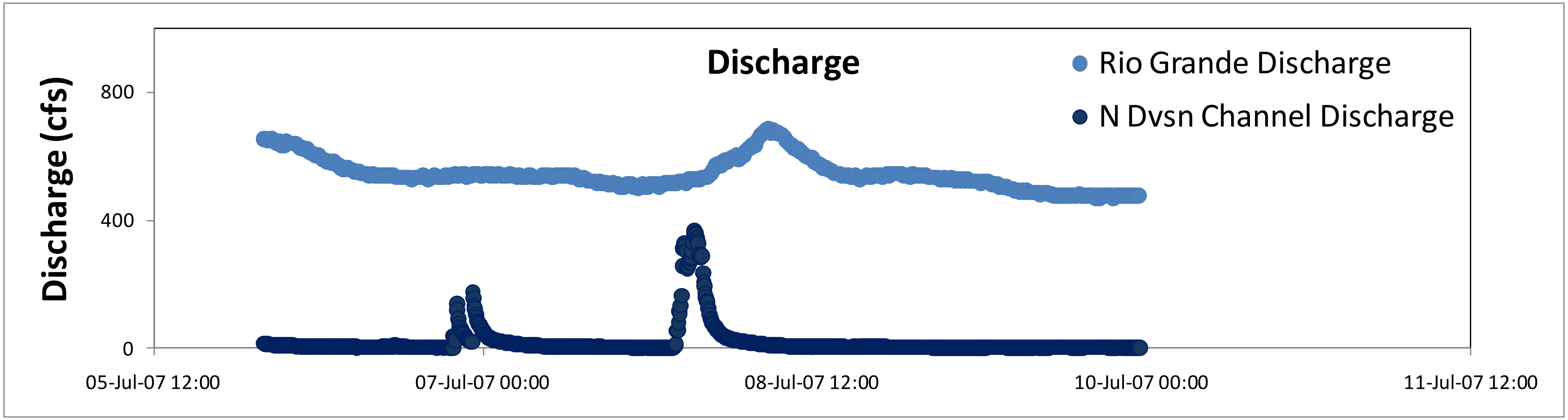
The effects of catastrophic wildfire on water quality along a river continuum

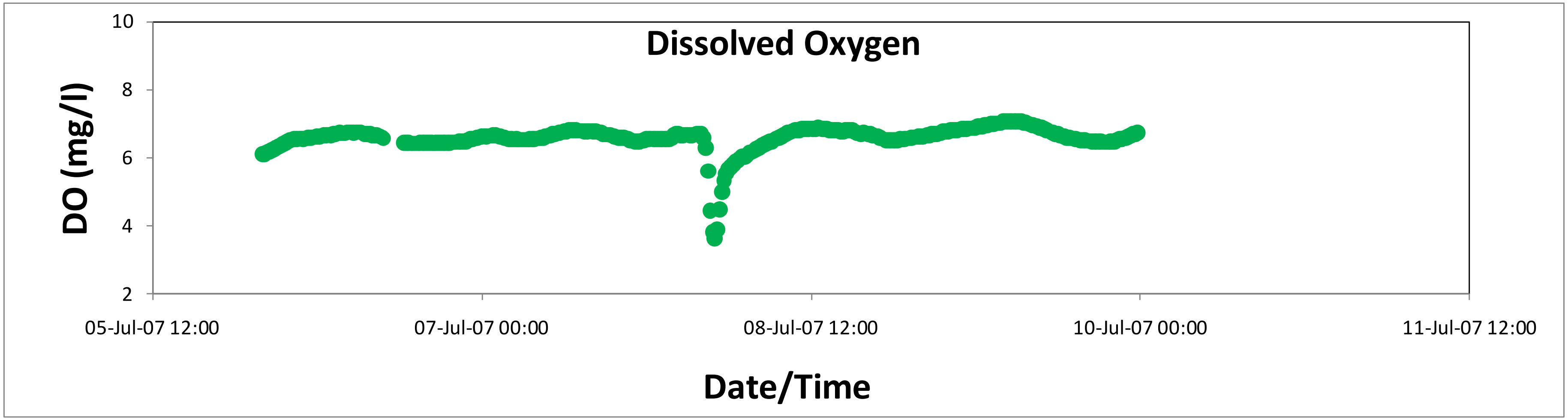
Justin K. Reale[1,2,4], David J. Van Horn[1,5], Katherine E. Condon[3,6], and Clifford N. Dahm[1,7]
[1]Department of Biology, University of New Mexico, Albuquerque, New Mexico 87131 USA
[2]US Army Corps of Engineers, Albuquerque, New Mexico 87109 USA
[3]Valles Caldera National Preserve, Jemez Springs, New Mexico 87025 USA

Stormwater Impacts to WQ in the MRG

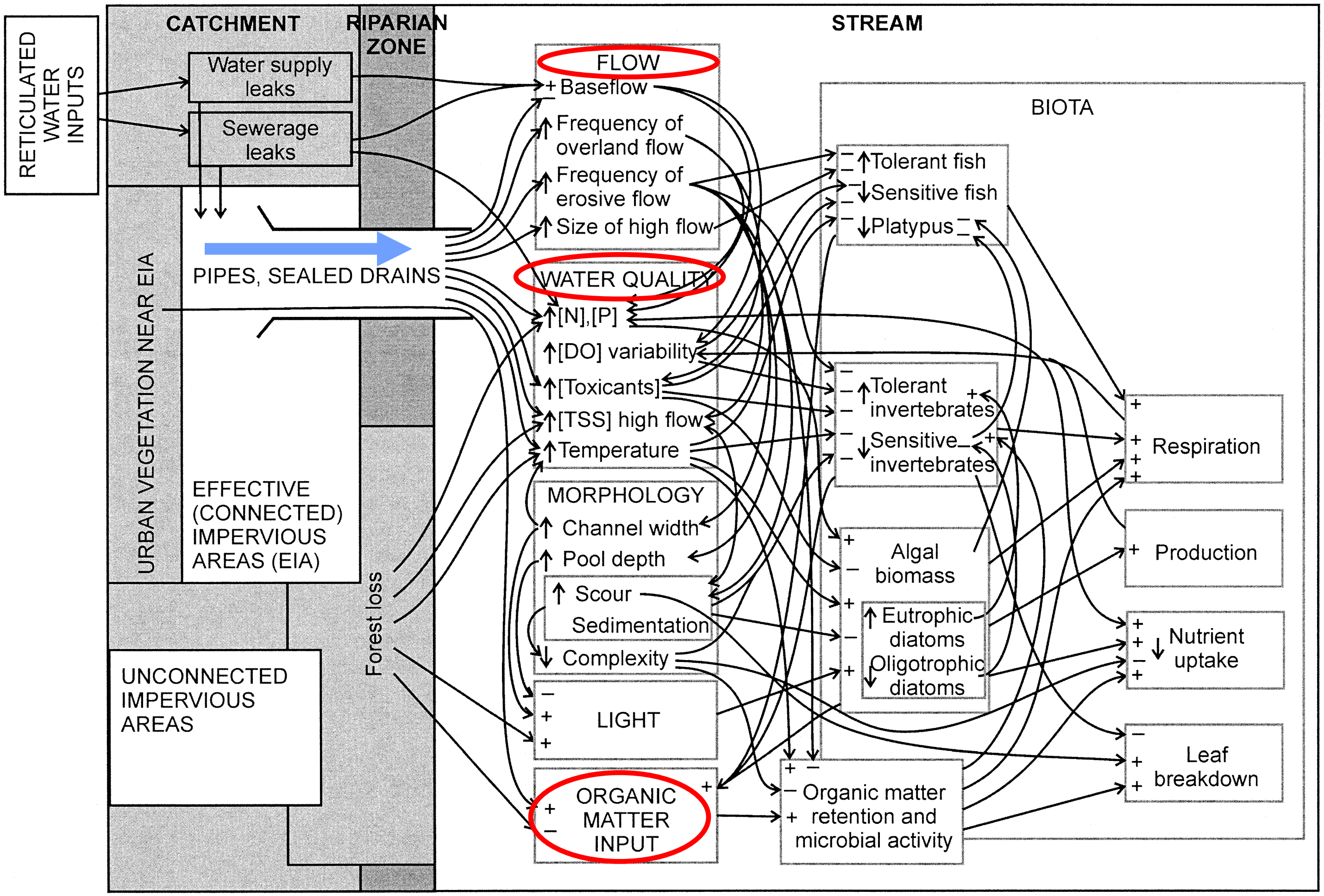
NDC – 21MAY18

Episodic Events in the MRG - 2007



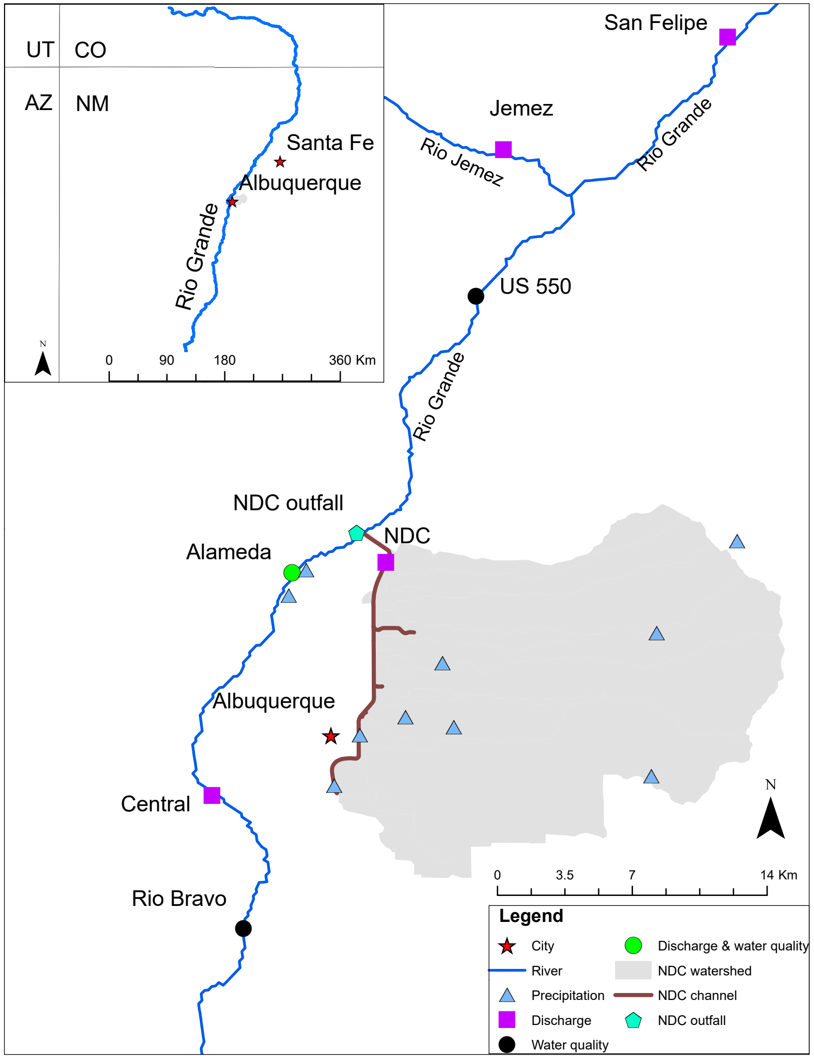


Stormwater Background - Urban Stream Syndrome

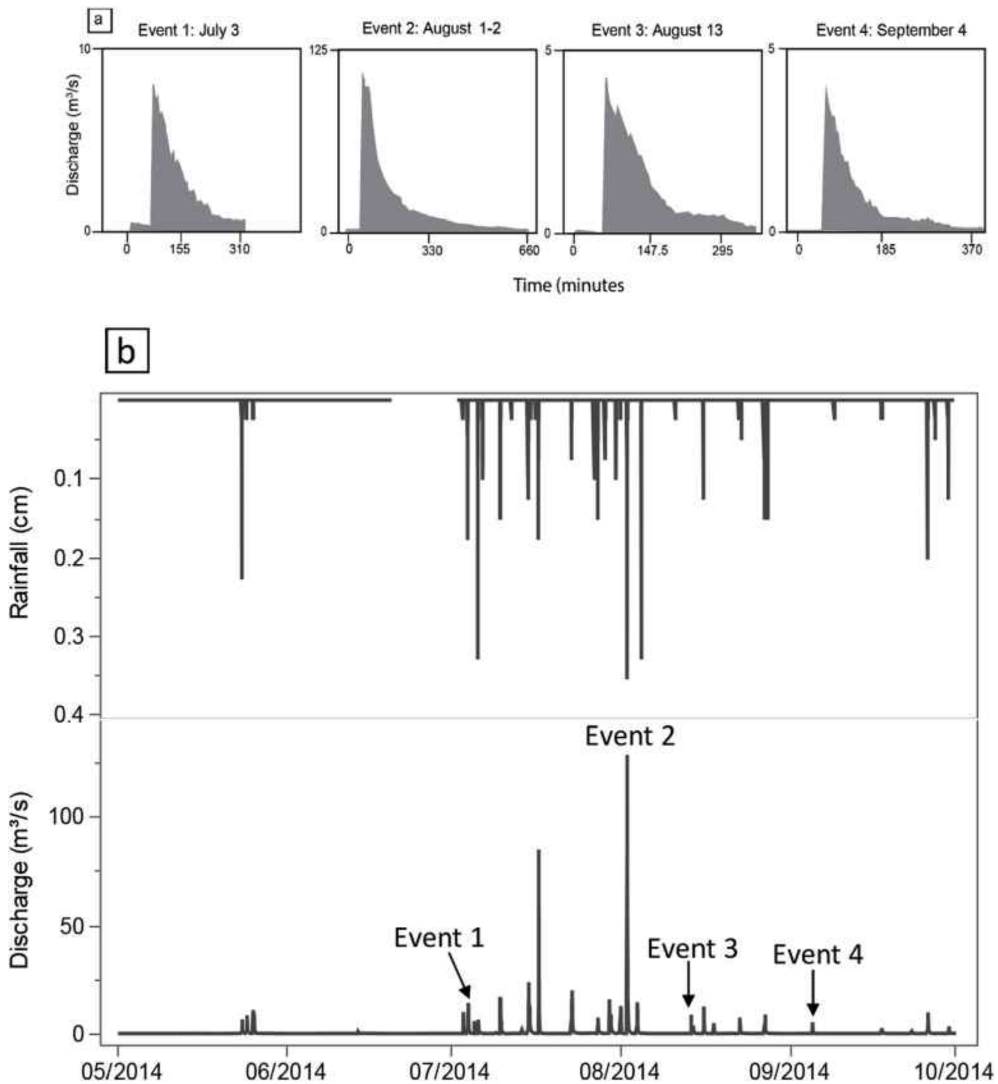


Walsh et al. 2005

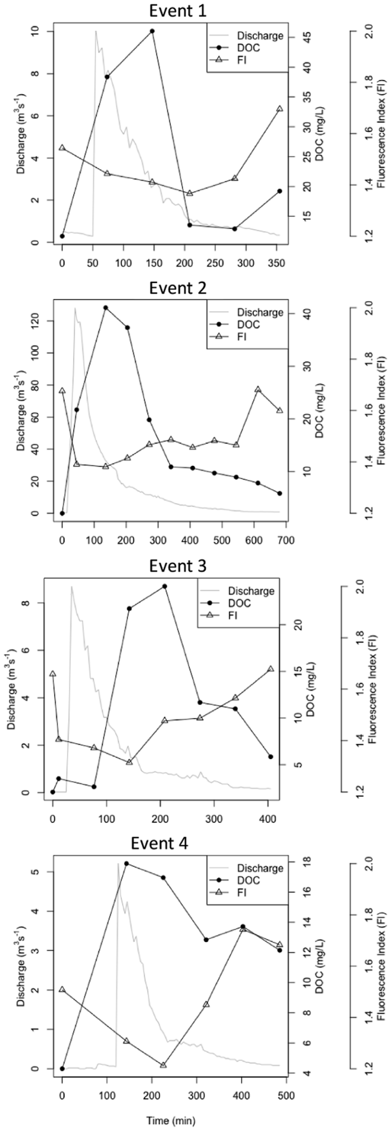
Study Design

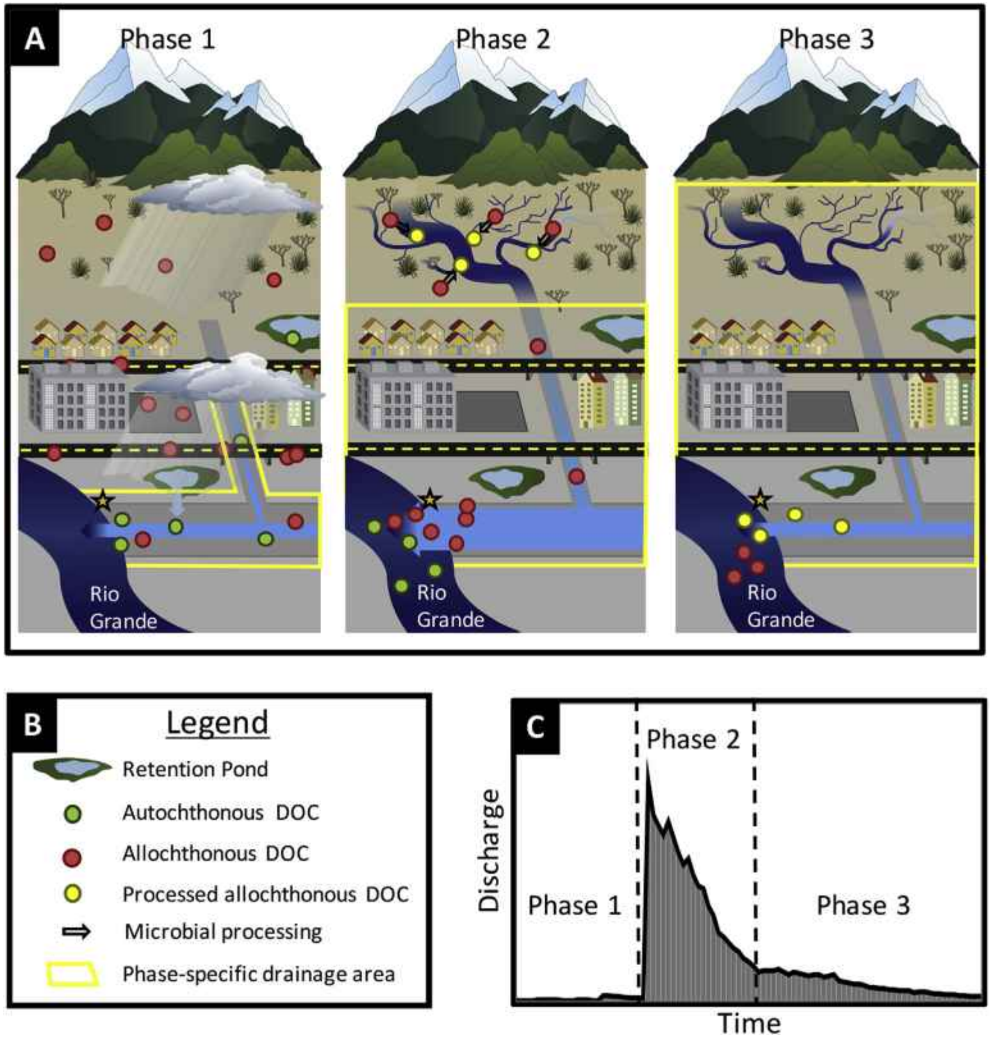


Storms Sampled - 2014

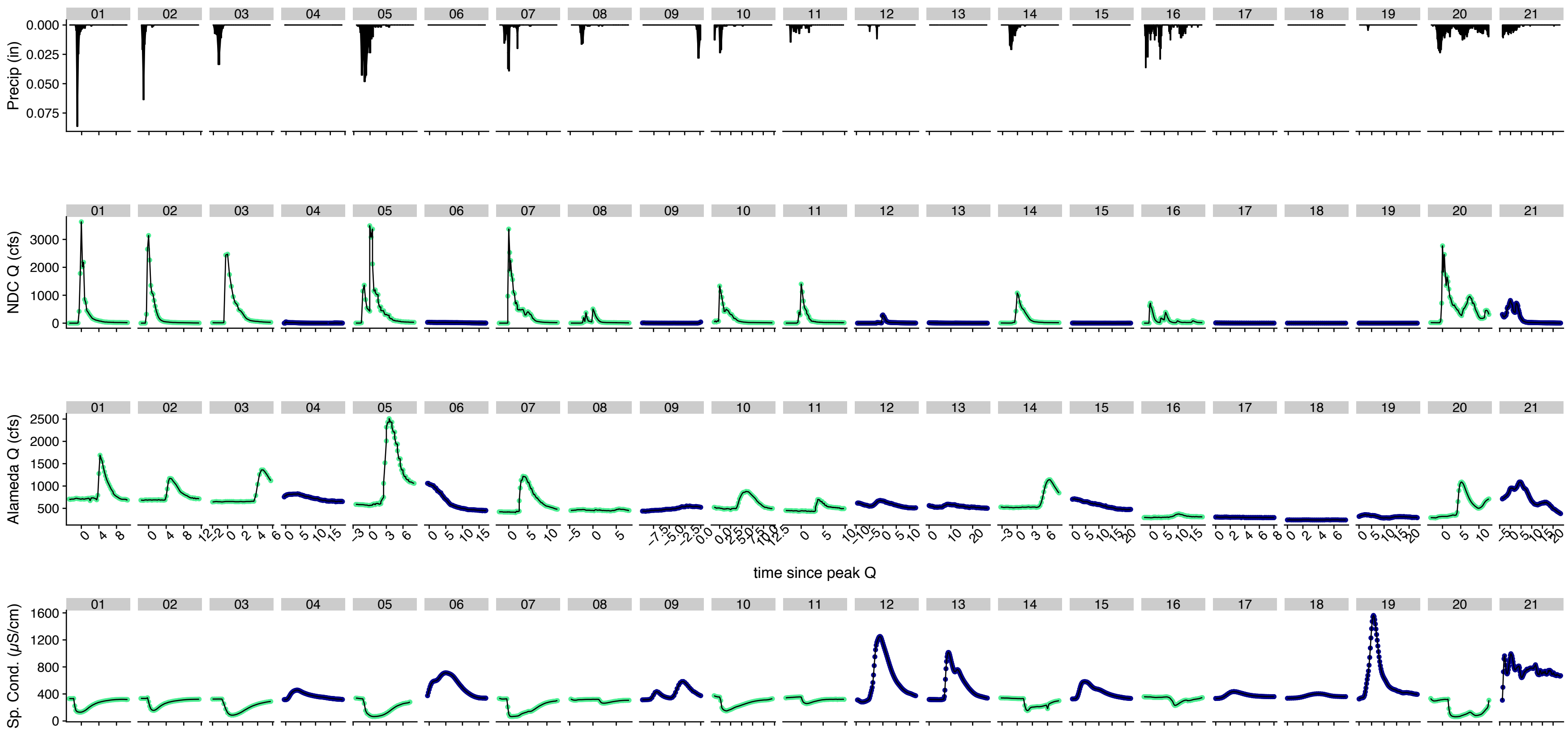


DOM Data - 2014

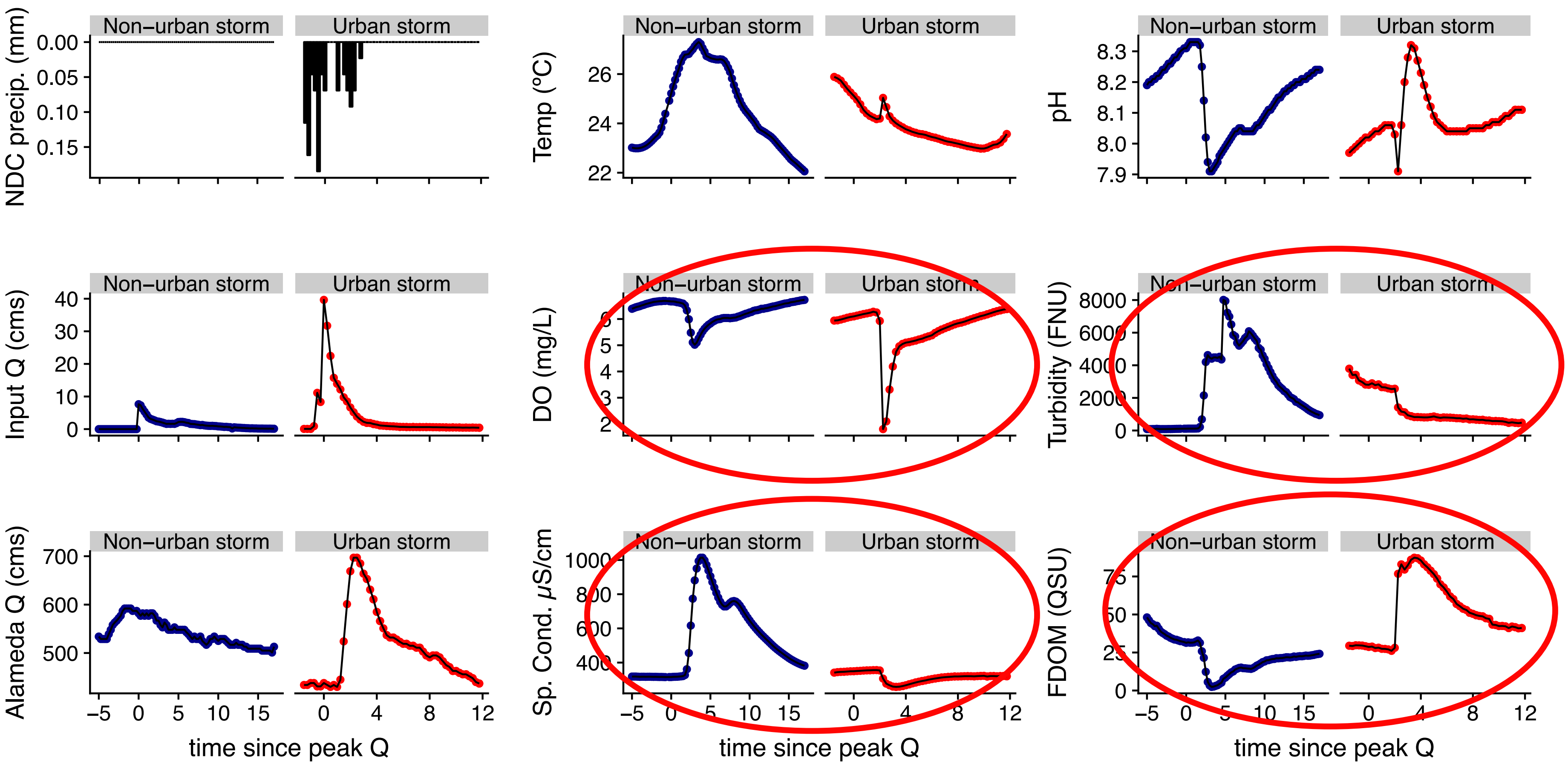




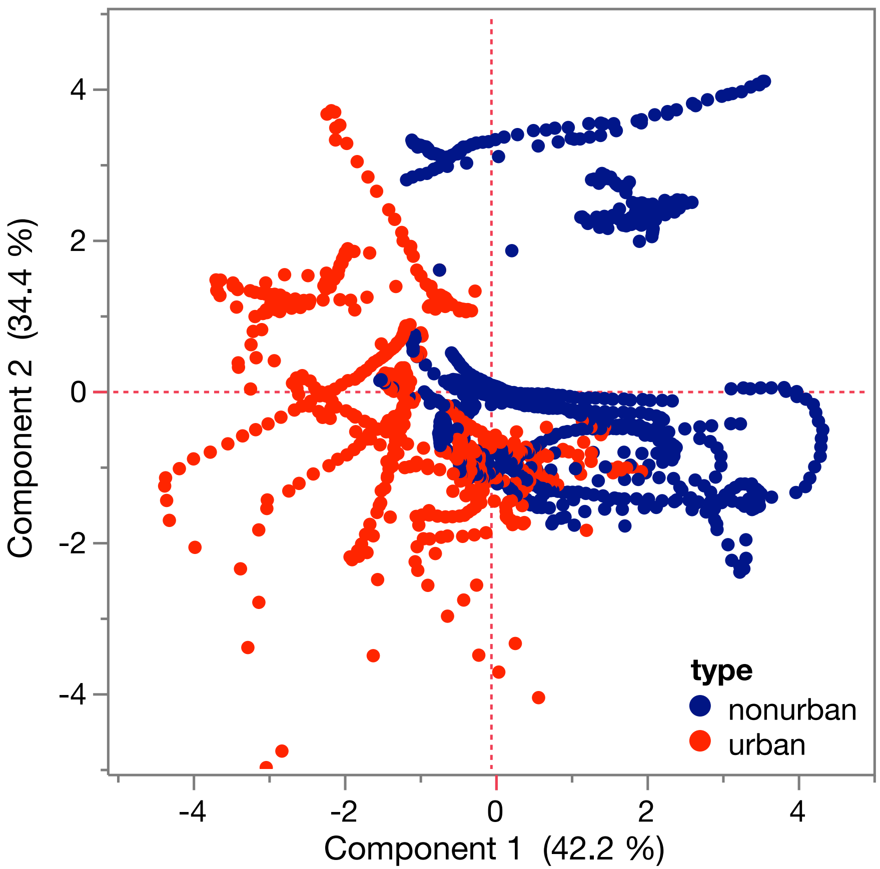
Storms Sampled - 2018

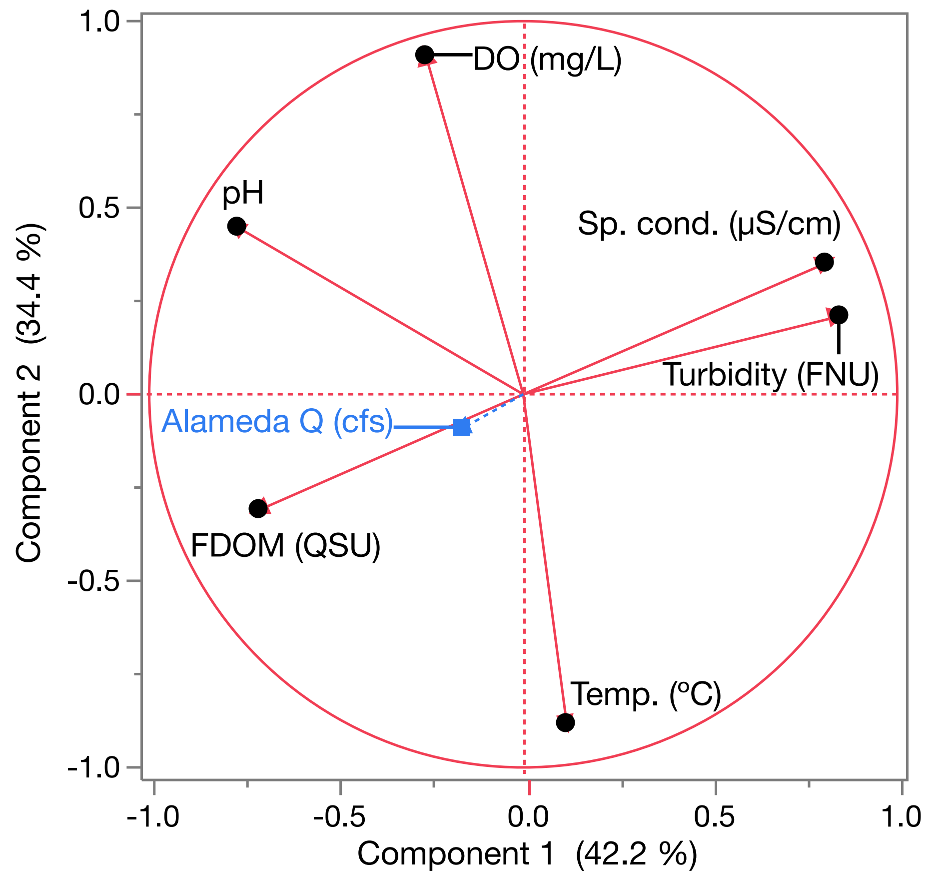


Water Quality Data - 2018

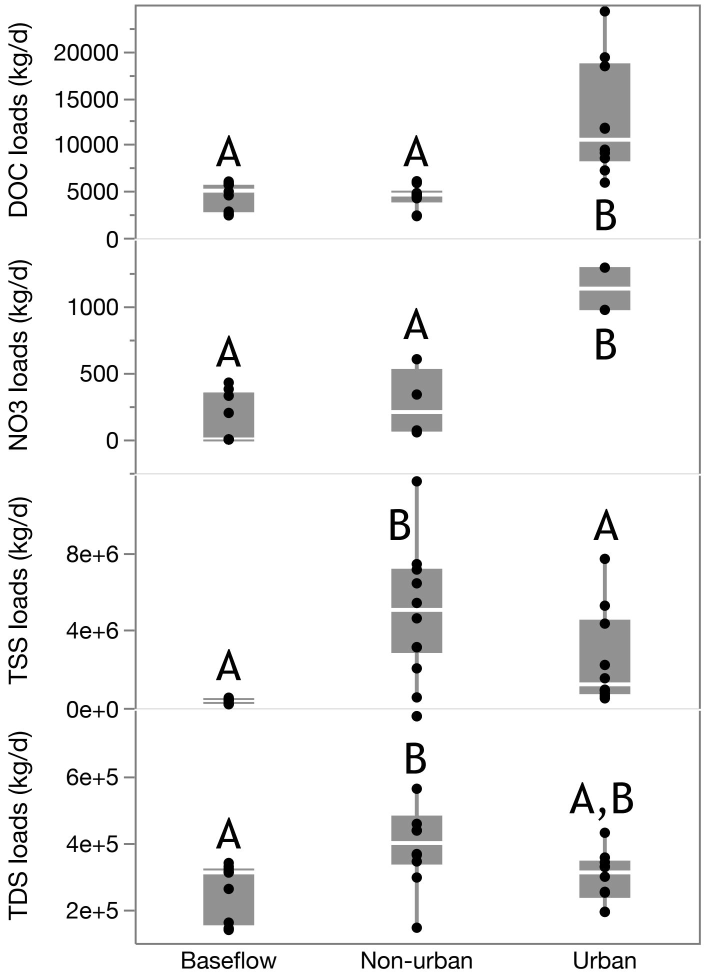


Water Quality Data - 2018

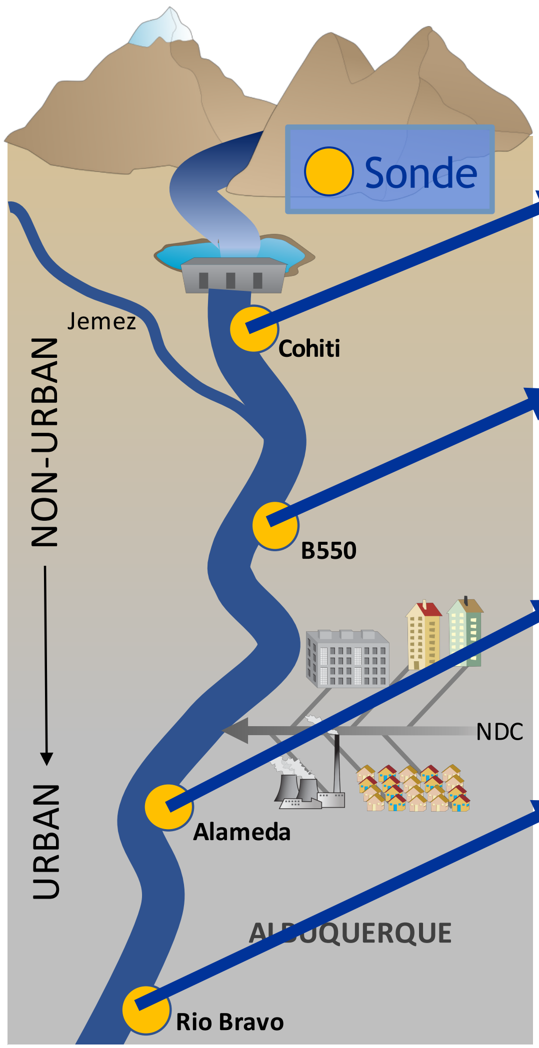


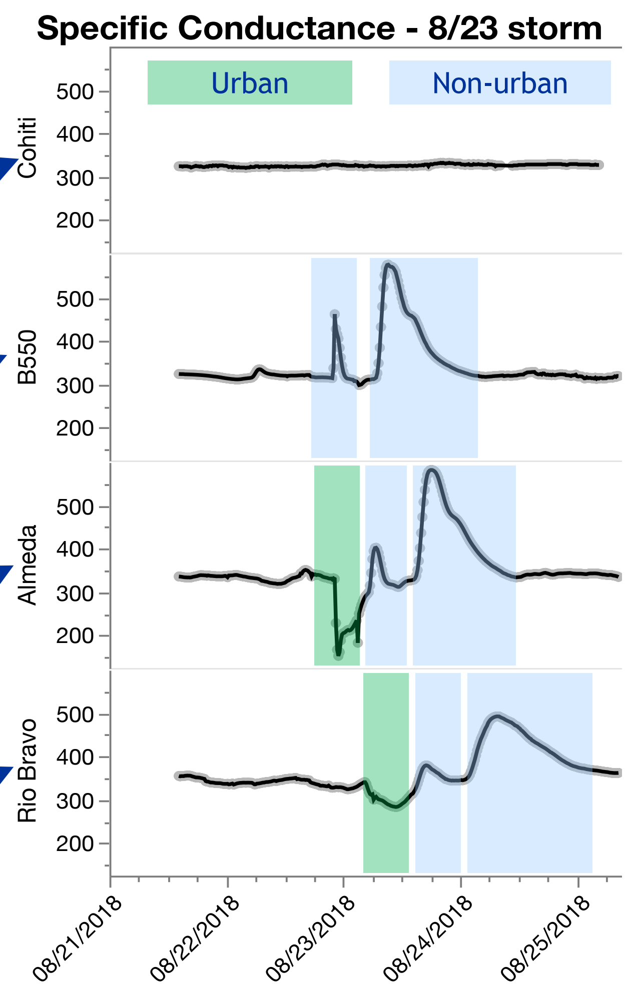


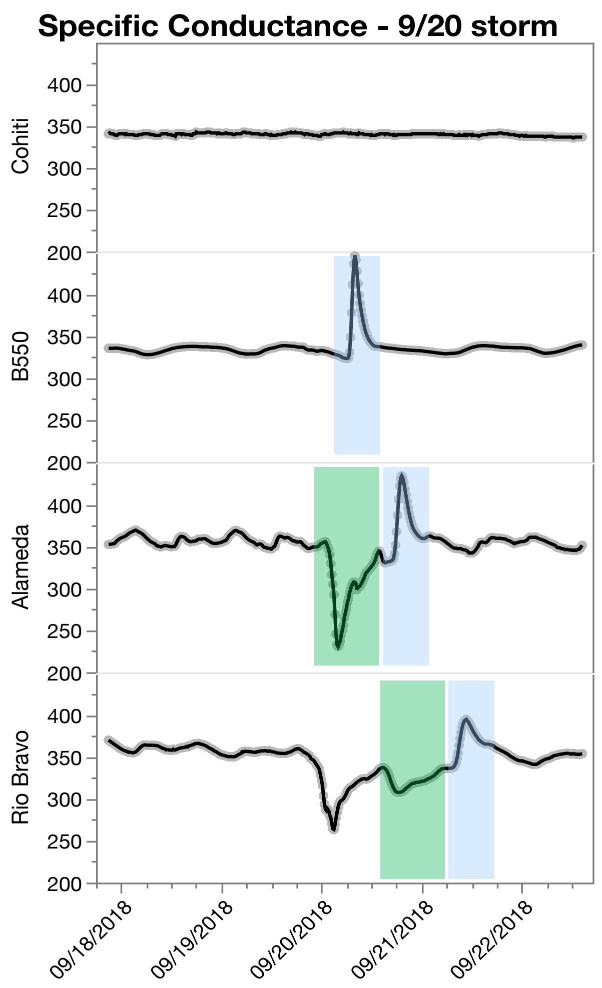
Water Quality Data - 2018



Water Quality Data – 2018







Stormwater Quality Implications for MRG Biota

Urban stormwater impacts to MRG water quality

- Frequent DO sags below the MRG Silvery Minnow No Acute Lethal Concentration (~4 mg/l)
- Large point-source input of resources including allochthonous DOC and nitrate
- During monsoon inputs flows from the NDC constitute the vast majority of the water in the river

Non-urban stormwater impacts to MRG water quality

- Large dissolved solids and suspended sediment loads
- Minimal impact to DO and resource availability

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Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Dissolved organic matter dynamics in storm water runoff in a dryland urban region

Julia L. Wise[a,c], David J. Van Horn[b,*], Aaron F. Diefendorf[a], Peter J. Regier[d], Thomas V. Lowell[a], Clifford N. Dahm[b]

[a] Department of Geology, University of Cincinnati, USA
[b] Department of Biology, University of New Mexico, USA
[c] Office of Science and Technology, State of New Mexico, USA
[d] Center for Water and the Environment, University of New Mexico, USA

Urban and non-urban storm water chemistry in the Rio Grande

Authors: Peter J. Regier[1], Ricardo González-Pinzón[1], Justin K. Reale[2], David J. Van Horn[3]

[1] Department of Civil Engineering, University of New Mexico, Albuquerque, NM, U.S.A.
[2] U.S. Army Corps of Engineers, Albuquerque, NM, U.S.A.
[3] Department of Biology, University of New Mexico, Albuquerque, NM, U.S.A.

Estimating Whole Stream Metabolism in the MRG

Whole Stream Metabolism Background

Governing equation:

$$\frac{dO_2}{dt} = GPP + ER + K$$

GPP = gross primary production

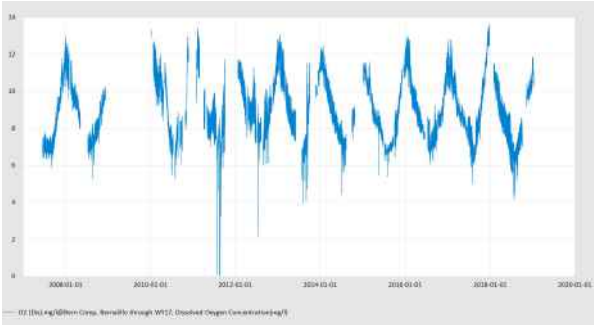
$$GPP = AI^p$$

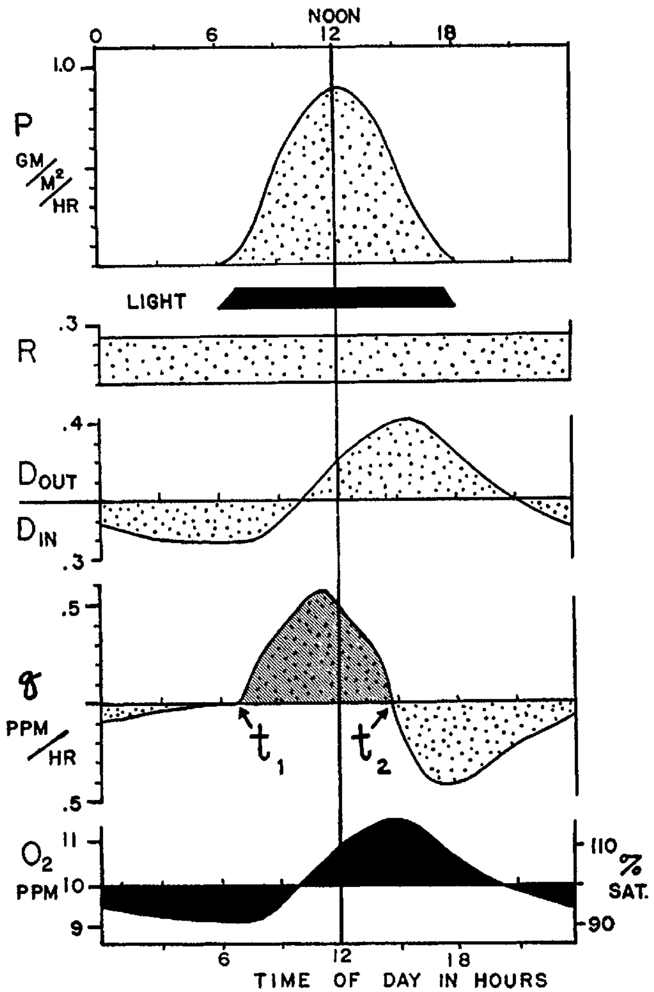
ER = ecosystem respiration (negative)

$$ER = R_a + R_h$$

K = reaeration

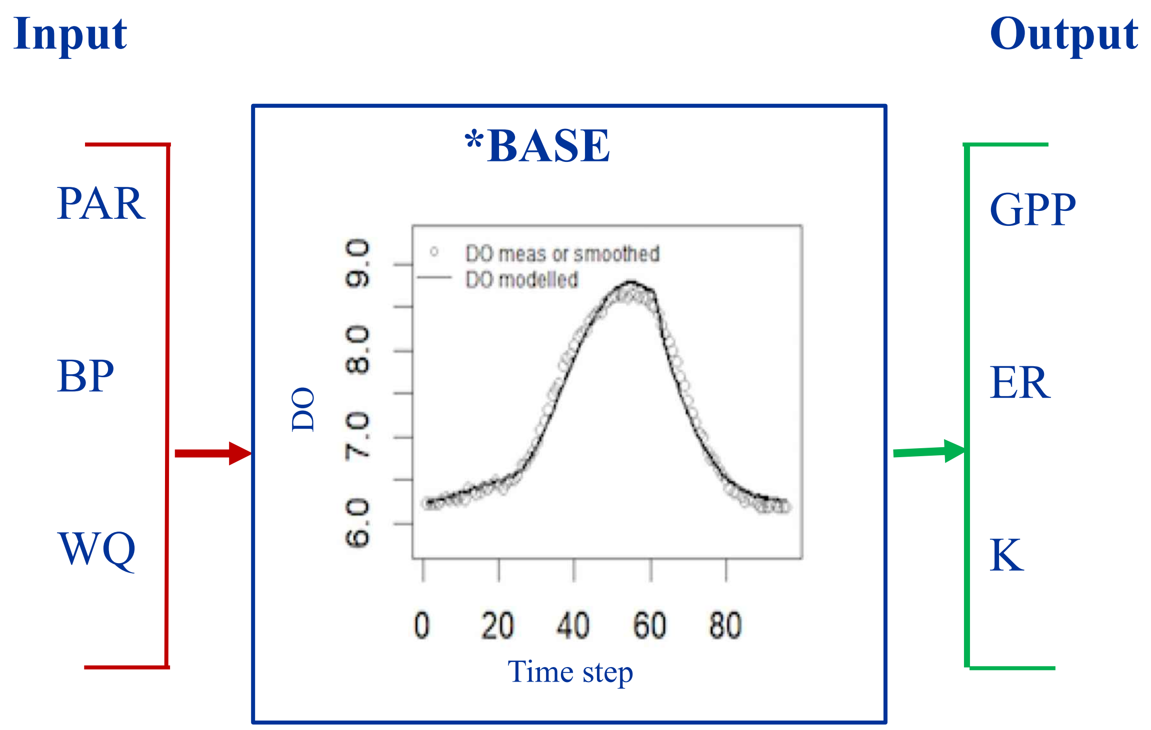
$$K = K_{O2}(DO_{sat} - DO_{meas})$$





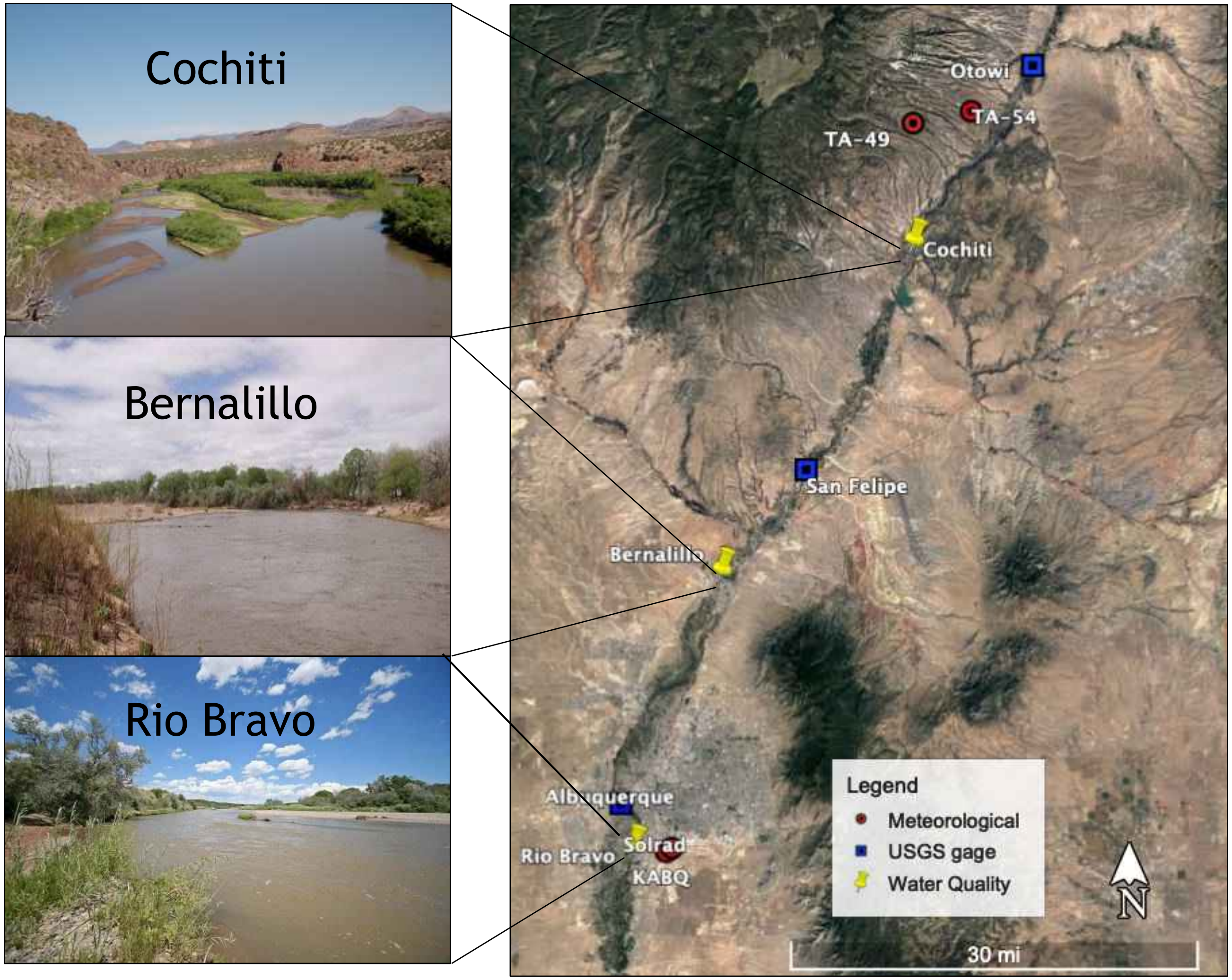
Odum 1956

Whole Stream Metabolism Background

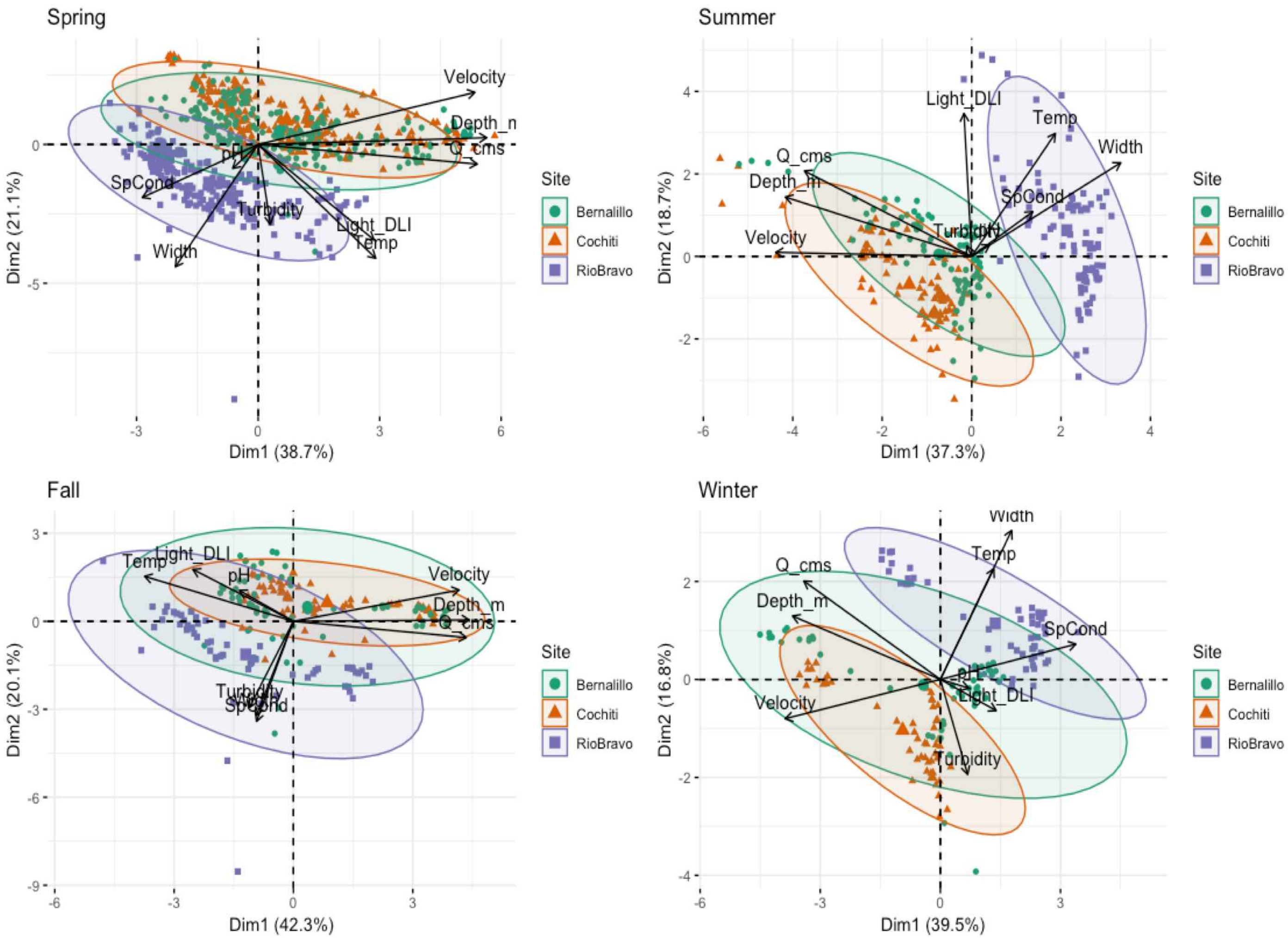


*BAyesian Single station Estimation (BASE – Grace et al. 2015)

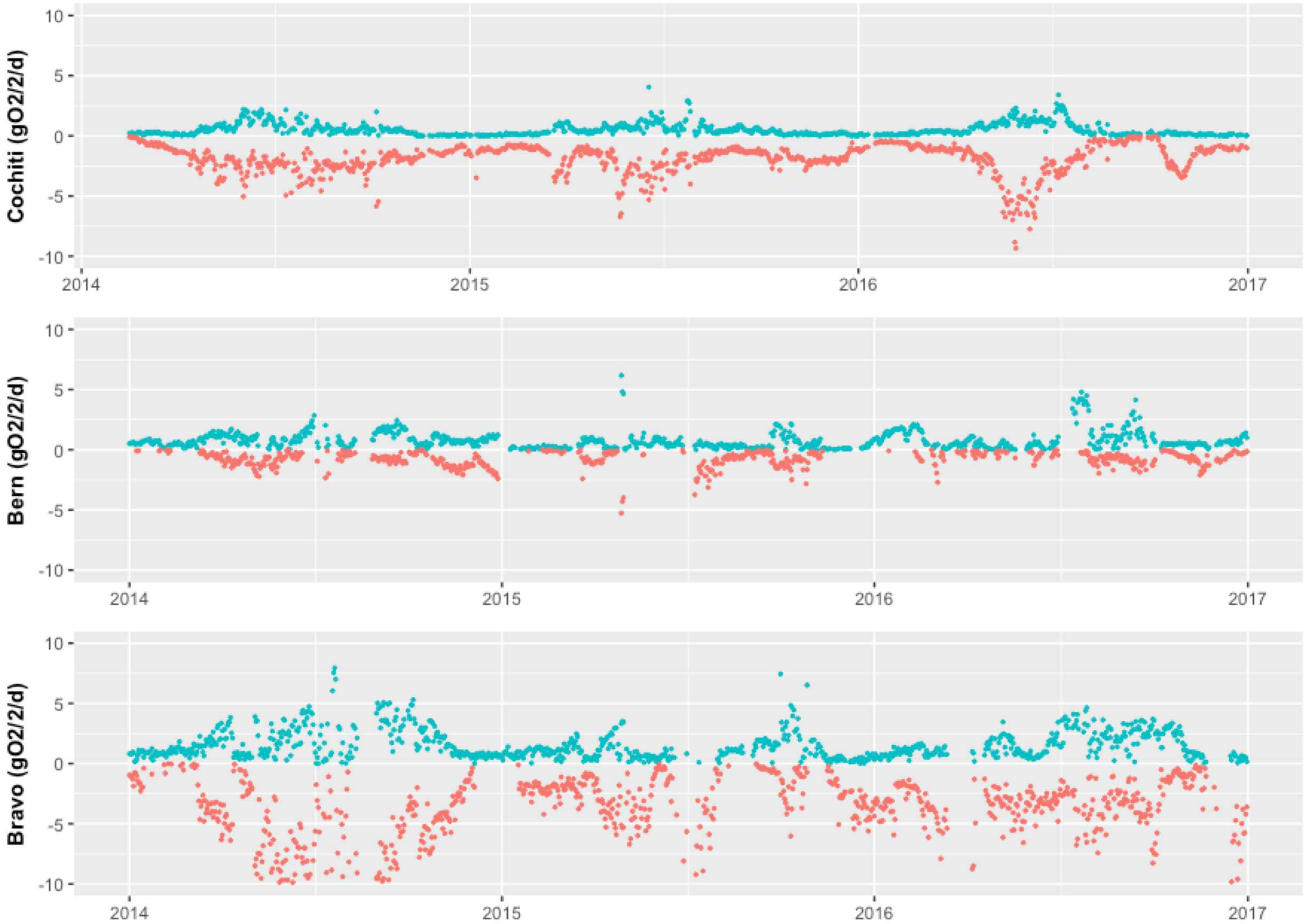
Study Design



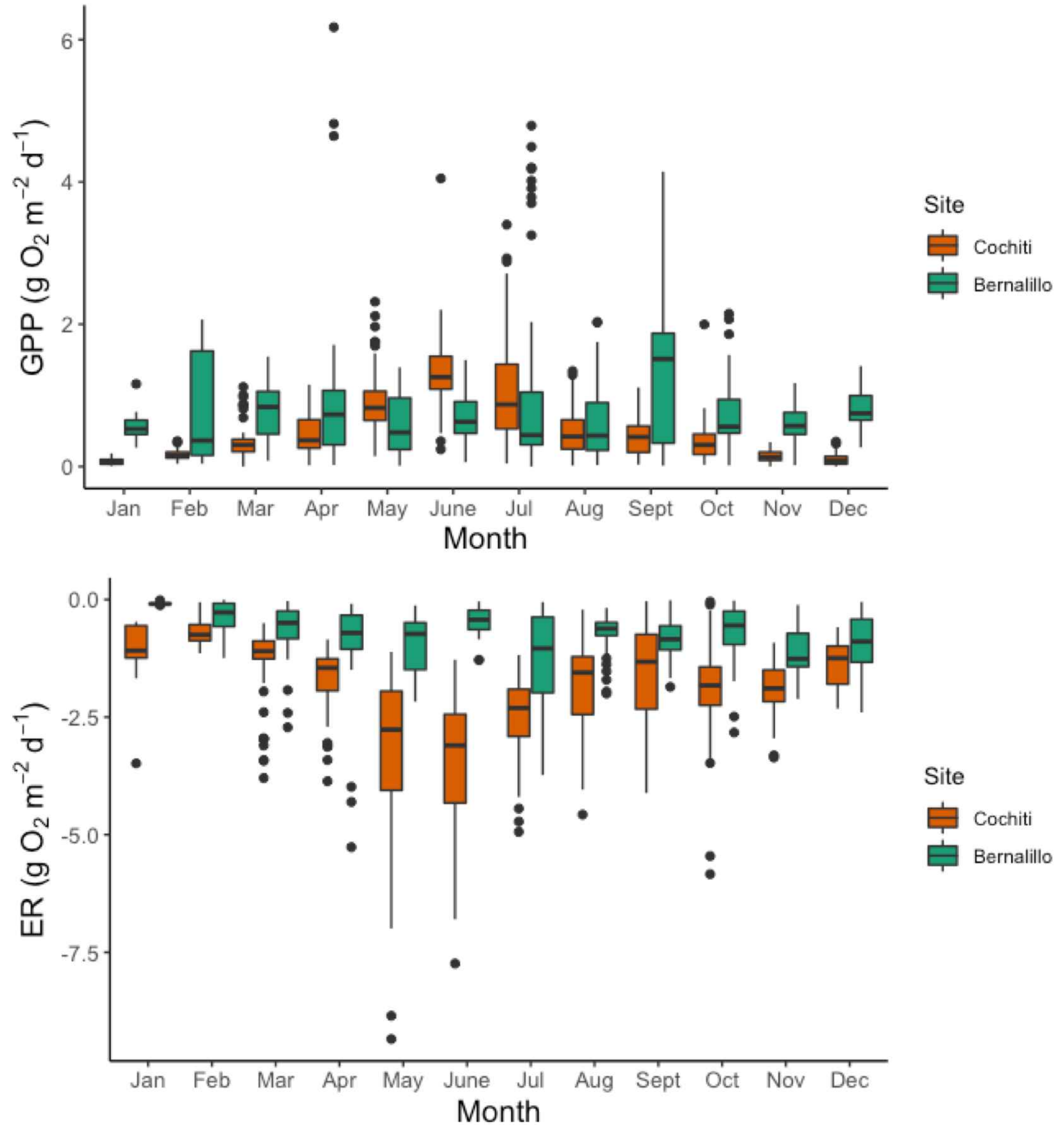
Whole Stream Metabolism Data



Whole Stream Metabolism Data



Whole Stream Metabolism Data

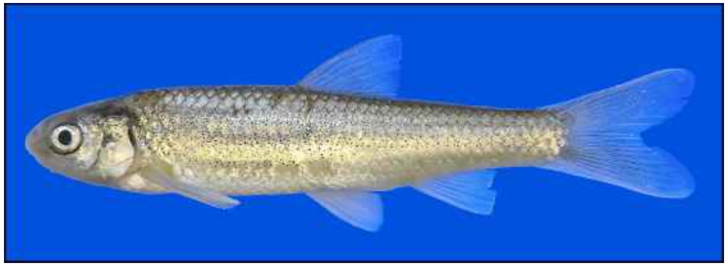


Whole Stream Metabolism Implications for MRG Biota

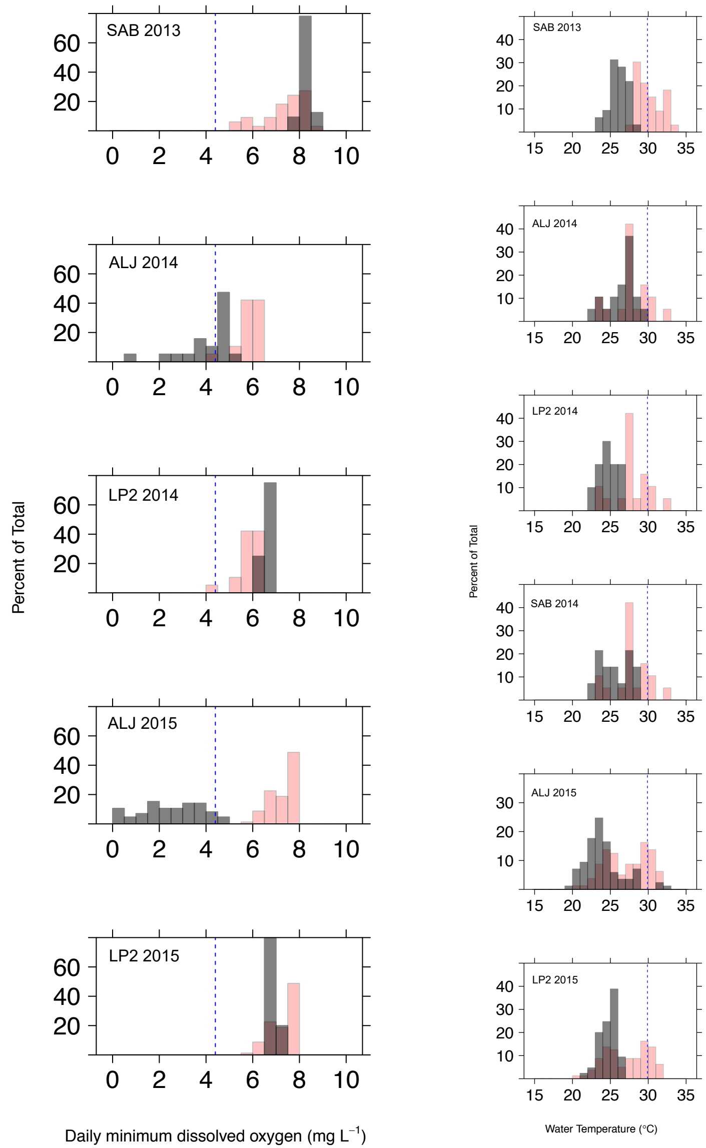
Spatial and temporal variation

- Previous studies (Lusk 2012) suggest "*low rates of GPP and ER in the MRG are likely limiting fish growth and distribution, decreasing benthic aquatic invertebrate richness, and increasing chronic stress to the federally endangered Rio Grande silvery minnow (Hybognathus amarus, RGSM)*".
- Metabolism appears to vary between sites, suggesting significant variation in resource supply
- Seasonal variation is also apparent
- Additional analyses are needed to document GPP and ER hotspots/hot-moments

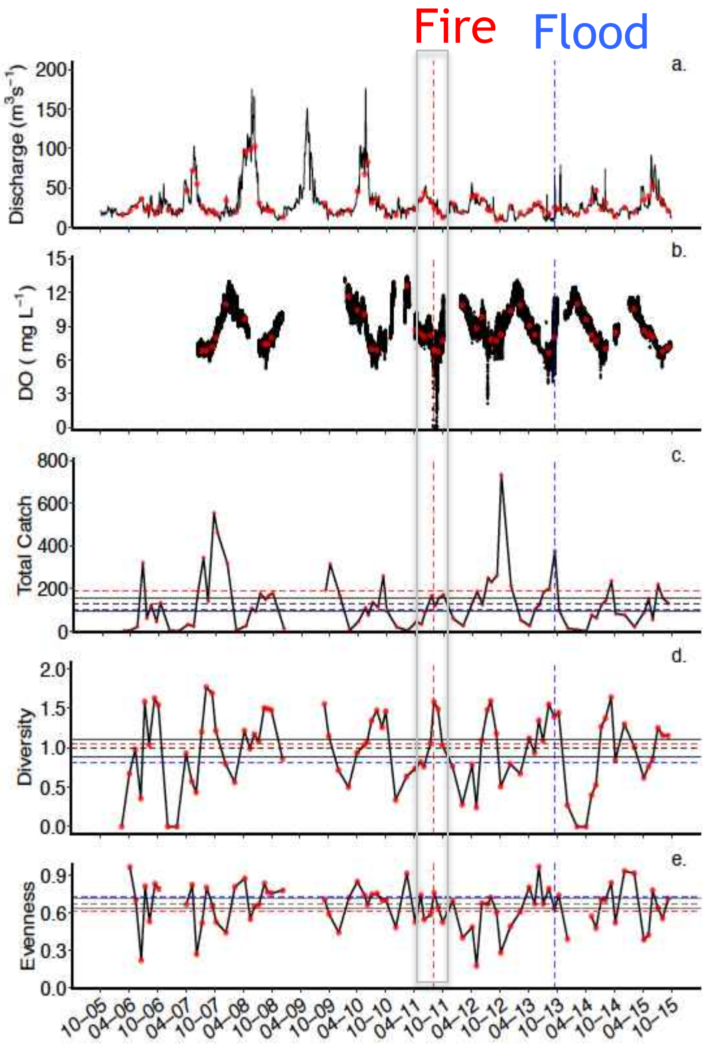
Other Connections Between WQ and Species of Interest



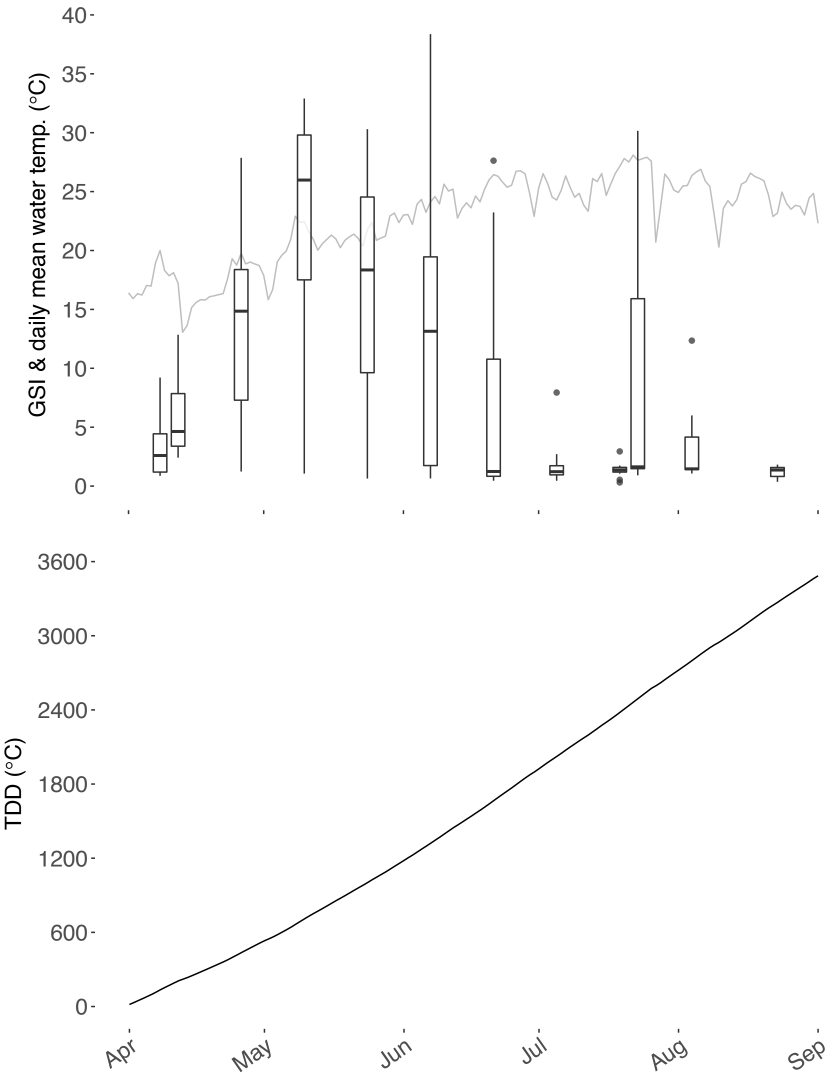
Other Connections Between WQ and Species of Interest – Comparing Refugia to the Mainstem



Other Connections Between WQ and Species of Interest – Fish Response to Fire



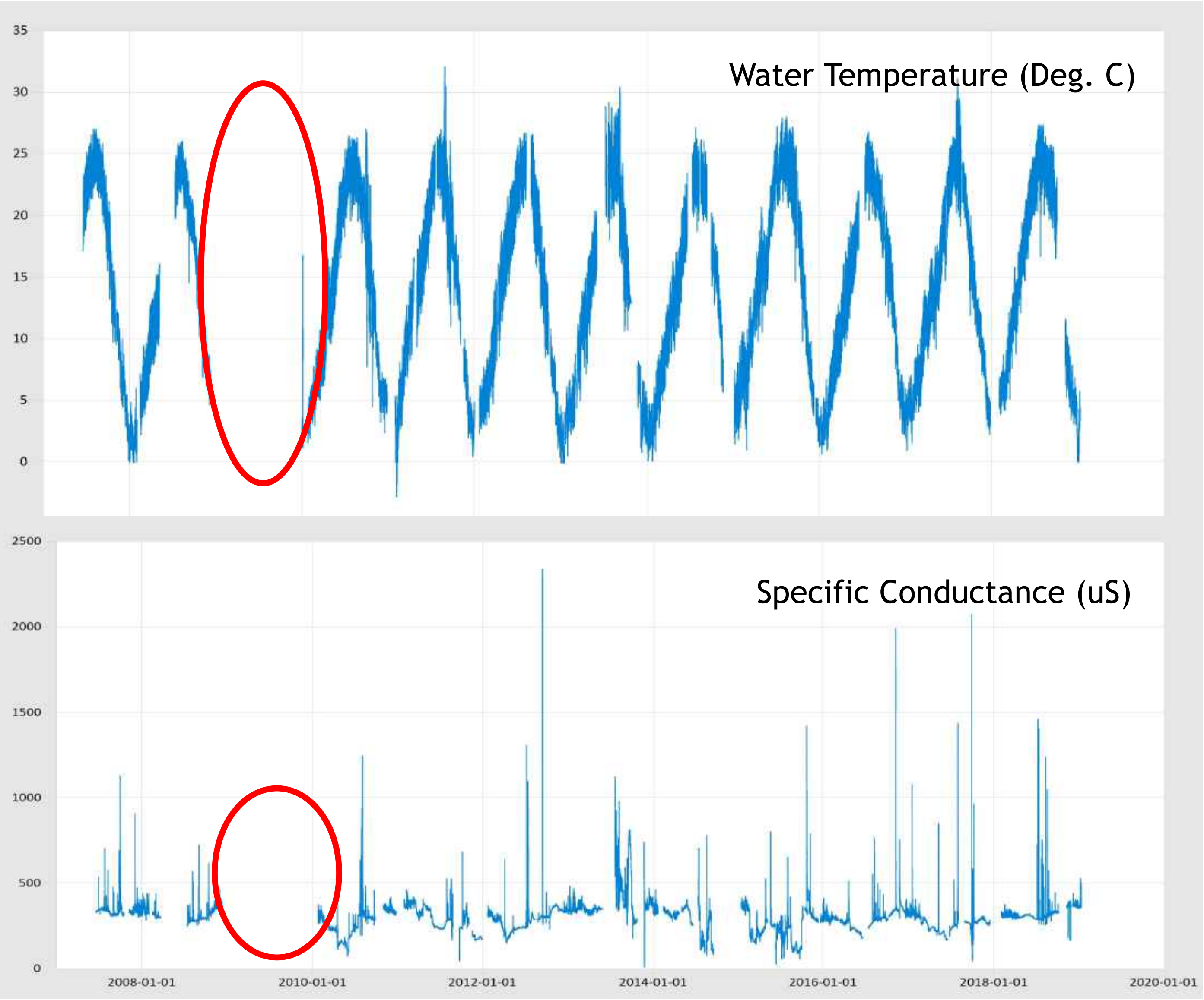
Other Connections Between WQ and Species of Interest – Water Temp. and Gonadosomatic Index



Conclusions

- WQ data are fundamental for understanding the local conditions and the stressors that aquatic biota experience
- The MRG is a dynamic system, with wide spatial and temporal variation in WQ values, driven by natural geomorphic change, anthropogenic impacts, and periodic episodic disturbances
- Discrete sampling is important, however, near-continuous data is necessary to document the impacts from episodic events and spatial/temporal variation
- While we now have solid baseline WQ data in the MRG, additional data is necessary to document future disturbances and long-term change, and to interpret fish abundance/health/reproductive data

Data – Bernalillo 550



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USGS science for a changing world

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Cody Walker – IP

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Aashish Sanjay – UNM
Justin Nichols - UNM
Betsy Summers – UNM
Roxanne Candelaria-Ley – UNM
Alex Clark – UNM
Grady Ball – UNM
Matt Seguera – UNM
Lydia Zeglin – UNM
Becky Bixby – UNM
Mariah Zuni – UNM/IP

Julia Wise – UC
Aaron Diefendorf – UC
Thomas Lowell – UC

Rio Grande Silvery Minnow Population Monitoring
(1993–2018)

Robert K. Dudley[1,2], Steven P. Platania[1,2], and Gary C. White[1,3]

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[2] Museum of SW Biology (Fishes), UNM; MSC03-2020, Albuquerque, NM, 87131-0001
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Hybognathus amarus (Cyprinidae)

(Rio Grande Silvery Minnow [Girard, 1856])

Photo by
Tom Kennedy

Native Distribution
(*Hybognathus amarus*)

Current

Historical

Experimental

Rio Grande PBS Reproductive Guild:

Rio Grande Silvery Minnow *Hybognathus amarus*

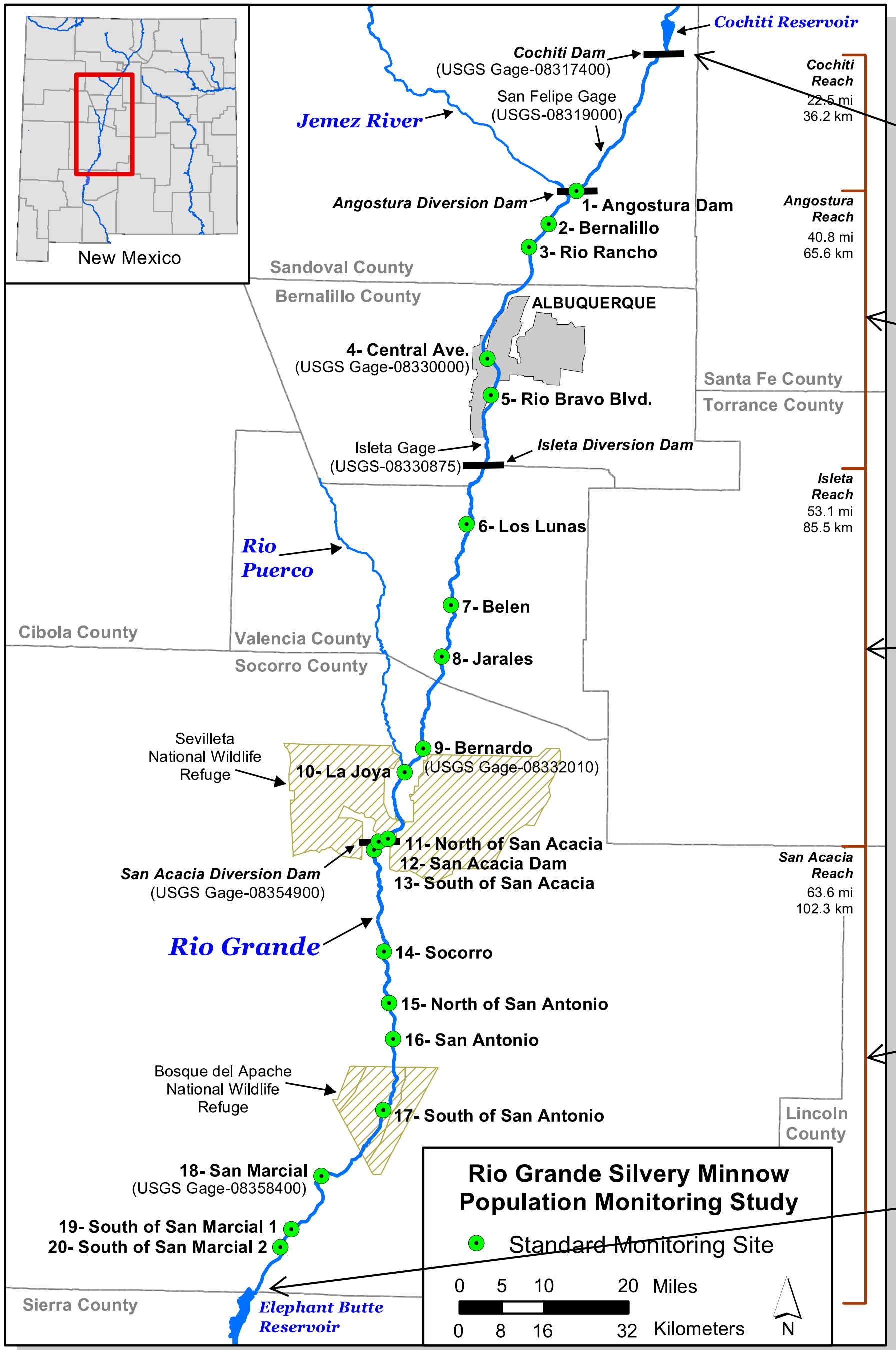
Speckled Chub *Macrhybopsis aestivalis*

Rio Grande Shiner *Notropis jemezanus*

Phantom Shiner *Notropis orca*

Rio Grande Bluntnose Shiner *N. simus simus*

Study Area



Cochiti Dam

Angostura Reach

Isleta
Reach

San Acacia
Reach

Elephant Butte Reservoir

Cochiti Dam

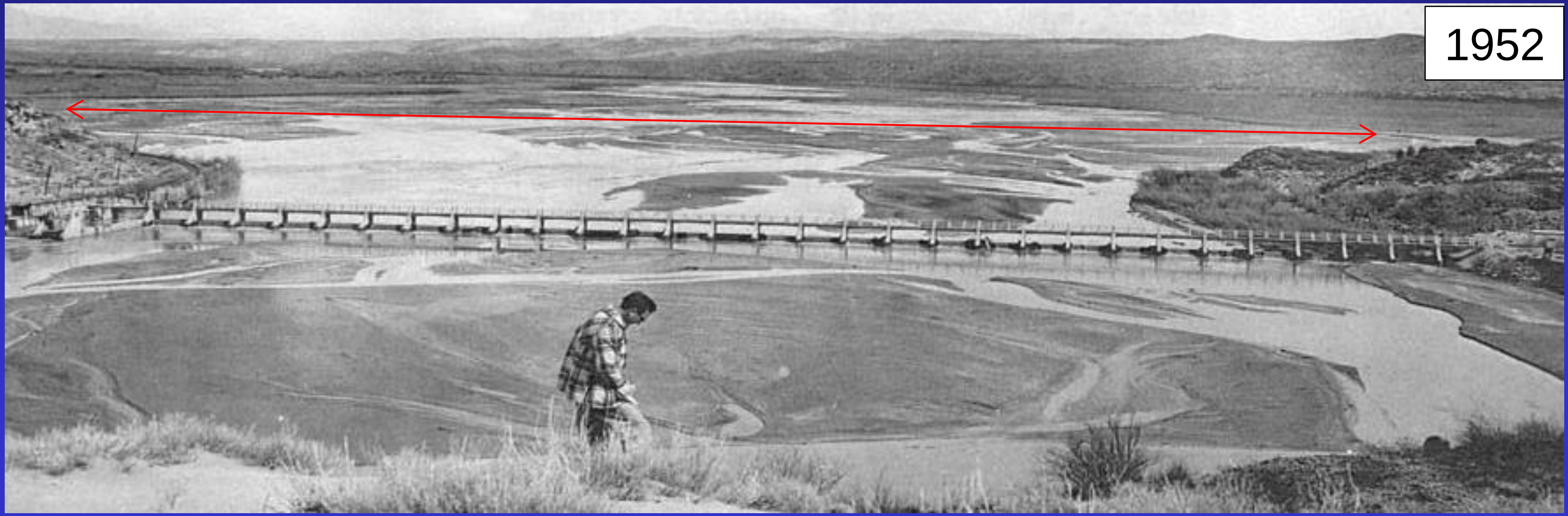
Angostura Diversion Dam

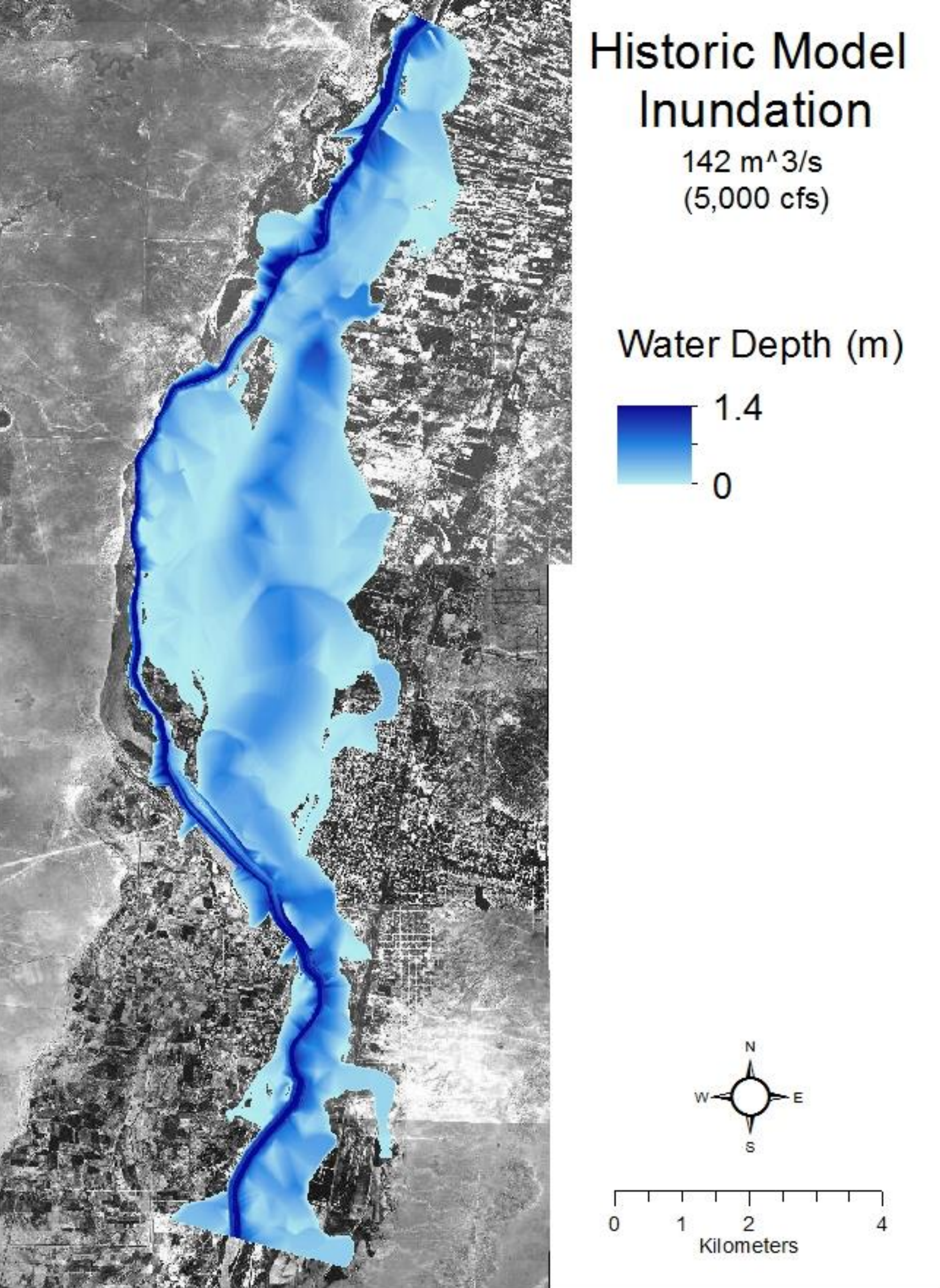
Isleta Diversion Dam

San Acacia Diversion Dam

Elephant Butte Reservoir

Historical and Recent River Channel

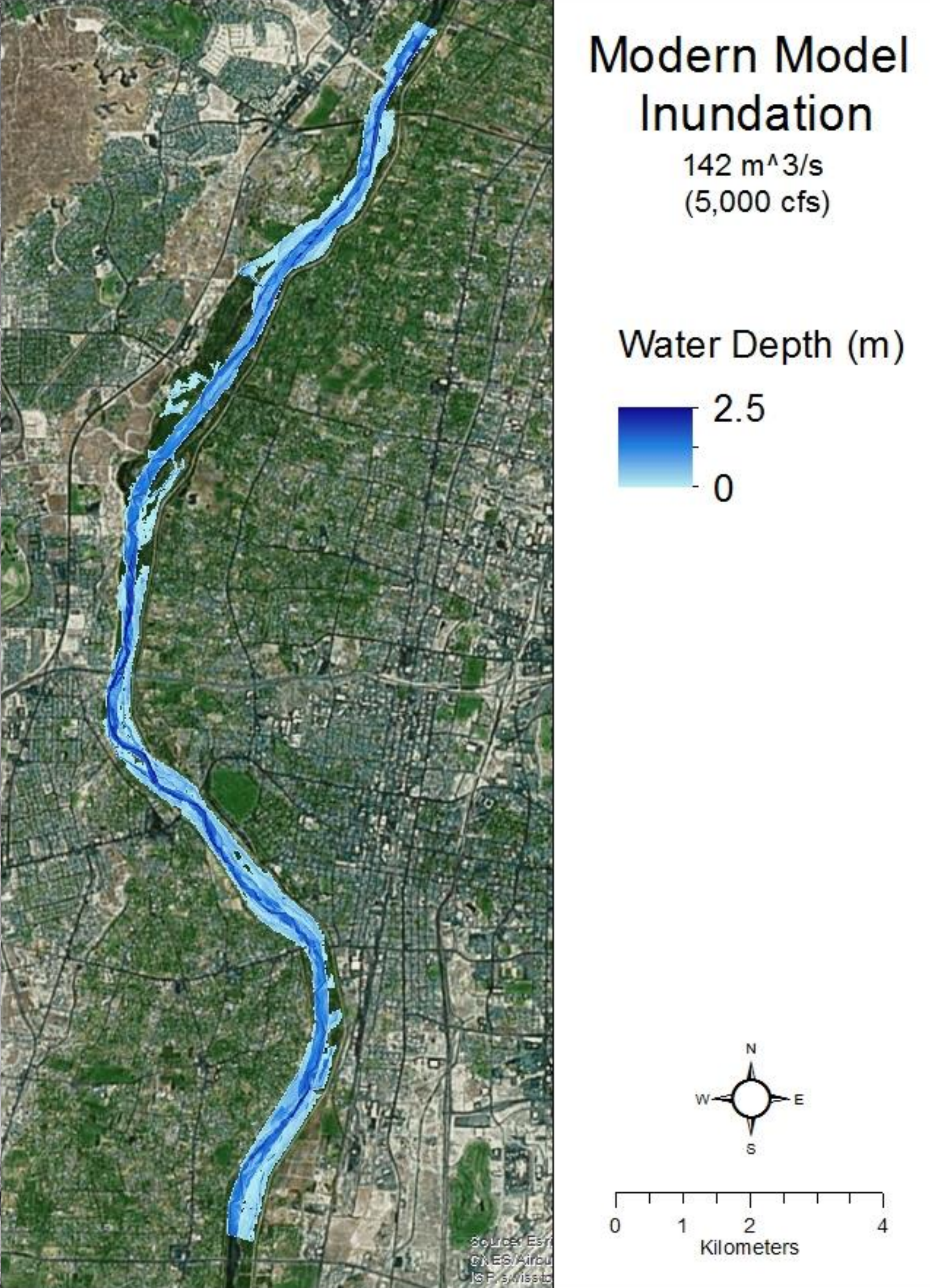




River Inundation

Historical (ca. 1918)
Channel: 19.0%
Floodplain: 81.0%

Adair, J.B.M. 2016. M.S. thesis, Civil Engineering, UNM, Albuquerque, NM.



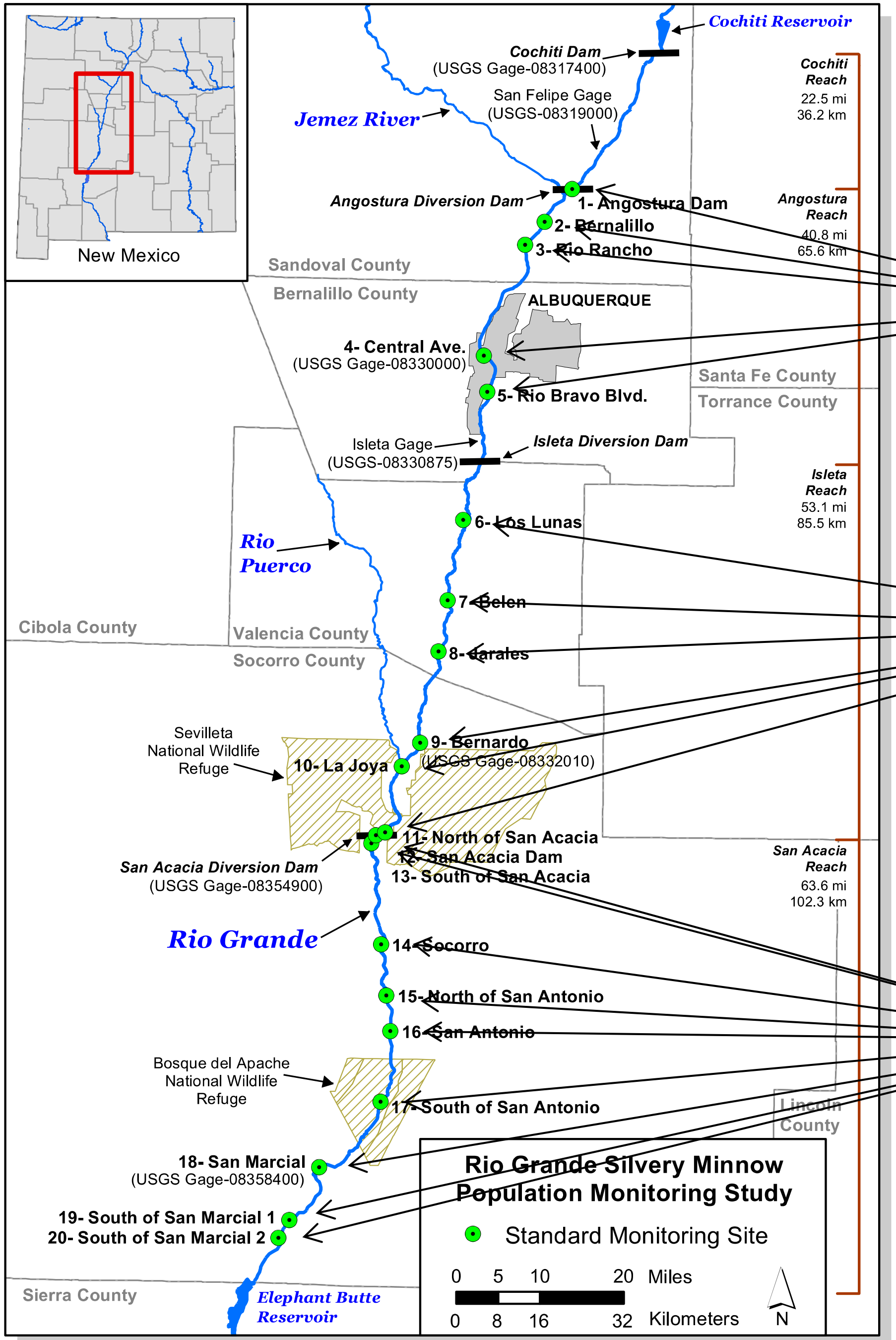
River Inundation

Historical (ca. 1918)
Channel: 19.0%
Floodplain: 81.0%

Recent (ca. 2014)
Channel: 72.9%
Floodplain: 27.1%

Adair, J.B.M. 2016. M.S. thesis, Civil Engineering, UNM, Albuquerque, NM.

Sampling Sites

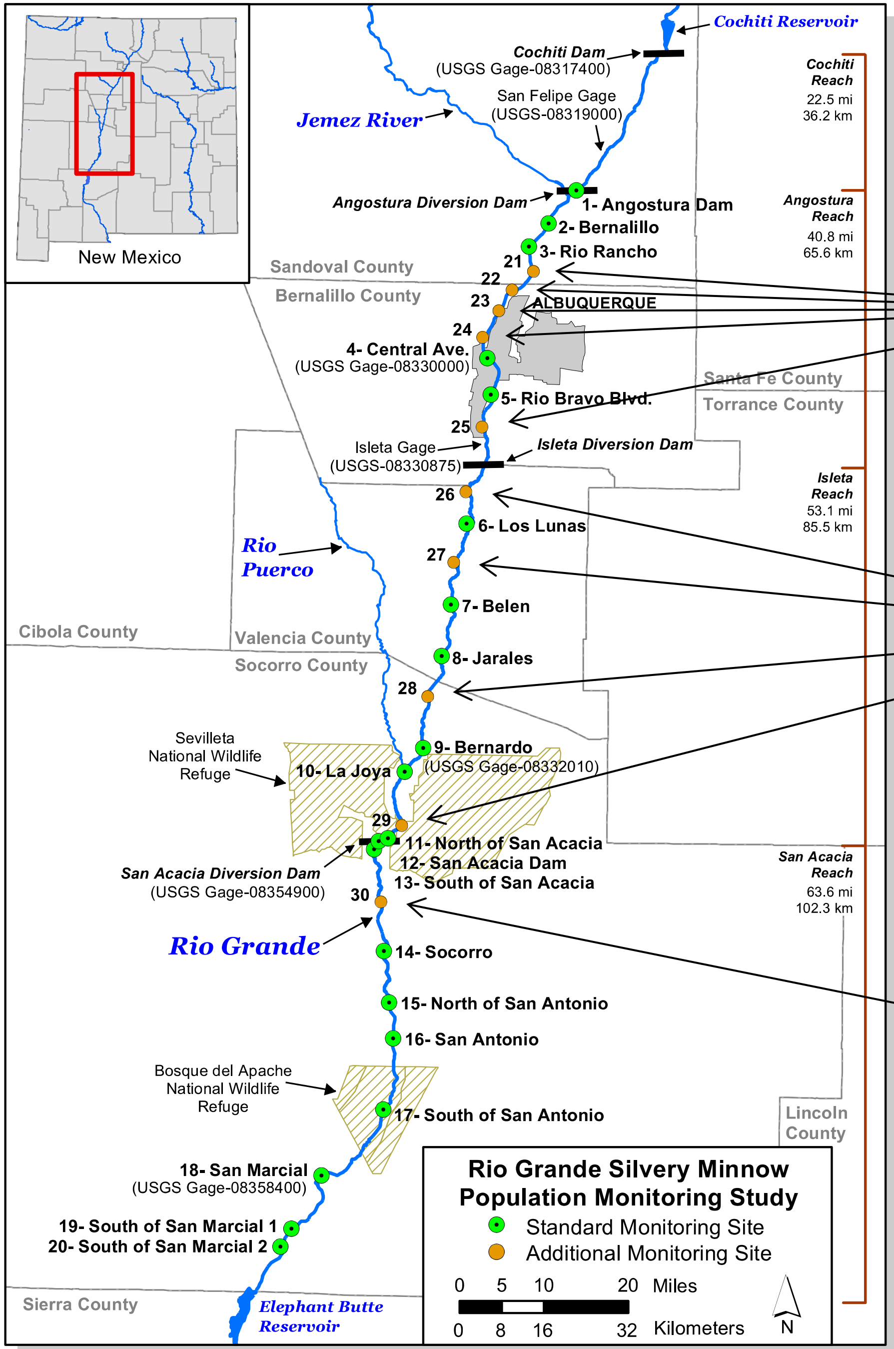


Angostura Reach sites (5)

Isleta Reach sites (6)

San Acacia Reach sites (9)

Additional Sites

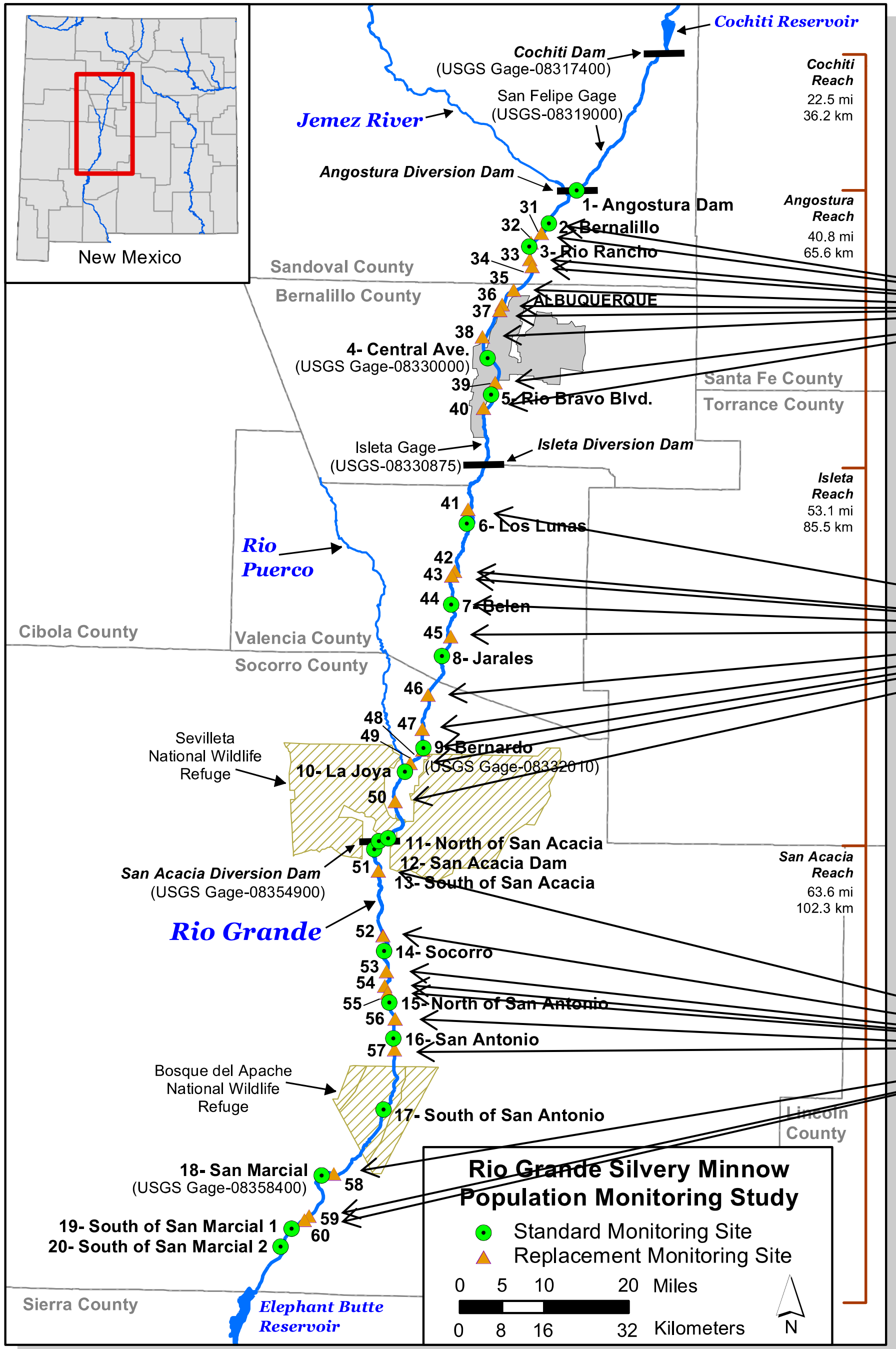


Angostura Reach sites (5)

Isleta Reach sites (4)

San Acacia Reach sites (1)

Replacement Sites

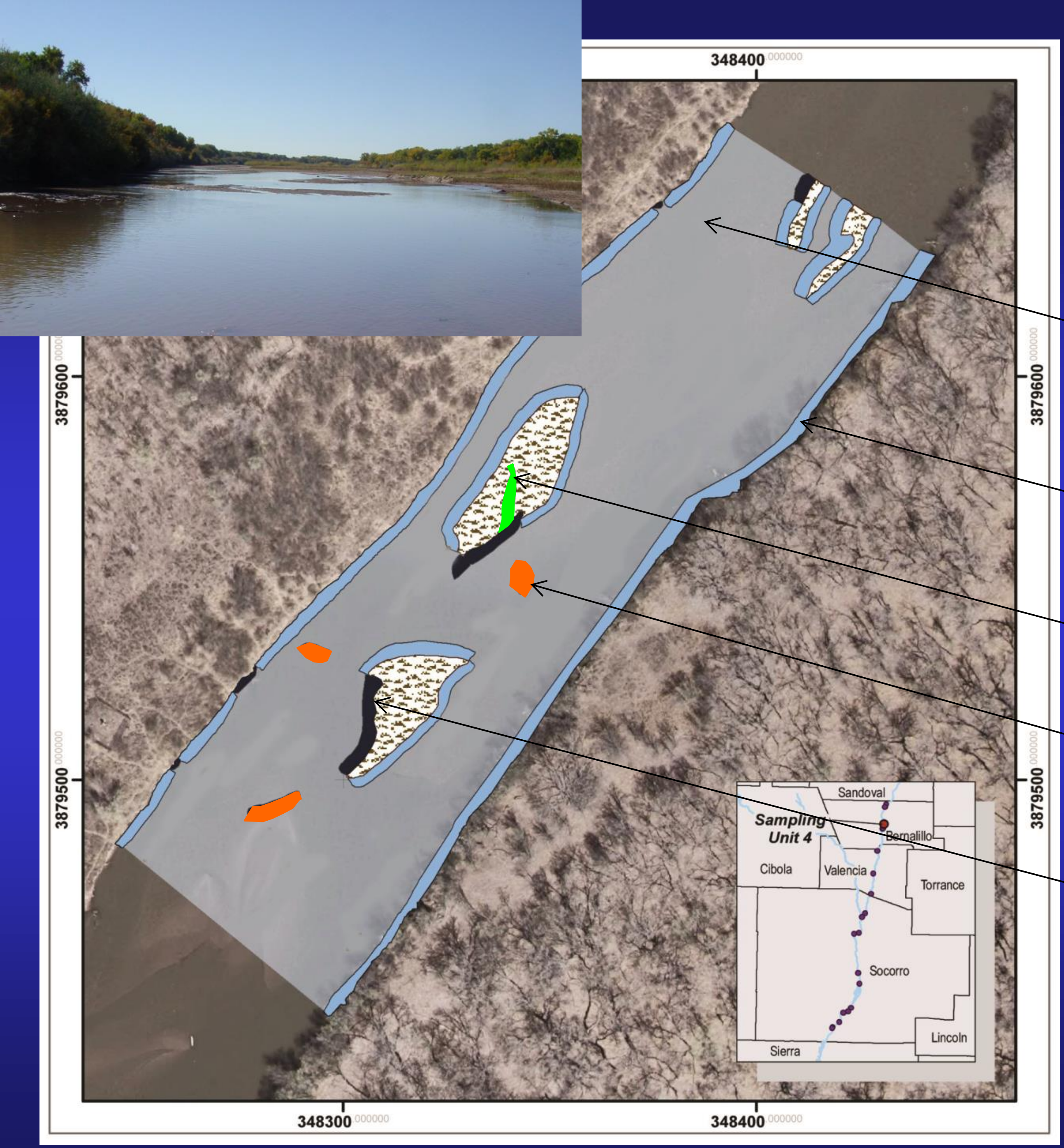


Angostura Reach sites (10)

Isleta Reach sites (10)

San Acacia Reach sites (10)

Mesohabitats



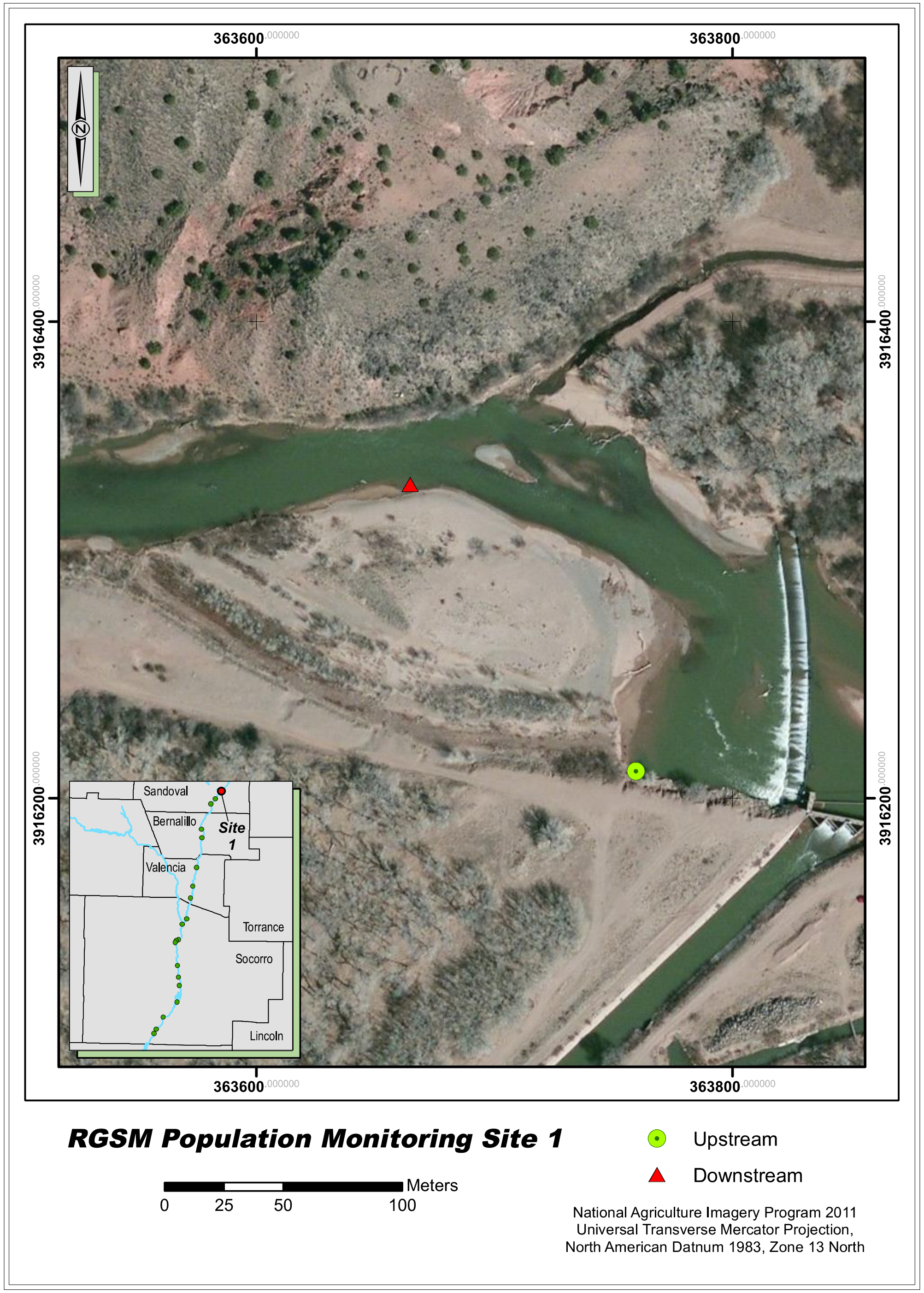
Runs (RU)

Shoreline runs (SHRU)

Backwaters (BW)

Pools (PO)

Shoreline pools (SHPO)



Sampling Methods

Seine hauls by mesohabitat:

- (BW/PO = 2, RU/SHPO = 4)
- (SHRU = 6–14)

Adult fish seining:

- (3.1 m x 1.8 m; small mesh)

Larval fish seining:

- (1.0 m x 1.0 m; fine mesh)

Twenty seine hauls per site:

- Mesohabitats standardized
- Area sampled (ca. 500 m^2)

Evolution of Project Design

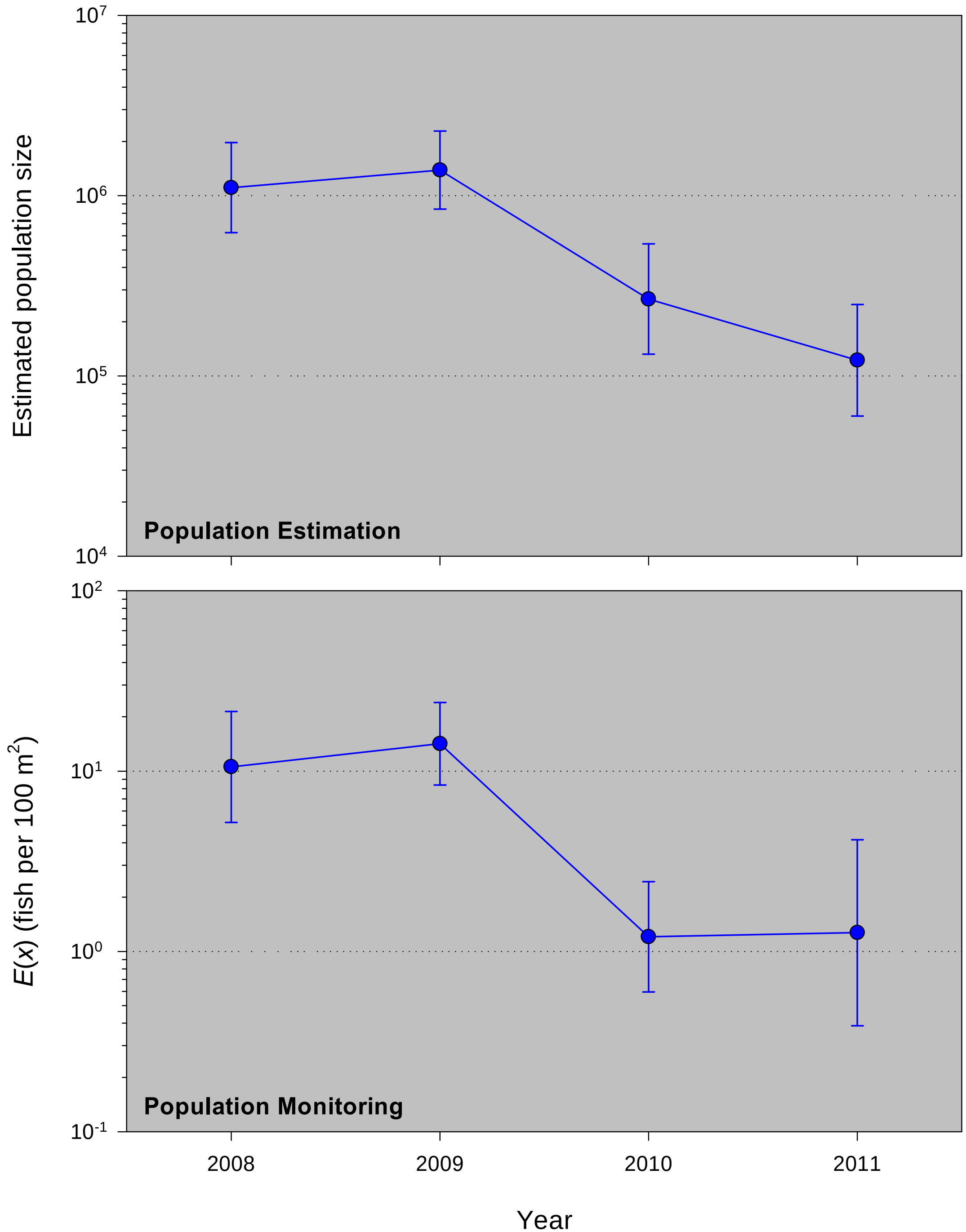
- The decline of RGSM during a prolonged drought (2000–2003), and formation of the MRGESCP, prompted notably increased sampling efforts (i.e., from quarterly to monthly).
- An external review, led by nationally-recognized experts, resulted in a workshop and a report (2004–2005).
- Most of the sampling recommendations and research studies, suggested by the experts, were initiated in 2006.
- The Population Monitoring Group (MRGESCP) produced a consensus report in 2006 on the desired protocols and objectives for this study.
- The most recent external review, led by nationally-recognized experts, resulted in a workshop and a report (2015–2016), along with several recommendations for increased sampling efforts.

Population Trends
(Estimation vs. Monitoring)

- Similarities: Twenty sites, mesohabitats standardized, area sampled (ca. 500 m^2)

- Differences: Random sites and mesohabitats, mapping of mesohabitats and samples, electrofishing removal-sampling in enclosures

- Despite notable differences in methodology and required effort, both studies indicated very similar trends over time.

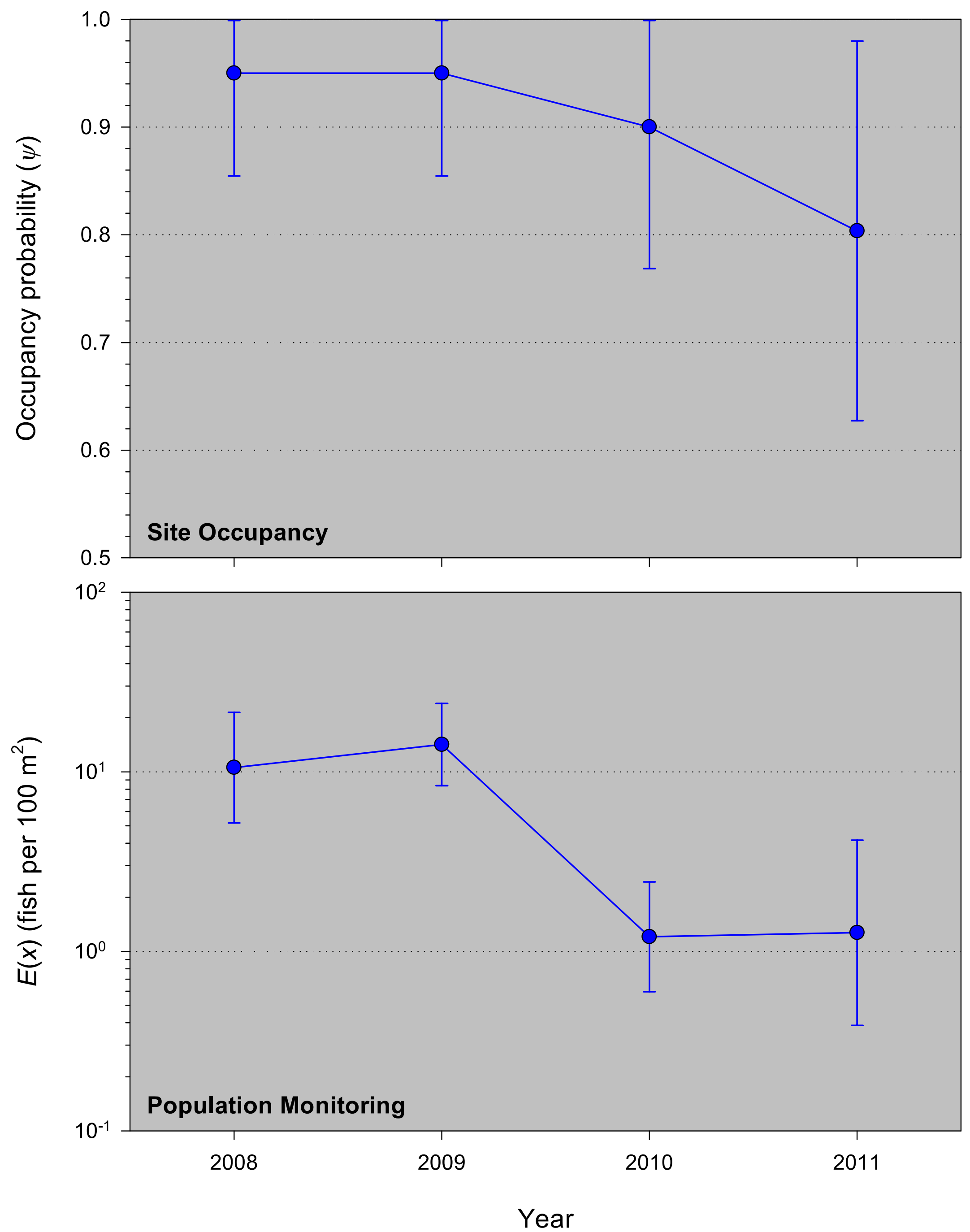


Population Trends
(Occupancy vs. Monitoring)

- Similarities: Twenty sites, mesohabitats standardized, area sampled (ca. 500 m^2)

- Differences: Sampled in November, same mesohabitats sampled repeatedly, sites were each sampled four times

- Despite notable differences in methodology and required effort, both studies indicated very similar trends over time.



Comparing Different Studies

Study strengths	**Lower abundance**	**Higher abundance**	**Overall**
Population monitoring	Early indication of decreased occurrence and abundance	Early indication of increased occurrence and abundance	Seasonal & annual trends in occurrence and abundance
Population estimation	Robust measure of decreased abundance	Robust measure of increased abundance	Robust estimate of annual abundance
Site occupancy	Robust measure of decreased occurrence (extinction)	Robust measure of increased occurrence (colonization)	Robust estimate of annual occurrence

Population Monitoring Objectives

1. Determine trends in the occurrence and abundance of native and nonnative fishes, with a focus on Rio Grande Silvery Minnow (RGSM).

2. Evaluate the influence of discharge (e.g., timing, magnitude, and duration) on RGSM population fluctuations.

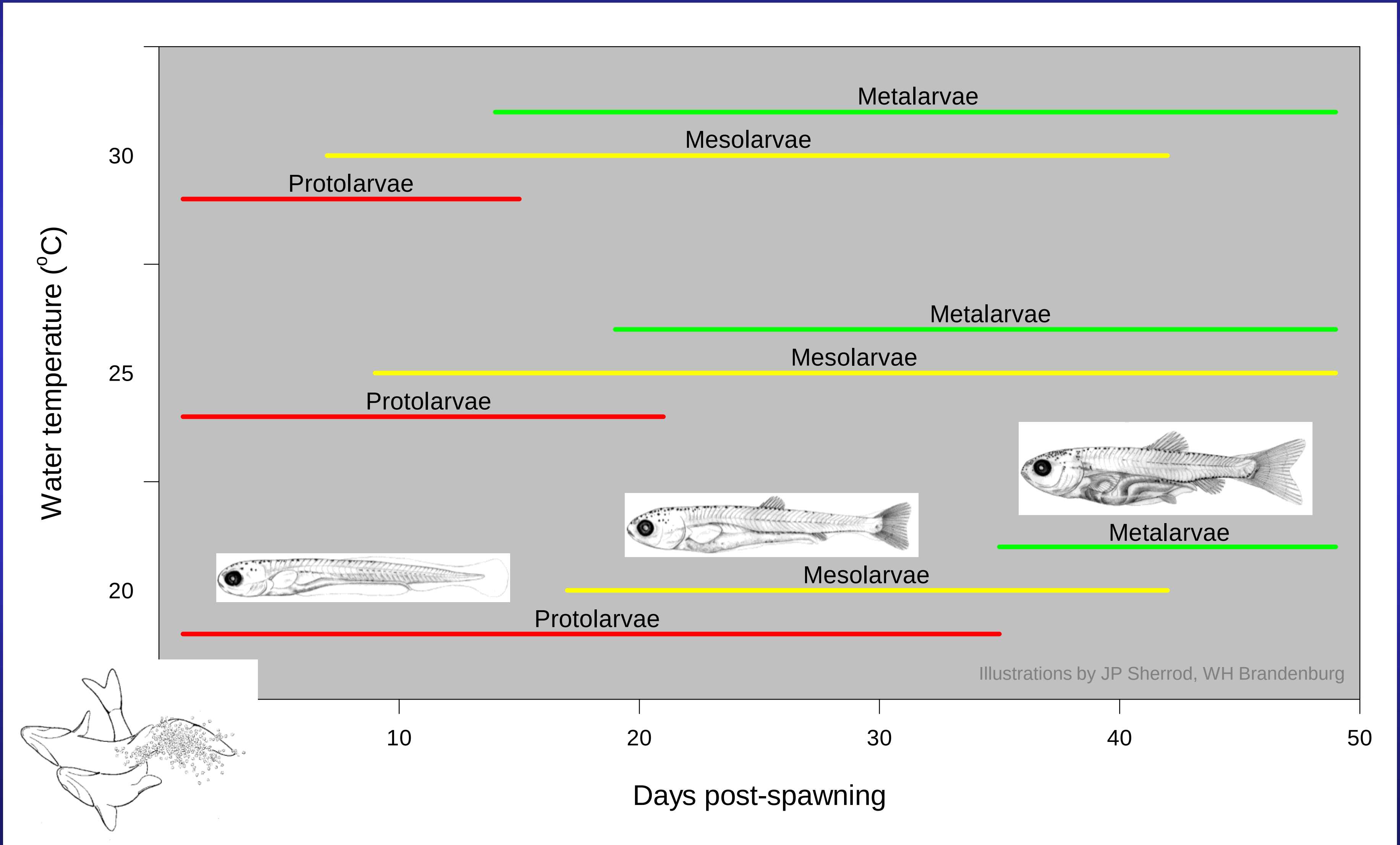
3. Determine long-term trends in RGSM densities across different mesohabitats.

4. Compare changes in RGSM relative and rank abundance to that of other native and nonnative fishes.

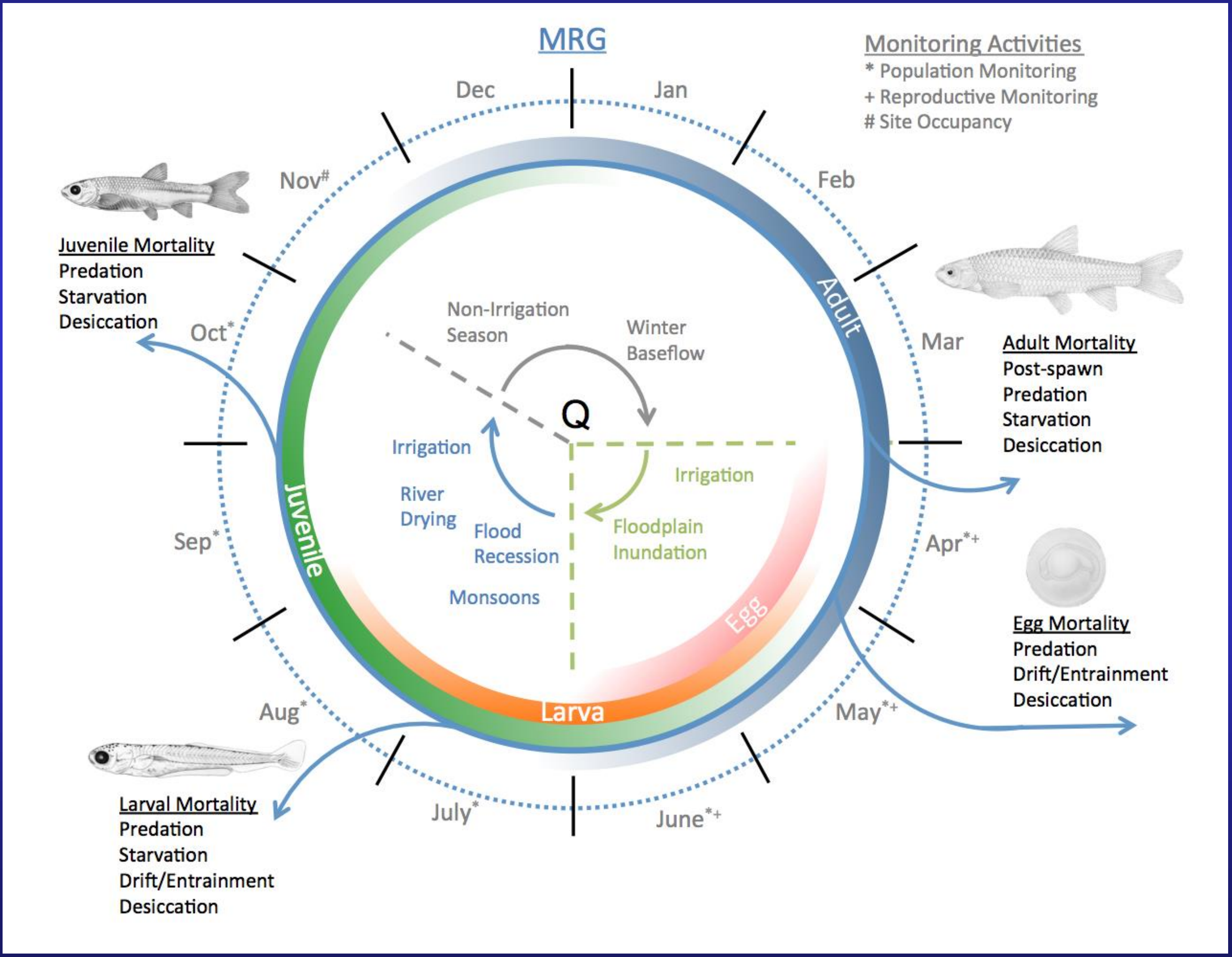
5. Determine variation in RGSM densities and estimate their site occupancy rates, based on repeated-sampling efforts.

Population Monitoring & Research (1993–2018)

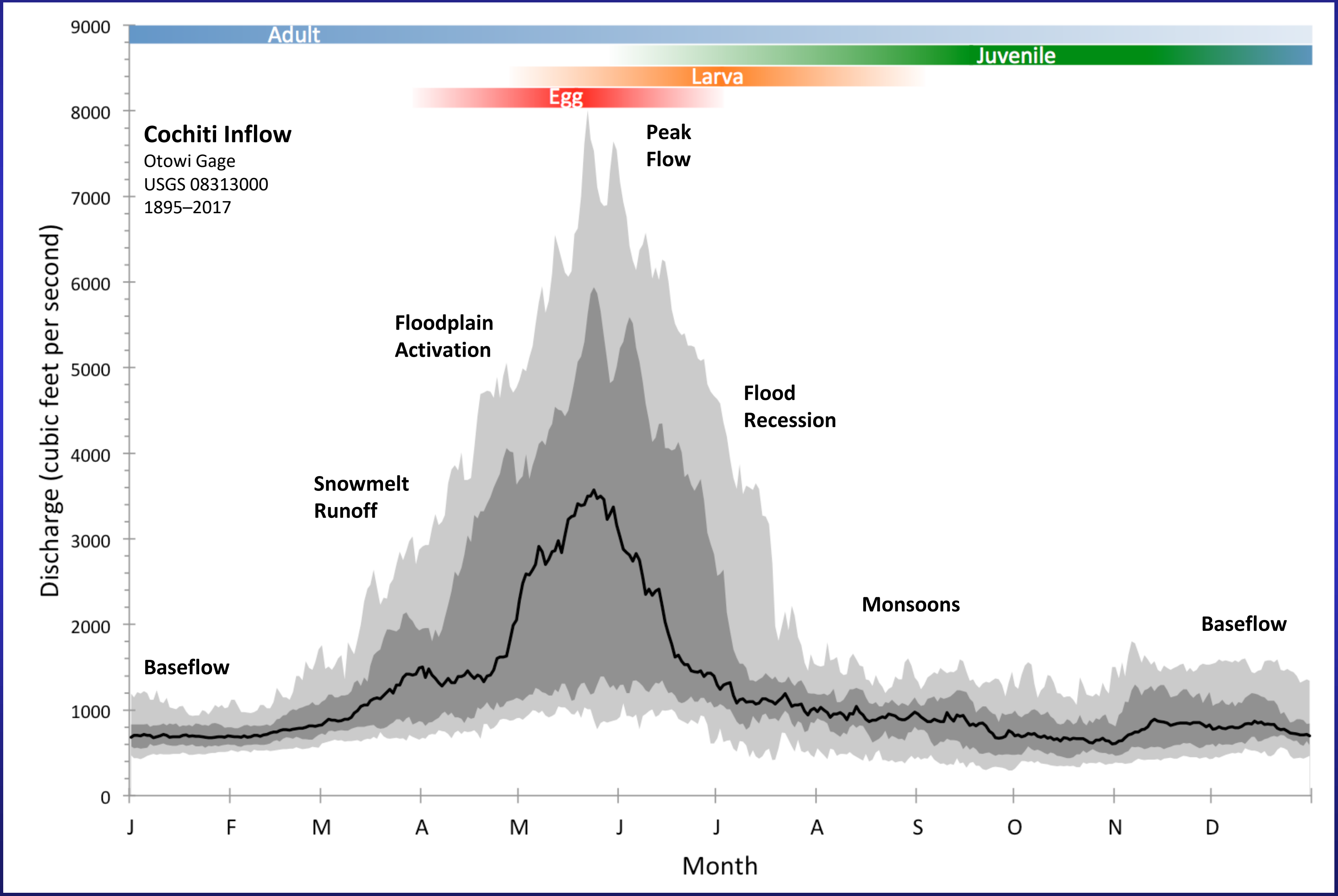
RGSM Developmental Stages (Platania, 2000)



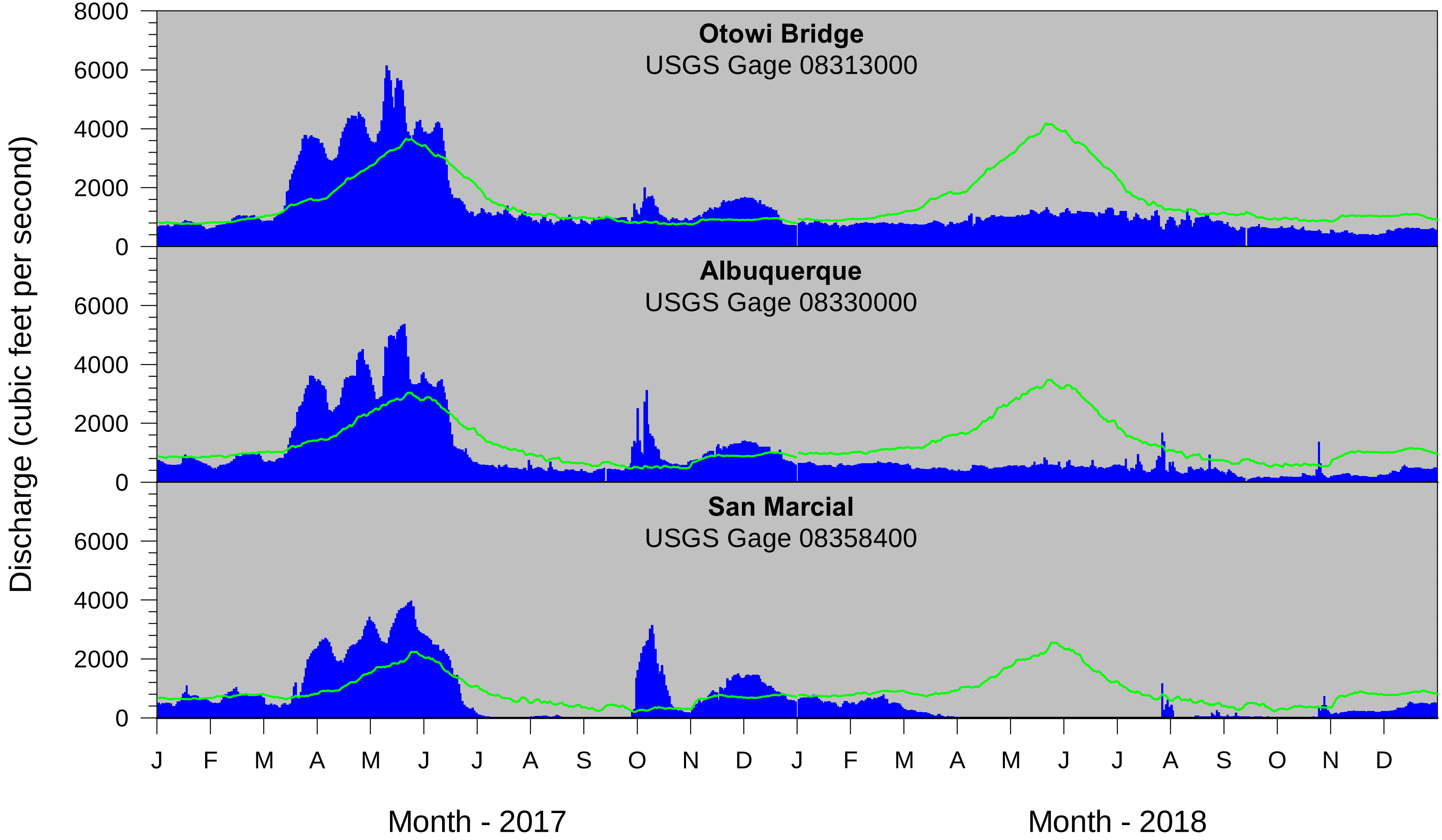
Life History of Rio Grande Silvery Minnow



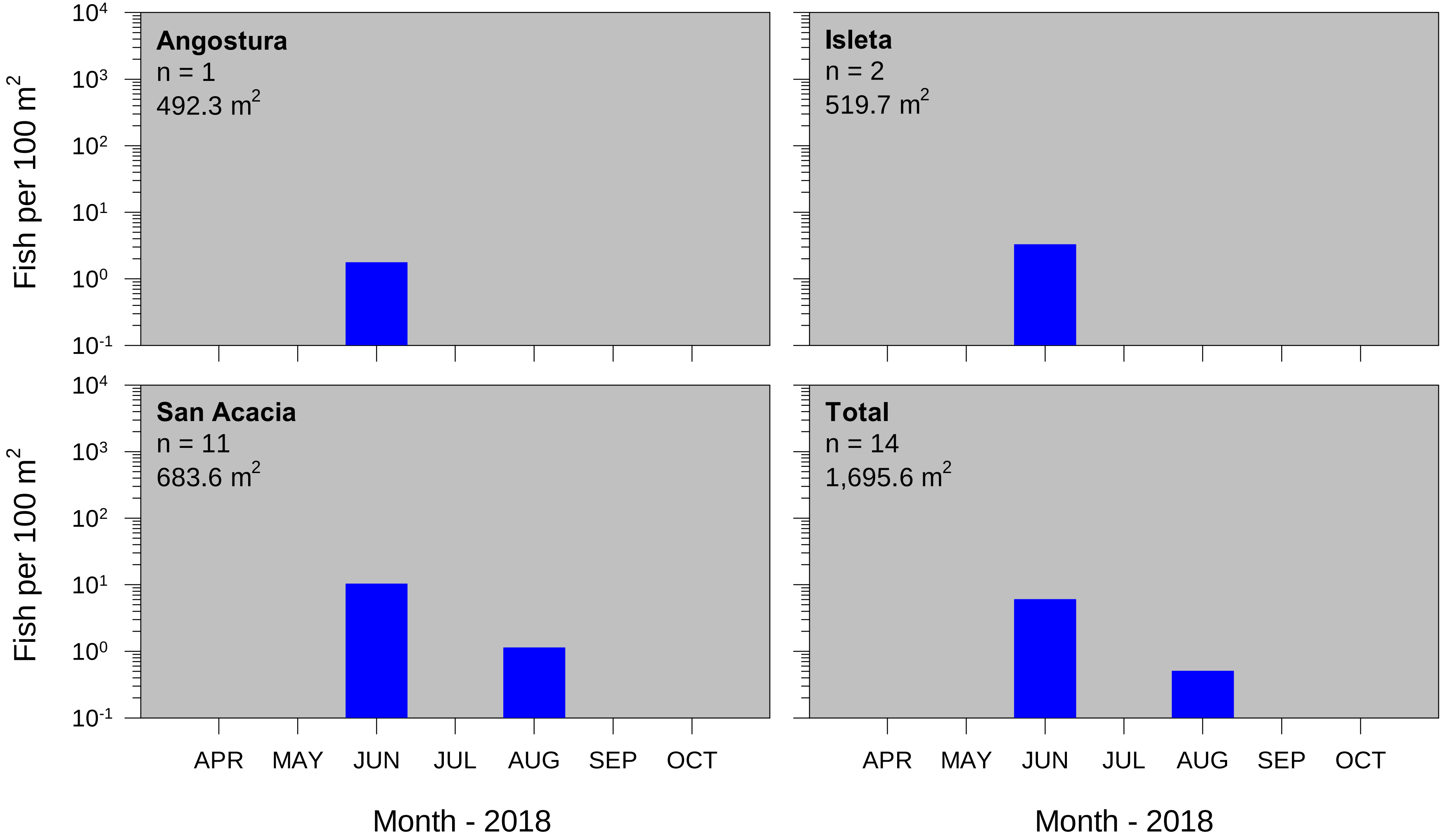
Life History of Rio Grande Silvery Minnow



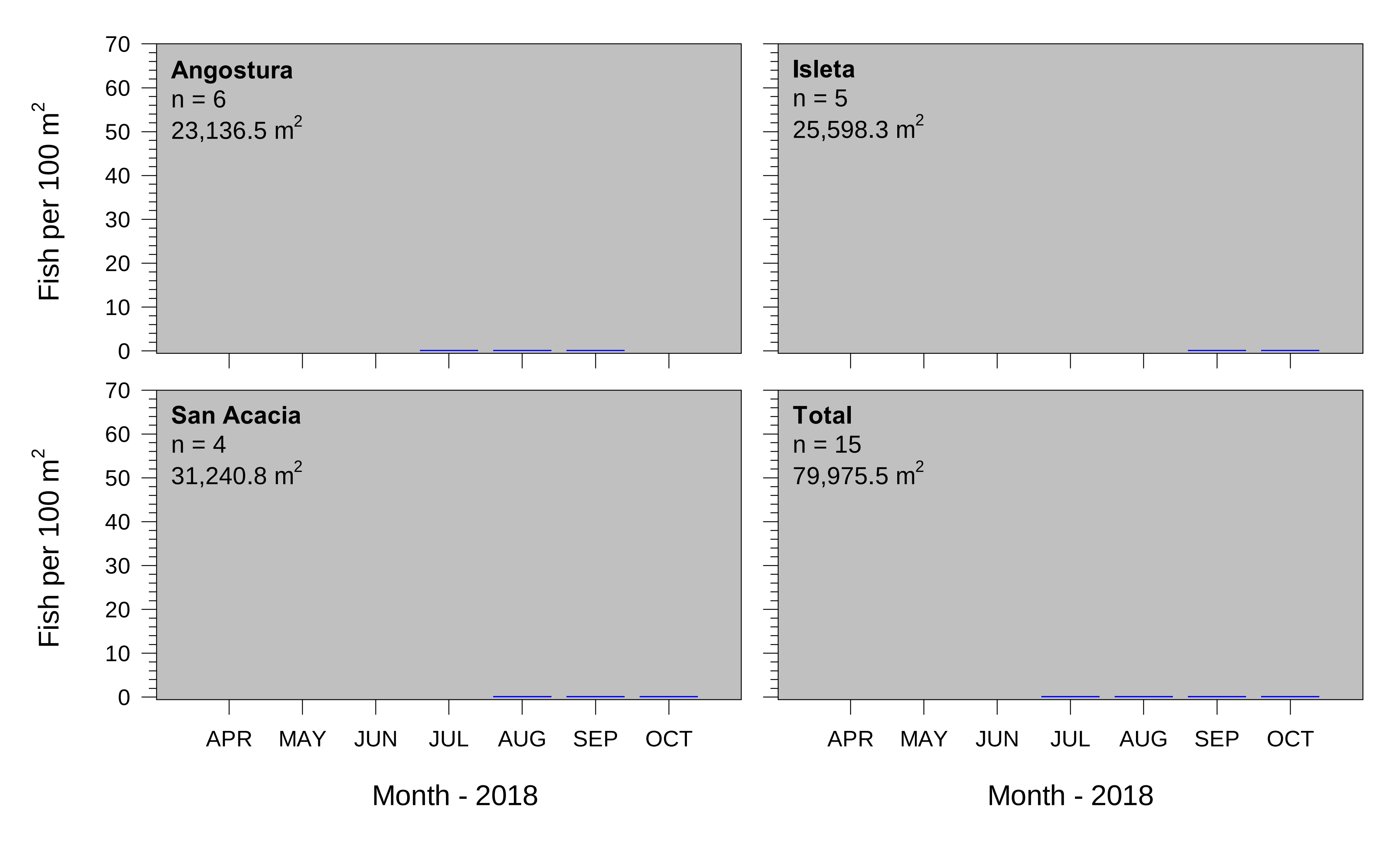
Discharge in the Middle Rio Grande (2017–2018)



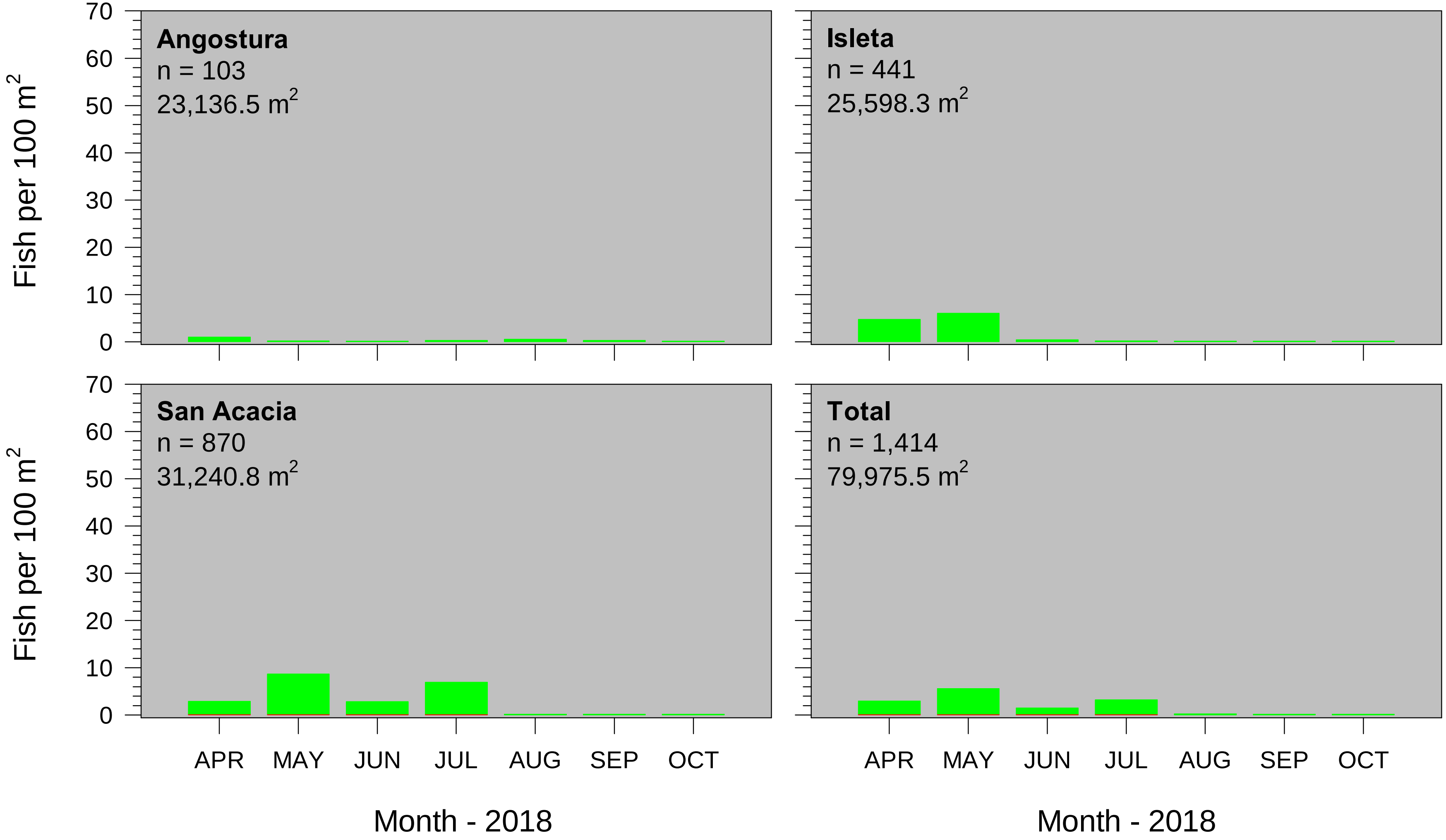
RGSM Population Trends in 2018 (Larval)



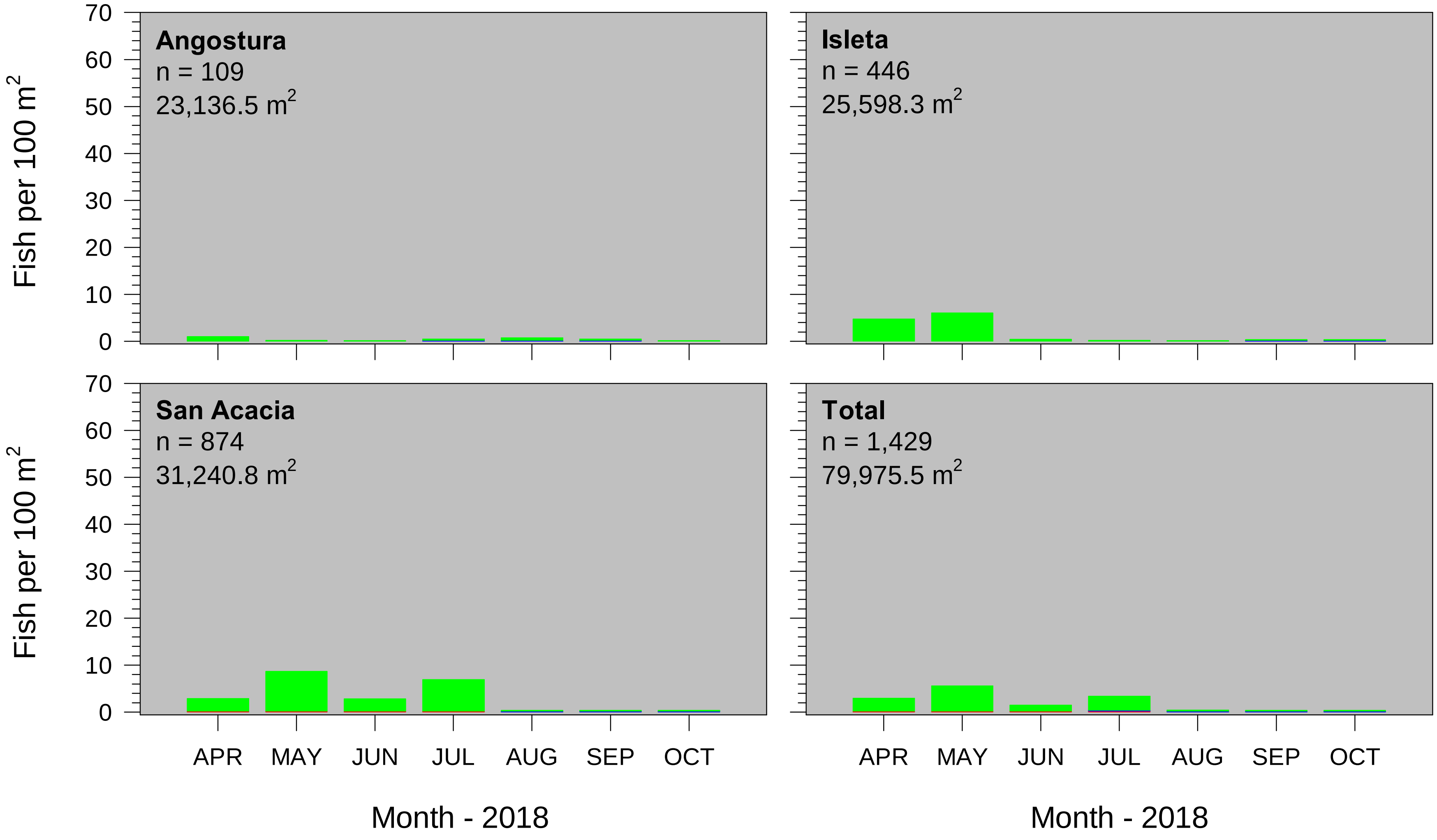
RGSM Population Trends in 2018 (Age-0)



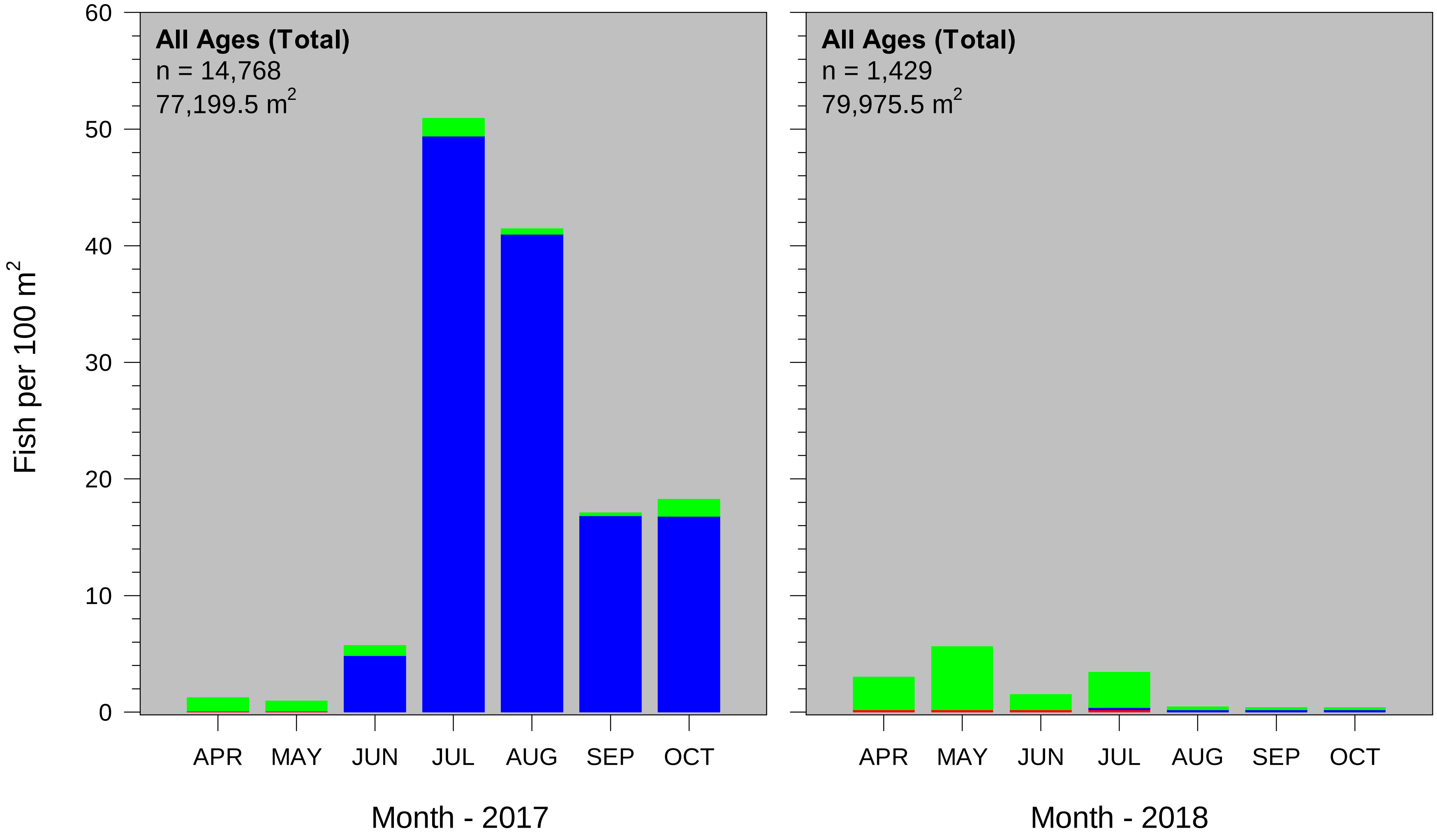
RGSM Population Trends in 2018 (Age-1+)



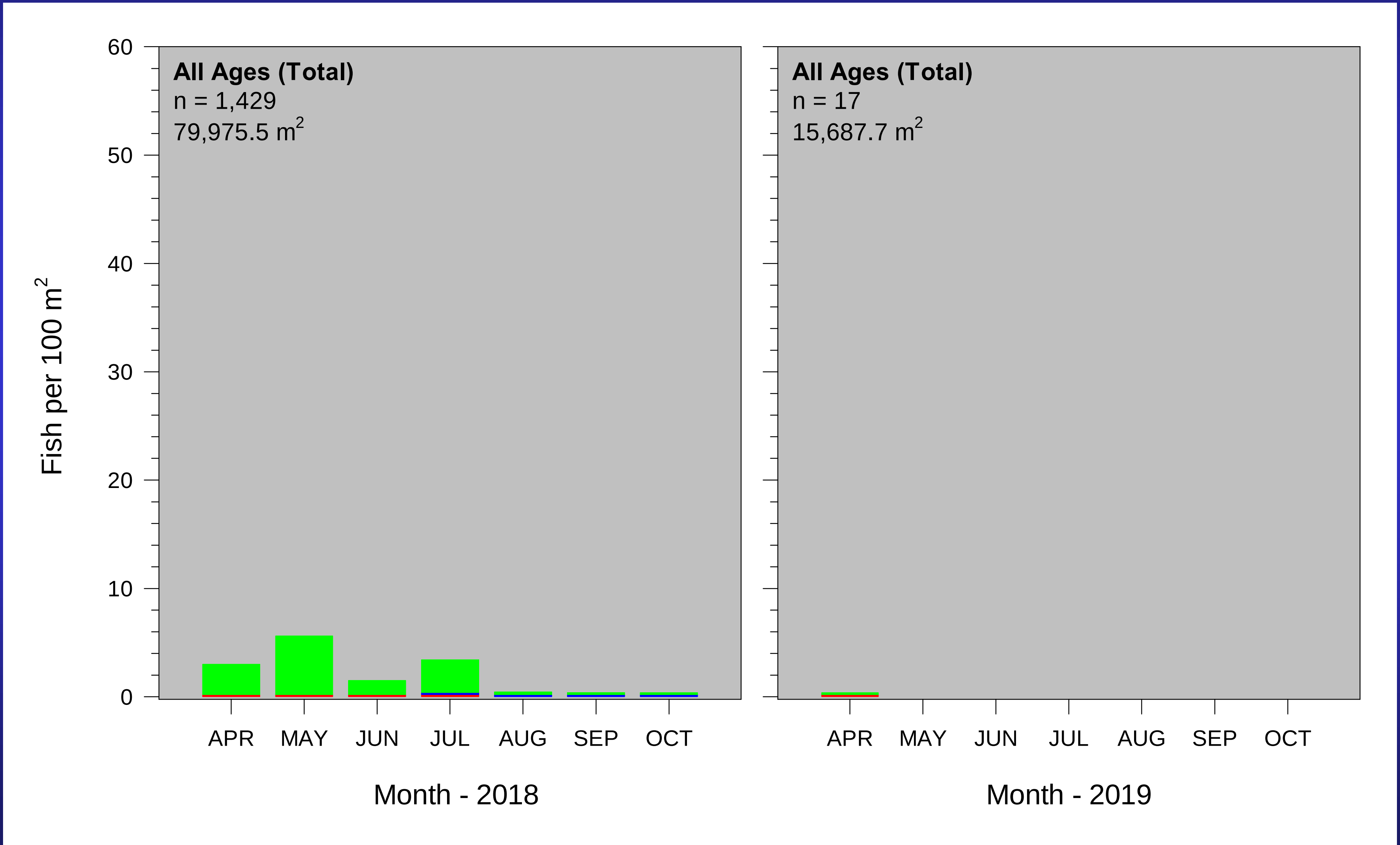
RGSM Population Trends in 2018 (All Ages)



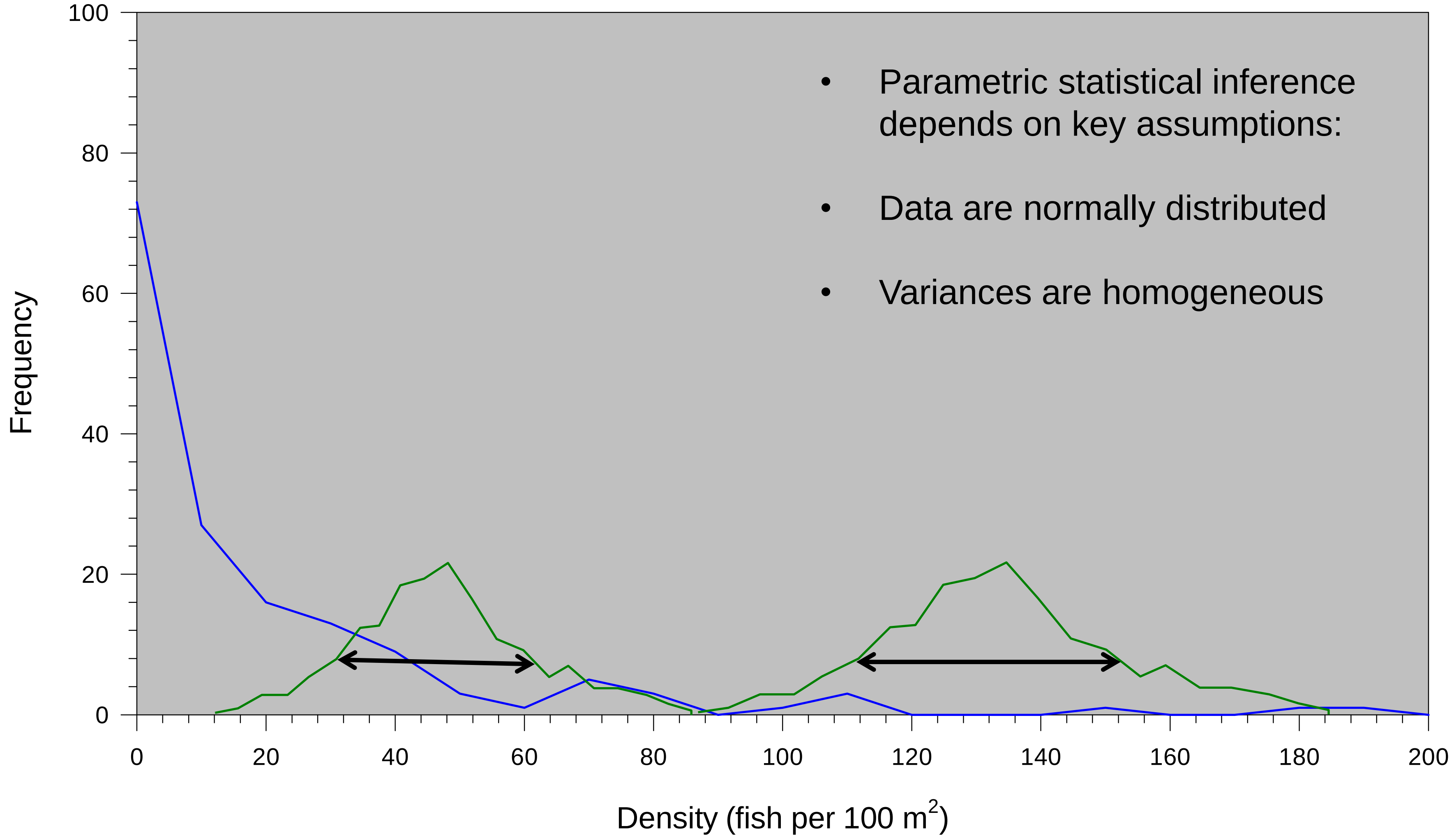
RGSM Population Trends (2017–2018)



RGSM Population Trends (2018–2019)

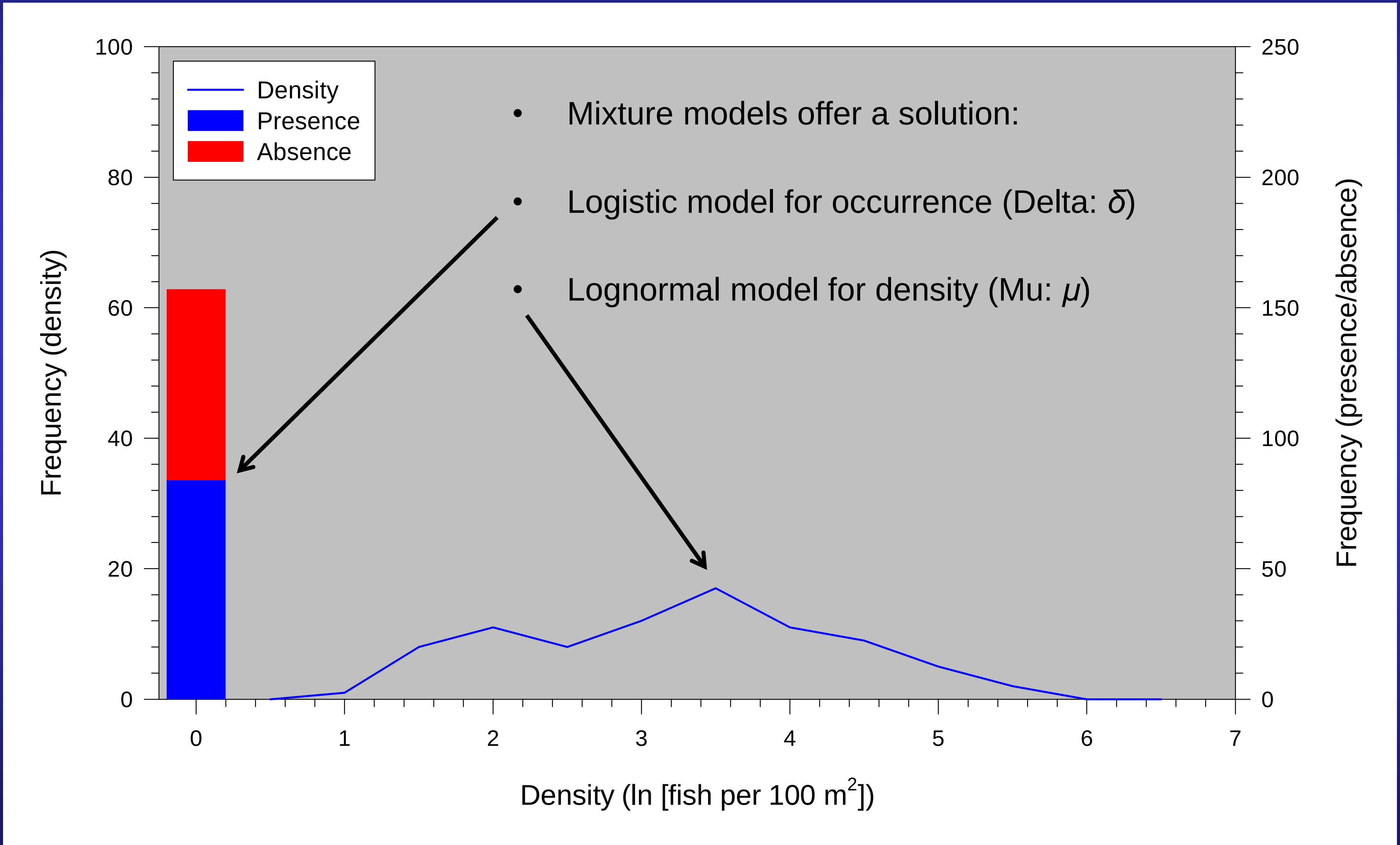


Frequency Distribution of Raw Data



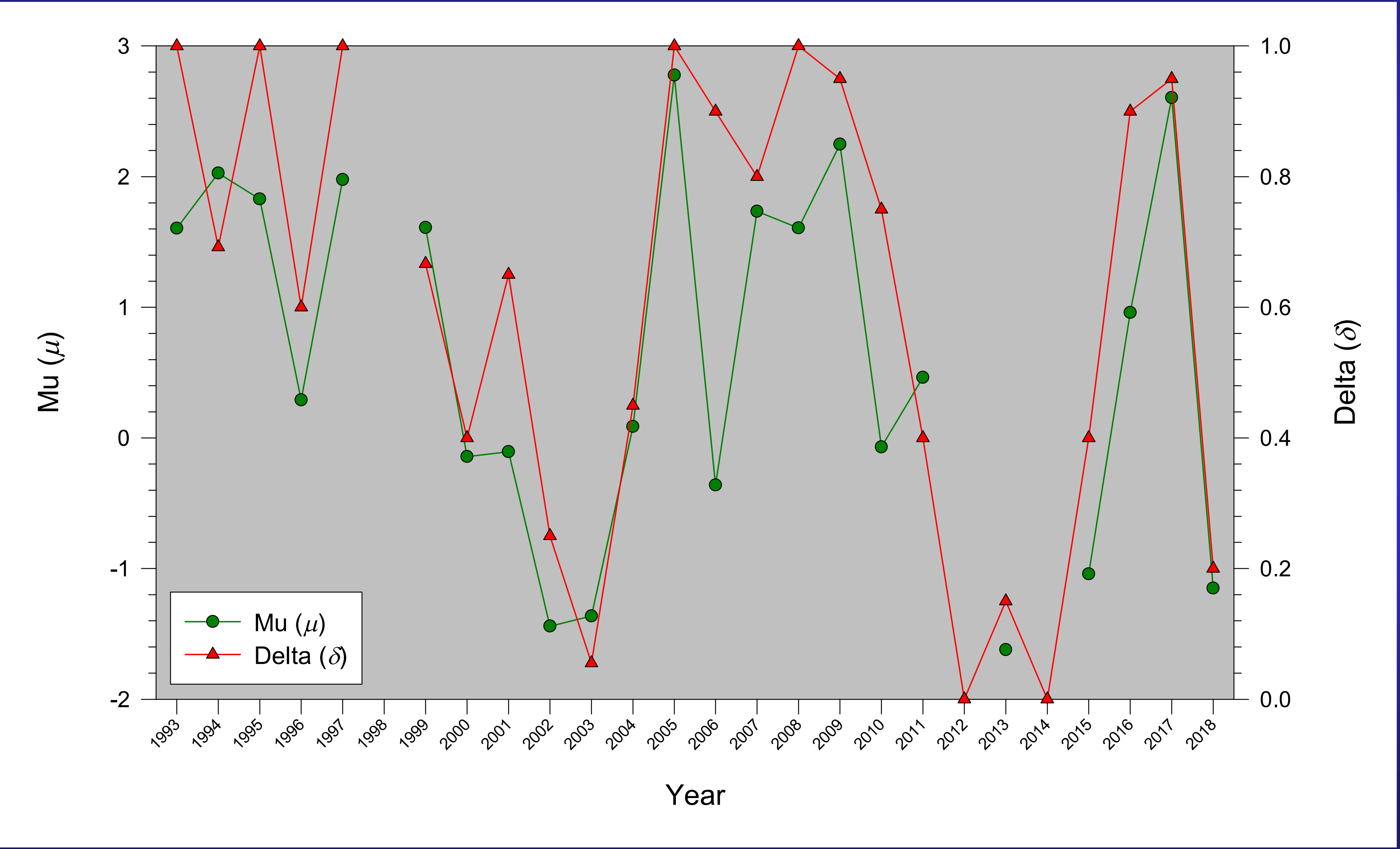
- Parametric statistical inference depends on key assumptions:
- Data are normally distributed
- Variances are homogeneous

Occurrence and Density Data



- Mixture models offer a solution:
- Logistic model for occurrence (Delta: δ)
- Lognormal model for density (Mu: μ)

Model Estimates in October (1993–2018)



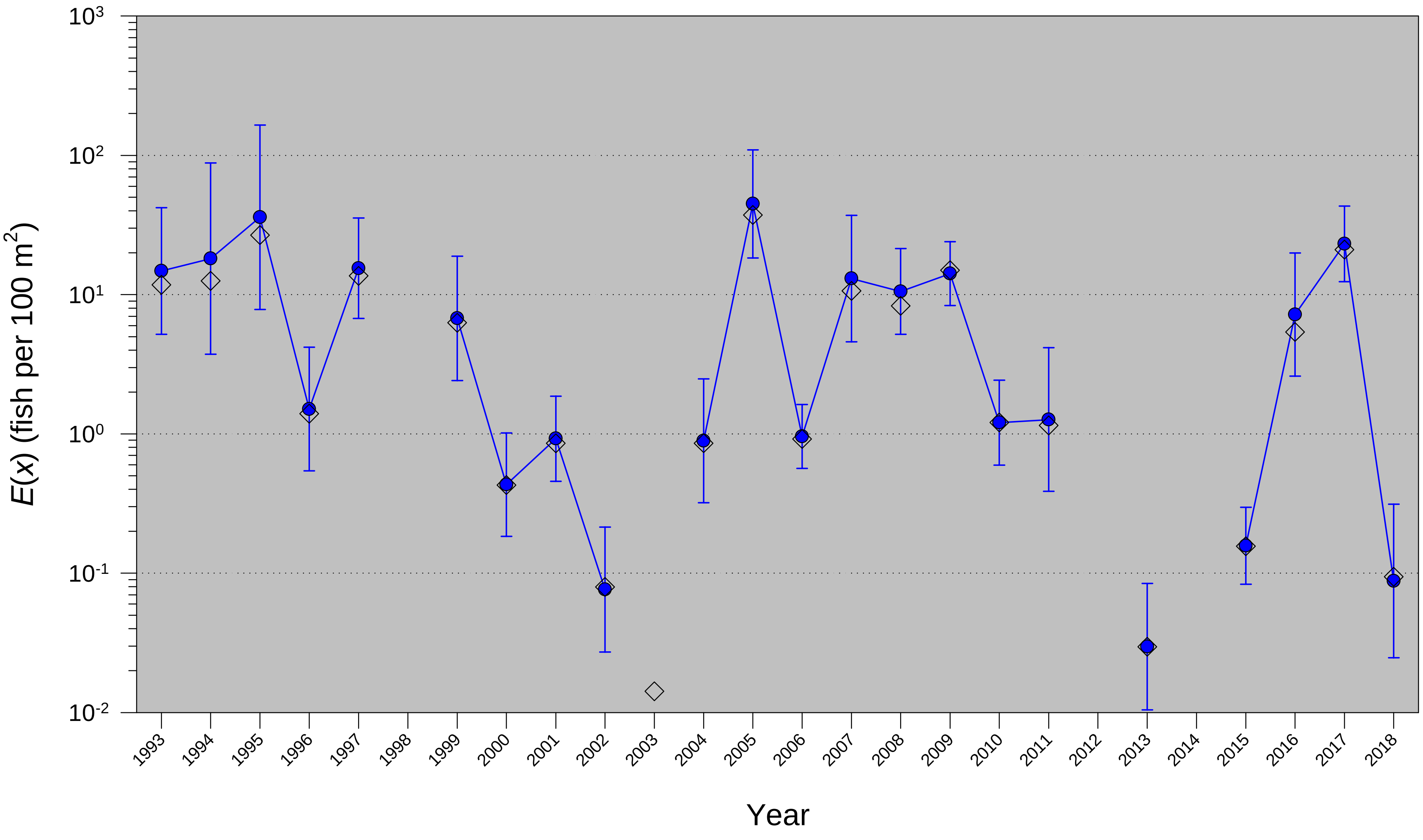
Computing the Expected Density

$$E(x) = d\exp\left[m + \frac{s^2}{2} \right]$$

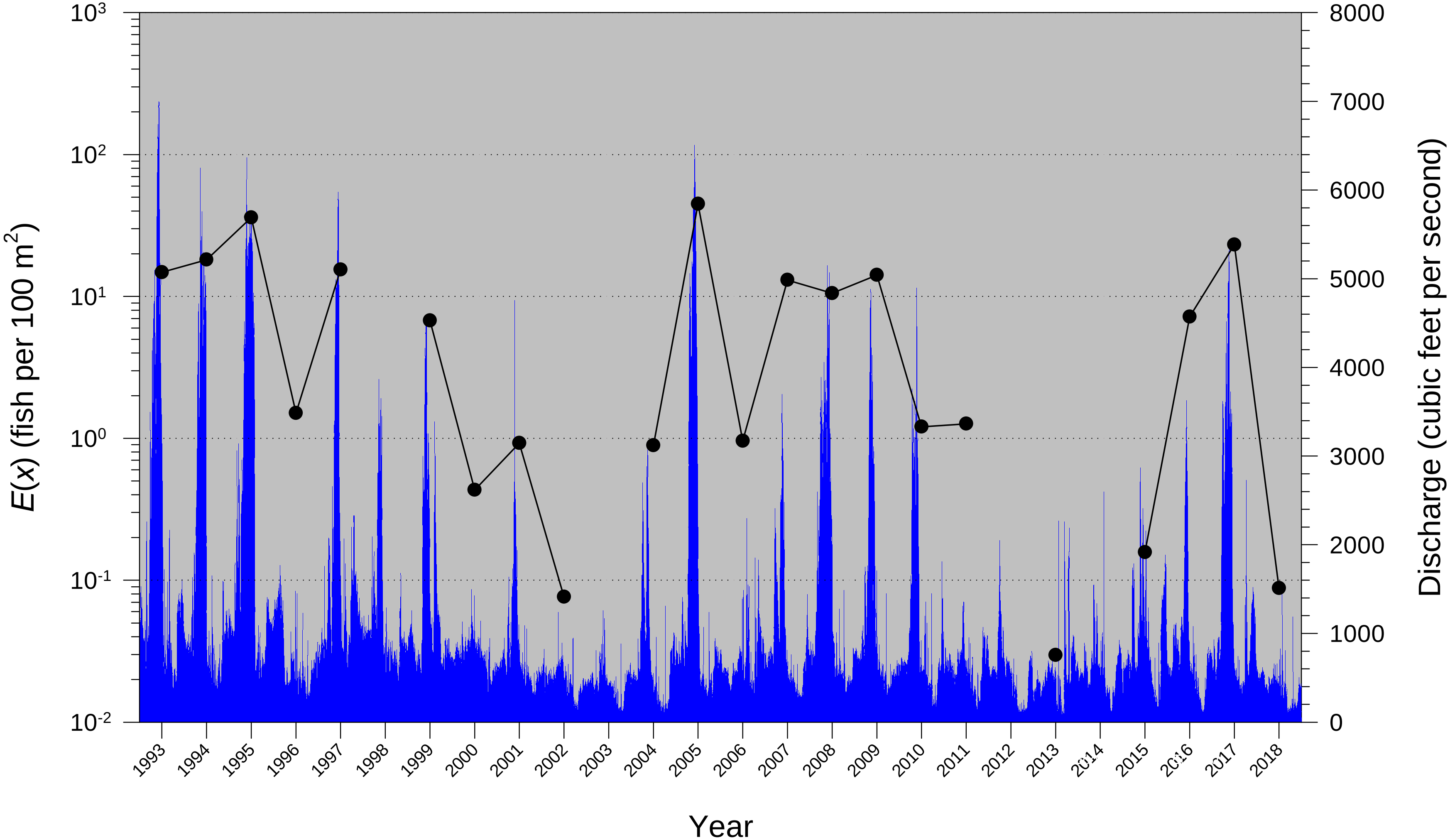
$$\mathrm{LCI} = \exp\left[\log\left(E(x) \right) - 1.96 \times \mathrm{SE}\left(E(x) \right) / E(x) \right]$$

$$\mathrm{UCI} = \exp\left[\log\left(E(x) \right) + 1.96 \times \mathrm{SE}\left(E(x) \right) / E(x) \right]$$

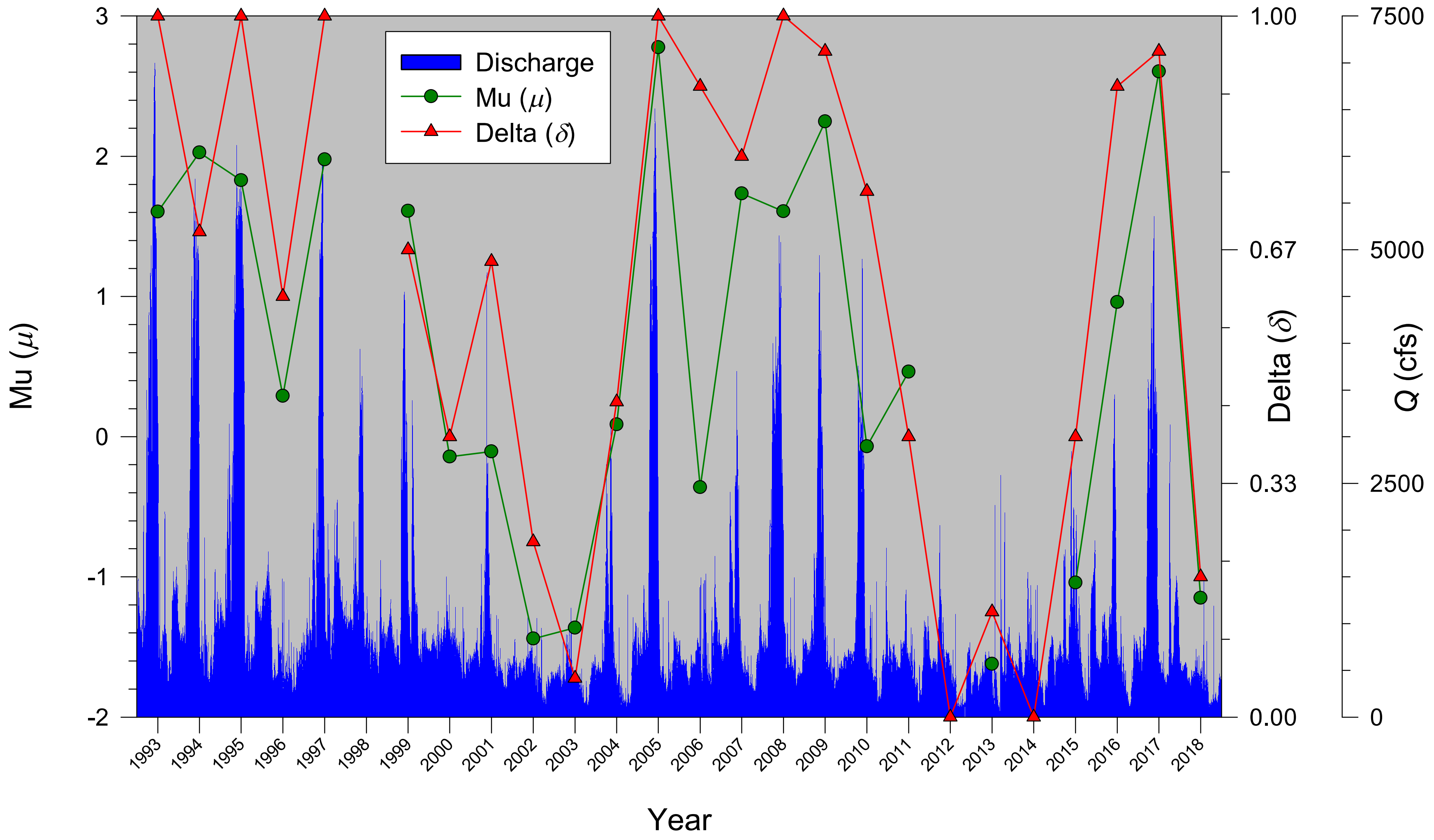
Densities of RGSM in October (1993–2018)



Densities of RGSM and Discharge (1993–2018)



Model Estimates and Discharge (1993–2018)



Modeling the Ecology of RGSM

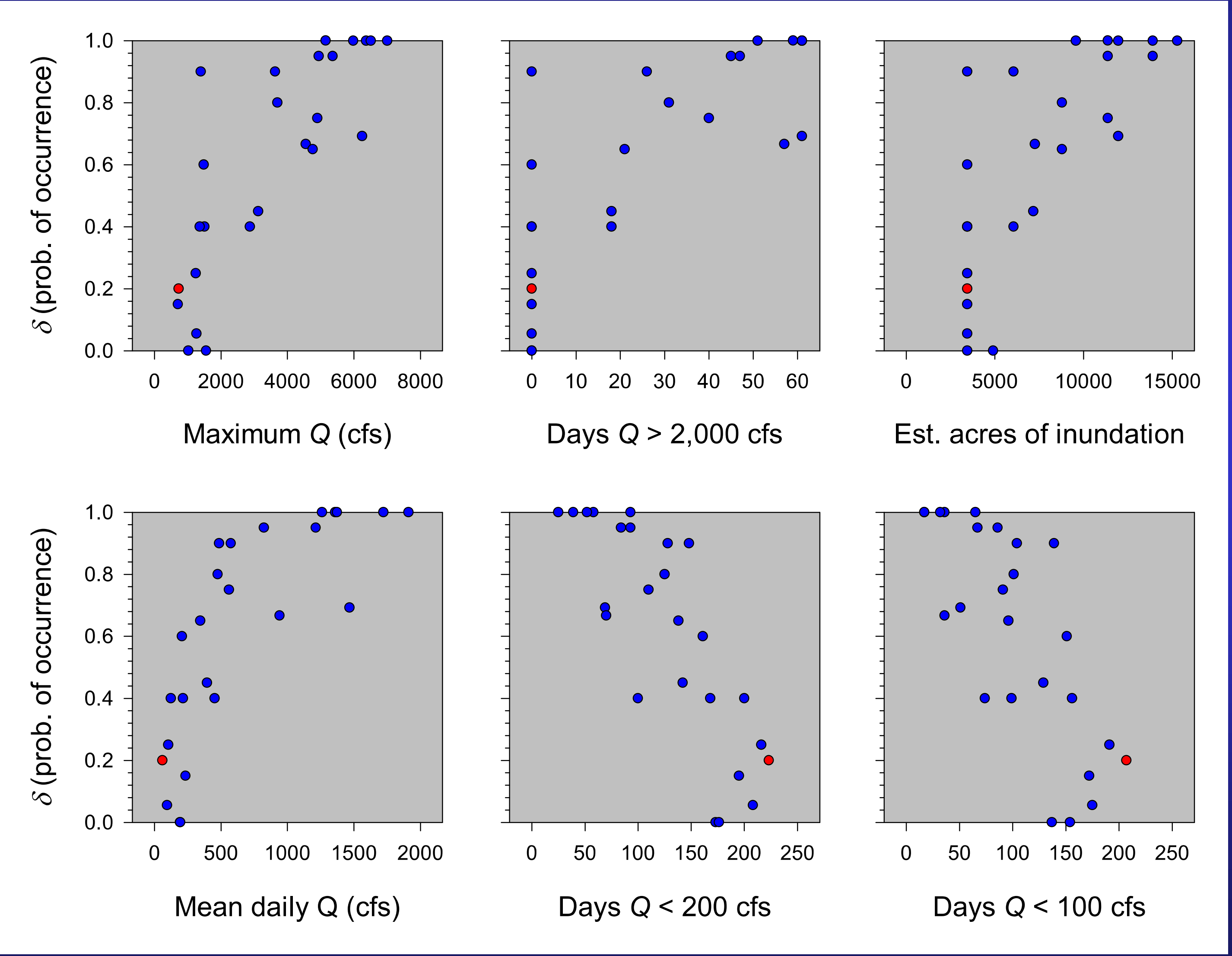
- Each model included both δ and μ with a single covariate for each estimated parameter (e.g., δ[SAN<200] μ[ABQ>3,000]).

- Covariates representing spring runoff conditions, estimated floodplain inundation, and summer low flow conditions were included in models.

- Hydraulic covariates included both fixed effects (i.e., covariate explains variation) and random effects (i.e., random error [*R*] around covariate).

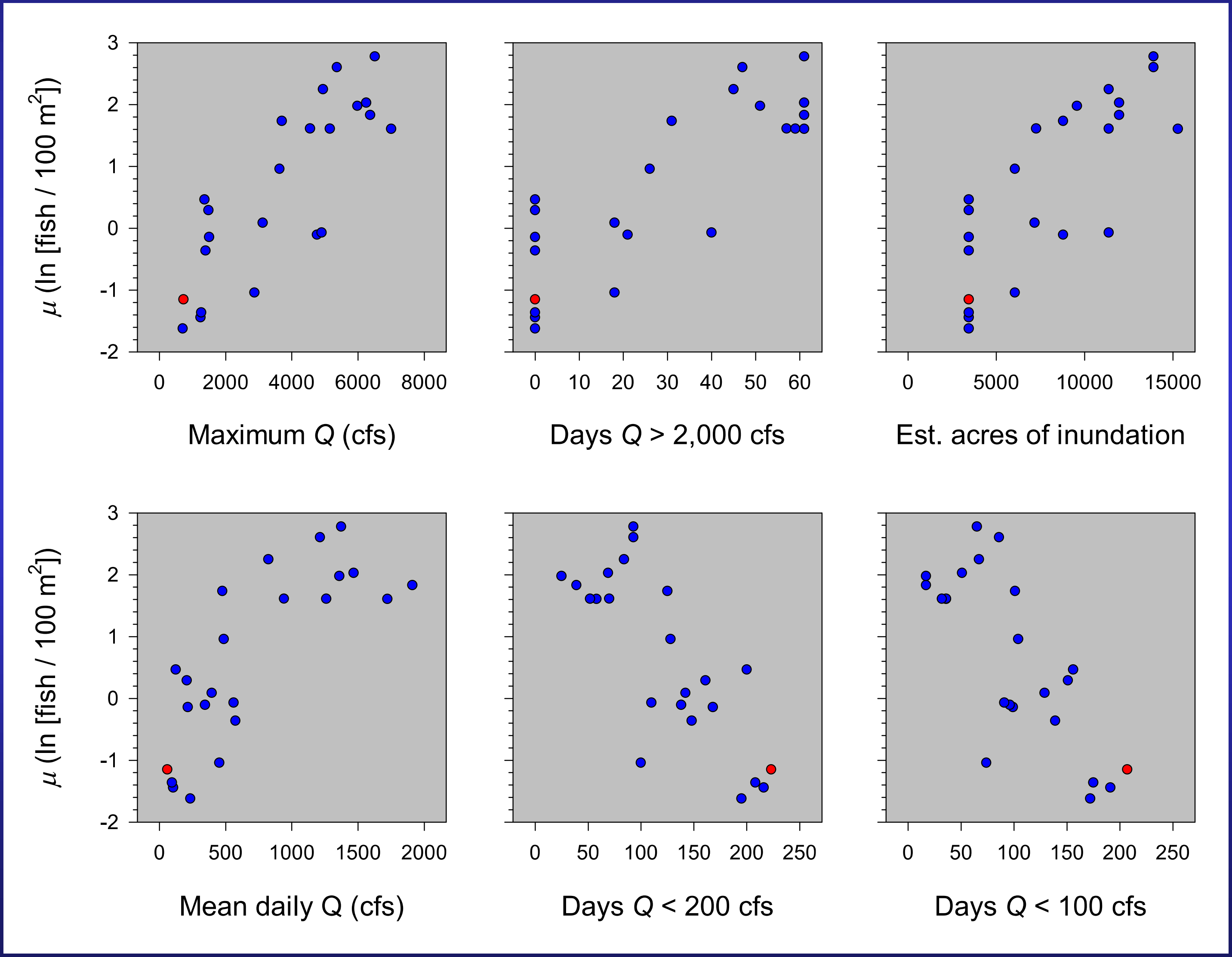
- Goodness-of-fit statistics (log-likelihood and Akaike's information criterion [AIC_c]) were used to assess the fit of data to various models.

Occurrence Probability vs. Discharge (1993–2018)





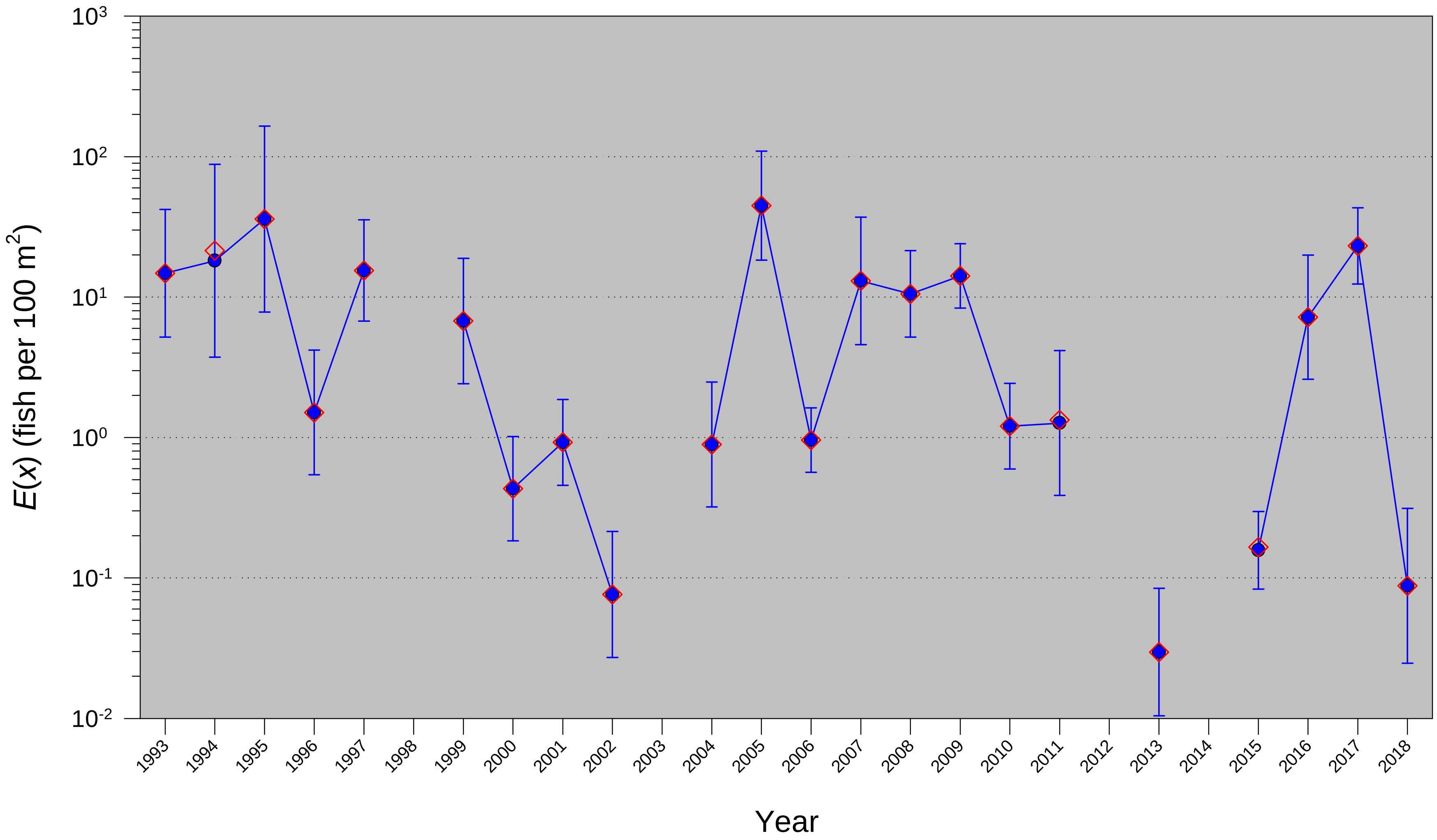
Lognormal Densities vs. Discharge (1993–2018)



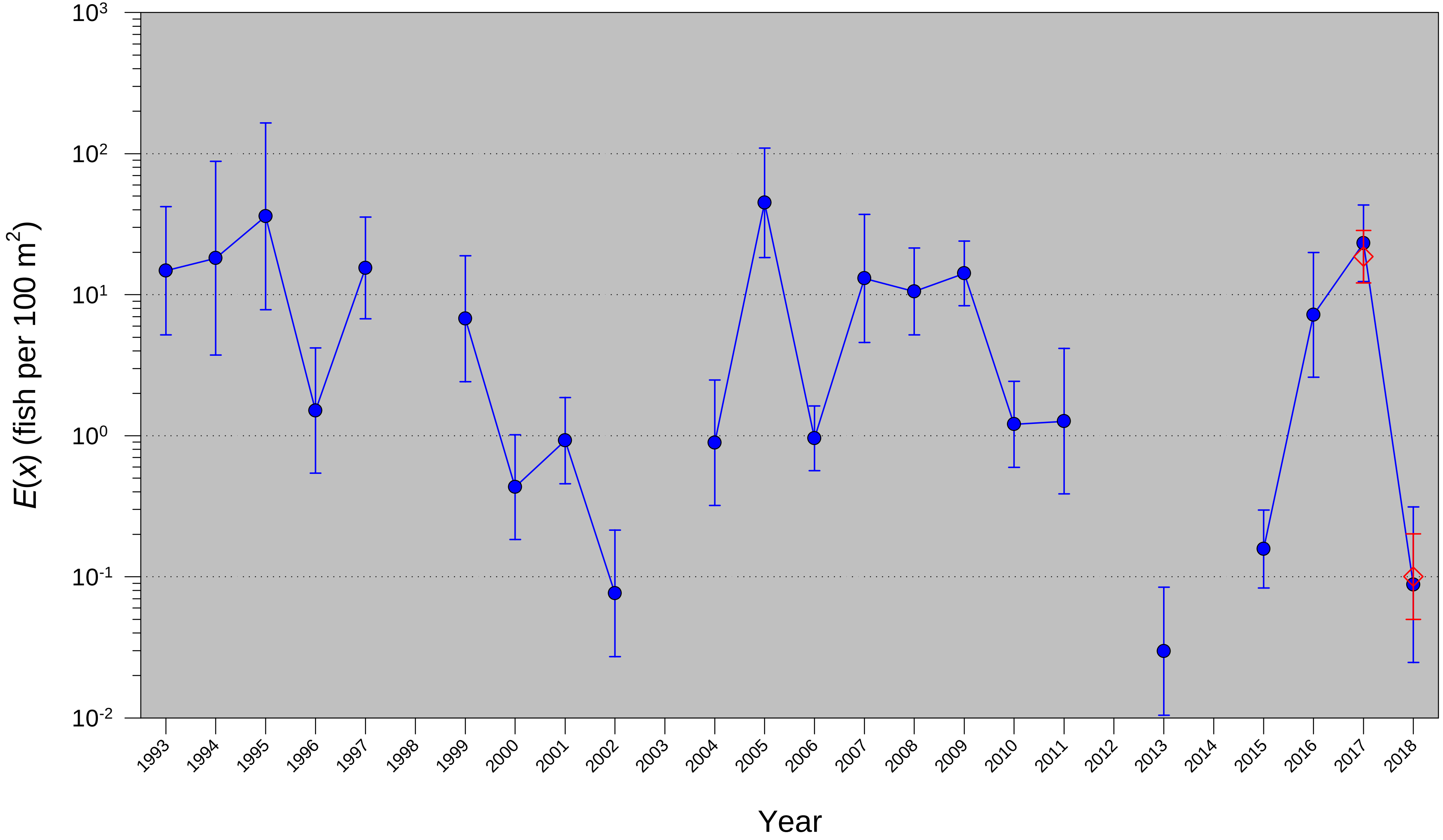
Ecological Model Results for RGSM (1993–2018)

Model	logLike	K	AIC_c	w_i
δ(Year) μ(ABQ>2,000+R)	769.09	30	833.40	0.3886
δ(Year) μ(ABQmean+R)	769.63	30	833.93	0.2971
δ(Year) μ(ABQ>3,000+R)	771.21	30	835.52	0.1346
δ(Year) μ(ABQmax+R)	771.83	30	836.14	0.0989
δ(Year) μ(ABQ>1,000+R)	774.64	30	838.95	0.0243
δ(Year) μ(SANmean+R)	774.81	30	839.12	0.0222
δ(Year) μ(Year)	675.02	70	840.38	0.0119
δ(Year) μ(Inundation+R)	778.61	30	842.92	0.0033
δ(Year) μ(SAN<200+R)	778.74	30	843.05	0.0031
δ(SANmean+R) μ(Year)	736.00	48	843.37	0.0027

Densities of RGSM in October (No Dry Sites)

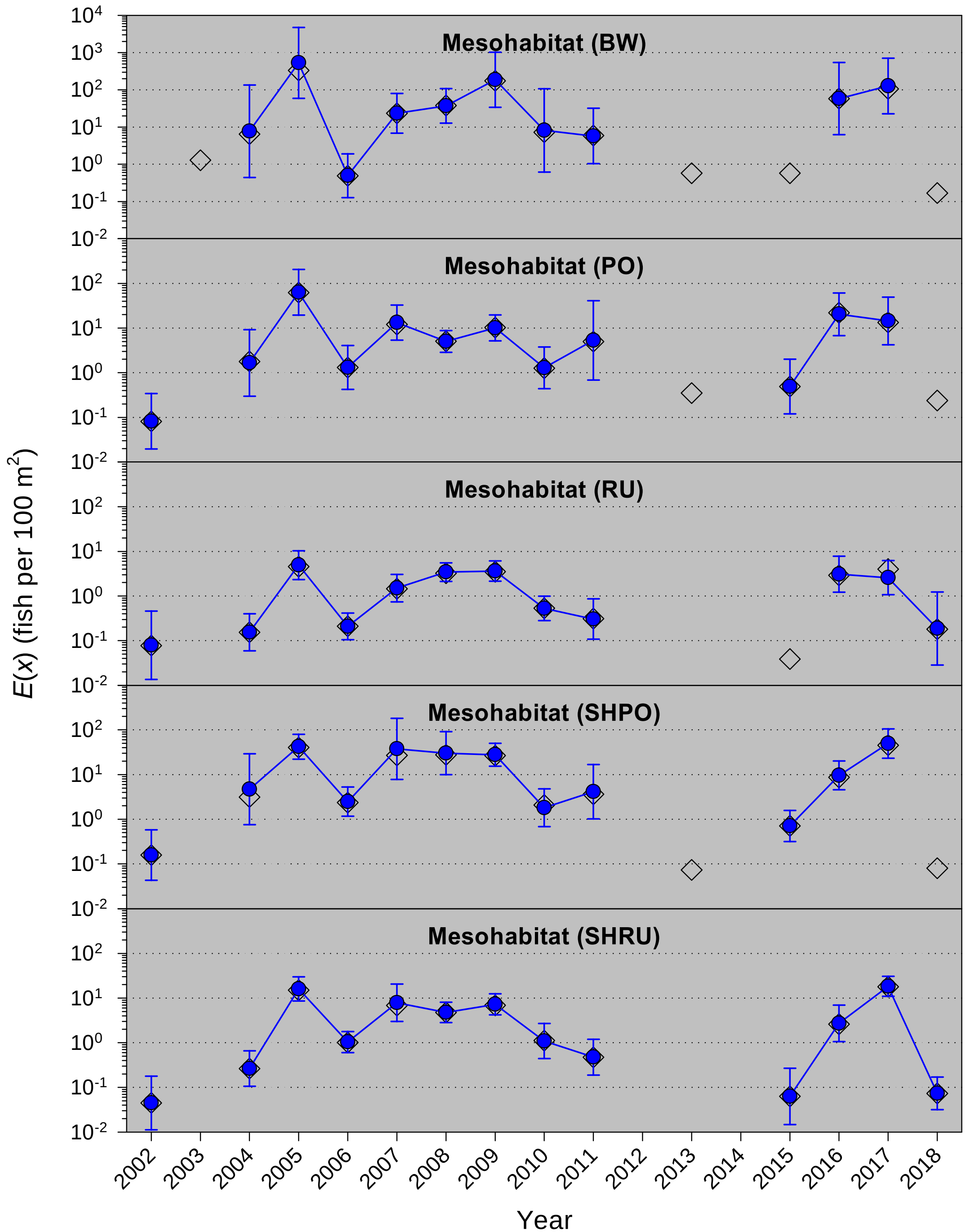


Densities of RGSM in October (Additional Sites)



Densities of RGSM
(Mesohabitats)

- Mesohabitat-specific density trends were very similar to the overall long-term trend.
- Estimated densities in BW, PO, and SHPO were generally higher and more variable as compared to SHRU or RU.



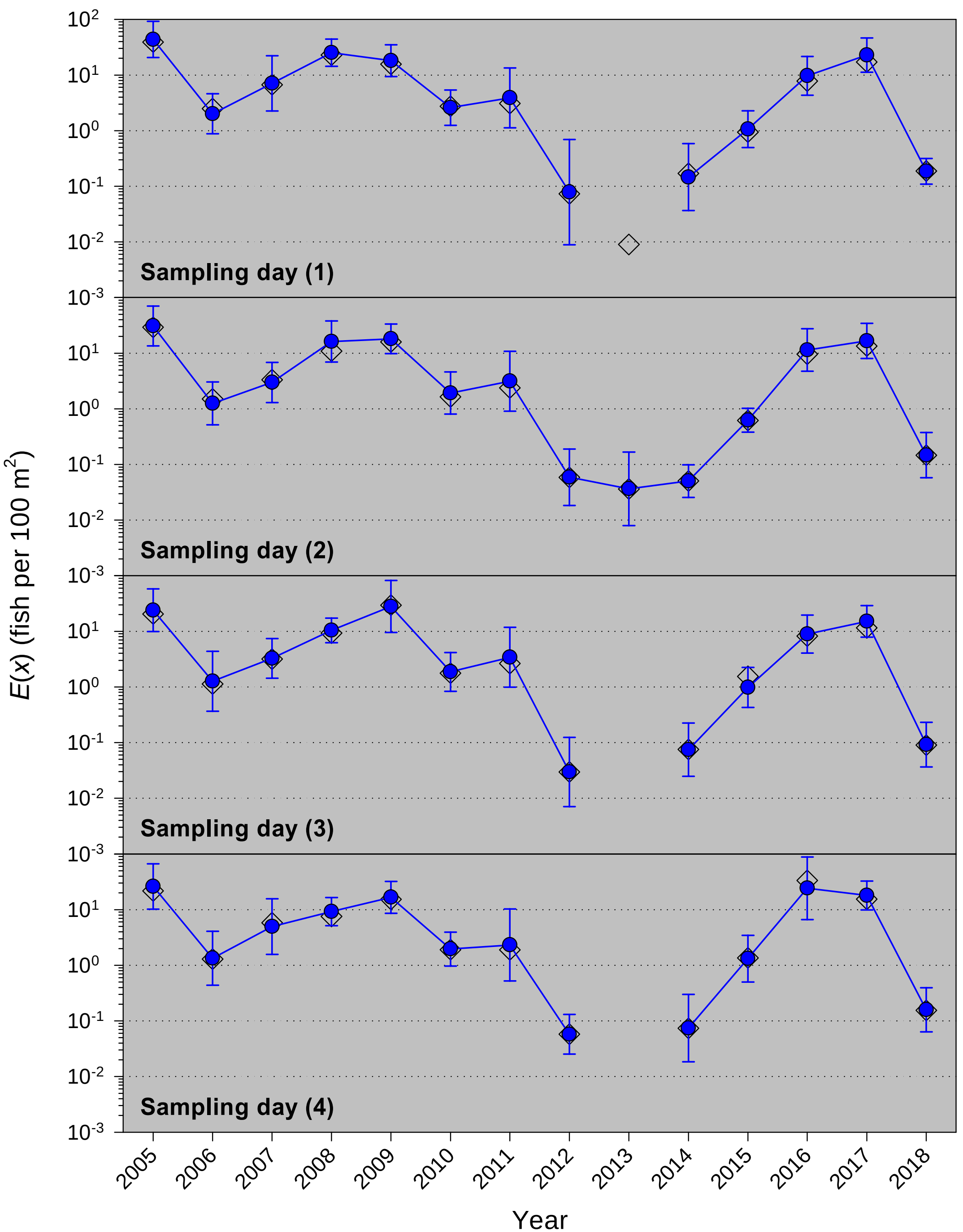
Mesohabitat Model Results for RGSM (2002–2018)

Model	logLike	K	AIC_c	w_i
δ(Year+Mesohabitat) μ(Year+Mesohabitat)	1,859.28	58	1,980.06	>0.9999
δ(Year) μ(Year+Mesohabitat)	1,899.07	54	2,011.20	<0.0001
δ(Year+Mesohabitat) μ(Mesohabitat)	2,081.46	31	2,144.82	<0.0001
δ(Year*Mesohabitat) μ(Year*Mesohabitat)	1,662.58	212	2,157.24	<0.0001
δ(Year) μ(Mesohabitat)	2,121.25	27	2,176.28	<0.0001
δ(Year+Mesohabitat) μ(Year)	2,106.94	50	2,210.48	<0.0001
δ(*R*) μ(Mesohabitat)	2,203.32	12	2,227.53	<0.0001
δ(Year) μ(Year+Reach)	2,131.57	50	2,235.12	<0.0001
δ(Year+Reach) μ(Year+Reach)	2,131.40	52	2,239.23	<0.0001
δ(Year) μ(Year)	2,146.73	46	2,241.72	<0.0001

Densities of RGSM
(Variation)

- Density trends, based on the four sampling occasions, were very similar to the overall long-term trend.

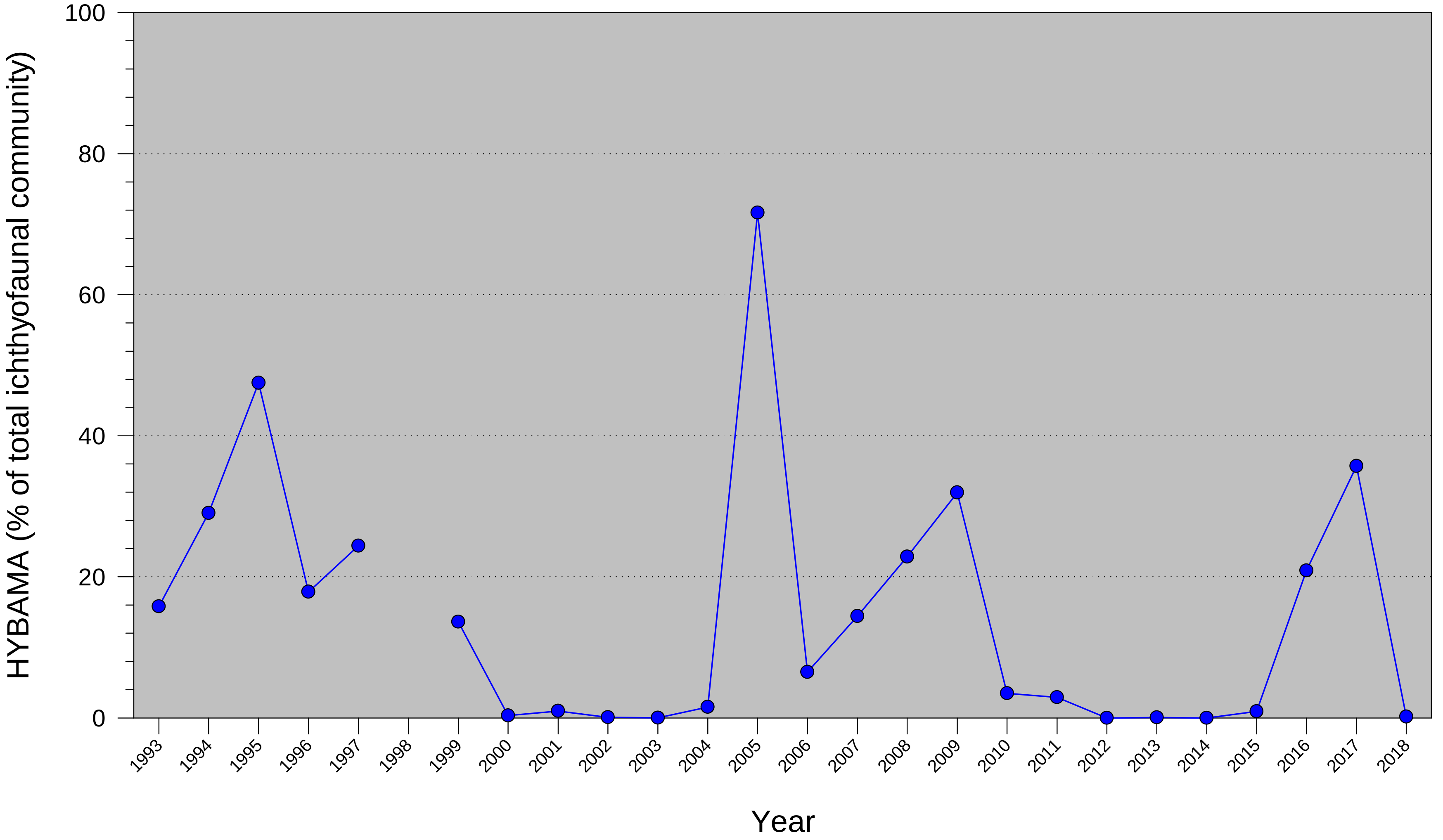
- Estimated densities were quite similar across the four sampling occasions.



Model Results for RGSM Variation (2005–2018)

Model	logLike	K	AIC_c	w_i
δ(Year*Reach) μ(Year*Reach)	1,487.86	120	1,756.93	>0.9999
δ(Year+Reach) μ(Year+Reach)	1,791.56	48	1,891.96	<0.0001
δ(Year+Reach) μ(Year)	1,852.36	44	1,944.04	<0.0001
δ(Year) μ(Year+Reach)	1,849.24	46	1,945.26	<0.0001
δ(Year) μ(Year)	1,910.03	42	1,997.38	<0.0001
δ(Year+Occasion) μ(Year)	1,906.50	45	2,000.35	<0.0001
δ(Year) μ(Year+Occasion)	1,900.57	48	2,000.96	<0.0001
δ(Year+Occasion) μ(Year+Occasion)	1,897.04	51	2,004.00	<0.0001
δ(R) μ(Year)	1,972.54	30	2,034.25	<0.0001
δ(Year) μ(R)	2,031.12	17	2,065.68	<0.0001

Relative Abundance of RGSM (1993–2018)



Rank Abundance for Focal Species (2009–2018)

Species	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Red Shiner	1	1	1	1	1	1	1	1	2	1
Common Carp	10	9	10	6	9	8	9	7	6	8
Rio Grande Silvery Minnow	2	5	4	10	10	10	7	2	1	10
Fathead Minnow	6	6	7	5	4	6	6	8	8	6
Flathead Chub	5	2	3	3	6	3	3	4	5	3
Longnose Dace	9	7	8	8	3	5	5	6	7	7
River Carpsucker	7	8	5	7	8	7	8	9	10	5
White Sucker	8	10	9	9	7	9	10	10	9	9
Channel Catfish	4	4	6	4	5	4	4	5	3	4
Western Mosquitofish	3	3	2	2	2	2	2	3	4	2

Coefficient of concordance ($W = 0.66$) indicated consistency in species' ranks (1993–2018; $P < 0.001$).

Pterygoplichthys disjunctivus (Loricariidae)

(Vermiculated Sailfin Catfish [Weber, 1991])

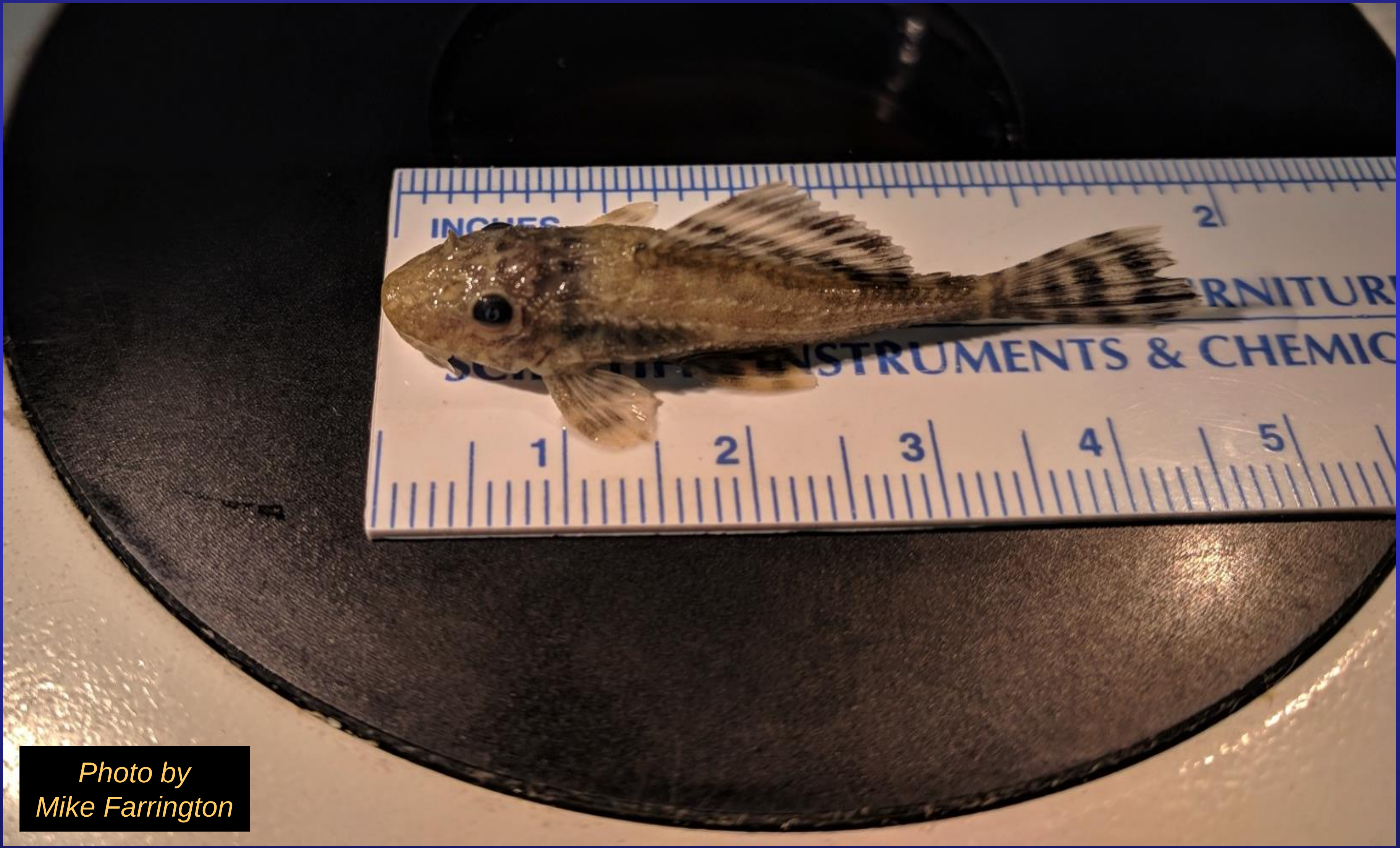


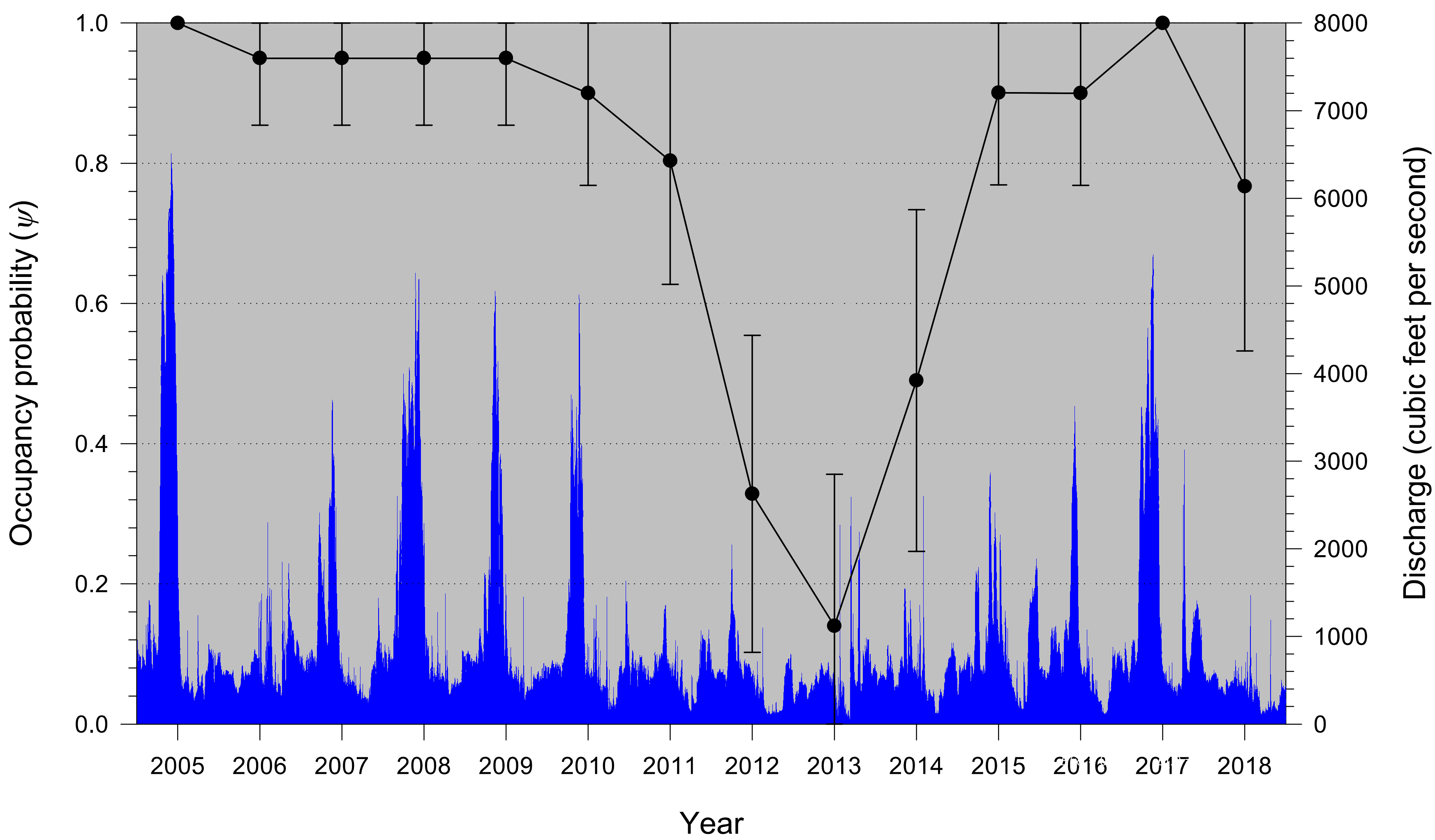
*Photo by
Mike Farrington*

Site Occupancy Results (2005–2018)

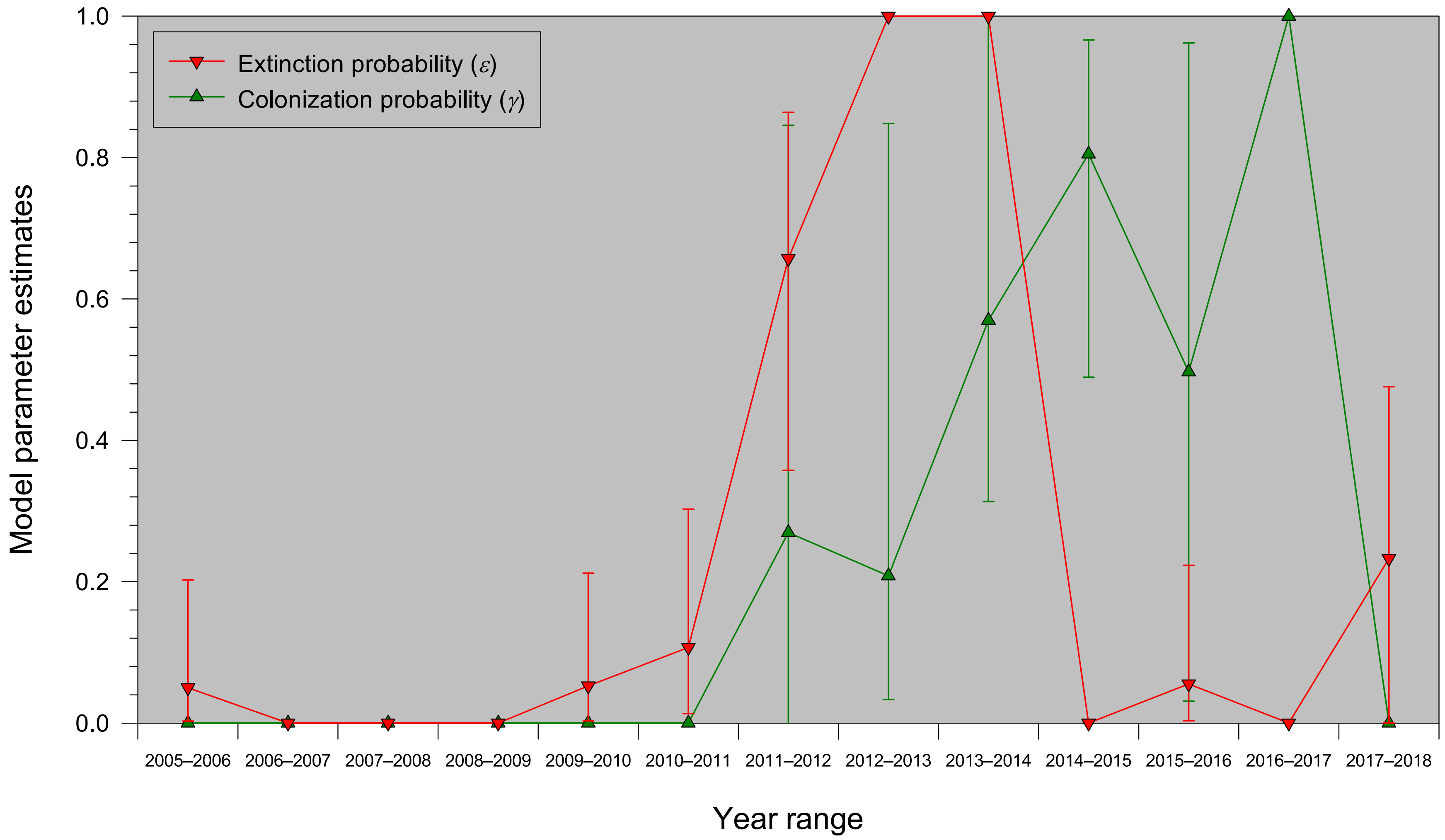
Site Occupancy Rates

- “Few species are likely to be so evident that they will always be detected when present.” (MacKenzie et al. 2003)
- Site occupancy analyses were based on RGSM repeated-sampling data (presence vs. absence) collected in November (2005–2018).
- Estimates of site occupancy rates were based on methods developed by MacKenzie et al. (2002, 2003, 2006), and Program MARK (White and Burnham, 1999) was used to compute all parameter estimates.
- Modeled parameter estimates included probability of detection (p), probability of occupancy (ψ), probability of extinction (ε), and probability of colonization (γ).

Occupancy Probabilities (All Ages)



Extinction & Colonization Probabilities (All Ages)



Summary

- While the estimated densities of RGSM were notably higher from 2015 to 2017 as compared with 2012 to 2014, their densities decreased substantially from 2017 to 2018.

- Prolonged high flows during spring were most predictive of increased density, whereas prolonged low flows during summer were most predictive of decreased occurrence.

- Mesohabitat-specific and sampling-occasion density trends both closely mirrored the long-term RGSM density trend.

- At times, RGSM has been lost from > 85% of its occupied sites since 2005. Occupancy, extinction, and colonization estimates for RGSM improved markedly from 2013 to 2017 before declining again in 2018.

Future Challenges & Opportunities

1. Ongoing efforts to restore dynamic river flows, reconnect fragmented reaches, and reestablish a functional floodplain should help to promote resilient and self-sustaining populations of Rio Grande Silvery Minnow.

2. Continued efforts to provide reasonable spring spawning and summer survival conditions will be essential for securing a self-sustaining wild population of this imperiled species in the Middle Rio Grande.

3. The reestablishment of resilient populations of this species at other locations within its historical range in the Rio Grande Basin would help to further ensure its long-term persistence in the wild.

4. Continued study of the key factors that control this complex aquatic ecosystem will be essential for developing and implementing successful strategies for the long-term recovery of Rio Grande Silvery Minnow.

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