



Annual Reporting Meeting Update 2: Natural Processes (Goal 2), Humpback Chub (Goal 3), Other Native Fish (Goal 5), Rainbow Trout Fishery (Goal 9), and Nonnative Invasive Species (Goal 10)

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Glen Canyon Dam Adaptive Management Program, Adaptive Management Workgroup Meeting February 25, 2026

U.S. Department of the Interior
U.S. Geological Survey

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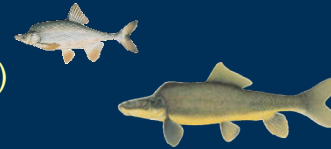
Photo credits: Freshwaters Illustrated & David Herasimtschuk

Thank you!

Glen Canyon Dam Adaptive Management Program

Numerous biologists, volunteers, logistics crew, boatmen, citizen scientists

Fish illustrations by Joe Tomelleri (unless otherwise noted)



Thank you to the
Grand Canyon
Native American
Tribes!




Outline

- Background
- Natural Processes (Goal 2)
- Humpback Chub (Goal 3)
- Other Native Fish (Goal 5)
- Rainbow Trout fishery (Goal 9)
- Non-native Invasives (Goal 10)
- Conclusions

From 2016-2022, adaptive management focus was enhancing Natural Processes (Goal 2)

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Natural Processes:
Restore, to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems.

From 2016-2022, adaptive management focus was enhancing Natural Processes (Goal 2)

Colorado River ecosystem model (2018)

Goals 3, 5, 9, 10

Goal 2

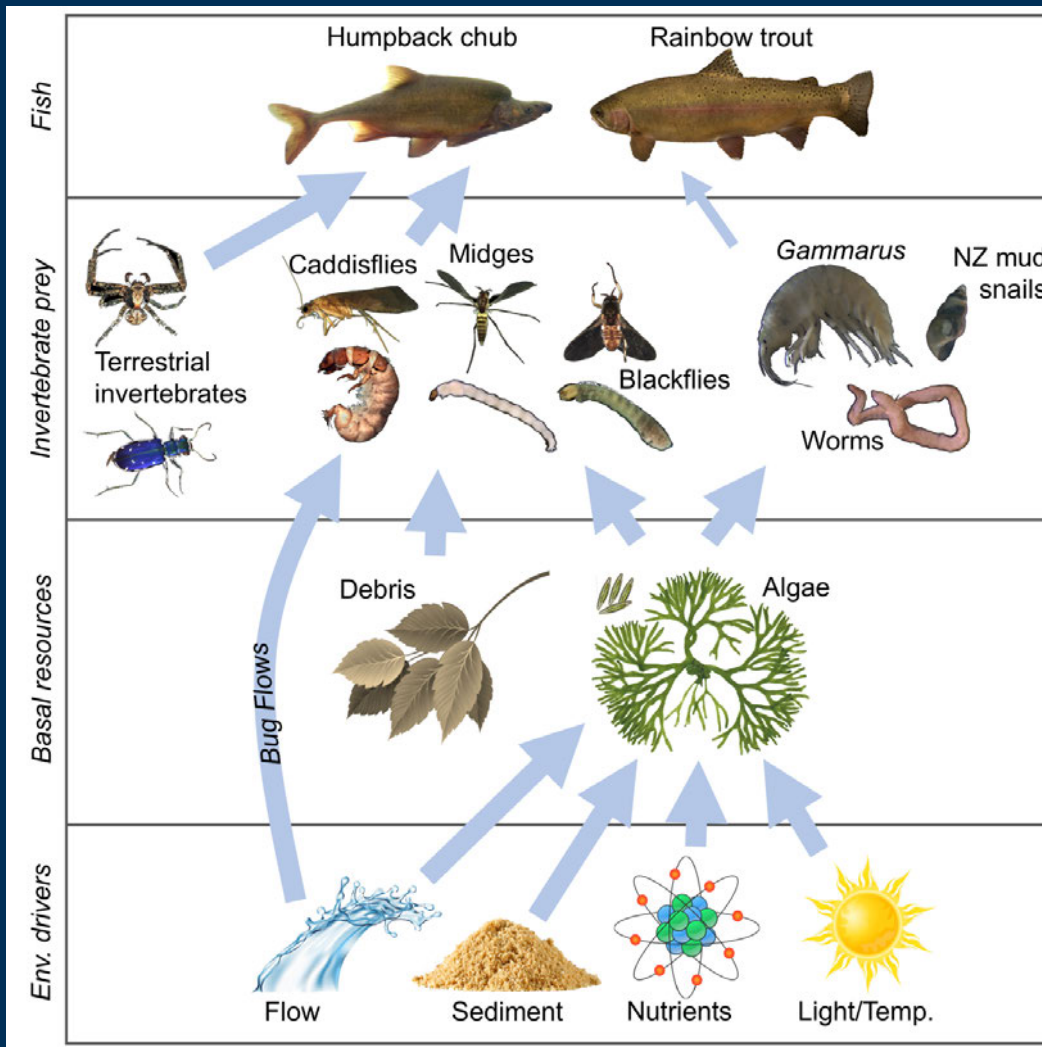


Figure courtesy of Jeff Muehlbauer, USGS-Alaska



Colorado River ecosystem model (2018)

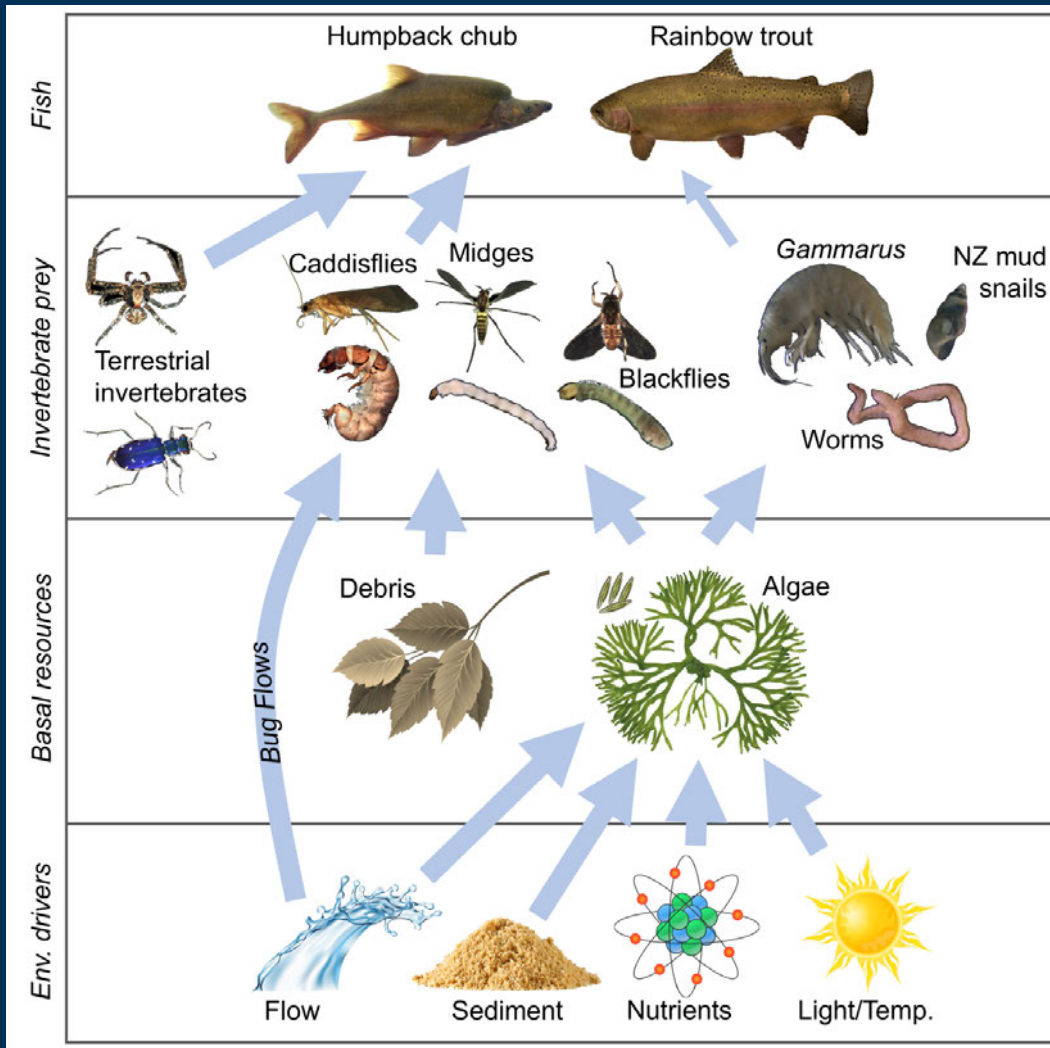


Figure courtesy of Jeff Muehlbauer, USGS-Alaska

Colorado River ecosystem model (2025)

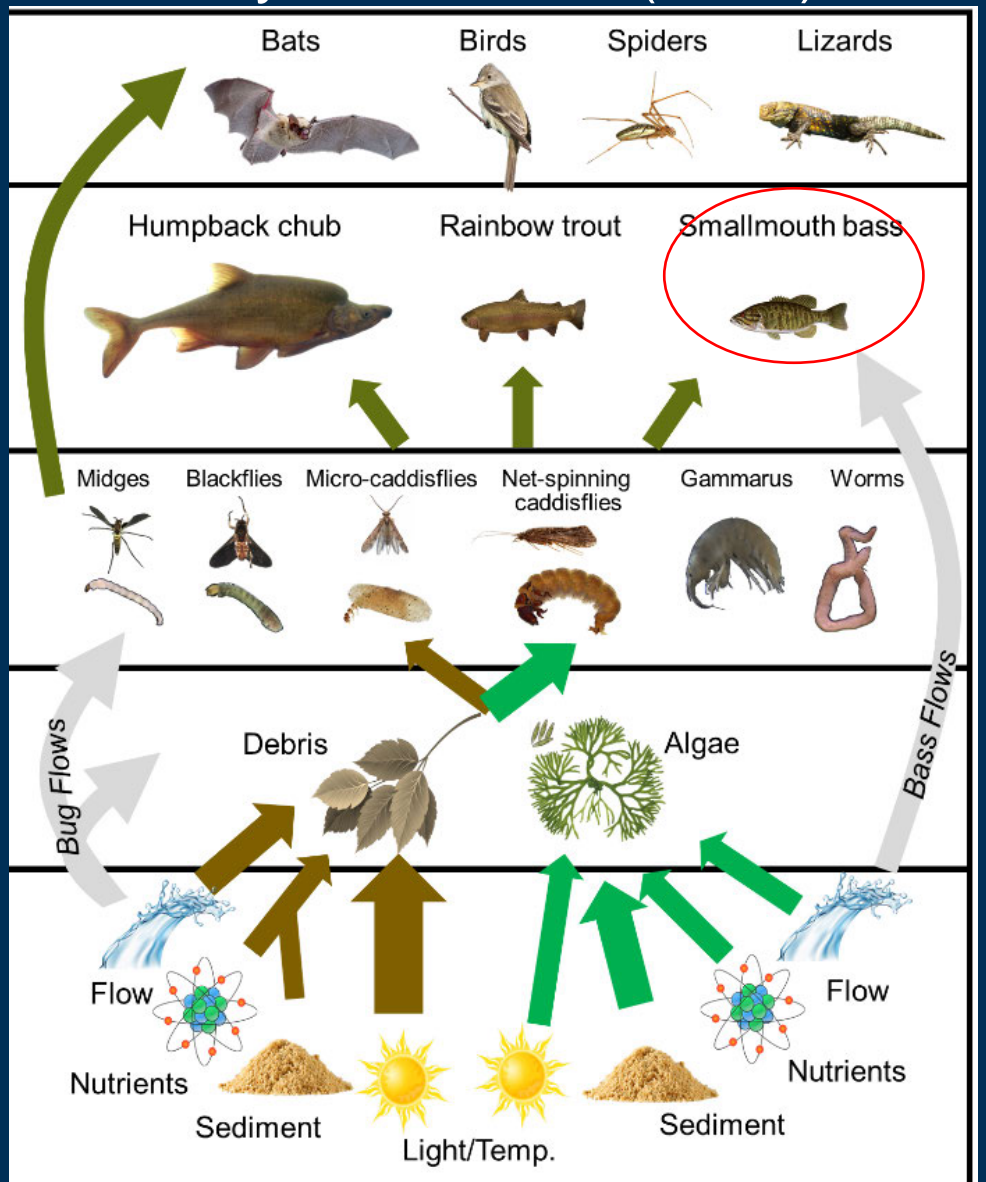


Figure courtesy of Eric Scholl, formerly Grand Canyon Monitoring and Research Center

Goals 3, 5, 9, 10

Goal 2

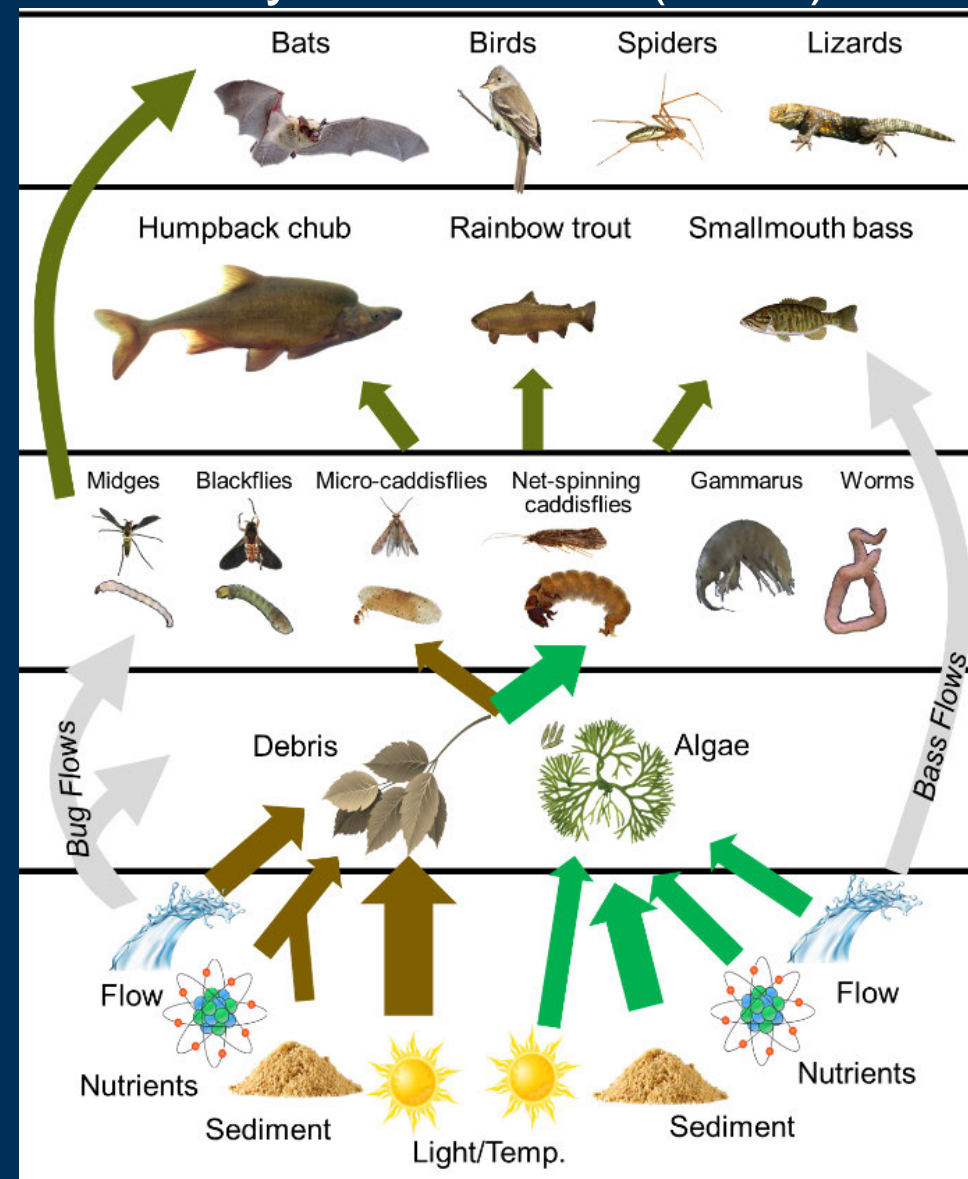


Drought & aridification evident across metrics

- Natural Processes: Flow statistics more natural, insect diversity higher
- Humpback Chub: Mainstem reproduction, growth rates higher, but large latent threat exists
- Other Native Fish: Mainstem reproduction, growth rates higher, but large latent threat exists
- Rainbow Trout Fishery: Low recruitment & abundance, low angler satisfaction
- Non-native Invasive Species: Introduction and reproduction of Smallmouth Bass is a large latent threat

From 2022-present, adaptive management focus is disadvantaging Non-Native Invasive Species (Goal 10)

Colorado River ecosystem model (2025)



Natural Processes metrics

Metrics focus on natural processes

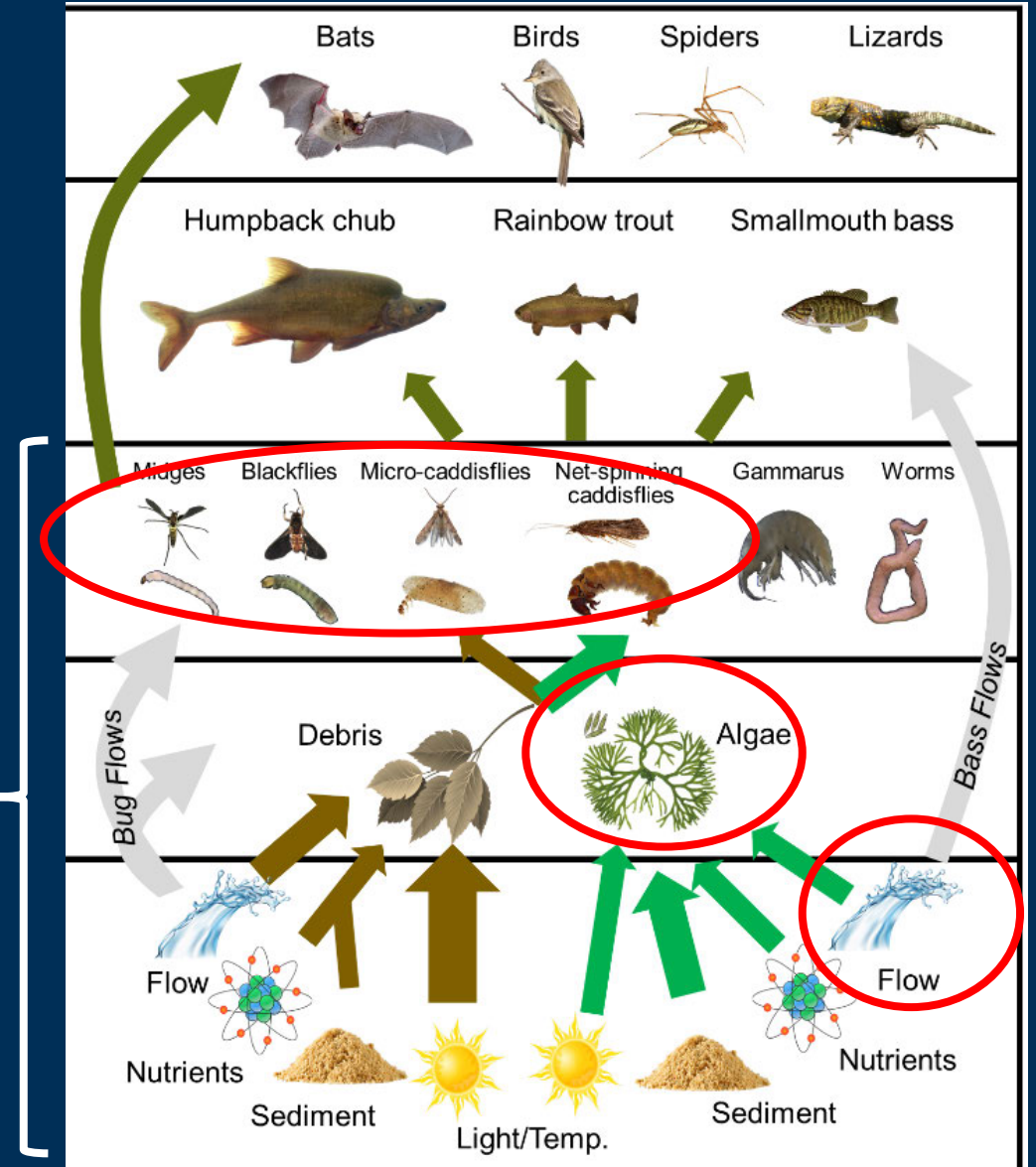
- 1) primary physical drivers
- 2) indicators of biological response
- 3) influenced by management actions
- 4) not included in other LTEMP goals (e.g., sediment)

Metrics:

- 2.1 Deviation from Natural Flow
- 2.2 Subdaily Stage Fluctuation
- 2.3 Springtime Primary Production in Marble and Grand Canyon
- 2.4 Percent Mayflies, Stoneflies, & Caddisflies (EPT) in Light Traps

Colorado River ecosystem model (2025)

Natural Processes Metrics



Natural Processes—Flow Metrics

A river's flow is the “master variable”...

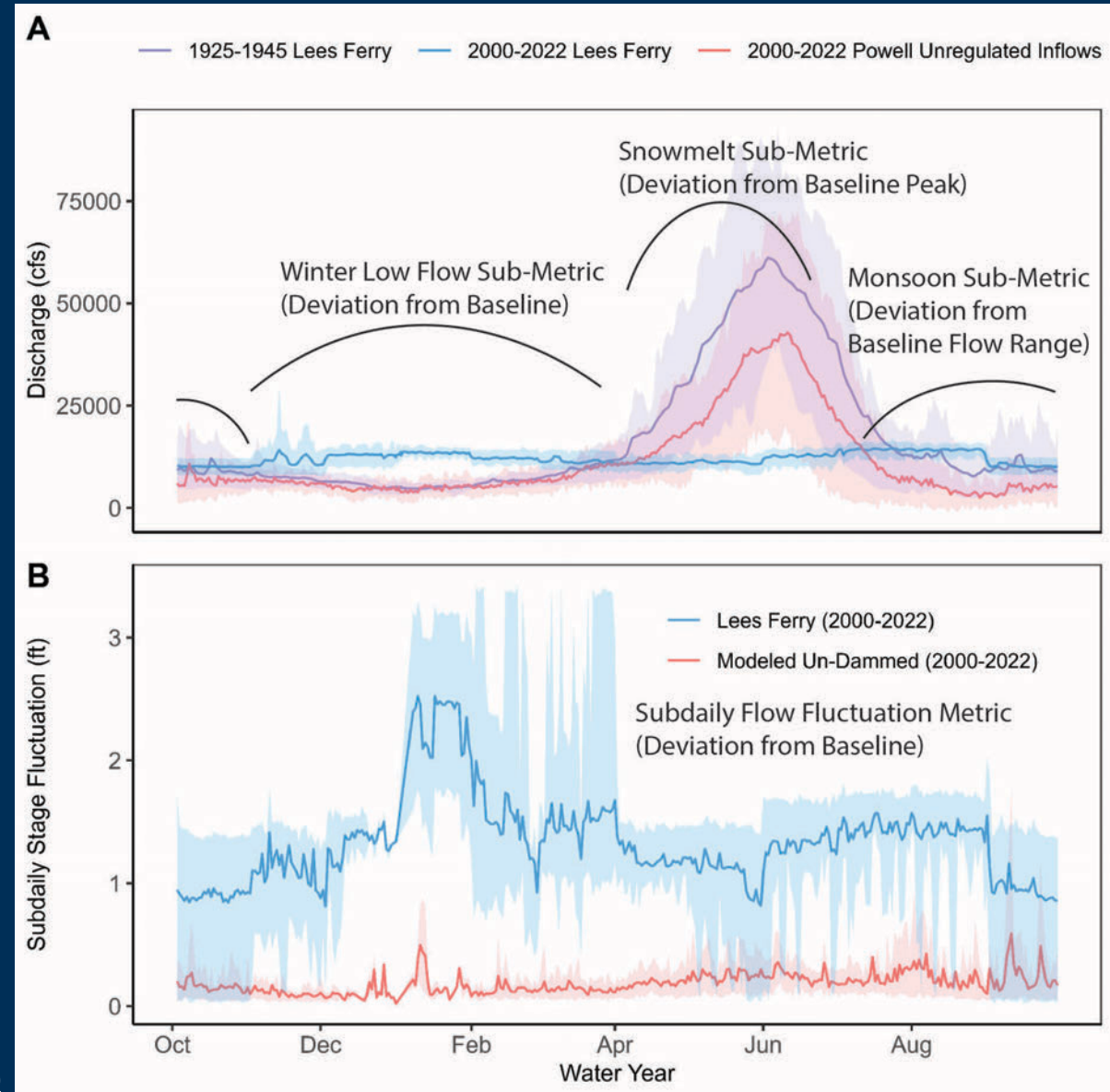
Glen Canyon Dam operations:

- Eliminated spring flooding
- Elevated baseflows
- Increased subdaily flow fluctuations

Metrics:

- 100-year monitoring record at 2 sites
 - Project A-data collection, Project C & E-analysis
- Statistically compare actual daily flow to estimated natural baseline
- Z-scores, units are standard deviations from natural

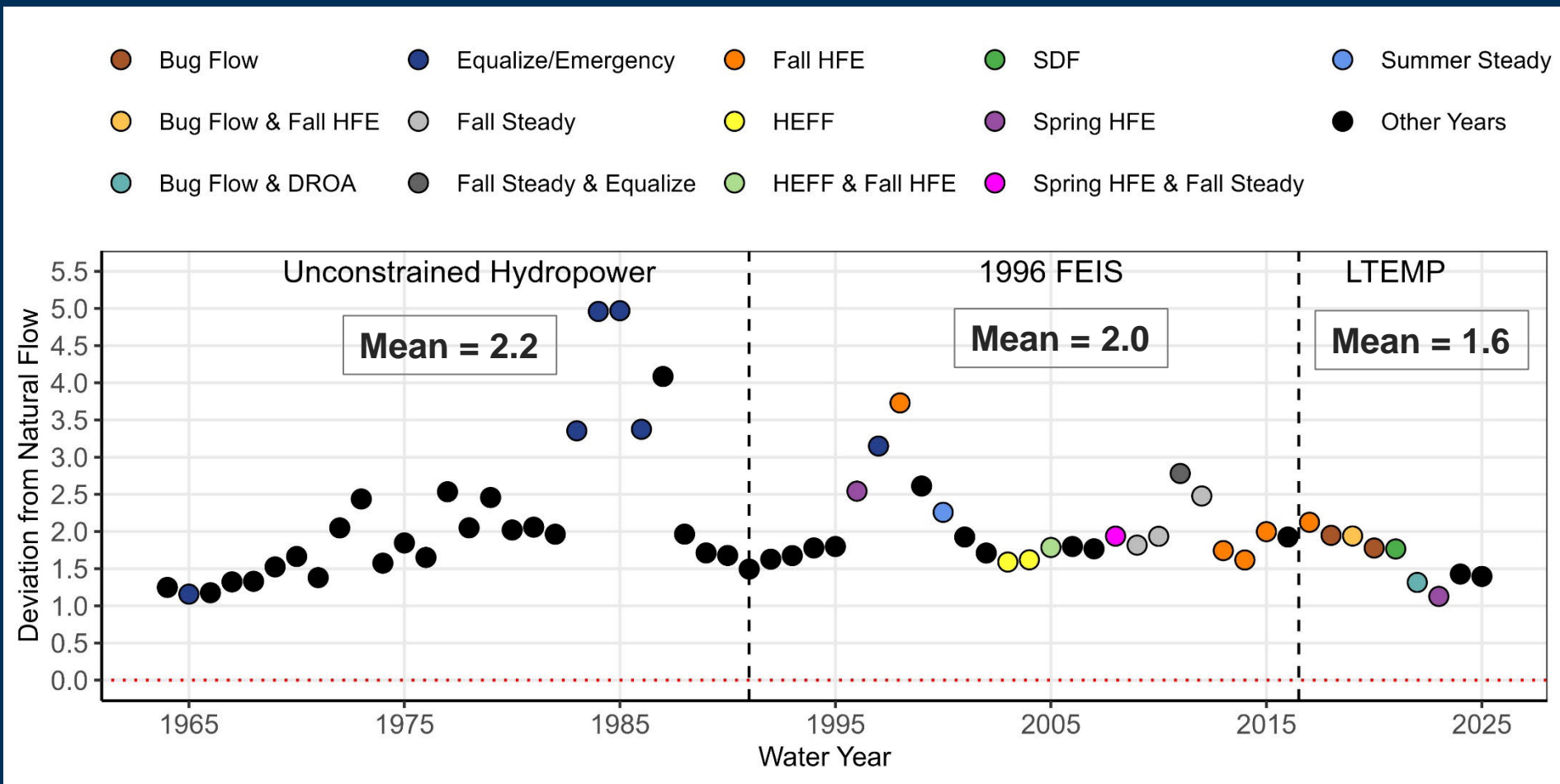
From: Palmquist, E.C., B.R. Deemer, A. Metcalfe, T. Kennedy, L. Bair, H. Fairley, P. Grams, J.B. Sankey, and C.B. Yackulic. 2025. eZ flow metrics: Using z-scores to estimate deviations from natural river flows. *River Research Applications* 41(2): 252-267. <https://doi.org/10.1002/rra.4360>



Adapted from Palmquist & Deemer et al. 2025

Deviation from Natural Flow

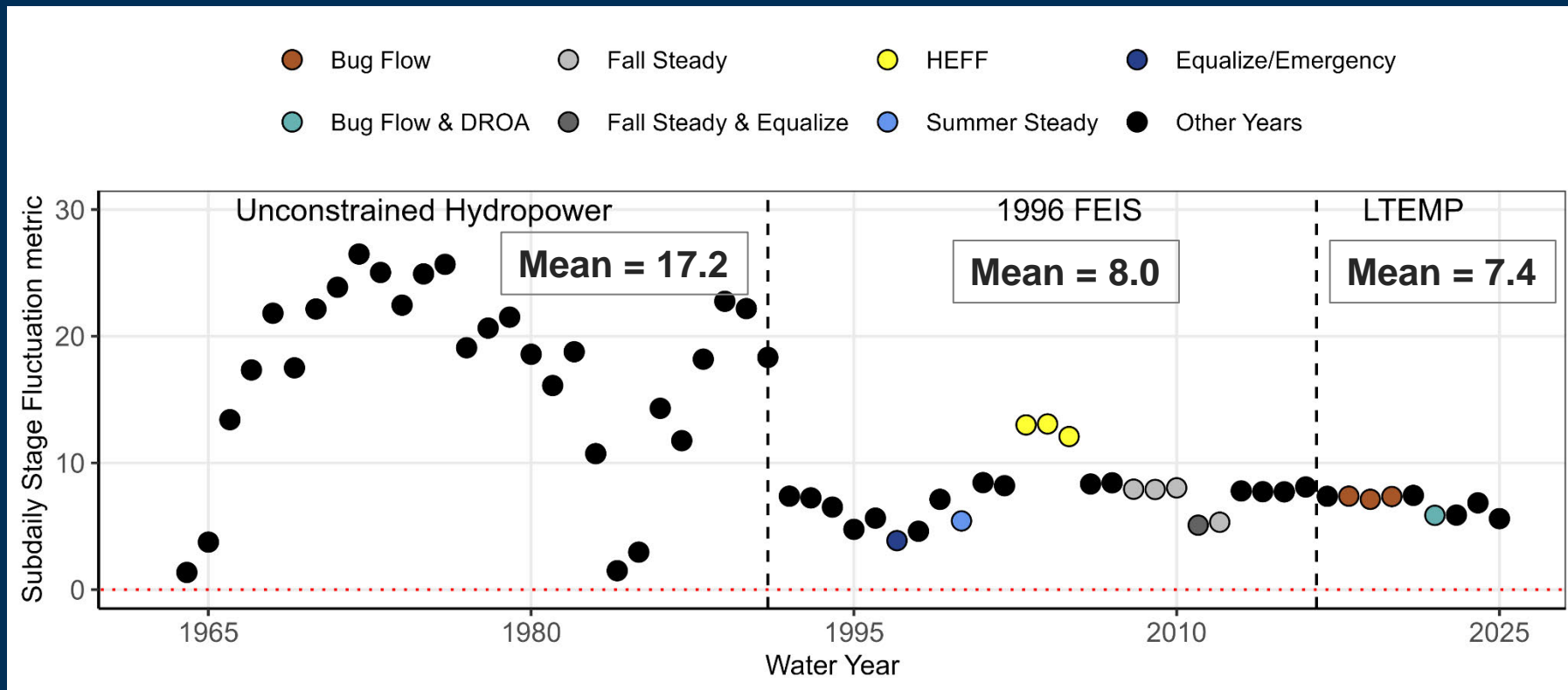
Lower values are closer to *NATURAL*
LTEMP is closer to *NATURAL* than other periods



Adapted from Palmquist & Deemer et al. 2025

Subdaily Stage Fluctuation

2025 was lowest of LTEMP record (5.6 SD)
2025 was still a significant departure from *NATURAL*
LTEMP had the lowest average metric score of any period



Adapted from Palmquist & Deemer et al. 2025



Role of Drought and Flow Experiments

WY2023-case study

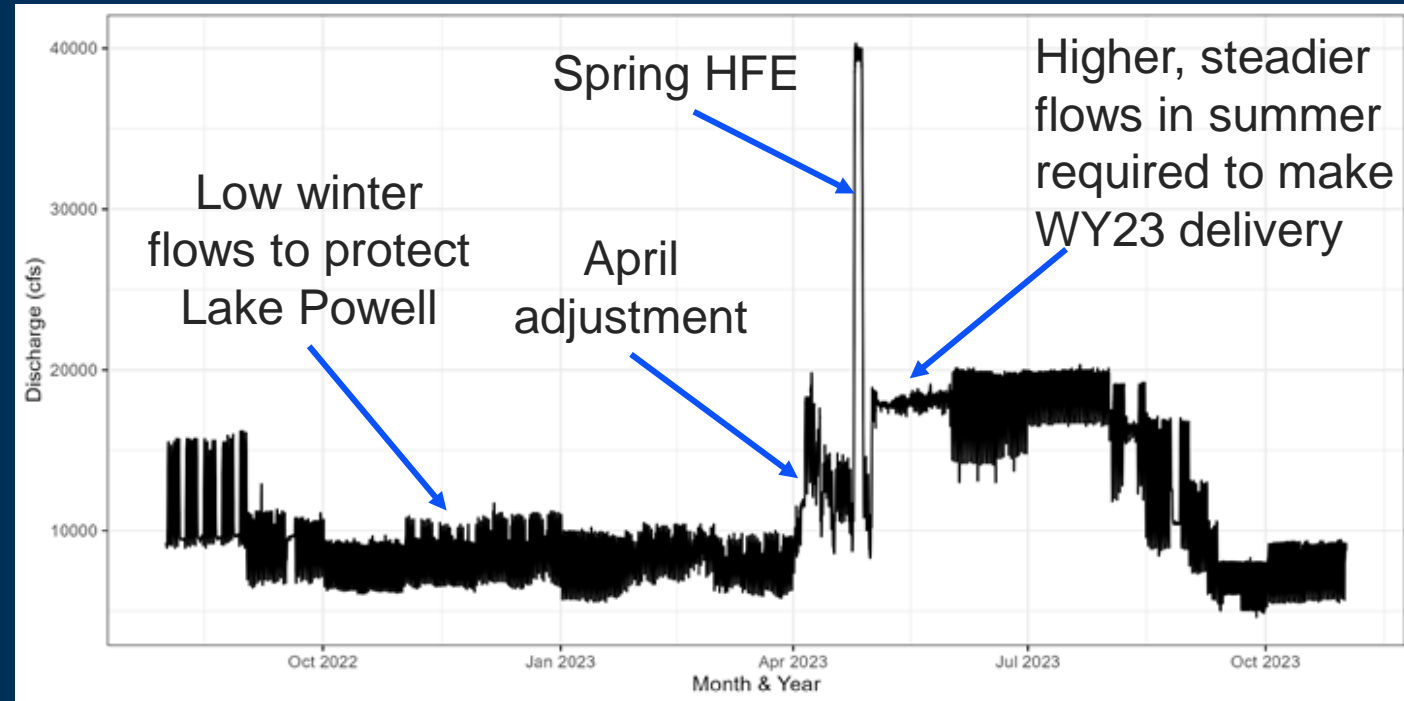
- Lower flows in winter
- Seasonally appropriate timing for HFE (late April)

LTEMP flow experiments have minimal impact on flow statistics compared to drought because:

- Timing not seasonally appropriate (e.g., Fall HFEs)
- Short duration (e.g., HFEs, Bug Flows)

See Palmquist & Deemer et al. 2025 for additional thoughts on LTEMP → flow statistics

Water Year 2023



Data from U.S. Geological Survey, 2026, Discharge, sediment, and water quality monitoring: Flagstaff, Ariz., Grand Canyon Monitoring and Research Center, online data, https://www.gcmrc.gov/discharge_qw_sediment/

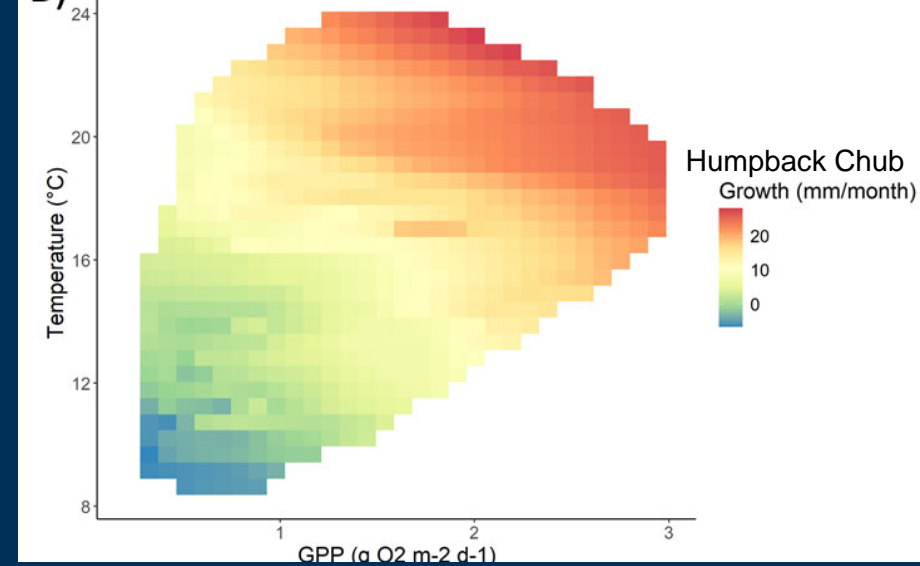
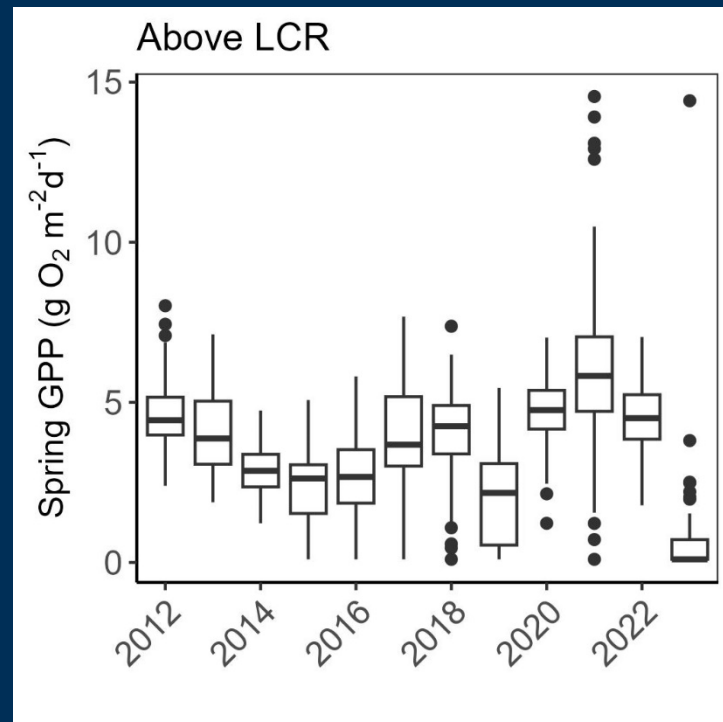


Natural Processes—GPP Metric

- GPP = gross primary production (algae production)

Metrics:

- 14-year record at 3 sites
 - Project A-data, Project E-analysis
- Units are grams $O_2 / m^2 / day$
- Directly proportional to new carbon production
- Derived from dissolved oxygen budgeting
- Metric is average springtime (March-June) GPP across 3 monitoring locations



Humpback chub growth in Western Grand Canyon increases with GPP, Hansen et al. In Revision



Photo Credit: Ian Bishop

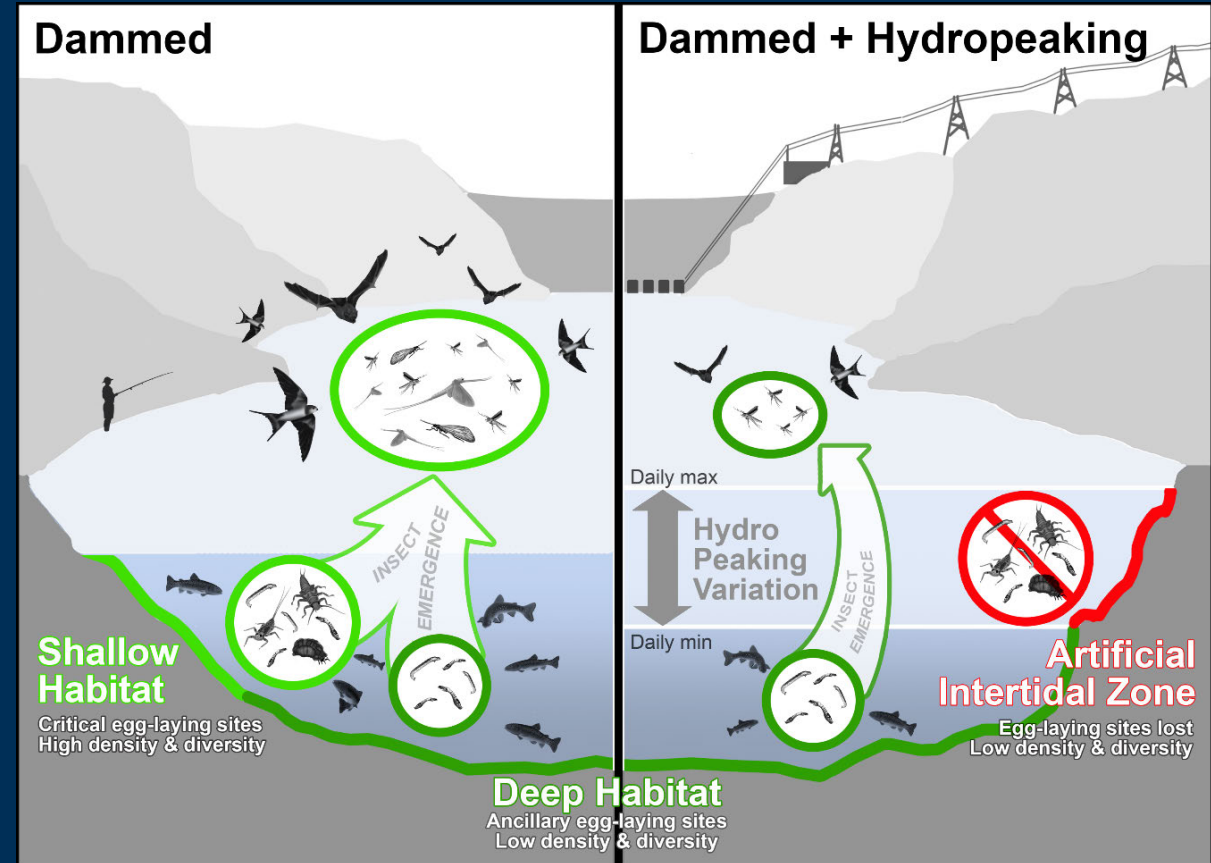
Natural Processes—EPT% metric

- EPT = mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera)
 - Ancient aquatic insects, >200-million-year-old
 - Ubiquitous in rivers, sensitive to disturbance
 - Used globally as bio-indicator of river health

Metric

- 14-year record, canyon-wide (Project F)
- Units are % EPT species in samples
- Higher values indicate greater proportion sensitive EPT species

LTEMP “Bug Flow” experiment tested:
2018-2020 & 2022 (May-Aug., weekend steady flow)



Many EPT species lay eggs along river shorelines making them especially vulnerable to daily hydropower fluctuations

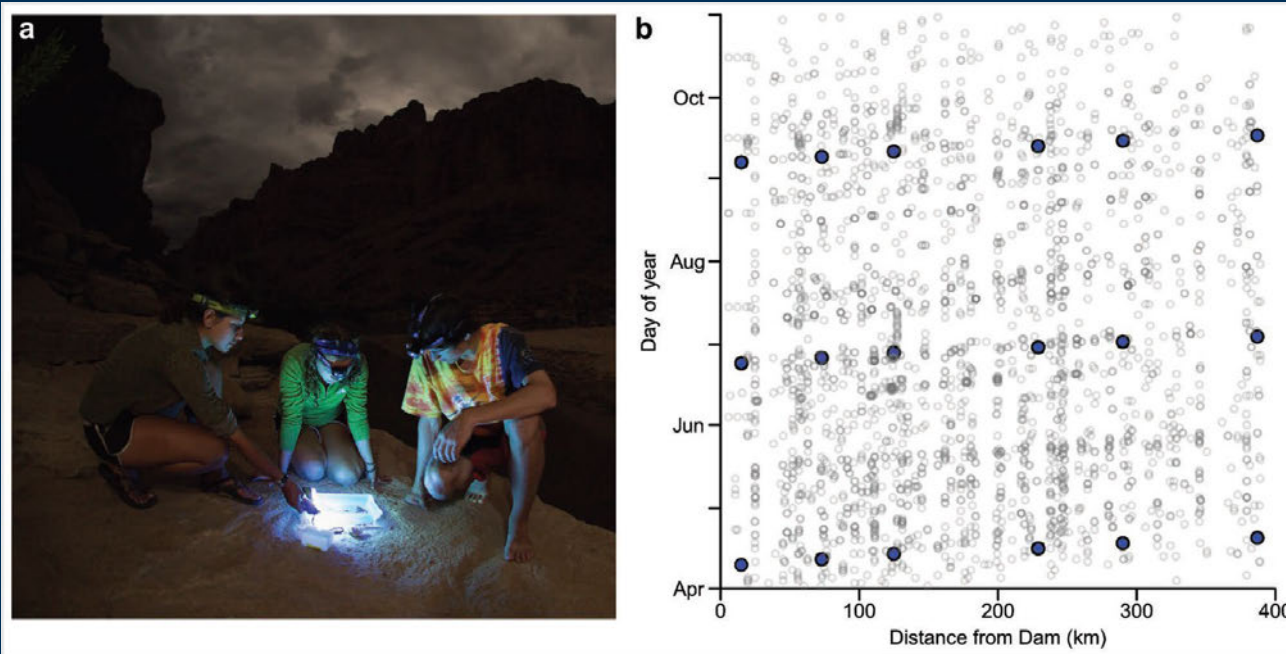


Natural Processes—EPT% metric

Citizen science monitoring started in 2012

Comprehensive monitoring of insect emergence

Abundance of key species 2012-2025



	Count	Percent of total
Total Catch		
Glen & Grand Canyon, Aquatic + Terrestrial	5,648,420	100%
Aquatic	4,548,272	81%
Diptera (flies)	3,132,995	56%
Chironomidae (midges)	2,546,253	45%
Simuliidae (black flies)	22,327	0.4%
Trichoptera (caddisflies)	1,886,086	33%
Hydroptilidae (micro-caddisfly)	1,797,484	32%
Hydropsychidae (net-spinning caddisfly)	14,962	0.3%

From: Kennedy, T. A., Muehlbauer, J. D., Yackulic, C. B., Lytle, D. A., Miller, S. W., Dibble, K. L., ... & Baxter, C. V. (2016). Flow management for hydropower extirpates aquatic insects, undermining river food webs. *BioScience*, 66(7), 561-575.

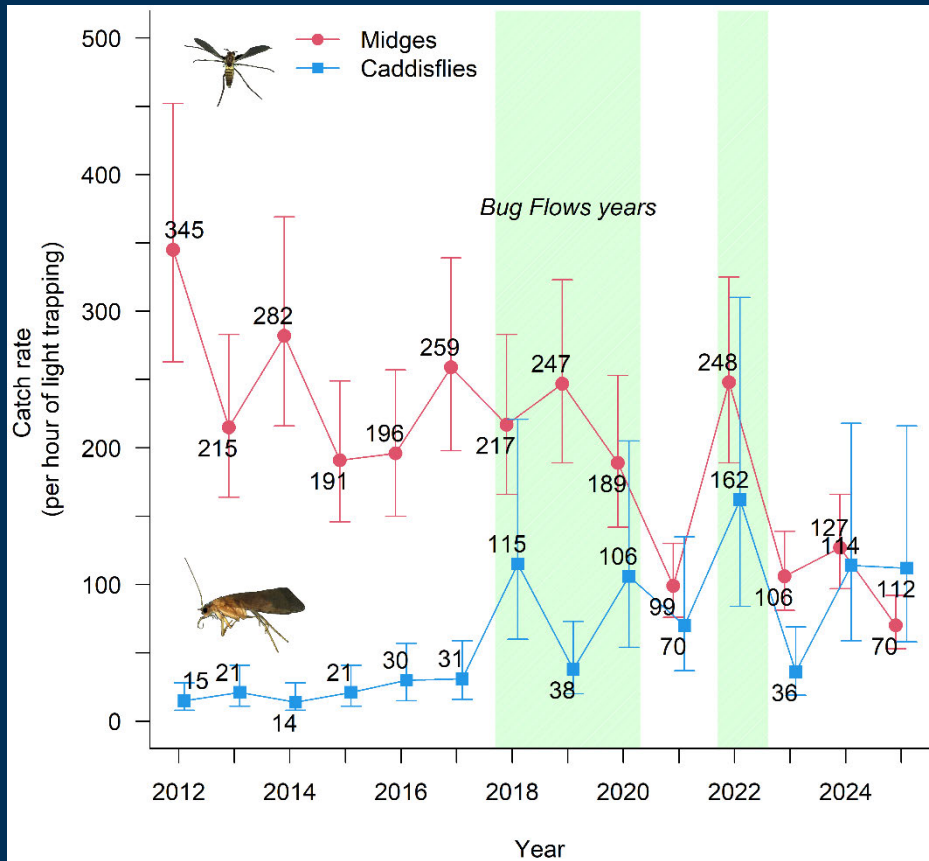


Natural Processes—EPT metric

Two common aquatic insects

Caddisflies: long-term increase, + Bug Flow effect

Midges: long-term decrease, + Bug Flow effect



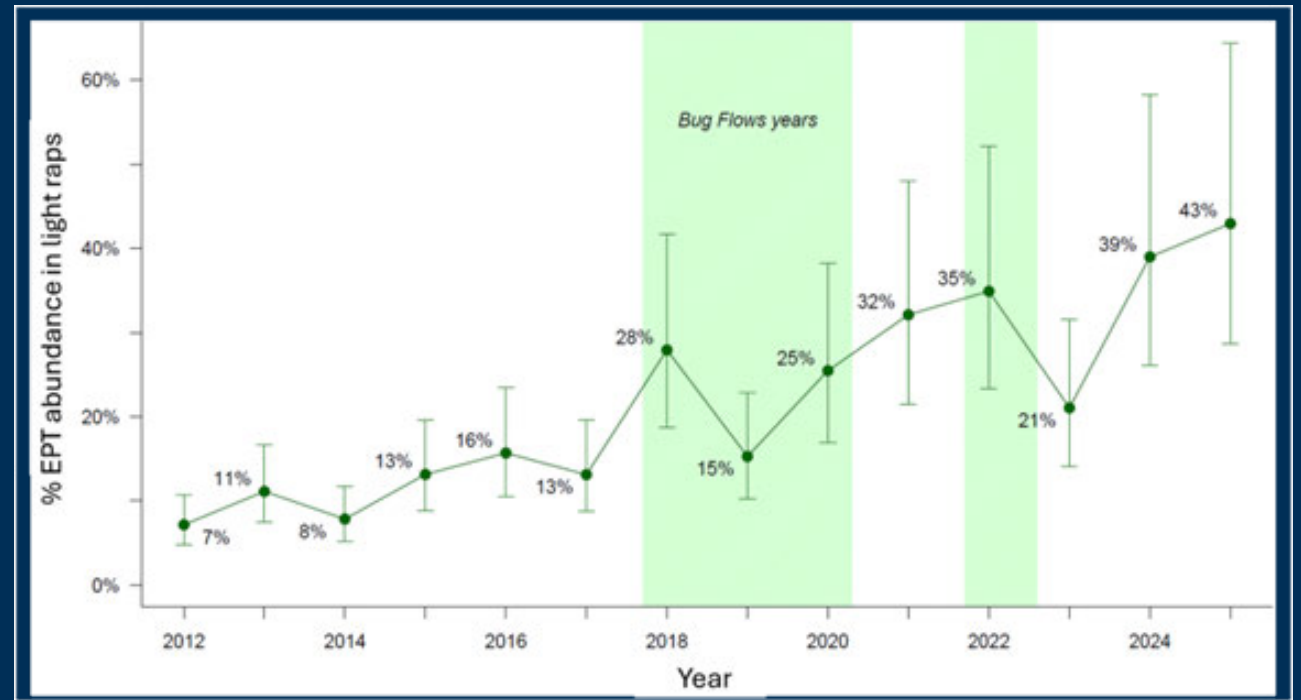
2025 is incomplete, 60% of samples processed



EPT% Metric in 2025:

Caddisflies are now common and widespread

But 80% decline in midges since 2012



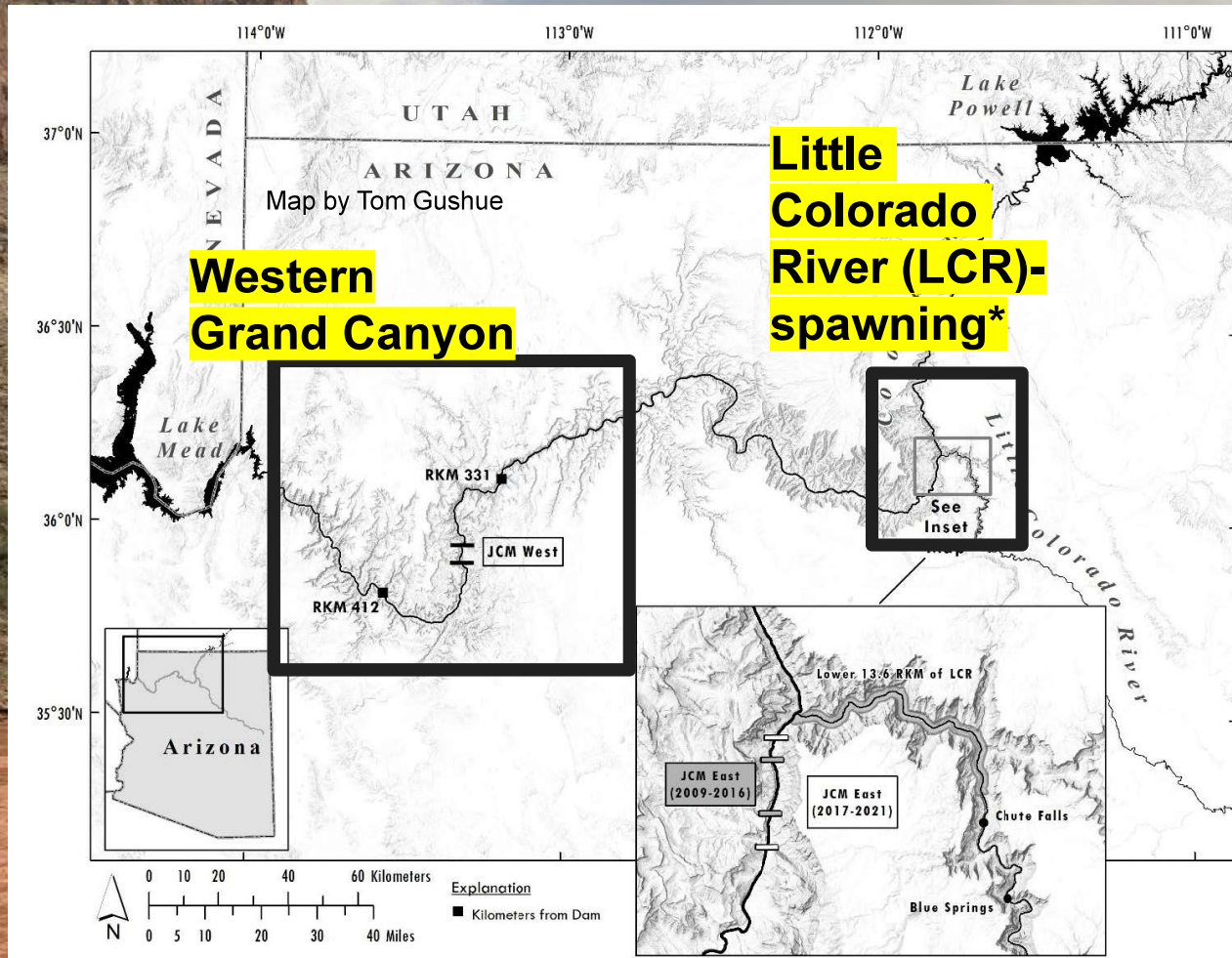
New family of statistical models now possible

-3 years post-treatment data

-Intervention analysis and other causal inference tools

-See T. Kennedy, D. Lytle ARM talks for details, insights

Humpback chub (HBC)

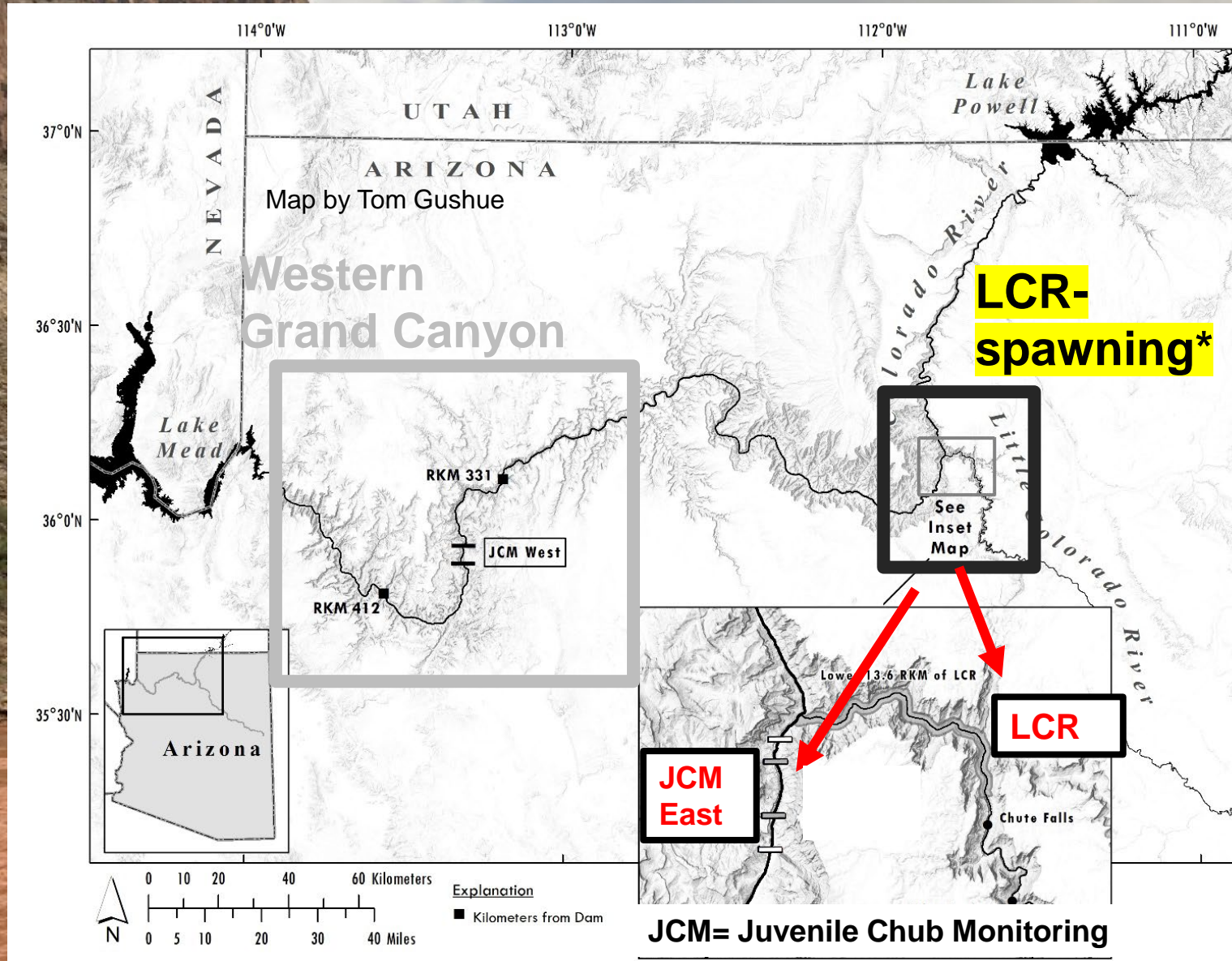


*Note: Spatial distribution for LCR-spawning humpback chub is approximate.
Preliminary Information - Subject to Revision. Not for Citation or Distribution.

Photo by Lindsay Hansen



Humpback chub (HBC)

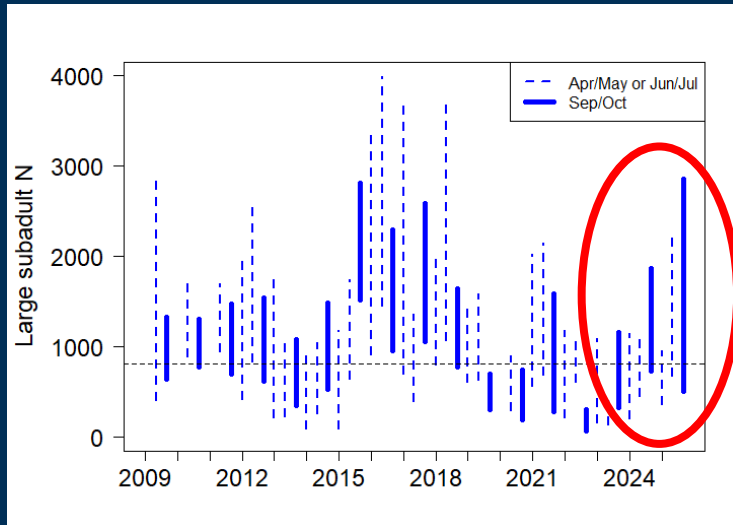


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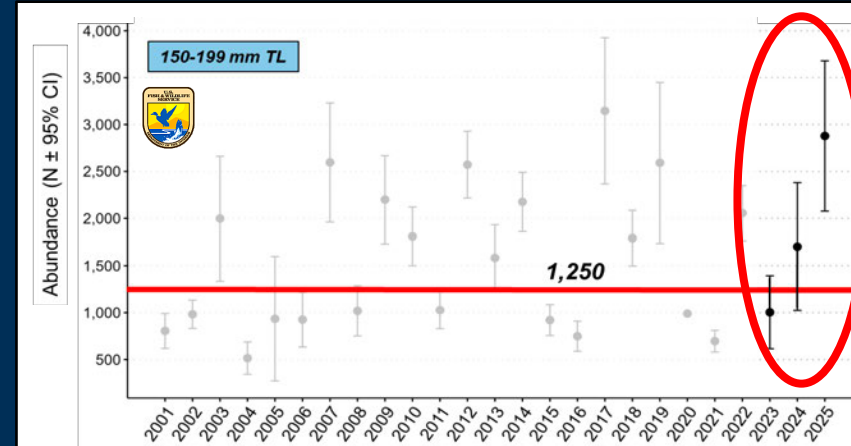


Abundances of LCR-spawning HBC for the Biological Opinion

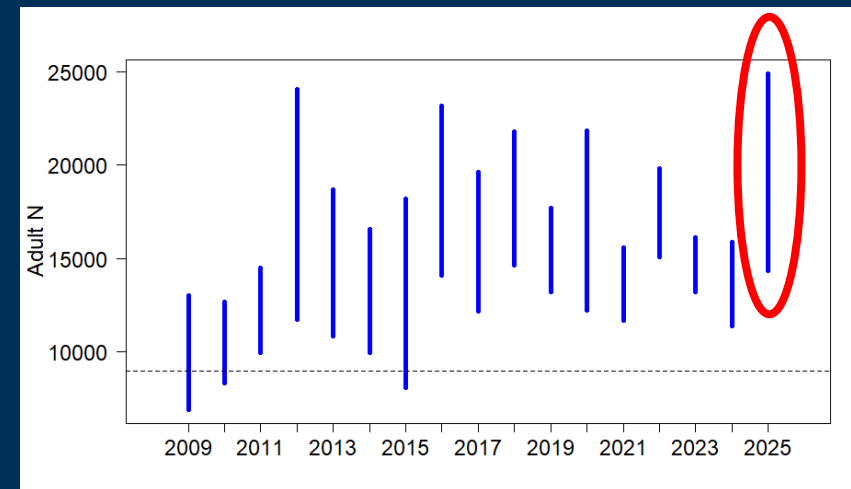


Large subadults in JCM-East in fall, Maria Dzul, USGS
P

Adult abundance is likely to remain higher than 9,000 over the next few years



Large subadults in the LCR in spring, Mike Pillow (USFWS)

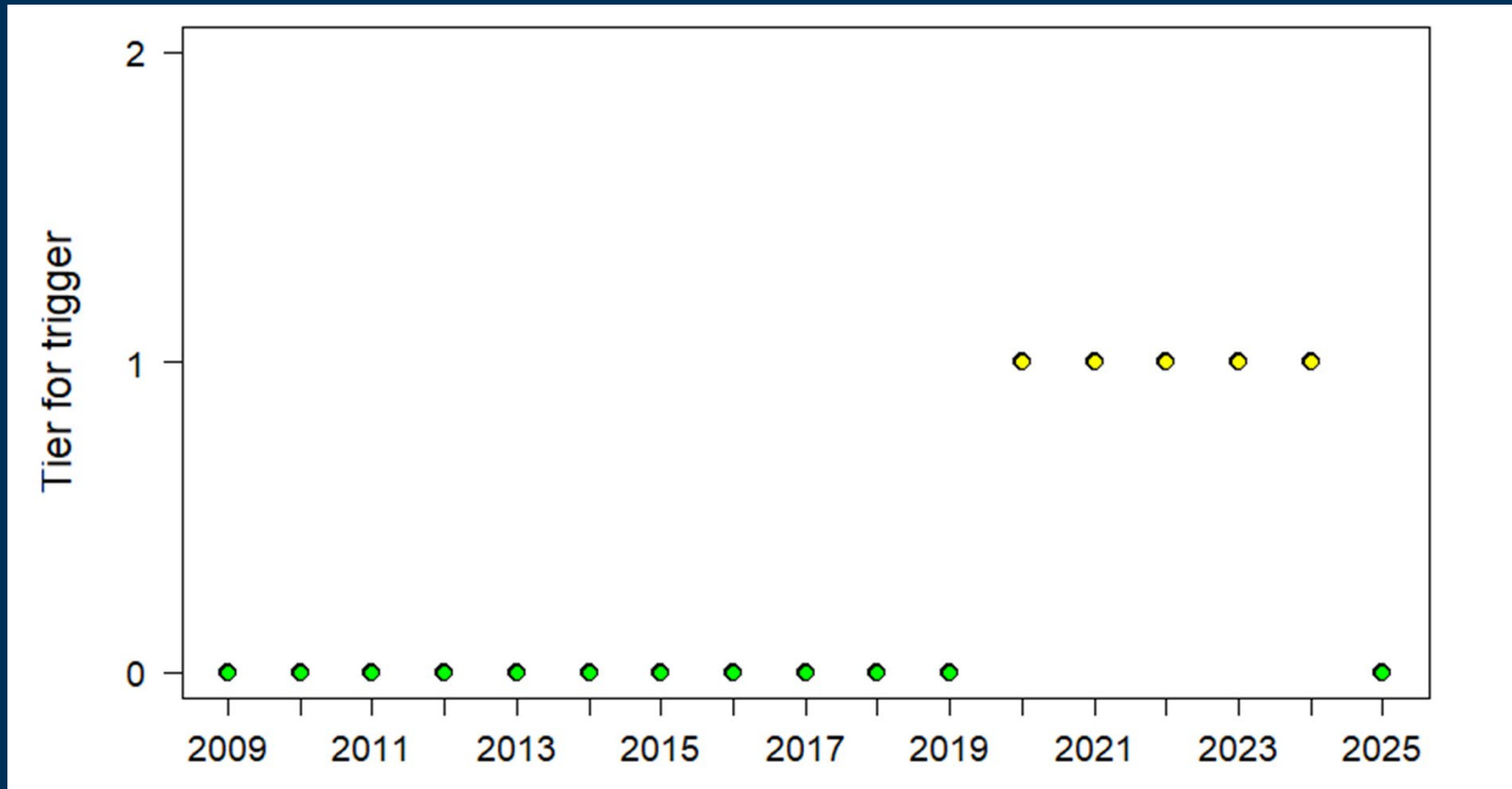


Total adults (LCR-spawning) in fall, Maria Dzul, USGS

Large subadults (150-199mm total length), Adults (≥200mm total length)



Metric 3.1: Current Tier of Humpback Chub in the LCR Aggregation (as described in the 2016 LTEMP Biological Opinion)



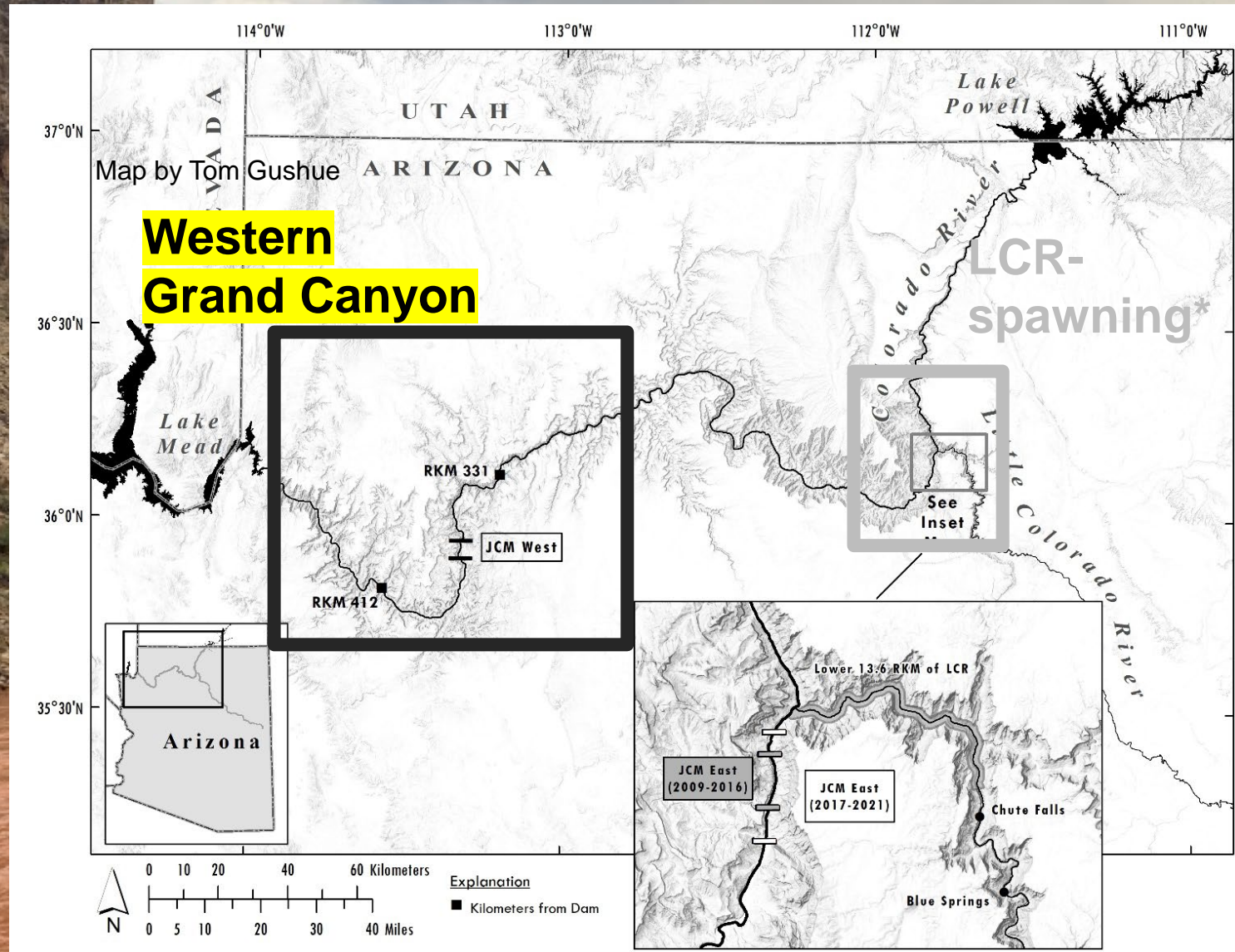
For more info on triggers, see U.S. Bureau of Reclamation. 2016. Record of decision, Glen Canyon Dam long-term experimental and management plan, final environmental impact statement. U.S. Department of the Interior, Bureau of Reclamation, Salt Lake City, Utah, National Park Service, Lakewood Colorado, Dec. Available at: https://ltempeis.anl.gov/documents/docs/LTEMP_ROD.pdf



Preliminary Information - Subject to Revision. Not for Citation or Distribution.



Humpback chub (HBC)

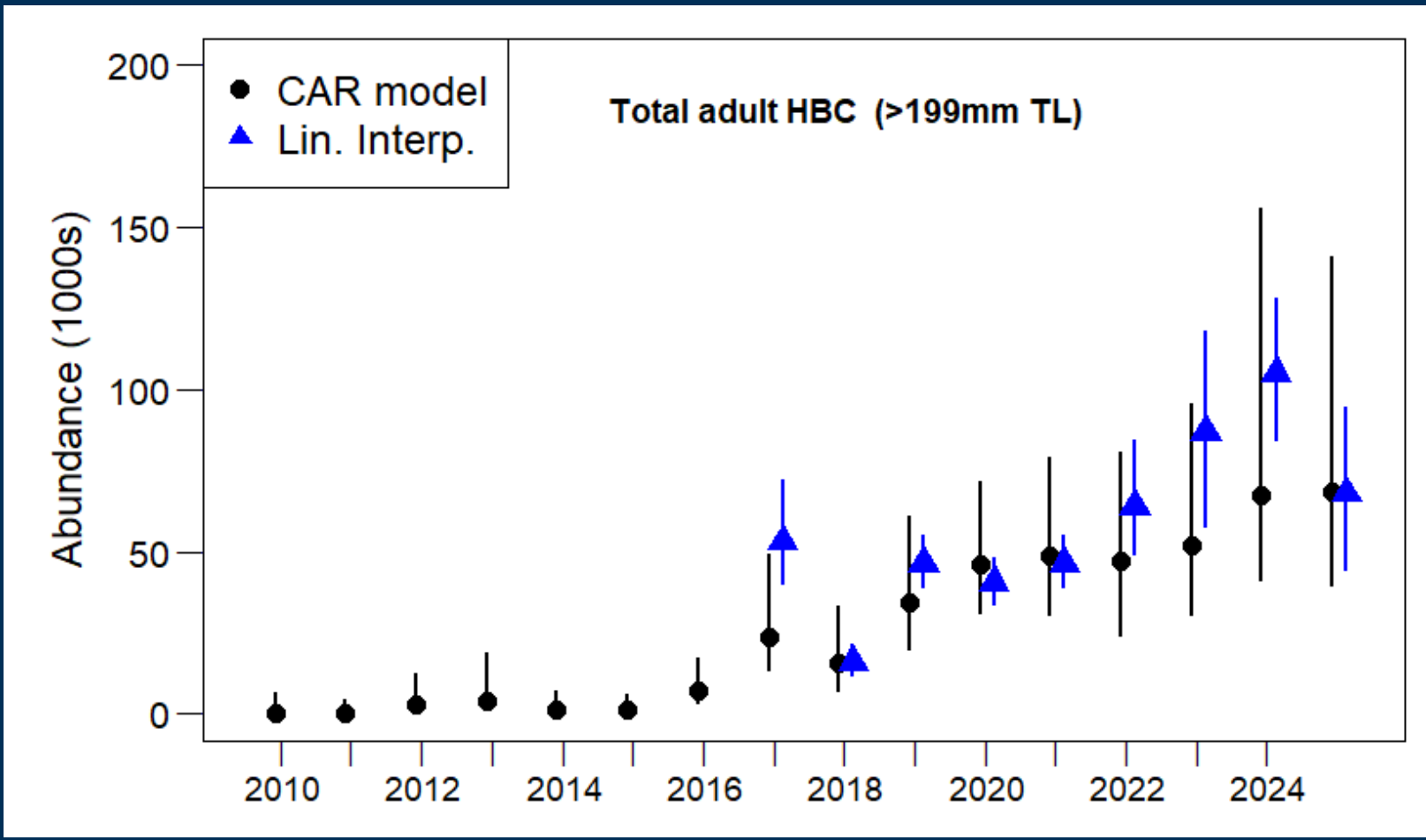


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Photo by Lindsay Hansen

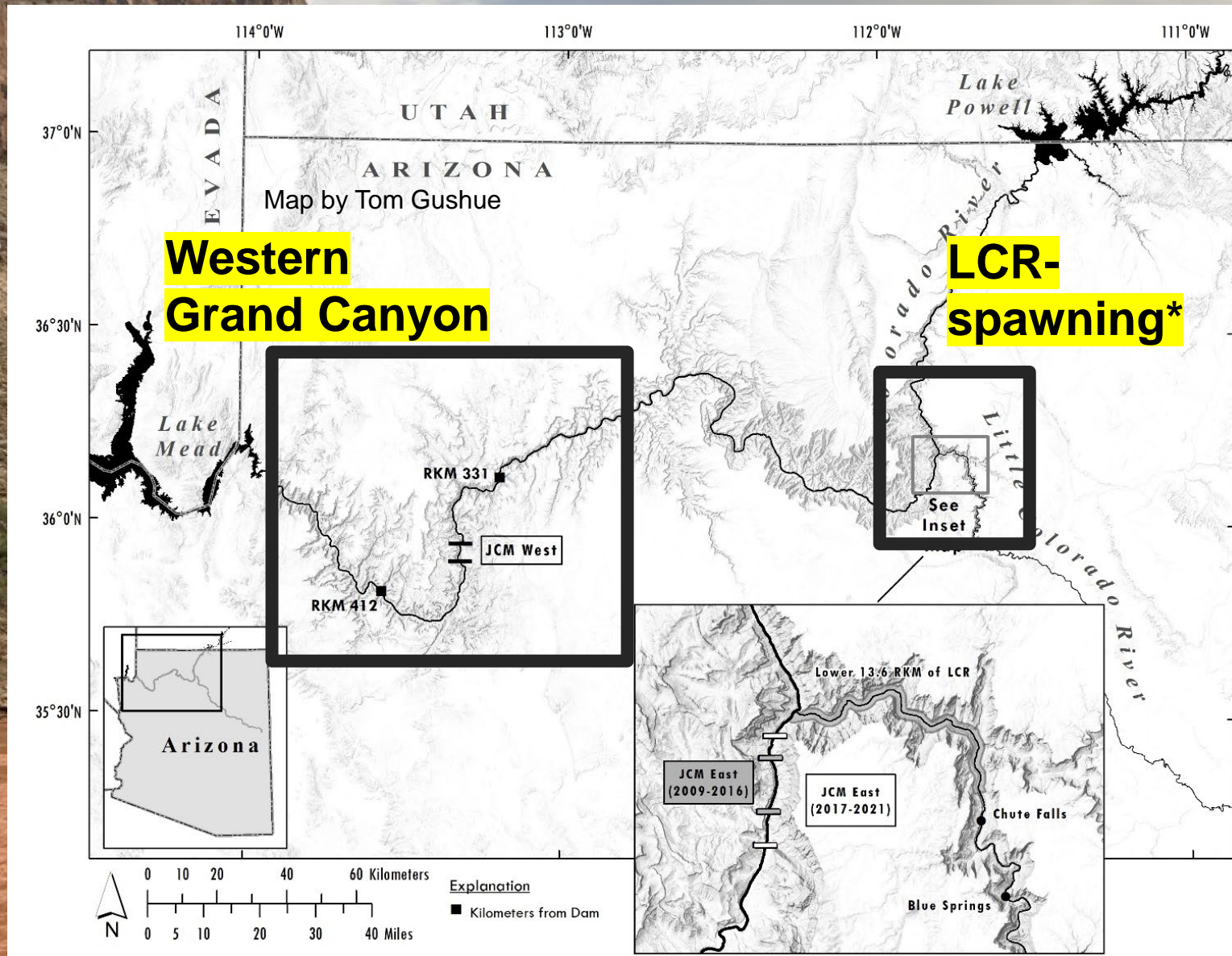


Abundance of adult humpback chub in western Grand Canyon



Preliminary Information - Subject to Revision. Not for Citation or Distribution.

Humpback chub (HBC)

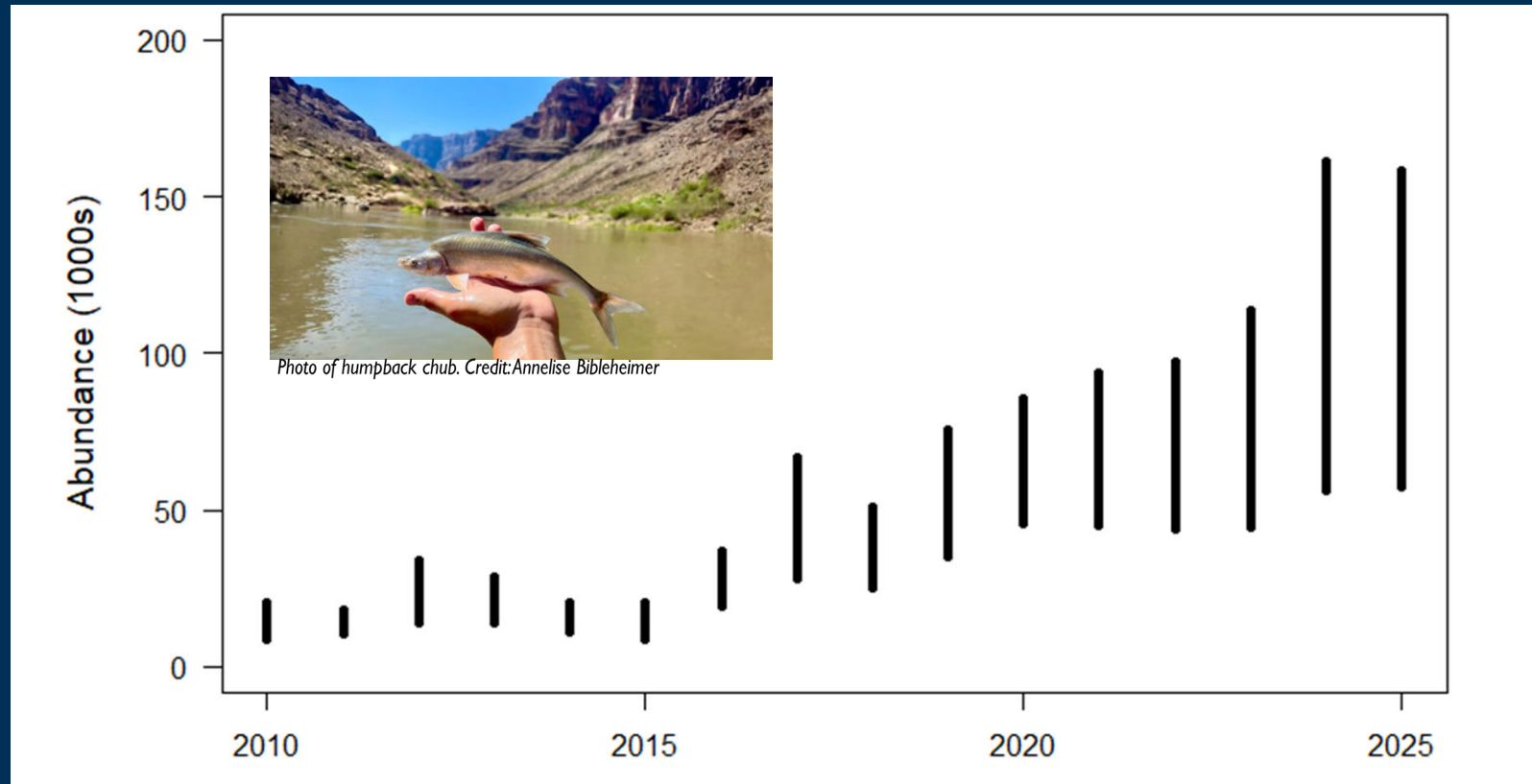


*Note: Spatial distribution for LCR spawning humpback chub is approximate.
Preliminary Information Subject to Revision. Not for Citation or Distribution.

Photo by Lindsay Hansen



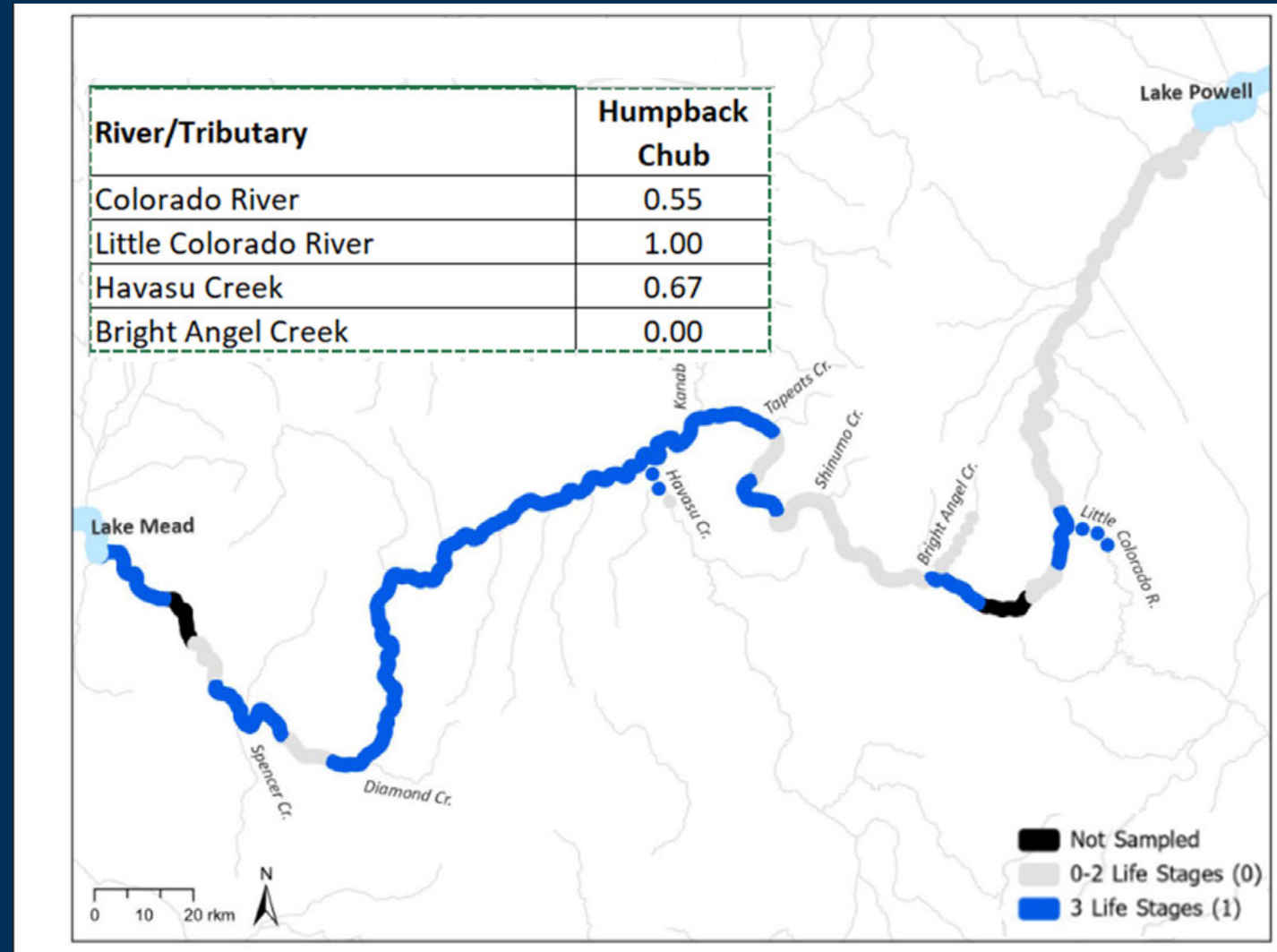
Metric 3.2: Grand Canyon-wide Abundance of Adult Humpback Chub



- Sum of abundances across all sites within the Colorado River ecosystem
 - LCR-spawning
 - Western Grand Canyon
 - Other tributaries (e.g., Havasu Creek*)

*The Havasu Creek estimate (mean = 15; 95% CI: 11-28) is not included in the graph for adult HBC.

Metric 3.3: Proportion of the Grand Canyon Ecosystem with Evidence of all 3 Life Stages of Humpback Chub



Credit: Kim Dibble, USGS

Preliminary Information - Subject to Revision. Not for Citation or Distribution.

Summary of other humpback chub findings from the Annual Reporting Meeting



Low age-0 production in the LCR in 2025

Data suggest winter floods are essential for HBC reproduction

Observations from warming waters over last 5 years

Faster HBC growth

Shifts in spatial distribution in western Grand Canyon HBC

Potential for more food limitation & increased predation by non-native fishes

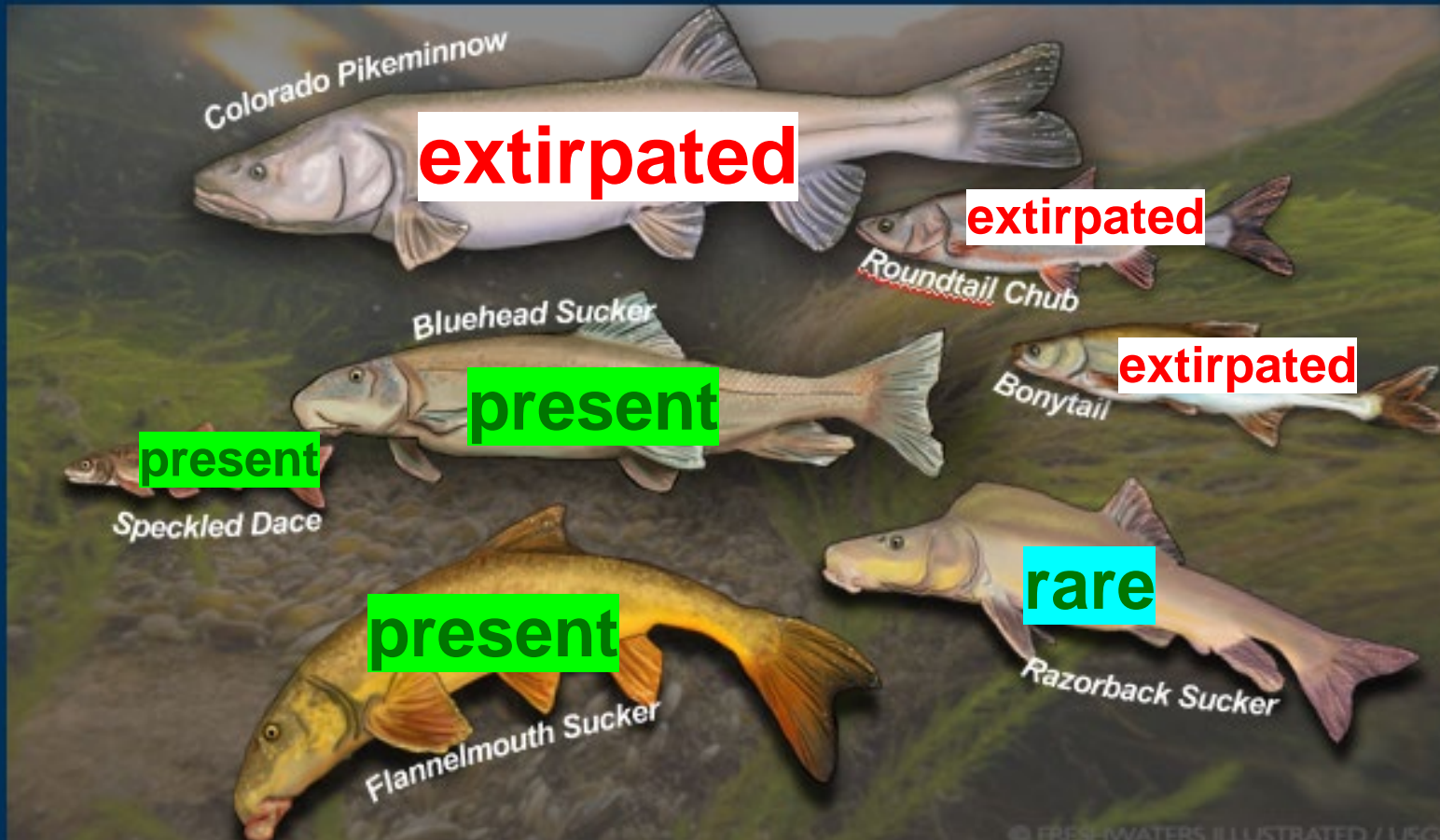
Chute Falls translocations did not occur in 2025 (not enough fish)

Dragon-Bravo fire

No effects on mainstem HBC have been observed yet

The worst may be yet to come in terms of debris flows

Other native fishes: background

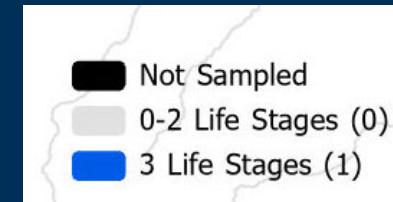
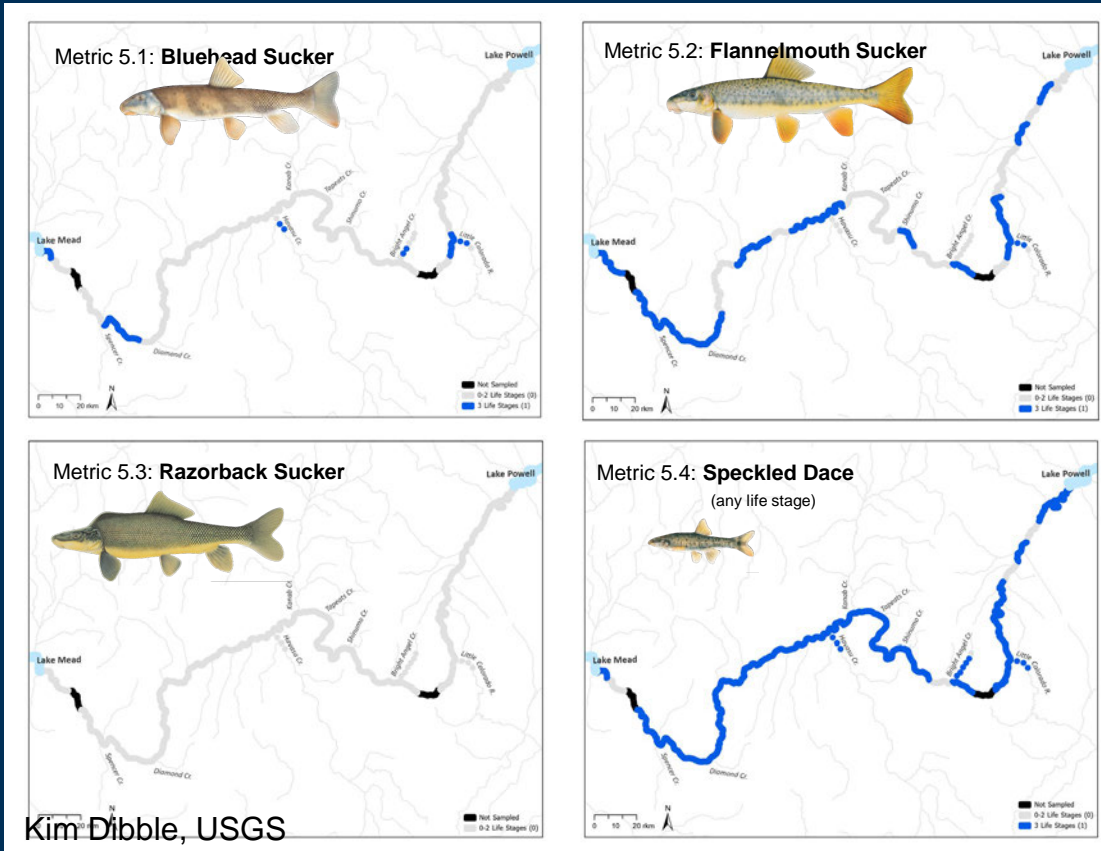


Fish images: Lindsay Hansen (USGS), photo in background: modified from Freshwaters Illustrated



Bonytail, Colorado pikeminnow, and razorback sucker are listed as federally endangered

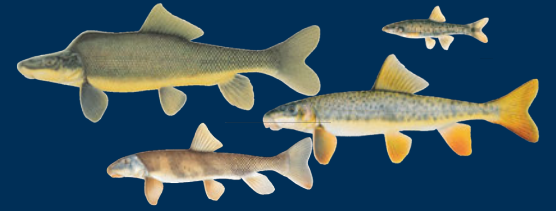
Metric 5.1-5.5: Proportion of the Grand Canyon Ecosystem with Evidence of all 3 Life Stages of Native Fishes



River/Tributary	Bluehead Sucker	Flannelmouth Sucker	Razorback Sucker	Speckled Dace	Extirpated Species (Bonytail, Roundtail Chub, Colorado pikeminnow)
Colorado River	0.10	0.50	0.00	0.88	0.00
Little Colorado River	0.67	0.67	0.00	1.00	0.00
Havasu Creek	0.67	0.00	0.00	1.00	0.00
Bright Angel Creek	0.33	0.00	0.00	0.83	0.00

Score Key	
Absent/rare	0.00-0.09
Occasional	0.10 - 0.49
Common	0.50-1.00

Summary of other native fish findings from the Annual Reporting Meeting



Speckled Dace and Flannelmouth Sucker widely distributed

Comprehensive analysis, including early life stage data may change conclusions

Bluehead Sucker likely more widely distributed than reflected in available data, but extirpated from Shinumo Creek (NPS data, 2014-2019)

Future analyses may reveal effects of management actions

Example-Razorback Sucker augmentation (few fish recaptured thus far)

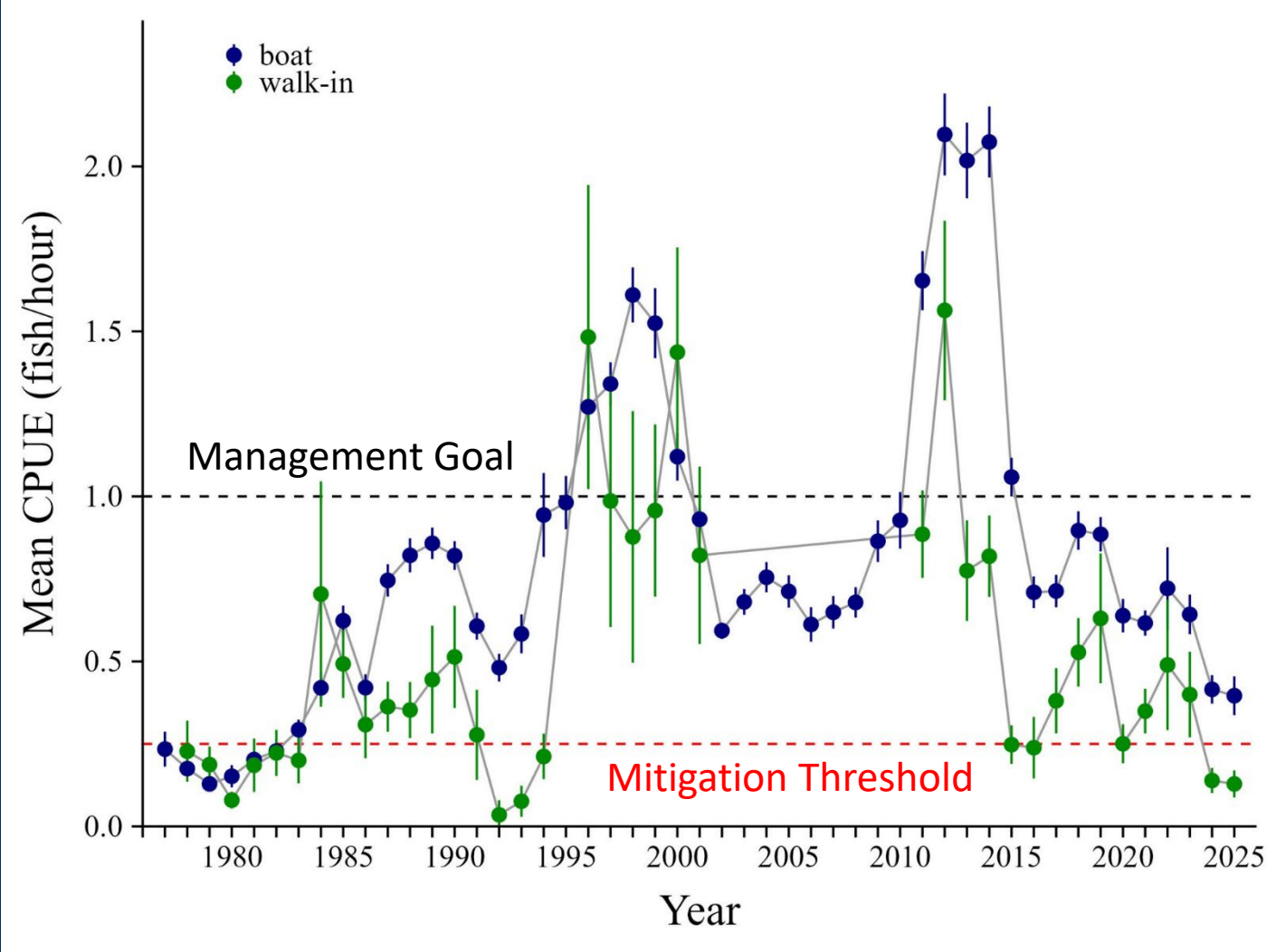
Rainbow trout metrics and research



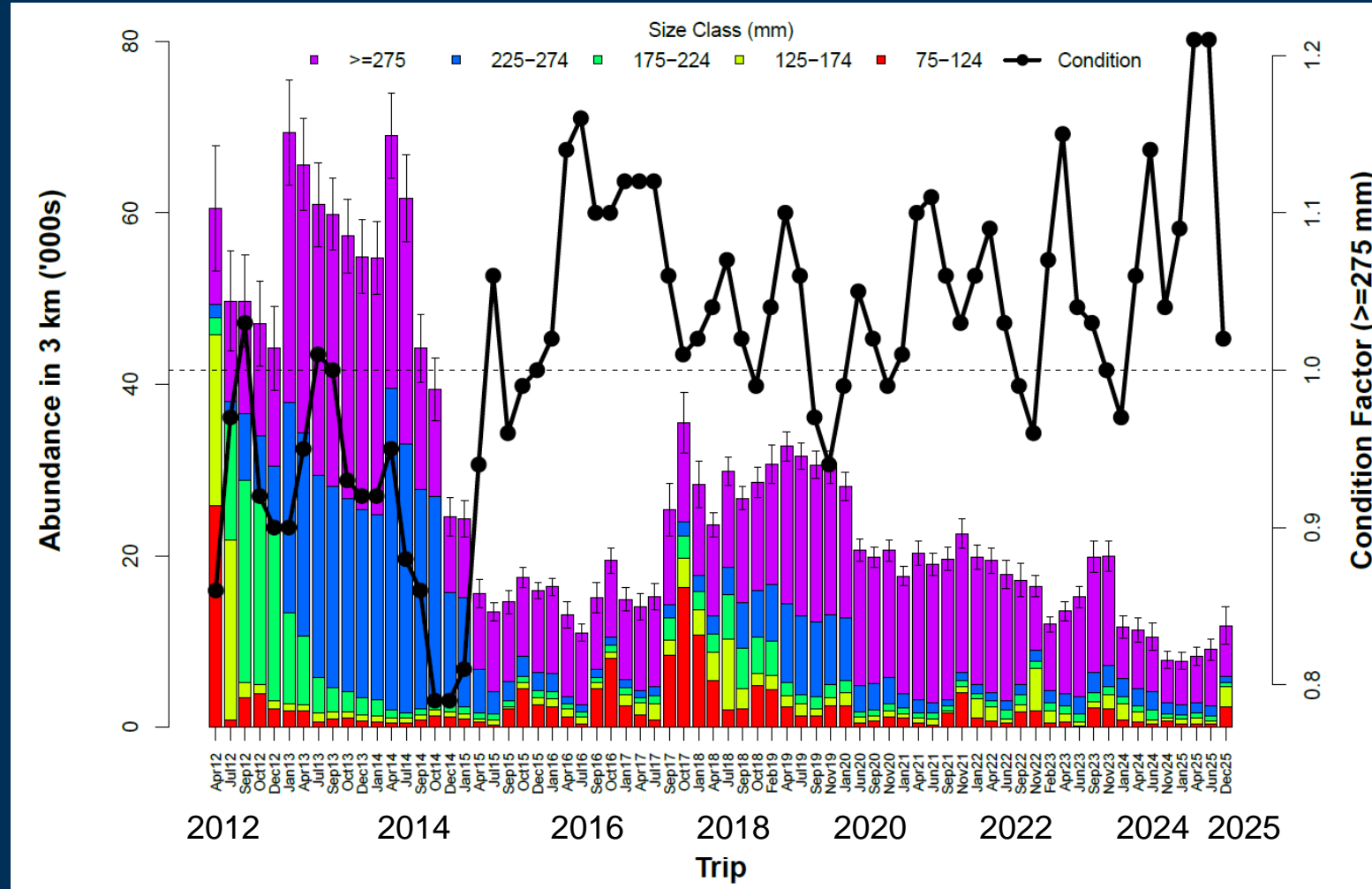
DAVID HERASIMTSCHUK

© FRESHWATERS ILLUSTRATED / USGS

Angler CPUE (fish/hr) for Rainbow trout remains low.



Rainbow trout abundance increased slightly but remains very low.



Flow Experiment Summary

Flow	Primary Objective	Design considerations/ timing	Replicates
High flow experiments	Conserve sediment & beaches	Triggered by sediment loading	Spring (3) Fall (6)
Low steady summer flows	Improve native fish growth & recruitment	Summer (June-Sept.)	2000 (1)
Nonnative fish suppression flows	Reduce Rainbow Trout recruitment	Spring (January-March)	2003-2005 (3)
Fall steady flows	Stabilize shoreline habitats for native fish rearing	Limited to fall	2009-2012 (4)
Macroinvertebrate production flows	Improve egg-laying conditions	Weekends May-August	2018-2020, 2022 (4)
Coolmix	Suppress Smallmouth Bass reproduction	Summer	2024-2025

Bioeconomic modeling

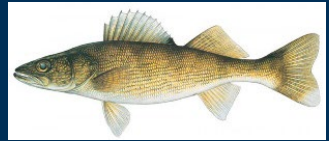
- **Combines models of interacting fish species (e.g., rainbow or brown trout and humpback chub) with estimates of hydropower costs to determine whether flow experiments are cost-effective relative to removals near Little Colorado River.**
- **Flows to minimize rainbow trout recruitment are very rarely cost-effective.**
- **Flows to minimize recruitment for brown trout (longer lived and more predatory) are cost effective in more circumstances.**

Nonnative Aquatic Species metrics and research

Very-High Risk



Smallmouth Bass



Walleye



Flathead Catfish



Brown Trout



High Risk



Northern Pike



Green Sunfish



Striped Bass



Rainbow Trout (GCNP)



White Sucker



Rusty Crayfish



Burbot

Medium Risk



Largemouth Bass (MH)



Black Bullhead



Yellow Bullhead



Channel Catfish



Blue tilapia (and other cichlids)



Grass Carp (and Asian carps)



Black Crappie



Redear Sunfish



Bluegill



Common Carp



Red Shiner

Low Risk



Mosquitofish



Fathead Minnow



Plains Killifish



Golden Shiner



Gizzard Shad



Threadfin Shad



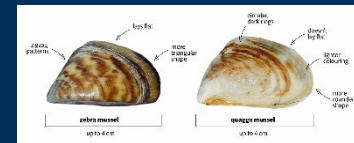
Rainbow Trout (GLCA)



Brook Trout (or other salmonids)



Northern/
Virile
Crayfish

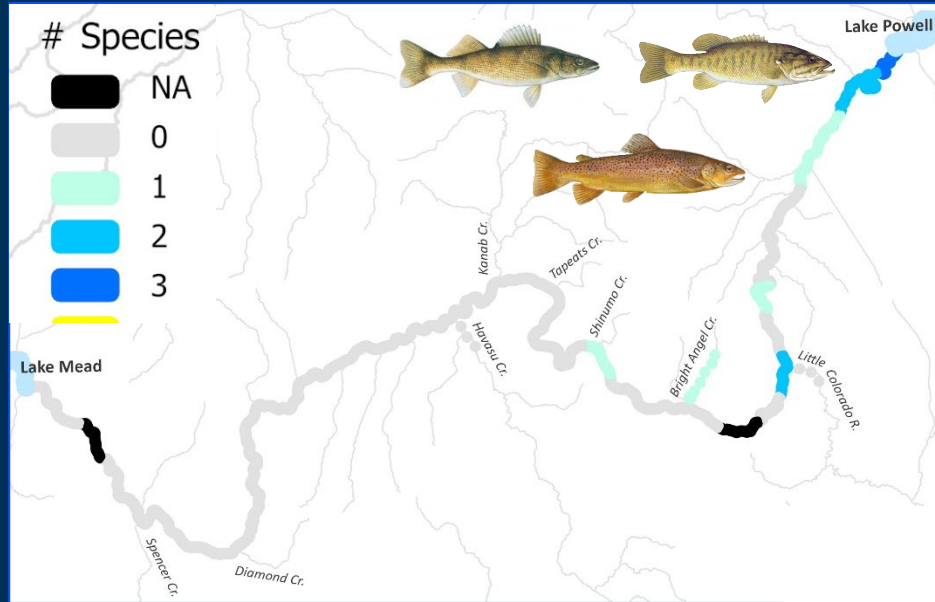


Zebra and Quagga
Mussels (in the river)

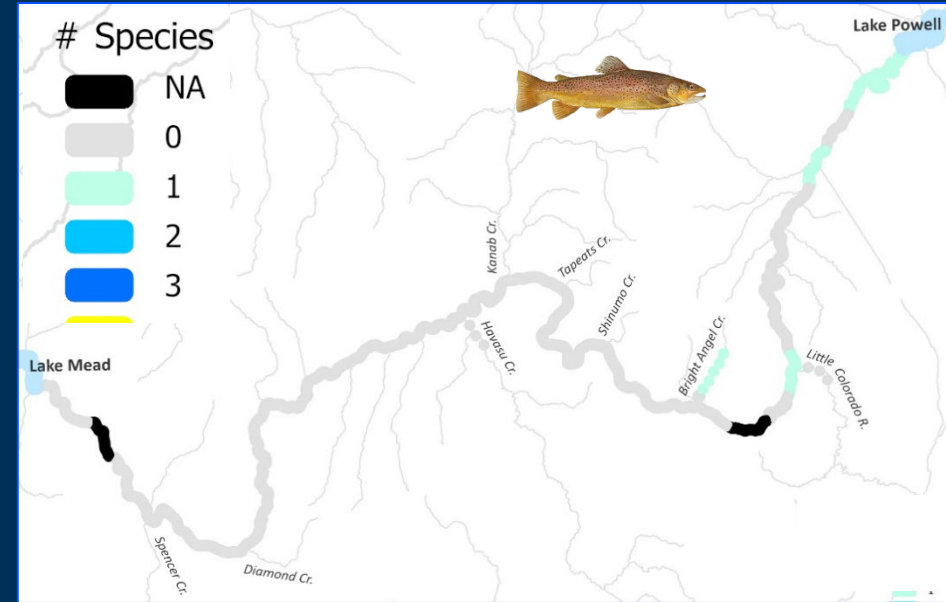
Illustrations: Joe Tomelleri and Duane Raver

Risk Levels assigned in the NPS Expanded Non-Native Aquatic Species Management Plan

Average number of species per river segment within each risk level



Very-high risk species detected.



Very-high risk species with evidence of reproduction.

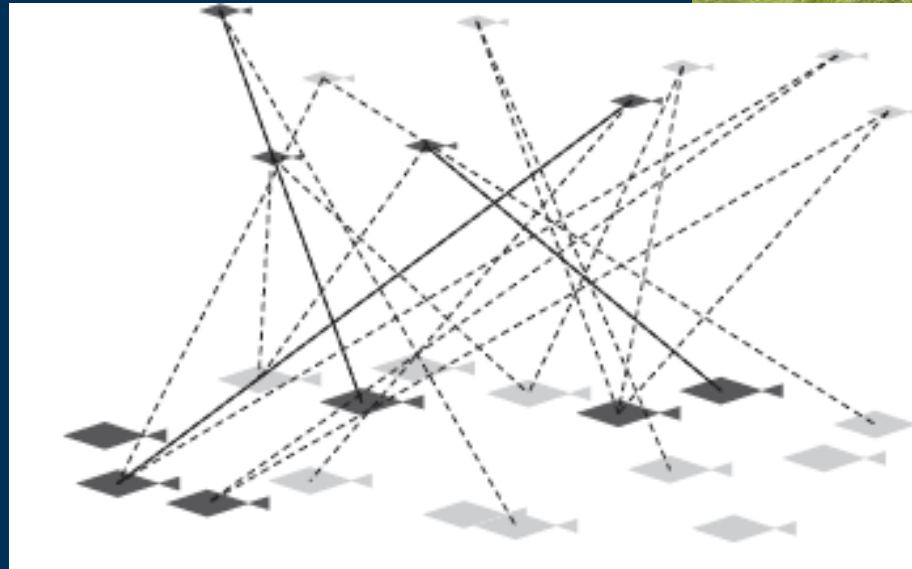
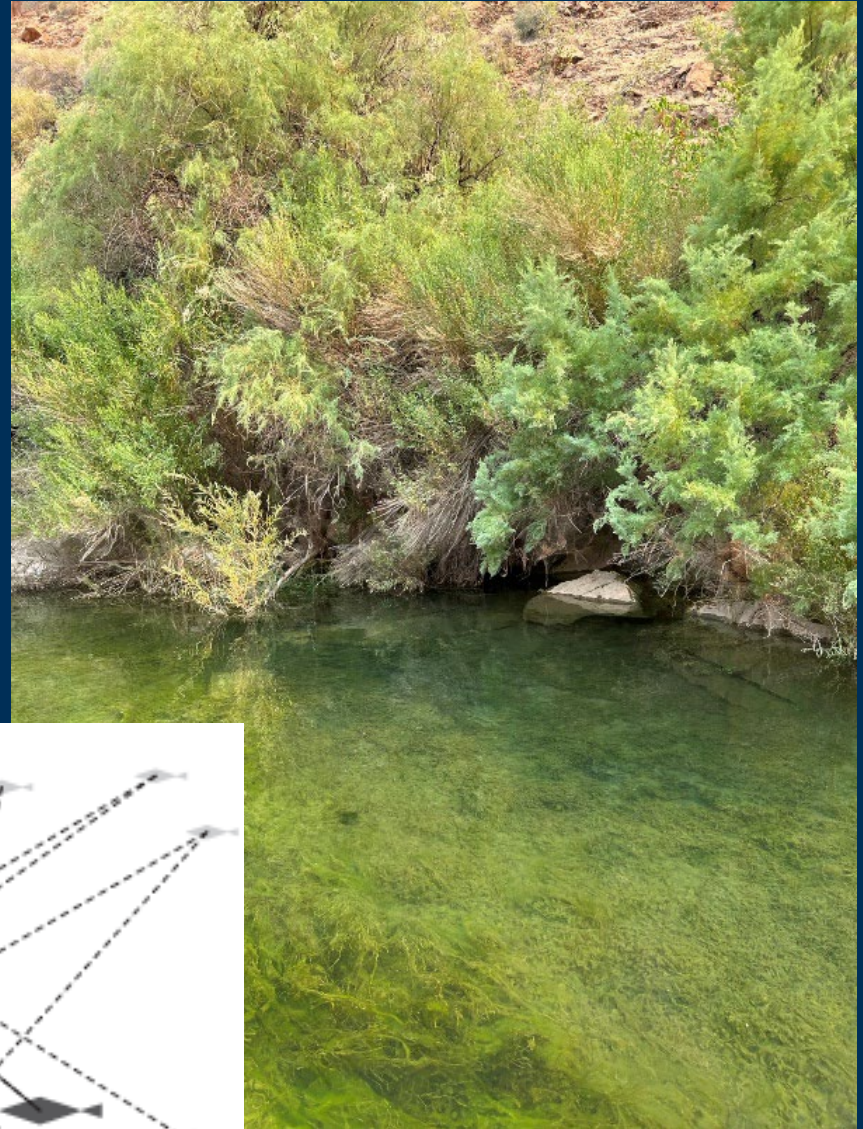
Risk Category	# Species Present	# Species Reproducing
Low	1.2	0.6
Medium	1.2	0.6
High	0.9	0.4
Very-high	0.4	0.1

* Mainstem values only reported here.



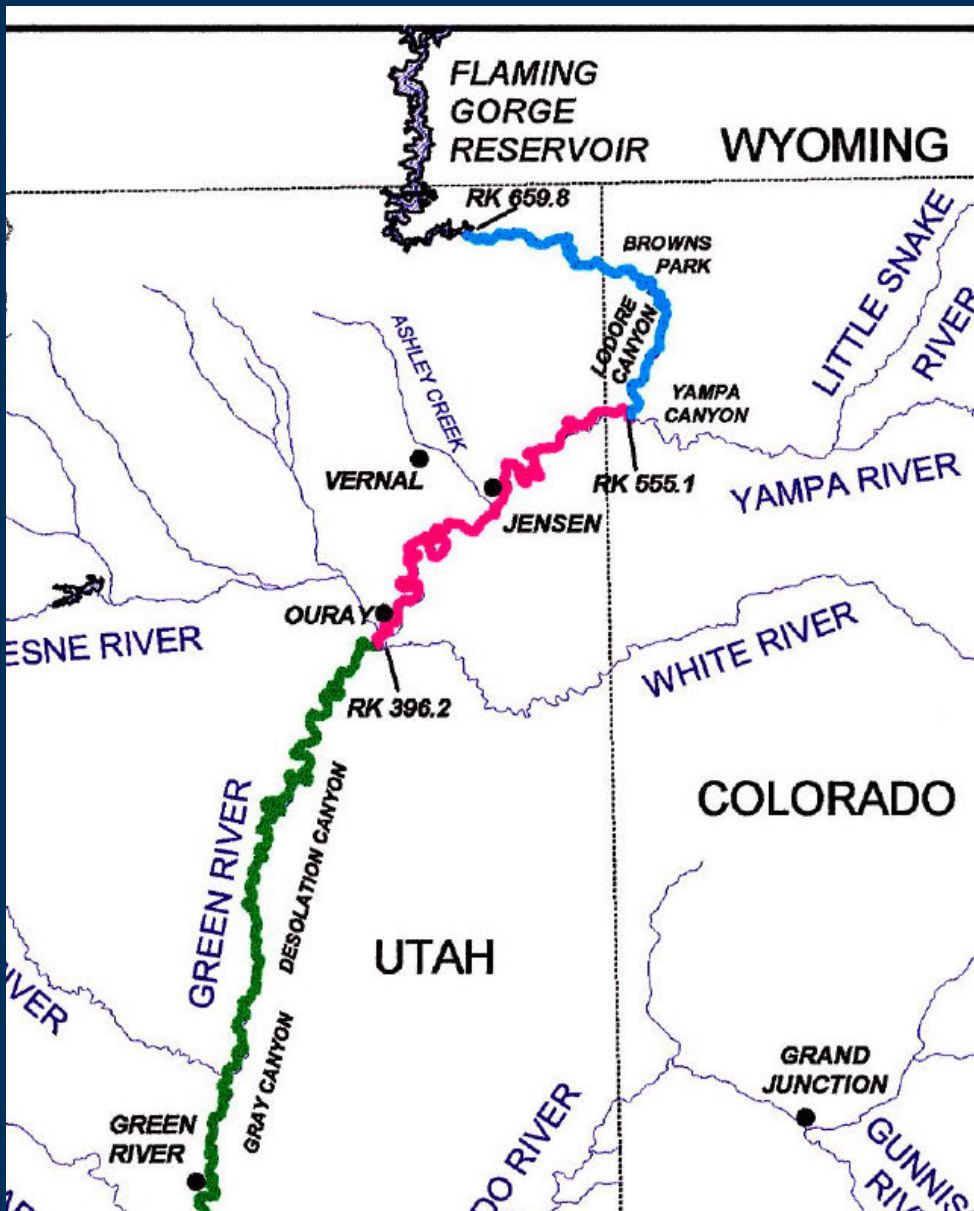
Research updates

- Environmental DNA
- Kinship work
- Modeling
- Laboratory studies

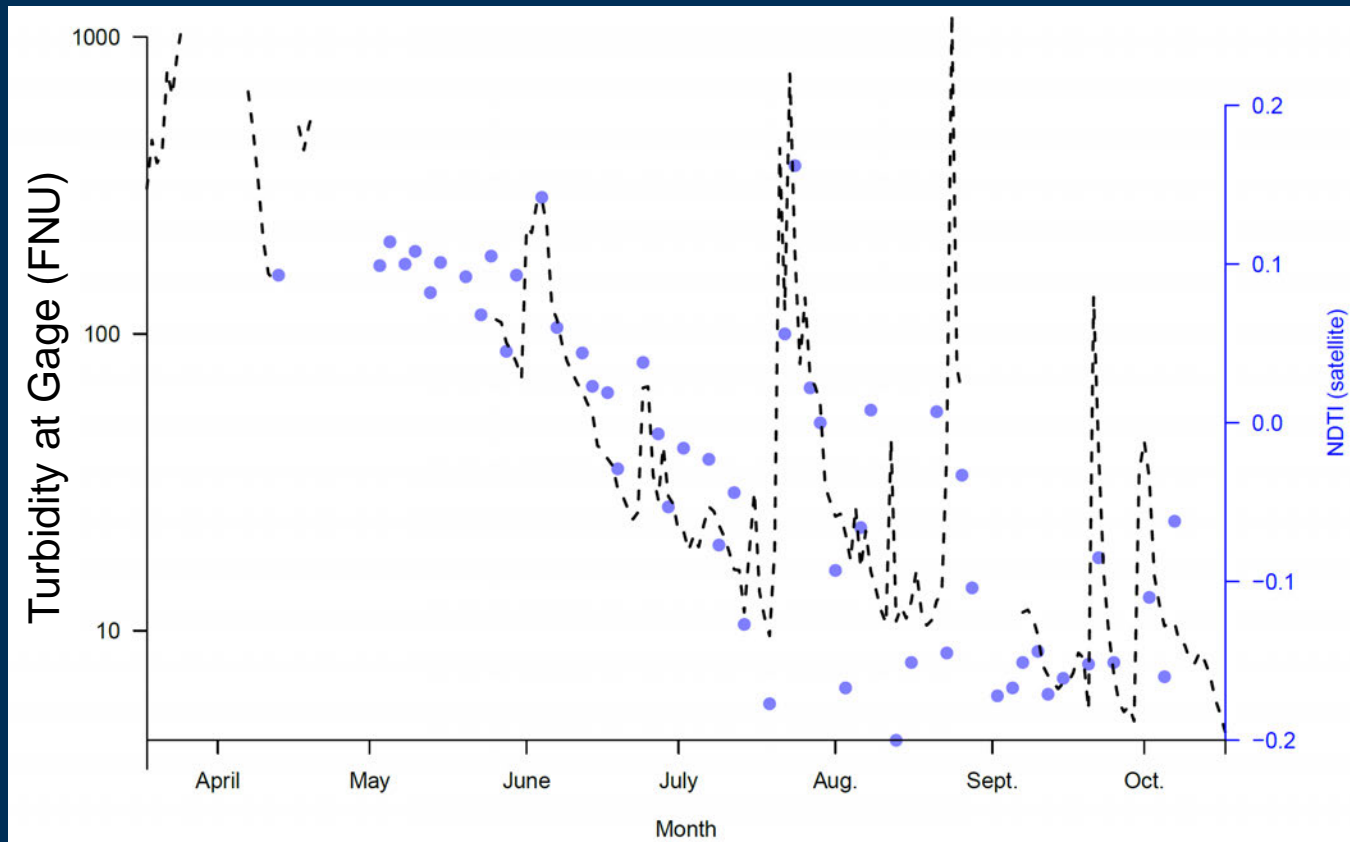


Learning from the Green River

- Turbidity and warm season temperatures generally increase as you travel downriver.
- Studies of SMB hatch dates focused on Lodore, Yampa and Whirlpool. Humpback chub functionally extirpated from this location 20 years ago.
- Desolation and Gray Canyons are warmer and more turbid. This population of Humpback chub declining by ~22% per year over last half-decade.



Using satellite data to fill in gaps in the turbidity record

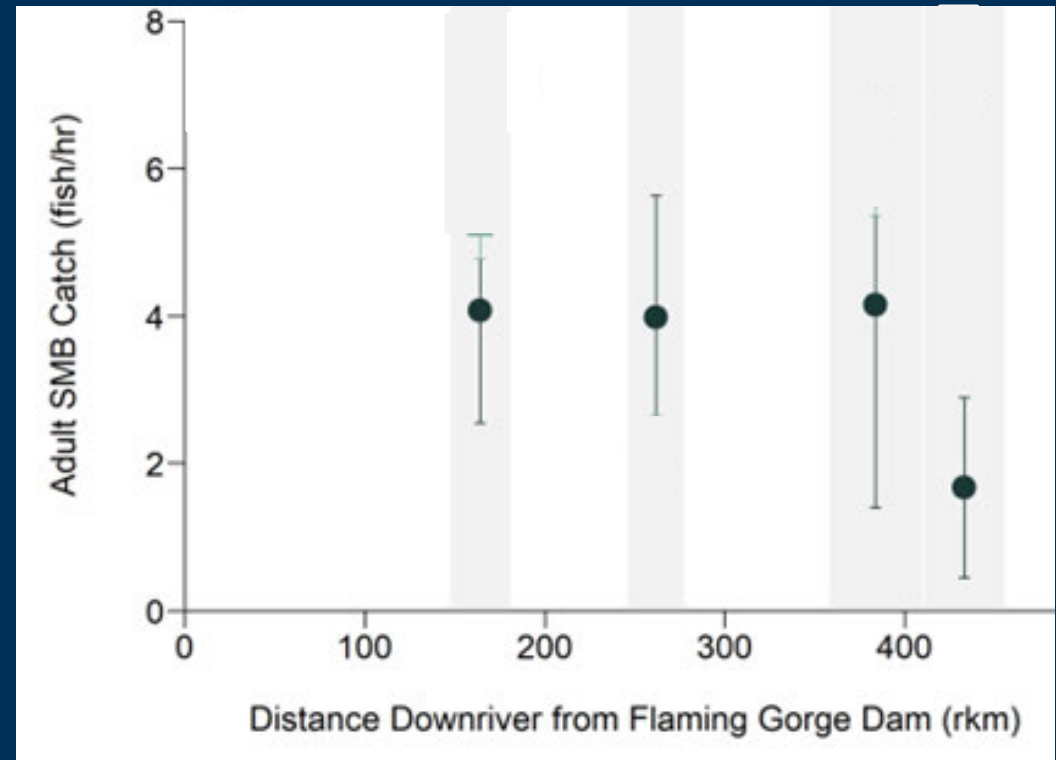
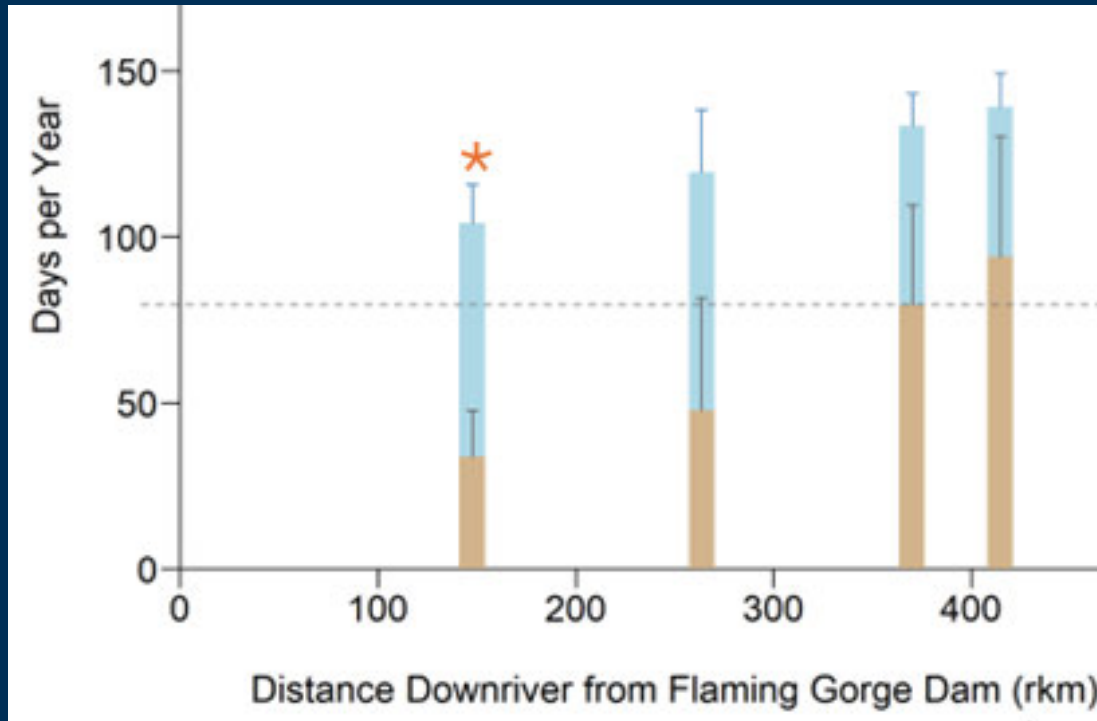
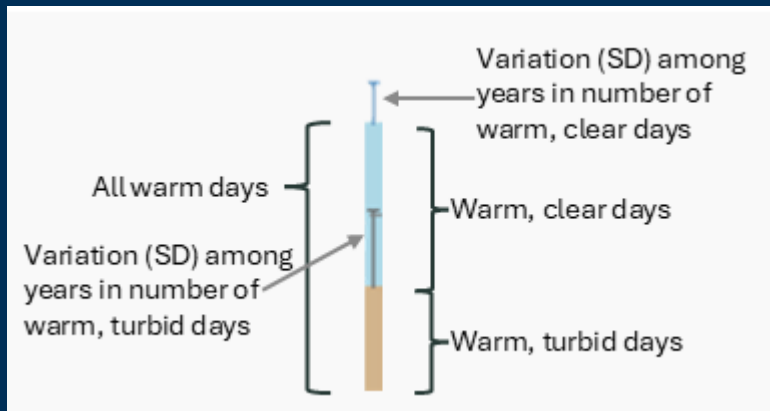


~ 525 FNU

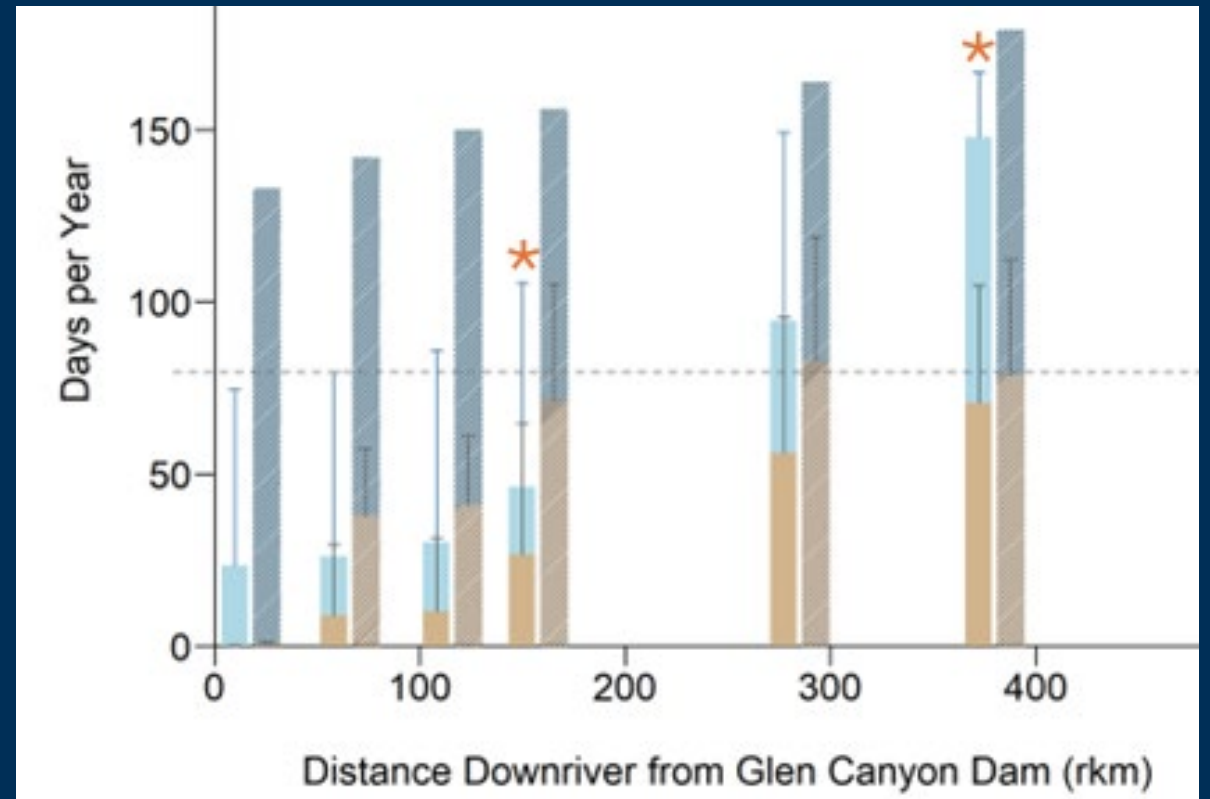
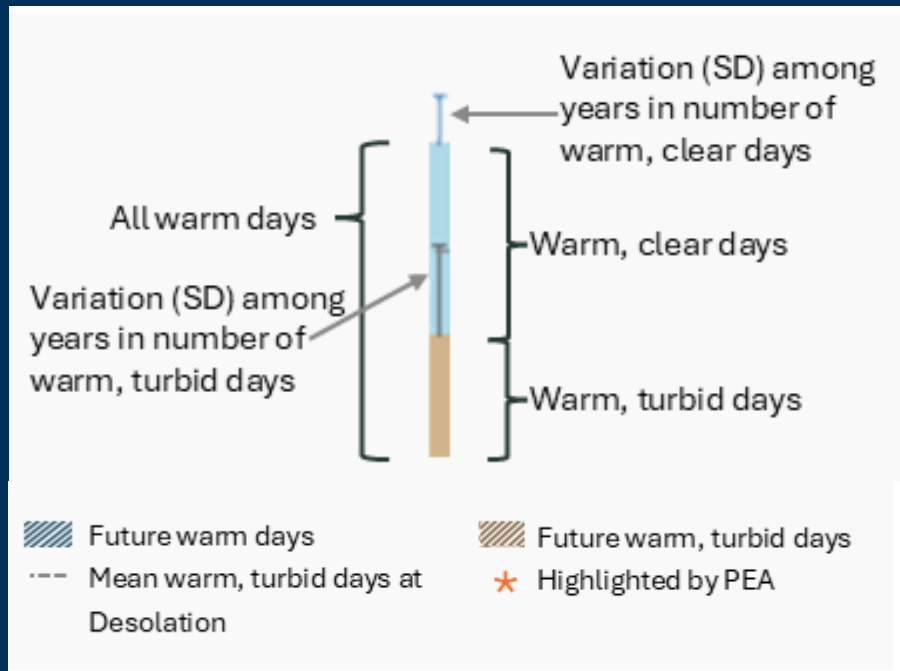


<10 FNU

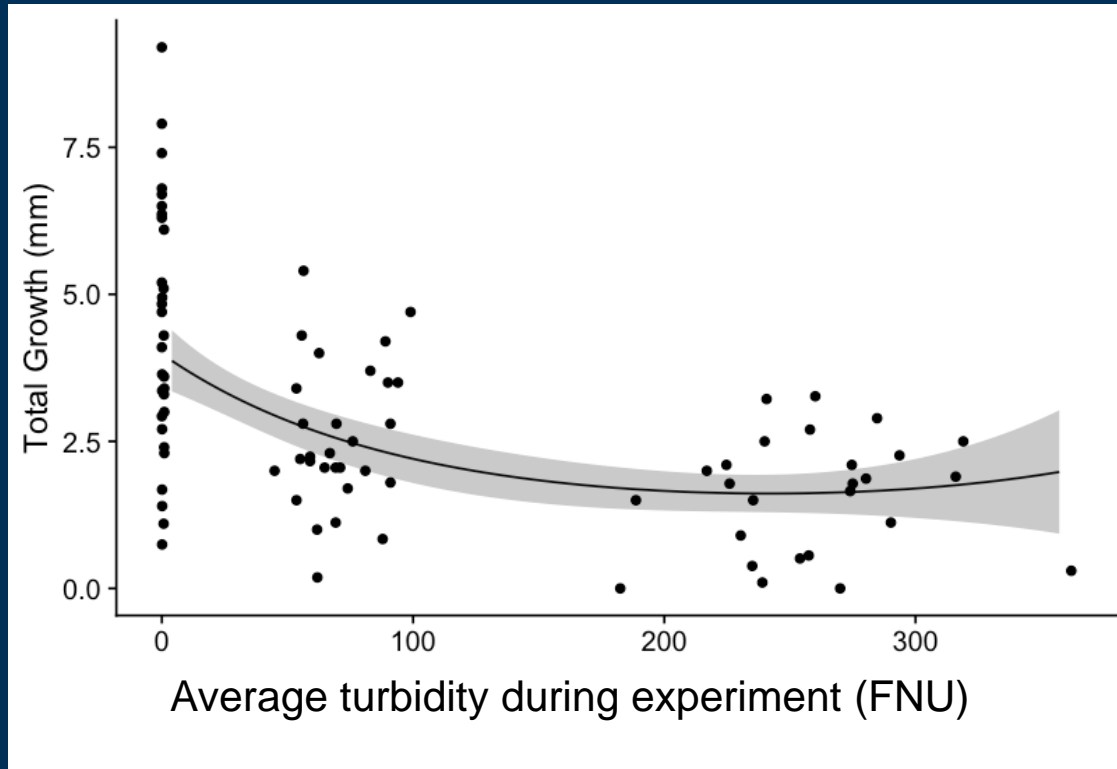
When we calculate metrics like the number of warm, turbid days (>16° C and 50 FNU) and compare to smallmouth bass catch data, we see no decline in catch until >80 warm, turbid days.



And the Colorado River in the Grand Canyon is not expected to average >80 more warm, turbid days.

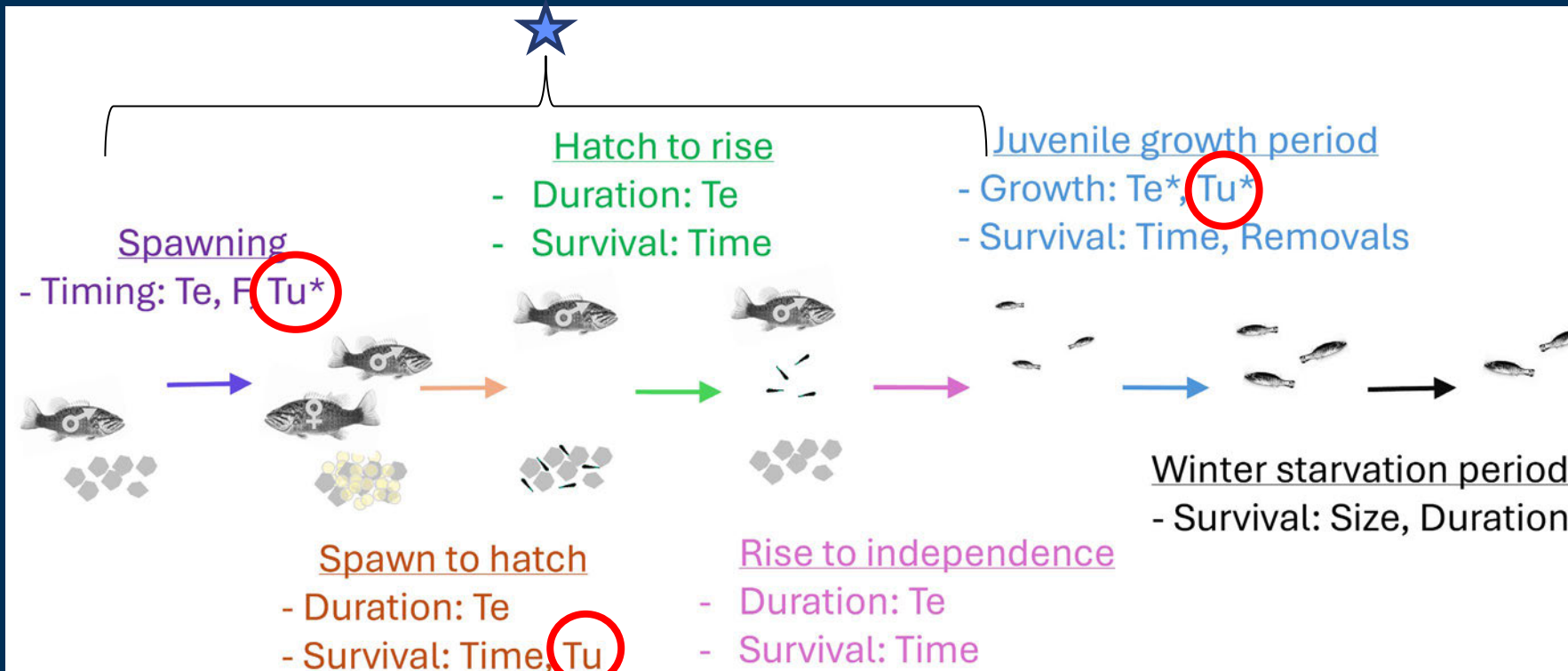


In a recent laboratory study, Smallmouth Bass growth declined with increasing turbidity but remained positive above 50 FNU.

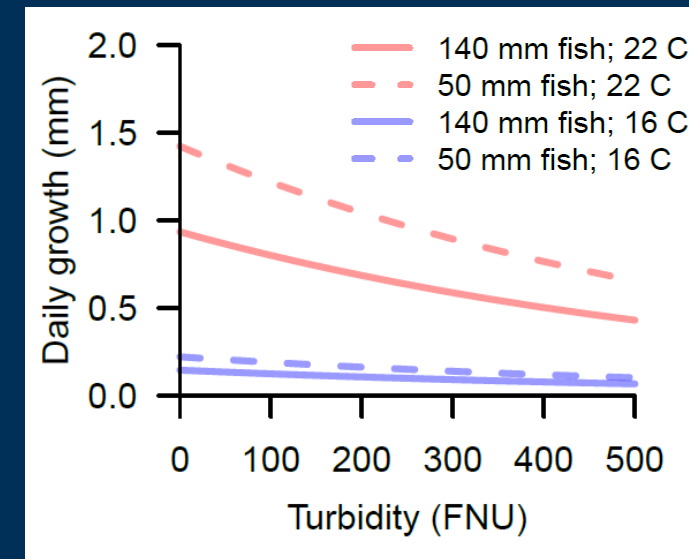


Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Models informed by past studies and fit to field data yield similar inferences.



**Being estimated to models fit to Upper Colorado River Basin data*



Take home messages

- Lower reservoir elevations and lower annual volumes in recent years have coincided with slightly more natural flows and substantial increases in insect diversity and abundances of humpback chub and some other native fish species.
- Low reservoir elevations in 2022 and 2023 led to significant increase in abundances of very high-risk non-native fish species, however the abundances of these species declined in 2024 & 2025.
- Rainbow Trout fishery has declined in recent years and remains in poor condition despite small improvements in 2025.

New & upcoming papers

- Bishop, I., *et al.* In Revision. A simplified two-station approach for modeling metabolism in dam tailwaters subject to diel flow variation. For *Limnology and Oceanography Methods*.
- Brooks, *et al.*, Accepted. Development and analysis of length–mass regressions for adult Chironomidae with notes on their application. *Journal of Freshwater Science*.
- Bruckerhoff, L.A., *et al.* (2025). Estimating drivers and identifying uncertainties in smallmouth bass population dynamics in an invaded river network. *Canadian Journal of Fisheries and Aquatic Sciences*.
- Deemer, B.D., *et al.* (2025). Low water levels interact with reservoir aging to increase the severity of summertime metalimnion dissolved oxygen minima in Lake Powell, desert Southwest, USA. *Inland Waters*.
- Dzul, M. C., *et al.* (2025). Genetic structure of an expanding population of Humpback Chub in Grand Canyon. *North American Journal of Fisheries Management*.
- Dzul, M.C., *et al.* Accepted. Integrating mark-recapture, catch, and expert habitat assessments to quantify recent increases in humpback chub abundance over a 200 km long river segment in western Grand Canyon. *Canadian Journal of Fisheries and Aquatic Sciences*.
- Eppehimer D.E., *et al.* (2025) Declining reservoir elevations following a two-decade drought increase water temperatures and non-native fish passage facilitating a downstream invasion. *Canadian Journal of Fisheries and Aquatic Sciences*.
- Hansen, L.E., *et al.* In Review. Growth of a threatened desert fish becomes resource dependent when released from temperature limitation in a regulated river. *Journal of Freshwater Ecology*.
- Metcalf, A., *et al.* (2025). Trade-offs in designing a participatory acoustic study of bats: comparison of user engagement and data quality between two ultrasonic detectors. *Journal of North American Bat Research*. Special Issue 1 (2025): 89–99., 89-99.
- Scholl, E., *et al.* Accepted. Effects of temperature on ectothermic predators are modulated by warming-induced changes to prey. *Food Webs*.
- Yackulic, C.B., *et al.* In Review. Comment on “Assessing the potential for Smallmouth Bass population establishment in Grand Canyon.” *Transaction of the American Fisheries Society*.

