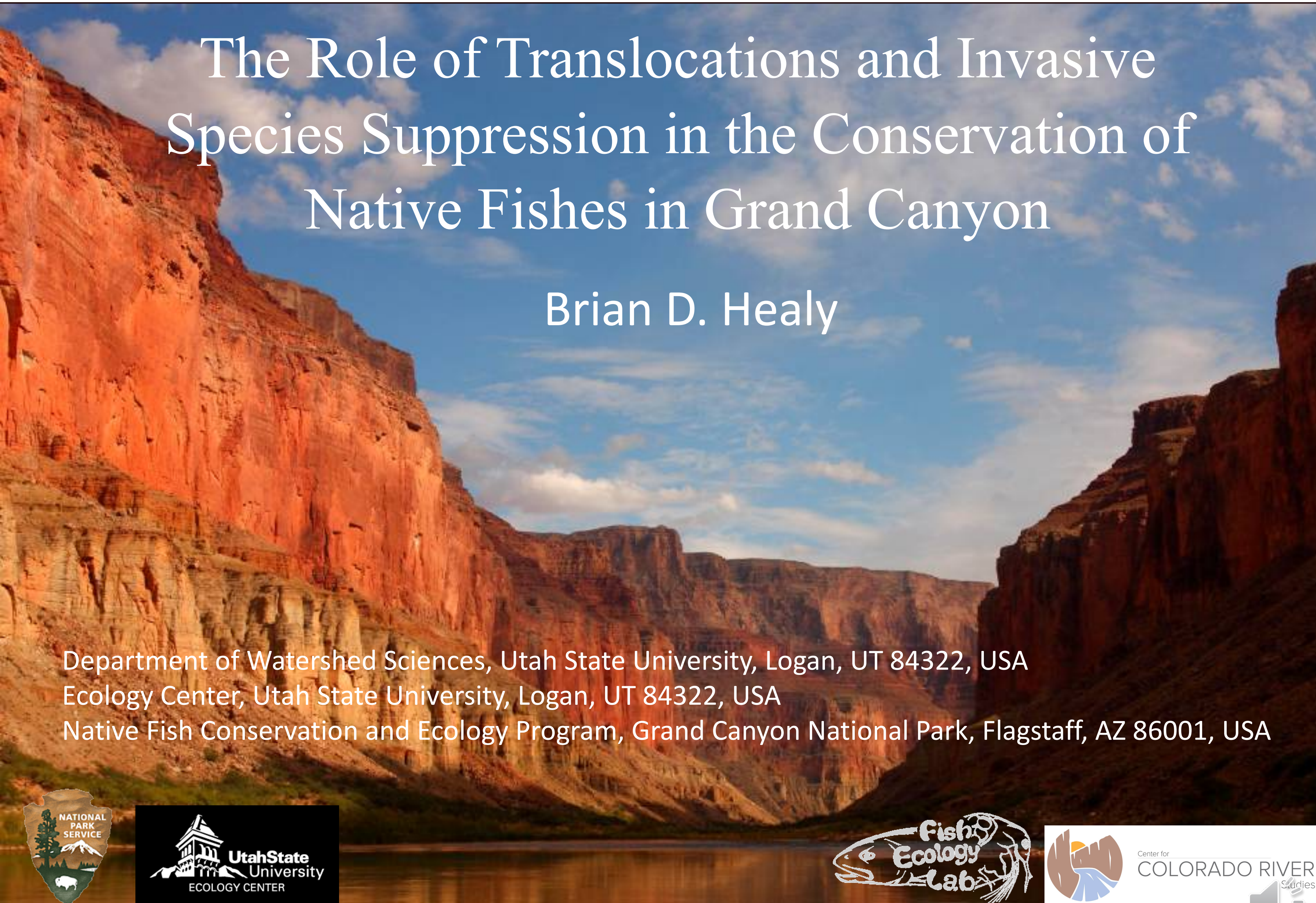

The Role of Translocations and Invasive Species Suppression in the Conservation of Native Fishes in Grand Canyon

Brian D. Healy

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Ecology Center, Utah State University, Logan, UT 84322, USA
Native Fish Conservation and Ecology Program, Grand Canyon National Park, Flagstaff, AZ 86001, USA

Acknowledgments

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- Grand Canyon Conservancy
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- Center for Colorado River Studies – Utah State
- US Geological Survey, Utah Cooperative Fish and Wildlife Unit (In Kind)
- Utah State University-Ecology Center/Watershed Sciences
- Arizona Game and Fish Department

Thank you to many volunteers and technicians!

Collaborators

- National Park Service
  - Emily Omana Smith, Robert Schelly, Rebecca Koller, Melissa Trammell, Nic Medley, Clay Nelson, Sarah Haas, Jan Balsom, Santiago Garcia
- Reclamation:
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- US Geological Survey – Grand Canyon Monitoring and Research Center
  - Charles Yackulic, David Ward, Mike Yard
- Utah State University
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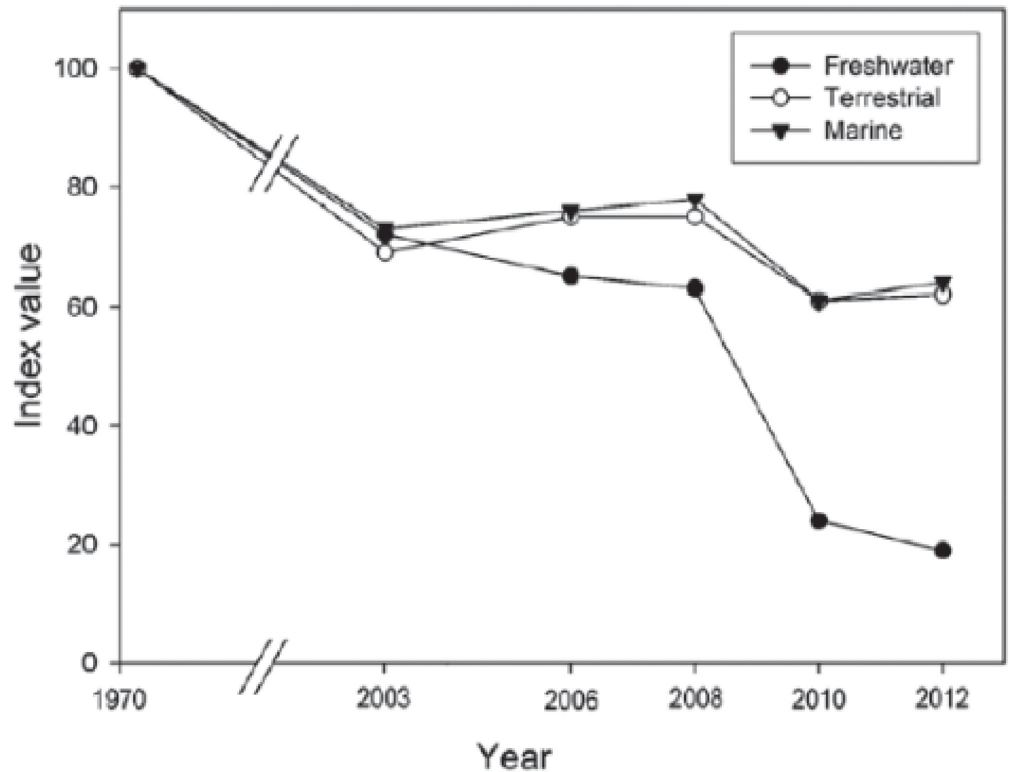
- US Geological Survey, Utah Cooperative Fish and Wildlife Unit (In Kind)
  - Phaedra Budy
- University of Missouri
  - Craig Paukert, John Spurgeon, Dan Whiting
- University of Florida
  - William Pine
- Arizona Game and Fish Department

Outline

- Challenges to effectively conserve native fishes in "novel" environments, including in Grand Canyon
- Focus on tributary* - case studies:
    - Invasive trout control to conserve native fishes
    - Translocations of humpback chub
- Discuss "lessons learned" and design considerations

Trends: Freshwater vs. Terrestrial Biodiversity

Freshwaters: 1% of global H_2O,
≈ 40-43% of fishes



BIOLOGICAL REVIEWS

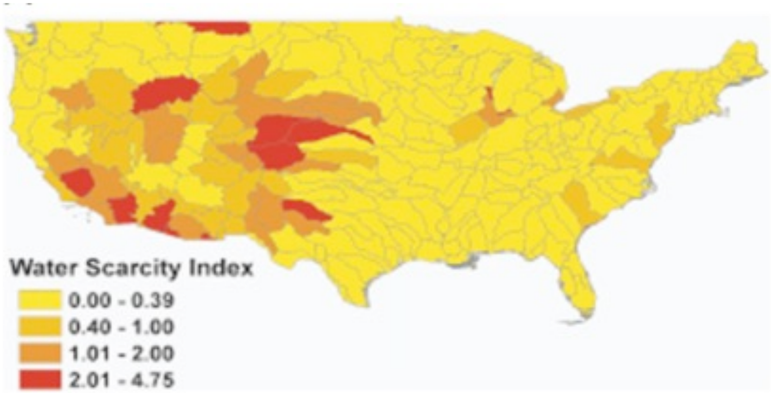
Cambridge Philosophical Society

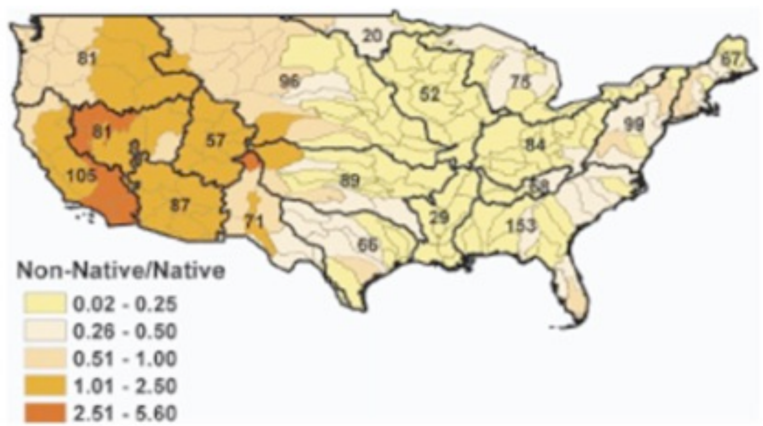
Biol. Rev. (2019), **94**, pp. 849–873. 849
doi: 10.1111/brv.12480

Emerging threats and persistent conservation challenges for freshwater biodiversity

Andrea J. Reid[1]*, Andrew K. Carlson[2], Irena F. Creed[3], Erika J. Eliason[4], Peter A. Gell[5], Pieter T. J. Johnson[6], Karen A. Kidd[7], Tyson J. MacCormack[8], Julian D. Olden[9], Steve J. Ormerod[10], John P. Smol[11], William W. Taylor[2], Klement Tockner[12,†], Jesse C. Vermaire[13], David Dudgeon[14] and Steven J. Cooke[1,13]

Conservation constraints





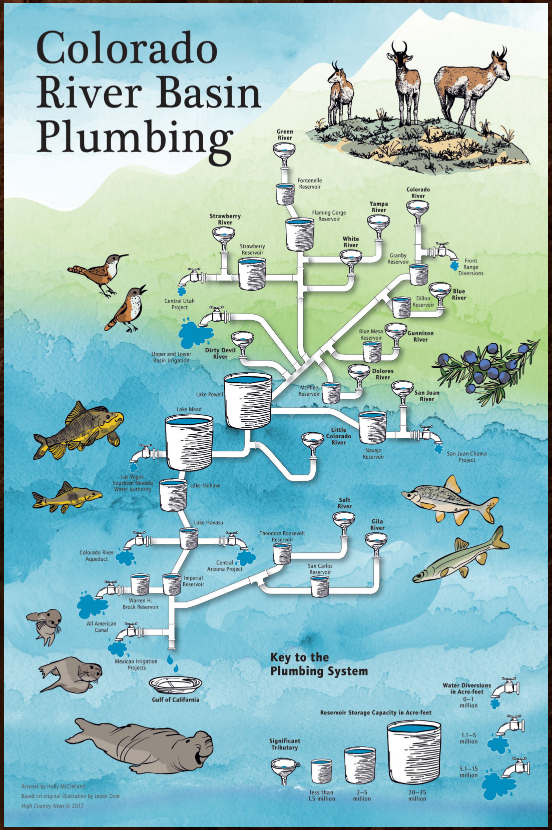
Sabo et al. 2010 –PNAS, *Reclaiming freshwater…Cadillac desert*


Colorado River: “America’s most endangered river”

Colorado River: “America’s most endangered river”

Extensive water development:

- 15 large mainstem dams:
- Reservoirs store 7x mean annual flow!
- 100’s of water diversions

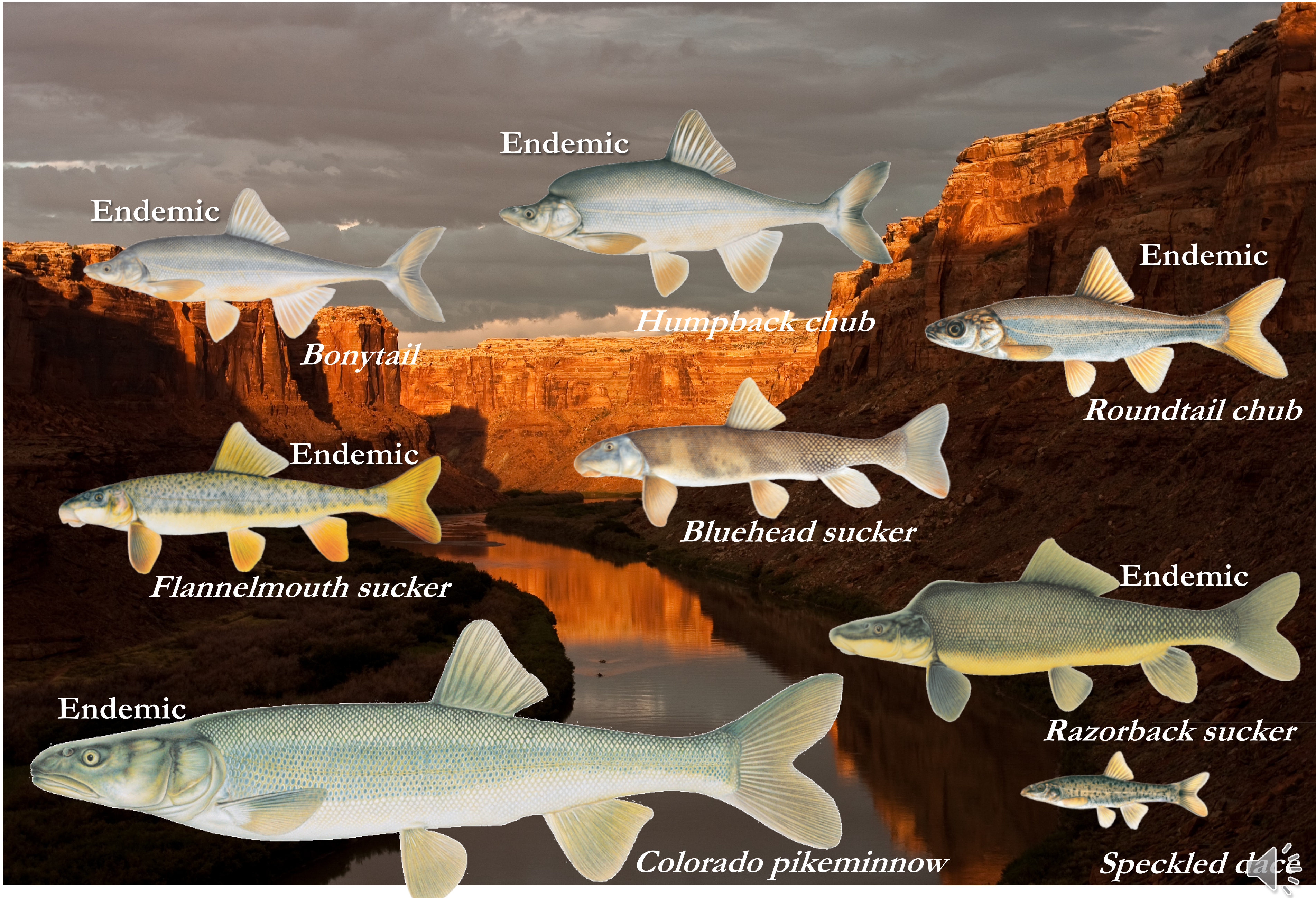


High Country News

Colorado River: "America's most endangered river"

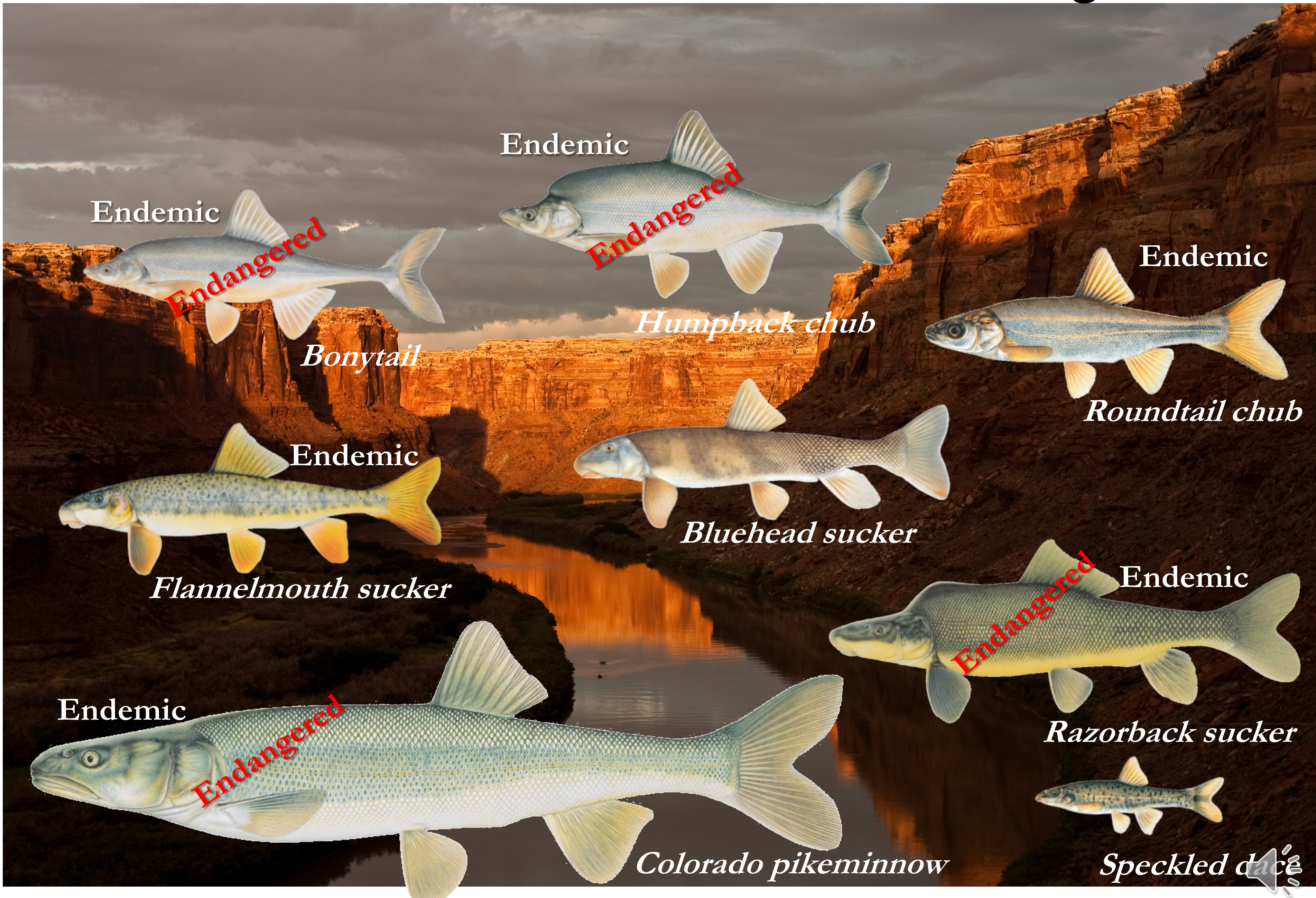
Joe Tomelleri Illustrations

75% are Endemic



Joe Tomelleri Illustrations

50% are Endangered



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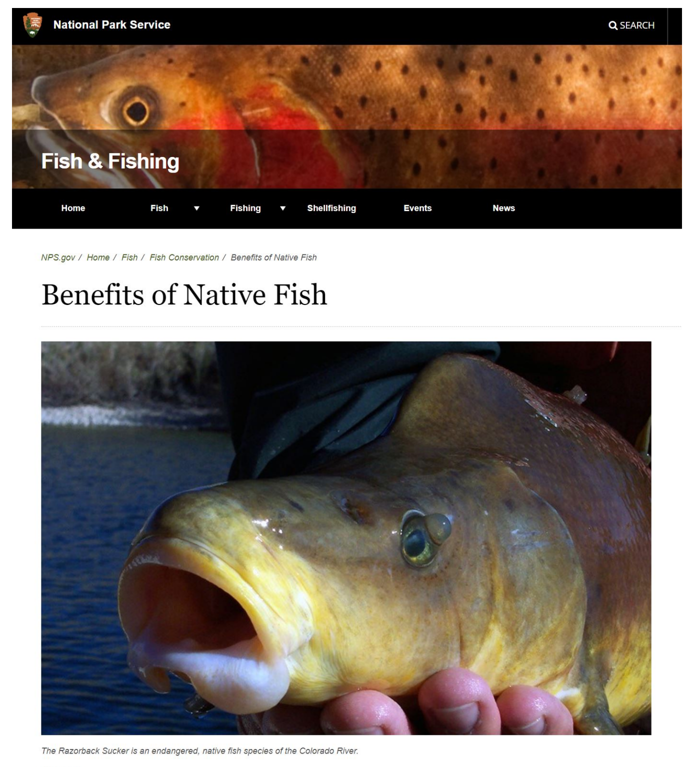
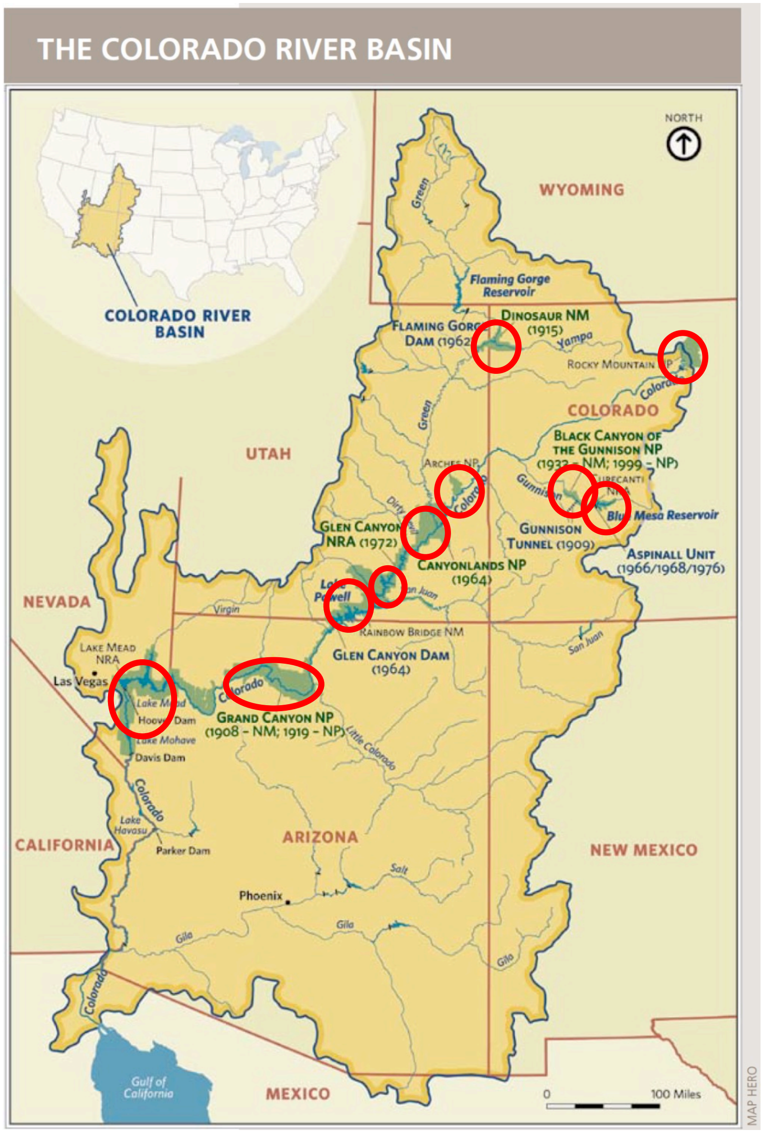
Colorado River – National Parks

- Potentially significant role in conservation



Colorado River – National Parks



- Potentially significant role in conservation
- 9 NPS units along Colorado River
- Mandate to conserve resources over recreation
    - Organic Act, enabling legislation

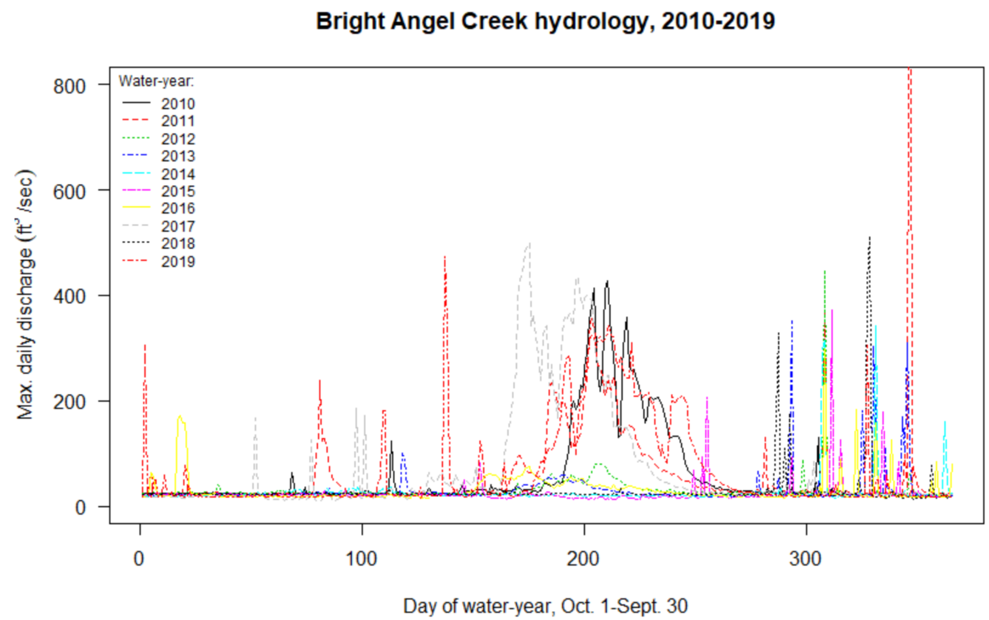
Grand Canyon

Our Challenge:

Develop, test, and monitor management strategies to conserve native fish under novel conditions

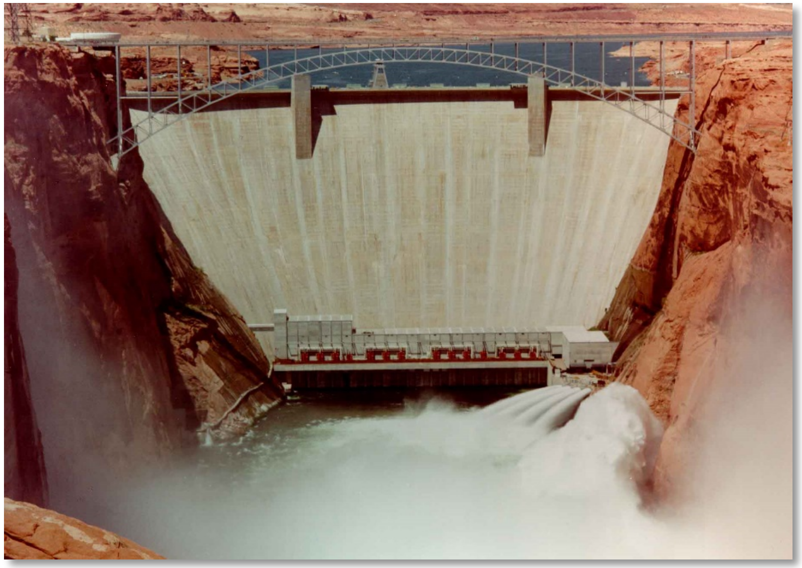
Colorado River fishes

- Evolved in disturbance-prone environments
- Seasonally-warm thermal regime
- Life history strategies-
    - Long-lived
    - High fecundity
    - Migratory
    - Unique morphology



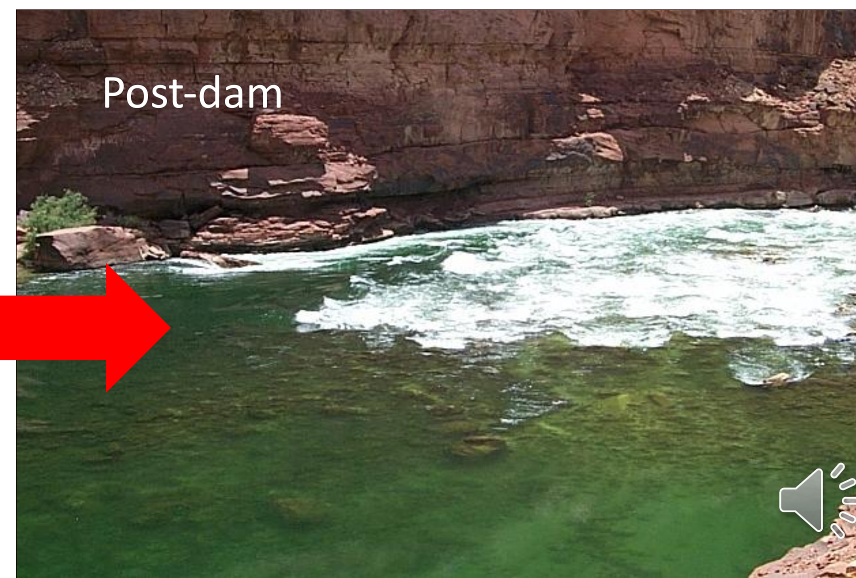
Novel habitats – post "disturbance"

- Damming & diversions
- "Stable" and predictable
- Favors fishes evolved in stable environments

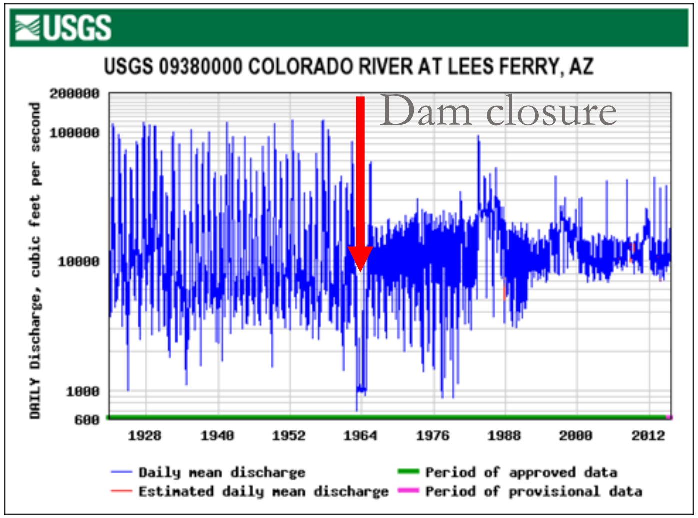


Novel habitats – post “disturbance”

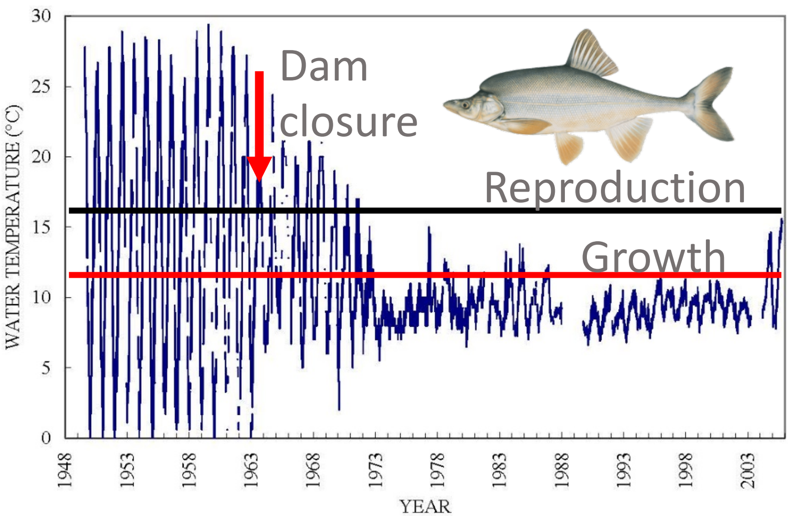
- Damming & diversions
- “Stable” and predictable
- Favors fishes evolved in stable environments (e.g., salmonids)

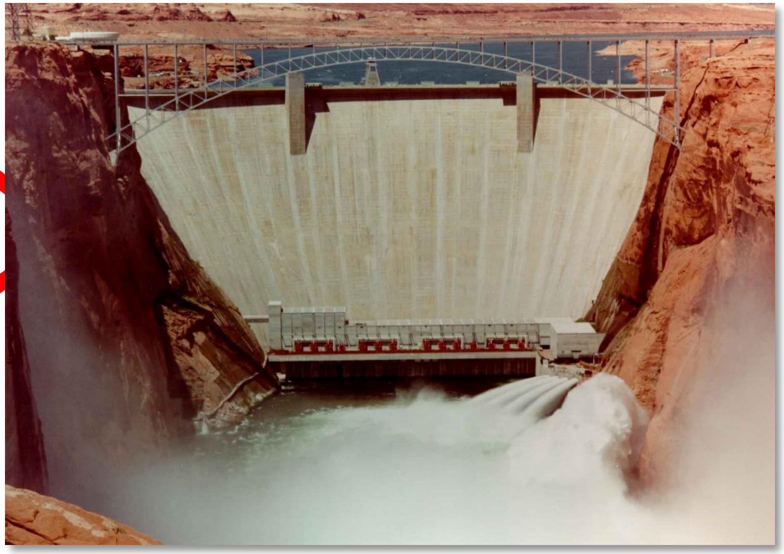


Study area: Grand Canyon



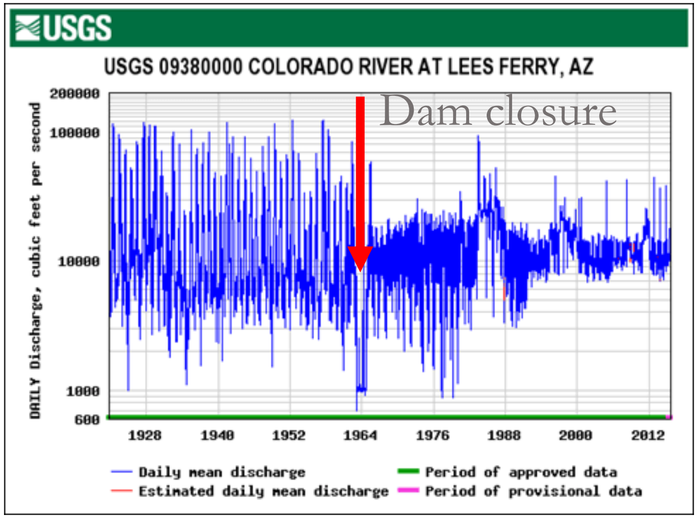
Altered hydrology

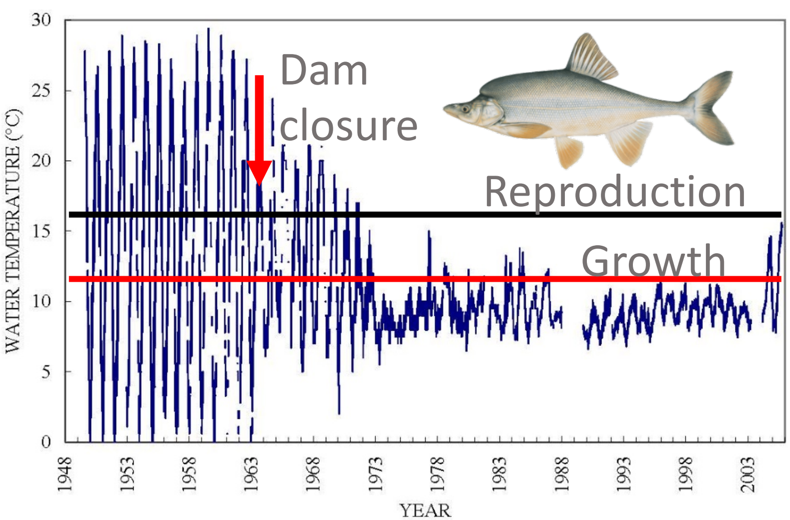




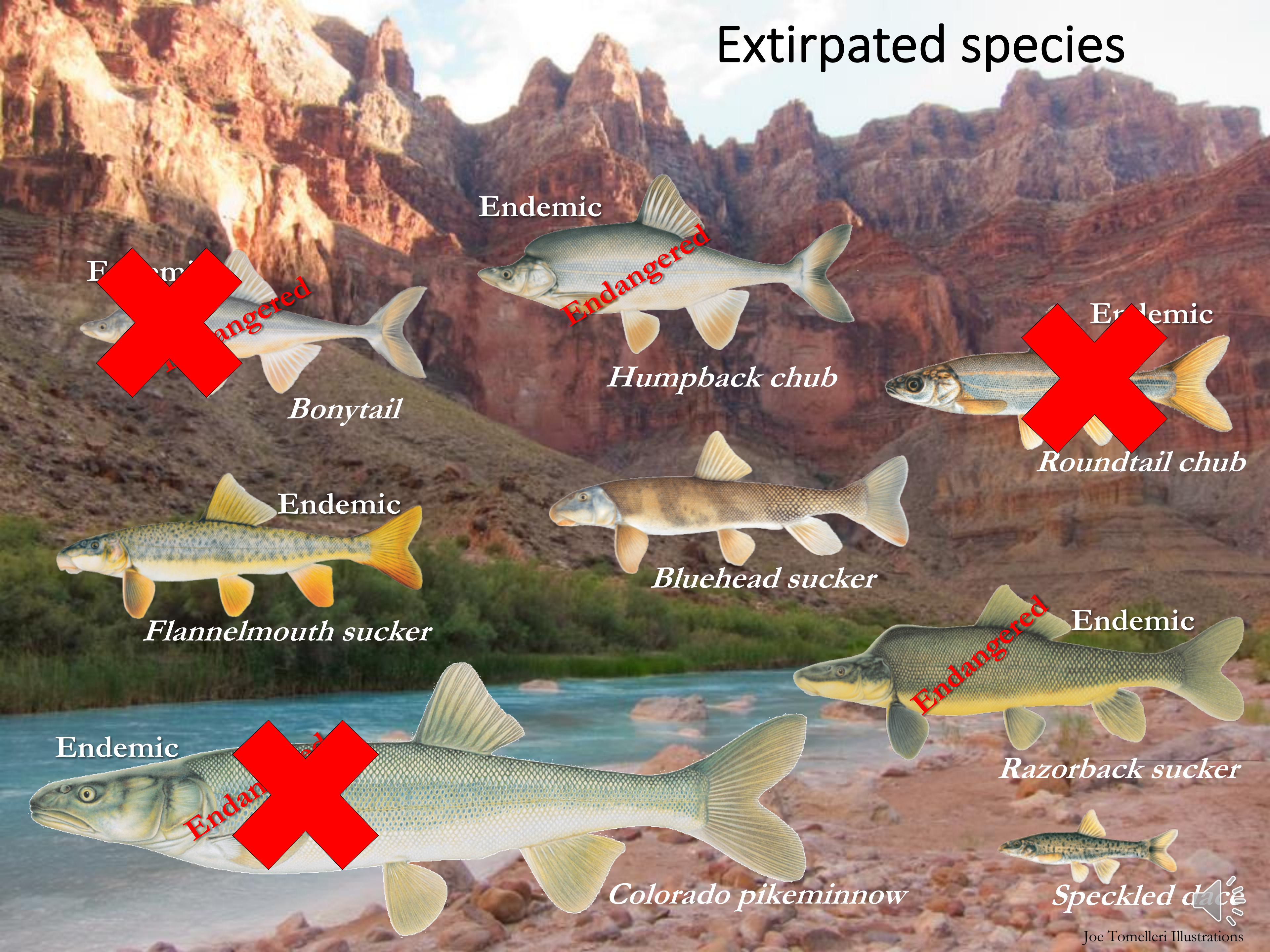
Altered thermal regime

Study area: Grand Canyon





Extirpated species



How do we conserve riverine fishes?

Joe Tomelleri Illustrations

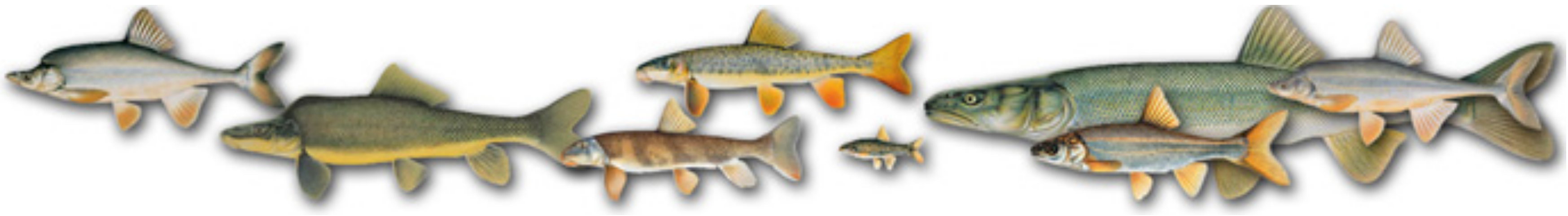
How do we conserve riverine fishes?

Joe Tomelleri Illustrations

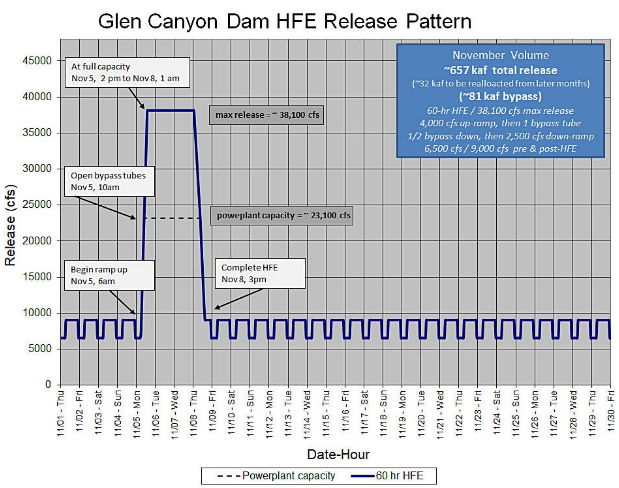
- Restore habitat

How do we conserve riverine fishes?

Joe Tomelleri Illustrations



- Dam management:
  - Outcomes difficult to predict
  - Low summer steady flow cost >$23 million
- Restore habitat



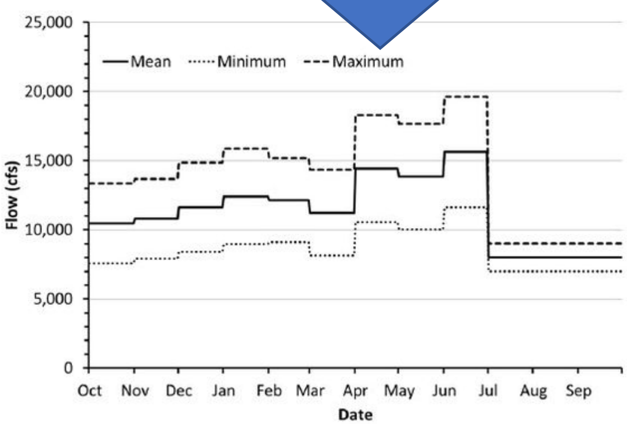
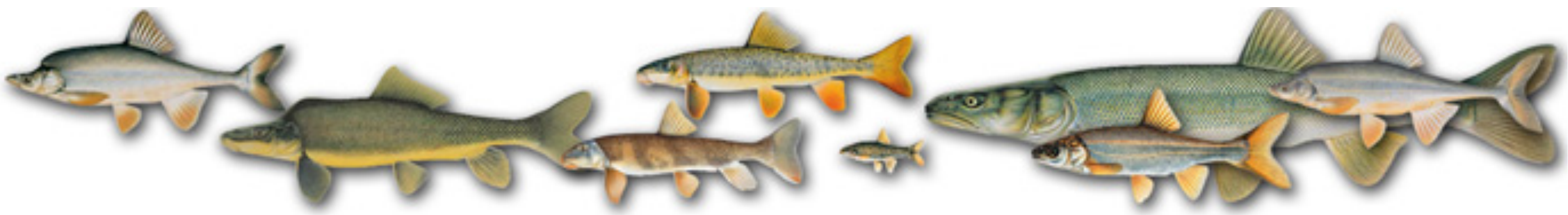


FIGURE 2-22 Mean, Minimum, and Maximum Daily Flows under Triggered Low Summer Flows of Alternative D in an 8.23-maf Year Based on the Values Presented in Table 2-10

Colorado River – stakeholders

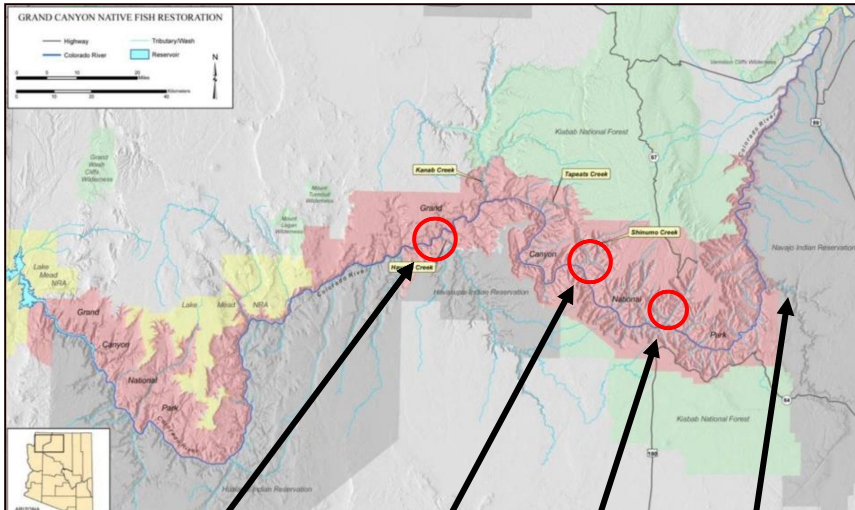
Stakeholder	Objective
Federal agency	
U.S Bureau of Reclamation	Water management
National Park Service	Protect/conserve natural and cultural resources
U. S. Fish and Wildlife Service	Endangered species recovery
Bureau of Indian Affairs	Tribal interests
Tribes	
Hualapai	Maintain/protect cultural values
Hopi	Maintain/protect cultural values
Navajo	Maintain/protect cultural values
Pueblo of Zuni	Maintain/protect cultural values
Southern Paiute Consortium	Maintain/protect cultural values
San Juan Paiute	Maintain/protect cultural values
Basin States	
Arizona	Water distribution/rights
California	Water distribution/rights
Colorado	Water distribution/rights
Nevada	Water distribution/rights
New Mexico	Water distribution/rights
Utah	Water distribution/rights
Wyoming	Water distribution/rights
Environmental Groups	
Grand Canyon Wildlands Council	Environmental protection/conservation
American Rivers	Environmental protection/conservation
Recreation Interests	
Grand Canyon River Guides	Commercial and recreational river running
International Federation of Flyfishers/Trout Unlimited	Fishing for invasive trout
	Federal Power Purchasers
Colorado River Energy Distributors	Hydropower
Utah Municipal Power	Hydropower
Other	
Arizona Game and Fish Department	Fishing interests and native fish conservation
Western Area Power - Department of Energy	Hydropower distribution

How do we conserve riverine fishes?


Joe Tomelleri Illustrations

- Manipulate populations
- Restore habitat

Study area



Havasu Creek

Shinumo Creek

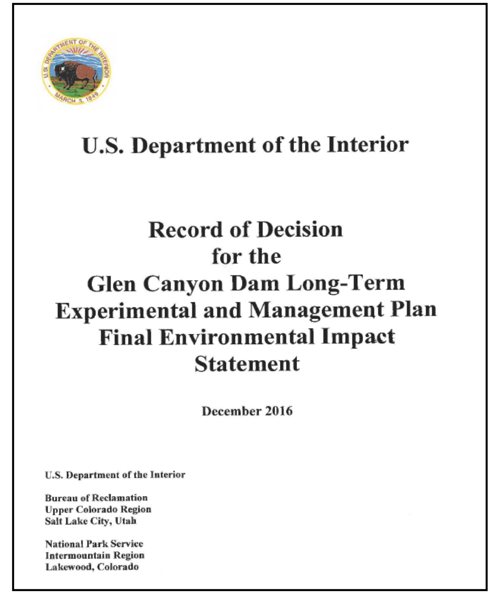
Bright Angel Creek

Little Colorado

*Natural flow & thermal regimes

Conservation measures- Humpback chub

- Glen Canyon Dam operations Biological Opinions:
  - Control of nonnative fish (rainbow and brown trout)
  - Translocations to Grand Canyon tributaries


U.S. Department of the Interior

Record of Decision
for the
Glen Canyon Dam Long-Term
Experimental and Management Plan
Final Environmental Impact
Statement

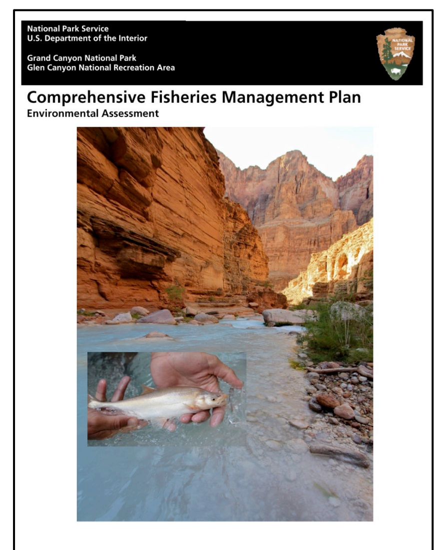
December 2016

U.S. Department of the Interior

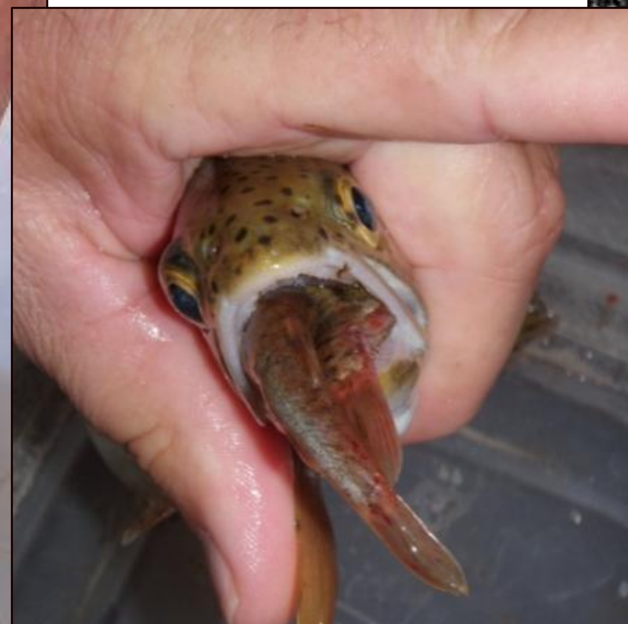
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

National Park Service
Intermountain Region
Lakewood, Colorado

- NPS Comprehensive Fisheries Management Plan (2013)



Case study: Non-native trout control



Nonnative fish introductions

- Trout were introduced by agencies, including NPS, into tributaries beginning in the 1920s.
- NPS stopped stocking in 1964, but AGFD continued to stock rainbow trout near Lees Ferry until the 1990s, also in 2018-19.

Grand Canyon Nature Notes

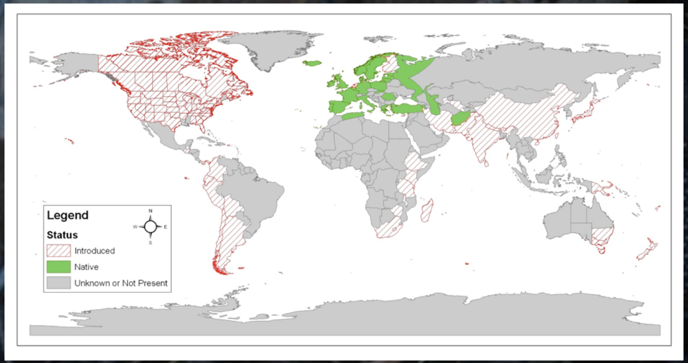
TROUT PROPAGATION IN GRAND CANYON NATIONAL PARK

By Robert R. Williamson, Ranger
and
Carol F. Tyler, Clerk-Stenographer

THE PROPAGATION of fish in Grand Canyon National Park has been carried on for a number of years and though there is no record of the species of fish or of the number planted prior to 1920, it is known that the Forest Service made some planting in the more accessible streams prior to the creation of the National Park in 1919.

Brown trout – a global invader

- Introductions both inadvertent and intentional
- Can thrive in altered habitats
- Impacts due to predation and competition



Brown trout – a global invader

- Survival of humpback chub: rainbow vs brown trout
  - Temperature and size matters less to chub survival when faced with a brown trout!

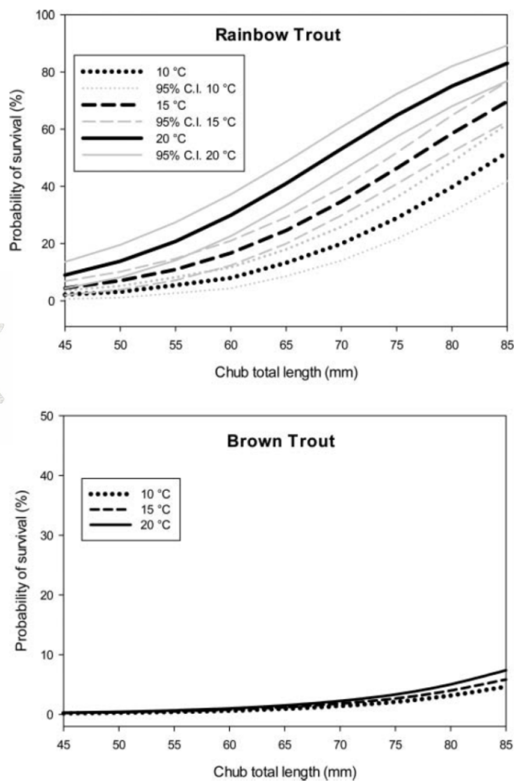


FIGURE 1. Percent (%) probability that a juvenile chub will survive predation by a 285-mm Rainbow Trout (top) or Brown Trout (bottom) as chub size increases from 45 to 85 mm TL at 10, 15, and 20°C. Note that the y-axis scale for Brown Trout is one-half that for Rainbow Trout. Confidence intervals for Brown Trout are not individually distinguishable and not shown.

Effects of Water Temperature and Fish Size on Predation Vulnerability of Juvenile Humpback Chub to Rainbow Trout and Brown Trout

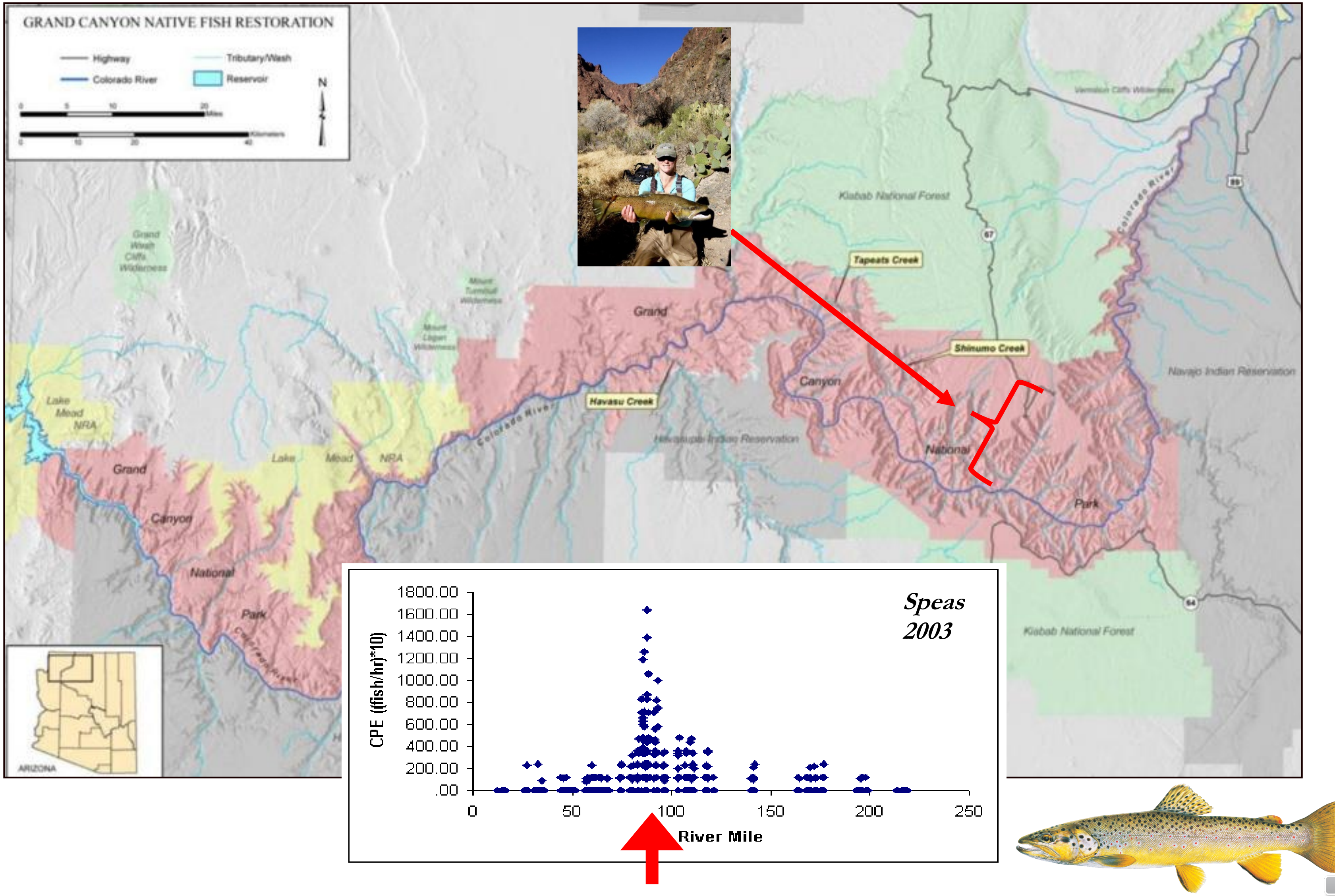
Transactions of the American Fisheries Society 144:1184–1191, 2015

David L. Ward* and Rylan Morton-Starner

U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center, 2255 North Gemini Drive, Flagstaff, Arizona 86001, USA

Illustrations by Joseph Tomelleri

Study stream – Bright Angel Creek



Bright Angel Creek Inflow

Joe Tomelleri Illustrations

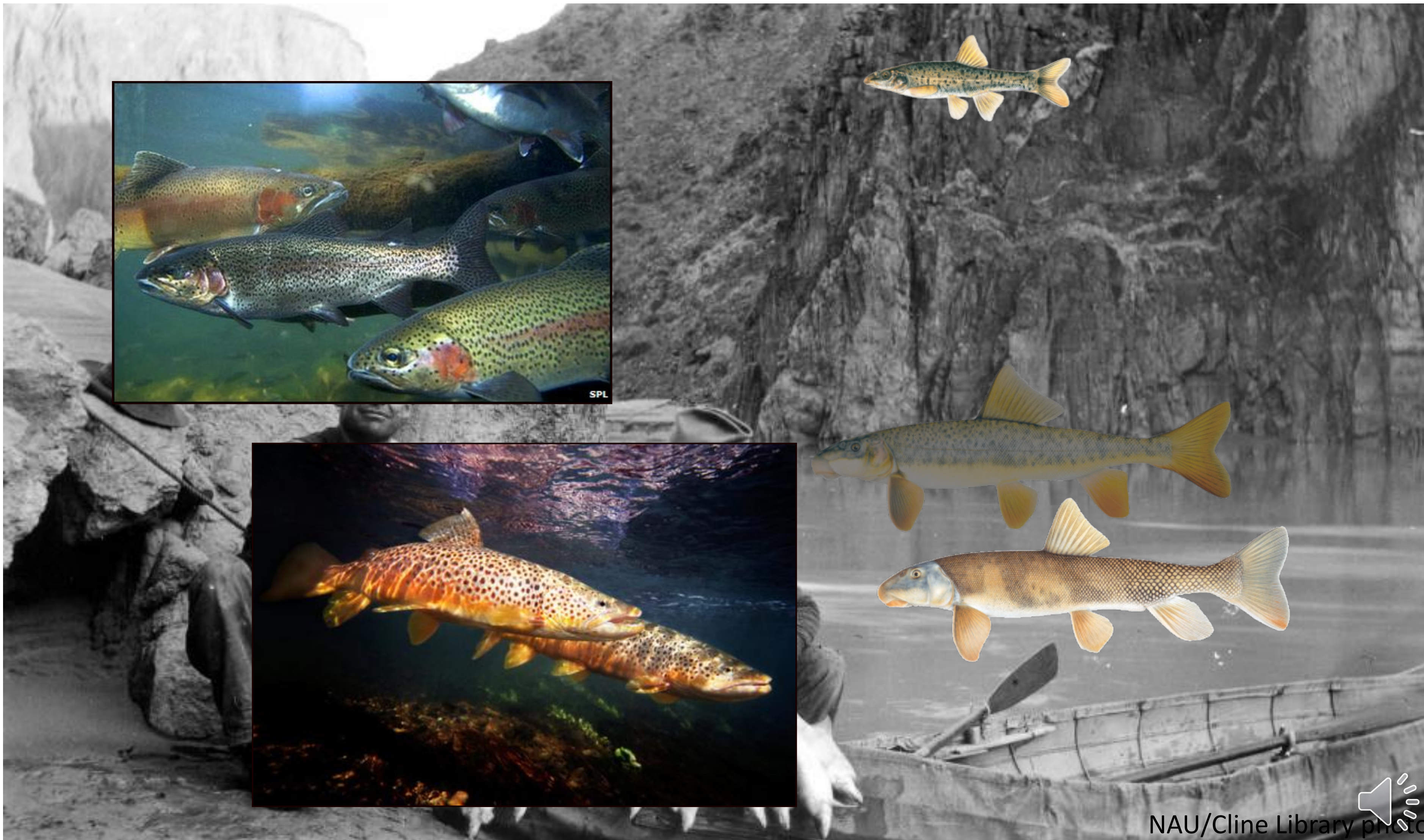
Bright Angel- fish community

Joe Tomelleri Illustrations

NAU/Cline Library photo

Bright Angel- fish community

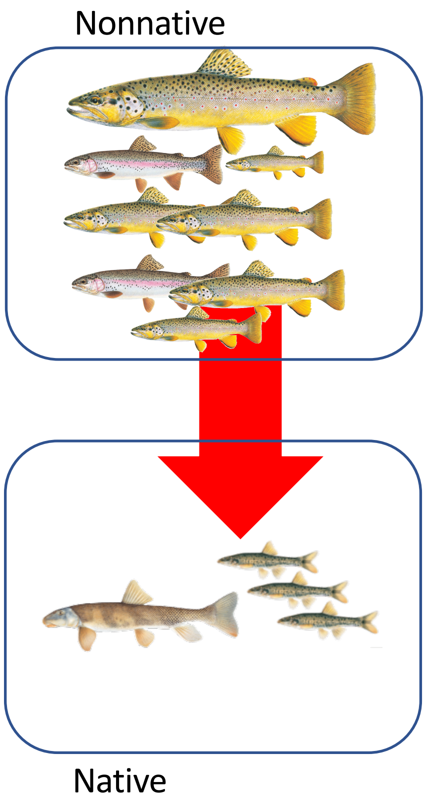
Joe Tomelleri Illustrations



Nonnative trout suppression –

- **Goals:**
  - Enhance and restore native fish populations in Bright Angel Creek, to the extent possible
  - Reduce risk of predation upon humpback chub in Colorado River
  - Foster meaningful tribal relations and integrate perspectives into management
- **Mechanical Removal Objectives:**
  - Reduce trout abundance by 80%
  - Maintain/improve native fish populations in Bright Angel Creek
  - When trout reduction objective met, translocate humpback chub

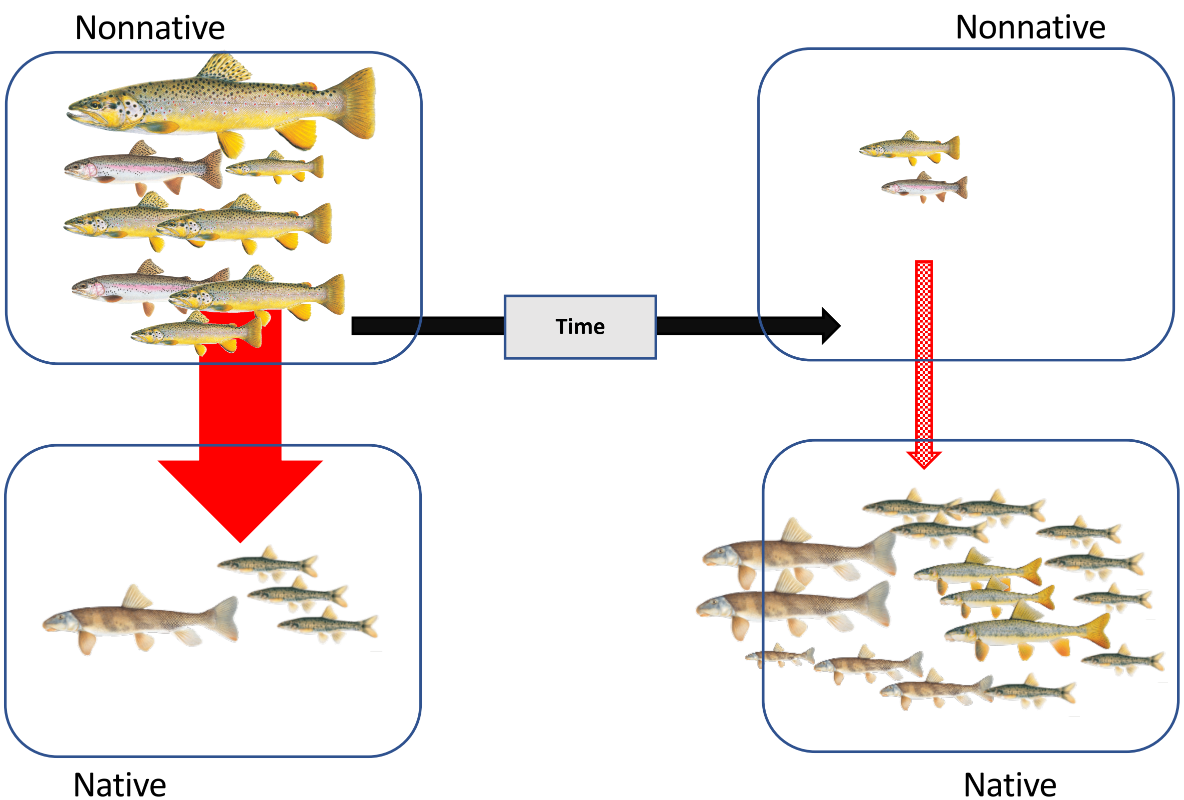
Response of a desert fish community to the suppression of invasive salmonids



Native fishes ~ *f* (Invasive fishes, environmental variation, electrofishing, time, space)

Joe Tomelleri Illustrations

Response of a desert fish community to the suppression of invasive salmonids



Native fishes ~ *f* (Invasive fishes, environmental variation, electrofishing, time, space)

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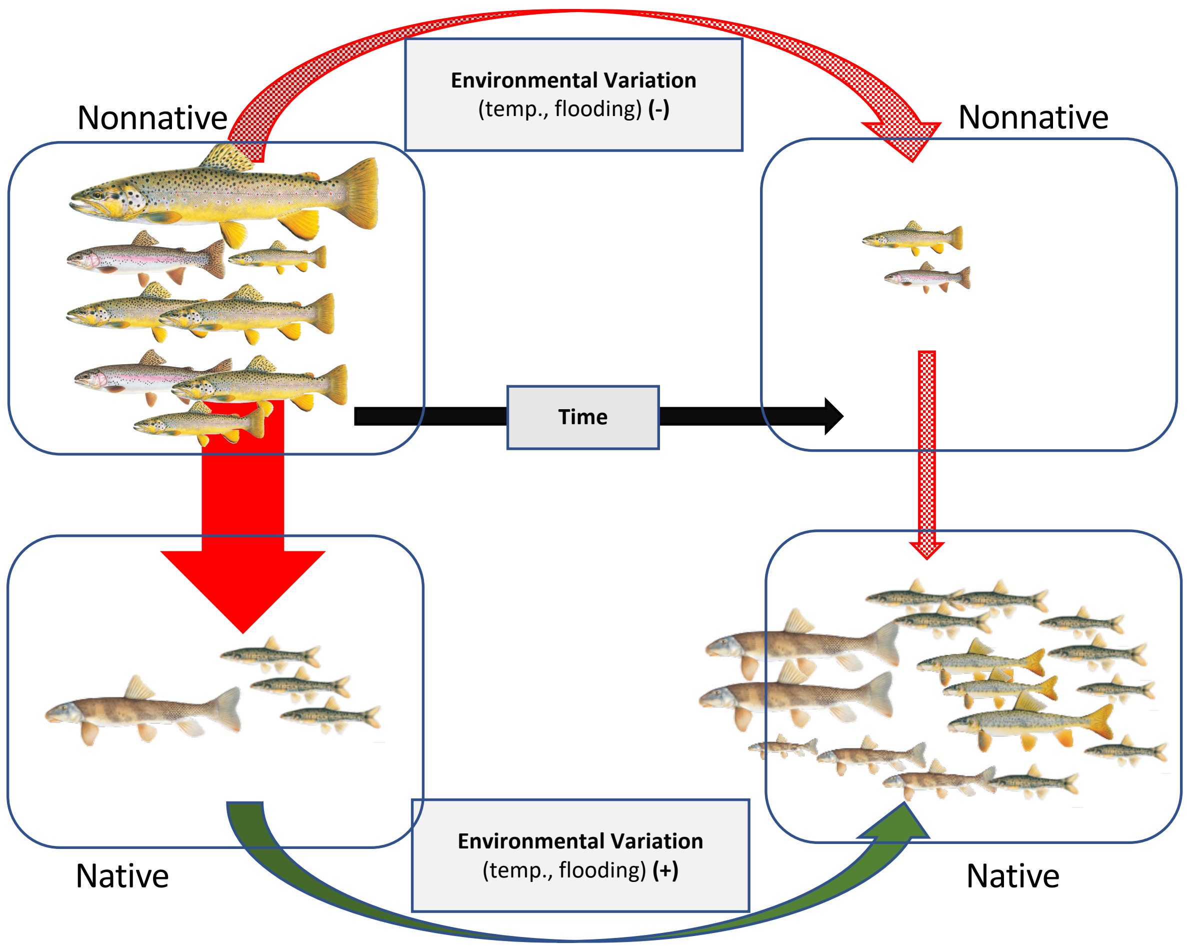
Response of a desert fish community to the suppression of invasive salmonids



Native fishes ~ *f* (Invasive fishes, environmental variation, electrofishing, time, space)

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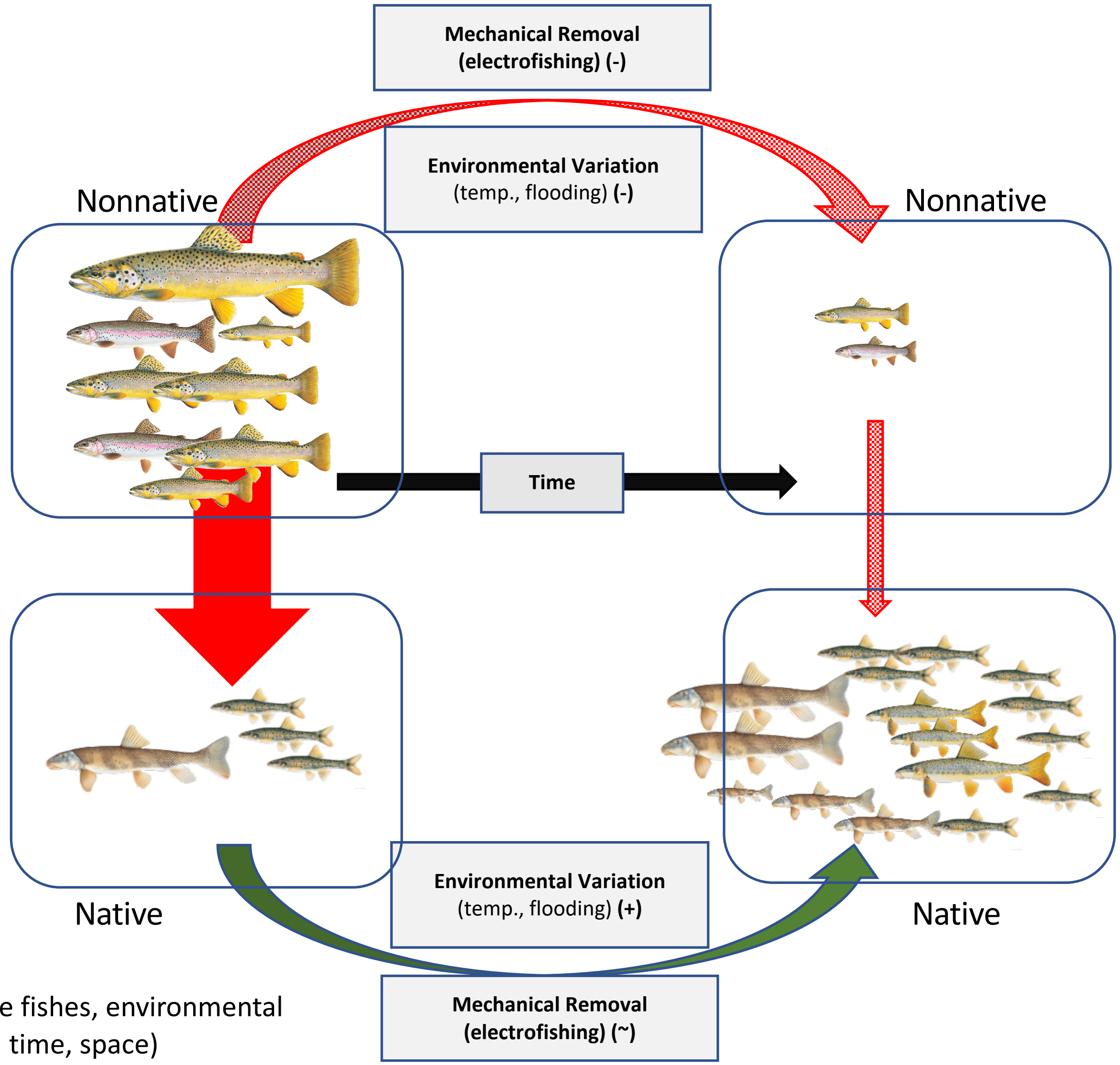
Response of a desert fish community to the suppression of invasive salmonids



Native fishes ~ *f* (Invasive fishes, environmental variation, electrofishing, time, space)

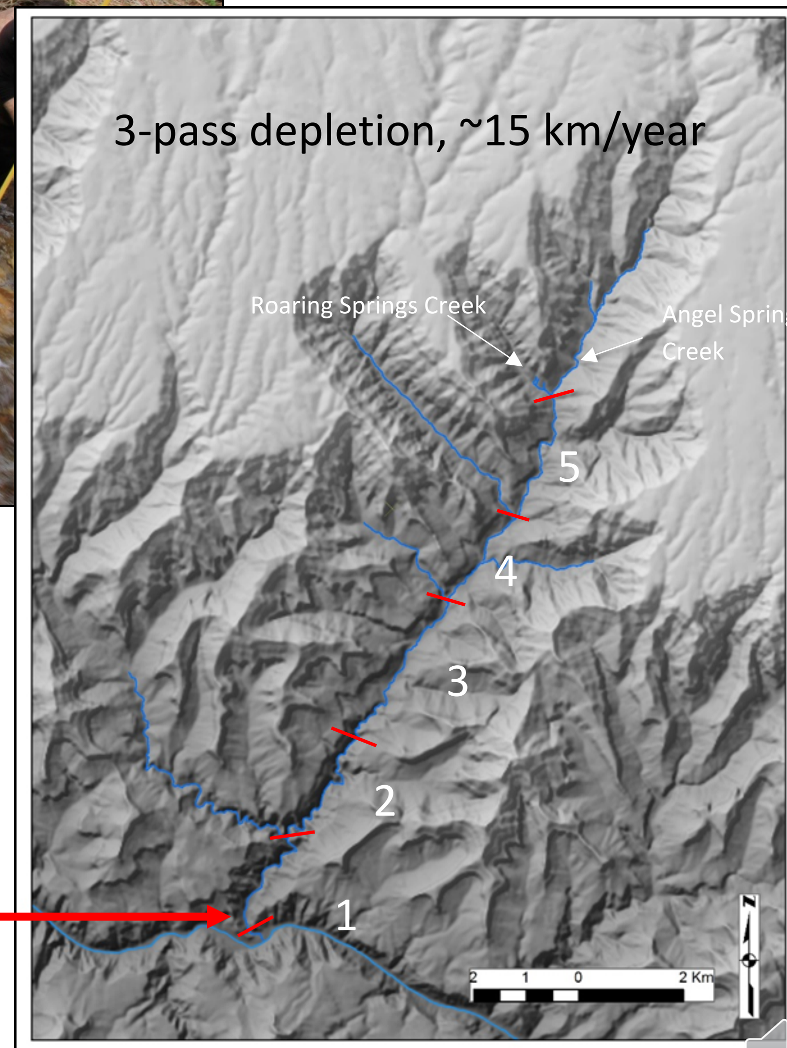
Joe Tomelleri Illustrations

Research Objectives

1. Quantify temporal trends in abundance with stream-wide trout suppression

2. Assess importance of abiotic and biotic drivers of the distribution and abundance of native fishes

Sampling: 2012-2018



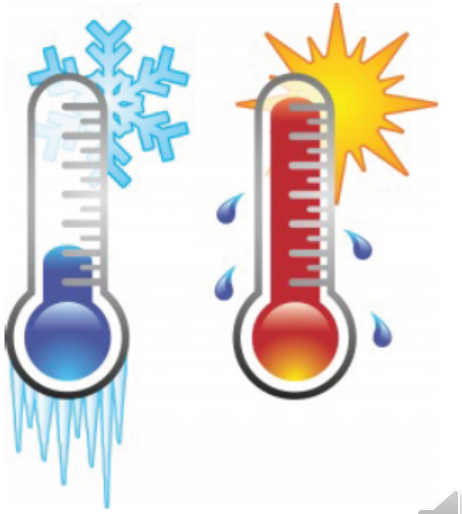
Methods – Beneficial Use

- Section 106 Consultation: Tribes expressed concern related to taking life
- Memorandum of Agreement Stipulation:
  - *"GCNP….will, to the greatest extent feasible, use euthanized trout for human consumption."*
- Avoided electrofishing sacred areas (100 m of stream)

Methods – Data Analysis

1. Quantify temporal trends in abundance:
   - Depletion models:
     - Trout, speckled dace
   - Total catch (native suckers)

2. Assess drivers of distribution and abundance of native fishes*:
   - Generalized linear mixed-effects models
     - Predictors:
       - Trout density
       - Monsoon and spring flooding indices
       - Thermal variation
       - Electrofishing effort



*Healy et al. *in review.*

Joe Tomelleri Illustrations

Results - overview

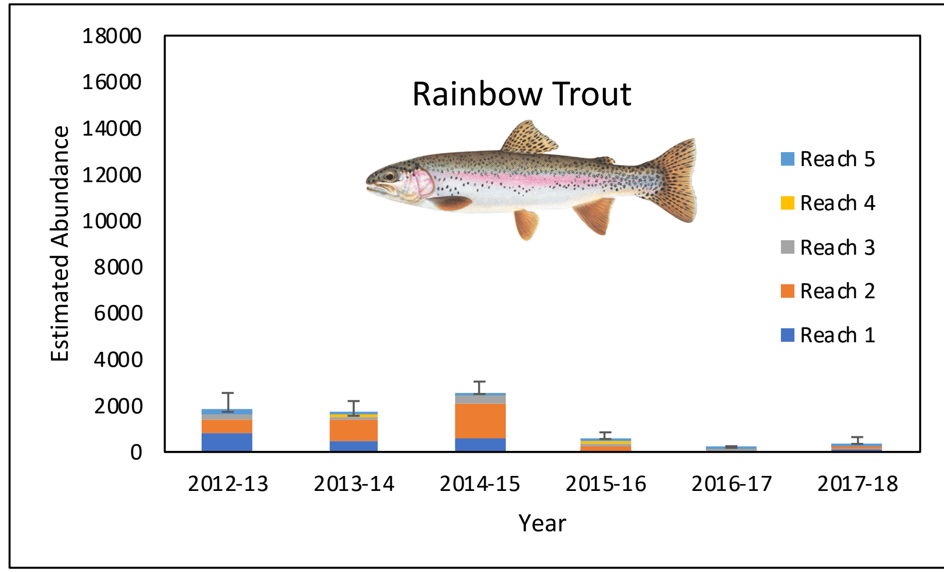
- 2012-2018 –
  - Effort:
    - 15 km/year
    - N= 877 three-pass samples
  - Removed:
    - 42,830 brown trout
    - 7,856 rainbow trout
  - Native fishes:
    - Increased recruitment
    - Flannelmouth sucker rearing – first records

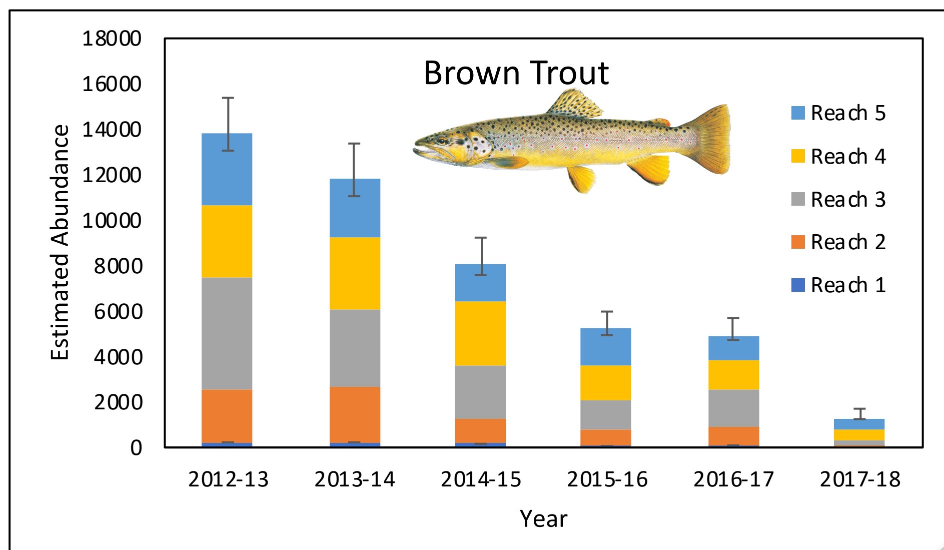
A. Bachelier photo

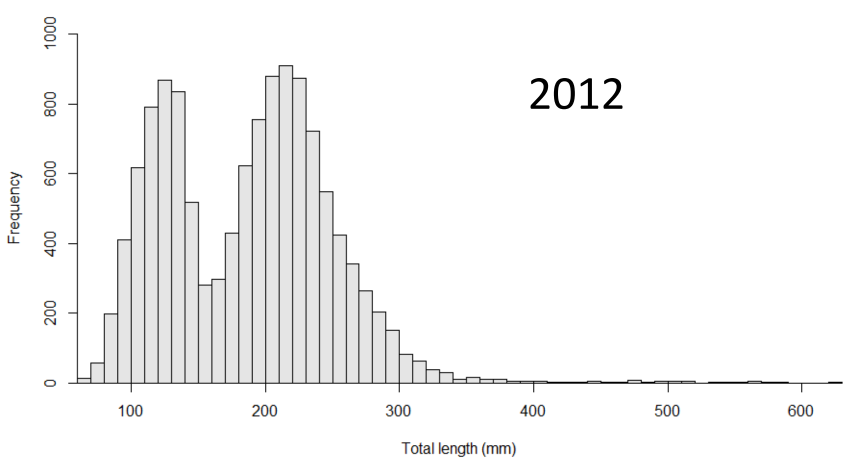
Joe Tomelleri Illustrations

Results - trends

- Abundance:
  - Rainbow trout:
    - ≈80% decline
  - Brown trout:
    - ≈91% decline



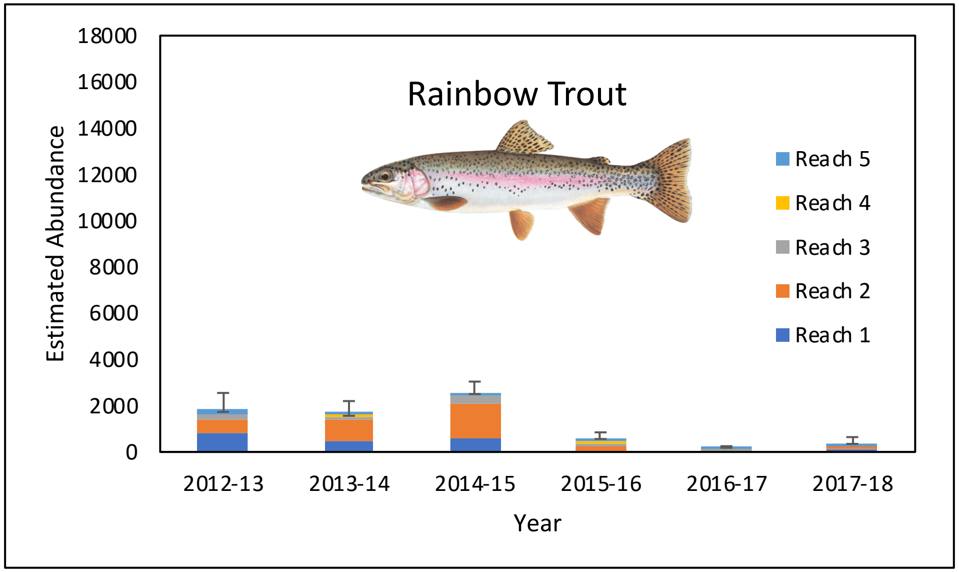


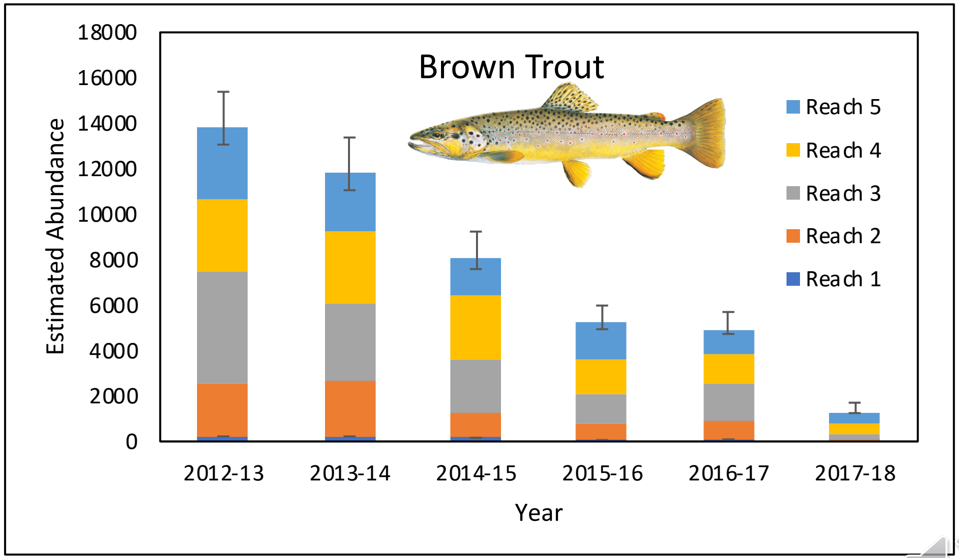


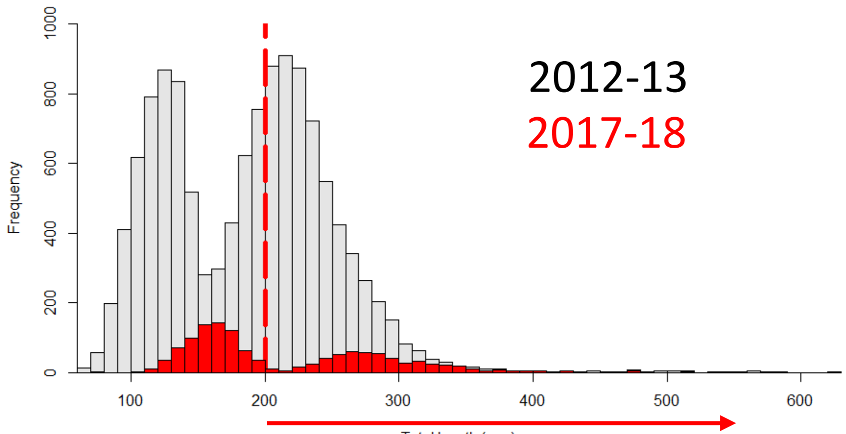
Joe Tomelleri Illustrations

Results - trends

- Abundance:
  - Rainbow trout:
    - ≈80% decline
  - Brown trout:
    - ≈91% decline
    - Size-structure shift



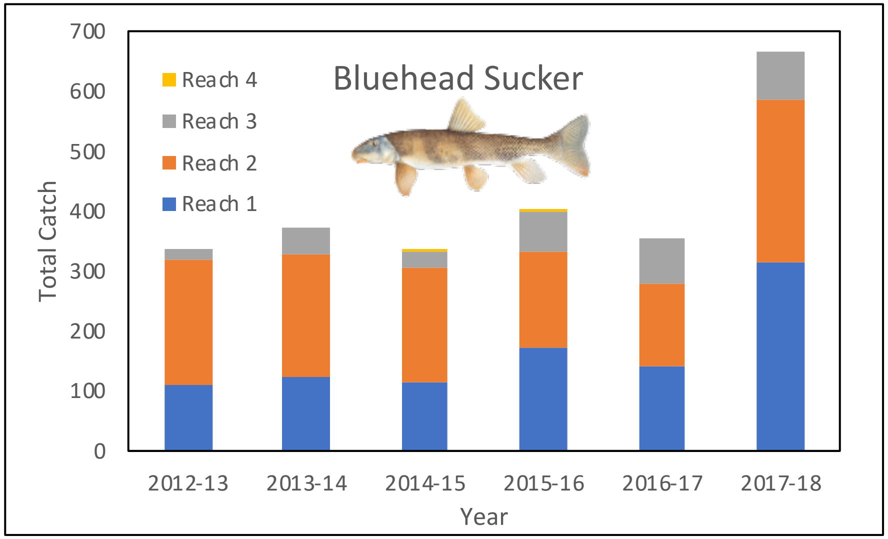


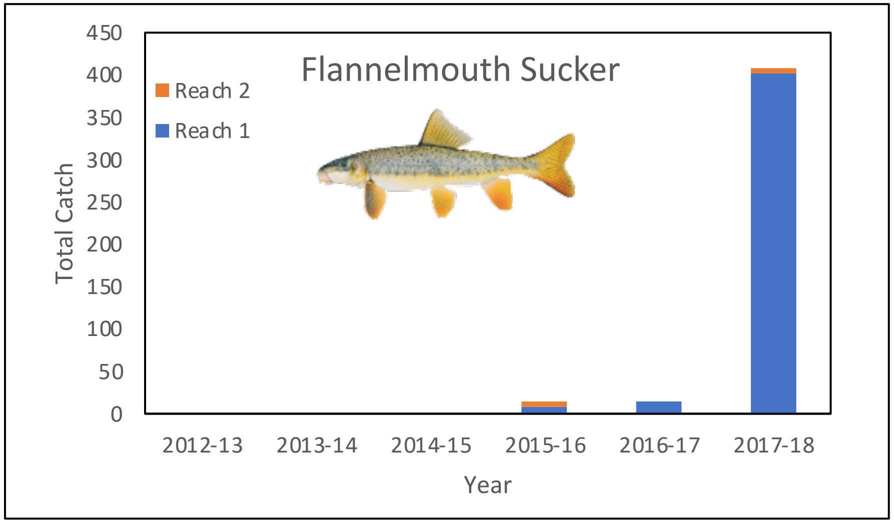


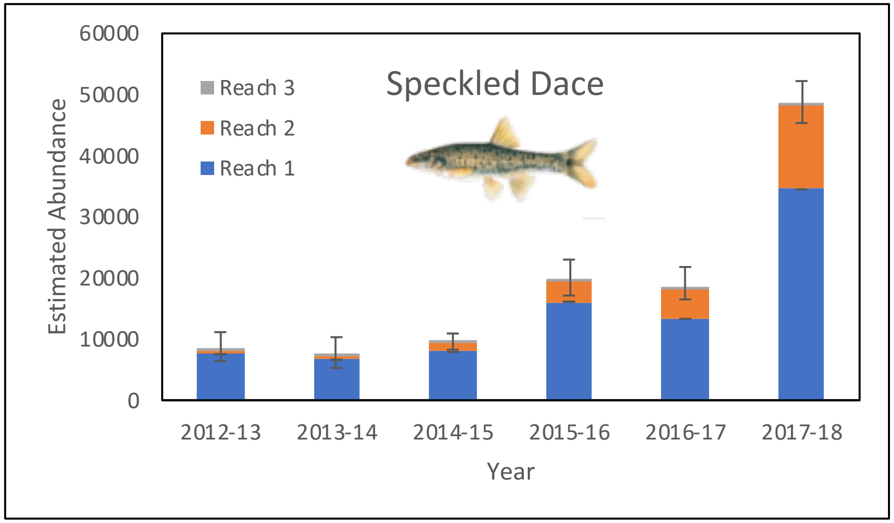
Piscivorous size

Results - trends

- Trends in native fishes:
  - ≈480% total increase
    - Primarily reaches 1-2







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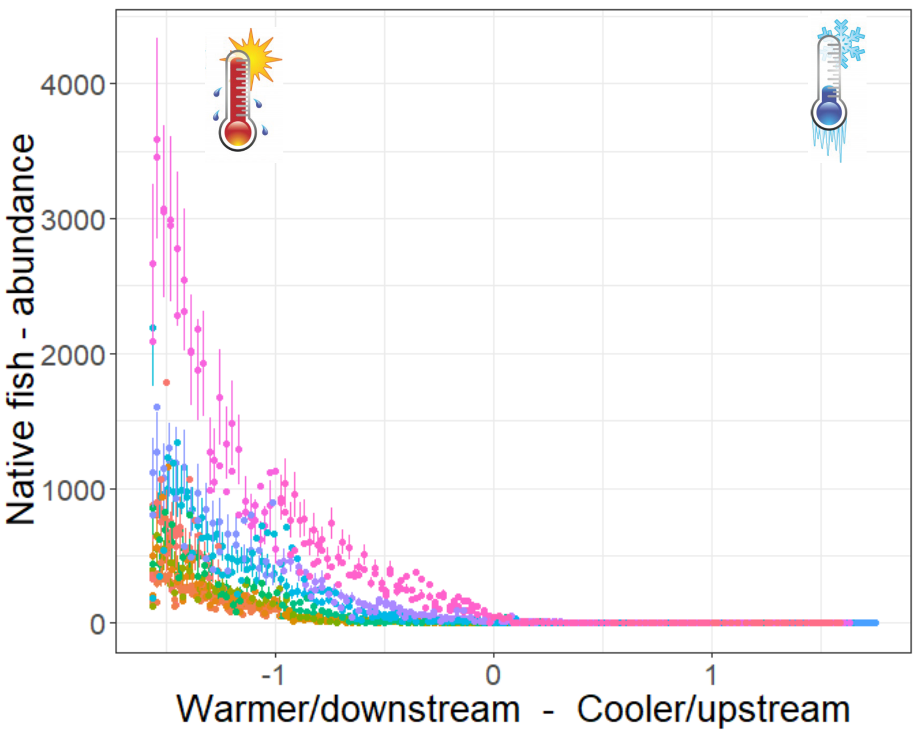
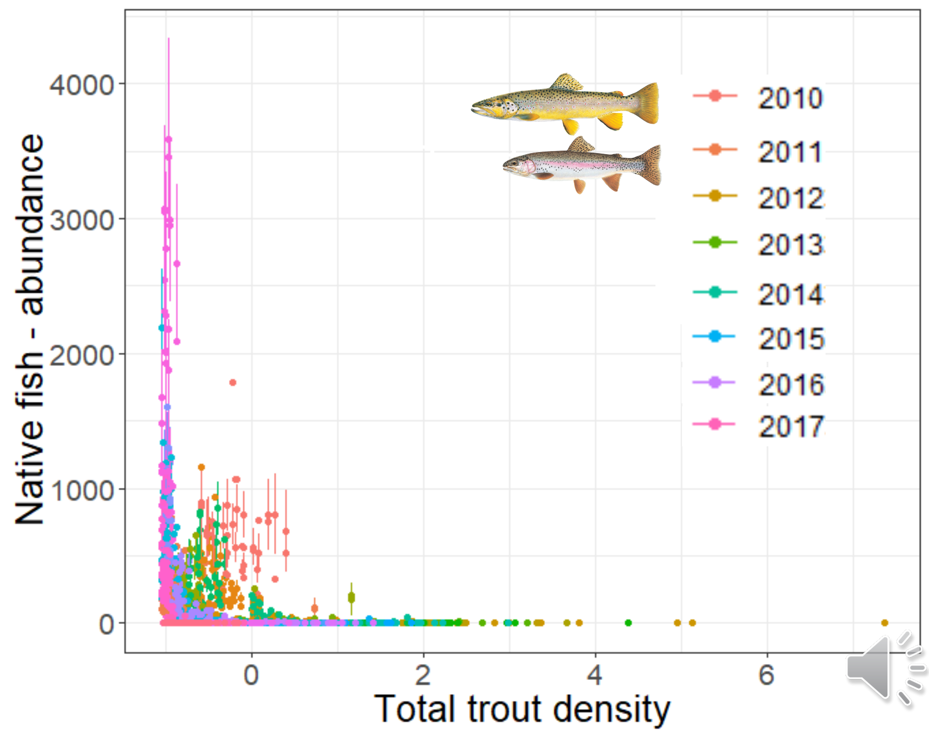
Results - GLMM

- Top Model: Native fishes (aggregated)
  - Distribution and Abundance ~
    - *Spatial-thermal (+)*
    - *Trout density (-)*
    - *Spring flooding index (+)*
    - *Monsoon flooding (-)*

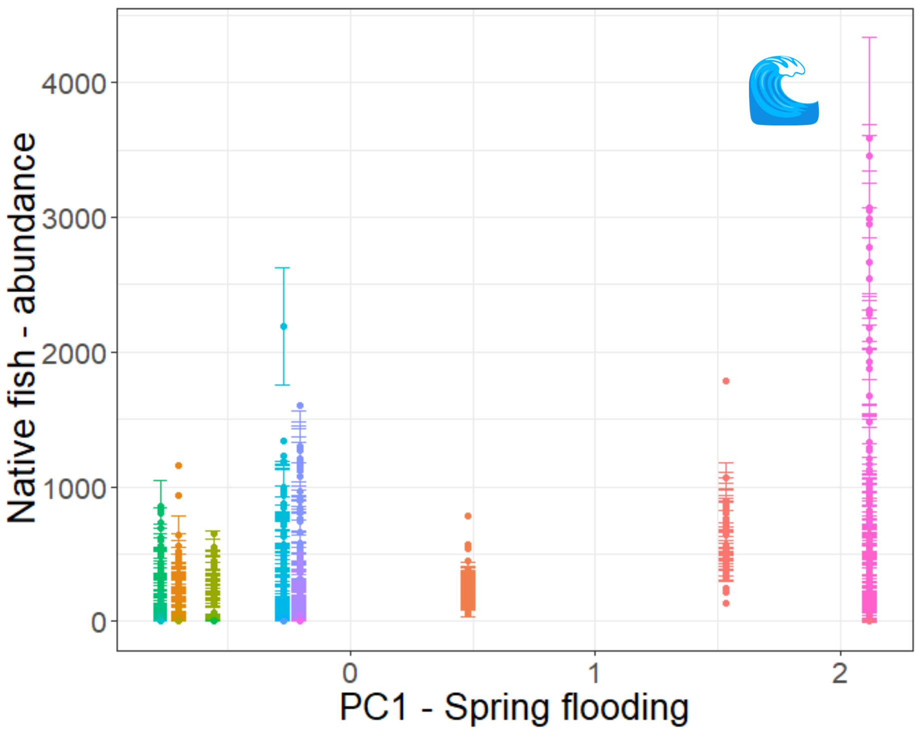


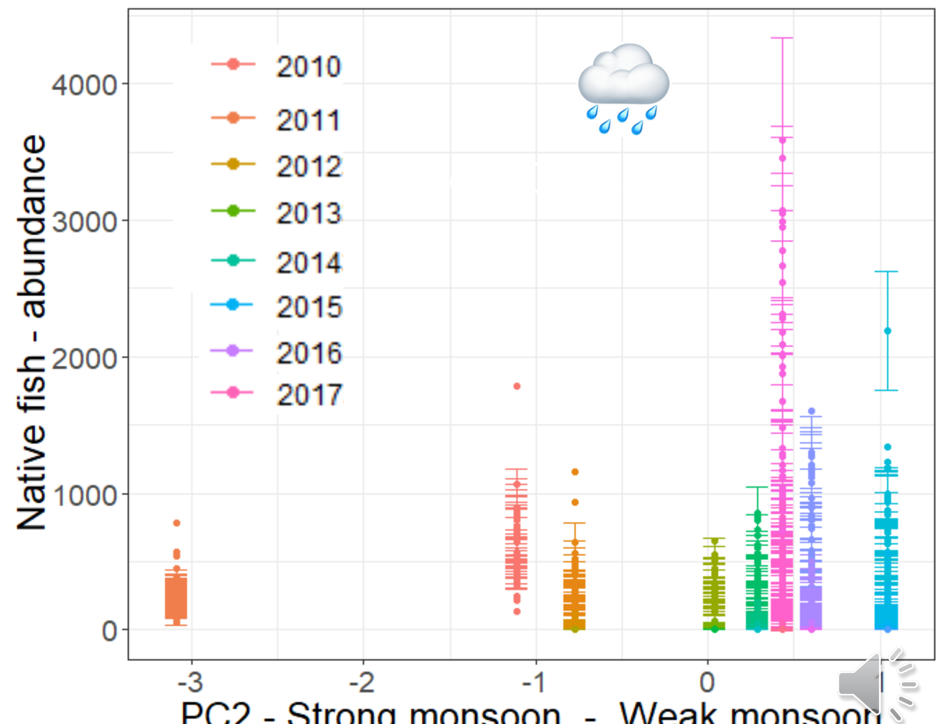


Results - GLMM

Joe Tomelleri Illustrations

- Top Model: Native fishes (aggregated)
  - Distribution and Abundance ~
    - *Spatial-thermal (+)*
    - *Trout density (-)*
    - *Spring flooding index (+)*
    - *Monsoon flooding (-)*





Nonnative fish control - summary

- **Mechanical suppression proved to be effective -**
  - **Trout abundance <80-90% of baseline**
  - **Native fishes increased and expanded upstream with declines in trout**
  - **Reductions in invasive trout outweigh potential negative effects of repeated electrofishing**
  - **Brown trout catch at a 20-year low in the Colorado River in Grand Canyon**

- **Native fish abundance highest-**
  - **In warmer sites, with fewer trout**
    - Temperature may mediate biotic interactions
  - **During years with higher spring flows and weaker monsoons**

- **Next steps –**
  - **Translocations recommended by peer-reviewers (2018)**

Nonnative trout suppression – design considerations

- Target source population/stream (if it can be identified)
- Find vulnerabilities - spawning areas
- “Go big or go home”
- Be realistic – set goals accordingly
- Define objectives – establish monitoring metrics ahead of time – what does success look like?

Conservation Implications

- Tributaries can provide opportunities for “large river fish” conservation
- Successful mechanical suppression of invasive fishes with sustained, widespread effort
- Understanding environmental drivers of native response to predator removal
- Inform conservation under “novel” conditions

Questions?

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Center for Colorado River Studies
Utah State University Ecology Center

U.S. Fish & Wildlife Service
Grand Canyon Conservancy
Joe Tomelleri Illustrations
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