Potential implications of a warmer future for the Colorado River ecosystem

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Presentation Outline

- Drivers of water temperature in the CRe
  - What drives water temperatures in Grand Canyon and across the CRe?

- Present and future river temperatures
  - How will climate change, drought, and reservoir storage decisions influence future river temperatures?

- Implications of warmer temperatures on fish
  - How has river temperature shaped post-dam aquatic communities, and how may they change in the future?
FY18-20 Project Elements, Study Objectives, and LTEMP Resource Goals

- **Project Element E1**: Temperature and nutrients in the CRe – patterns, drivers, and improved predictions
  - *Study Objective*: Modify previous models for predicting CRe temperatures to reflect exponential (rather than linear) warming.

- **LTEMP Resource Goals**: Identify processes that drive spatial and temporal variation in nutrients and temperature within the CRe and establish quantitative and mechanistic links among these ecosystem drivers, primary production, and higher trophic levels.
  - Natural Processes (#3), Humpback Chub (#1), Other Native Fish (#1), Rainbow Trout Fishery (#2)
  - *Builds off data collected during Project Element H.4 (FY13-14) and Project Element 9.8 (FY15-17 Workplan)*
Lake Powell thermal stratification

Vernieu et al. 2005
Lake Powell elevation as a driver of temperature

Lake Powell storage strongly influences river temperature downstream from Glen Canyon Dam

Preliminary Data – Do Not Cite
Warmer reservoir releases contain less nutrients

Deemer and Yackulic, Unpub. Data

Phosphorus concentrations are elevated in bottom water

Deemer and Yackulic, Unpub. Data

Warmer withdrawals may decrease nutrient availability → fish

Preliminary Data – Do Not Cite
To model future river temperatures, we modified the current CR temperature model.
FY 2013-14 & FY 2015-17 Workplans = Data on Hand + USGS WaterSmart Funding

Flow management and fish density regulate salmonid recruitment and adult size in tailwaters across western North America


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Warm water temperatures and shifts in seasonality increase trout recruitment but only moderately decrease adult size in western North American tailwaters

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Dibble et al., 2018, Ecol Apps

Western North American dams included in synthesis

Dibble et al., 2015, Ecol Apps
Current thermal regime

Upper Basin
- Short tailwaters
- Warm summer thermal regime

Lower Basin
- Long tailwaters
- Cold summer thermal regime

Dibble et al., In Review, Ecol Apps
Photos: J. Tomelleri

Preliminary Data – Do Not Cite
Fish community distribution and abundance

1. Species-Level Information

- **Native**
  - Colorado Pikeminnow
  - Humpback Chub
  - Roundtail Chub
  - Rainbow Trout
  - Red Shiner

- **Non-Native**
  - Smallmouth Bass

2. Relative Abundance

- Extirpated
- Rare
- Not Present
- Abundant

Photos: J. Tomelleri

Preliminary Data – Do Not Cite
Fish community dynamics relative to current thermal regime

Cold-water non-native salmonids common to abundant in tailwaters

Warm-water non-native fish common to abundant in Upper Basin

Warm-water native fish rare or extirpated in basin

Humpback chub abundant in Grand Canyon despite cold water temperatures

Dibble et al., In Review, Ecol Apps
Photos: J. Tomelleri

Preliminary Data – Do Not Cite
Humpback Chub decadal scale trends in abundance relative to temperature

Dinosaur National Monument
Desolation/Gray Canyons
Black Rocks
Westwater Canyon

Little Colorado River (Eastern Grand Canyon)
Western Grand Canyon

Grand Canyon
Upper Basin

Decadal Scale Trends in Relative Abundance

Average Peak Summer Temperature (°C)

Temperature Trends

Average Peak Summer Temperature (°C)

Grand Canyon
Upper Basin

Preliminary Data – Do Not Cite

Dibble et al., In Review, Ecol Apps
Photos: J. Tomelleri
Warm-water non-native fish in Upper Basin

Comparison of Large Bodied Predator Densities in the Yampa River, Northwestern Colorado

Nonnative Walleye Captures: Green and Colorado River Sub-basins

Humpback Chub                  Bonytail                    Colorado Pikeminnow           Razorback Sucker

Bestgen and Hill 2016
Photos: J. Tomelleri

What are basin-wide expectations for the future?

Increased air temperature (2.6°C)

Decreased flow (17%)

** High emissions: business-as-usual, SRES A2 and RCP8.5; Moderate emissions: somewhat reduced by mitigation, SRES A1B and RCP4.5

Udall and Overpeck 2017 **
Drier hydrology traces based on mean annual inflows indicate release temperatures in summer have the potential to reach ~20 °C

Preliminary Data – Do Not Cite
To what degree will changes in air temperature, discharge, and storage drive future river temperatures?

- Increased air temperature (2.6°C)
- Decreased Colorado River flow (17%)
- Decreased reservoir storage
Future thermal regime
Effects of warmer water on rainbow trout

Dibble et al. 2018, EBF

Warmer Water Year

Smaller adults

Mean Annual Temp (°C)

300
350
400
450

5 6 7 8 9 10 12

FY15-17; Project Element 9.8

Warmer Summer

Recruitment increases

Maximum Annual Temp (°C)

0 10 20 30 40 50 60

6 10 14 18

Dibble et al. 2018, EBF

Warmer temperatures = smaller adult trout with current foodbase

Dodrill et al. 2016, CJFAS, with modifications

Drift Biomass Inflation Factor

02
05

02
05

05
02
Effects of warmer water on humpback chub

Positive effect on growth (transition to larger fish)

Yackulic et al. 2018, Ecology

Positive effect on growth

Dzul et al. 2016, CJFAS

Expansion into Western Grand Canyon

VanHaverbeke et al. 2018, Southwestern Naturalist
Warm-water non-native fish invasion into GC?

Dibble et al., In Review, Ecol Apps

Dibble et al., Unpub. Data

Preliminary Data – Do Not Cite
Potential ecological outcomes of a warmer CRe

- **Potential mainstem spawning and higher growth of native fish**
  - Humpback Chub
  - Razorback Sucker

- **Potential boost in invertebrate taxa; better food base**
  - Caddisflies
  - Midges

- **Potential nutrient decline (warmer, epilimnetic), implications for food base**
  - Diatoms
  - Midge

- **Potential rainbow trout decline, replacement by piscivorous non-native fish**
  - Smallmouth Bass
  - Northern Pike

Preliminary Data – Do Not Cite
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- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation, Hydromet
- USDA NRCS National Water and Climate Center
- Upper Colorado River Endangered Fish Recovery Program
- USFWS San Juan River Basin Recovery Implementation Program
- USGS BioData and WaterWatch
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