USGS
science for a changing world

Estimating the efficacy of trout management flows using bioeconomic and hydropower modeling

Lucas S. Bair, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center
Pierce Donovan, Colgate University
Matthew N. Reimer, University of California at Davis
Charles B. Yackulic, U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center
Michael R. Springborn, University of California at Davis
Dominique M. Bain, Excel Energy

Glen Canyon Dam Adaptive Management Program Annual Reporting Meeting
January 11-12, 2022

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

Presentation Background

- Project Element J.1. Predictive Models for Adaptive Management
  - Humpback Chub. Meet humpback chub recovery goals, including maintaining a self-sustaining population, spawning habitat, and aggregations in the Colorado River and its tributaries below the Glen Canyon Dam.
- Project Element N.1. Hydropower Monitoring and Research
  - Hydropower and Energy. Maintain or increase Glen Canyon Dam electric energy generation, load following capability, and ramp rate capability, and minimize emissions and costs to the greatest extent practicable, consistent with improvement and long-term sustainability of downstream resources.

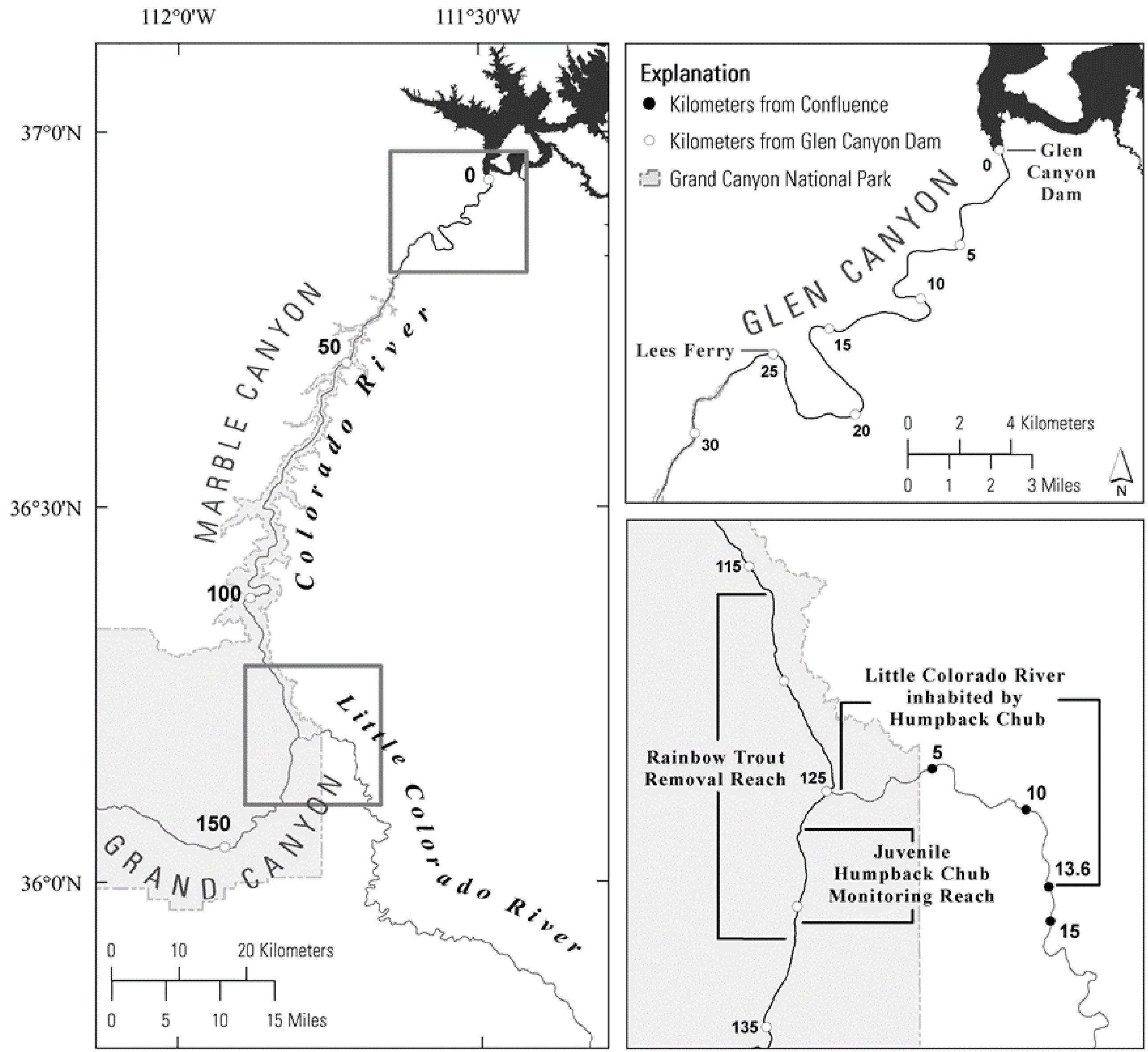
USGS science for a changing world

Humpback Chub (*Gila chypha*)

Cost-effectiveness Analysis

- Comparing the costs of alternative means to achieve goals set through a political or public process (Mark Sagoff)
- Cost-effectiveness analysis shifts the focus from the ends to the means and this is important where stakeholders have various world views.

Sagoff, Mark. 2009. “Regulatory Review and Cost-Benefit Analysis.” Philosophy and Public Policy Quarterly 29 (3–4): 21–26.



USGS science for a changing world

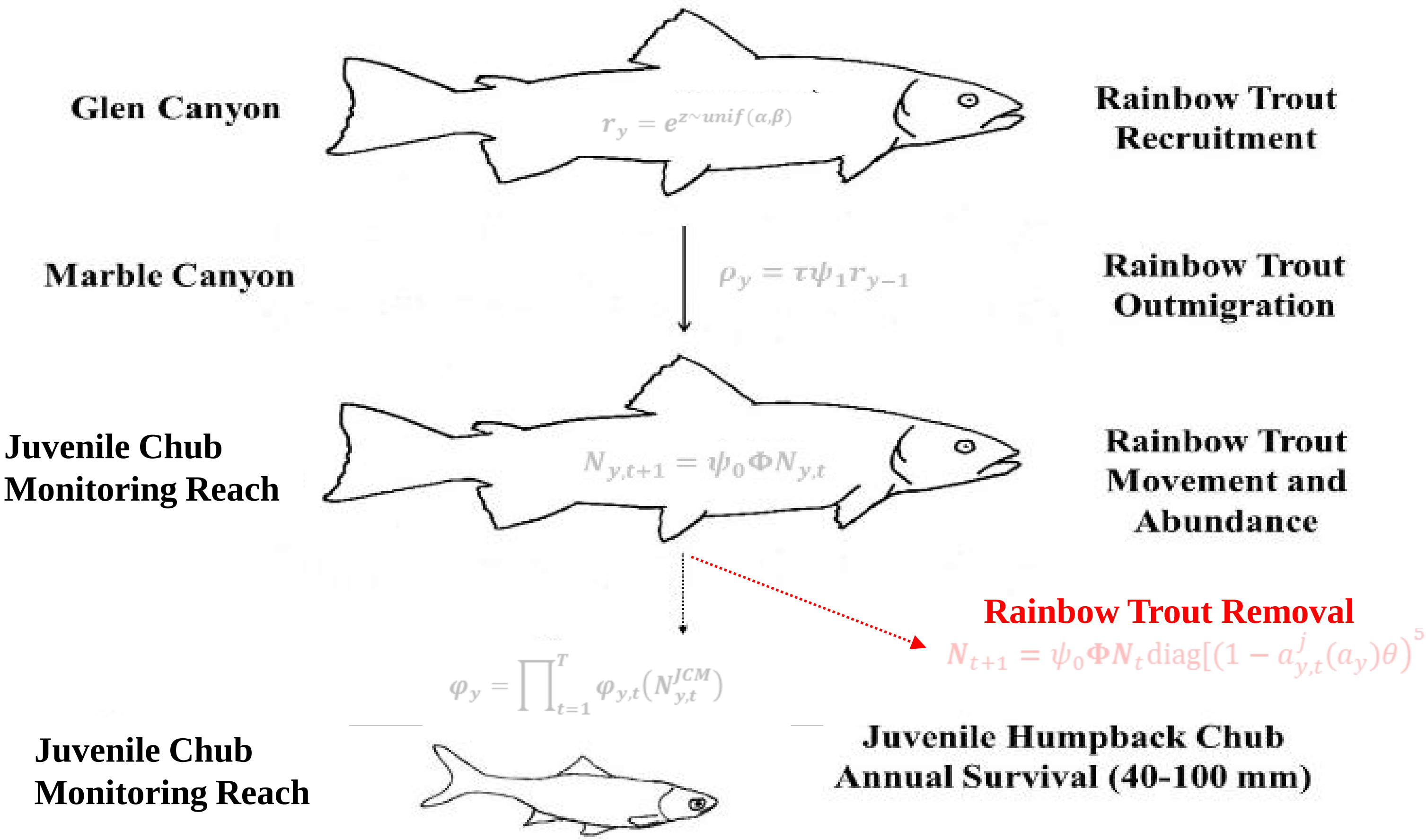
Bair, L.S., Yackulic, C.B., Springborn, M.R., Reimer, M.N., Bond, C.A., and Coggins, L.G., 2018, Identifying cost-effective invasive species control to enhance endangered species populations in the Grand Canyon, USA: Biological Conservation, v. 220, p. 12-20, https://doi.org/10.1016/j.biocon.2018.01.032.

Population Viability Analysis (PVA)

- Develop a bioeconomic model to identify cost-effective management strategies for rainbow trout, and other alternatives, that achieve conservation objectives for the humpback chub.
- PVA problems are hard to solve because they often involve achieving a population goal over many periods with a given level of confidence.

USGS
science for a changing world

Simulation Based PVA



USGS science for a changing world

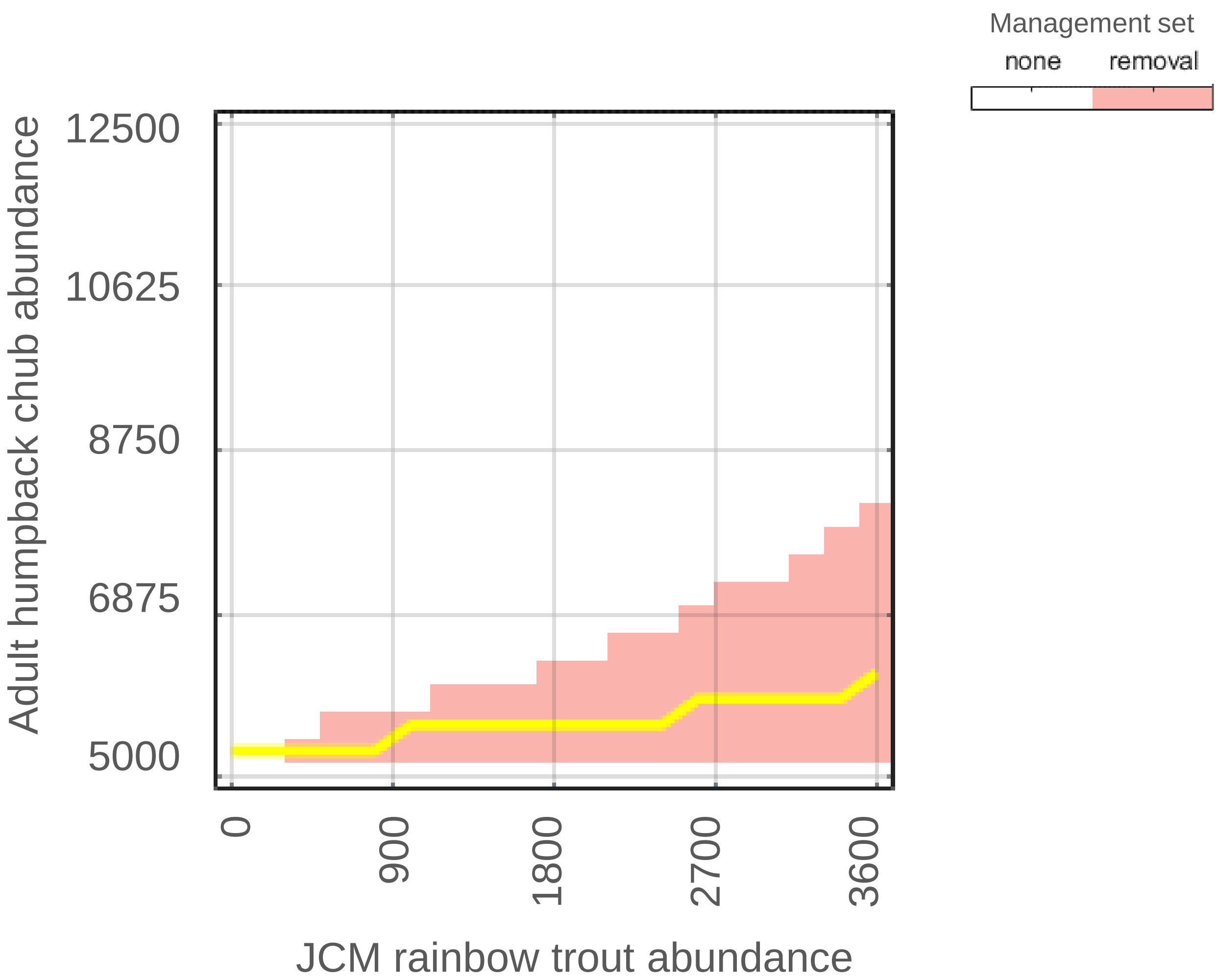
Bair, L.S., Yackulic, C.B., Springborn, M.R., Reimer, M.N., Bond, C.A., and Coggins, L.G., 2018, Identifying cost-effective invasive species control to enhance endangered species populations in the Grand Canyon, USA: Biological Conservation, v. 220, p. 12-20, https://doi.org/10.1016/j.biocon.2018.01.032.

Dynamic Programming Based PVA

- Identify the cost-minimizing trout control policy (removals) that achieves a target population viability.
- The target population viability goal is to maintain **adult humpback chub abundance** above 5,000 at least 90 percent of the time over the planning horizon.
- This is all subject to the population dynamics of rainbow trout and humpback chub.

Donovan, P., Bair, L.S., Yackulic, C.B., and Springborn, M.R., 2019, Safety in numbers—Cost-effective endangered species management for viable populations: Land Economics, v. 95, no. 3, p. 435-453, https://doi.org/10.3368/le.95.3.435.

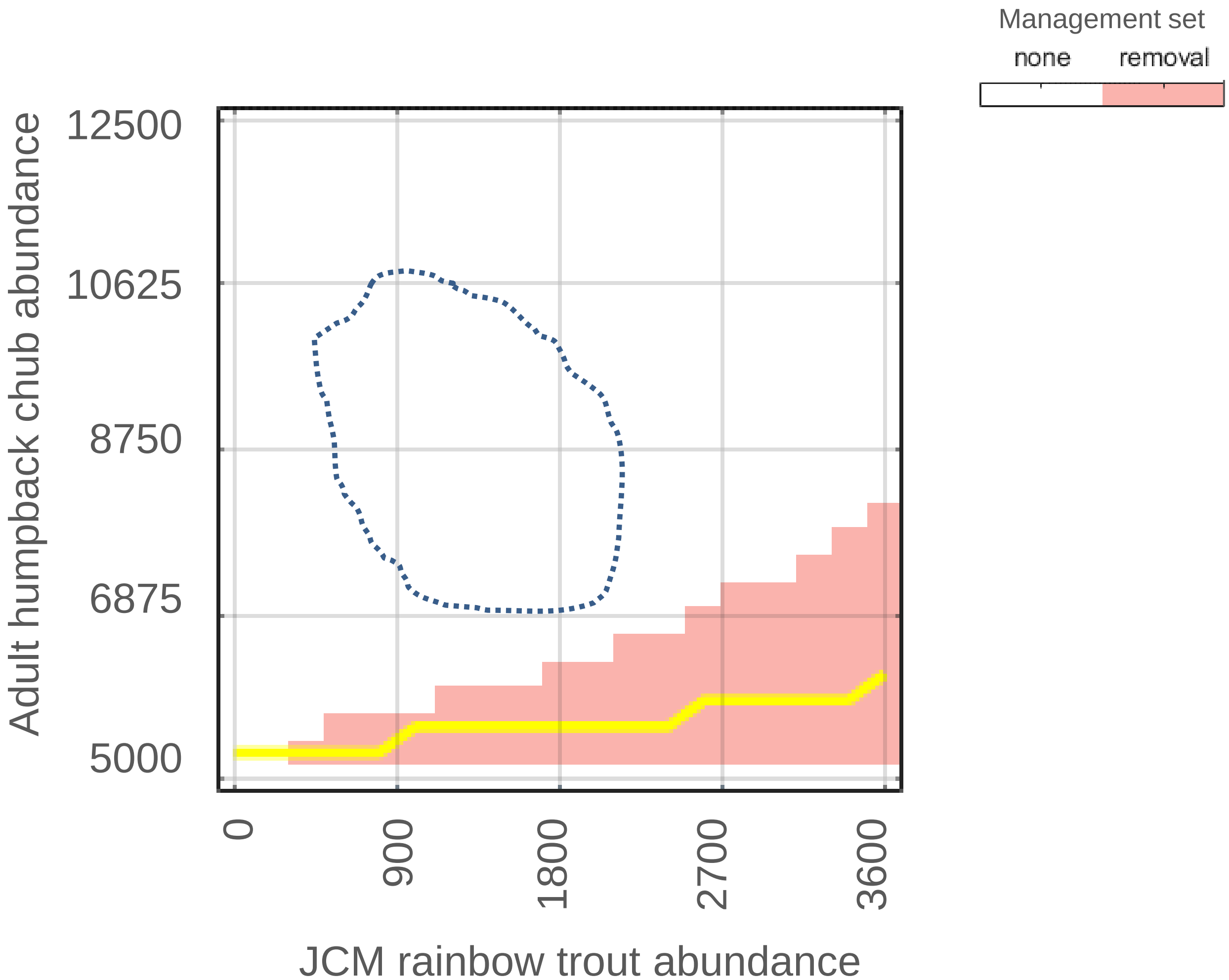
Results of Dynamic Programming Based PVA



USGS science for a changing world

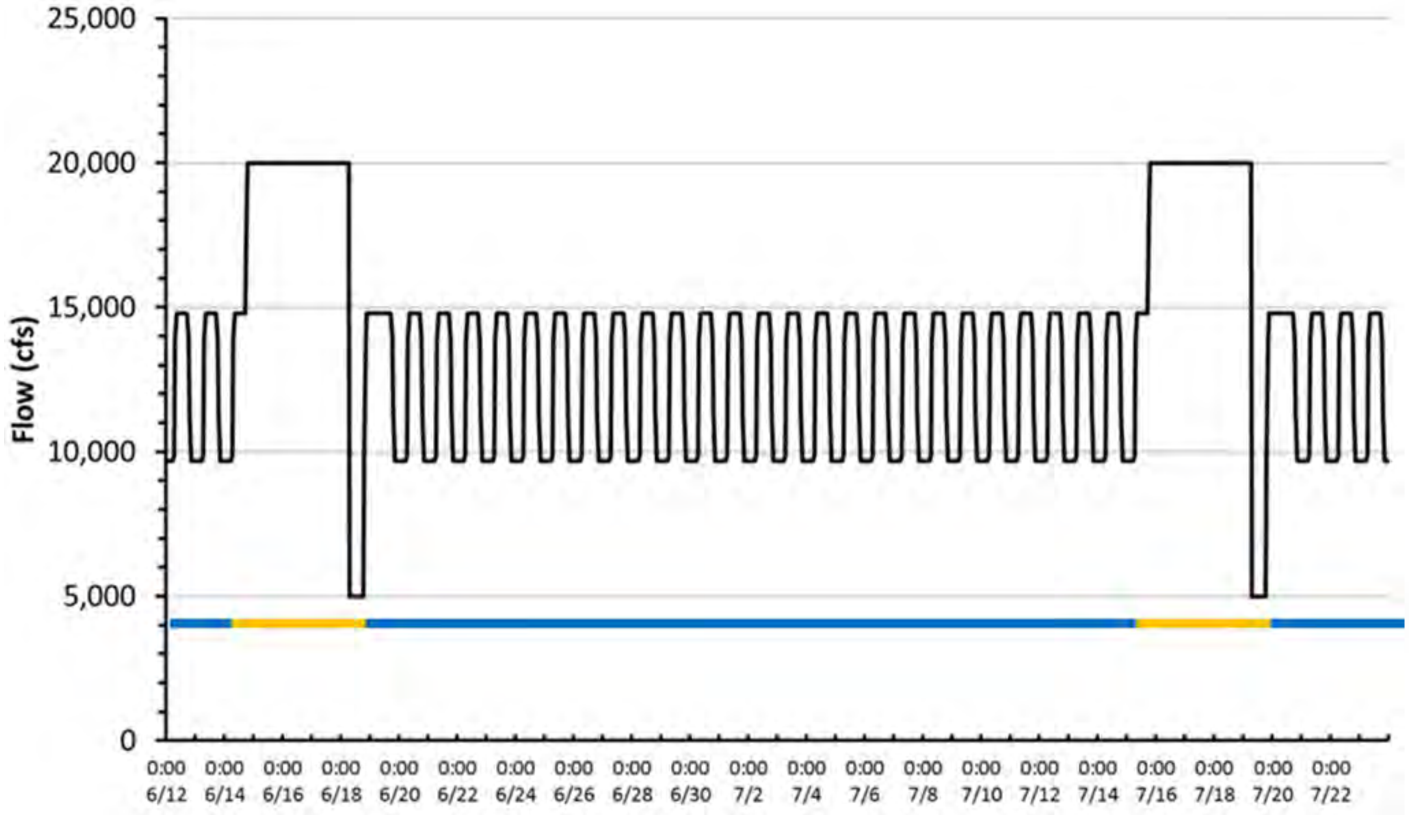
Donovan, P., Bair, L.S., Yackulic, C.B., and Springborn, M.R., 2019, Safety in numbers—Cost-effective endangered species management for viable populations: Land Economics, v. 95, no. 3, p. 435-453, https://doi.org/10.3368/le.95.3.435.

Results of Dynamic Programming Based PVA



Donovan, P., Bair, L.S., Yackulic, C.B., and Springborn, M.R., 2019, Safety in numbers—Cost-effective endangered species management for viable populations: Land Economics, v. 95, no. 3, p. 435-453, https://doi.org/10.3368/le.95.3.435.

Trout Management Flows



USGS science for a changing world

U.S. Department of Interior, 2016, Glen Canyon Dam Long-term Experimental and Management Plan final Environmental Impact Statement (LTEMP FEIS): U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, National Park Service, Intermountain Region, online, http://ltempeis.anl.gov/documents/final-eis/.

Hydropower modeling

Assessing the Short-Run Economic Cost of Environmental Constraints on Hydropower Operations at Glen Canyon Dam

David A. Harpman

ABSTRACT. *Environmental externalities resulting from the construction and operation of a number of hydropower plants are now being reexamined. The focus of many recent analyses is on identifying new, often more restrictive, operational regimes which will improve downstream environmental conditions. These new regimes may create significant market and nonmarket benefits but constraints on hydropower operations frequently lead to economic costs. This paper introduces an hourly constrained optimization framework for estimating the short-run costs of restricting hydropower operations. Glen Canyon Dam, on the Colorado River in Arizona, is used as a case study. Newly available market-based prices are employed.* (JEL Q25)

I. INTRODUCTION

Hydropower plants produce electricity without burning fossil fuels and producing air pollution and are sometimes thought of as

reassessment of a number of other facilities. Although dam removal is an option in some cases (Loomis 1996), the focus of many recent analyses is on identifying new operational regimes which will result in improved downstream environmental conditions. These new regimes may well create significant market and nonmarket benefits but the resultant constraints on hydropower operations inevitably lead to economic costs of varying magnitudes.

This paper introduces an hourly constrained optimization framework for analyzing the effects of environmental constraints on hydropower operations. The short-run economic cost of these impacts is determined using market-based prices. Glen Canyon Dam, located on the Colorado River in Arizona, is used as a case study.

II. BACKGROUND

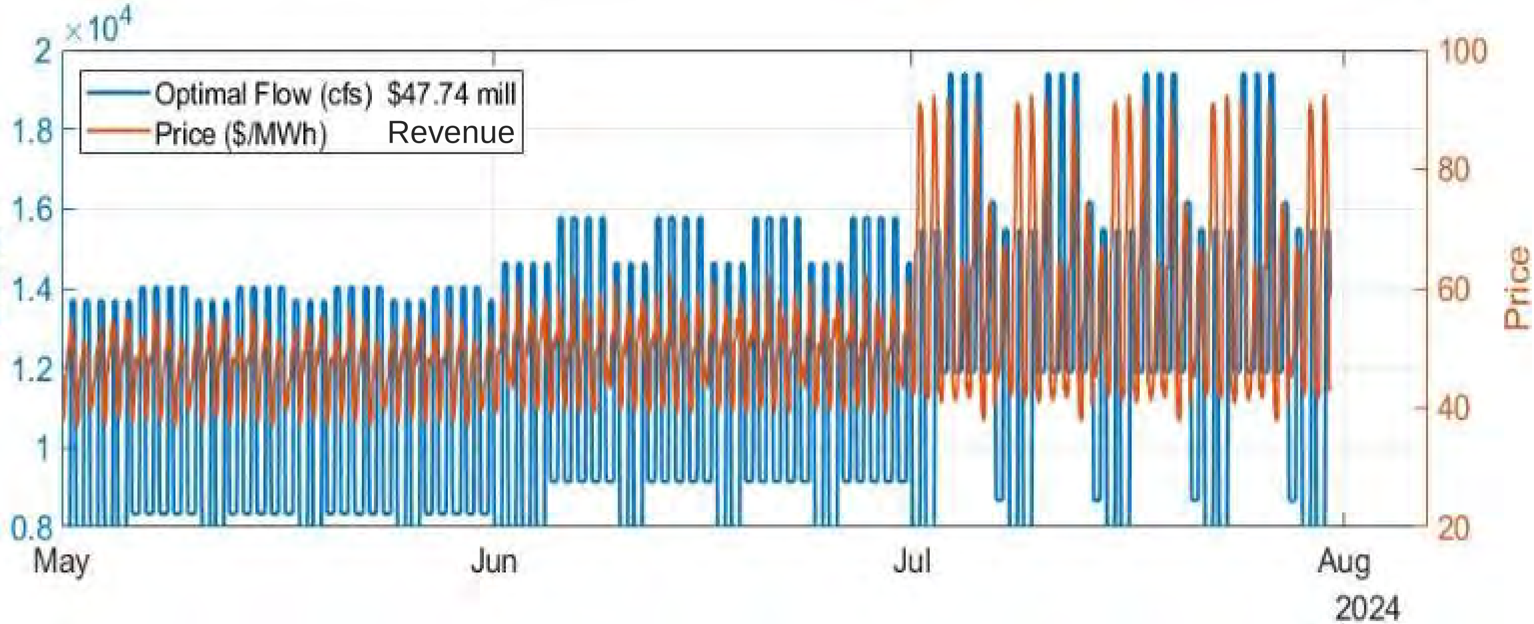
- We developed a constrained optimization problem to assess the short run economic costs of environmental constraints on hydropower operation.
- The objective of the hydropower model is to maximize the **economic value** of hydropower over the planning horizon subject to reservoir levels and operational constraints.

Harpman, D., 1999, Assessing the Short-Run Economic Cost of Environmental Constraints on Hydropower Operations at Glen Canyon Dam: Land Economics, v. 75, no. 3, p. 390-401.

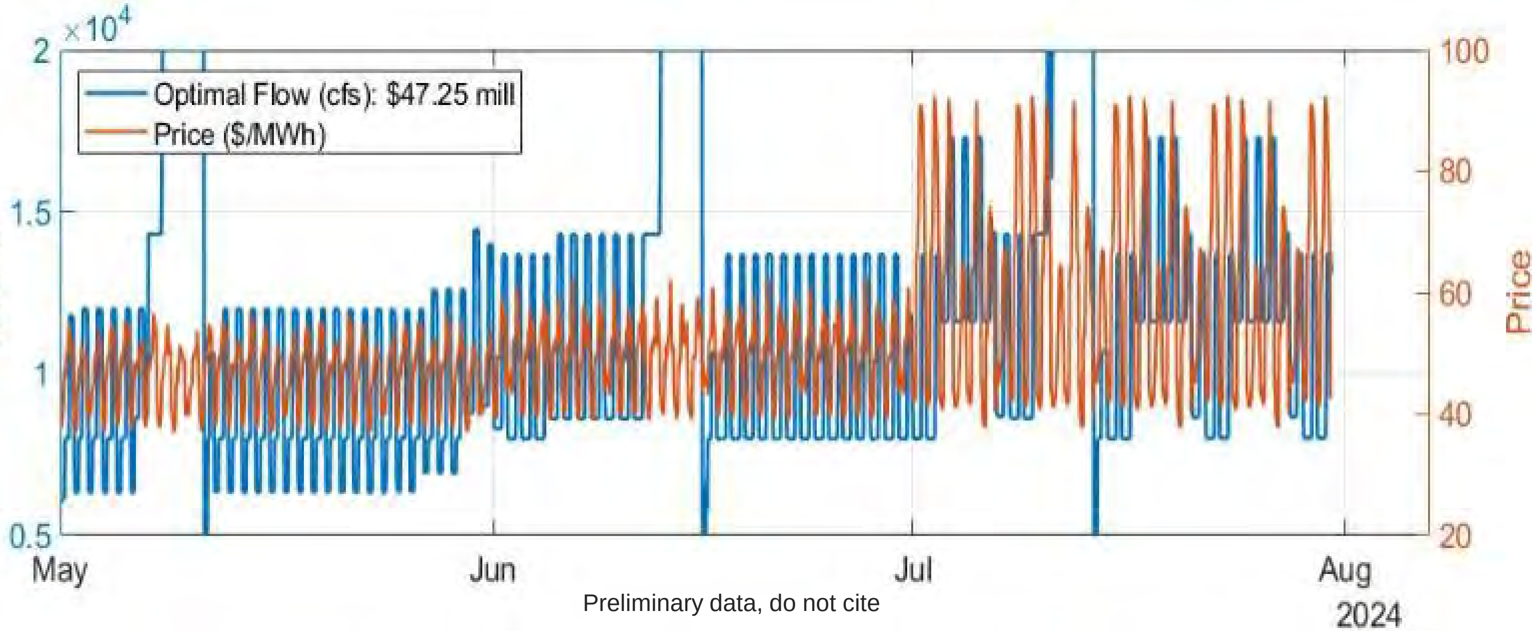
USGS science for a changing world

Hydropower Optimization Results

Without TMFs

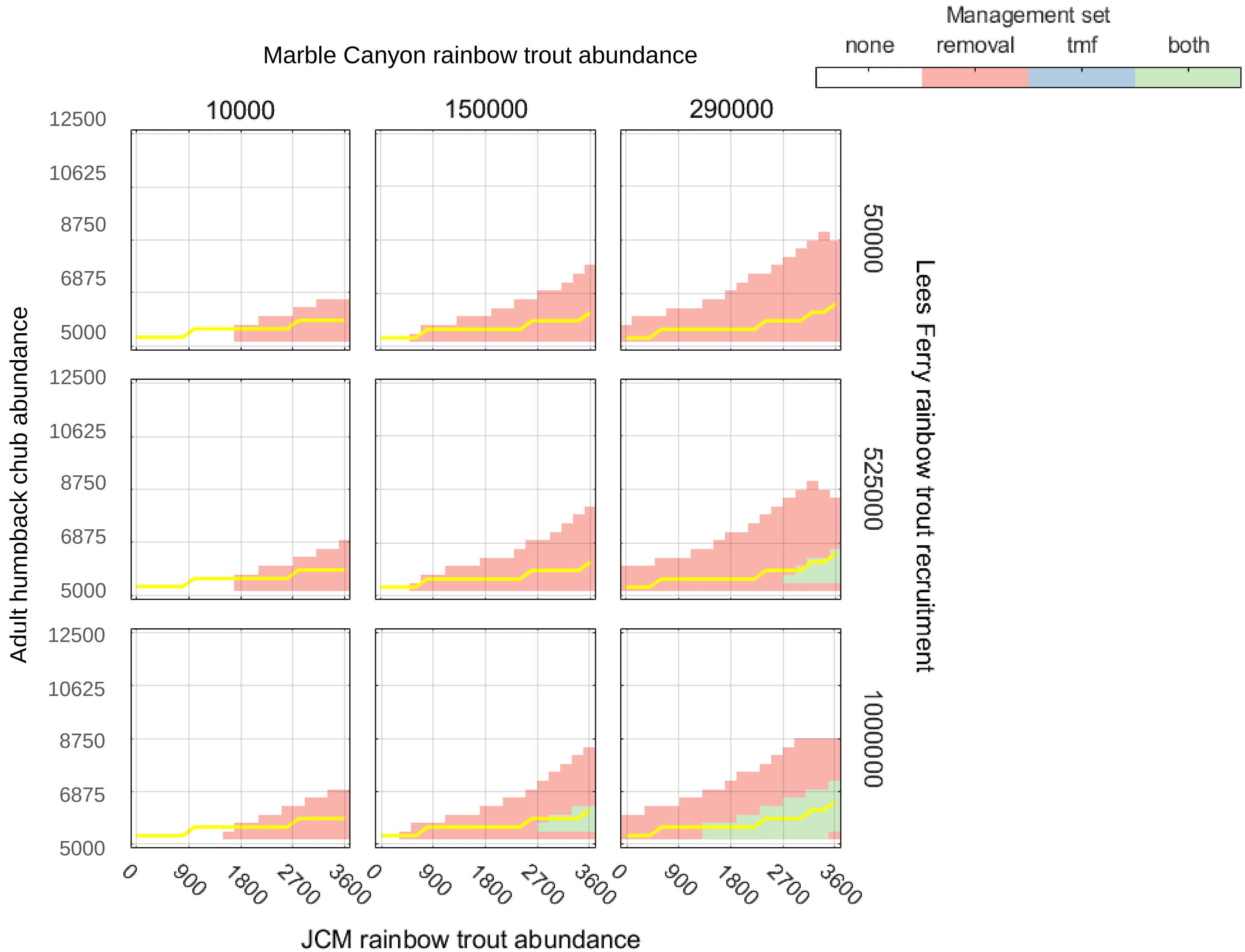


With TMFs



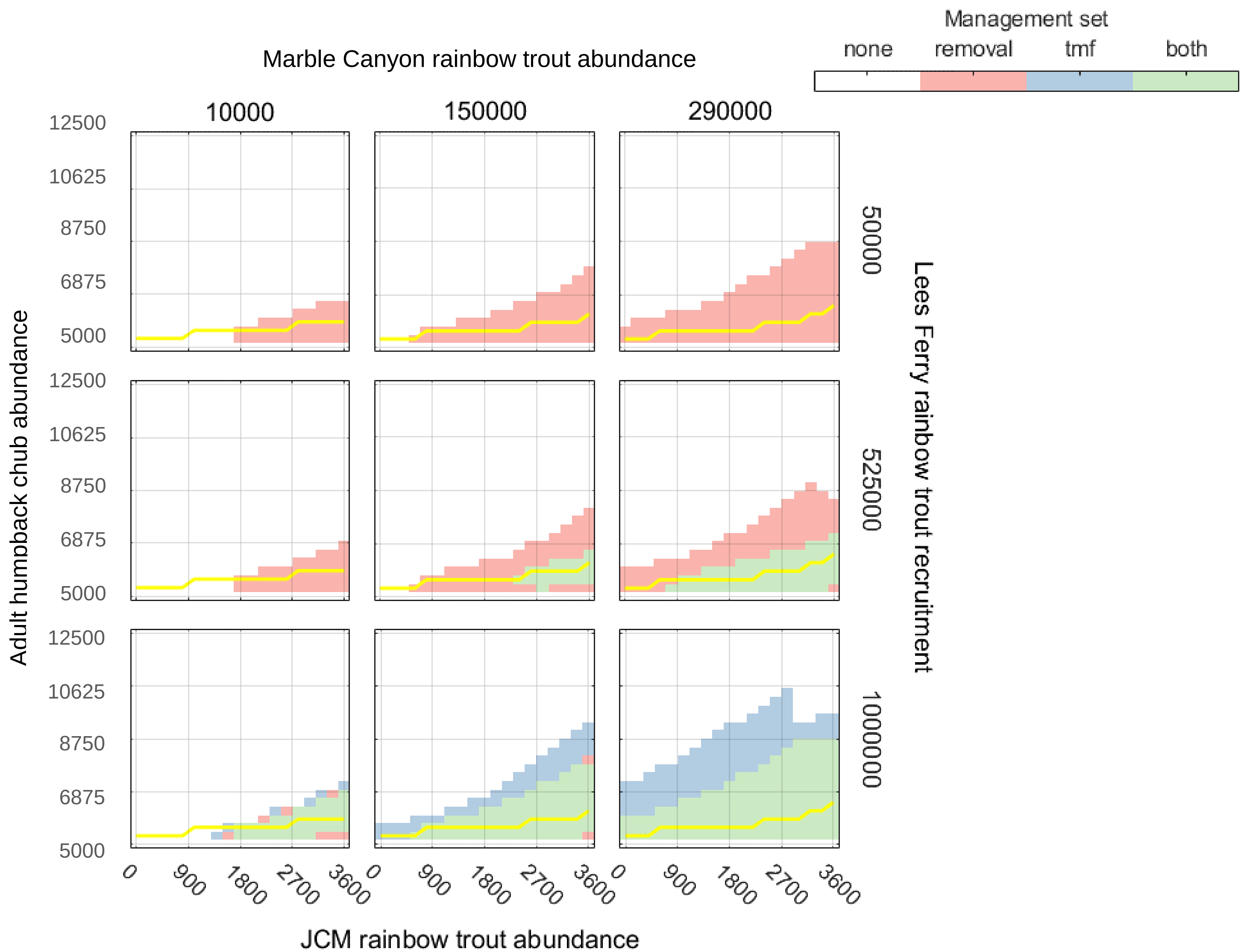
Preliminary data, do not cite

Optimal TMF Policy



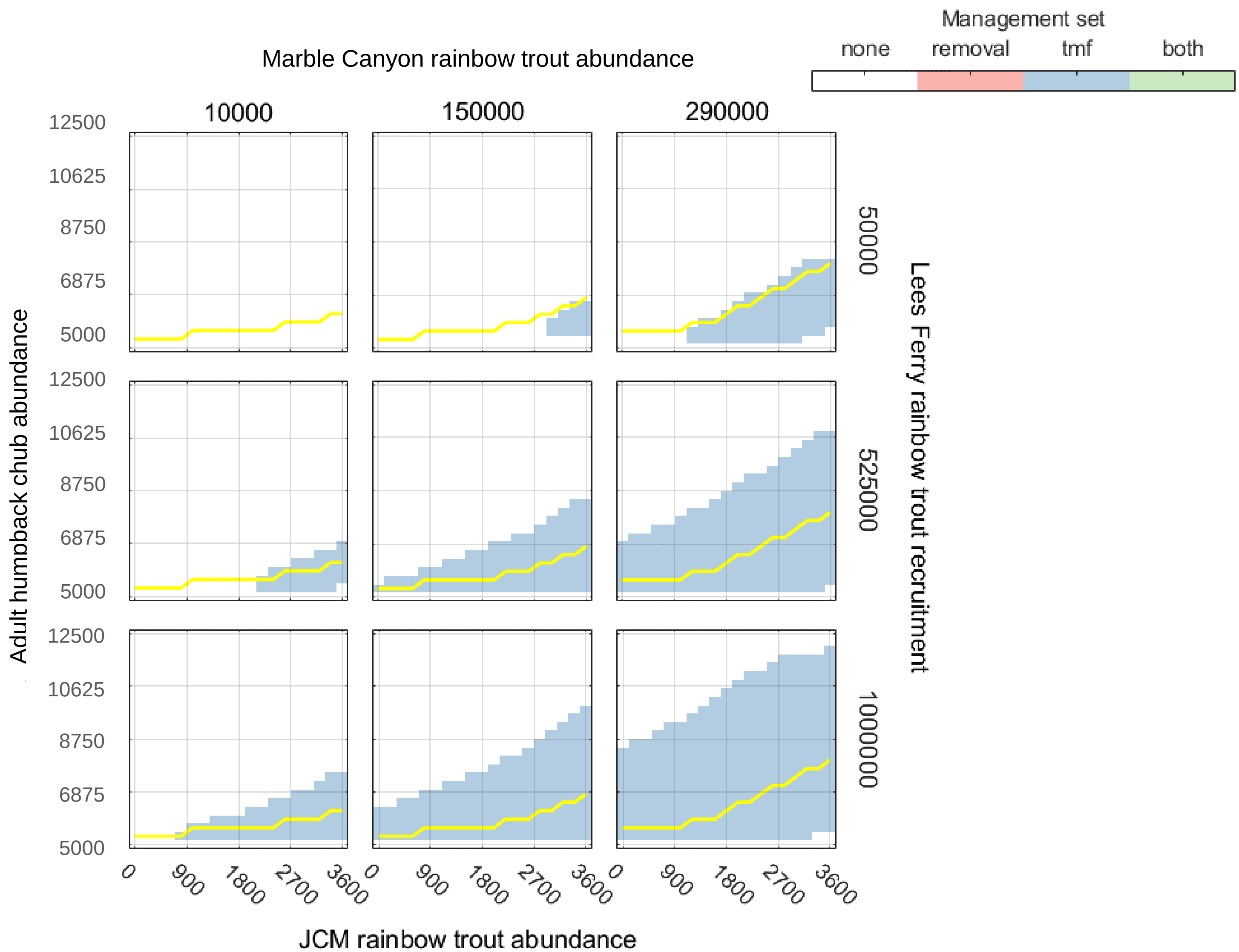
Preliminary data, do not cite

Optimal TMF policy – low cost TMF



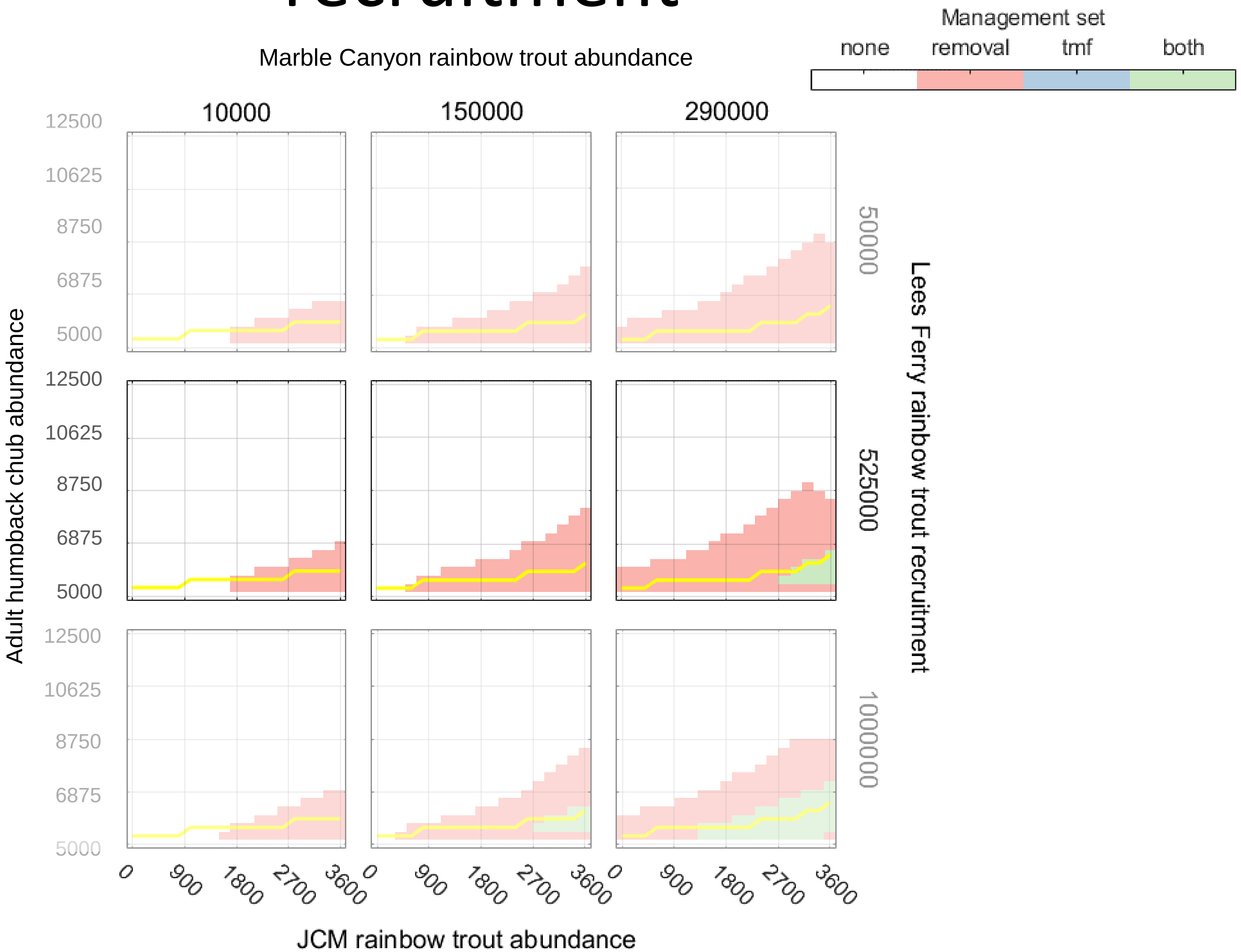
Preliminary data, do not cite

Optimal TMF Policy – TMF only



Preliminary data, do not cite

Optimal TMF Policy – no observation of recruitment



Preliminary data, do not cite

Conclusions

- Preliminary results indicate that TMFs are viable (effective and economically efficient) control measures at achieving humpback chub abundance goals only when rainbow trout recruitment in Lees Ferry is high, humpback chub aggregation abundance is low, and rainbow trout abundance in Marble Canyon and the Juvenile Chub Monitoring (JCM) reach is high.
- These baseline results are sensitive to the estimated economic cost of TMFs (see Project N) relative to rainbow trout removal cost and the effectiveness of TMFs specified in the LTMEP EIS (U.S. Department of Interior, 2016).

U.S. Department of Interior, 2016, Glen Canyon Dam Long-term Experimental and Management Plan final Environmental Impact Statement (LTEMP FEIS): U.S. Department of the Interior, Bureau of Reclamation, Upper Colorado Region, National Park Service, Intermountain Region, online, http://ltempeis.anl.gov/documents/final-eis/.


USGS
science for a changing world