Modelling to support Adaptive Management

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U.S. Geological Survey

Two Messages

In an applied setting, where the focus is on recurring decisions,

1. The central role of scientists is prediction

2. Critical uncertainty (*uncertainty that matters to the decision maker*) is reduced by confronting predictions with data from monitoring (and research).

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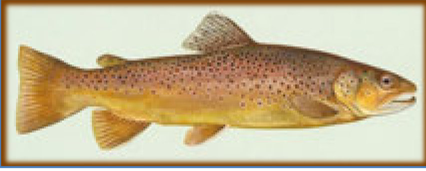

Expected number of adult brown trout as a function of management alternative and causal hypothesis

	Hypotheses							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
Weights	0.25	0.07	0.07	0.25	0.07	0.07	0.25	
Alternatives								
Status Quo	13,228	11,439	15,476	19,820	12,505	17,995	20,587	16,948
Incentivized Fishing	8,077	5,976	8,311	12,097	6,577	9,185	11,572	9,772
Reduced Fall Flow	7,366	11,439	15,476	6,881	12,505	17,160	9,782	9,629
Enhanced Spring Flow	6,225	9,723	13,051	5,929	10,875	14,553	8,708	8,299
Trout Mgmt Flows	11,446	9,136	12,112	16,952	10,245	15,204	17,259	14,283
Trout Removal	7,303	4,801	6,393	10,329	5,277	7,560	9,731	8,299
Best	*6,225*	*4,801*	*6,393*	*5,929*	*5,277*	*7,560*	*8,708*	*6,704*

Session Goals

Discuss the role of modeling in an adaptive management program

- Review some of the predictive models developed during LTEMP EIS
- Discuss developments since 2015
- Consider the interplay between monitoring and modeling

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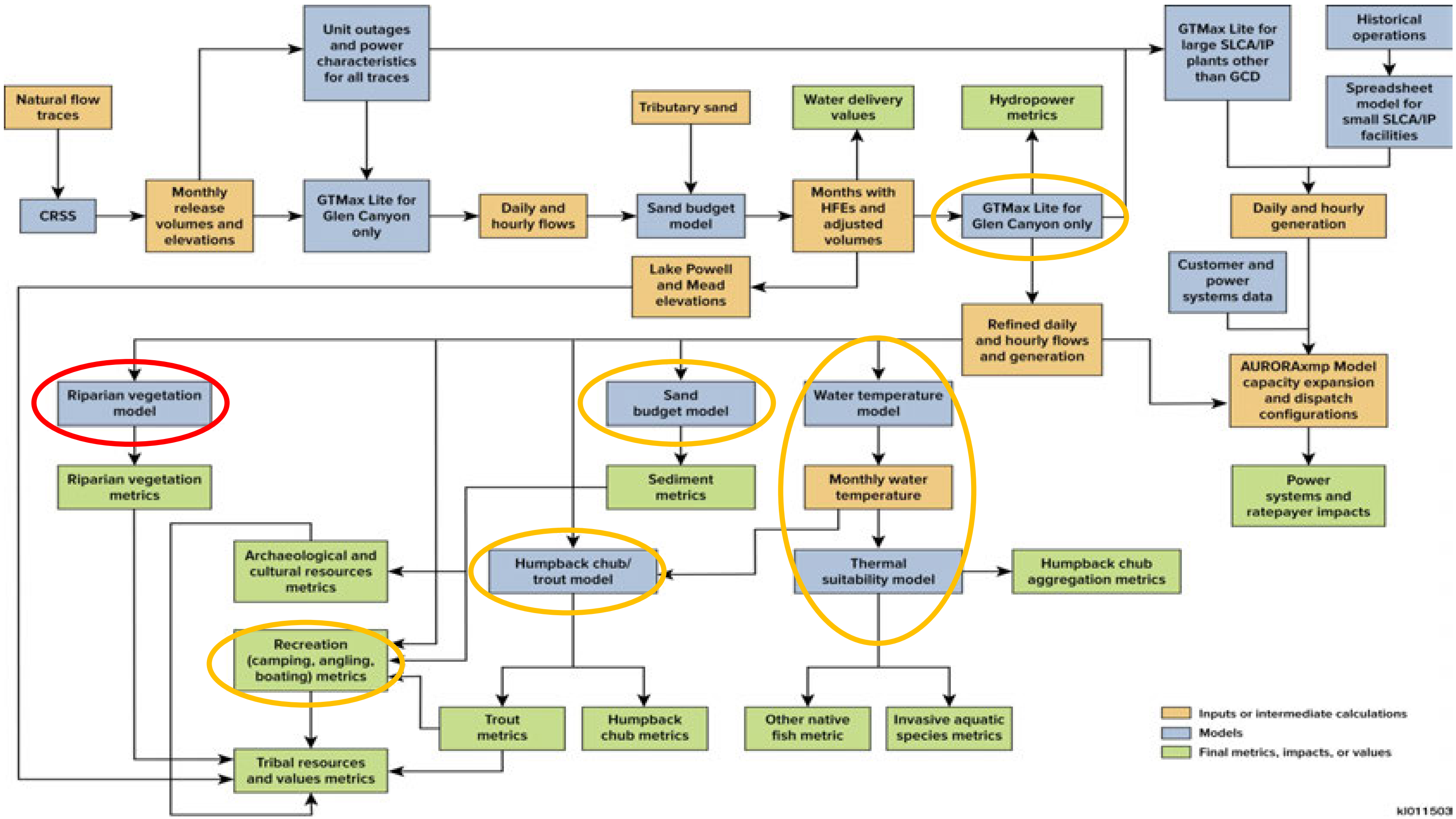
LTEMP Modeling Framework (1)



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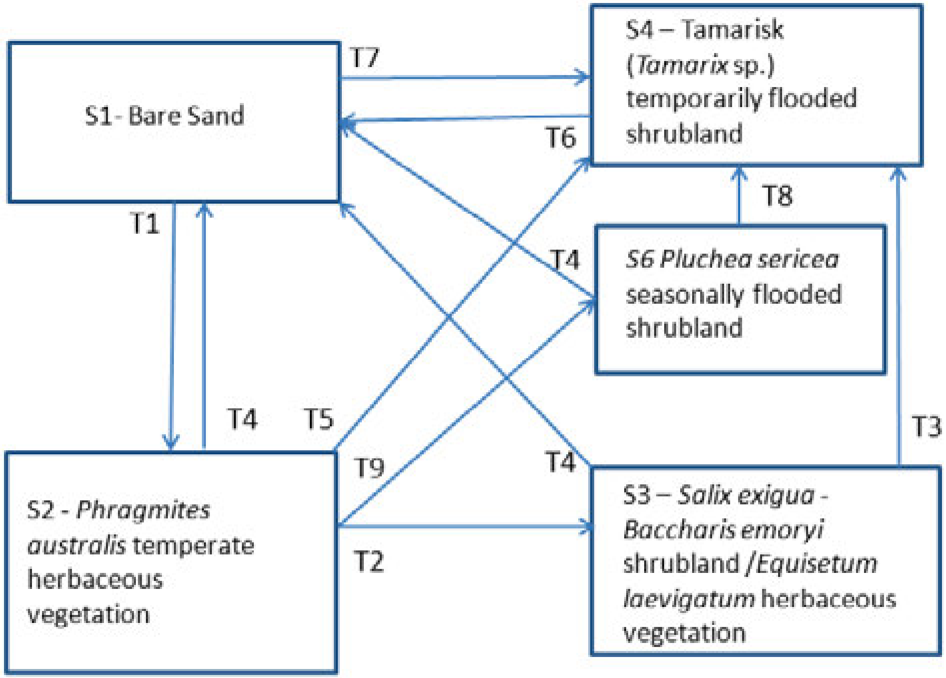
LTEMP EIS (2014): State and Transition Model

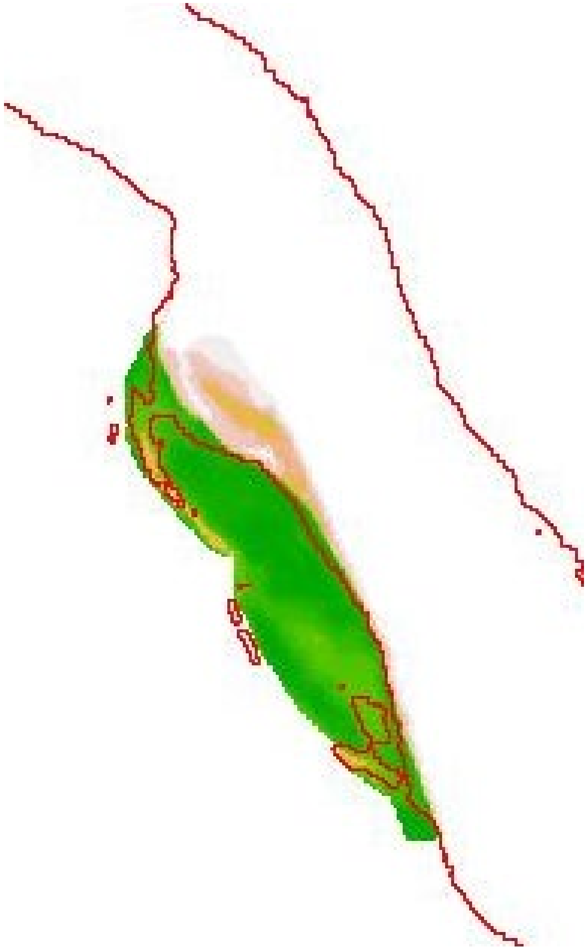
- Common vegetation types
- Transitions between states triggered by
  - Plant growth
  - Flow change (e.g. inundation, drying)
- Combinations of 5 1996 LTEMP options
  - Daily fluctuations
  - HFE
  - Equalization
  - Sustained low flows
  - Spill control flood
- Transitions based on studies from within CRe and the broader region



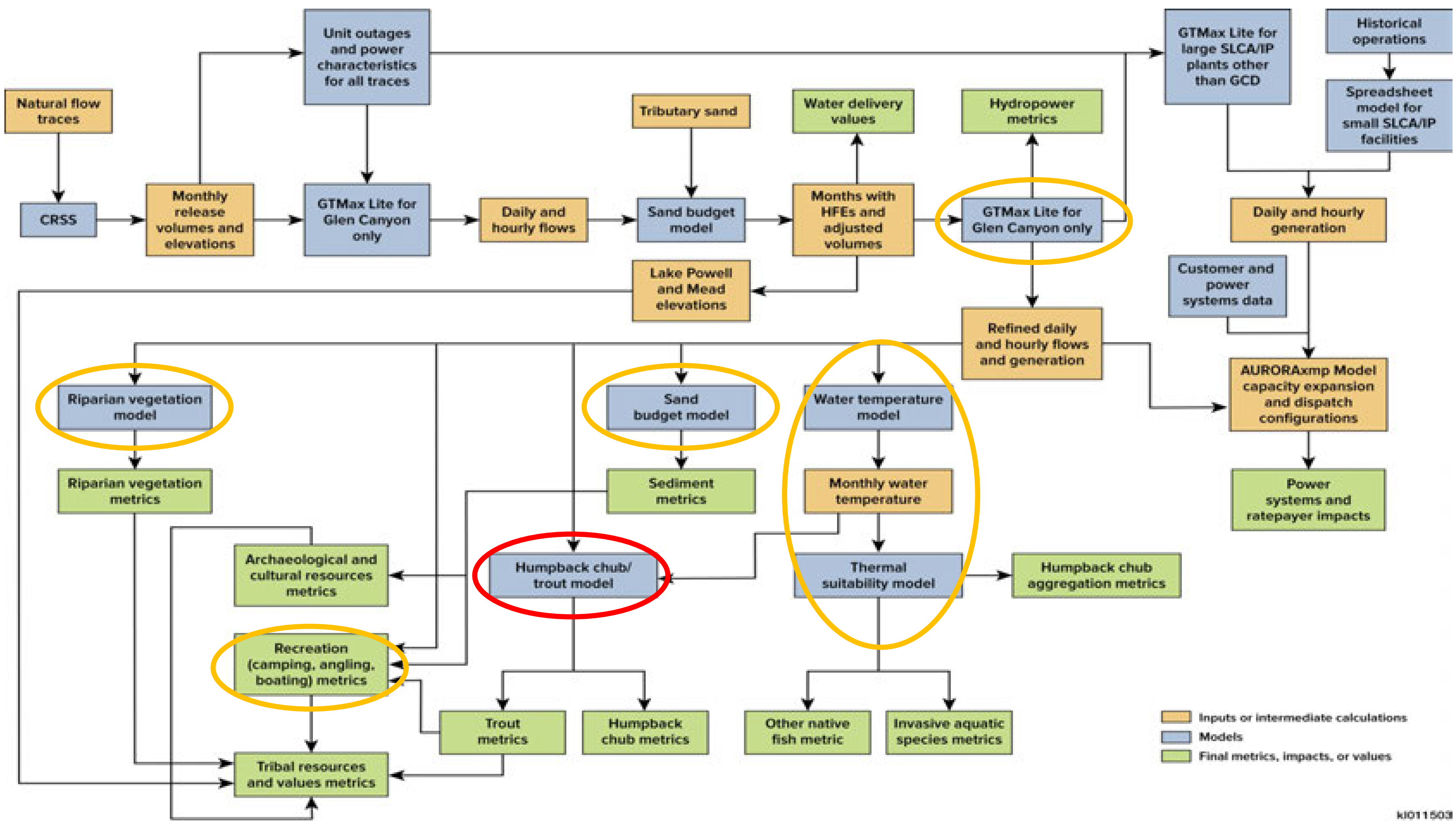
From Ralston and others 2014 USGS OFR 2014-1095

Advances Since 2014

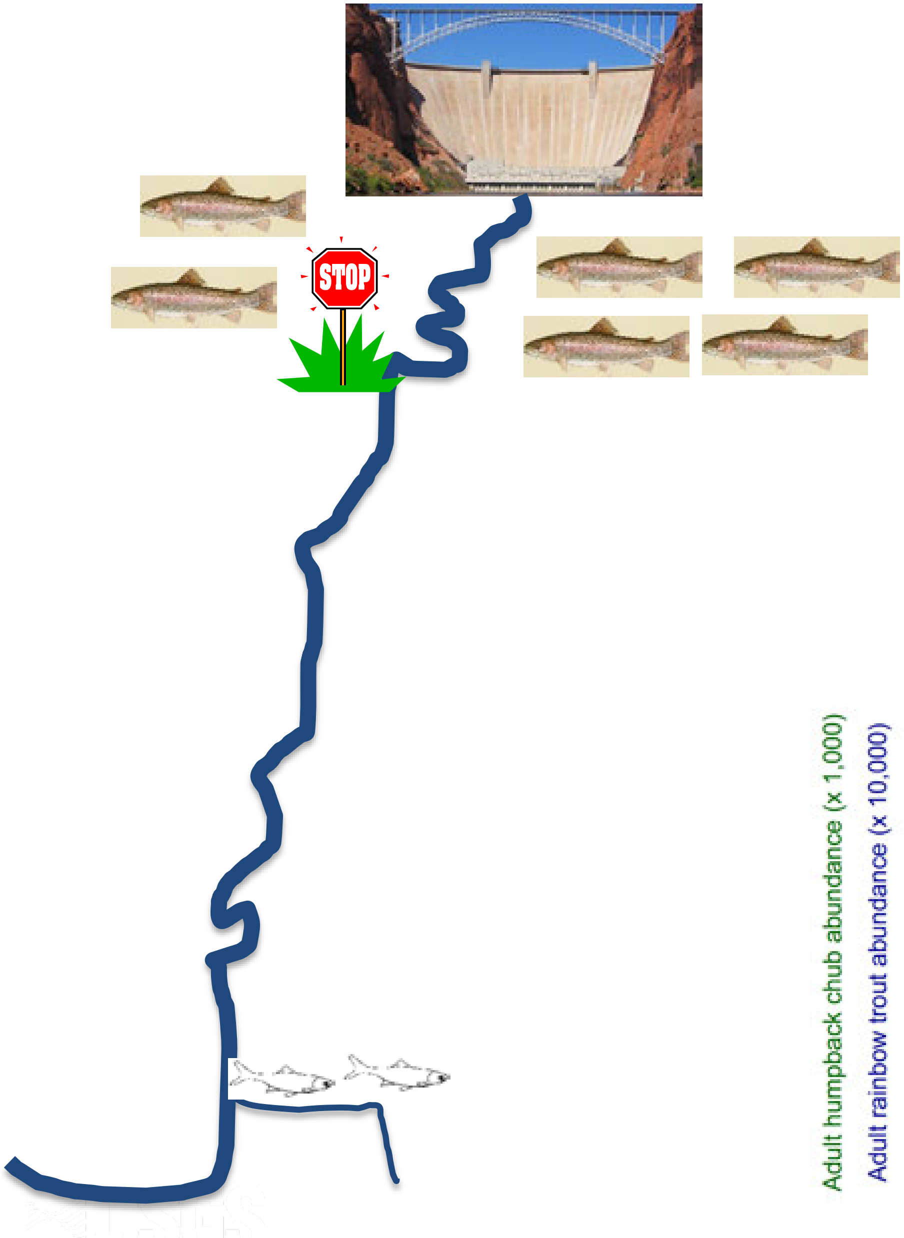
- Annual monitoring program 2014-present
  - >20,000 plots surveyed in systematic way
- New types of data
  - Remotely-sensed vegetation classifications
  - Plant functional traits
  - Greenhouse experiments
  - Biodiversity informatics
- New modeling approaches
  - Niche modeling with continuous flow variables for >70 common species
  - Hierarchical Bayesian modeling that can integrate diverse data and model types



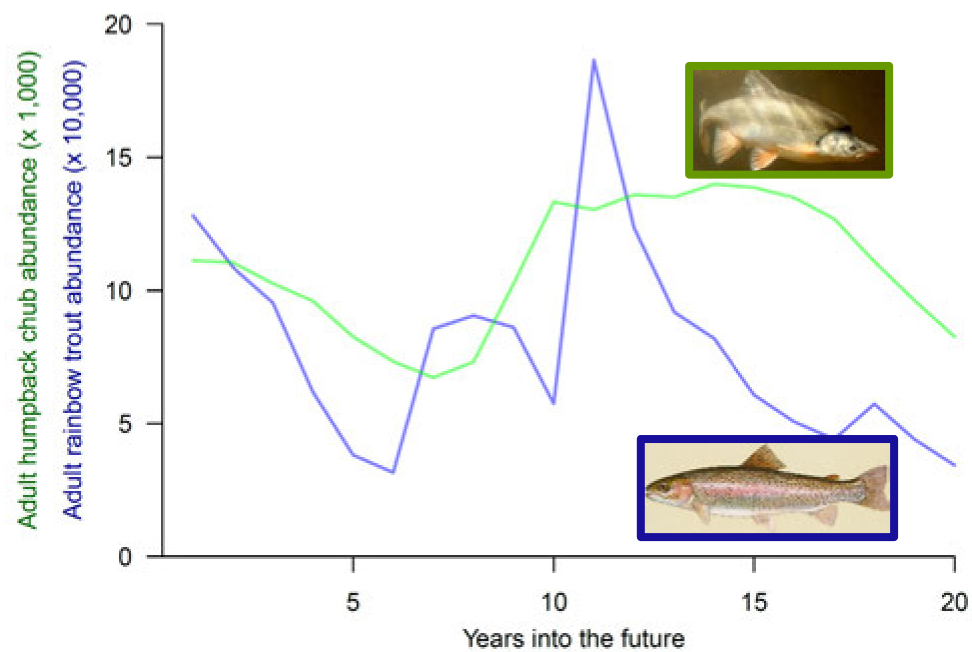
LTEMP Modeling Framework (2)

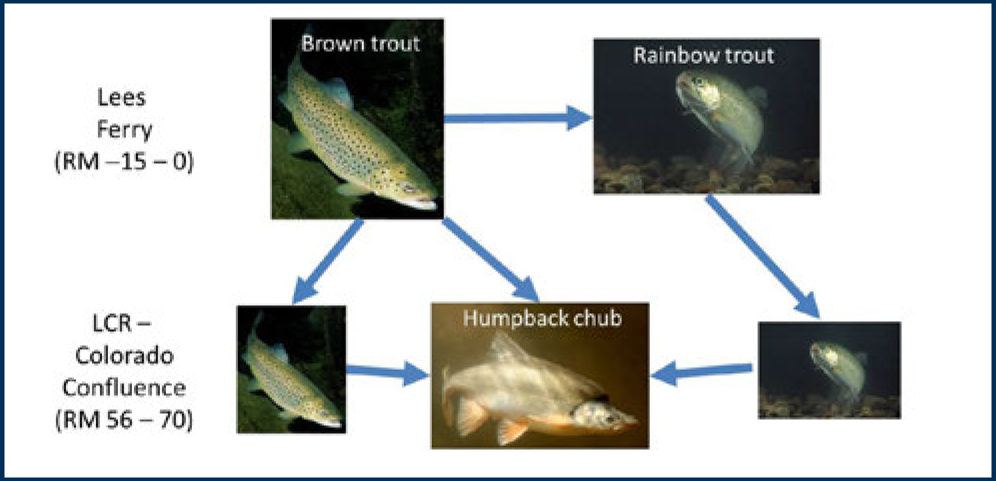


Broad overview of coupled Itemp models

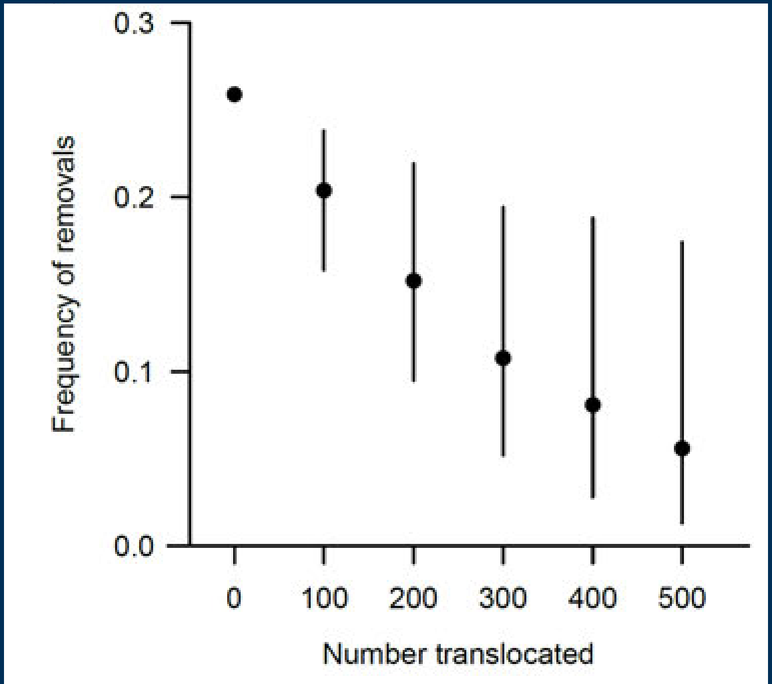


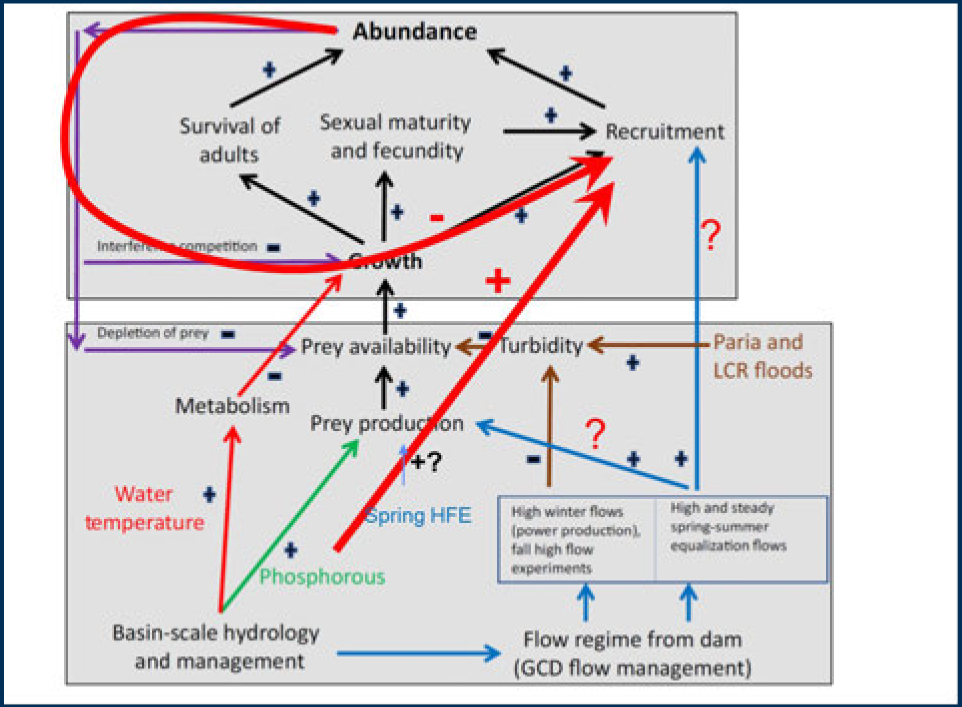
- Rainbow trout dynamic in Lees Ferry and outmigration driven by flows.
- Movement to LCR and mechanical removal.
- Chub dynamics driven by water temp, rainbow trout, and other drivers.





- Added Brown trout
- Phosphorous as driver of rainbow trout
- Improved understanding of chub dynamics and role of translocations





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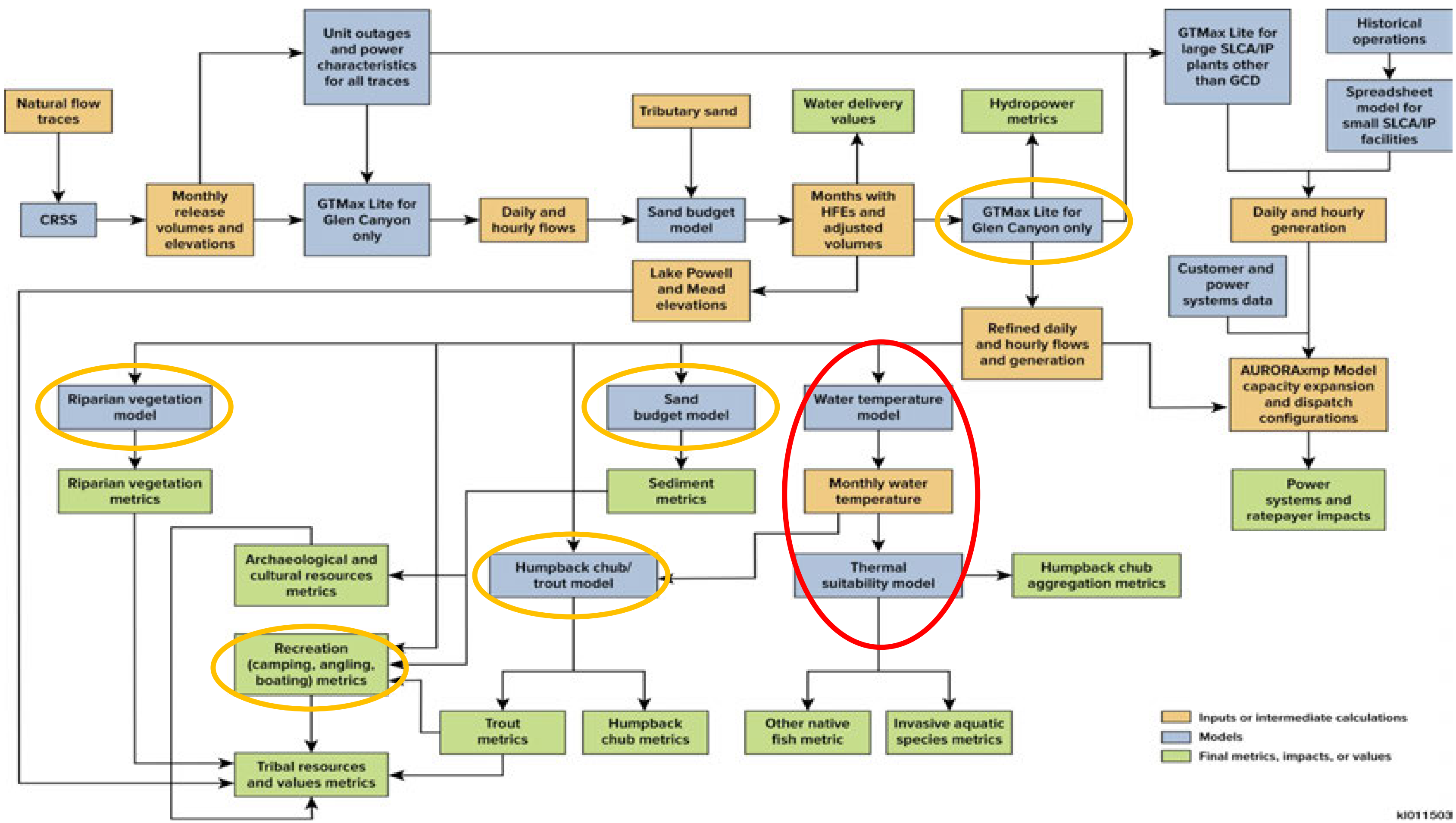
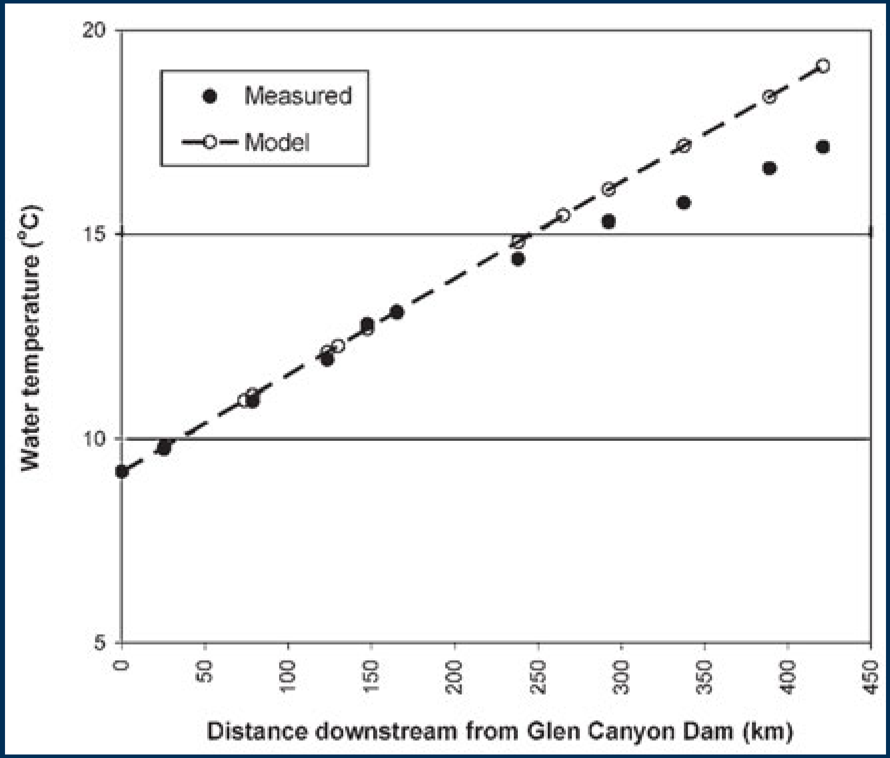
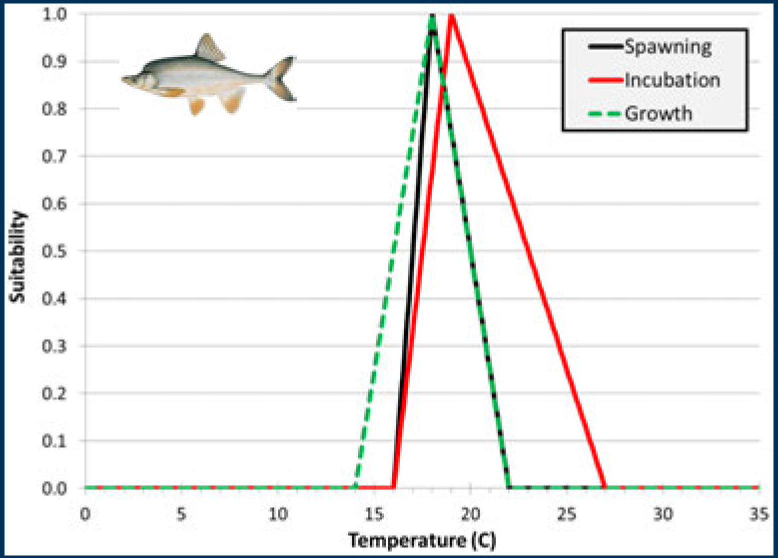
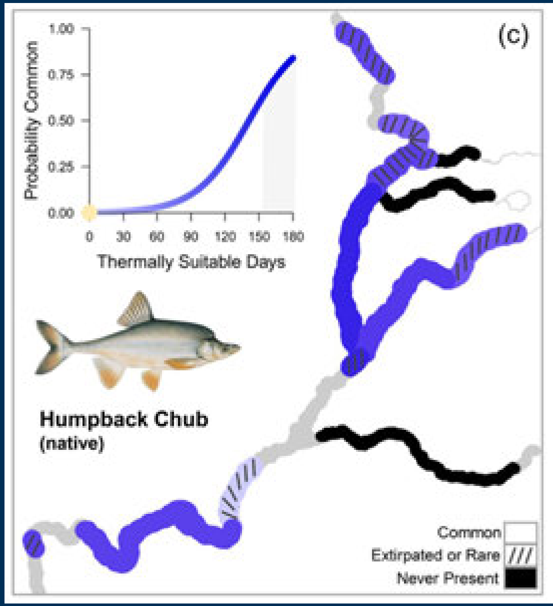
LTEMP Modeling Framework (3)



LTEMP modelling and recent improvements







- Updates to Temperature models
  - Improved through added complexity (nonlinear, solar insolation, tributaries)
- Updates to Suitability models
  - Switch to thermal degree days fit to basin-wide occurrences

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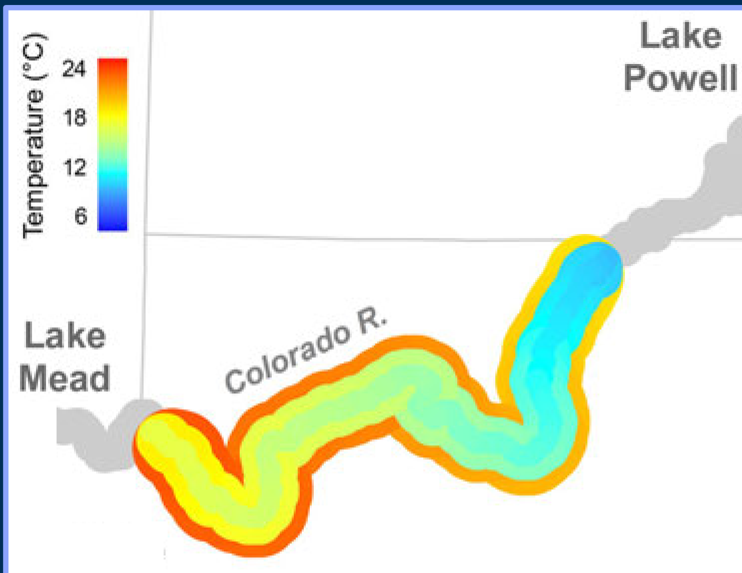
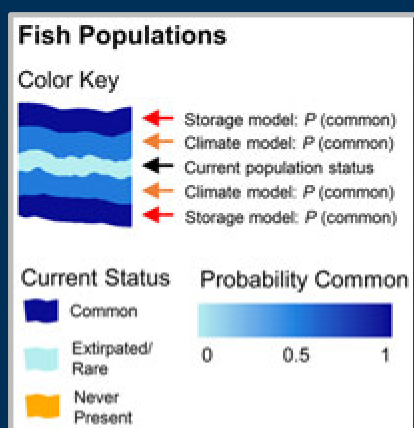
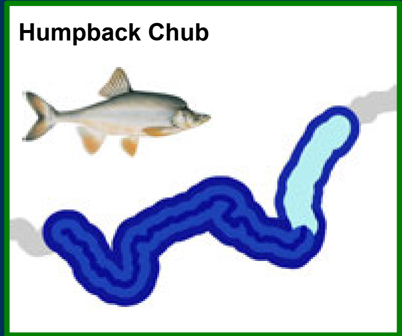
Example of Future Thermal Suitability

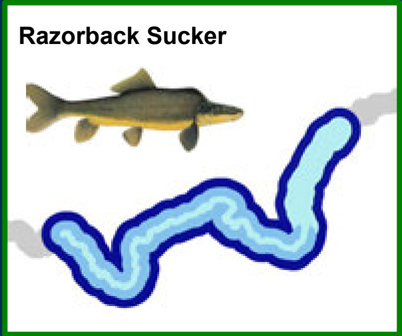
Water Temperature Predictions

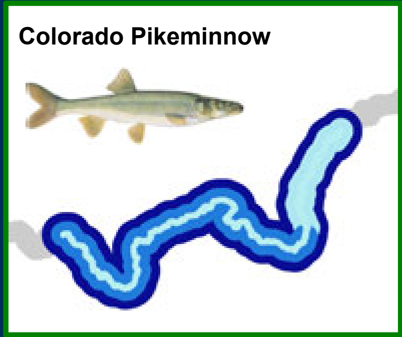




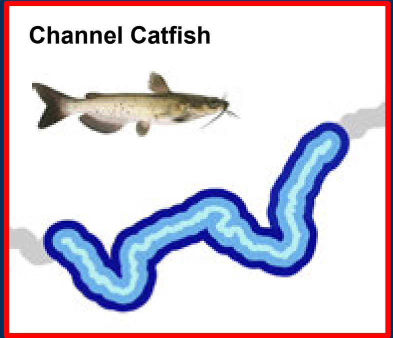
Native Fish

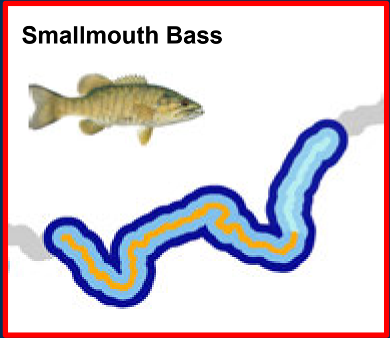


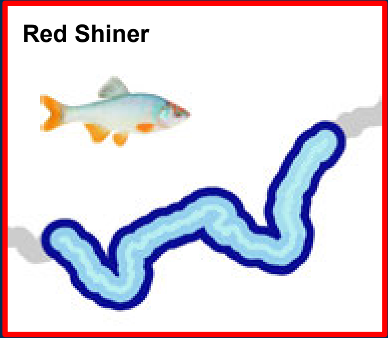




Nonnative Fish







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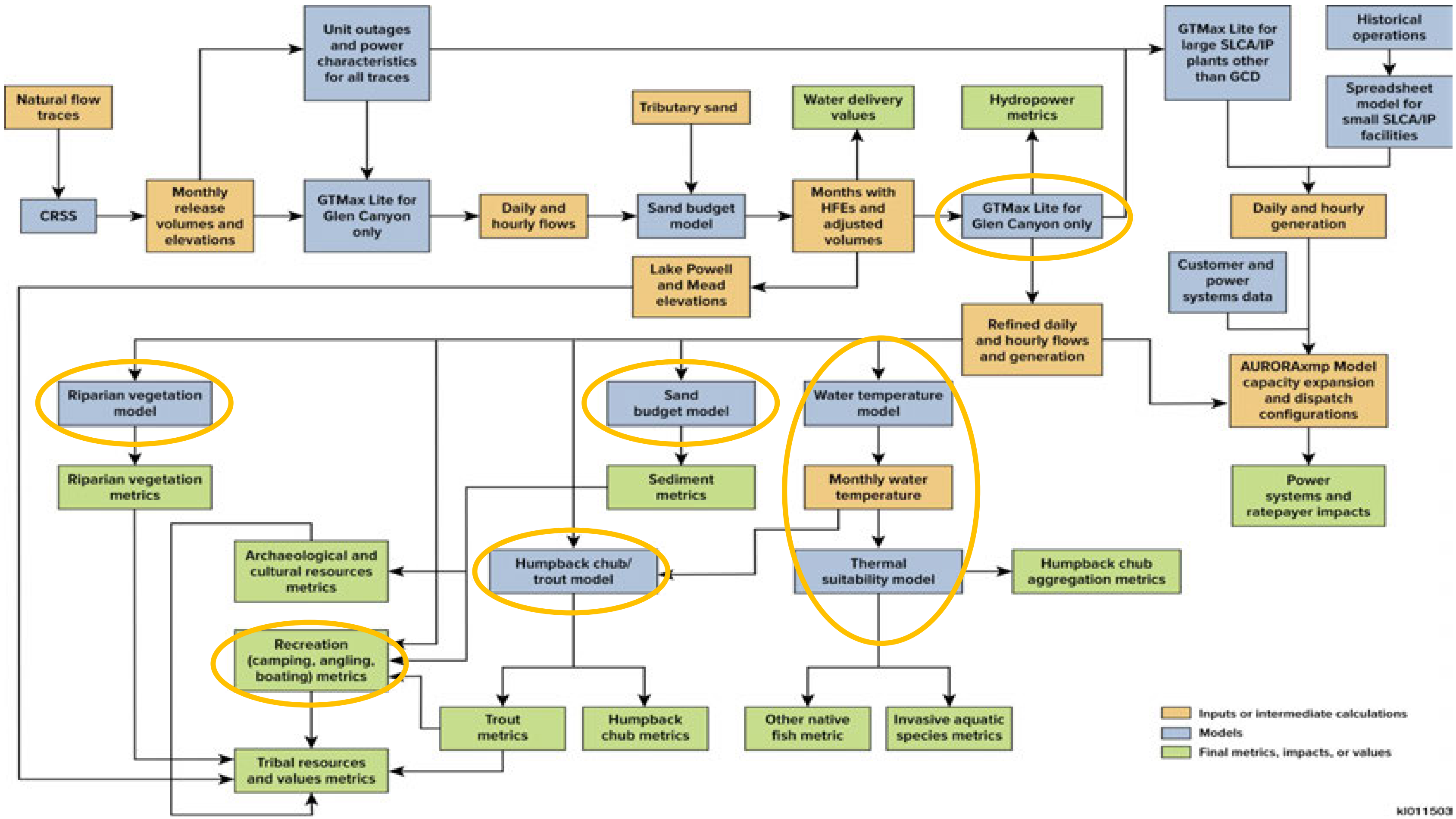
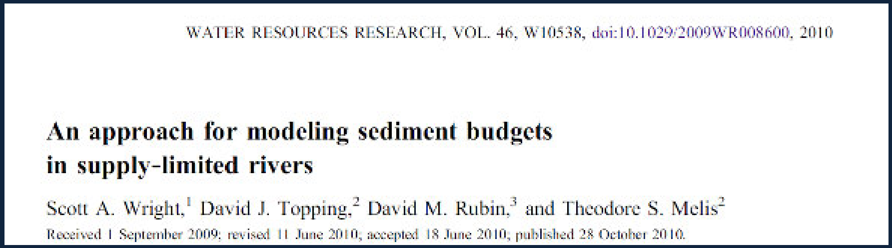
Dibble and others, 2020

LTEMP Modeling Framework (4)



Sediment model used for LTEMP

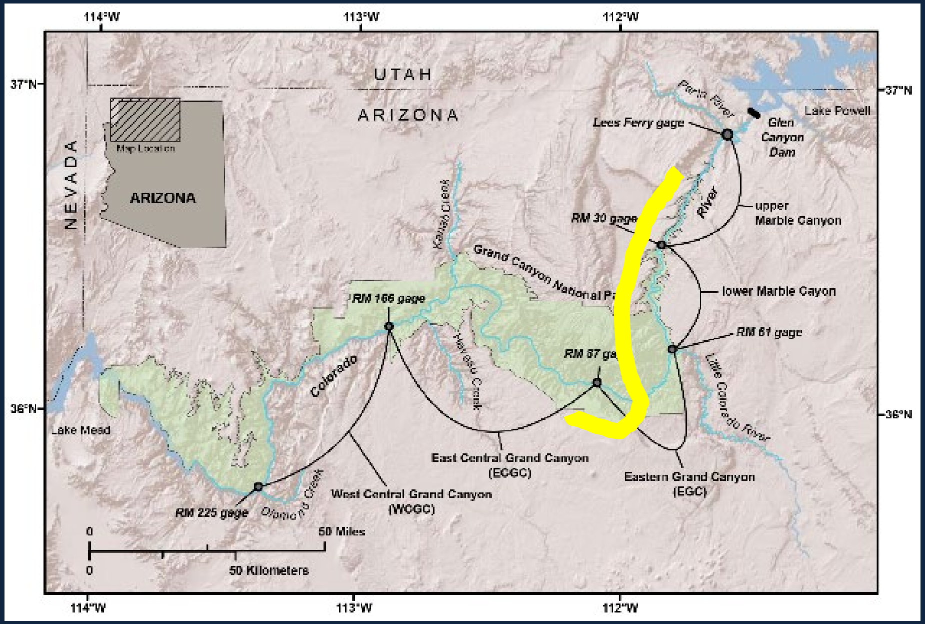
Shifting-rating curve sand routing model


WATER RESOURCES RESEARCH, VOL. 46, W10538, doi:10.1029/2009WR008600, 2010

An approach for modeling sediment budgets in supply-limited rivers

Scott A. Wright,[1] David J. Topping,[2] David M. Rubin,[3] and Theodore S. Melis[2]

Received 1 September 2009; revised 11 June 2010; accepted 18 June 2010; published 28 October 2010.



- In the LTEMP analyses, metrics were derived for:
  - Sediment resources
  - Archeological and cultural resources
  - Recreation resources
- This is also the model used by Reclamation to plan HFEs

Model covers RM 0 to RM 87 (Lees Ferry to Phantom Ranch)

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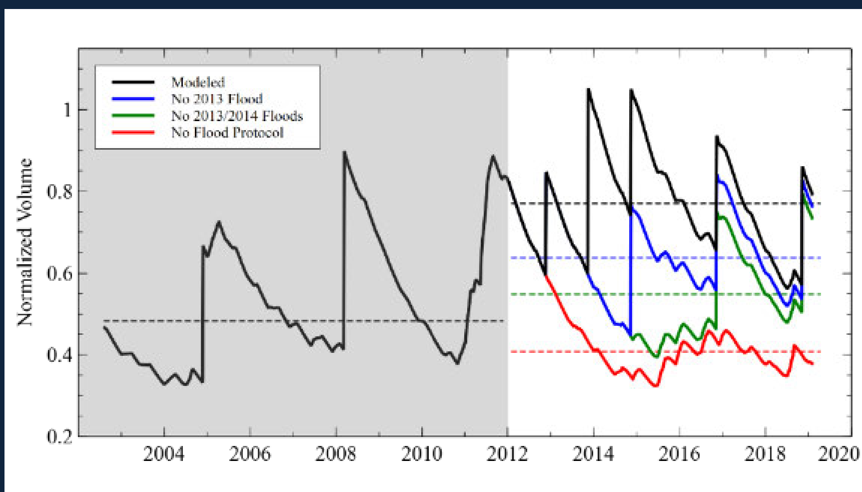
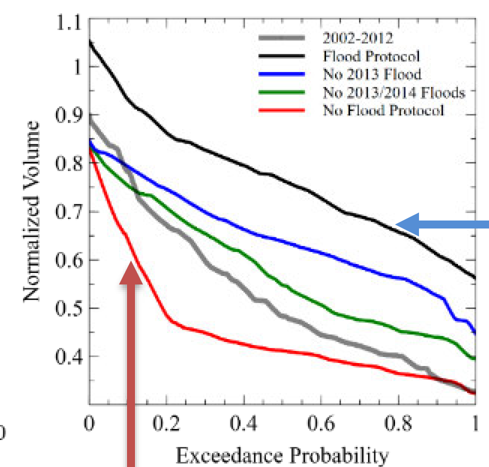
New sandbar model will soon be available for scenario testing

Model simulations reducing the number of HFEs



Fewer HFEs = reduced sandbar size

Proportion of time sandbars are larger during HFE protocol.



Over the period of the protocol, sandbars are at least 70% of maximum observed size for 80% of the time.

Without protocol, sandbars are that large only 20% of the time.

preliminary data and results subject to review, do not cite

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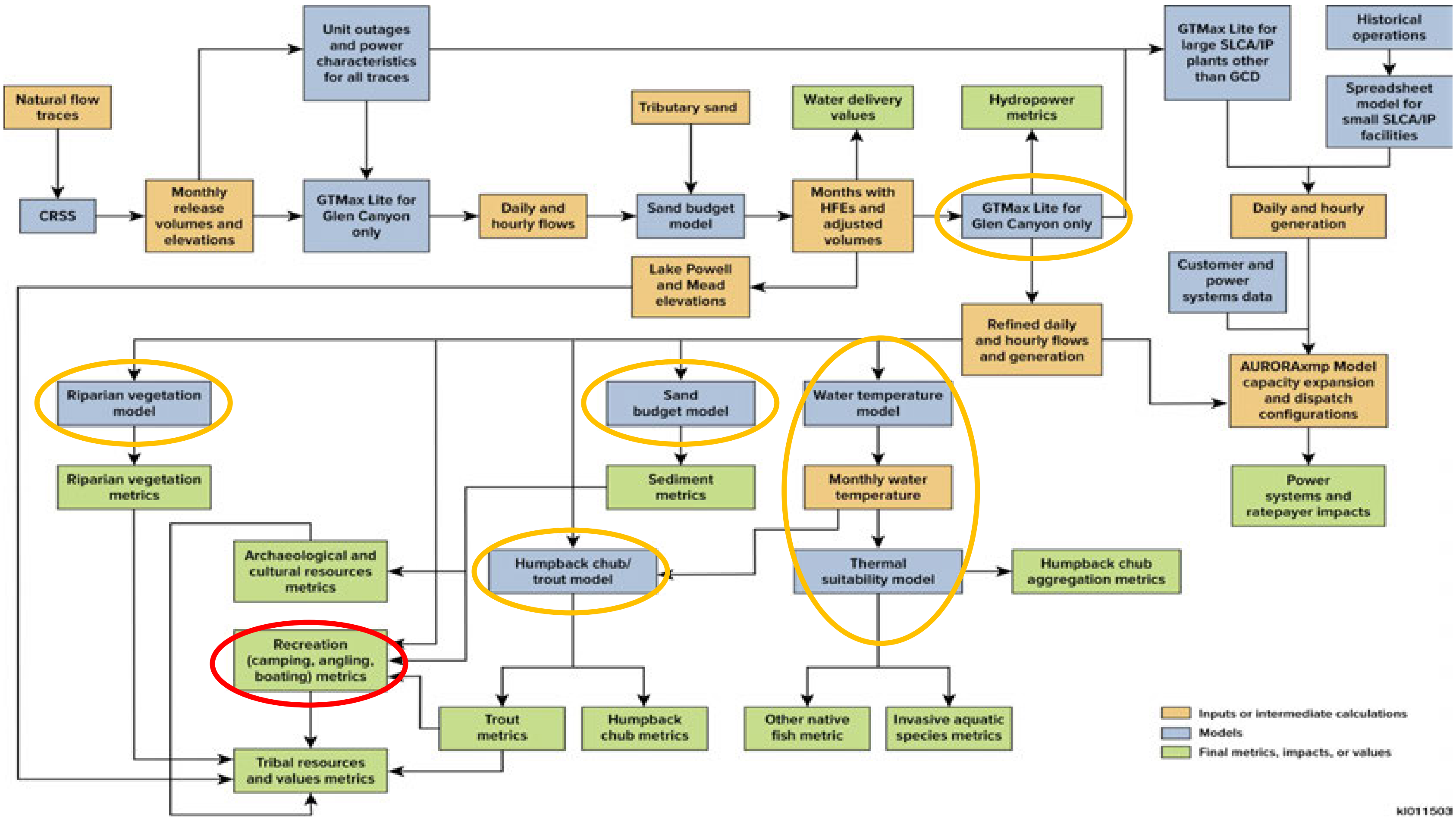
LTEMP Modeling Framework (5)



Glen and Grand Canyon Performance Metrics in the LTEMP EIS

- Glen Canyon Rafting Metric
- Catch Rate Index
- Number of trout >16 inches
- Glen Canyon Inundation Metric

- Camping Area Index
- Navigational Risk Index
- Fluctuation Index
- Time Off River Index

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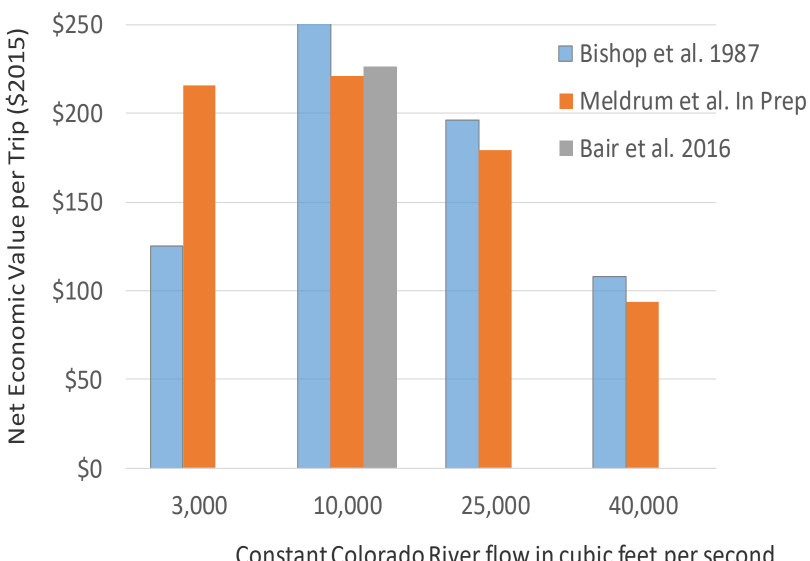
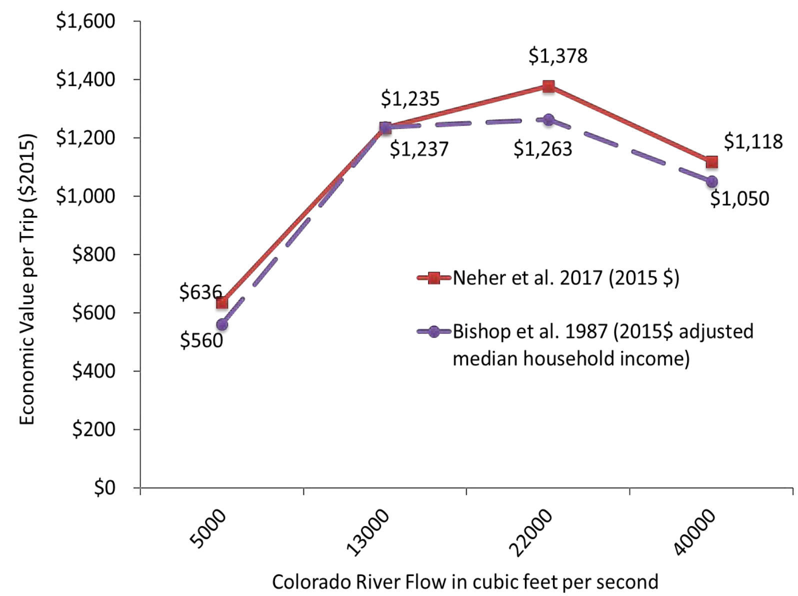
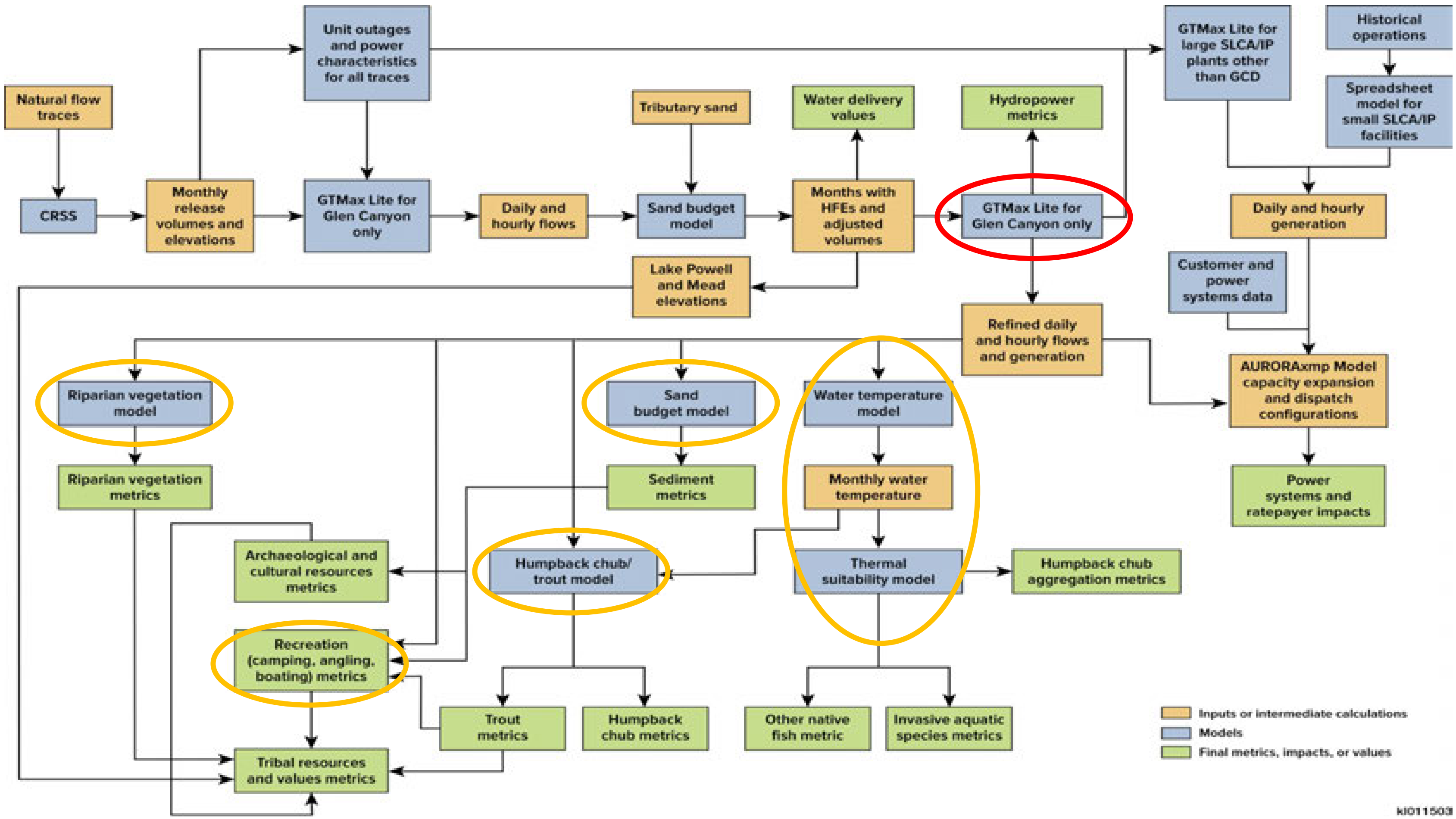
science for a changing world

Updated Recreation Metrics





LTEMP Modeling Framework (6)



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Three Main Models and Several Supporting Tools Were Used to Support LTEMP Power System Analyses

Colorado River System Simulation (CRSS)

- Simulates Colorado River Basin water management under uncertainty – monthly time step
- Monthly reservoir water releases and storage levels are projected for a large number plausible futures
- Water management (model results) vary by LTEMP EIS Alternative

AURORA

- Estimates hourly Western Interconnection (WI) energy market price trends that are used a primary driver for basin hydropower plant operations
- Projects the expansion of new generating resources for each large CRSP customer
- Customer-level expansion plans vary by Alternative

Generation and Transmission Maximization (GTMax) model

- Patterns hourly water releases and associated electricity generation from basin hydropower plants
- Estimates the firm capacity at Glen Canyon Dam and other basin hydropower resources based on operating criteria and constrains during the peak demand month of the year
- Generation patterns and firm capacity levels vary by Alternative

Model results from AURORA and GTMax were input into a tool that computed power system economic value for <u>capacity</u> and <u>energy</u> under each LTEMP EIS Alternative

GTMax Optimizes SLCA/IP Hydropower Plants Operation *(Capacity: 1,820 MW)*

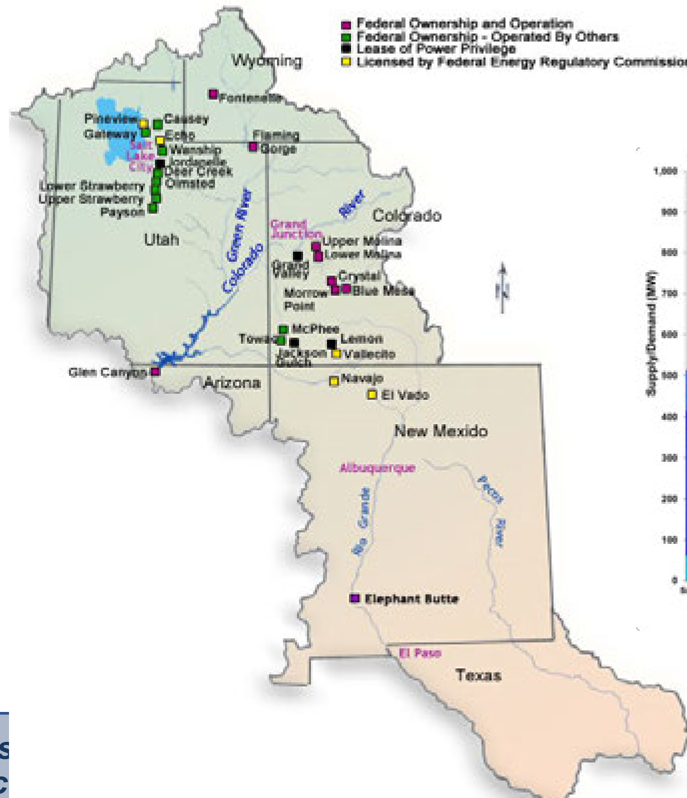
Colorado River Storage Projects
- Glen Canyon
- Flaming Gorge
- Blue Mesa
- Morrow Point
- Crystal

Collbran Project
- Upper Molina
- Lower Molina

Rio Grande Project
- Elephant Butte

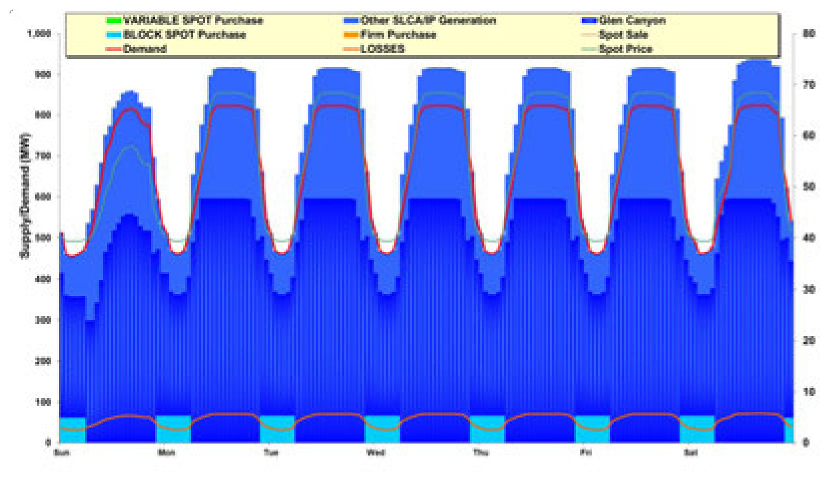
Seedskadee Project
- Fontenelle

Dolores Project
- McPhee Dam
- Towaoc Canal



> ➢ ***Elephant Butte Serves***
> ➢ ***Dolores serves projec***

Operations
- Plant-level generation
- Ancillary service assignments
- Goals/guidelines



Constraints
- Physical water/power limits
- Environmental/water delivery

Conclusion

- Substantial improvement in predictive modeling
- Potential to continue to improve and integrate models across resources
- Need to prioritize monitoring, research and modeling that directly and efficiently addresses uncertainties to achieve potential