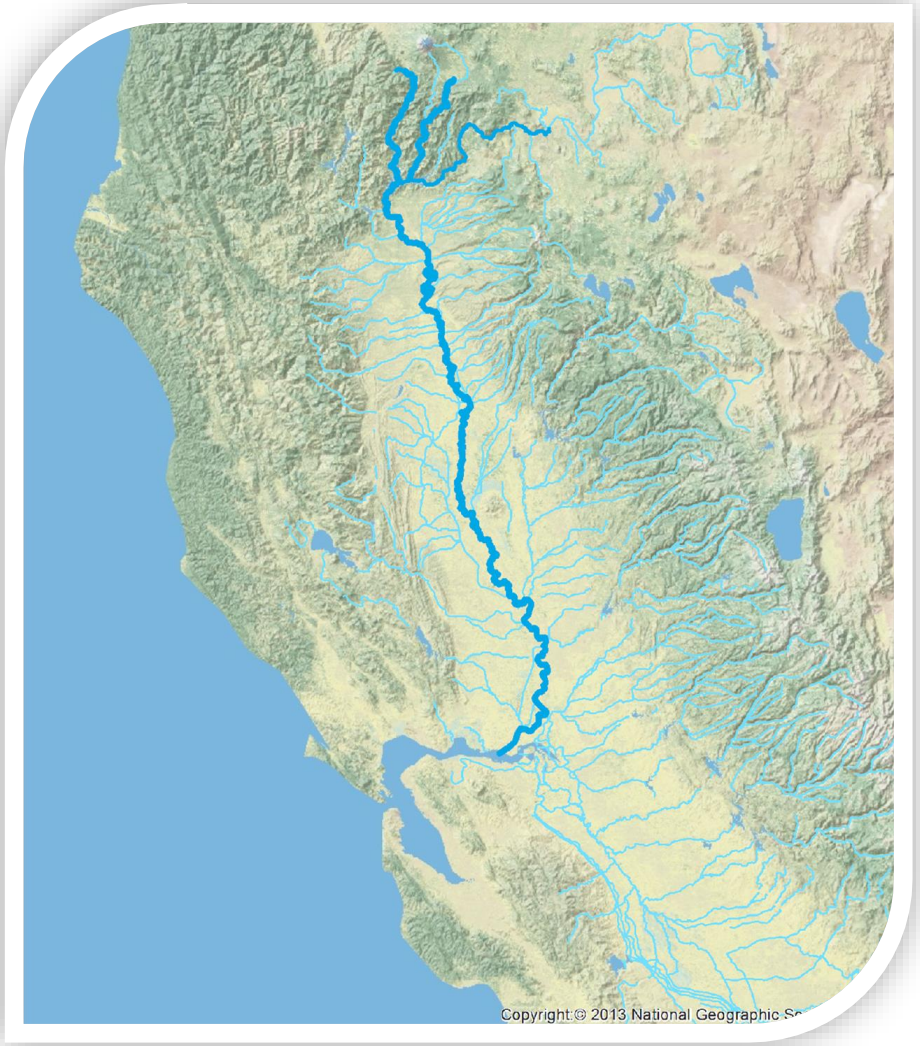
Temperature-dependent egg mortality (TDM)

for winter-run on the Sacramento River

a hindcast analysis for 2022



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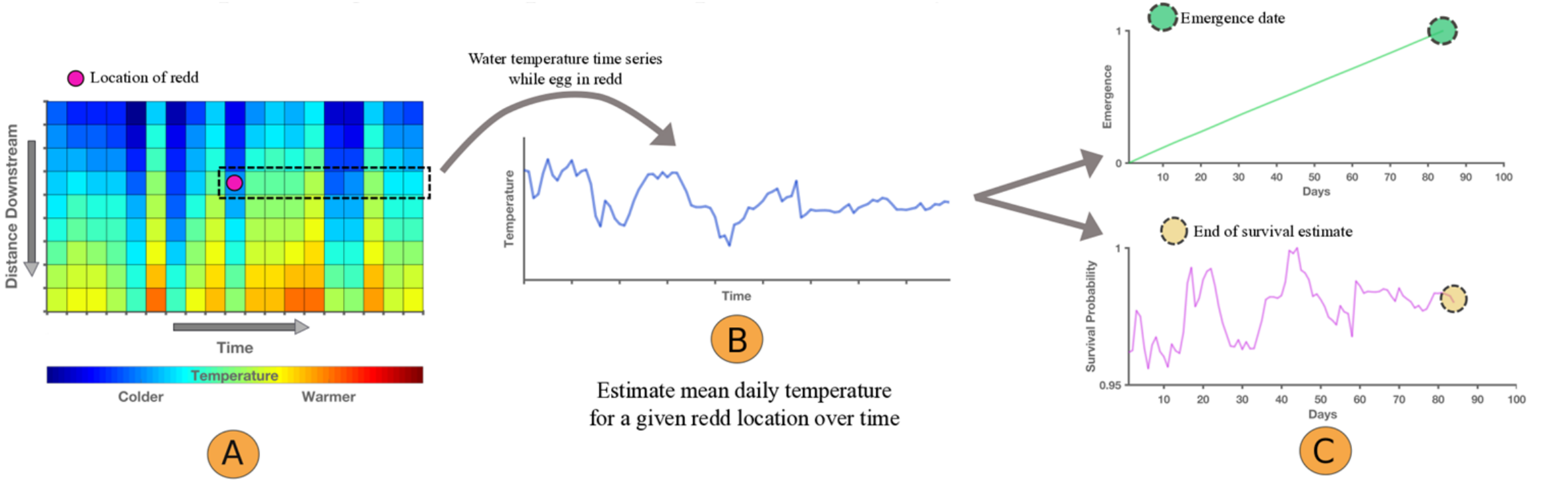
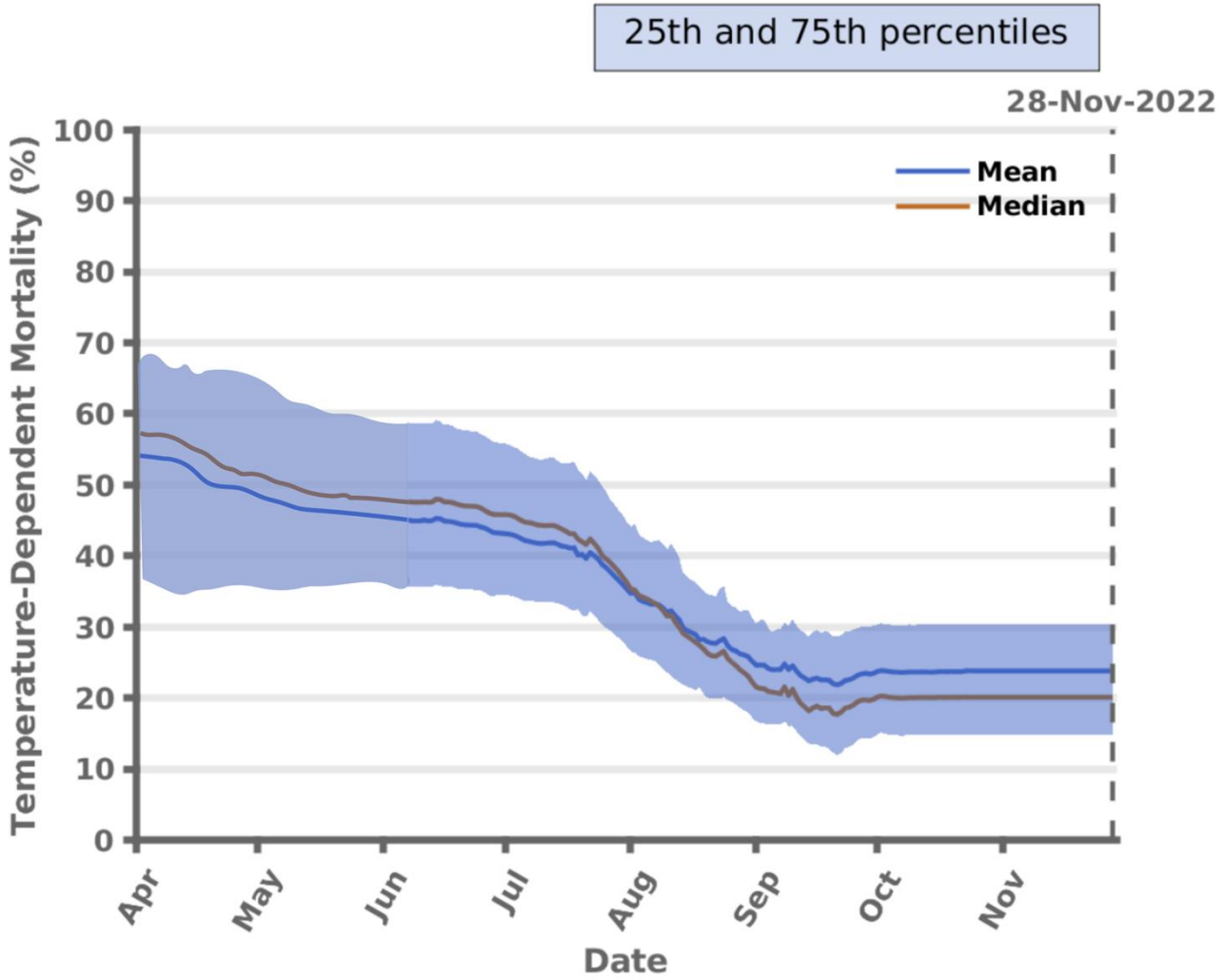
Conceptual model of TDM



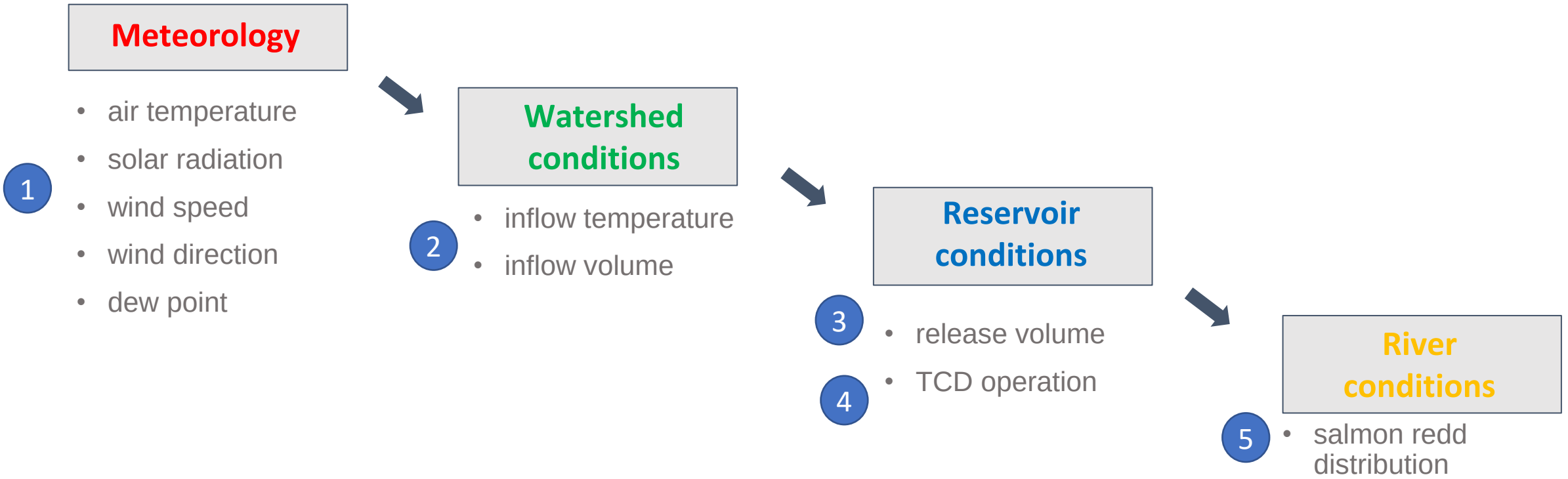
****Critical temperature of 12C**

TDM change in the 2022 season

- Estimates of TDM changed from a forecasted value of 54% in April to an observed value of 17% in October.



Factors related to TDM and explored here

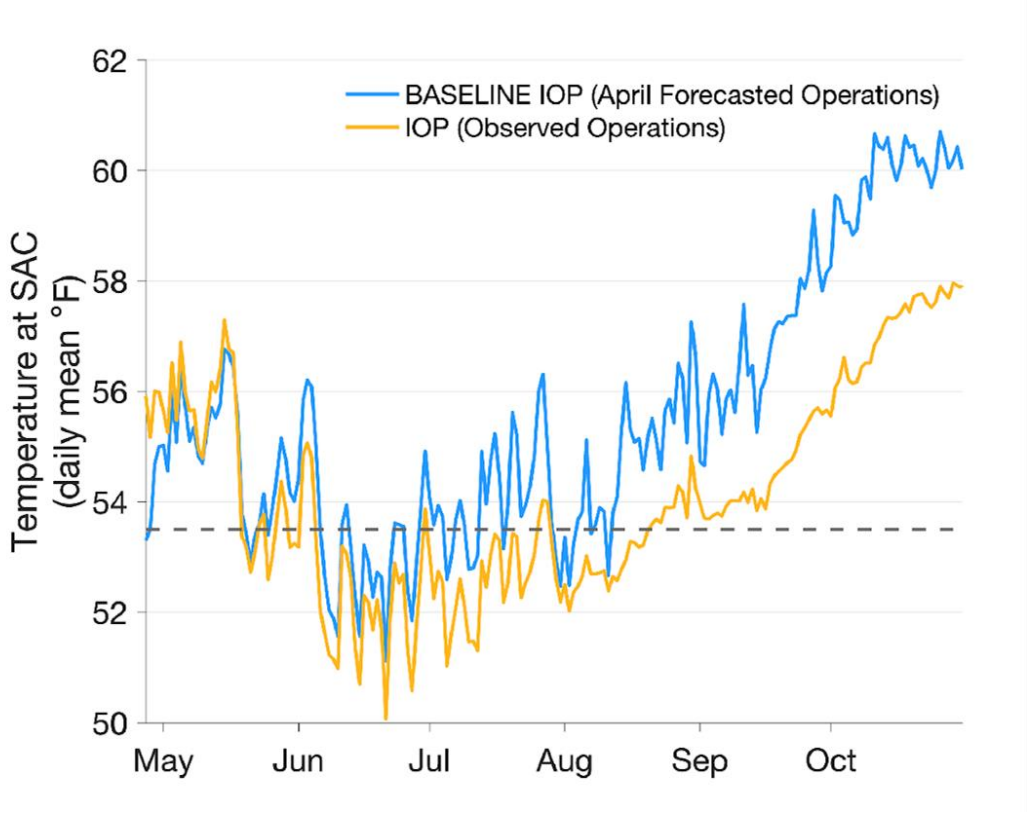


*** Five factors were explored in this analysis.***

TDM change analysis

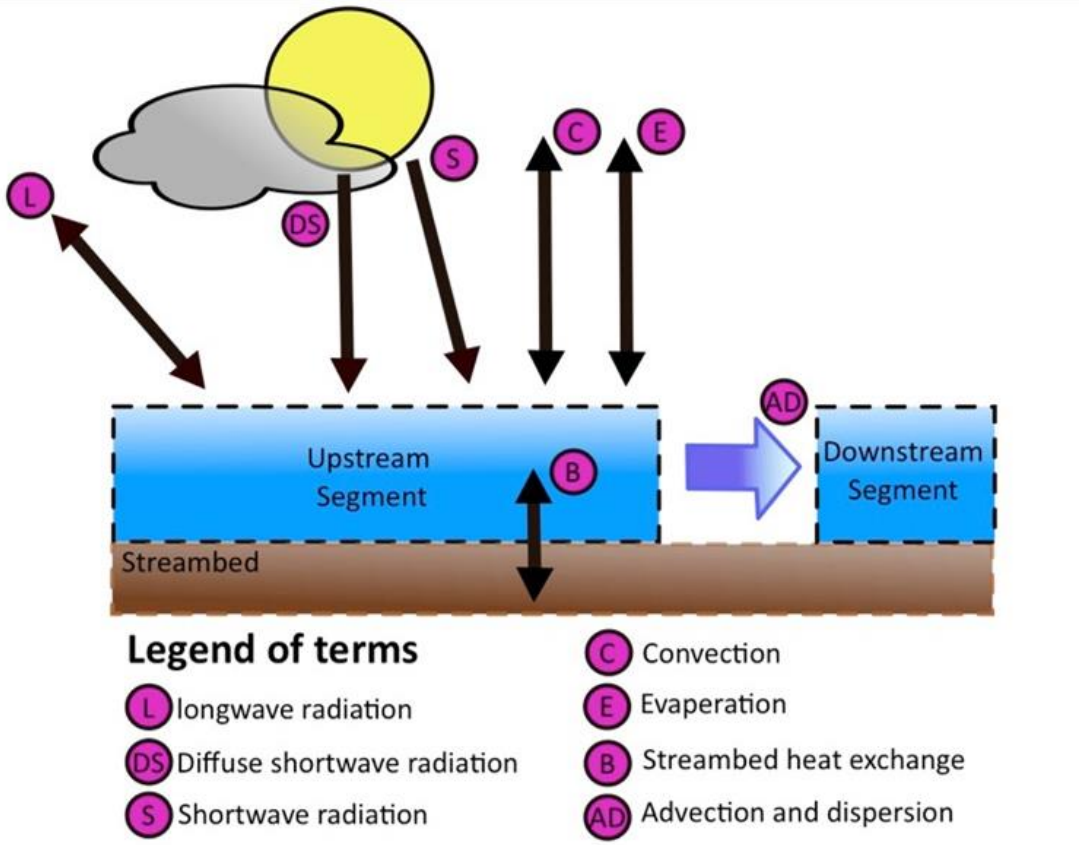
Baseline
Alternative

- One factor was changed at a time while all others were held at the forecasted values.
- Each factor's individual contribution to the change in TDM was compared to a baseline.
- A primary point of interest is temperature at the SAC gauge between a BASELINE and ALTERNATIVE.



Temperature models used

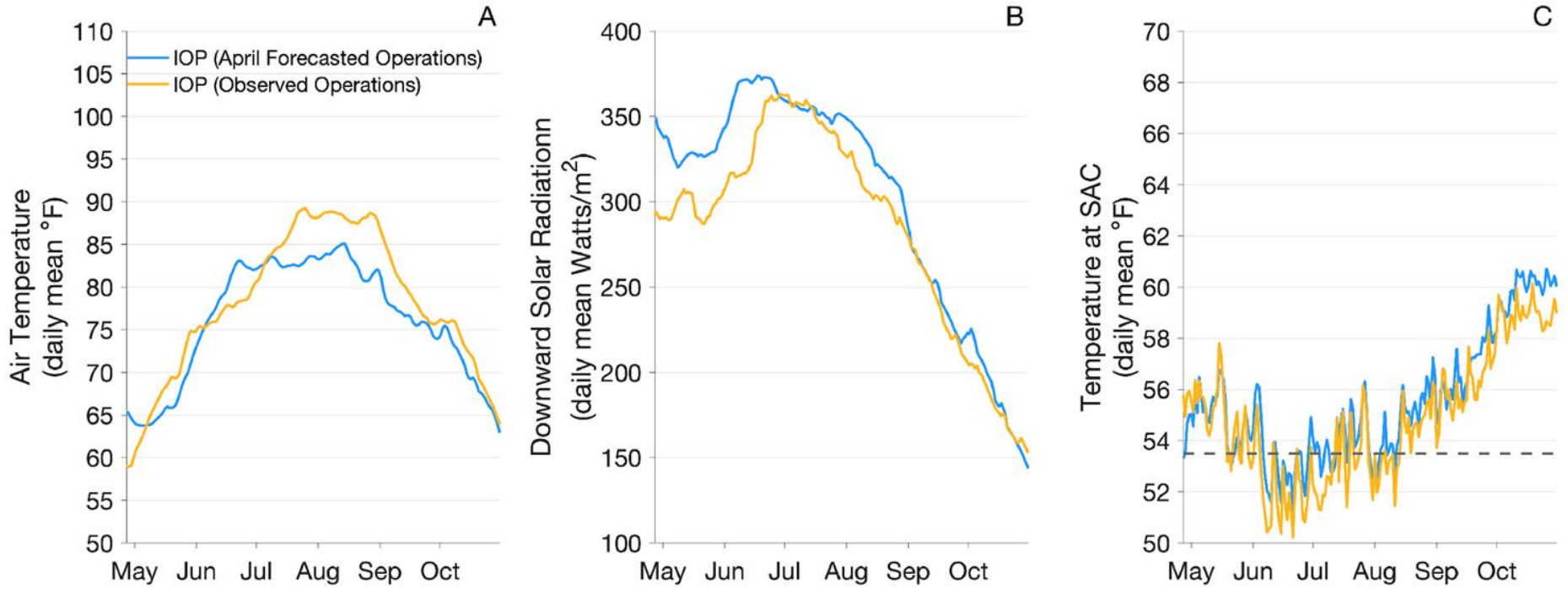
- We used a set of linked physically-based water temperature models.
- CE-QUAL-W2 for Shasta and Keswick reservoirs
  - 2D laterally averaged model
- RAFT for Sacramento River
  - 1D longitudinal model



Results

Meteorology

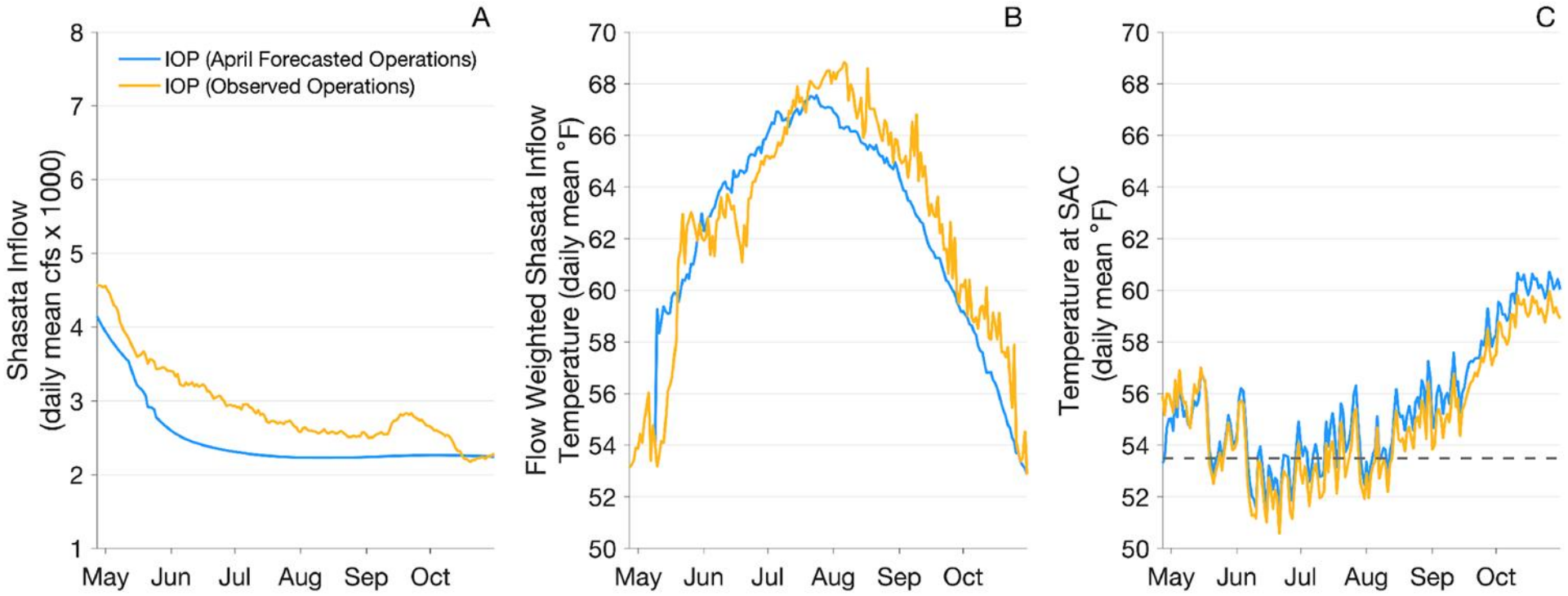
Baseline
Alternative



- Time series of air temperature (A) with daily data smoothed over a 30-day moving average window, downward solar radiation (B) with daily data smoothed over a 30-day moving average window, and downstream SAC temperature (C) under the 2 scenarios simulated.

Reservoir inflow operations

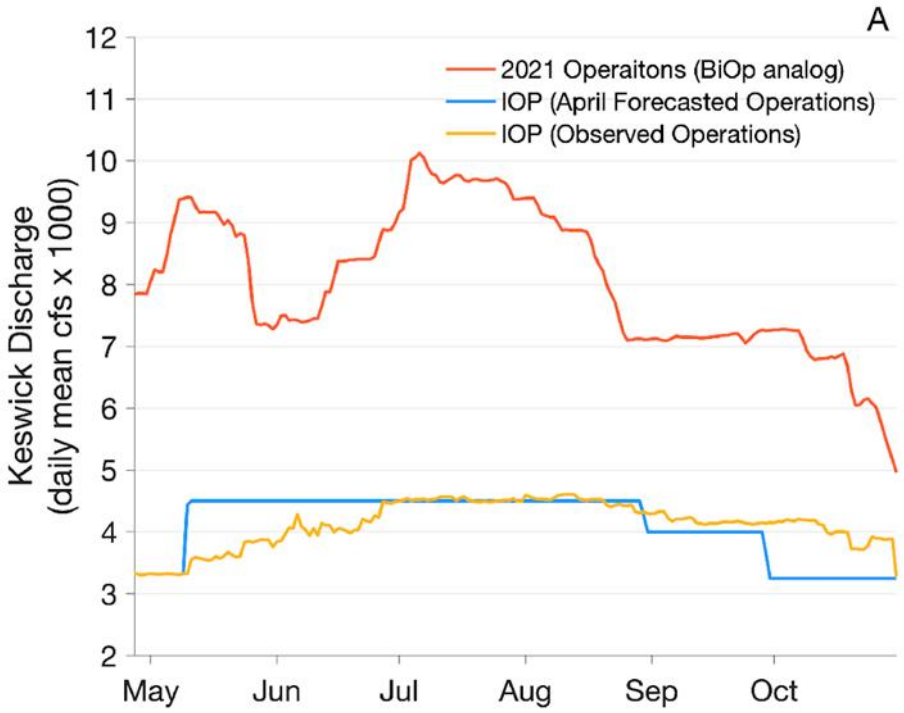
Baseline
Alternative

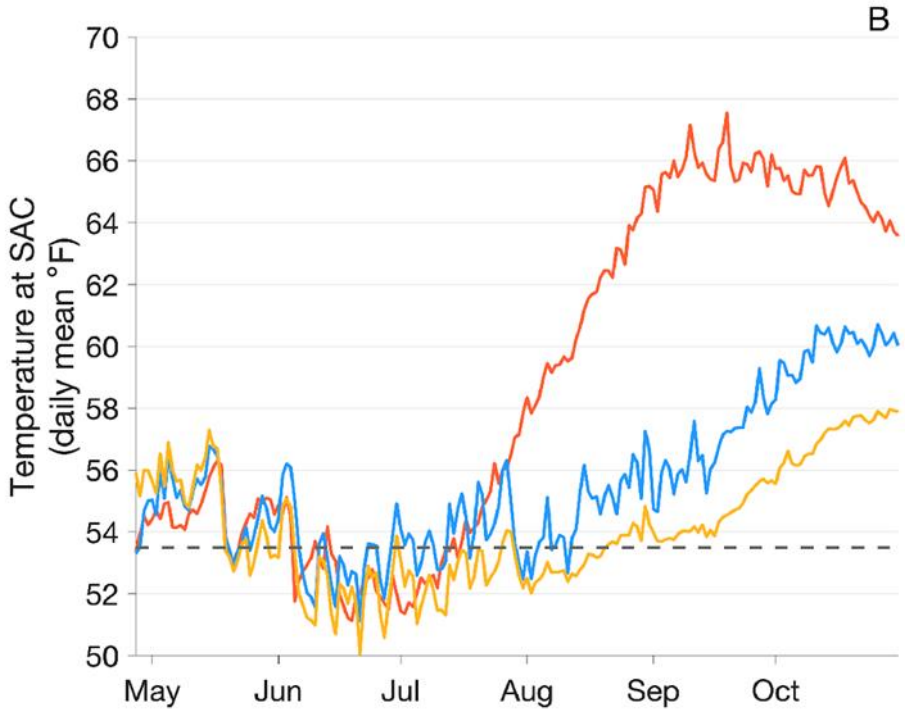


- Time series of Shasta inflow volume (A) with daily data smoothed over a 30-day moving average window, Shasta inflow temperature (B), and downstream SAC temperature (C) under the 2 scenarios simulated.

Reservoir outflow operations

Baseline
Alternative

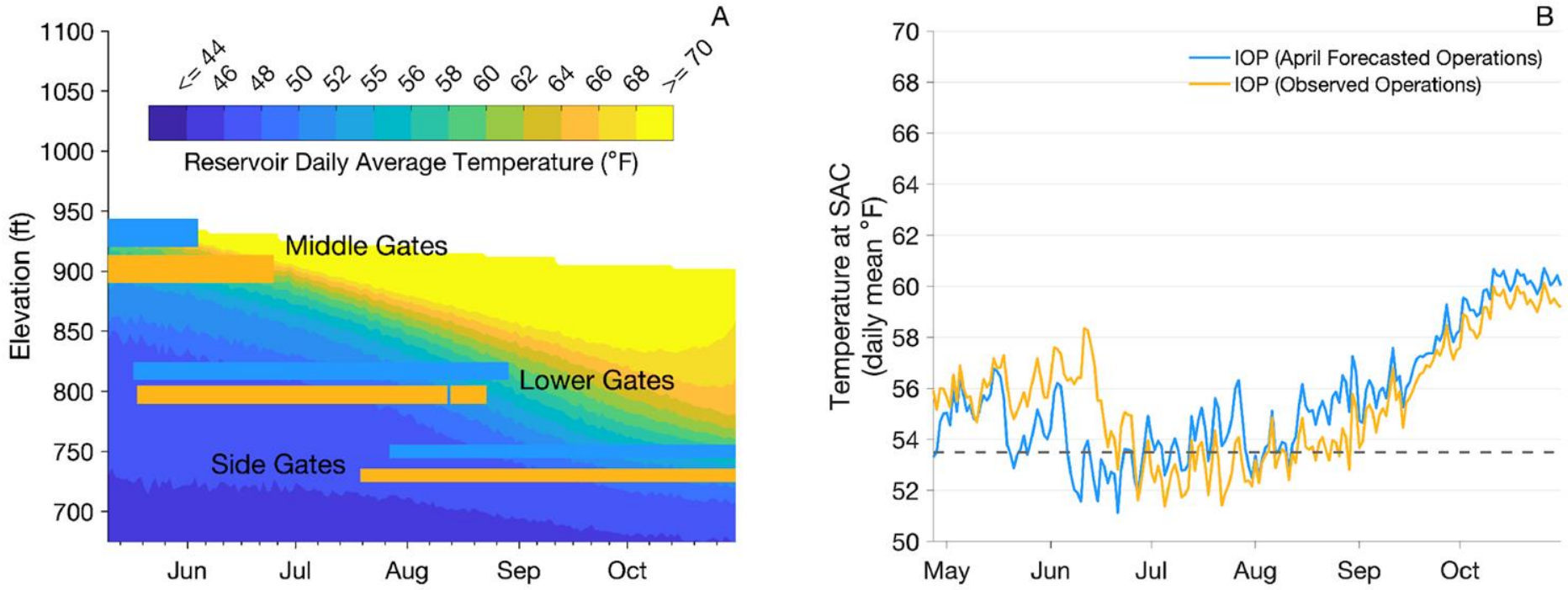




- Time series of Keswick release volume (A) and downstream SAC temperature (B) under the 3 scenarios simulated.

TCD operations

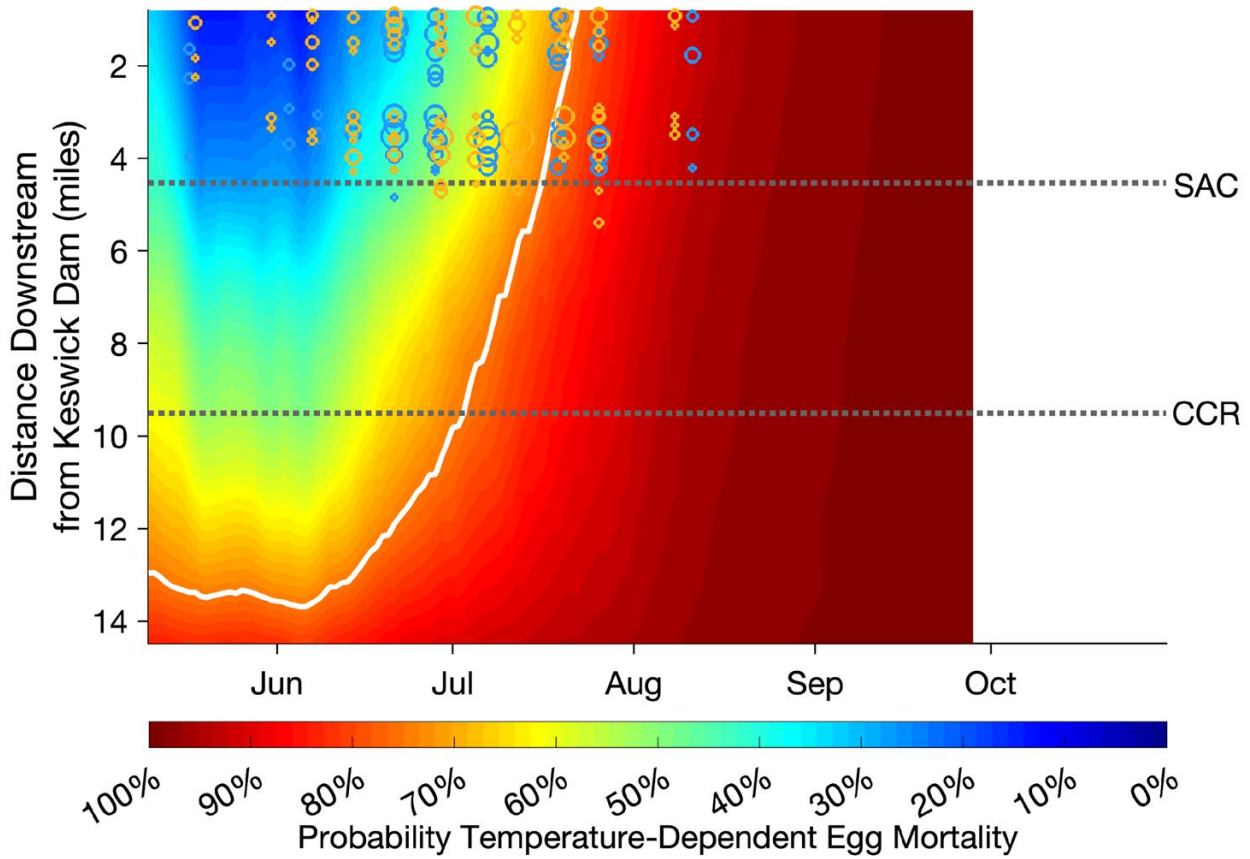
Baseline
Alternative



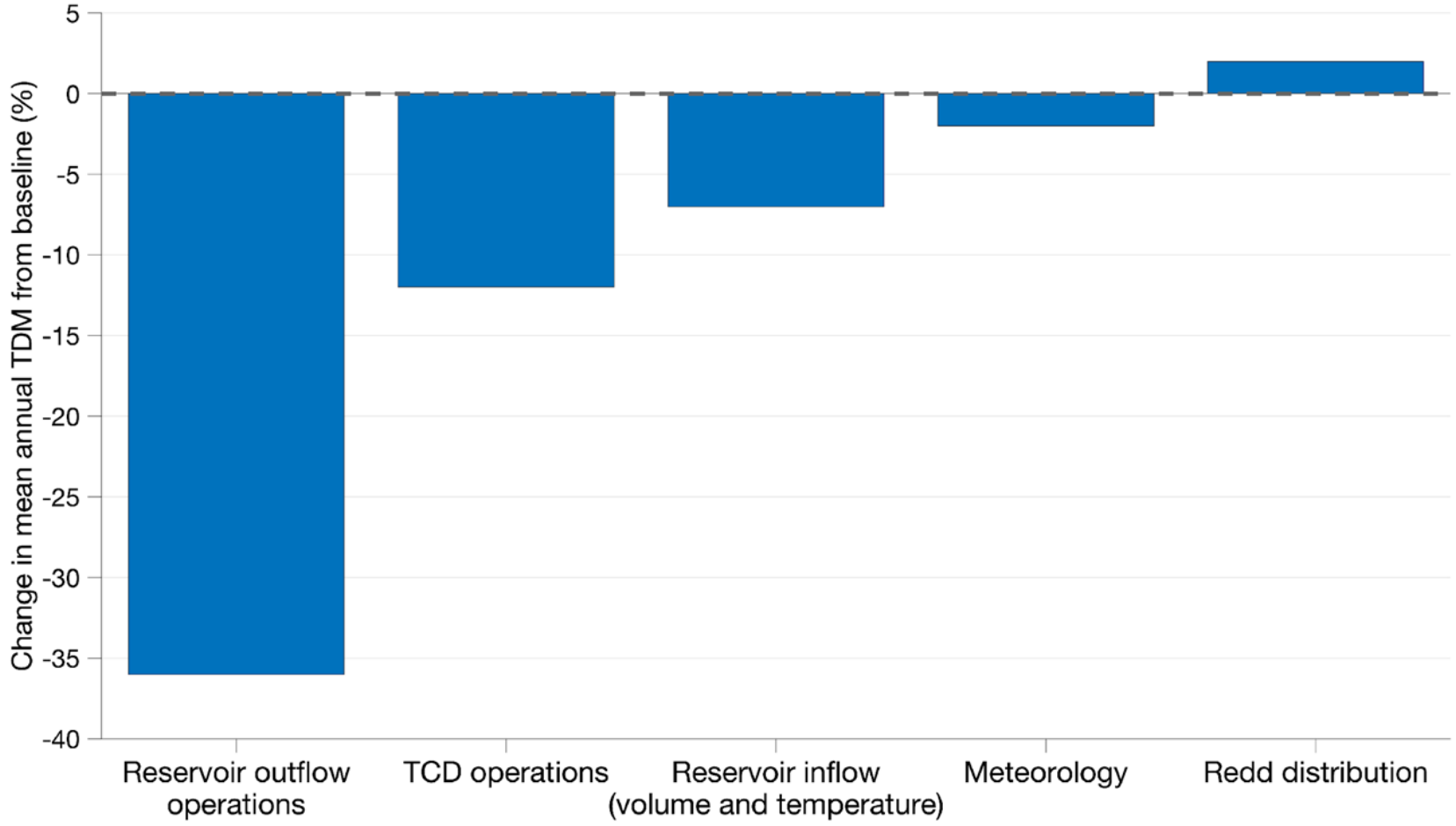
- Shasta TCD operations time series (colored horizontal lines) overlaid on Shasta's vertical temperature distribution near the dam (A) and downstream SAC temperature (B).

Redd distribution

- Spatial and temporal redd distributions for 2021 and 2022 overlaid on top of the TDM landscape for the baseline scenario (i.e., all forecasted inputs).



Results



- The estimated change in TDM when using observed inputs compared to the baseline scenario (i.e., all inputs as forecasted in April) for each factor examined.

Lessons and caveats

- All but one factor (redd distribution) resulted in the observed TDM estimate to be lower than forecasted in April.

- Changes in reservoir outflow operations had the largest effect on TDM, with TDM dropping by 36% in this case.

- This analysis indicates that using conservative inputs into a scenario in April will often result in TDM to drop over the season if less-conservative conditions are observed and manifest in system operations.

- *Disclaimer: The factors investigated here are not inclusive of all factors contributing to TDM. Additionally, perturbing model inputs one at a time assumes that each input is independent of others. This assumption is known to be incorrect for this system. Interpretation of this analysis should therefore acknowledge these limitations.*

Thanks for listening!

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NMFS Model

$$ETF = \left(S_o \times \frac{1}{1 + \frac{N}{K}}\right) \times \prod_{i=1}^{n} \exp\left(b_T \times max(T_i - T_{crit}, 0)\right)$$

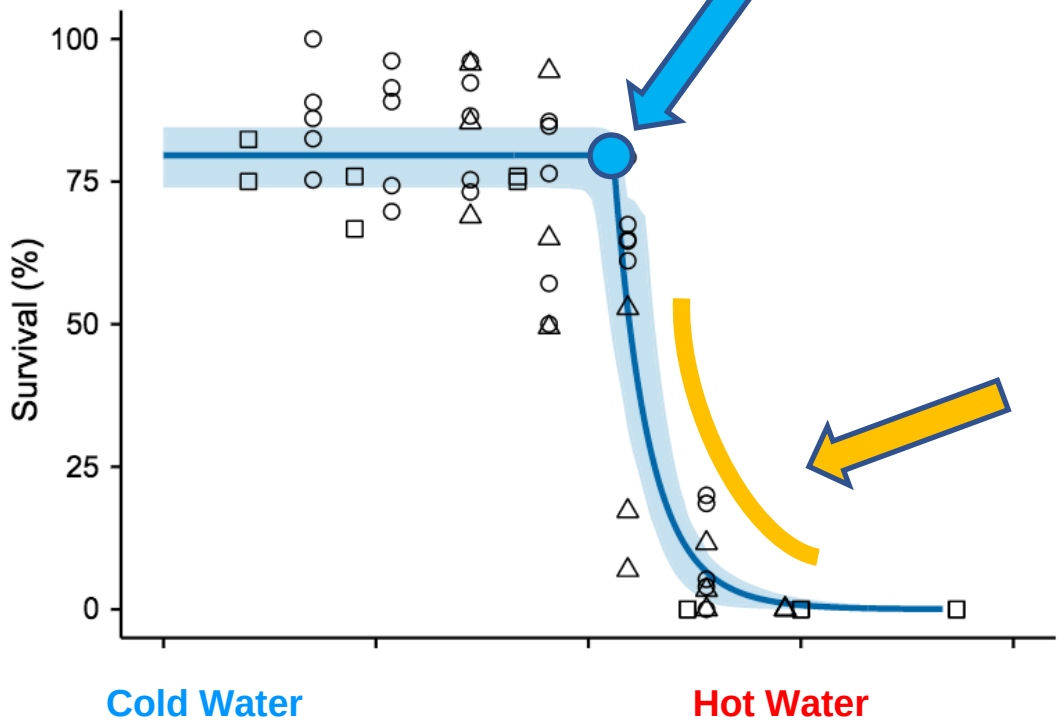
- S_o = *Background survival w/out temperature and density dependence effects, ~36%*
- $\frac{1}{1+\frac{N}{K}}$ = *Background survival w/ density dependence*

  N = number female spawners, K = carrying capacity
- T_{crit} = *Temperature threshold for temperature-dependent egg mortality (TDM)*
- b_T = *slope of TDM relationship when temperature is above threshold*

NMFS Model
Temperature-dependent mortality (TDM)

Best fit T_{crit} = ~12℃

Best fit b_T = 0.02 ℃/day



T_{crit} = *Sets when TDM starts to occur*

b_T = *Sets rate of TDM*