Predicted macroinvertebrate responses to water diversion from a subalpine stream in Yosemite National Park using ecological and two-dimensional hydrodynamic models

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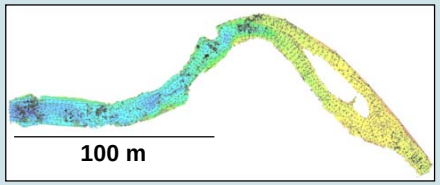
Introduction

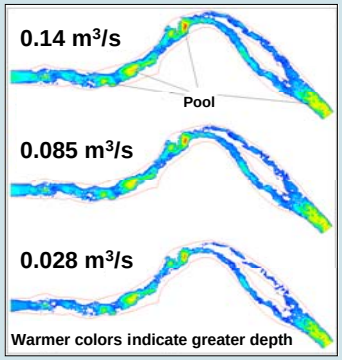
Yosemite National Park is currently involved in planning efforts for the Tuolumne River watershed. Damming, water withdrawal, and other forms of river and stream regulation can have diverse effects on organisms; the duration and seasonal timing of associated low flow conditions can strongly influence organisms both directly and indirectly via changes to habitat. The subalpine Dana Fork of the Tuolumne is representative of common water withdrawal conditions: maximum water removal coinciding with seasonally low flows. We coupled ecological and hydrodynamic models to assess the potential ecological impacts of water withdrawal on habitat and associated benthic macroinvertebrates.

Methods, Modeling, Results

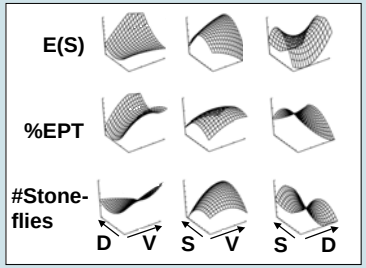
We measured bed topography, flow, depth, and substrate particle size at 3198 points on the study reach; we sampled fauna at 100 points and measured substrate size, depth, and velocity at each point.



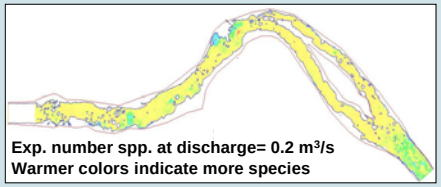
A two-dimensional hydrodynamic model was used to estimate velocity, depth, and wetted area at all 3198 points across a range of flows. Modeled wetted area and depth at three selected flows below:



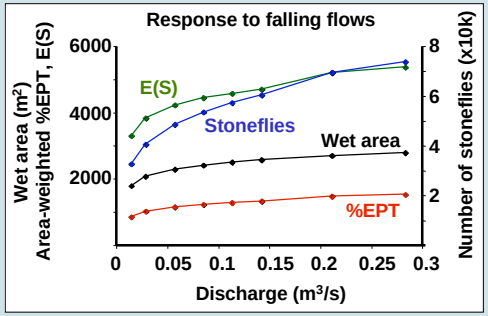
We modeled response of a) expected number of species (E(S)), b) % mayflies, stoneflies, and caddisflies (%EPT), and c) stonefly abundance to physical predictors using ternary quadratic exponential polynomials with cross-product terms. Response surfaces below demonstrate relationships with depth (D), velocity (V), and substrate particle size (S):



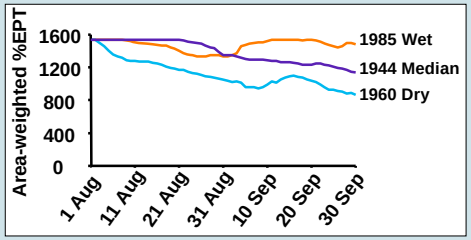
The faunal models were then coupled to the two-dimensional hydrodynamic model allowing prediction of invertebrate metrics at each of the 3198 points across a range of flows. Example below:



Modeled decreases in %EPT paralleled losses of wetted area; E(S) and stonefly abundance declined more precipitously.



Modeled %EPT in wet, dry, and median years during late summer, during seasonal low flows and high withdrawal rates.



Conclusions

Some faunal variables would be expected to decline by a factor of 2-3 in response to flow reductions over the modeled range. Near-zero flow modeling from our companion study in the Merced River suggests that more dramatic losses of wetted area and faunal metrics would begin when discharge falls to 0.02 m^3/s. Our results also likely anticipate responses to lower late season flows due to decreasing snow:rain ratio in a changing climate.

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Further Information

Waddle TJ, Holmquist JG. In Press. River Research and Applications.

Holmquist JG, Waddle TJ. 2013. Ecological Indicators 28:115-124.

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