Ecosphere

Appendix S2: Fish predation on a landscape scale

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Methods for how top covariates were estimated for each 1-km river segment throughout the South Delta.

For 1-km predation risk predictions, we used predator densities as predicted by the most parsimonious Predator Density Model (Loomis 2019) as a proxy mean predator distance. This submodel included sinuosity, bottom roughness, and number of SAV patches as predictor variables. We first generated predator densities for the same 1-km segments throughout the South Delta. We assumed random (Poisson) distribution of predators and simulated a point pattern based on these predator densities in order to convert those values to mean predator distances. We then estimated the mean distance to the ten nearest neighbors for each point in the point pattern, using the “rpoispp” and “nndist” functions in the “spatstat” package (vers. 1.58-2; Baddeley et al. 2015) in R. Finally, the average value of mean distances to ten nearest neighbors was calculated per 1-km segment for use as a predictor in the Predation Risk Model.

The number of SAV patches for the Predator Density submodel were estimated using side-scan sonar in our study sites. For out-of-sample predictions throughout the South Delta, we used a remote-sensed 2015 SAV GIS layer (Hestir et al. 2008, GIS data provided by K. Shapiro, UC Davis). In order to improve correspondence of the remote-sensed SAV data with our in-situ measurements, we removed SAV features less than 5 meters across their longest axis. Additionally, the remote-sensed data included some SAV features occurring in water deeper than SAV is typically found so we removed the features that were found in water deeper than 5 m (*pers. comm.* S. Khanna, UC Davis 2019).

In order to estimate predation risk for the entire 303 1-km segments of the South Delta at a day time-step for the spring of 2017, we needed to estimate water temperature at this same resolution. We downloaded water temperature data from all available water quality gauges in the South Delta from the California Department of Water Resources California Data Exchange Center (http://cdec.water.ca.gov/). In total, 27 gauges spread throughout the South Delta had daily temperature data for the period spanning from March 25th to May 31st of 2017. We then used spatial inverse-distance weighting to interpolate daily temperatures for that same period for the remaining 276 1-km segments that did not include a temperature gauge. To interpolate temperature (*T*) at site *s* for a given day:

$$T_s = \frac{\sum_{i=1}^{27} \left(\frac{T_i}{{d_i}^2}\right)}{\sum_{i=1}^{27} \left(\frac{1}{{d_i}^2}\right)} \qquad (1)$$

Where *i* denotes one of the 27 temperature gauges, and therefore T_i denotes the temperature at that gauge on that day and d_i denotes the distance to that gauge (in meters), as measured by the shortest distance along a waterway (generated using ArcGIS Network Analyst Package). We performed crossvalidation by leaving one of the 27 temperature gauges out at a time, interpolating the temperatures at that site for the same time period using the remaining 26 gauges, and compared the interpolated temperatures to the actual gauge temperatures. A linear regression between these two for the 27 iterations of the crossvalidation resulted in a median r-squared of 0.99 (ranging from 0.95 to 1.0) and a median slope of 1.0 (ranging from 0.79 to 1.17), suggesting that the temperature interpolation was successful in capturing both the magnitude and daily fluctuations in actual measured temperature.

References

Baddeley, A., E. Rubak, and R. Turner. 2015. Spatial Point Patterns: Methodology and Applications with R. London: Chapman and Hall/CRC Press, 2015. http://www.crcpress.com/Spatial-Point-Patterns-Methodology-and-Applications-with-R/Baddeley-Rubak-Turner/9781482210200/

Hestir, E. L., S. Khanna, M. E. Andrew, M. J. Santos, J. H. Viers, J. A. Greenberg, S. S. Rajapakse, and S. L. Ustin. 2008. Identification of invasive vegetation using hyperspectral remote sensing in the California Delta ecosystem. Remote Sensing of Environment 112:4034-4047.

Loomis, C. M. 2019. Density and distribution of piscivorous fishes in the Sacramento – San Joaquin Delta. Master’s Thesis. Humboldt State University, Arcata, California. 319. https://digitalcommons.humboldt.edu/etd/319