8803. Building of the Bayesian Network Relative Risk Model for the Upper San Francisco Estuary and the Analysis of Risk.

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Preliminary Results and Conclusions

1) It is possible to build conceptual model and Bayesian network relative risk model to exposure the causes of risk within the Upper San Francisco Estuary (USFE or commonly called the Delta) in California.

2) The dataset is comprised on hundreds of thousands of entries from the CEDEN and SURF data collections. The last ten years of data were used to parameterize the current models in order to make the risk estimates.

3) Does response curves were derived to estimate the toxicity of mixtures that are constructed to specific toxicity targets such as the EC_{20} or other values. The dose-responses curves are derived from primary data in each instance.

4) In the toxicity pathway, Bifenthrin is the driver in the risk analysis as shown by the model and the sensitivity analysis. In the ten years of data used do derive the distribution Bifenthrin does exist at concentrations that would exceed an EC_{20} value for total fish mortality.

Introduction

The Sacramento-San Joaquin River Delta Watershed (Delta) drains the entirety of the Central Valley of California with many different contaminants ending up in Suisun Bay and the Delta. Agricultural and urban land use practices are the primary sources for these contaminants. Contaminants have long been considered a threat to fish, as well as other aquatic organisms in the Suisun/Delta region of the upper San Francisco Estuary (USFE). The USFE contains key species and ecosystem services. The Delta smelt, a key forage fish endemic to California and only present in the San Francisco Estuary. Chinook salmon are an iconic species and many runs pass through the USFE to spawning grounds upstream. The macroinvertebrate community is a food resource to multiple fish and other species. The habitats in the region support these and numerous other birds, mammal, amphibian, and insect species, as well as provide recreational opportunities and water for irrigation, drinking, transportation.

Figure 1. Map of the Delta Region.

Methods

Bayesian Network Relative Risk Model

We apply the Bayesian Network Relative Risk Model (BN-RRM). It is the current incarnation of the Relative Risk Model (Landis and Wiegers 1997, 2005, 2007) using Bayesian networks to describe the relationships between sources of stressors, stressors, habitats, effects, and endpoints (Ayre and Landis 2012. Landis 2021, Mitchell et al 2021). Bayesian networks easily incorporate a variety of types of data, including that from expert elicitation, as well as integrate probabilistic interactions and provide detailed descriptions of uncertainty and the importance of the variables in the estimation of risk. This approach is used across the world to assess risks in estuaries of Southeast Queensland, Australia (Graham et al. 2019), the South River, VA (Landis et al. 2017a, 2017b, Harris et al 2017, Johns et al. 2017, Landis et al 2020), and Africa (O'Brien et al. 2018). Specific types of stressors have included stormwater runoff (Hines and Landis 2014), invasive species, and emergent diseases (Herring et al. 2015, Ayre et al. 2014).

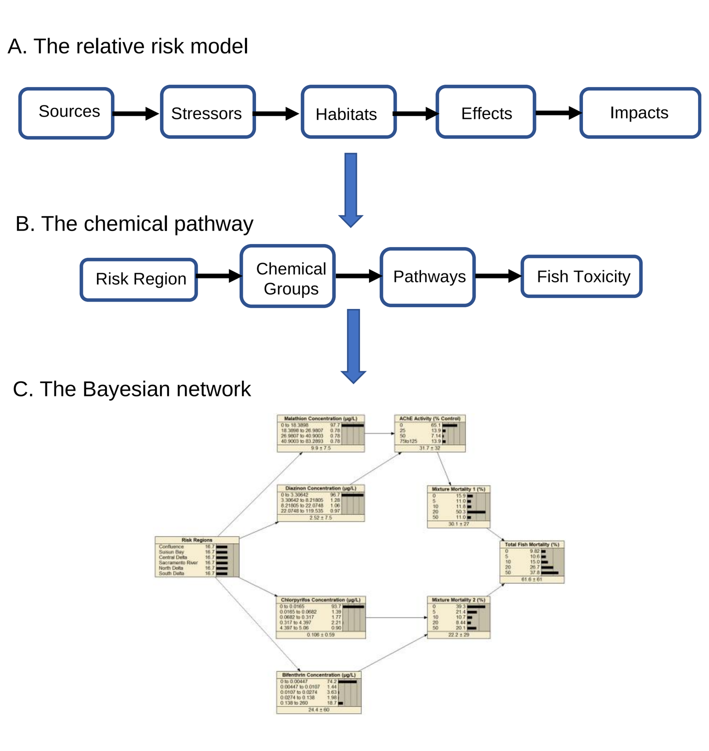

Figure 2. Pathway from conceptual model to Bayesian network.

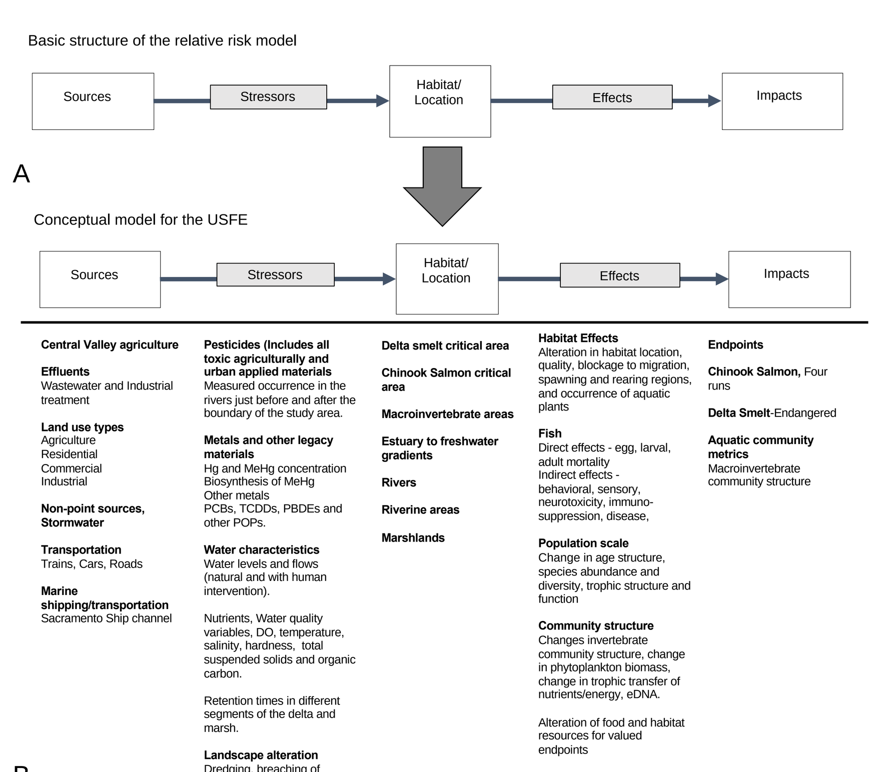

Figure 3. Conceptual model for overall Delta program.

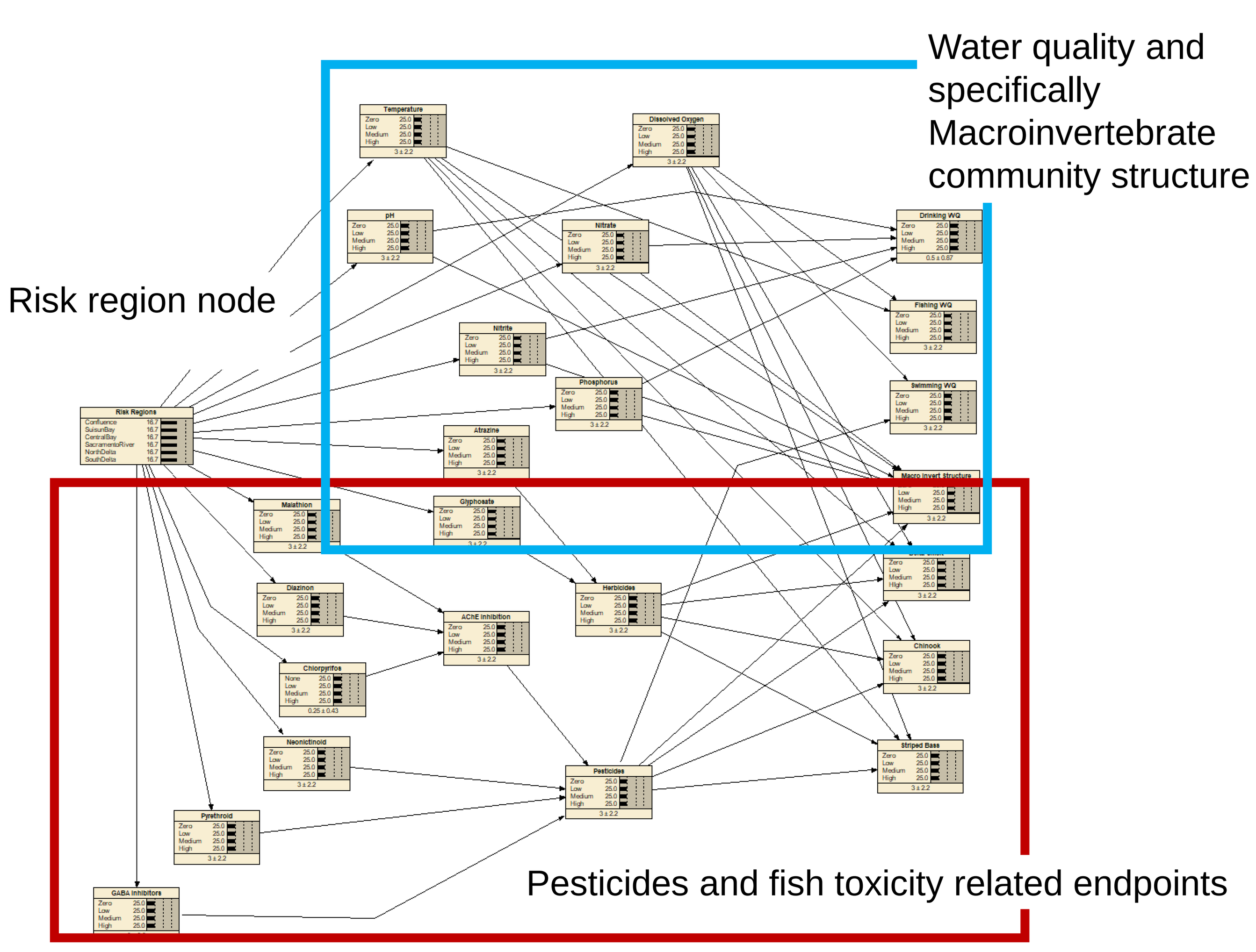

Figure 4. Preliminary Bayesian network outline for the Delta risk calculation. This step corresponds to Step C in Figure 2. In this presentation we are focusing on pesticides and toxicity endpoints.

To see the final version of this poster and other publications/presentations, check out the website at https://wp.wwu.edu/toxicology/research/presentations.

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Dataset construction

Project Data. The data for the Bayesian networks for the USFE were developed using an integration of water quality and chemical data from California Environmental Data Exchange Network (CEDEN) and DPR Surface Water Database (SURF) , land use data from USGS NLCD , and precipitation data from Oregon State University PRISM Climate Database. IETC-modified data and R code are accessible through GitHub . The core data components for this project are currently stored within 6 GitHub repositories. Each repository contains R markdown documentation on how to fully reproduce data processing and analyses from a data source to its modified output. Output data is then incorporated into Bayesian networks in Netica.

IETC GitHub repositories contain the data, code, and documentation for modifying CEDEN data, modifying and integrating SURF data with CEDEN data, creating dose-response models, analysis of macroinvertebrate data, land use tabulations for our project area, and the preparation of source and stressor data for Bayesian network conditional probability tables.

The USFE project also utilizes spatial project data compiled and maintained within a local geodatabase for map production and spatial analysis. Essential shapefiles –such as project boundaries and sampling station locations– are derived from this geodatabase and stored within our GitHub repositories.

Therefore, we can build datasets that contain the concentrations of chemicals in the different regions of the USFE or California Delta.

Estimating the Toxicity of Mixtures

1. For each mixture component, fit a log logistic 3 parameter model to the available toxicity data.
2. For each mixture component, calculate the ECx.
3. For each mixture component, normalize the concentrations of the toxicity data by the EC_x.
4. For each mixture component, fit a log logistic 3 parameter model to the EC_x normalized data.
5. Take the geometric mean of the three-log logistic 3 parameter model parameters for the EC_x normalized models.
6. Use the geometric means in the log logistic 3 parameter model to create the mixture equation.

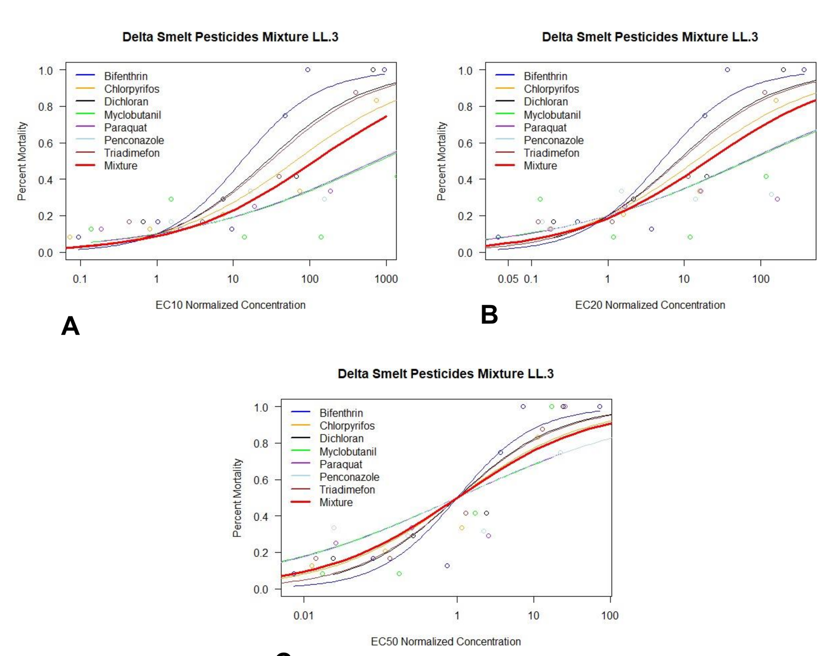

Figure 5. Comparison of the exposure-response model curves for several chemicals using EC10 (A), EC20 (B) and EC50 (C) normalized concentrations. The data are from Hutton et al. (2021).

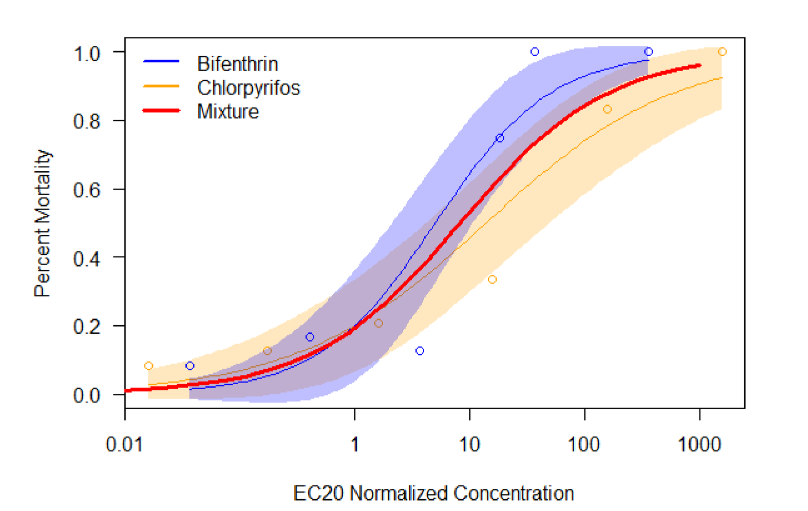

Figure 6. Model averaging approach for EC20 normalized mixture of Bifenthrin and Chlorpyrifos. Individual curves are color coded. The points are average concentrations, and the shaded areas are 95% confidence intervals. Data are from Hutton et al. (2021).

Preliminary Analysis

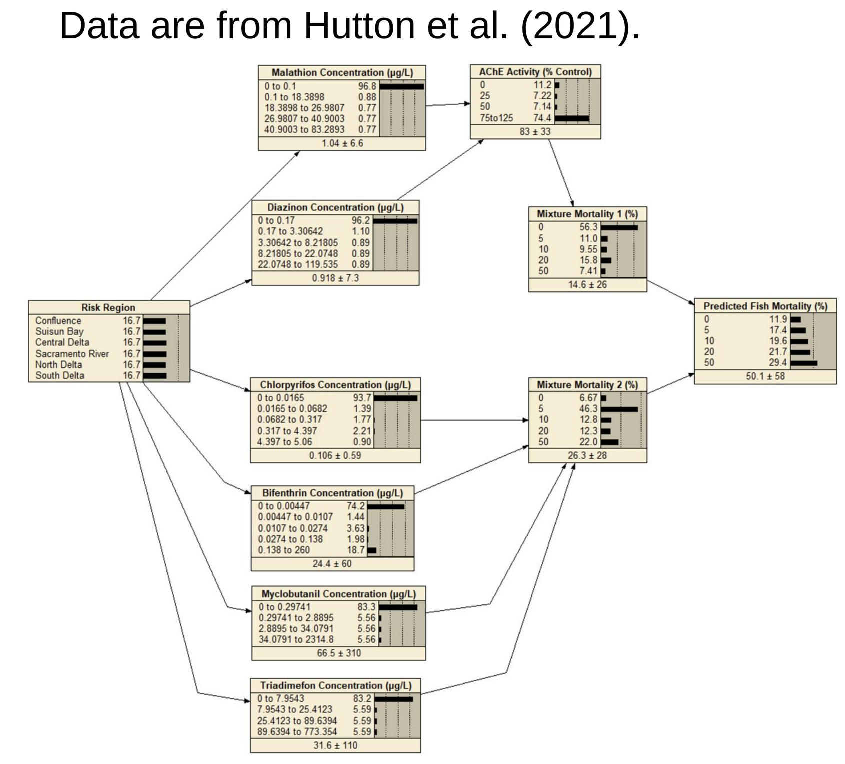

Figure 7. Current BN model. The calculation of the probability of Fish Mortality for the overall Delta Region.

Bifenthrin is the driver in the risk analysis as shown by the model and the sensitivity analysis. In the ten years of data used do derive the distribution Bifenthrin does exist at concentrations that would exceed TRVs for total fish mortality.

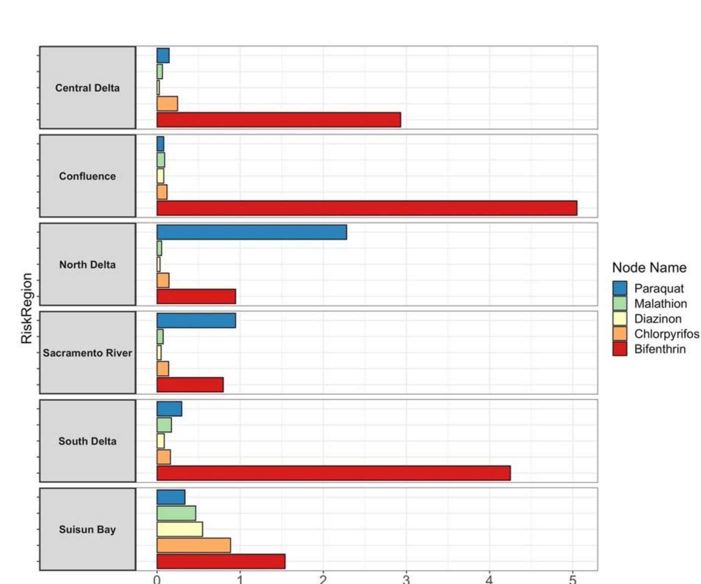

Figure 8. Sensitivity analysis for each of the risk regions for each node

Sensitivity analysis (Figure 8). The next step is to rank the most important nodes in determining the estimated Fish Mortality for each of the risk regions. We performed a sensitivity analysis on each BN that was created for the study (7 BNs total). The "Sensitivity to Findings" tool within Netica was used to run this analysis. "Sensitivity to Findings" measures mutual information between each of the input nodes and the endpoint node (Pollino et al. 2007; Norsys Software 2014). A high value of mutual information for an input indicates a greater degree of influence on the endpoint node (Marcot 2012). Mutual information is a function of both the findings in the node (input frequency) and the relationship described in the CPT (Marcot 2012; Norsys Software 2014). The outputs for each Risk Region are illustrated in Figure 8.