**Investigative Workshop: Modeling Contamination of Fresh Produce**
**NIMBioS April 24-25, 2014**
**Speakers, Title and Abstracts:**

**Bob Whitaker**:
Title: Opportunities and Challenges: the state of food safety in the produce industry

Abstract: This talk will be a welcome message on behalf of the industry, set the tone for the workshop and highlight the significance of produce contamination modeling.

**Jim Brennan**:
Title: Pathogen risk assessment: A review of commercial pre-harvest surveillance data

Abstract: This presentation is a summary review of over 7-years of commercial leafy green pre-harvest pathogen testing data. The review will encompass data from the major leafy greens growing areas of California and Arizona. Differentiation between commodities, agricultural practices and growing regions will be discussed. Several case studies of pathogen detection will be included in the review.

**Devon Zagory**:
Title: Postharvest Food Safety and Modeling Opportunities

Abstract: Much of contamination of fresh produce with human pathogens probably occurs in the field during production and harvest. Subsequent handling can amplify and spread that initial contamination. In addition, there are some pathogens that typically are carried by people that can contaminate produce postharvest. Finally, the environmental pathogen *Listeria monocytogenes* can become established in handling facilities and then contaminate fresh produce. This presentation will briefly discuss the biology of pathogens and the consequent likelihood of finding or excluding them and the implications for modeling in postharvest handling operations.

**David Oryang**:
Title: FDA Risk Modeling Tools for Enhancing Fresh Produce Safety

Abstract: Human foodborne outbreaks associated with the consumption of fresh produce continue to occur in the United States. For the Food and Drug Administration (FDA), prevention of foodborne outbreaks is at the heart of food safety. The FDA Food Safety Modernization Act (FSMA) Standards for Produce Safety (Sec. 105) directs the Agency to establish science-based, minimum standards for the safe production and harvesting of fruits and vegetables. In this effort, FDA is developing several risk tools for modeling the likelihood and public health consequences of produce contamination, and characterizing the public health impacts of interventions.
Risk assessment is a structured and reproducible means of determining the impacts of specific control measures and proposed standards on produce safety and public health, and can be used to inform decision-making. A conceptual overview of three produce risk models being developed at FDA will be presented as follows:

1. FDA-iRISK®: An interactive, Web-based, risk assessment modeling tool (freely available at http://foodrisk.org/exclusives/). It quantitatively compares and ranks risks posed by multiple food/hazard combinations that involve FDA-regulated products, taking into account consumption, dose-response relationship, as well as contamination in the food supply system, from production to consumption. It can provide an industry-wide or farm-level perspective of the risk.
2. GIS-Risk: A collaboration between FDA and NASA, to link geographic information systems with predictive risk-assessment models. The ultimate goal is to forecast when, where, and under what conditions microbial contamination of crops is likely to lead to human illness. It provides a regional perspective of risk.
3. QPRAM: The Quantitative Produce Risk Assessment Model (QPRAM) is an agent based virtual laboratory that models specific practices and risk factors along the farm to fork continuum. QPRAM tracks each unit of produce; keeping a history of how, when, where, and by how much it was contaminated, and allowing risk evaluation. It provides a facility (individual farm or processing facility) level perspective of risk.

This is joint work with Yuhauan Chen.

**Amy Greer**:
Title: A practical introduction to modeling complex systems: a primer for thinking about the introduction and spread of infectious diseases along the farm to fork continuum.

Abstract: Agricultural systems have become more complex over time. Industrial processes used to prepare agricultural products such as produce to enter the commercial market combined with the inherent complexity of the environment in which we grow crops create both opportunities and challenges for the prevention and control of pathogens within the food chain. A model is a simplified replica of a complex system. Mathematics provides a powerful language to translate a verbal description of a problem into a mathematical formulation that we can use as a virtual laboratory. Models can provide a potential mechanistic explanation for observed patterns and allow us to untangle the underlying biological mechanisms regulating the dynamics. I will demonstrate how to translate a research question into a mathematical model and then use this simple model to discuss how simulation can provide insight into the potential pathogen contamination of fresh produce. Ultimately, all models are challenged with the task of deciding which aspects of the "real-world" to include and which to ignore. There is a compromise between realism and the tractability of the mathematics. Model choice will depend on not only the perceived importance of different factors but also on data availability and the overall purpose of the model. I will highlight different ways that we can incorporate complexity into a simple model in order to better represent the true nature of the complex system.

**Hermann Eberl**:
Title: Listeria overgrowth as a mathematical problem

Abstract: In a standard procedure of food safety testing, the presence of the pathogenic bacterium *Listeria monocytogenes* can be masked by non-pathogenic *Listeria*. This phenomenon of *Listeria* overgrowth is not well understood. We present a mathematical model for the growth of a mixed population of *L. innocua* and *L. monocytogenes* that includes competition for a common resource and allelopathic control *of L. monocytogenes* by *L. innocua* when this resource becomes limited, which has been suggested as one potential explanation for the overgrowth phenomenon. The model is a relatively simple system of four ordinary differential equations. It is tested quantitatively and qualitatively against experimental data in batch experiments.
This is joint work with Hedia Fgaier, Martin Kalmokoff and Tim Ellis.

**Partha Srinivasan**:

Title: A Mathematical Model of Chlorine Wash-Cycles with Cross-Contamination

Abstract: We present a simple quantitative mathematical description of the effect of chlorine in effectively dealing with pathogen survival and cross-contamination during a produce wash-cycle of lettuce and spinach. Our model is based on the experimental work done by Yaguang Luo's group and reproduces the amount of free chlorine measured, and the MPN of pathogens both in the lettuce and in water. We also estimate some of the parameters involved in this process, and propose relevant experiments that can validate the estimation of these parameters. Our hope is that the model can give precise dynamics of chlorine and pathogen levels in a typical wash-cycle.

This is joint work with Daniel Munther, Yaguang Luo, Bin Zhao, Jianhong Wu and Felicia Magpantay