Climate Change and Foodborne Disease

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Manifestations and Predictions

- Temperature changes
  - Projected increase of 1.8-4° C over next century
- **Associated weather changes**
  - Regional in nature
  - Increased humidity, rainfall
  - More arid environments
  - Associated changes in ocean currents/temps (ENSO)
- **Manifestations**
  - Catastrophic weather events
    - Flooding
    - Droughts
    - Hurricanes
  - Changes in population dynamics
  - Changes in agricultural production
  - Eutrophication (nutrient loading)

Why Global Climate Change Matters to Food Safety and Security

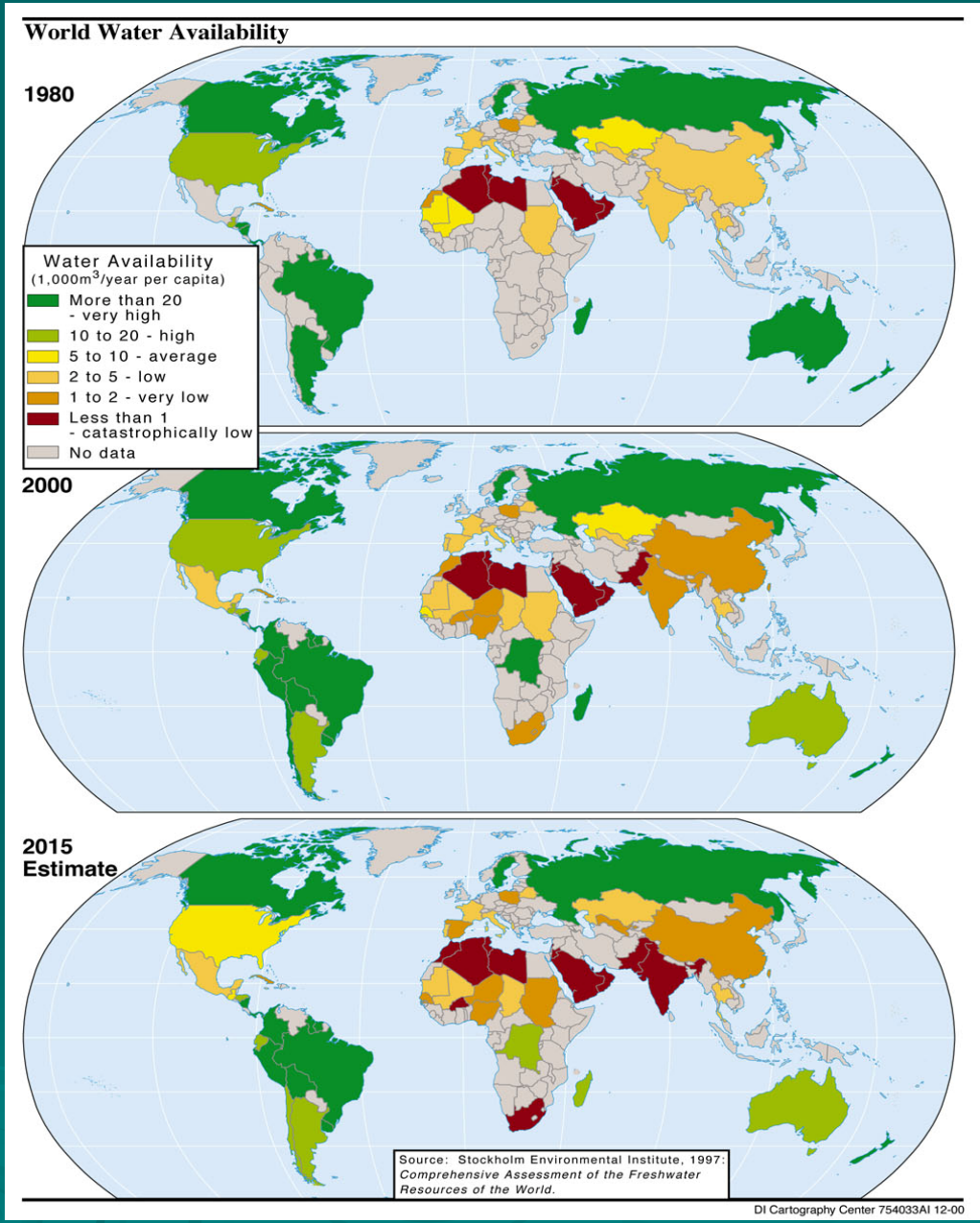
- Premise #1: Water and food safety and security are intimately linked and cannot be separated from one another: WATER IS THE COMMON DENOMINATOR!
- Premise #2: The major manifestations of climate change are temperature and nutrient overload, both of which impact the safety and security of the earth's food and water supplies
- Premise #3: The major result of changes to temperature and nutrient load are changes in ecology, of people, animals, pests, and microbes
- Premise #4: These ecological changes have unintended consequences in the form of risks to human health

Anticipated Changes to Food Safety

- Water
  - Availability
  - Drought
  - Flood
  - Catastrophic weather events
- Frequency and distribution of food borne disease
  - Seasonality
  - Distribution
- Pathogen emergence
- Examples

Importance of Water Availability

- Clean and abundant water is essential to food production, processing and preparation
- Without water, adequate hygiene is impossible
- Too much water results in increased risk of fecal contamination



Implications of Catastrophic Weather Events

- Loss of infrastructure
- Population Displacement
- Hurricane Katrina-An example

Widespread Outbreak of Norovirus Gastroenteritis among Evacuees of Hurricane Katrina Residing in a Large "Megashelter" in Houston, Texas: Lessons Learned for Prevention

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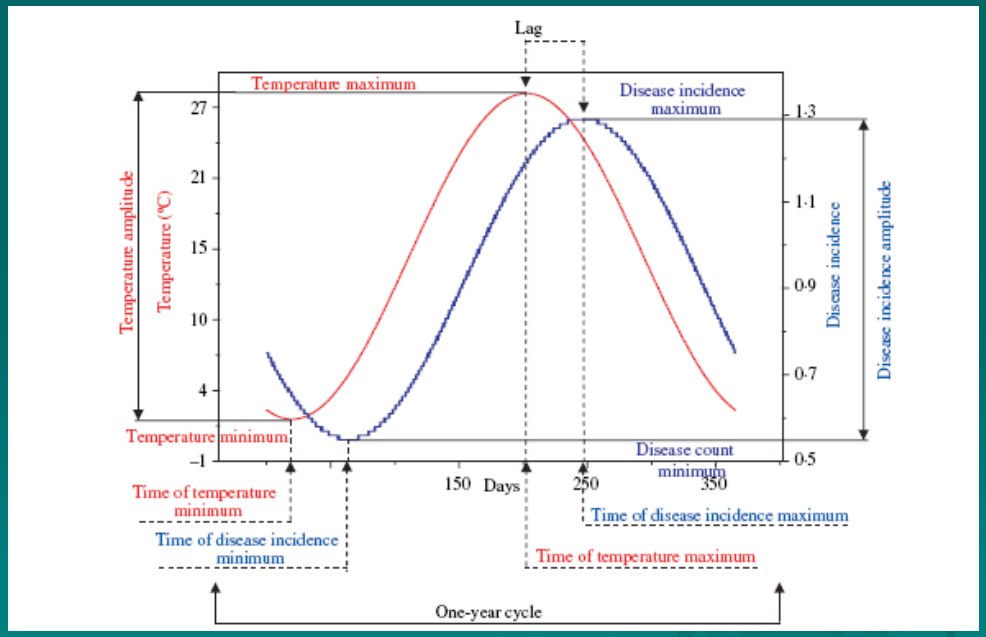
Frequency and Distribution of Disease: Seasonality

- Many enteric diseases have seasonal increases, presumed to be associated with increased temperature



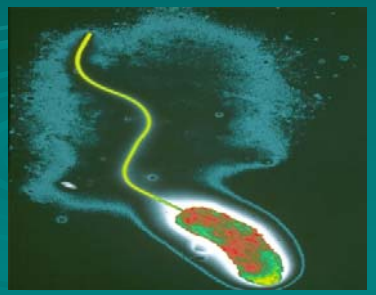
For *Salmonella* and *Campylobacter*, disease peaks 2-14 days after ambient temperature peak

For *Cryptosporidium*, *Giardia*, and *Shigella*, disease peaks ~40 days after ambient temperature peak

From: Naumova et al., 2007

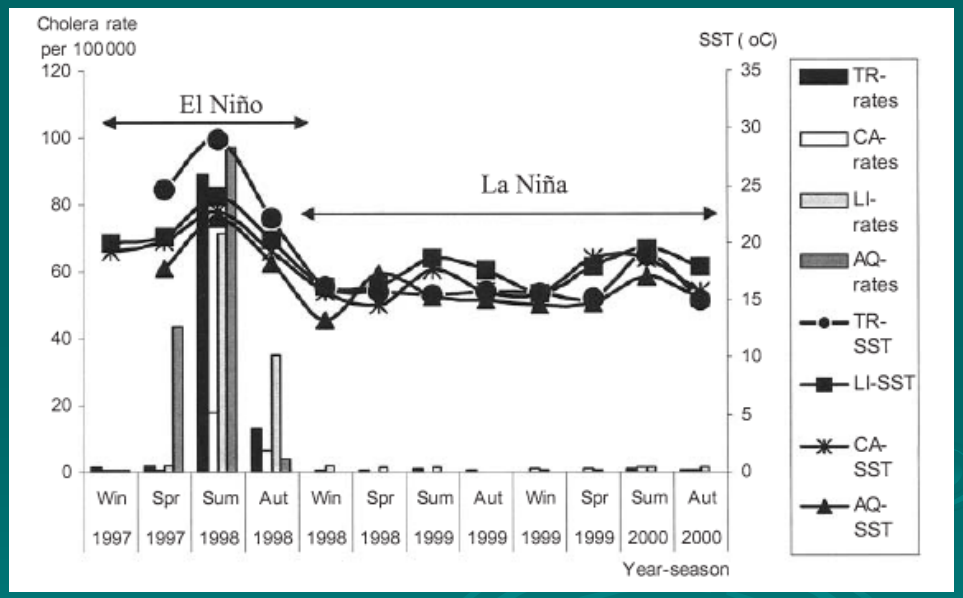
The Pathogenic *Vibrio* Species

- Ubiquitous marine organisms associated with food and waterborne disease (*V. cholerae, V. parahaemolyticus, V. vulnificus*)
- *Vibrio parahaemolyticus*
  - U.S. outbreaks in late 1990's (northern US waters)
  - Emergence of pandemic strain (O3:K6)
  - Strains of increased virulence?
- *Vibrio vulnificus*
  - Emergence of biotype 3
  - Cases in Europe
- *Vibrio cholerae*



Frequency and Distribution of Disease: Geographic Range and Temperature

- Cholera epidemic in Latin America (early 1990's) likely extension of the 7th pandemic into the Western hemisphere in association with
  - International trade
  - Increased water temperature



From: Gil et al., 2004

Vibrio cholerae: Example of Microbe-Climate-Environment Interactions

- Cholera is endemic in certain areas of the world, with disease peaks associated with increasing sea surface temperature and sea surface height
- Microbial ecology of *V. cholerae* is complex and influenced by several factors:
  - Abiotic
  - Phytoplankton
  - Zooplankton
- Toxin production?

Box 2: Interaction of ecological factors on the proliferation of *V. cholerae*:

- Some investigators believe that photosynthetic phytoplankton proliferation results in elevated environmental pH. This alkaline pH:
  i) gives *V. cholerae* a competitive advantage over other marine bacteria since it thrives at higher pH and
  ii) promotes attachment of *V. cholerae* cells to zooplankton (particularly copepods); this protects *V. cholerae* cells from external stresses.
- As phytoplankton populations disintegrate, additional nutrient sources are available to stimulate the growth of the organism. Together, the interplay of these factors results in extremely high populations of *V. cholerae* in tight association with copepods.

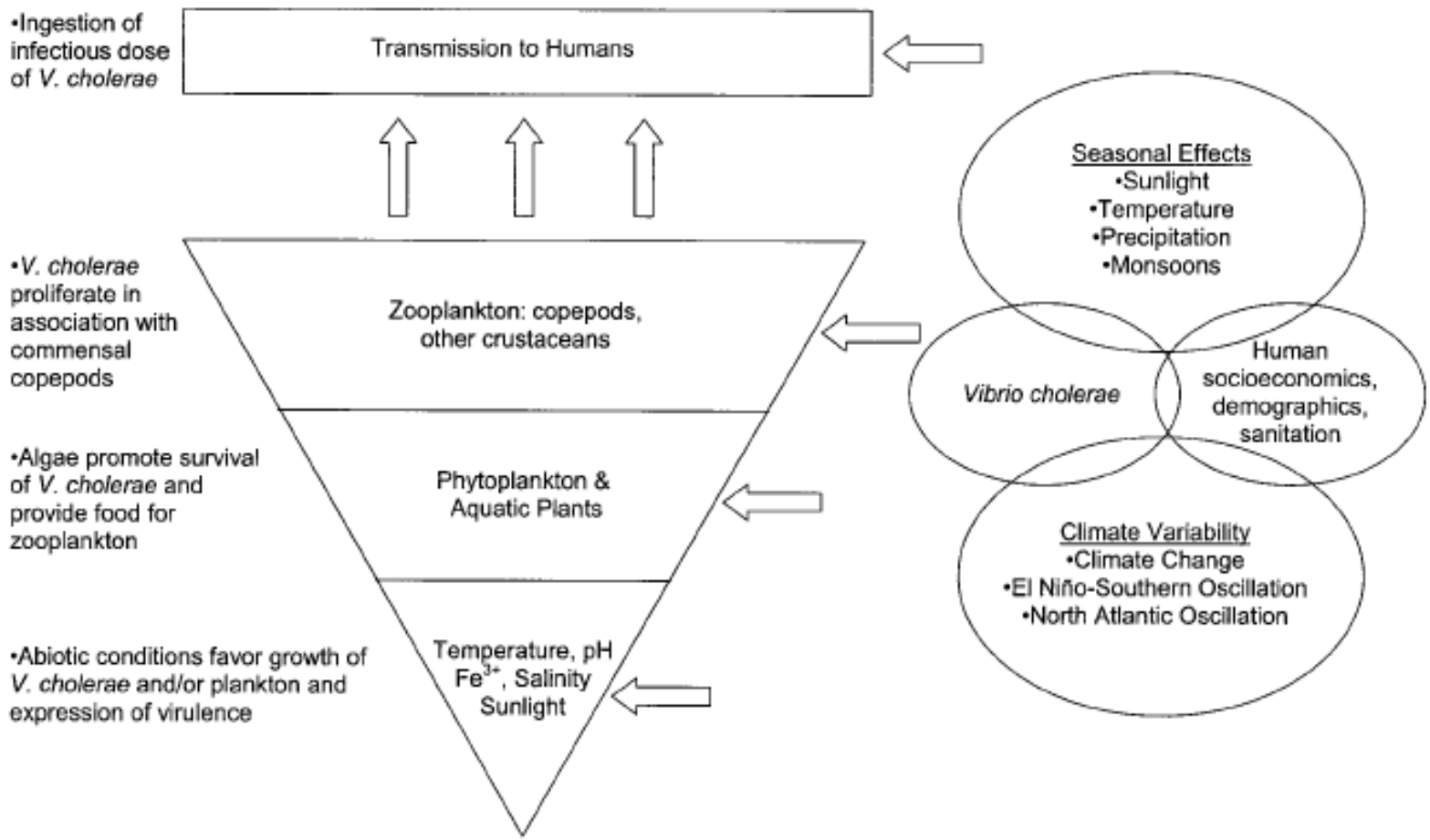
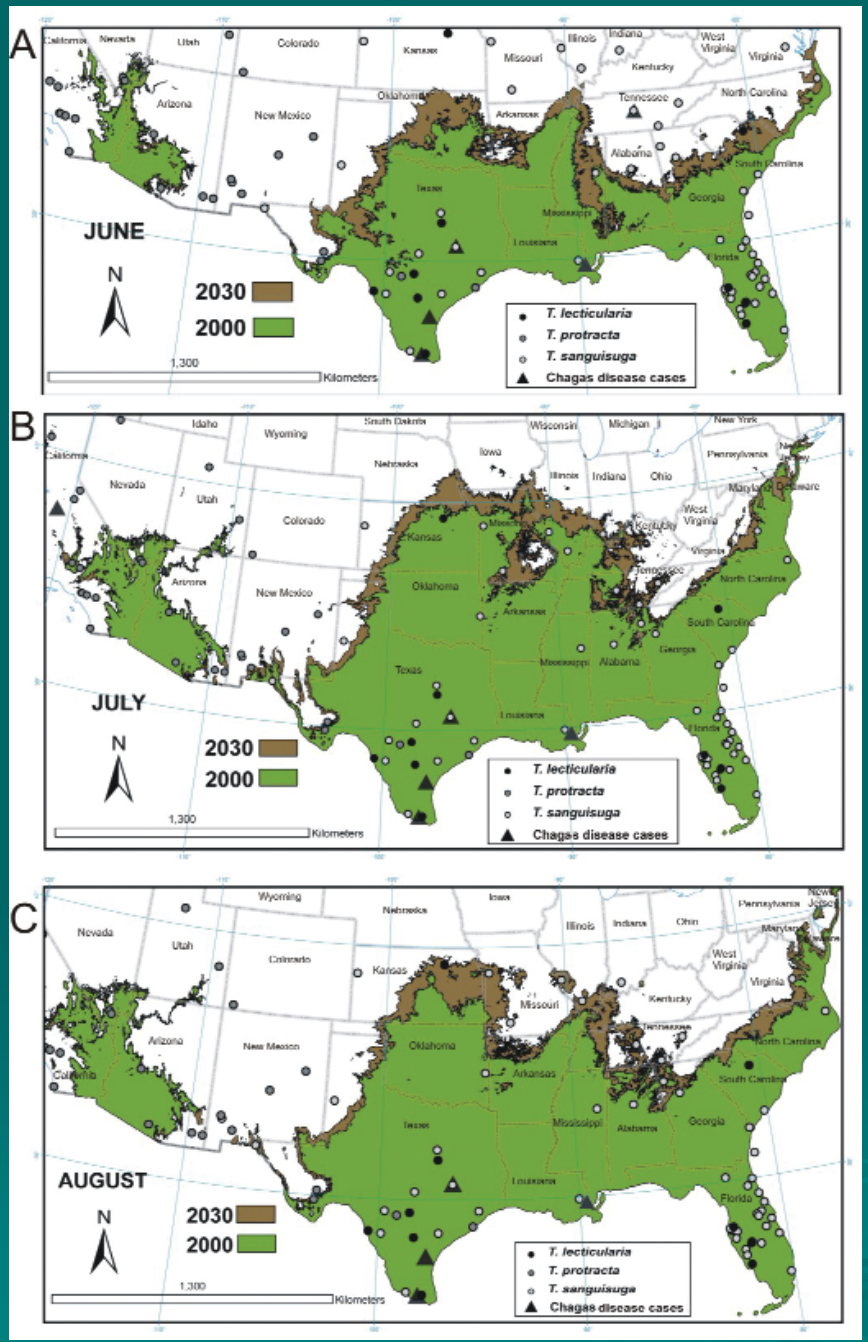


FIG. 1. Hierarchical model for environmental cholera transmission (modified from Colwell and Huq [30]).

From: Lipp et al., 2002

Zoonotic Disease

- Diseases transmitted to humans via animal reservoirs
- Climate change
  - Increases susceptibility of animals to diseases
  - Increases range and abundance of vectors/animal reservoirs
  - Prolongs transmission cycles of vectors
  - Affects animal husbandry practices
  - Veterinary drug use and residues



Emerging Pathogens: Chagas Disease

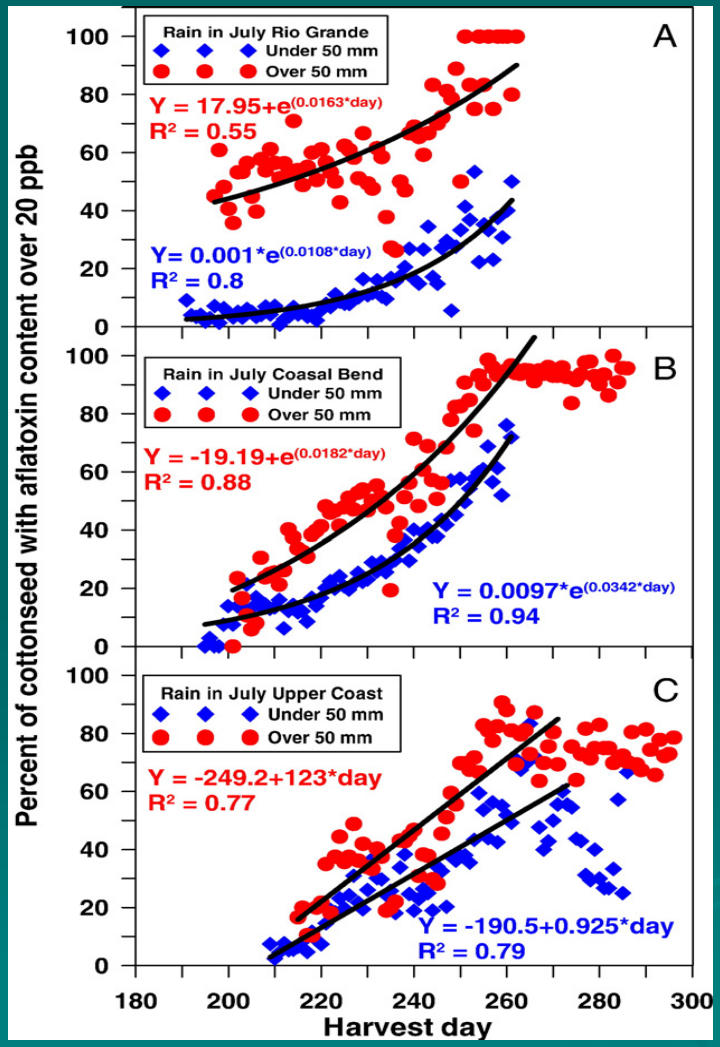
- Trypanosomiasis caused by intracellular parasite *Trypanosoma cruzi* transmitted by triatomine bugs
- High temperatures
  - Accelerate development of the pathogen in the vector
  - Lead to shorter vector life cycles and
  - Higher vector population densities
- Food borne transmission recently documented in Central and South America (juices)

From: Lambert et al., 2008

Mycotoxins

- Highly toxic chemicals produced by toxigenic moulds
  - *Aspergillus* (aflatoxin)
  - *Fusarium* (trichothecenes)
  - Corn (maize), rice
- Moist, humid, and warm conditions favor mold growth
- Conditions adverse to plant (stress induced by drought, pest attack, poor nutrient status) favor mycotoxin production
- Temperature, humidity and precipitation

An Aflatoxin Example



Infection occurs pre-harvest in the developing crop (promoted by hot, dry conditions and by plant damage as might occur by pests)

Proliferation and extensive toxin production occur during maturation and post-harvest (promoted by hot, humid conditions and further crop damage)

From: Cotty and Jaime-Garcia, 2007

Conclusions

- Climate change impacts food safety due to:
  - Effects on water availability
  - Effects on frequency and distribution of food borne disease
  - Pathogen emergence
- There are already well documented instances in which climate change has apparently had an effect on food borne disease
- It is all about ecology
- Unfortunately….
  - It continues
  - Effects not necessarily predictable