Climate Change and the Rising Microbial Tide

Steve Jones
Natural Resources & the Environment, NH Sea Grant

Cheryl Whistler, Vaughn Cooper
Molecular, Cellular, and Biomedical Sciences

Tom Safford
Sociology
Respondent: 
Lori Howell
Weather and Climate Extremes in a Changing Climate

Increase in Heavy Daily Precipitation (Top 5%)

- 95% Confidence Interval
- CMIP3 MME A1B (24)
- CMIP5 MME RCP4.5 (39)
- MRI-AGCM3.2H A1B (12)

Observations
Emission Scenario A2*: High at 2100
Emission Scenario A1B*: High at 2050, mid-range at 2100
Emission Scenario B1*: Low at 2100

U.S. Climate Change Science Program
Synthesis and Assessment Product 3.3
Effects of Extreme Precipitation to the Distribution of Infectious Diseases in Taiwan, 1994–2008

Mu-Jean Chen¹, Chuan-Yao Lin², Yi-Ting Wu³, Pei-Chih Wu⁴, Shih-Chun Lung², Huey-Jen Su¹

Vibriosis, Deadly Disease Associated With Raw Oysters, May Get More Common As Ocean Warms

Posted: 02/07/2013 10:31 am EST | Updated: 02/07/2013 1:32 pm EST

428 people like this.

Figure 1. Risk maps of the 8 climate-related infectious diseases following extreme precipitation events were generated when the analysis was integrated with the GIS system. The townships that had a significant association between the outbreak of the specified disease with the category of extreme precipitation events are marked on each map. Townships that had significant associations with heavy precipitation are marked in light purple, with torrential precipitation are marked in purple, while those that only had significant associations with extreme torrential precipitation are marked in dark purple.

doi:10.1371/journal.pone.0034651.g001
Who are *Vibrio*?

- Ubiquitous, FAST-growing bacteria in brackish water
- A group of 50 or more species
- Several are associated with human disease
  - *Vibrio cholerae*  \( Vc \)
  - *Vibrio vulnificus*  \( Vv \)
  - *Vibrio parahaemolyticus*  \( Vp \)
Why do we care?

• Oysters are a growth industry and a primary source of infection because they are uncooked.

• We have decades of experience working together to study Vibrios in the environment here at UNH.

• *Vibrio*-associated disease is emblematic of other microbial rising tides.
Coherent, multidisciplinary science is essential to respond to and mitigate emergent infection associated with climate change.

The scale of UNH, and the long history of studying Vibrios in the Great Bay Estuary, have positioned us ideally.
Cases of Vibriosis* in New England states: 2000-13
(no NH vibriosis cases have been associated with NH shellfish)

*Vibriosis-Infections caused by Vibrio species (~6 different species in New England)

Data from CDC, MA DPH, ME CDC, RI DH
Sources of Vibriosis in the Northeast US

Most vibriosis is caused by *Vibrio parahaemolyticus* (Vp).

Most vibriosis cases in the Northeast are associated with shellfish/oyster consumption.

Most implicated shellfish are from the Northeast.

### 2013 Shellfish-borne Vibriosis Cases in Northeast US:

<table>
<thead>
<tr>
<th>State</th>
<th>Vp cases</th>
<th>In-state</th>
<th>Regional*</th>
<th>Possible source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>45</td>
<td>23</td>
<td>15</td>
<td>84%</td>
</tr>
<tr>
<td>MA</td>
<td>52</td>
<td>33</td>
<td>13</td>
<td>88%</td>
</tr>
</tbody>
</table>

*Regional= Northeast source implicated, possibly with non-regional sources*
What factors could explain these REGIONAL trends?

• Increased *regional* production & consumption during the summer
• Increased vibriosis reporting in Northeast *region*
• *Regional* environmental & climatic factors
• Invasion of new strains or *regional* population evolution

How do we manage this issue?

• How do *regional* ecosystem and climatic factors affect pathogenic Vibrios, & can we forecast problem/non-problem conditions?
• Post-harvest management strategies
Great Bay Estuary-NH & ME

Major Oyster Bed Locations

Nannie Island, Oyster River, Piscataqua River, Spinney Creek = study sites
Figure 1: Commercial Oyster Aquaculture Operations, 2013
DETECTION: Enrich to increase numbers, culture to isolate, & molecular analysis

Isolate Vibrios by growth on nutrient-enriched agar media

or use quantitative PCR
Vibrio parahaemolyticus (Vp), V. vulnificus (Vv) & V. cholerae (Vc) in Great Bay oysters

Inter-annual *Vibrio parahaemolyticus* concentrations (MPN/g) in Great Bay oysters: 2007-14
Water Temperature and *Vibrio parahaemolyticus* Concentrations in Oysters at Nannie Island and Oyster River from 2007-2014

NOTE: 2012 was the warmest year on record in the Gulf of Maine (NERACOOS)
Average monthly salinity (NOAA-PREP datasonde) in the Oyster River

-wide variations

Other factors: plankton species & abundance, nutrients, pH
Average monthly water temperature (15 min readings) at Nannie Island: 2002 to 2013
Average monthly *V. parahaemolyticus* levels (Vp/100g) in Nannie Island oysters over 3 decades

→ Ecosystem conditions are becoming more favorable for Vp
Reduction of *V. parahaemolyticus* by “Relaying” oysters (from harvest site to area with low Vp levels)

<table>
<thead>
<tr>
<th></th>
<th>At harvest</th>
<th>14 day relay</th>
<th>Reduction factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>129</td>
<td>9</td>
<td>14x</td>
</tr>
<tr>
<td>July</td>
<td>5630</td>
<td>372</td>
<td>15x</td>
</tr>
<tr>
<td>August</td>
<td>1600</td>
<td>3</td>
<td>533x</td>
</tr>
<tr>
<td>September</td>
<td>30</td>
<td>3</td>
<td>10x</td>
</tr>
</tbody>
</table>

→ The mechanism is a biological factor associated with higher salinity water
*V. parahaemolyticus* constitutes a small fraction of the diverse & variable microbial community in oysters.

How variable is the 'microbiome' of oysters?
Putative pathogenic *V. parahaemolyticus* strains in Great Bay oysters

<table>
<thead>
<tr>
<th>DATE</th>
<th>tdh</th>
<th>trh</th>
<th>Concentration</th>
<th>Temperature</th>
<th>Salinity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total Vp/g</td>
<td>°C</td>
<td>ppt</td>
</tr>
<tr>
<td>2007</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009*</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>-</td>
<td>-</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013†</td>
<td>18%+</td>
<td>15%+</td>
<td>150 to 460,000</td>
<td>23-26</td>
<td>18-29</td>
</tr>
</tbody>
</table>

*tdh/trh detected in 'temperature-abused' samples

†tdh/trh positive samples collected from June 25 to August 5