The Power of Observations for...

... improved decision making in support of public health and economic vitality:

Gathering Alligators, Taking Observations, Realizing Solutions (GATORS)

Dwayne E. Porter*
Arnold School of Public Health, University of South Carolina
and the NOAA National Estuarine Research Reserve System

* And a host of others who actually do the work including:
But before we begin ...

So take it all with a grain of salt...
Usual anthropogenic culprits...

... along with farm animals, wildlife and pets...
... and some we did not realize!
<table>
<thead>
<tr>
<th>Source</th>
<th>Bacteria</th>
<th>No. Isolates</th>
<th>No. Isolates</th>
<th>Total No. of Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alligator</td>
<td><em>Aeromonas hydrophila</em></td>
<td>24</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td><em>Aeromonas punctata</em></td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><em>Aeromonas veronii</em></td>
<td>23</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td><em>Citrobacter freundii</em></td>
<td>47</td>
<td>45</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td><em>E. coli</em></td>
<td>21</td>
<td>20</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td><em>Edwardsiella tarda</em></td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td><em>Enterobacter aerogenes</em></td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><em>Enterobacter cloacae</em></td>
<td>16</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella planticola</em></td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><em>Klebsiella pneumoniae</em></td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td><em>Plesiomonas shigelloides</em></td>
<td>64</td>
<td>14</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td><em>Salmonella enterica</em></td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>207</td>
<td>118</td>
<td>325</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>Fecal Coliform (density/g [wet wt] feces)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alligator</td>
<td>8.0 x 10⁹</td>
<td>Johnston et al., 2010</td>
</tr>
<tr>
<td></td>
<td>3.0 x 10⁹</td>
<td>Current Study</td>
</tr>
<tr>
<td></td>
<td>1.6 x 10¹⁰</td>
<td></td>
</tr>
<tr>
<td>Duck</td>
<td>3.3 x 10⁷</td>
<td>Schueler and Holland, 2000</td>
</tr>
<tr>
<td></td>
<td>8.1 x 10³</td>
<td>Cox et al. 2005</td>
</tr>
<tr>
<td>Human</td>
<td>1.3 x 10⁷</td>
<td>Schueler and Holland, 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holland, 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Schueler and Holland, 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cox et al. 2005</td>
</tr>
<tr>
<td>Dog</td>
<td>2.3 x 10⁷</td>
<td>Schueler and Holland, 2000</td>
</tr>
<tr>
<td></td>
<td>3.1 x 10⁷</td>
<td>Cox et al. 2005</td>
</tr>
<tr>
<td>Turtle</td>
<td>1.6 x 10⁶</td>
<td>Harwood et al., 1999</td>
</tr>
<tr>
<td>Cow</td>
<td>2.3 x 10⁵</td>
<td>Schueler and Holland, 2000</td>
</tr>
<tr>
<td></td>
<td>1.8 x 10⁵</td>
<td>Cox et al. 2005</td>
</tr>
</tbody>
</table>
Observations? ... Data? ...

Underwhelming!

Unknown and/or overwhelming!
Explanatory variables available from coastal real-time monitoring programs include:

- **Meteorological**
  - Rainfall
  - Wind
  - Weather

- **Physical/Chemical**
  - Current
  - Salinity

- **Tidal Conditions**
  - Tide Range
  - Lunar Phase
The real value is in integrating observing systems!
Data assimilation and integration from multiple monitoring sources including:

**Field programs**
- Bacteria density
- Salinity
- Air/water temp
- Tide
- Weather

**Observing systems**
- Rainfall
- Currents
- Salinity
- Wind

**Remote sensing / Models**
- Salinity
- Air/water temp
- Rainfall
- Currents
- Wave activity
Data collection, assimilation and integration

Data assimilation  ≠  Data integration
Models have to be accurate, reliable, understandable and implementable!

Database
- Rain
- Temp
- Tide
- Wind
- Salinity
- General weather

Model Development
- Tree model
- Regression model
  \[ E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon \]

Operational model
- Decision Rules
  If \( x < a \), then P1, else P2
- Prediction Equation
  \[ E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... \]

Selected new data

GIS
Officials still advise swimmers to stay out of ocean

People ignore warning of high bacteria levels

Golden Beach is one of three beaches where swimmers were being warned July 18, 2018, to stay out of the water because of high levels of fecal matter. Pedro Portal - pportal@miamiherald.com

MIAMI-DADE COUNTY

High levels of poop lead to swimming advisory at three South Florida beaches

BY CARLI TEPROFF
coproff@miamiherald.com
July 18, 2018 07:15 PM
Updated July 18, 2018 07:23 PM

The Florida Department of Health in Miami-Dade County is warning people to think twice before swimming at three South Florida Beaches — Golden Beach, Crandon Beach North and Crandon Beach South.

That’s because water samples show that there’s too much fecal matter.

Bacteria level in surf draws DHEC warning

By Scott Harper

Last week’s coastal storm did more than just soak the area. It is believed to have caused high levels of bacteria in the ocean, and a warning to stay out of the surf.

According to Georgetown’s Communications Director, Thomas Williams, the storm dumped more than 6.04 inches of rain on the coast Thursday and Saturday.

The South Carolina Department of Health and Environmental Control in Hollywood warned swimmers to stay out of the ocean due to bacteria levels.

The public is especially advised against swimming in the general area of storm drains, according to Ross Tate, DHEC’s district director.

DHEC conducted bacteria tests throughout the weekend and will lift the advisory when water quality improves.

Number of beach closures due to pollution rose last year, report says

Asia-Pacific
Investments

Aberdeen-Asset.US/Asia-Funds

Closures were up to their second-highest level in 20 years, the Natural Resources Defense Council study said, partly because of the Gulf of Mexico oil spill and heavy rainfall.
CAUTION
A SWIMMING ADVISORY HAS BEEN ISSUED FOR THIS SECTION OF THE BEACH BY THE SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL. HIGH BACTERIA LEVELS HAVE BEEN DETECTED IN THIS BEACH AREA AND SWIMMING IS NOT ADVISED UNTIL BACTERIA LEVELS RETURN TO NORMAL. WADING, FISHING, AND SHELL COLLECTING DO NOT PRESENT A RISK.

FOR INFORMATION ABOUT THIS ADVISORY CONTACT YOUR LOCAL DHEC EQC OFFICE OR CALL (803) 898-4015

FOR MORE INFORMATION:
1-800-441-4636 ext. 1500
www.wibeaches.us

CAUTION
WATER QUALITY ADVISORY
FOR YOUR SAFETY
- Swim at your own risk
- Do not ingest lake water
- Shower after swimming
- Wash hands before eating
- Do not swim if you are ill

Increased risk of illness may be present
Based on recent monitoring for E. coli bacteria

A health advisory has been posted based on monitoring results. The current conditions at this beach are not suitable for recreational water activities. Small children and chronically ill people are at higher risk for increased illness.
360-407-6543 or the Web at: www.doh.wa.gov/beach
Clean swimming waters –
  •  Mom and dad happy!
  •  Chambers of Commerce happy!

Exposure to bacterial-laden swimming waters –
  •  Mom and dad happy!
  •  Chambers of Commerce happy!

*Tain’t no one happy!!!*
In response to water quality concerns and associated public health concerns

- State health agency routinely (weekly, post rain event, repeat) samples water quality at ocean beaches
- Results used to inform public of potential health risk
Swimming advisories are issued if *Enterococcus* levels

- **>500 MPN/100mL**
  - Issue advisory
- **>104 MPN/100mL**
  - Resample

So … today’s advisory is based on yesterday’s water quality!
A potential improvement offered up to public health officials was that

- Bacterial levels can be predicted with an accuracy adequate to assist decision-makers in the preemptive advisory process
Bacterial levels are driven by multiple inputs and varied forcing functions

**LOADING**
- Precipitation
- Animal waste
- Fertilizer application
- Bacterial input
- Failed septic systems

**SURVIVABILITY**
- Sedimentation
- Solar inactivation
- Temperature
- Tidal flushing
- Salinity
- Wind
- Deposition/resuspension
Building on (student) efforts supported by state beach, shellfish and public health managers, NOAA (SECOORA / IOOS) and EPA, new models from integrated data and simple statistical techniques include:

- Multiple Linear Regression (MLR)
- Classification and Regression Trees (CART)
- Ensemble Modeling integrated with EPA’s VB
2017 Five-Year Review of the 2012 Recreational Water Quality Criteria

U.S. Environmental Protection Agency
Office of Water Office of Science and Technology
Washington, D.C.
Model complexity is dependent upon

- Location
- Availability of data
- Acceptable error

- Errors of omission
  - Fail to issue advisory when water quality is poor
  - Public health risk

- Errors of commission
  - Issue advisory when water quality is good
  - Poor image / revenue loss (i.e. the Chamber of Commerce is not happy)
End result is a decision-support tool available at your fingertips for public health, economic and personal decision making resulting in...
... a win–win situation for *public health* and *economic vitality*!
For more information

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