Supporting Public Health and Local Beach Economies by Integrating In Situ Monitoring, Remotely Sensed Products, and Coastal/ Ocean Observing Systems

Matthew Neet, Dan Ramage and Dwayne Porter[1]
Heath Kelsey and Adrian Jones[2]
[1]University of South Carolina, Arnold School of Public Health
[2] University of Maryland Center for Environmental Science, Integration and Application Network

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Outline

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  * Data integration and processing
  * Predictive models
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  * Study area
  * Proposed collaborations
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* Wrap up

Introduction

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!~~

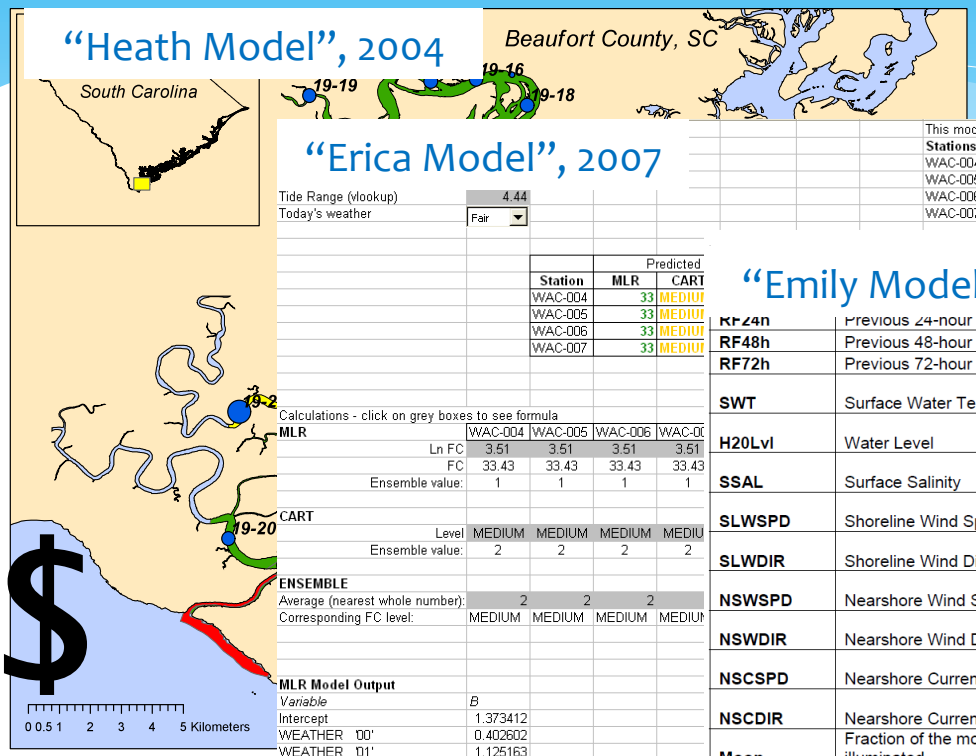
Ain't no one happy!!!

Who we are

* With funding from NOAA Geodetic Surveys and Services, IOOS, SECOORA, EPA, and SCDHEC, we are a collaboration among:

Our brief history

"Heath Model", 2004



"Erica Model", 2007

Tide Range (vlookup)	4.44			
Today's weather	Fair			

	Predicted	
Station	MLR	CART
WAC-004	33	MEDIUM
WAC-005	33	MEDIUM
WAC-006	33	MEDIUM
WAC-007	33	MEDIUM

Calculations - click on grey boxes to see formula

MLR	WAC-004	WAC-005	WAC-006	WAC-007
Ln FC	3.51	3.51	3.51	3.51
FC	33.43	33.43	33.43	33.43
Ensemble value:	1	1	1	1
CART				
Level	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Ensemble value:	2	2	2	2
ENSEMBLE				
Average (nearest whole number):	2	2	2	
Corresponding FC level:	MEDIUM	MEDIUM	MEDIUM	MEDIUM

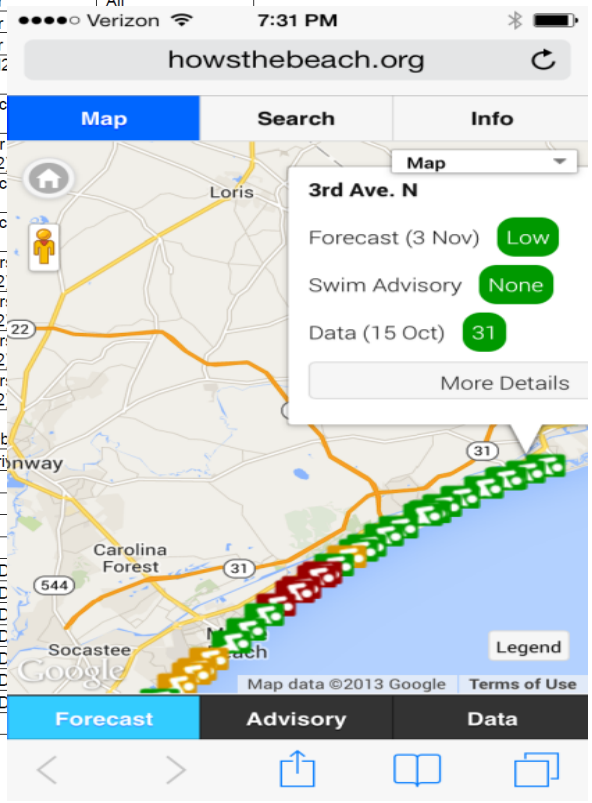
MLR Model Output	
Variable	*B*
Intercept	1.373412
WEATHER '00'	0.402602
WEATHER '01'	1.125163
WEATHER '02'	0.61325
WEATHER '22'	0
DWL	0.22767

This model applies to:

Stations	Description
WAC-004	16th Ave N
WAC-005	3rd Ave N
WAC-006	9th Ave S
WAC-007	17th Ave S

"Emily Model", 2008

		In Model Sets
		Pier CB,CC,CD,CE,CG
		Pier All
RF24h	Previous 24-hour rainfall	Apache Pier
RF48h	Previous 48-hour rainfall	Apache Pier
RF72h	Previous 72-hour rainfall	Apache Pier
SWT	Surface Water Temperature	SUN1; SUN2 Pier;
H20Lvl	Water Level	Sunset Beac (SUN1)
SSAL	Surface Salinity	Sunset Near Buoy (SUN2
SLWSPD	Shoreline Wind Speed	Sunset Beac (SUN1)
SLWDIR	Shoreline Wind Direction	Sunset Beac (SUN1)
NSWSPD	Nearshore Wind Speed	Sunset Near Buoy (SUN2
NSWDIR	Nearshore Wind Direction	Sunset Near Buoy (SUN2
NSCSPD	Nearshore Current Speed	Sunset Near Buoy (SUN2
NSCDIR	Nearshore Current Direction	Sunset Near Buoy (SUN2
Moon	Fraction of the moon illuminated	US Naval Ob
DWL	Tidal Range	NOAA - Deri
YR1212	Previous Days Rainfall	SCDHEC
1DDR	One Day Delayed Rain	SCDHEC
2DDR	Two Day Delayed Rain	SCDHEC
3DDR	Three Day Delayed Rain	SCDHEC
SP2DR	Sum of 2 Days Rainfall	SCDHEC - D
SP3DR	Sum of 3 Days Rainfall	SCDHEC - D
SP4DR	Sum of 4 Days Rainfall	SCDHEC - D
SP5DR	Sum of 5 Days Rainfall	SCDHEC - D
SP6DR	Sum of 6 Days Rainfall	SCDHEC - D
SP7DR	Sum of 7 Days Rainfall	SCDHEC - D
RFI	Rainfall Intensity	SCDHEC - D
Station	Station ID Number	SCDHEC



Goal and objectives

* The ultimate **goal** of our work is to assist public health, beach management, and tourism officials in support of improved decision making.

* Our **objectives** are to:
  * Develop locally-relevant decision-support tools to support our goal, and
  * Demonstrate the geographic and thematic transferability of our tool development approach.

Developing a tool

* In our previous efforts, a water quality tool (app) was developed for beach managers and beach-goers:
  * Designed to predict bacteria concentrations in beach waters
  * The forecasting tools synthesize data from multiple data platforms (e.g. remote sensing, sampling, Integrated Ocean Observing System, etc.)
  * Statistical models are developed to create predictions
  * The tool is automated and updates the database where decision rules are applied to generate the forecasts
  * Forecasts are provided to local health officials and displayed via the website and mobile app

Developing a tool

Tijuana River NERR Model Marsh 2003

Date	Time	Temp	SpCond	Sal	DO	DO	Depth	pH	Turb
MM/DD/YYYY	hh:mm:ss	C	mS/cm	ppt	%	mg/L	m		NTU
01/01/2003	00:00:00	12.4	056.75	37.6	066.0	05.6	0.52	07.7	.
01/01/2003	00:30:00	13.3	056.94	37.8	068.1	05.6	0.52	07.8	.
01/01/2003	01:00:00	14.1	057.25	38.1	011.0	01.7	0.72	01.9	.
01/01/2003	01:30:00	13.3	056.86	37.8	010.3	01.3	0.68	01.7	.
01/01/2003	02:00:00	13.0	056.22	37.3	071.3	06.0	0.55	01.6	.
01/01/2003	02:30:00	12.8	055.34	36.6	063.9	05.4	0.50	01.6	.
01/01/2003									
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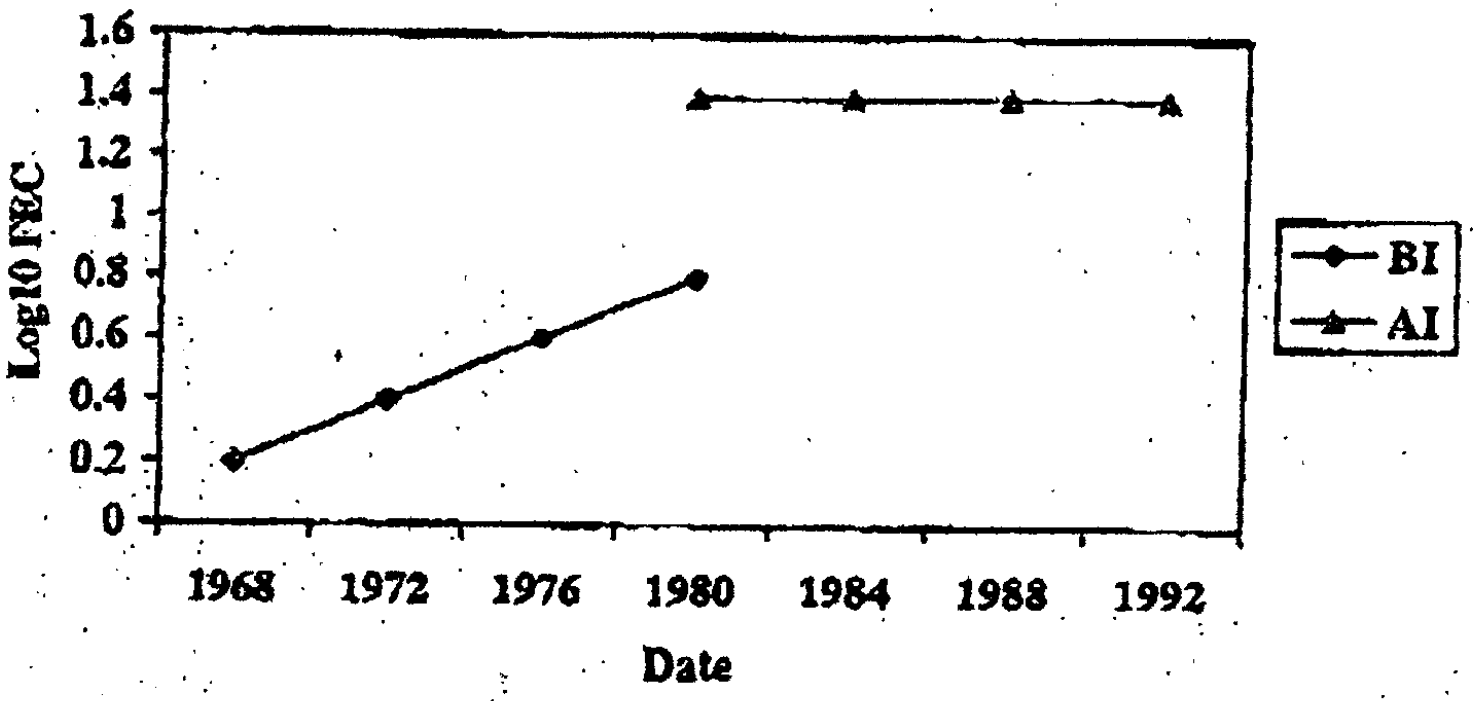
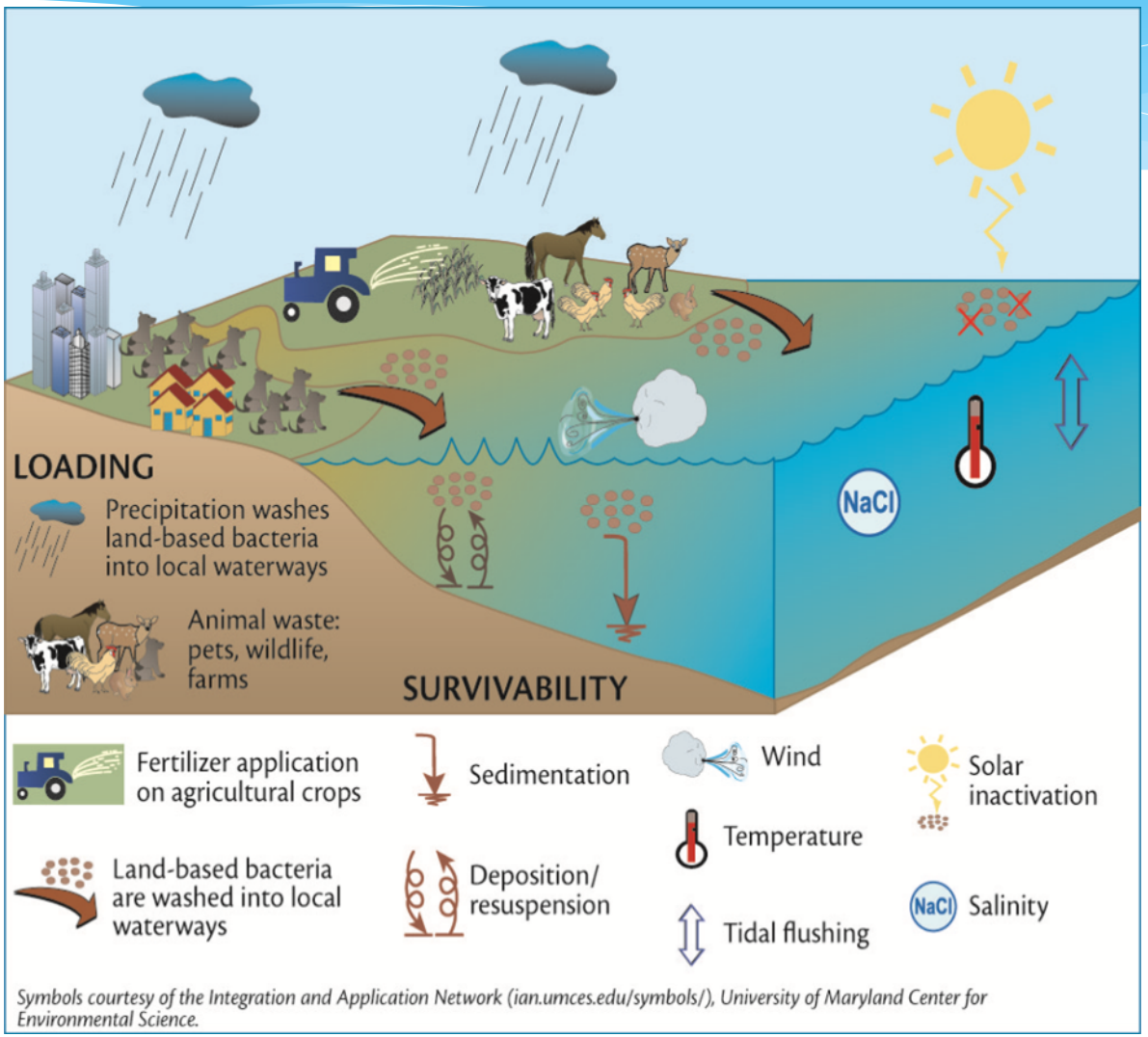


Developing a tool

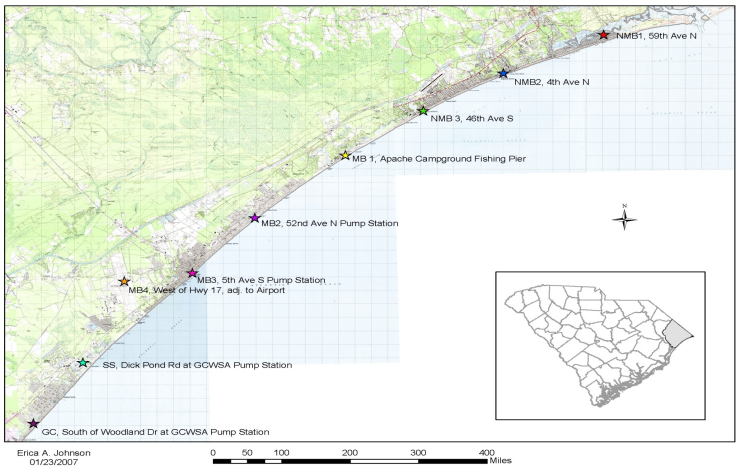
Species	Fecal Coliform (density/g [wet wt] feces)	Source
Alligator	8.0×10^9	Johnston et al. 2010
	3.0×10^9	Current Study
	1.6×10^{10}	
Duck	3.3×10^7	Schueler and Holland, 2000
	8.1×10^3	Cox et al. 2005
Human	1.3×10^7	Schueler and Holland, 2000
Dog	2.3×10^7	Schueler and Holland, 2000
	3.1×10^7	Cox et al. 2005
Turtle	1.6×10^6	Harwood et al., 1999
Cow	2.3×10^5	Schueler and Holland, 2000
	1.8×10^5	Cox et al. 2005

Source	Bacteria	No. Isolates	No. Isolates	Total No. of Isolates
Alligator	***Aeromonas hydrophila***	**24**	**7**	**31**
	Aeromonas punctata	**1**	**0**	**1**
	Aeromonas veronii	**23**	**1**	**24**
	Citrobacter freundii	**47**	**45**	**92**
	E. coli	**21**	**20**	**41**
	Edwardsiella tarda	**0**	**12**	**12**
	Enterobacter aerogenes	**0**	**3**	**3**
	Enterobacter cloacae	**16**	**5**	**21**
	Klebsiella planticola	**3**	**2**	**5**

Predictive models

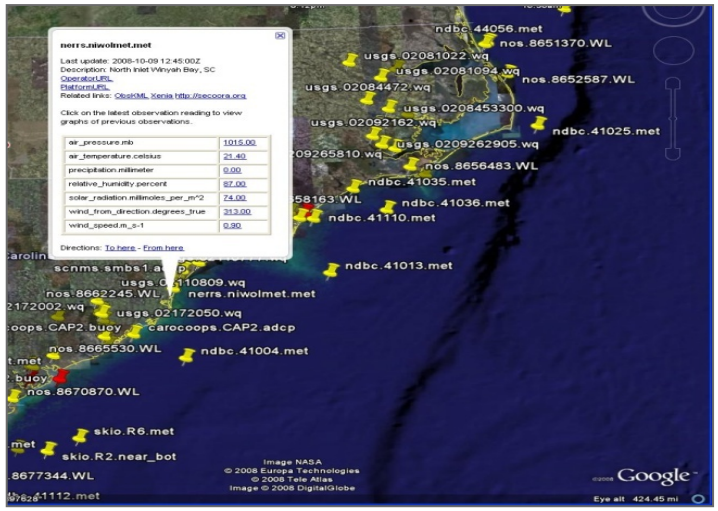


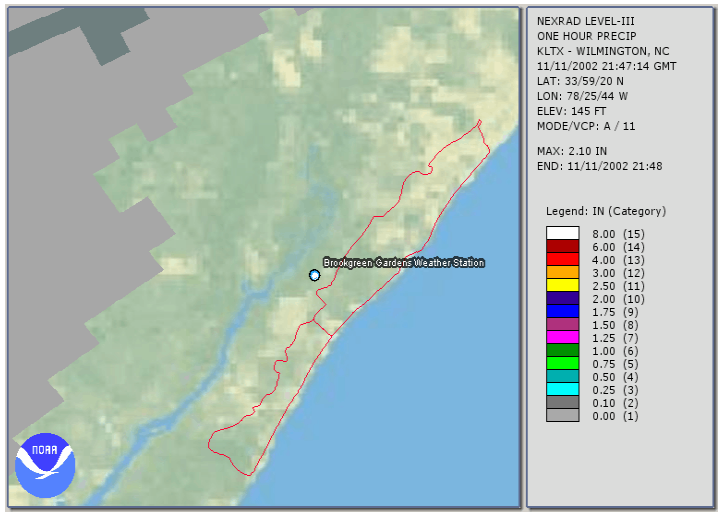
Data integration and processing



Observations? … what observations?

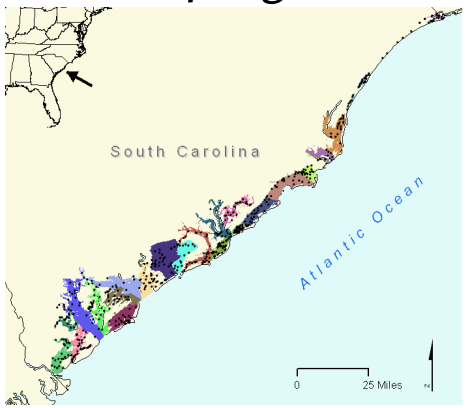
Unknown and/or overwhelming!





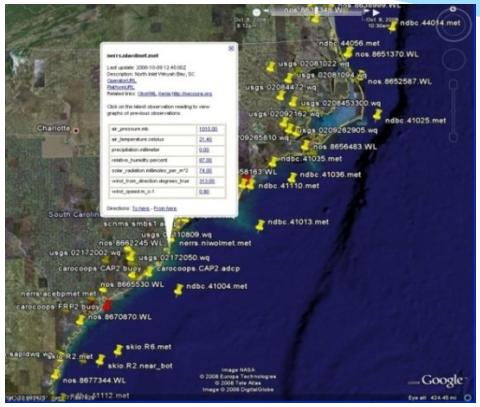
Data integration and processing

Field programs



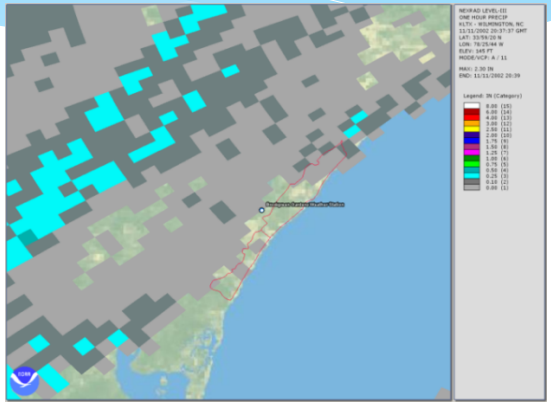
- *Bacteria density*
- *Salinity*
- *Air/water temp*
- *Tide*
- *Weather*

Observing systems



- *Rainfall*
- *Currents*
- *Salinity*
- *Wind*

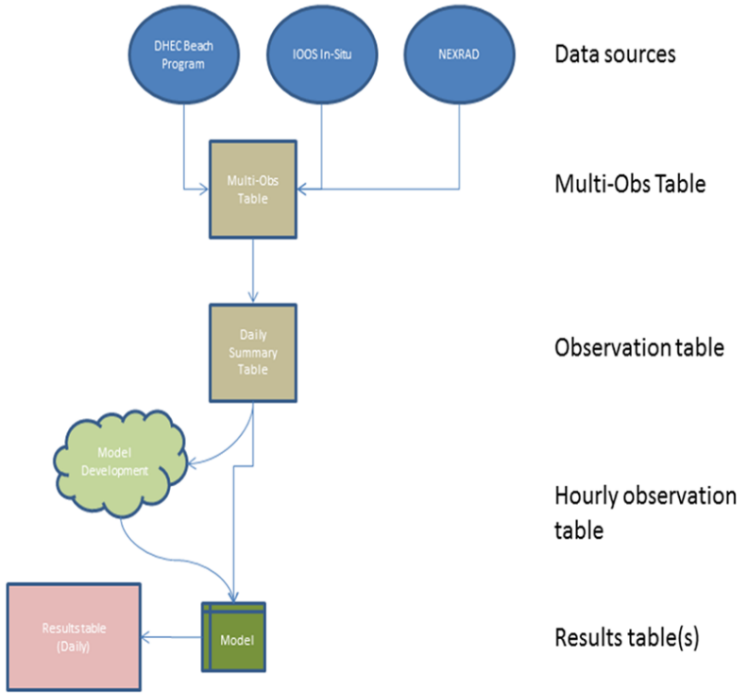
Remote sensing / Models



- *Salinity*
- *Air/water temp*
- *Rainfall*
- *Currents*
- *Wave activity*

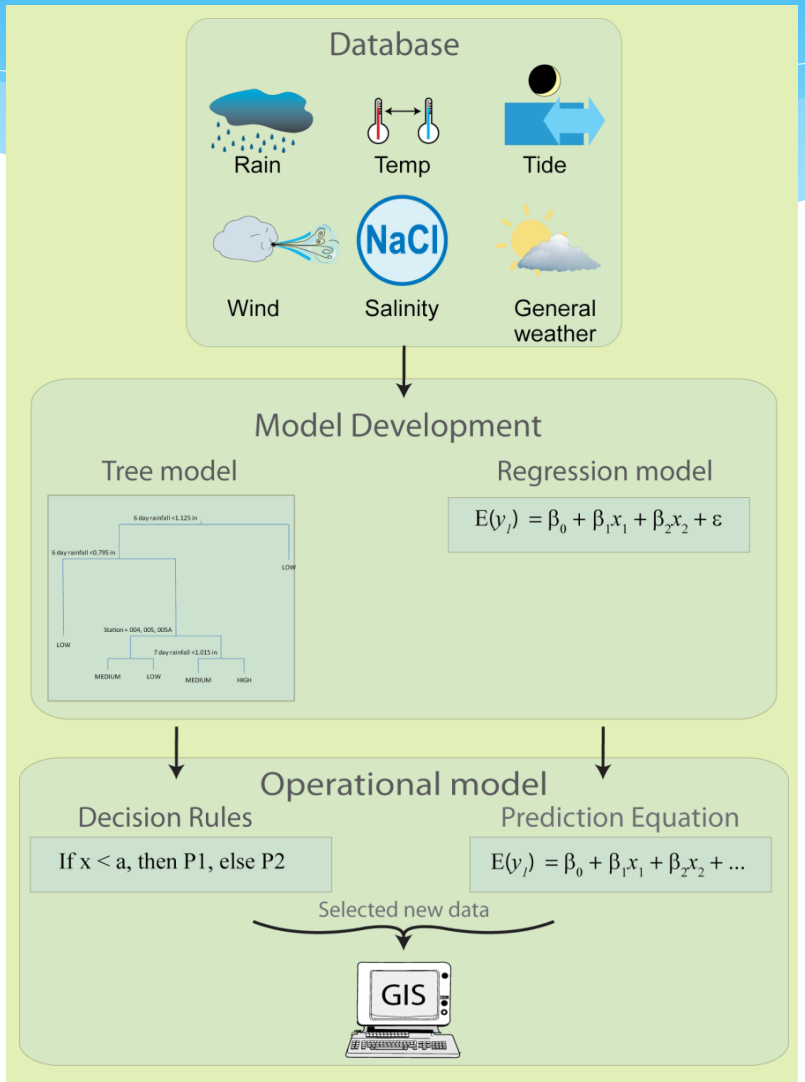
Data integration and processing

* Data collected from a variety of sources
* Collated, summarized, and processed
* Historical data used to develop water quality algorithms
  * Statistical modeling done with both:
    * R statistical software
    * EPA's Virtual Beach software
* Algorithms applied to new data and water quality predictions/forecasts made
* Results uploaded for use in app/ website



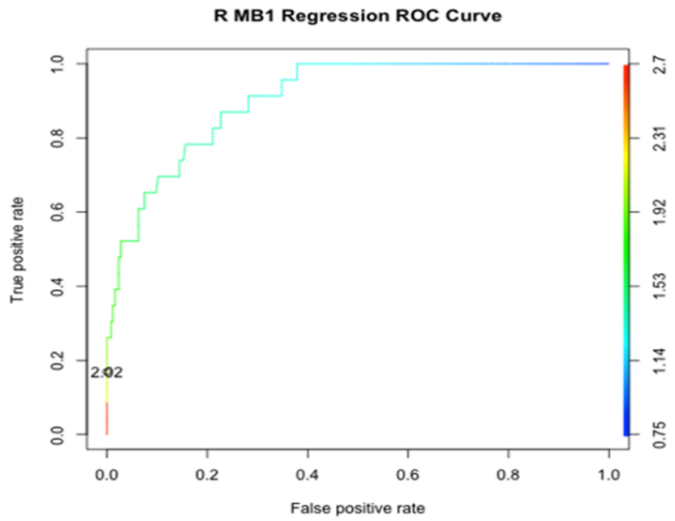
Predictive models

Models have to be accurate, reliable, understandable and implementable!



Predictive models

* Statistical models were created using input and survival factors
* Regression models were developed using VIF, p-values, BIC (Bayesian Information Criterion), and backwards elimination
* Model performance and validation utilized BIC, R^2, Adj-R^2, ROC curves



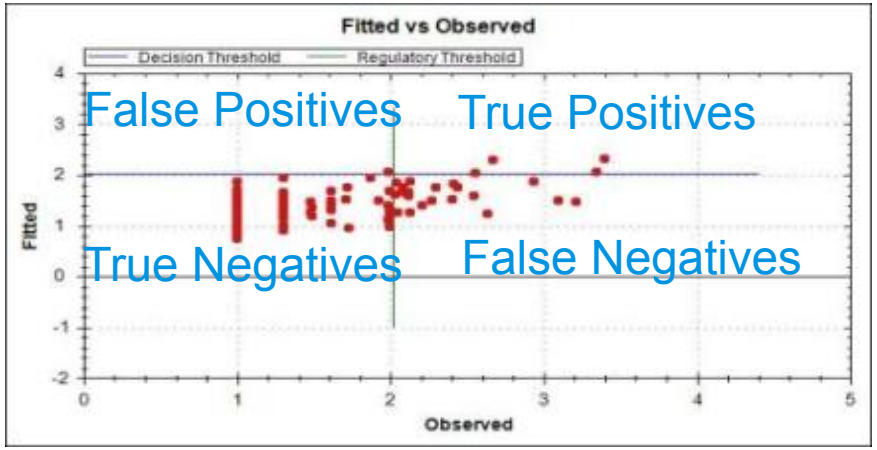
Predictive models

Model complexity is …

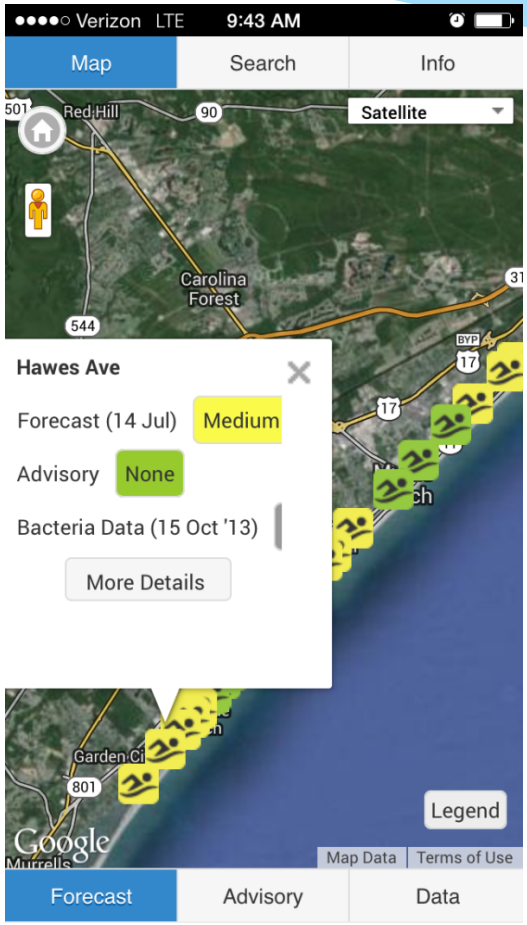
- Location
- Availability of data
- Acceptable error

- 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)

Level 1	Level 2	Level 3
Cumulative Rainfall	Cumulative Rainfall	Cumulative Rainfall
Rain Intensity	Rain Intensity	Rain Intensity
Preceding Dry Days	Preceding Dry Days	Preceding Dry Days
Weather	Weather	Weather
	Tidal Range	Tidal Range
	Lunar Phase	Lunar Phase
		Station
		Wind Speed
		Wind Salinity

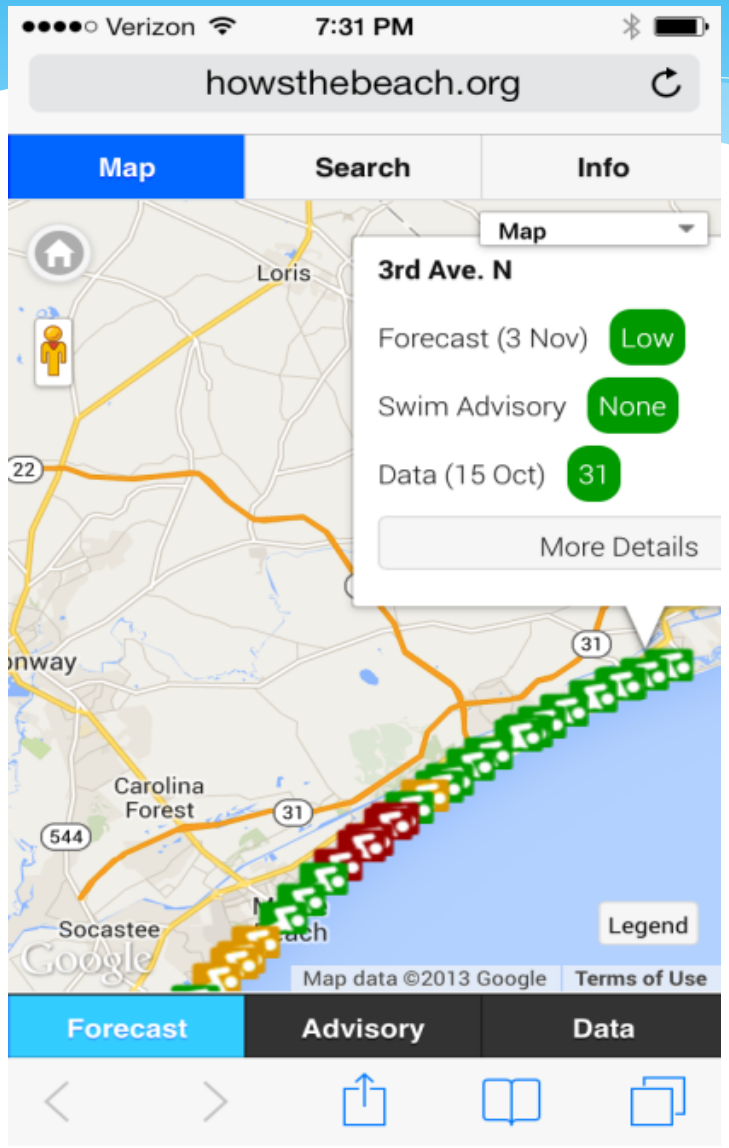


How's the Beach tool



* Water quality advisory app
* Provides near real-time forecasts along beach of interest
* Provides quick "go/no-go" recommendations for swimming and water activities

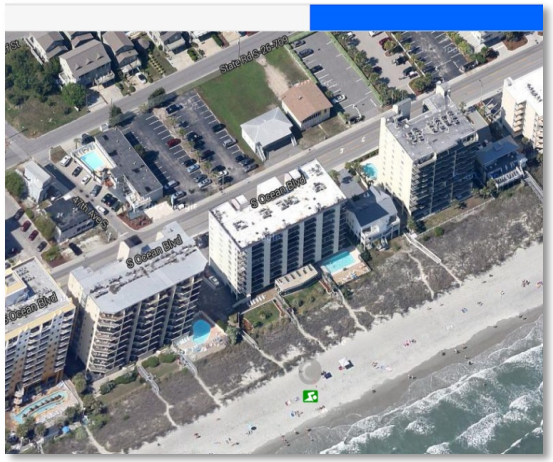
How's the Beach tool

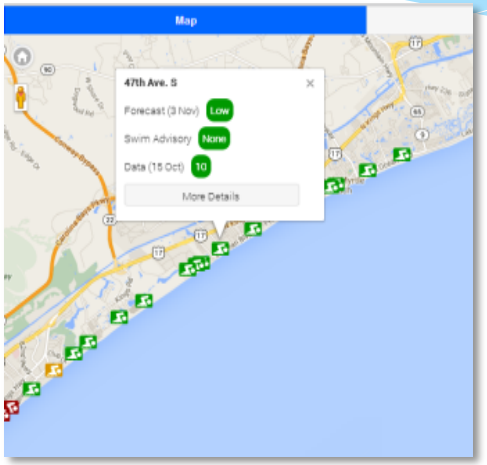


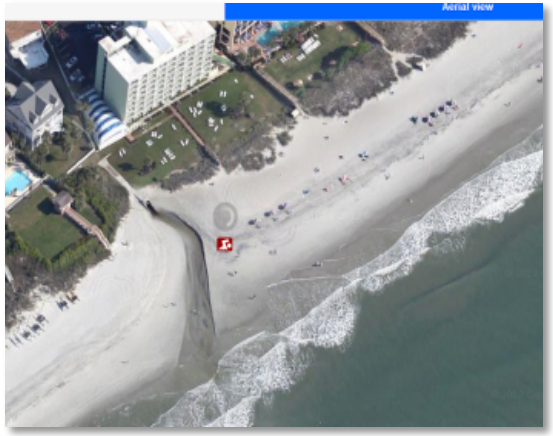
End result is a decision-support tool available at your fingertips for public health, economic and personal decision making resulting in…

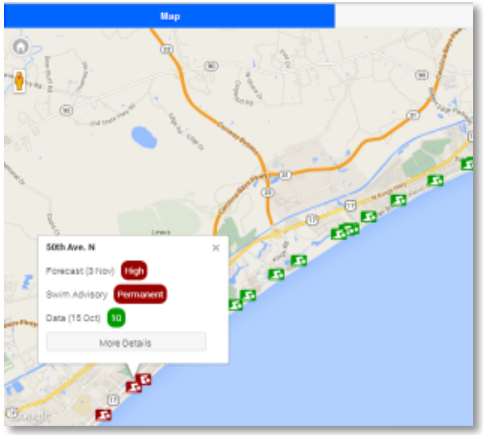
How's the Beach tool

… a win – win situation for *public health* and *economic vitality*!









Accomplishments

* Worked with public health officials, water quality scientists, beach managers, etc. to develop an ensemble modeling approach-based decision support tool that …
  * predicts bacterial concentrations for swimming beaches and shellfish harvesting waters
* Published mobile app and website
* Beach monitoring and coastal management programs can demonstrate a savings of tax dollars

Proposed future directions

* And now we would like to do the same in southwest Florida!

* The ultimate **goal** of our work is to assist public health, beach management, and tourism officials in support of improved decision making.

* Our **objectives** are to:
  * Develop locally-relevant decision-support tools to support our goal, and
  * Demonstrate the geographic and thematic transferability of our tool development approach.

Current status

* We have acquired and are working with weekly bacterial data from the FL DOH
  * From roughly Fall 2014 back to 2002
* We are acquiring historical data from a variety of buoys and other platforms
  * Salinity
  * NEXRAD rainfall
  * Water and wind temperature
  * Etc.

Study Area


Anna Maria
Anna Maria Island
Holmes Beach
Bradenton Beach
Longboat Key
DE SOTO NATIONAL MEMORIAL
Palma Sola
Palma Sola Park
Perico Island
PALMA SOLA BAY
Bradenton
Palmetto
Memphis
MANATEE
Bayshore Gardens
SARASOTA
BAY
Sarasota Airport
0 0.45 0.9 1.8 2.7 3.6
Miles
Copyright © 2013 National Geographic Society, i-cubed

Proposed collaborations

* Would like to work with you to:
  * Share our modeling techniques and results
  * Provide a beach app/website of modeling results in near real-time
* But, before that, we would like to know:
  * What is important to you and your respective departments?
  * What would you like to see in terms of informing populations using beach waters?
  * Etc.

Wrap up

* We appreciate the opportunity to work with:
  * FL and County Department of Health
  * Division of Disease Control and Health Protection
  * Bureau of Environmental Health, Water Programs
  * Water Toxins Program - Public Health Toxicology
  * GCOOS RA
  * Mote Marine Lab
  * Local tourism officials
  * Any other identified partners

Questions

* Questions?
* Concerns?
* Suggestions?
* Etc.