Modeling Bacteria Concentrations in Southwest Florida:

Integrating Historic In Situ, Remotely Sensed and Coastal Observation System Data Sources

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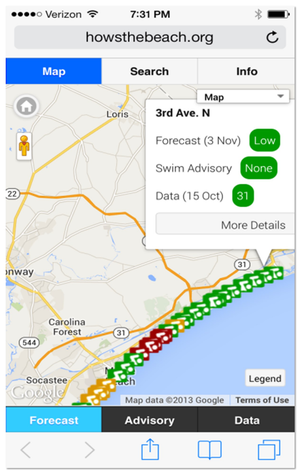
Expanding a Forecasting Tool Footprint:

The beach water quality app and website (howsthebeach.org) were developed to provide bacteria concentration estimates in coastal waters to both beach-goers and managers. This project continues a close collaboration between the University of South Carolina, University of Maryland Center for Environmental Science, and the Southeast Coastal Ocean Observing Regional Association in demonstrating the geographical transferability of the modeling approach developed in our previous study area. Our prediction system integrates data from remote sensing, coastal and ocean observing systems, and beach water quality sampling programs. The EPA's Virtual Beach (VB) toolset is being used to develop statistical bacteria concentration models for predictive beach water quality assessments. The system will auto-populate the database and apply prediction rules, based on the statistical models, to create bacteria forecasts. The new tool will allow beach water quality information and interpretation of bacterial results to be viewed interactively at select beaches in southwest Florida (FL).



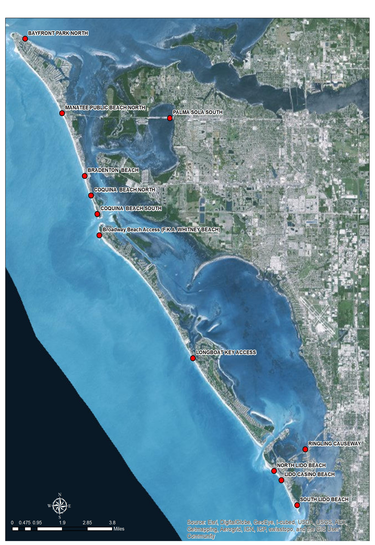
To decide if and where to visit the beach, beach-goers may use the mobile device app to review current water quality conditions. When forecasts predict high bacteria concentrations, they may decide to visit another beach or limit swimming exposure. Or, they may decide to seek other forms of recreation and entertainment.

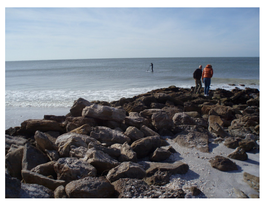
Stakeholder Involvement:

From the beginning, the team attempted to garner as much stakeholder involvement/investment as possible. During the summer of 2014, we held a conference call with Florida researchers, public health officials, and environmental scientists. From this call, a study area was recommended and access to historical sampling data was granted. In January 2015, a meeting was held at Mote Marine Lab to discuss our data challenges/needs and how to gain additional stakeholder buy-in. County officials, NWS representatives, etc. provided valuable input and recommendations for our project during this question and answer session.

Study Area:

Located west of Sarasota, the study area consists of 12 sampling sites along the southwest FL coast. Five marine sites are located on Anna Maria Island, two on Longboat Key, three on Lido Key, one on the causeway to Anna Maria Island, and one on Ringling Causeway (to Lido Key).

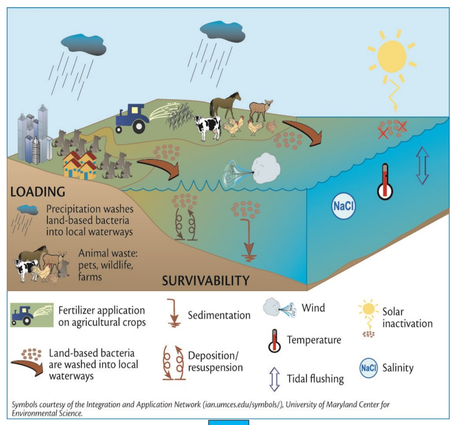


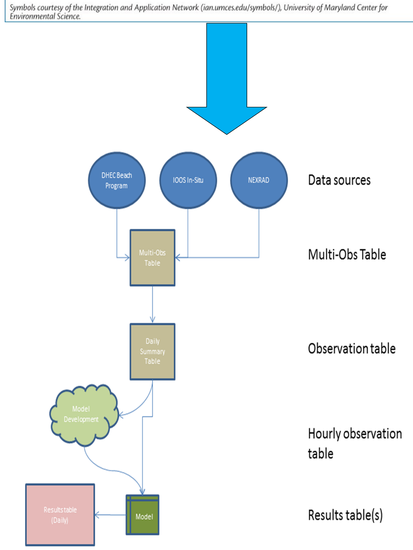


People enjoying the beach, even in the middle of January 2015.

Potential influences on bacteria: animal life, trash cans, sewers, and lift stations.

Signage is plentiful. Weekly bacteria samples are taken by state and local officials in the study area and will be used to generate statistical models.



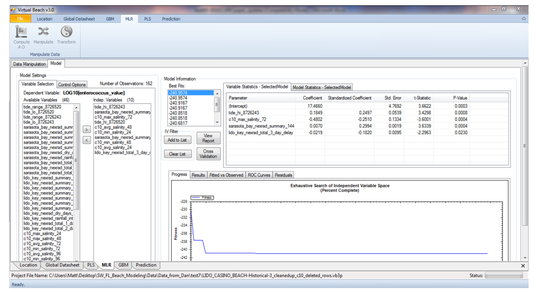


Data Integration:

Input factors (e.g. rainfall, land use, wildlife/pet waste, sewage sources, etc.) and survival factors (e.g. water temperature, salinity, wind/wave action, water level, etc.) influence and control bacteria concentration. Multiple observing systems, remotely sensed products, and monitoring programs were used to collect, collate, and summarize data for this effort. Data include: low/high tide, tidal range, wind speed and direction, 24-168 hr. NEXRAD rainfall totals, dry day counts, rainfall intensity, rainfall 1, 2, and 3 day delay, salinity max's and min's, 24-168 hr. salinity averages, water temperature max's and min's, and water temperature 24 hr. averages. Salinity and water temperature values were collected via in-situ (C-10 Gulf buoy) and modeling (HYCOM) data sources. Statistical models were, and will be, developed using historical data to create prediction algorithms. Forecasts will be made using new data uploaded to these decision algorithms. A website and app can then incorporate these new forecasts.

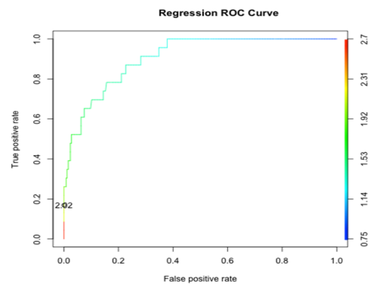
Modeling Approach:

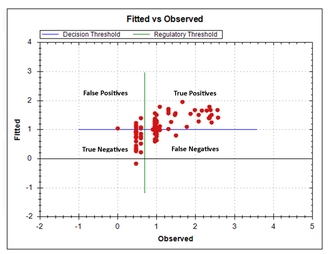
The EPA's VB tool is being used for statistical modeling. As reported in Neet et al. (2015), VB has a minimum learning curve, while allowing for the development of robust predictions or forecasts. Multiple linear regression (MLR) models will be created for each of the 12 sites in the study area. Wind values along and perpendicular to shore will be created in VB. Where appropriate, variables may be transformed to yield more linear results. With the use of dummy variables for location, study sites will be combined. The areas of Anna Maria Island, Longboat Key, and Lido Key will also be analyzed at the island-level scale. Once data are aggregated at the appropriate scale, regression models will be developed from roughly 82 variables.



Model Performance:

BIC (Bayesian Information Criteria), Akaike's Information Criterion (AIC), Adjusted R-square, and Receiver Operator Characteristic (ROC) curves will be used to evaluate model performance. ROC curves will be used to analyze false and true positive rates created from predicted to observed results comparisons (Morrison et al. 2003). Ideally, higher rates of true positives with steeper curves are more desirable. An Area Under the Curve (AUC) will be calculated to measure these values quantitatively. Models with values approaching 1 indicate better predictive ability. Ultimately, the goals are to minimize false positives/negatives, while maximizing the rates of true positives/negatives. Currently, NEXRAD rainfall summaries, salinity, high tide, wind, and rainfall total delay variables are important in the assessment of our initial site on Lido Key.





Future Directions and Recommendation:

Since our model development and implementation efforts in the Grand Strand area of South Carolina (SC), we have expanded our footprint to include freshwater bacteria forecasting in SC's Saluda River and, now, saltwater bacteria forecasting in southwest FL. These projects have demonstrated the geographical and thematic transferability of our modeling approach. Therefore, we would suggest expanding this footprint to include additional waters of southeast FL and those of the Albemarle-Pamlico Sound, North Carolina area. With these new areas, we envision adding riptide and shellfish harvesting closure modeling to our toolbox. UV, wave, and wind measures may also be added to our app.

Citation:

Morrison, A., K. Coughlin, J. Shine, B. Coull, A. Rex. 2003. Receiver Operator Characteristic Curve Analysis of Beach Water Quality Indicator Variables. *App. Environ. Microbiol.* 2003, 69(11):6405.

Neet, M., R. Kelsey, D. Porter, D. Ramage, A. Jones. 2015. Model Performance Results in Myrtle Beach, SC Using Virtual Beach and R Regression Software. Journal of S.C. Water Resources. In press.