

CARICOOS Beach Water Quality

Sylvia Rodríguez-Abudo, Peter Rivera Casillas and Priscila Vargas Babilonia
Department of Engineering Sciences and Materials
University of Puerto Rico-Mayaguez
Call Box 9000
Mayaguez, PR 00681-9000
email: rodriguez.abudo@upr.edu

LONG-TERM GOALS

CARICOOS beach water quality efforts aim at developing decision making tools to provide timely and accurate information to beachgoers and coastal managers across the region regarding beach water quality in their locality. This initiative is part of the CARICOOS Coastal Hazards Focus Area, as well as its Observational and Modeling Subsystem, and is well aligned with CARICOOS goal of integrating observations and models into coastal intelligence for the US Caribbean region.

MILESTONES / OBJECTIVES

- A. Develop two additional nowcasts for Crashboat, Aguadilla and Playa Santa, Guánica.
- B. Further fine tune the Rincón Public Beach (RPB) water quality nowcast.
- C. Continue and further develop collaborations to increase beach water quality monitoring efforts to help validate and fine-tune new and existing models.
- D. Formalize collaboration with the Puerto Rico Environmental Quality Board.
- E. Submit at least one manuscript to the Journal of Water and Health.

WORK COMPLETED

- A. Develop two additional nowcasts for Crashboat, Aguadilla and Playa Santa, Guánica: An experimental beach water quality nowcast has been developed for Playa Santa, Guánica. It provides hourly estimates of Enterococci concentration based on relative humidity, air temperature, solar radiation, and wind (data source: PRDNER weather station GCAP4). EPA's Virtual Beach software was used to develop this site-specific statistical model based on a multiple linear regression analysis. Table 1 provides information on the model and independent variables. During the development period (April-December 2016) the model was able to reproduce 56% of the positive samples, and 83% of the negative samples. Its overall accuracy, r^2 and RMSD was 70%, 0.44, and 10 MPN CFU/100mL, respectively (N = 57).

The validation period took place in January-May 2017 (N = 24, Figure 1). So far, the model has been able to reproduce 50% of the positive samples, and 68% of the negative samples. Its overall accuracy is 65%. Further fine-tuning will take place during the next performance period.

Table 1: Playa Santa Beach Water Quality Nowcast Model Information (equation: $\log_{10} \text{Ent} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$).

	Independent Variable	Averaging Period	$\beta \pm \epsilon$	Transformation	p-value
β_0	Intercept	-	9.04±4.74	-	0.0622
x_1	Air temperature	2hr	-954±451	1/x	0.0393
x_2	Relative humidity	1hr	1.19±0.30	$11.095182 - 3.5182285 \cdot 10^{-1}x + 3.1283838 \cdot 10^{-3}x^2$	0.0002
x_3	Solar radiation	4hr	1.24±0.47	$1.455049 + 2.9678164 \cdot 10^{-3}x - 4.6356153 \cdot 10^{-6}x^2$	0.0112
x_4	Alongshore wind	1hr	0.48±0.18	$1/(-WS \cdot \cos(WD - 235.304840087891))$;	0.0091
x_5	Cross-shore wind	1hr	0.46±0.22	$\text{SQRT}(WS \cdot \sin(WD - 235.304840087891))$	0.0420

WS = Wind Speed, WD = Wind Direction

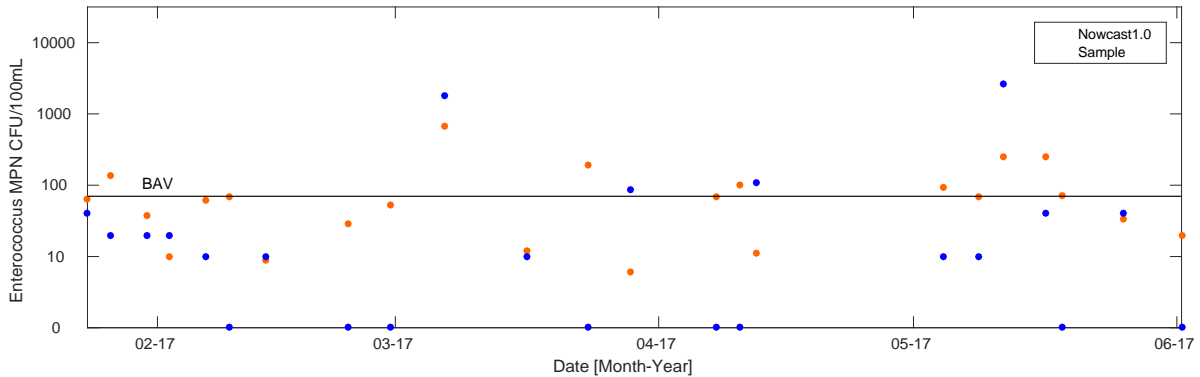


Figure 1: Playa Santa's beach water quality nowcast validation.

We were not able to develop the beach water quality nowcast for Crashboat, Aguadilla due to a lack of available weather stations. However, we are exploring the use of NOAA precipitation products to develop this and other models. Given that precipitation is strongly correlated to exceedances of Enterococci limits, the successful implementation of NOAA radars will allow for the development of several nowcast products, especially in beaches that lack historic meteo-ocean data.

- B. Further fine tune the Rincón Public Beach (RPB) water quality nowcast: The RPB Beach Water Quality Nowcast has evolved into twelve different versions. They are all are computed every hour, 24/7. A hierarchy has been established based on validation results to decide which prediction will be published online. At this moment version 3.3 leads the hierarchy followed by version 2.3. The most recent versions are as follows:
- Version x.3 – This version computes the output following equation 1 (please refer to the previous progress report for details on the RPB model equations), except for instances where the accumulated precipitation is zero and the tidal gradient is less than 0.85 m/day where an output of <EPA LIMIT is provided.

- Version 3.x – This version is similar to versions 1.x and 2.x, except for the fact that it uses Weather Underground station IPRRINCN2 for its rainfall data. This station is physically much closer than the other ones and its locally ran by CARICOOS.

With the implementation of these two versions the RPB nowcast performance increased significantly (Table 2). Validation plots for nowcast 2.3 and 3.3 can be found in Figure 2.

Table 2: RPB Nowcast before and after fine tuning.

	Best model on Dec 2016	Nowcast 2.3	Nowcast 3.3
Accuracy	0.77	0.83	0.84
Sensitivity	0.36	0.53	0.72
Specificity	0.91	0.90	0.86
N	78	143	92

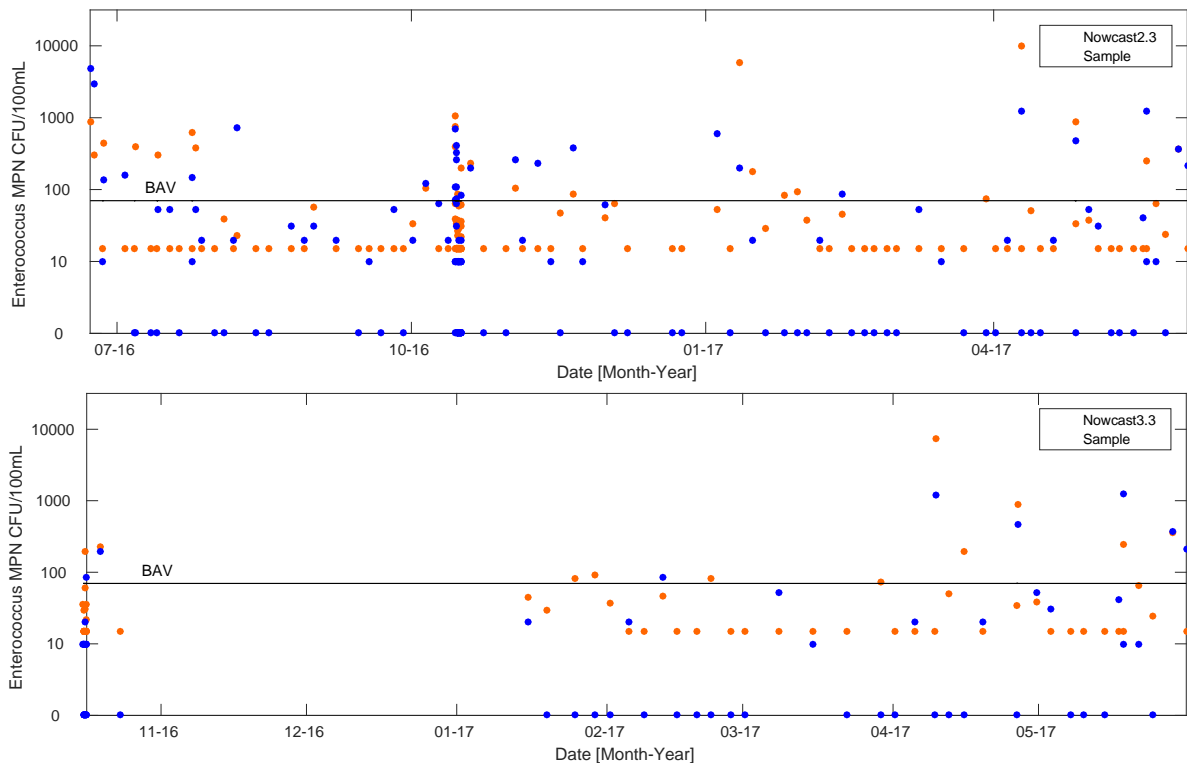


Figure 2: RPB beach water quality nowcast validation for versions 2.3 (top) and 3.3 (bottom).

- C. Continue and further develop collaborations to increase beach water quality monitoring efforts to help validate and fine-tune new and existing models:
 Development and validation of the Playa Santa beach water quality nowcast has been possible with the regular water sampling led by Ms. Geraldine Gomez. With support from CARICOOS, Ms. Gomez is completing a MS degree on this topic. In addition to this, we have started talks with María Elena García, Executive Director of OPAS (Organización Pro-Ambiente Sostenible) to further assess the need for beach water sampling around Puerto Rico.

- D. Formalize collaboration with the Puerto Rico Environmental Quality Board:
No progress to report. In fact, with the change in government this has become even more difficult. We will continue to reach out.
- E. Submit at least one manuscript to the Journal of Water and Health:
A manuscript is currently in preparation but has yet to be finished and submitted.
- F. Other:
CARICOOS continues to provide and maintain its different beach water quality data products including: a map with info boxes of the latest water quality samples as tested by JCA, Surfrider or CARICOOS (Figure 3); historical plots for each regularly tested beach (Figure 4); and validation plots for each nowcast (Figure 1).



Figure 4: CARICOOS beach water quality map. Each flag represents a sampling site. Clicking on the flags will show an info box with the latest sampling results. The “Historic Data” button provides a historic time series of all samples collected at the site (Figure 5).

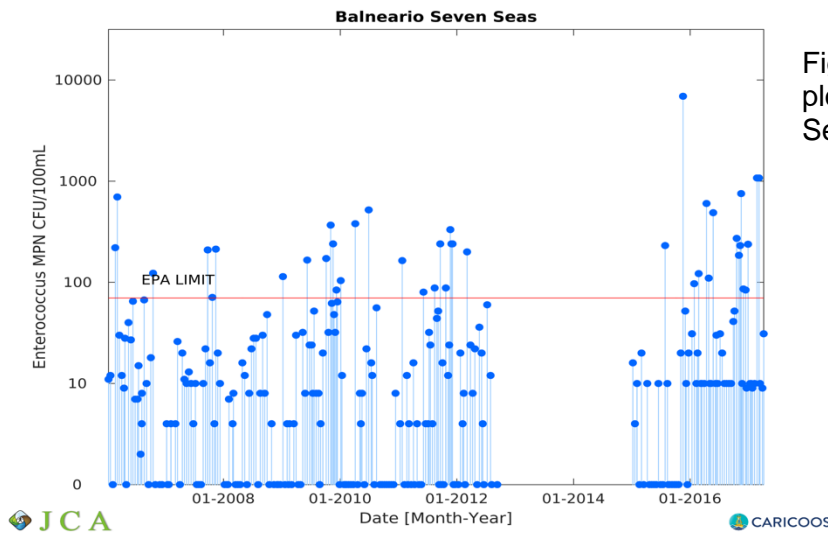


Figure 5: Example of historic plot for Balneario Seven Seas.

MAJOR OUTCOMES

CARICOOS RPB beach water quality nowcast has been significantly improved during the performing period. In fact, the sensitivity of the model (ability to predict positive values) has doubled over this period. Additionally, a new beach water quality nowcast was developed for Playa Santa, Guánica. It is fully operational since April 2016.

RELATED PROJECTS

In situ biosensor: CARICOOS is providing seed money to Pedro Resto's group to calibrate a bench version of the biosensor with respect to the Enterolert quantitray and to convert the current prototype into an in situ buoy unit. Funds have been used to purchase materials and reagents for performing the Enterolert assay using enterococcus faecalis inoculated water samples in quantitrays and within the acrylic millifluidic device

WORK PLAN FOR UPCOMING PERFORMANCE PERIOD (June 1st 2017 – Nov. 30th 2017)

- A. Continue to maintain and upkeep CARICOOS beach water quality data products.
- B. Develop additional nowcasts based on weather radar information. We are starting with Crashboat, Aguadilla.
- C. Engage USVI government and/or university to develop collaborations to include USVI beach water quality data as part of CARICOOS data products.
- D. Continue to engage the Puerto Rico Environmental Quality Board and others.
- E. Submit at least one manuscript to the Journal of Water and Health.

PUBLICATIONS & PRODUCTS

Resto, P., Wang, D., Carambot, U., Durán, O., Rosa, L., Cordero, G., Feliciano, A., Aponte, J. and S. Tamar, 2017, Automated, Portable Fecal Bacteria Biosensor for Recreational Water, poster at CARICOOS 2017 General Assembly Meeting, Añasco, PR.

Rivera, P. and S. Rodríguez-Abudo, 2017, CARICOOS Beach Water Quality Products, poster at CARICOOS 2017 General Assembly Meeting, Añasco, PR.

Rodríguez-Abudo, S., 2017, Beach Hazards: Drowning Prevention & Water Quality, moderator CARICOOS 2017 General Assembly Meeting, Añasco, PR.

Vargas, P. and S. Rodríguez-Abudo, 2017, Beach Water Quality at Rincon Public Beach: A 48-hour Sampling Campaign, poster at CARICOOS 2017 General Assembly Meeting, Añasco, PR.