Decreasing Water Quality Unmasked on Florida's Coral Reef

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Reduced water quality on Florida's Coral Reef (FCR) from anthropogenic sources has long been implicated in the decline of the reef system. Over a century of replumbing the Everglades and coastal development has altered the historic water flows, leading to large scale ecosystem changes in south Florida. Residing downstream of the hydrographic flow, the FCR has experienced significant declines in the last 50 years, including the loss of over 25% live coral cover. Most of the coral losses were attributed to various extreme temperate and disease events beginning in the late 1970's and becoming more frequent over time, including stony coral tissue loss disease, which continues to decimate populations. In dynamic ecosystems like coral reefs, pulse events of decline are easier to attribute to losses than slower incremental changes in water quality, which are much harder to detect. Analyses of *in situ* water quality data are confounded by a myriad of factors that affect analyte concentrations at specific times and locations. These factors must be accounted for before trends in the data can emerge.

This study uncovered annual increases in analyte concentrations previously masked by the dynamic nature of water quality sampling. Using machine-learning modeling, the relationships between water quality from reef sites and measured land-based outflow from the coastal inlets, rainfall and wind over the same period (2018 to 2023) were tested. The models explained 41.5 – 78.9% of the variation in the water quality concentrations (training data) and 21.8 – 63.9% of the variation within data the model had not previously seen (test data). Many factors contributed to the changes various analytes including inlet outflow, rainfall, and high winds, however year had a high influence in almost every test (8.1% for nitrate – 37% for orthophosphate). In almost every case, while holding all other predictors in the model (inlet outflow, wind, and rainfall over various temporal windows and a series of space/time categorical predictors) at their mean, the modeled relationship of each analyte showed increases by year. This suggests that some other factor not accounted for in the models was affecting yearly increases in analyte concentrations. One factor not in the models that might account for this effect is population growth. Miami-Dade and Broward are Florida's most populous counties totaling 4.88 million. From 2022 and 2024, they had a combined net increase of 270,353 new residents. Increases of this magnitude on already stressed infrastructure could account for temporal decreases in water quality.

The effects of these analytes are unknown and deserve significant research attention. Efforts are ongoing to expand this analysis to obtain a more complete picture of FCR's water quality dynamics, which is key to designing effective local mitigation strategies, prioritizing resources, and identifying areas suitable for restoration.