Water Quality, Seagrass, Coral Reef, and Episodic Event Monitoring

Florida Keys National Marine Sanctuary Water Quality Monitoring Project

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Goals

The Water Quality Monitoring Project for the Florida Keys National Marine Sanctuary (FKNMS) is part of the Water Quality Protection Program. The goal of this large-scale, long-term monitoring project is to assemble a holistic view of broad physical, chemical, and biological interactions occurring over the South Florida hydroscape. Water quality monitoring can be used as a tool for answering management questions and developing new scientific hypotheses, such as "Is water quality better or worse than it used to be?" This monitoring project, based on quarterly sample intervals, has revealed significant spatial trends in nutrients as described below, and we expect to see more trends in other variables as the database grows.

Methods

This project began in March 1995 and includes data collected from quarterly sampling events at 154 stations within the FKNMS, including the Dry Tortugas National Park. Since initiation we have added four sampling sites and adjusted six others to increase coverage in Sanctuary Preservation Areas and Ecological Reserves. Field parameters measured at each station include salinity, temperature, dissolved oxygen (DO), turbidity, in situ chlorophyll *a* fluorescence, and light attenuation (K_d). Water chemical variables measured at each station include the dissolved nutrients nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+), and soluble reactive phosphate (SRP). Total unfiltered concentrations of organic nitrogen (TON), organic carbon (TOC), phosphorus (TP), and silicate ($Si(OH)_4$) are also measured. The monitored biological parameters included chlorophyll *a* (CHLA) and alkaline phosphatase activity (APA).

Findings to Date

We have found that water quality monitoring programs composed of many sampling stations situated across a diverse hydroscape are often difficult to interpret because of the "can't see the forest for the trees" problem. This makes it difficult to see the larger, regional picture or to determine associations among sites. In order to gain a better understanding of spatial patterns of water quality of the FKNMS, we attempted to reduce the complicated data matrix into fewer elements, which would provide robust estimates of condition and connection. To this end we developed an objective classification analysis (OCA) procedure, which grouped stations according to similarities in water quality.

The OCA we used was a multivariate statistical protocol, which used 12 water quality variables at each site as fingerprints that were then grouped according to similarity. The result was the deconvolution of 150 stations into eight clusters of stations with distinct water quality signatures (Fig. 1). We believe this is a more functional zonation of the FKNMS than a geographical one because it is driven by physical, chemical, and biological aspects of the water column.

The bulk of the stations fell into five clusters (1, 3, 5, 6, and 8), which described a gradient of water quality throughout the FKNMS. Although the differences among them were subtle, they were statistically significant. OCA allowed us to say that the overall nutrient gradient, from highest to lowest concentrations, was Cluster 8&1 > 5 > 6 > 3. Clusters 3, 6, and 5 were distributed widely throughout the Atlantic side of the Keys and Tortugas while Clusters 1 and 8

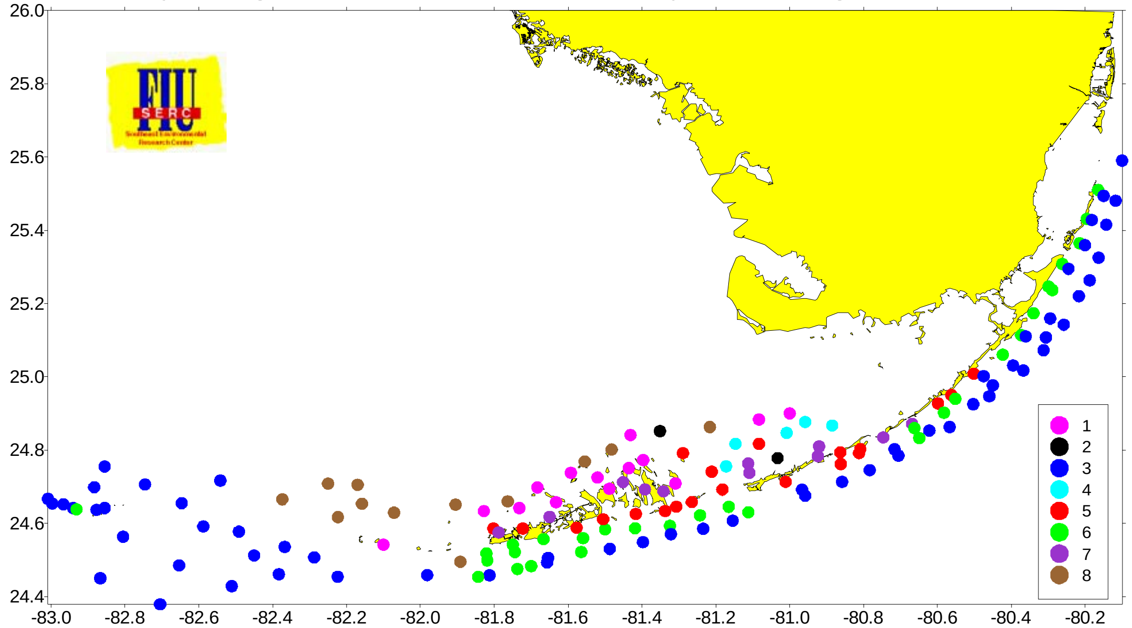

Figure 1. Sampling locations and cluster membership for all 154 sites in the FKNMS.

were present only on the Gulf side of the Keys. The stations in Cluster 3, located on the reef tract and Tortugas, had the lowest nutrient concentrations of all the groups (Fig. 2). This was followed by Clusters 6 and 5, which were driven mainly by increasing NO_3^- concentrations. Inshore stations of the less-inhabited Upper Keys exhibited lowest alongshore NO_3^- levels compared to the Middle and Lower Keys. Interestingly, NO_3^- concentrations in the single Tortugas transect were similar to those of reef tract sites in the Upper Keys, i.e., there was no inshore elevation of NO_3^- in the transect off uninhabited Loggerhead Key. We suggest that this source of NO_3^- in the Keys is due to shoreline development.

Cluster 1 was composed primarily of stations located within the Backcountry area north of the Lower Keys (Fig. 1). Along with Cluster 8, it was highest in TP and turbidity. Cluster 8 was made up of stations on the north side of the Backcountry extending west over the northern Marquesas and was highest in CHLA. This is the area most heavily influenced by advection of Southwest Florida Shelf waters.

Temporal analyses of water quality showed most variables were relatively consistent from year to year, with some showing seasonal excursions. The exception was increasing variability in TP concentrations throughout the region. This brings up an important point that, when looking at what are perceived to be local trends, we find that they seem to occur across the whole region but at more damped amplitudes. This spatial autocorrelation in water quality is an inherent property of highly interconnected systems such as coastal and estuarine ecosystems driven by similar hydrological and climatological forcings. Clearly, there have been large changes in FKNMS water quality over time, but no sustained monotonic trends have been observed. We must always keep in mind that trend analysis is limited to the window of observation; trends may change with additional data collection.

The large scale of this monitoring project has allowed us to assemble a much more holistic view of broad physical/chemical/biological interactions occurring over the South Florida hydroscape. Much information has been gained by inference from this type of data collection program: major nutrient sources have been confirmed, relative differences in geographical determinants of water quality have been demonstrated, and large-scale transport via circulation pathways has been elucidated. In addition, we have shown the importance of looking "outside the box" for questions asked within. Rather than thinking of water quality monitoring as being a static, non-scientific pursuit it should be viewed as a tool for answering management questions and developing new scientific hypotheses. We continue to maintain a website of the SERC water quality network (Florida Bay, Whitewater Bay, Biscayne Bay, Ten Thousand Islands, and Southwest Florida Shelf) displayed as downloadable contour maps, time-series graphs, and interpretive reports. Data from the FKNMS are integrated with the other parts of the monitoring network (http://serc.fiu.edu/wqmnetwork/).

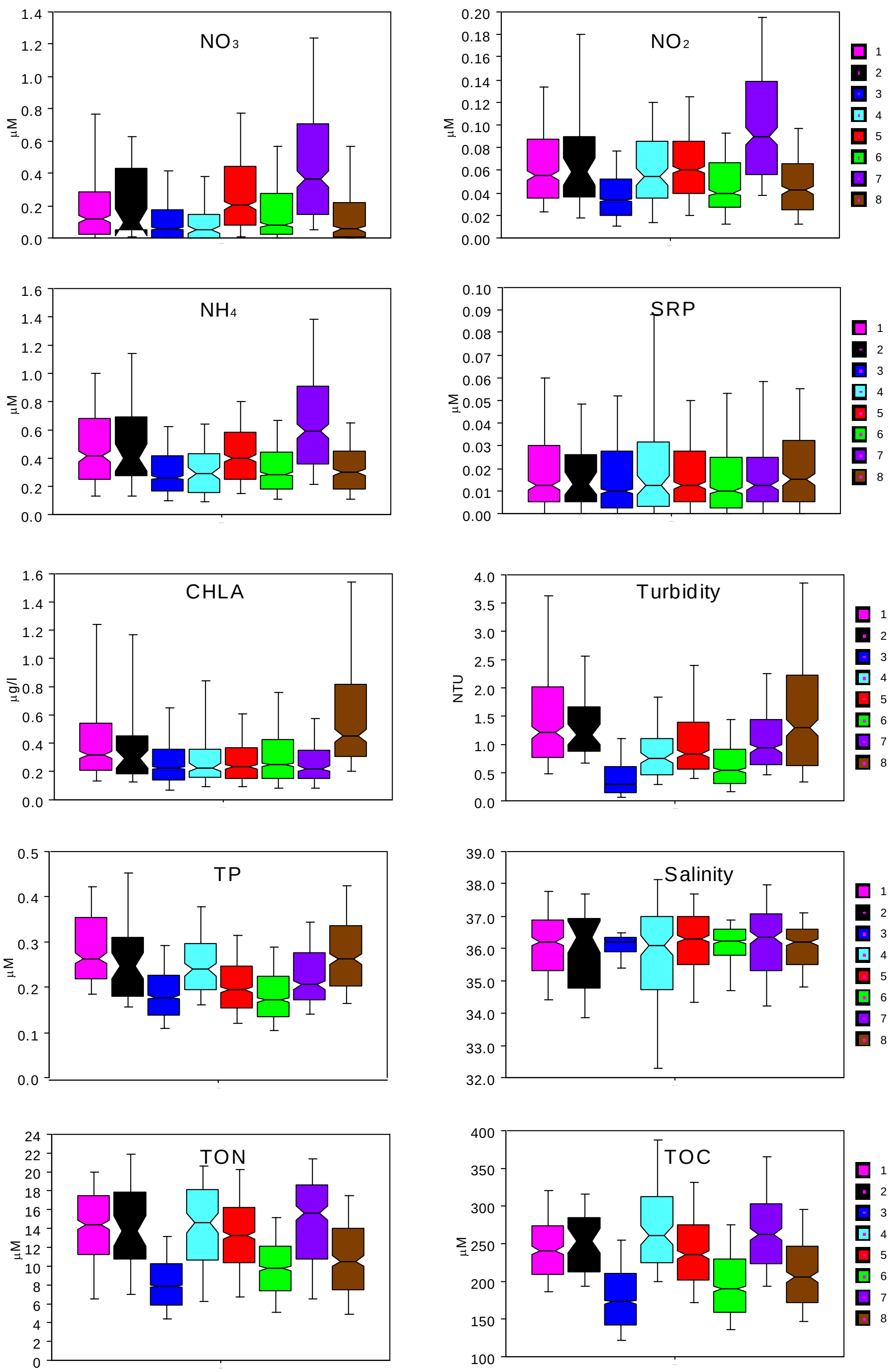

Figure 2. Median and range of variables stratified by cluster (see Fig. 1). Units are µM (nutrient and TOC concentrations), µg/L (CHLA concentration), Normal Turbidity Units (NTU; turbidity), and Practical Salinity Units (salinity).