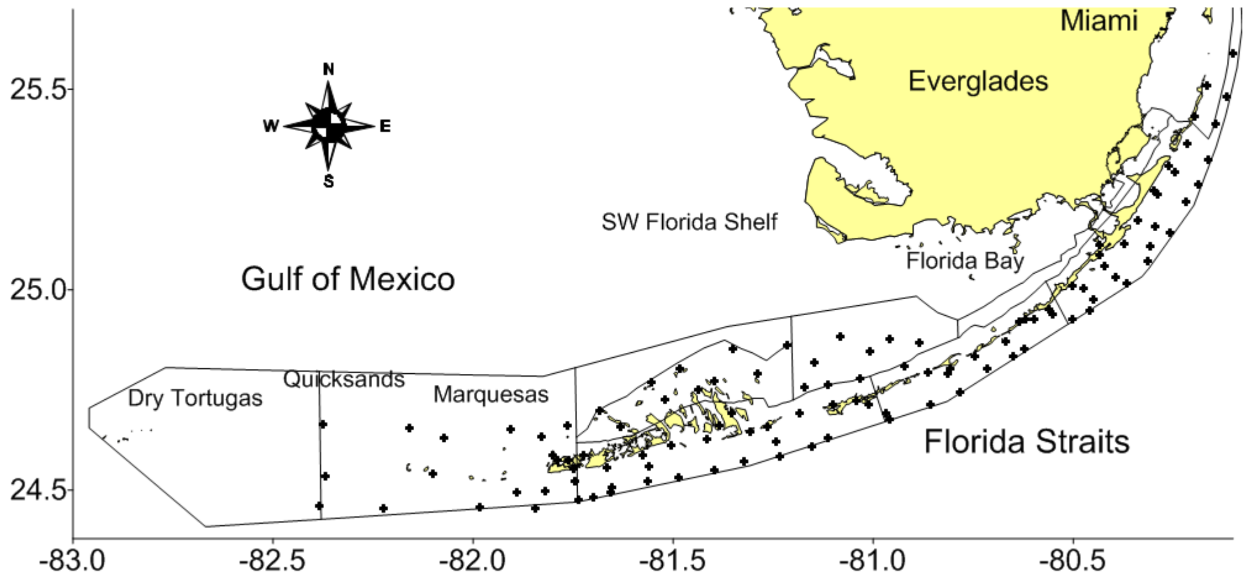
2012 ANNUAL REPORT
OF THE WATER QUALITY MONITORING PROJECT
FOR THE WATER QUALITY PROTECTION PROGRAM
OF THE FLORIDA KEYS NATIONAL MARINE SANCTUARY



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EXECUTIVE SUMMARY

This report serves as a summary of our efforts to date in the execution of the Water Quality Monitoring Project for the FKNMS as part of the Water Quality Protection Program. The period of record for this report is Mar. 1995 – Sep. 2012 and includes data from 69 quarterly sampling at 155 sampling sites events within the FKNMS, including the Dry Tortugas National Park (DRTO). This annual report reflects funding cutbacks resulting in reduction of spatial sampling to 112 sites, none within DRTO.

Field parameters measured at each station (surface and bottom at most sites) include salinity (practical salinity scale), temperature (ºC), dissolved oxygen (DO, mg l^{-1}), turbidity (NTU), relative fluorescence, and light attenuation (K_d, m^{-1}). Water quality variables include the dissolved nutrients nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+), and soluble reactive phosphorus (SRP). Total unfiltered concentrations include those of nitrogen (TN), organic carbon (TOC), phosphorus (TP), silicate (SiO_2) and chlorophyll *a* (CHLA, µg l^{-1}).

The EPA developed Strategic Targets for the Water Quality Monitoring Project (SP-47) which state that beginning in 2008 through 2012, they shall annually maintain the overall water quality of the near shore and coastal waters of the FKNMS according to 2005 baseline. For reef sites, chlorophyll *a* should be less than or equal to 0.2 micrograms/l and the vertical attenuation coefficient for downward irradiance (K_d, i.e., light attenuation) should be less than or equal to 0.13 per meter. For all monitoring sites in FKNMS, dissolved inorganic nitrogen should be less than or equal to 0.75 micromolar and total phosphorus should be less than or equal to 0.2 micromolar. Table 1 shows the number of sites and percentage of total sites exceeding these Strategic Targets for 2012.

We must recognize that the reduction of sampling sites in western FKNMS (less human-impacted sites) and the increase in inshore sites (heavily human-impacted sites) has introduced a bias to the dataset which results in a reporting problem, perhaps requiring a revision of SP-47 to correct this deviation.

Table 1: EPA WQPP WQ Targets from 1995-2005 Baseline

Targets for reef sites include chlorophyll *a* less than or equal to 0.35 micro grams/l and vertical attenuation coefficient for downward irradiance (K_d, i.e., light attenuation) less than or equal to 0.20 per meter. Targets for all sites in FKNMS include dissolved inorganic nitrogen (DIN) less than or equal to 0.75 micromolar and total phosphorus (TP) less than or equal to 0.25 micromolar. Compliances were calculated as percent of those achieving targets divided by total number of samples. Values in green are those years with % compliance greater than 1995-2005 baseline. Values in yellow are those years with % compliance less than 1995-2005 baseline.

EPA WQPP Water Quality Targets

	Reef Stations		All Stations	
Year	CHLA ≤ 0.35 µg l^{-1}	K_d ≤ 0.20 m^{-1}	DIN ≤ 0.75 µM (0.010 ppm)	TP ≤ 0.25 µM (0.0077 ppm)
1995-05	1778 of 2367 (75.1%)	1042 of 1597 (65.2%)	7826 of 10254 (76.3%)	7810 of 10267 (76.1%)
2006	196 of 225 (87.1%)	199 of 225 (88.4%)	432 of 990 (43.6%)	316 of 995 (31.8%)
2007	198 of 226 (87.6%)	202 of 222 (91.0%)	549 of 993 (55.3%)	635 of 972 (65.3%)
2008	177 of 228 (77.6%)	181 of 218 (83.0%)	836 of 1,000 (83.6%)	697 of 1,004 (69.4%)
2009	208 of 228 (91.2%)	189 of 219 (86.3%)	858 of 1,003 (85.5%)	869 of 1,004 (86.6%)
2010	170 of 227 (74.9%)	176 of 206 (85.4%)	843 of 1,000 (84.3%)	738 of 1,003 (73.6%)
2011	146 of 215 (67.9%)	156 of 213 (73.2%)	432of 569 (75.9%)	507 of 569 (89.1%)
2012	142 of 168 (84.5%)	135 of 168 (80.4%)	268 of 447 (60.0%)	368 of 447 (82.3%)

Several important results have been realized from this monitoring project. First is the documentation of elevated nutrient concentrations (DIN, TP and SiO2) in waters close to shore along the Keys, and corresponding responses from the system, such as higher phytoplankton biomass (CHLA), turbidity and light attenuation (K_d), as well as lower oxygenation (DO) and lower salinities of the water column (Figure 1). These changes, associated to human impact, have become more obvious in a new series of ten stations (# 500 to #509) located very close to shore and sampled since November 2011 (SHORE; Fig 1).

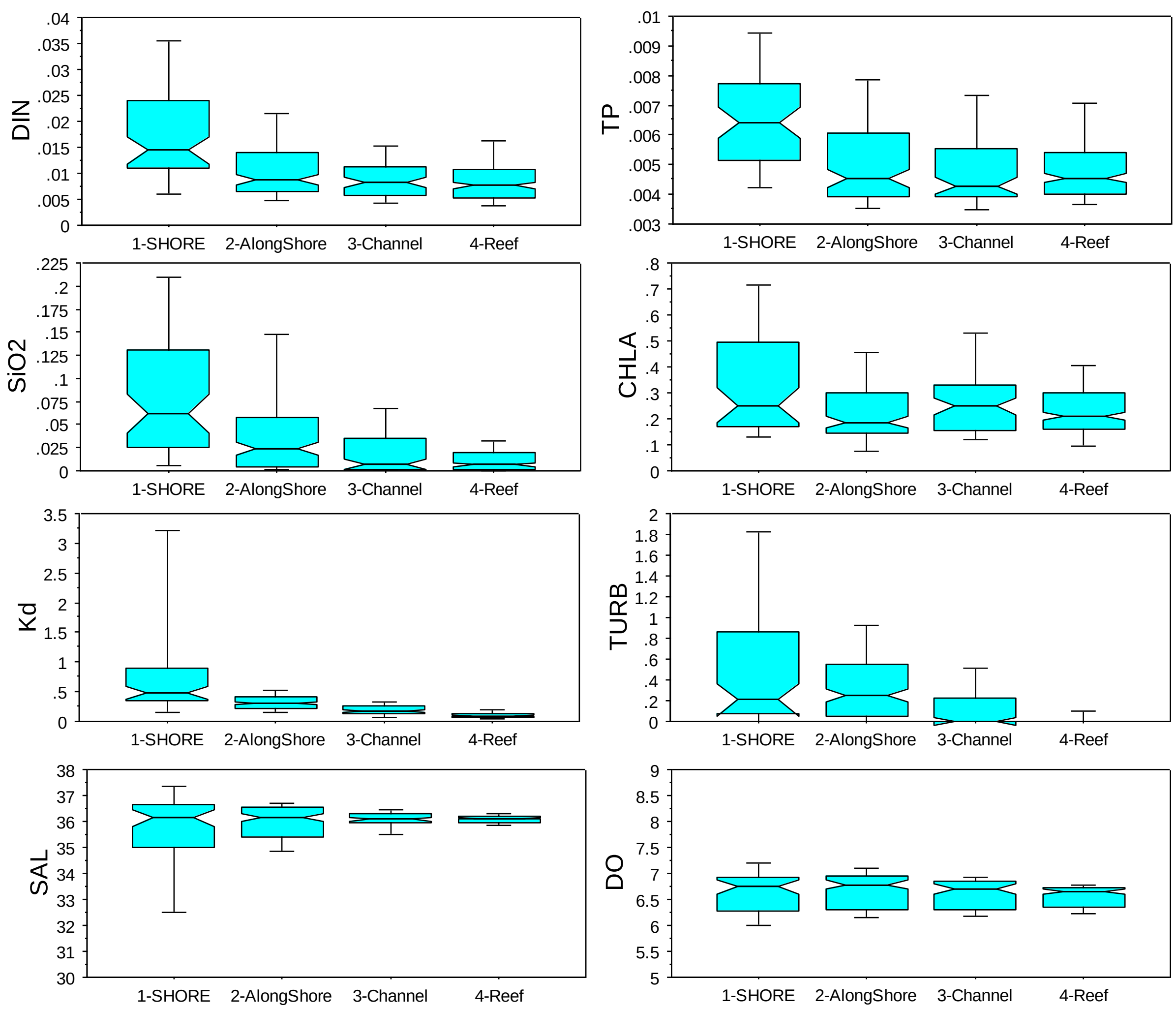

Figure 1. *Nutrient and response changes along transect from shore sites (~100 m) to reef-track*

This trend, especially for DIN was evident from our first sampling event in 1995 and was not observed in a comparison transect from the Tortugas (no human impact). This pattern suggests a land-bound, freshwater end-member as the main nutrient source. The slight increase in TP in reef samples may indicate a contribution from ocean upwelling as well. In summary, this type of distribution would imply a relatively nutrient-rich land source which is diluted by low nutrient Atlantic Ocean waters.

This raises another important point; 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 forcing. It is clear that trends observed inside the FKNMS are influenced by regional conditions outside the Sanctuary boundaries. The incorporation of new stations very close to shore, where human impact is more evident, opens a new window to our scope, one which will contribute to unravel the dynamics of human-ecosystem interactions in the Sanctuary.

Trend analysis has shown that many variables have undergone significant changes in concentration over the 18 year period of record. Examples are shown in Figures 3-6.

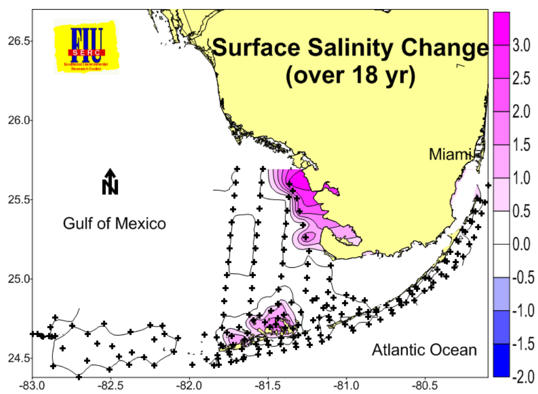

Figure 3

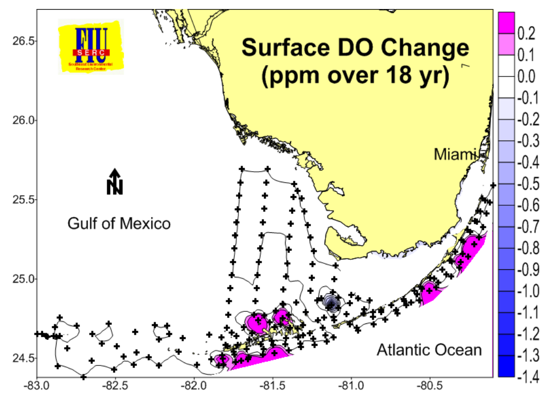

Figure 4

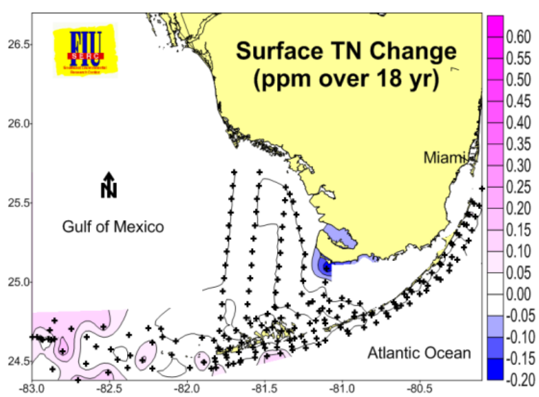

Figure 5

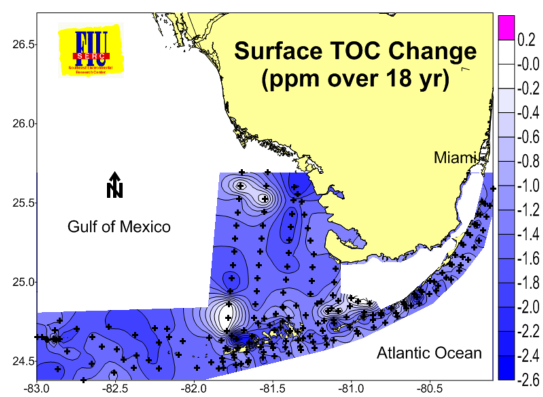

Figure 6

For 2012, in all regions of the FKNMS, water quality was generally very good with little change year to year. Overall, TOC was lower than the long term median mostly because it has been consistently declining over the years. We are not sure why this is happening, but expect it is tied to a larger, regional decline. DO and light penetration were better than the norm.

The large scale of this monitoring program has allowed us to assemble a much more holistic view of broad physical/chemical/biological interactions occurring over the South Florida hydroscape. We recently characterized and spatially subdivided South Florida's coastal and estuarine waters (Briceño et al. 2010, 2013), including the FKNMS which rendered seven biogeochemically distinct water bodies whose spatial distribution are closely linked to geomorphology, circulation, benthic community pattern, and to water management (Fig. 7). This segmentation has been adopted with minor changes by federal (EPA) and state (FDEP) environmental agencies to derive numeric nutrient criteria. This confirms that 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 (http://serc.fiu.edu/wqmnetwork/) where data and reports from the FKNMS are integrated with other available programs.

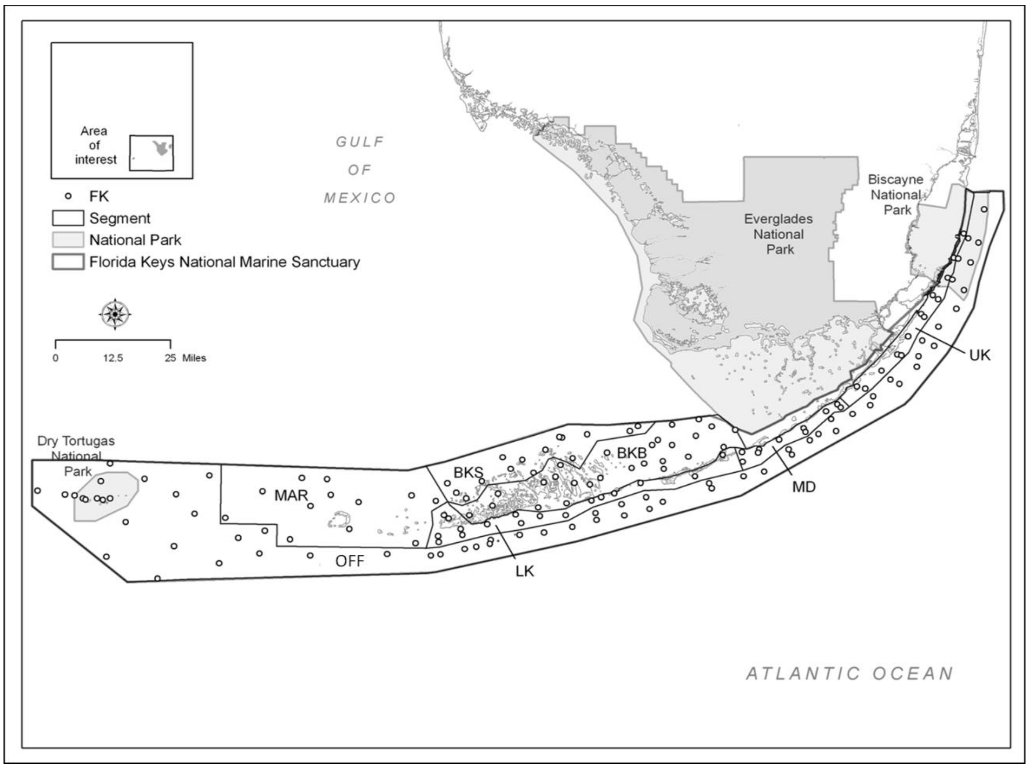

Figure 7: *Map of FKNMS showing segments derived from Factor and Cluster Analysis of biogeochemical data: OFF=Offshore; MAR=Marquesas; BKS=Back Shelf; BKB= Back Bay; LK= Lower Keys; MK= Middle Keys; UK= Upper Keys*