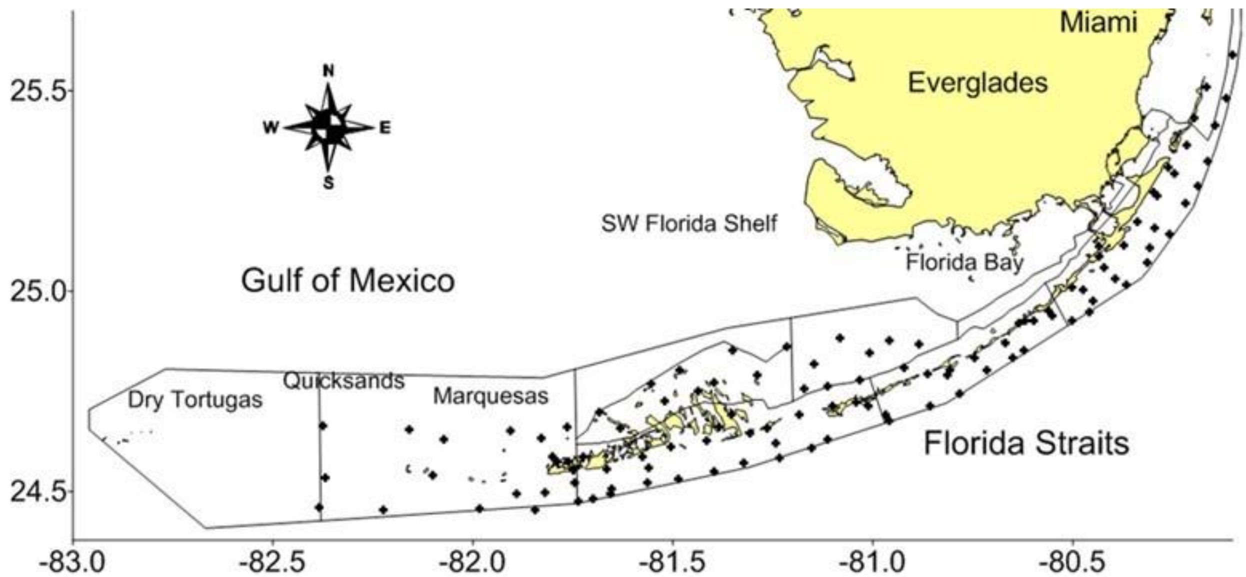
2017 ANNUAL REPORT
OF THE WATER QUALITY MONITORING PROJECT
FOR THE WATER QUALITY PROTECTION PROGRAM
OF THE FLORIDA KEYS NATIONAL MARINE SANCTUARY



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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 Apr. 1995 – Dec. 2017 and includes data from 92 quarterly sampling events within the FKNMS (23 years).

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 2017, 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 0.35 µg l^{-1} and the vertical attenuation coefficient for downward irradiance (K_d, i.e., light attenuation) should be less than or equal to 0.20 m^{-1}. For all monitoring sites in FKNMS, dissolved inorganic nitrogen should be less than or equal to 0.75 µM (0.010 ppm) and total phosphorus should be less than or equal to 0.25 µM (0.0077 ppm). Table 1 shows the number of sites and percentage of total sites exceeding these Strategic Targets for 2017.

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) introduces a bias to the dataset which results in a reporting problem, perhaps requiring a revision of SP-47 to correct this deviation. To avoid such complications, we have not included the recently added locations (#500 to #509) in the calculation of compliances.

Table 1: EPA WQPP Water Quality Targets derived from 1995-2005 Baseline

For reef stations, chlorophyll less than or equal to 0.35 micrograms liter^{-1} (ug l^{-1}) and vertical attenuation coefficient for downward irradiance (K_d, i.e., light attenuation) less than or equal to 0.20 per meter. For all stations in the FKNMS, dissolved inorganic nitrogen less than or equal to 0.75 micromolar and total phosphorus less than or equal to 0.25 micromolar. Water quality within these limits is considered essential to promote coral growth and overall health. The number of samples and percentage exceeding these targets is tracked and reported annually. 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 (excluding SHORE sites)	
Year	CHLA ≤ 0.35 µg l^{-1}	K_d ≤ 0.20 m^{-1}	DIN ≤ 0.75 µM (0.010 mg l^{-1})	TP ≤ 0.25 µM (0.008 mg l^{-1})
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%)	813 of 1,012 (80.3 %)	911 of 1,013 (89.9 %)
2012	142 of 168 (84.5%)	135 of 168 (80.4%)	489 of 683 (71.6 %)	634 of 684 (92.7 %)
2013	148 of 172 (86.0%)	150 of 172 (87.2%)	496 of 688 (72.1 %)	603 of 688 (87.6 %)
2014	141 of 172 (82.0%)	133 of 172 (77.3%)	426 of 690 (61.7%)	540 of 690 (78.3%)
2015	122 of 172 (70.9%)	135 of 172 (78.5%)	487 of 688 (70.8%)	613 of 688 (89.1%)
2016	131 of 172 (76.2%)	129 of 170 (75.9%)	427 of 687 (62.2%)	549 of 688 (79.8%)
2017	106 of 172 (61.6%)	120 of 170 (70.6%)	440 of 575 (76.5 %)	581 of 683 (85.1 %)

Trend Analysis – 23 years

No significant trends were observed for temperature or salinity however, surface and bottom dissolved oxygen did increase in most areas of the FKNMS. Greatest increases in DO occurred on the Atlantic side of the Keys, Marquesas, and in some inshore areas on the Bay side (Fig. ii). Bottom DO trends were similar (not shown). Increased DO is generally beneficial for animal life.

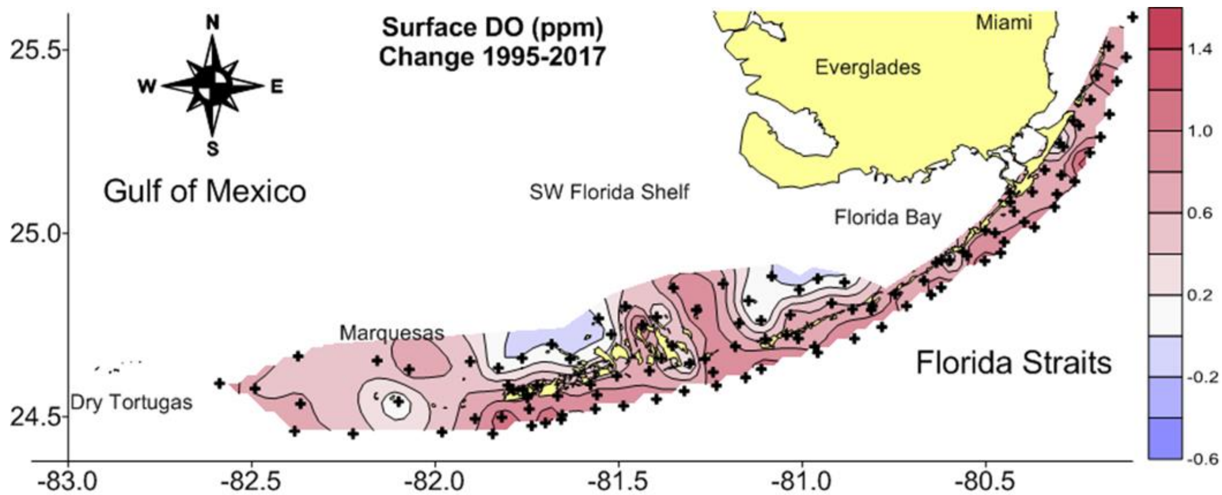

Figure ii. *Total change in DO of surface waters for 23 year period calculated from significant trends.*

Water column turbidity (cloudiness) declined throughout the FKNMS during the 23-year period (this is good). Some change in turbidity also occurred in bottom waters. The largest declines in turbidity occurred in western Florida Bay and west of the Marquesas (Fig iii).

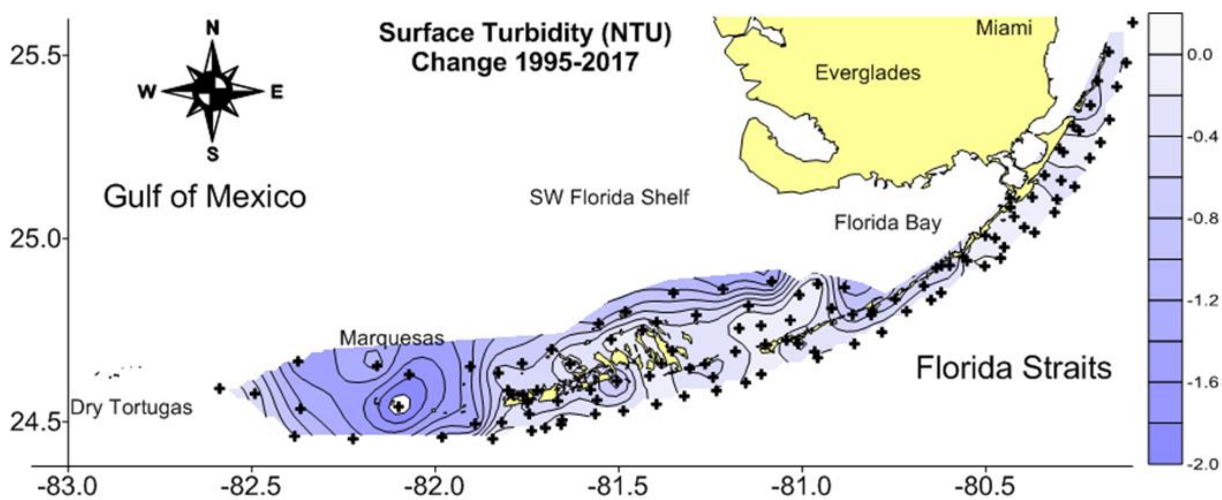

Figure iii. *Total change in Turbidity in surface waters for 23 year period calculated from significant trends.*

Decreased turbidity influenced light extinction (K_d) through the water column (Fig. iv) and inversely affected the percent of surface irradiance (I_o) reaching the bottom. Bottom light increased at most reef/offshore sites throughout the Keys and Marquesas (Fig. v). More light on the bottom is beneficial to corals, seagrass, and algae. Interestingly, the Backcountry and Sluiceway areas experienced increases in K_d which lead to corresponding decreases in bottom light.

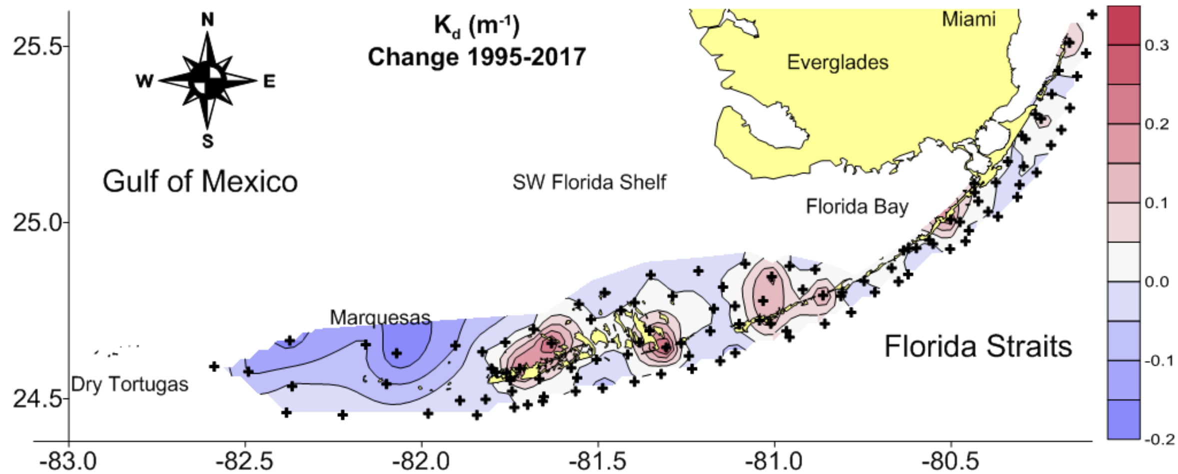

Figure iv. *Total change in K_d in surface waters for 23 year period calculated from significant trends.*

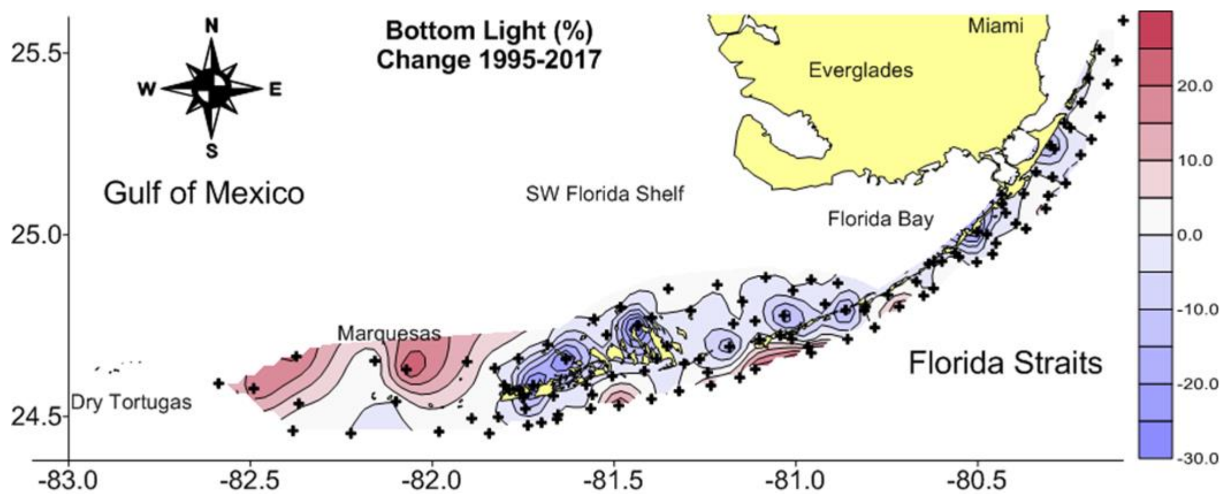

Figure v. *Total change in bottom I_o for 23 year period calculated from significant trends.*

Significant Keys-wide trends in NH_4^+, NO_3^-, TP, and SRP were detected but were very minor (not shown). However, chlorophyll *a* did exhibit variable trends, declining in the Marquesas while increasing in Backcountry, Sluiceway, and a few Keys areas (Fig. vi). The absolute changes were relatively small compared to normal concentrations (5-20% over 23 yr), but should be watched for continued increases.

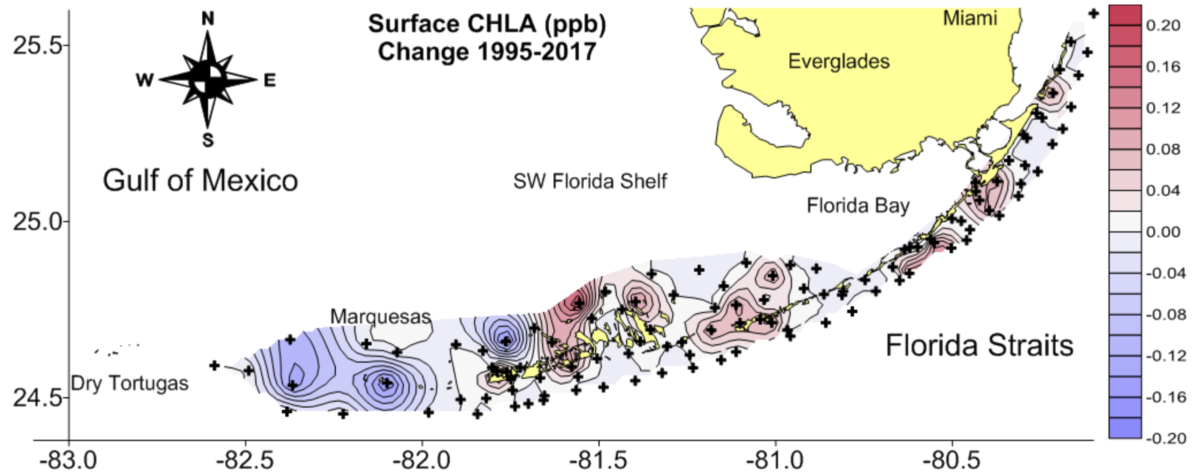

Figure vi. *Total change in TOC in surface waters for 23 year period calculated from significant trends.*

The largest sustained monotonic trends has been the decline in surface TOC and TON, especially in the Backcountry and the Marquesas (Fig. vii & viii). This is part of a regional trend in TOC observed on the SW Shelf, Florida Bay, and the Everglades mangrove estuaries. This decline could be considered favorable given that TOC is an important component of water color and affects light penetration, but could also be an indication of decreased upstream primary production.

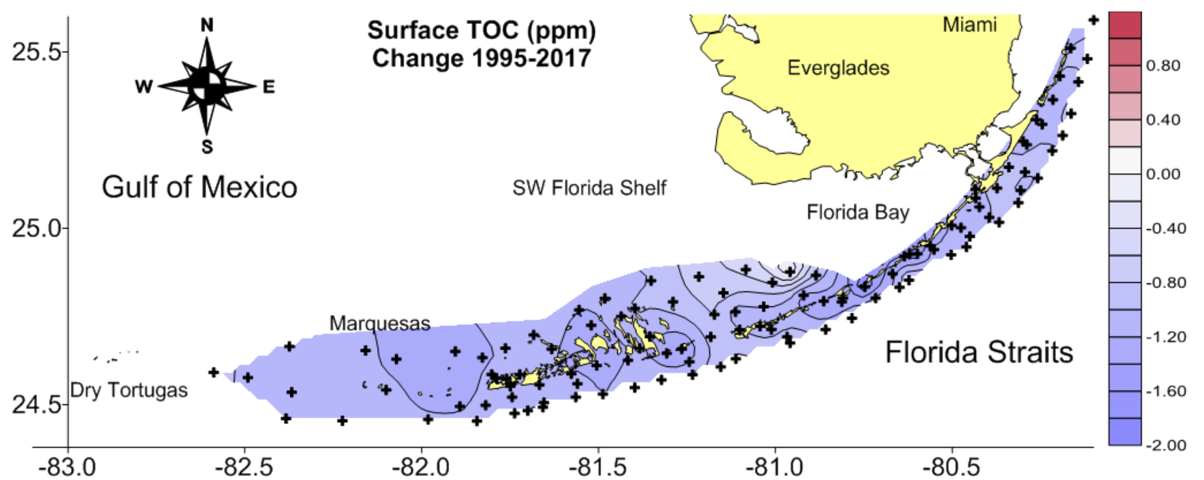

Figure vii. *Total change in TOC in surface waters for 23 year period calculated from significant trends.*

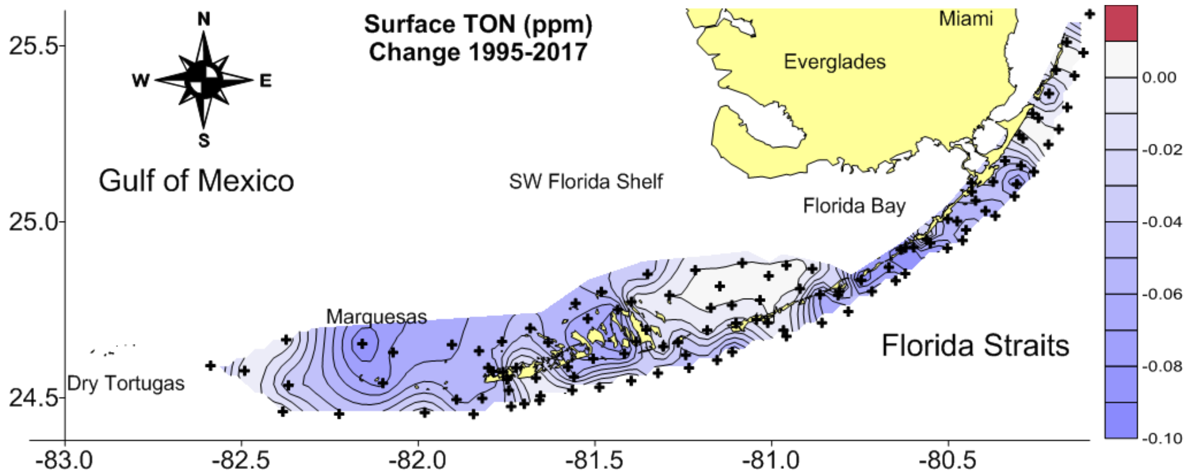

Figure viii. *Total change in TON in surface waters for 23 year period calculated from significant trends.*

As a result of this trend in TON, the TN:TP ratio has also declined overall (Fig. ix), especially in Upper and Lower Keys. The influence of the SW Shelf waters moving through the Middle Keys and Marquesas has attenuated any changes in those areas.

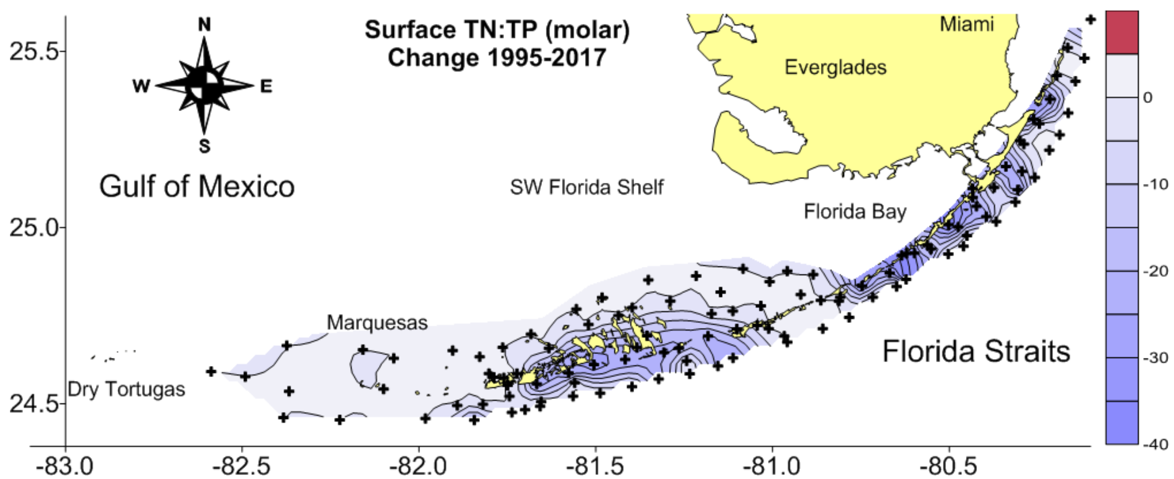

Figure ix. *Total change in TN:TP ratio in surface waters for 23 year period calculated from significant trends.*

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. 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 programs.

Hurricane Irma

The 2017 Atlantic hurricane season was extreme, featuring multiple Category 5 hurricanes, including Hurricane Irma. Irma made landfall in Cudjoe Key (Lower Keys) at 13:00 UTC on September 10, at Category 4 intensity, with winds of 130 mph (215 km/h). Later that day, and after crossing the

Gulf Shelf while pounding Florida Bay and the Coastal Everglades, Irma made a second landfall on Marco Island. Measurement of high water marks indicate that the combination of surge and tide caused maximum inundation levels of 5 to 8 ft above ground level from Cudjoe Key to Big Pine Key and Bahia Honda Key. Middle and Upper Keys experienced inundation levels of 4 to 6 ft above ground level. West of Cudjoe Key, maximum elevation levels reached 4 ft.

Water sampling during our Survey #89 (third Quarter of 2017) was halted on 9/5/17 when Irma was approaching the Keys. By that time, only 20 samples belonging to Offshore, Lower Keys and Marquesas segments were pending. We resumed sampling operations two weeks later, on 9/27. Changes in water quality are summarized as follows: TN in the Lower Keys (LK) and Offshore (OFF=reef-track) remained unchanged after impact, but DIN increased, especially in the LK where it almost tripled. TP and SRP increased about 40% in both, OFF and LK segments. TOC increased dramatically in reef-track waters (6X), while silica increased mostly in LK waters (3X). Chlorophyll-a rose about 5X in the LK and doubled on the reef-track, while turbidity, although low, doubled after Irma in LK and OFF. Finally, salinity experienced a drop of 1.5 in LK and 0.5 in reef-track samples, underscoring the large input of freshwater brought by the hurricane.

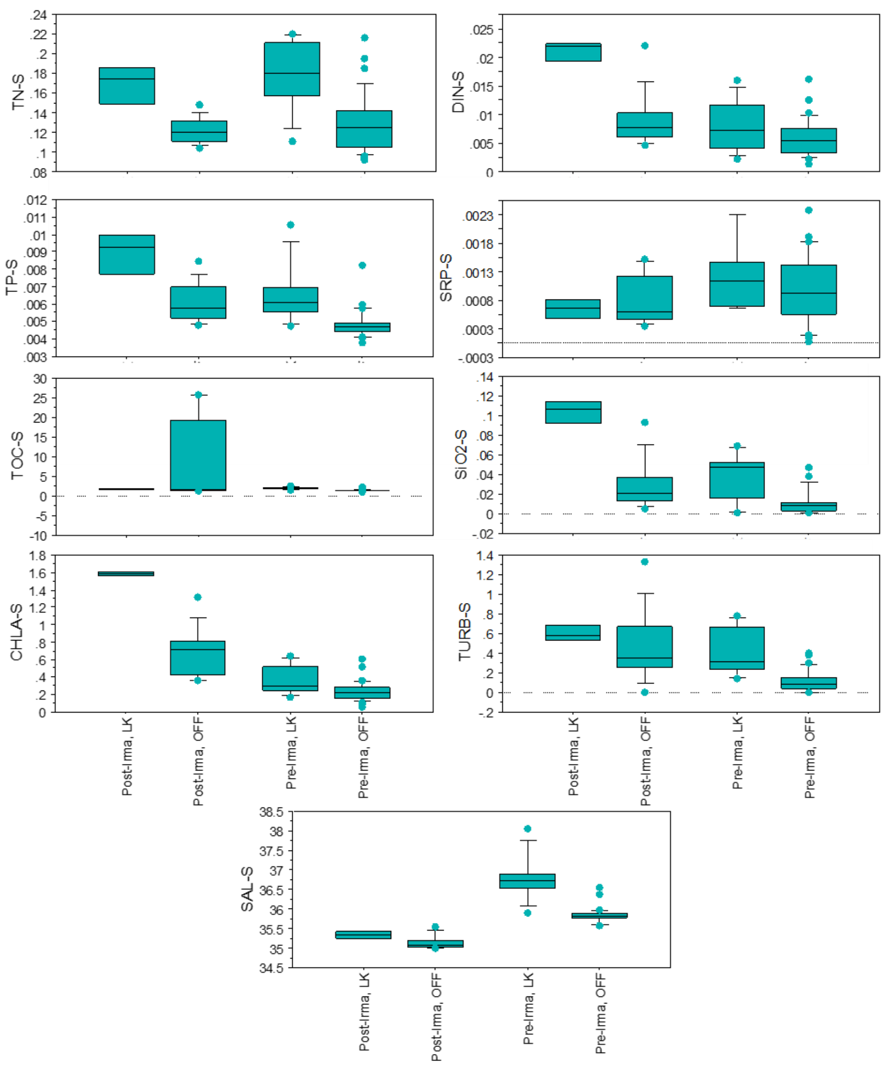

***Figure x**. Before-and-After Irma water quality in Lower Keys (LK segment) and coral reef (OFF segment)*