2021 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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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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2021 SEMI-ANNUAL PROGRESS REPORT

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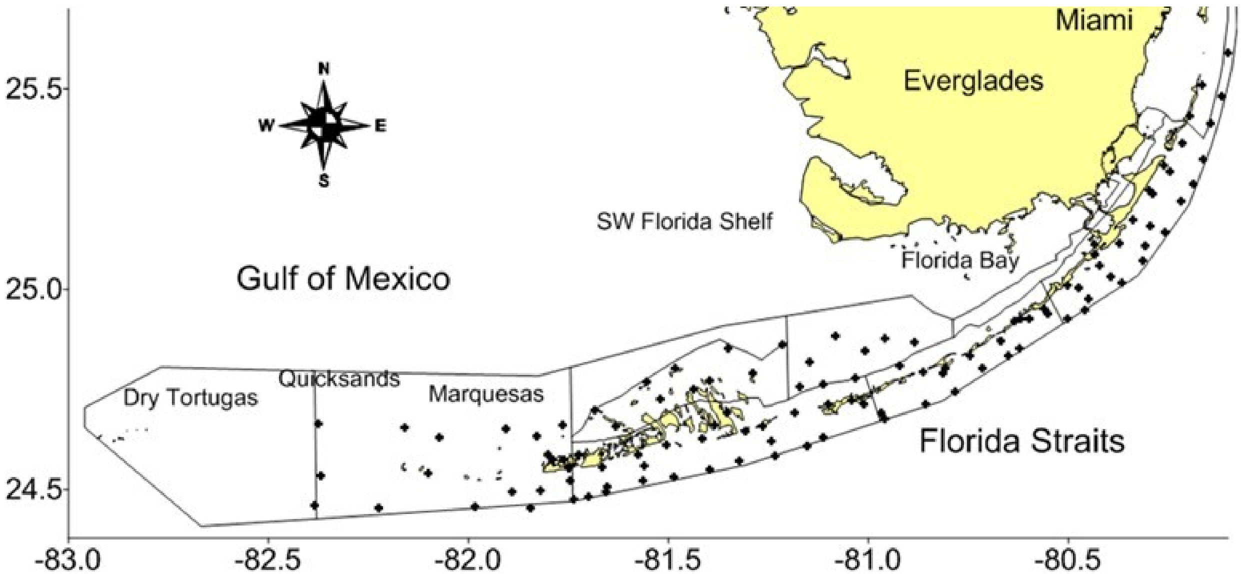

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EXECUTIVE SUMMARY

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. 2021 and includes data from 106 quarterly sampling events within the FKNMS (27 years).

Field parameters measured at each station (surface and bottom at most sites) include salinity (practical salinity scale), temperature (°C), 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}). All variables are reported in ppm (mg l^{-1}) unless otherwise noted.

The EPA developed Strategic Targets for the Water Quality Monitoring Project (SP-47) which state that beginning in 2008 through 2020, 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 (0.008 ppm). *Table i* shows the number of sites and percentage of total sites exceeding these Strategic Targets for 2019. In addition, *Figure i* shows percent of sites meeting the targets for DIN, TP, CHLA, and K_d.

The 2011 reduction of sampling sites in Tortugas/western FKNMS (TORT, less human-impacted sites) and addition of close in, shore sites (SHORE, heavily human-impacted sites) introduces a bias to the dataset which might require a revision of SP-47 to correct this deviation. To avoid such complications, we have not included the TORT or SHORE stations in calculation of compliances after 2010.

Table i: 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 ppb	K_d ≤ 0.20 m^{-1}	DIN ≤ 0.010 ppm	TP ≤ 0.008 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%)	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 %)
2018	92 of 170 (54.1%)	108 of 152 (71.7%)	558 of 689 (81.0 %)	573 of 689 (82.3 %)
2019	112 of 171 (65.5%)	133 of 168 (79.2%)	669 of 684 (97.8 %)	587 of 686 (85.6 %)
2020	129 of 172 (75.0%)	141 of 169 (83.4%)	617 of 688 (89.7%)	466 0f 688 (67.7%)
2021	123 of 172 (71.5%)	141 of 172 (82.0%)	611 of 688 (88.8%)	527 of 688 (76.6%)

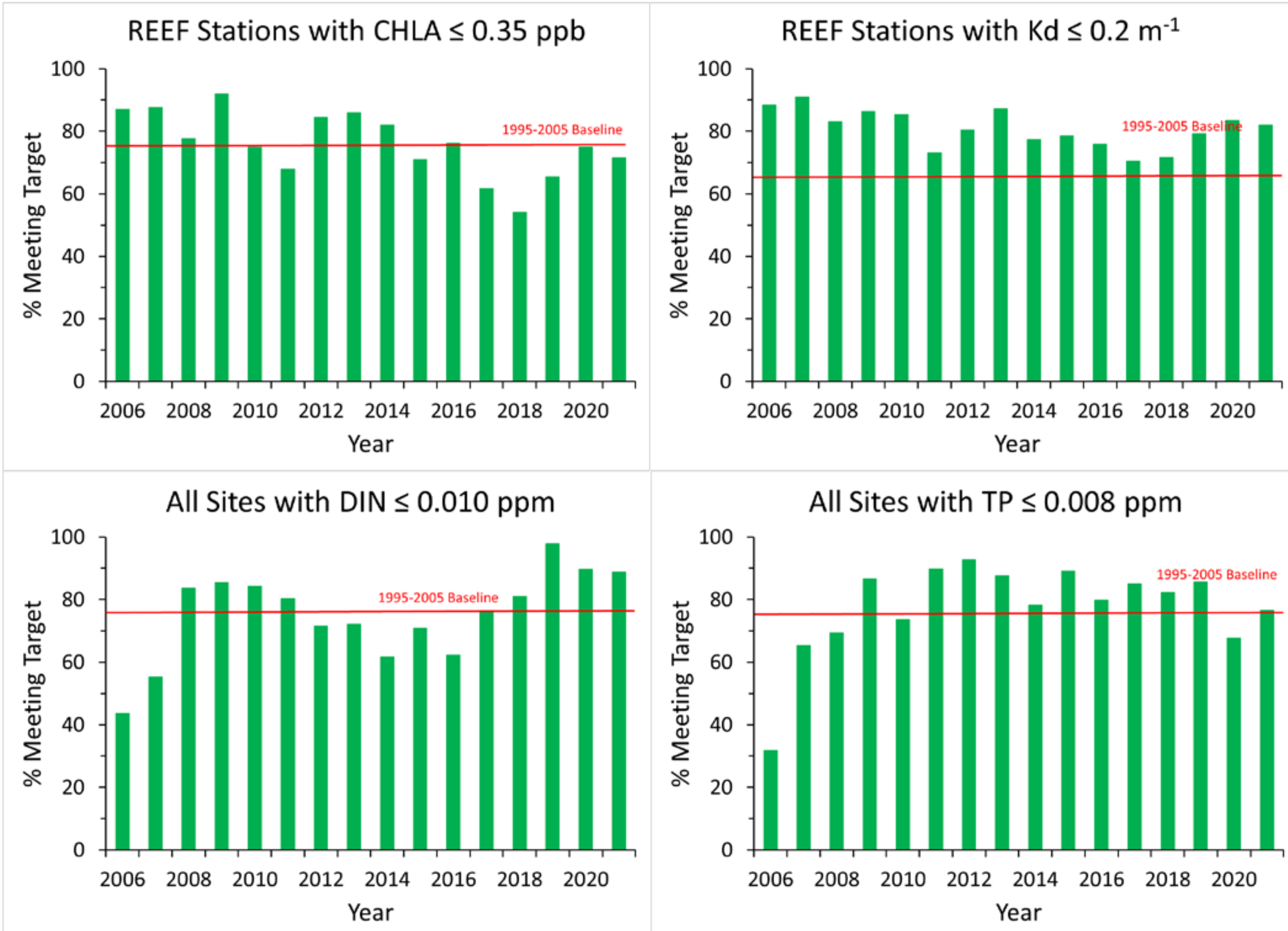

Figure i. *EPA targets expressed as percent of sites meeting baseline criteria by year.*

Trend Analysis – 27 years

Patterns in total change of surface salinity and temperature for the 27-year period of record across the FKNMS are shown in *Fig. ii & iii*. The areas in red – Sluiceway, Backcountry, Upper Keys – show small increase in salinity over time. The offshore Lower Keys exhibited lower salinities. Bottom salinity has a similar pattern. Changes in temperature reinforced the warming tendency discussed in last year for Marquesas and especially for Mid-Upper Keys, reaching values >1.0°C.

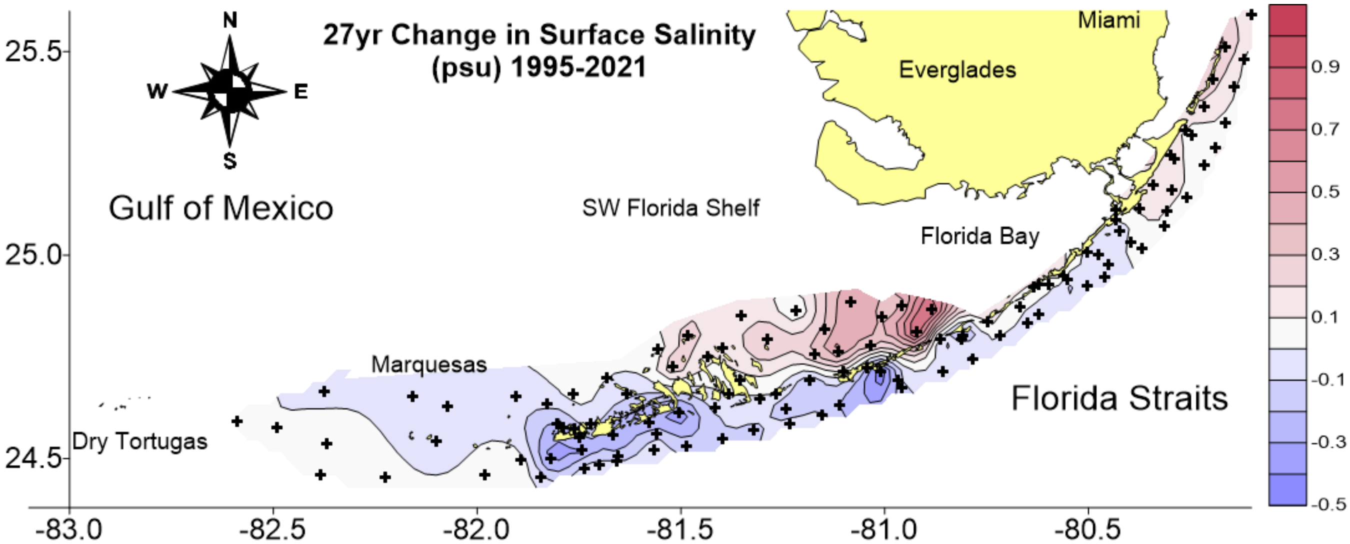

Figure ii. *Total change in salinity of surface waters for 27-year period.*

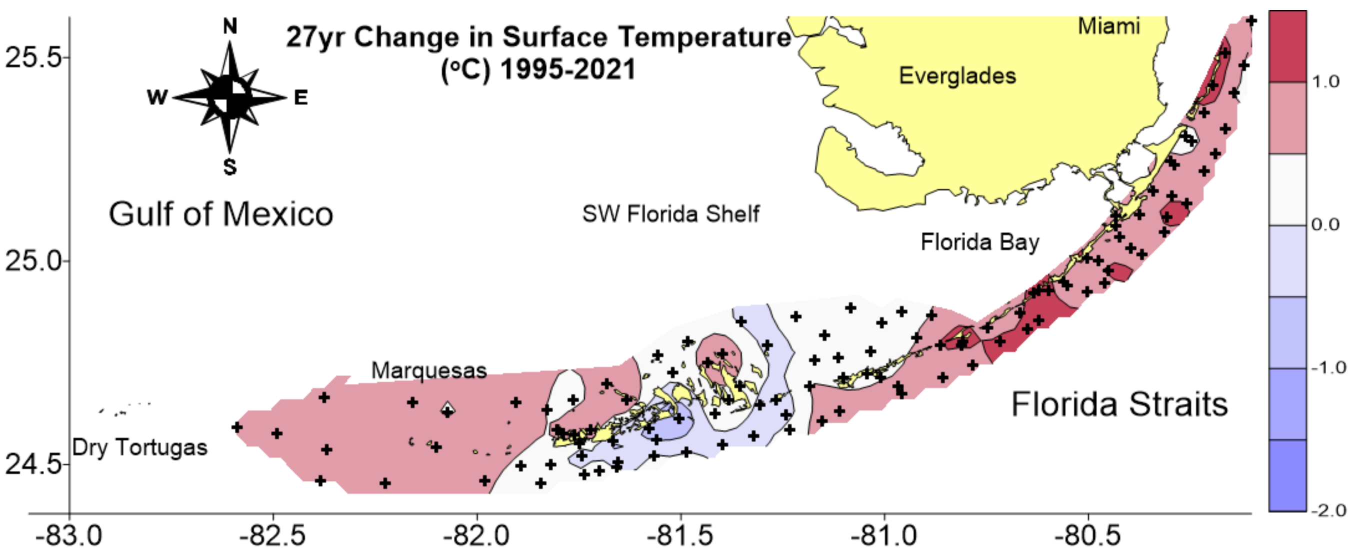

Figure iii. *Total change in temperature of surface waters for 27-year period.*

Increases in DO oxygen were widespread, with the greatest increases in DO_{sat} occurring offshore the Keys, and Middle Keys passes (*Fig. iv*), resembling very much those of bottom DO_{sat} and similar to those of last year. Something that is relevant is that DO concentration has increased despite increments in water temperature (Fig iii). Finally, increased DO_{sat} is generally beneficial for animal life.

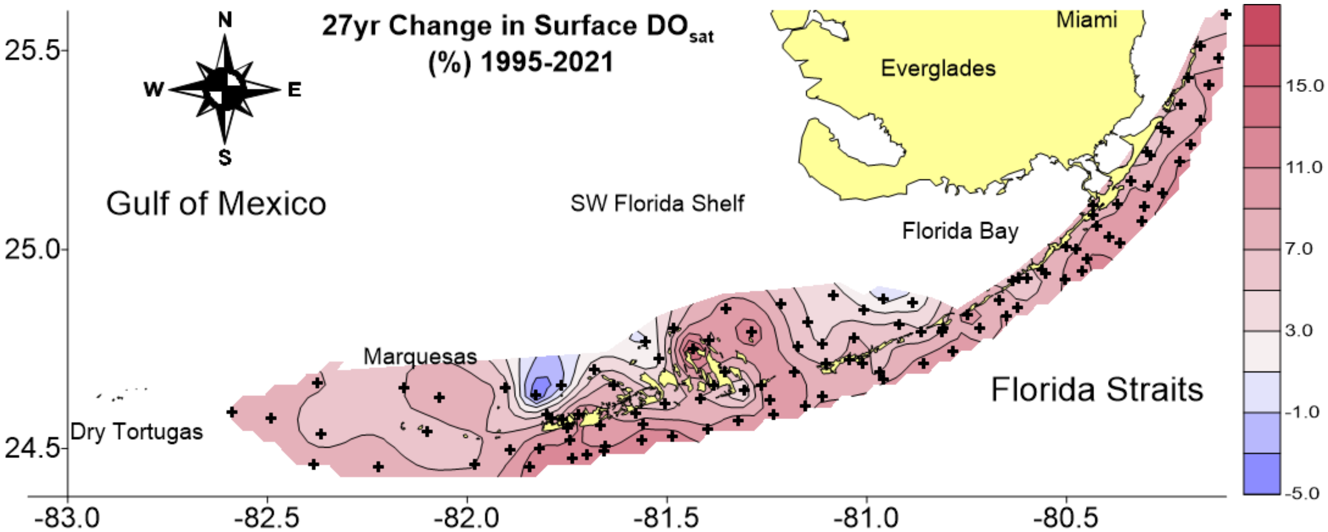

Figure iv. *Total change in DO saturation of surface waters for 27-year period.*

Water column turbidity (cloudiness) declined throughout the FKNMS during the 27-year period (a beneficial trend). The largest declines in turbidity occurred in the Sluiceway, Backcountry, and especially in Marquesas (*Fig v*). Changes in bottom turbidity are unremarkable (not shown).

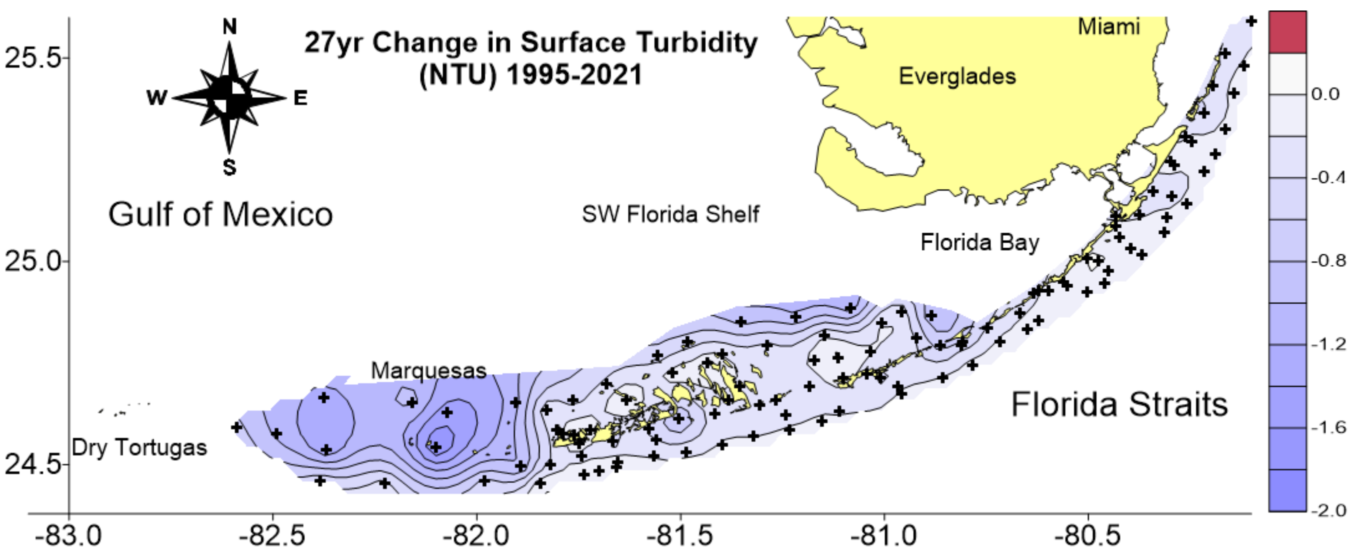

Figure v. *Total change in turbidity in surface waters for 27-year period.*

Decreased turbidity influenced light extinction (K_d) through the water column (*Fig. vi*) but not to a great extent. This inversely affected the percent of surface light (I_o; Fig vii) reaching the bottom. More light on the bottom is beneficial to corals, seagrass, and algae. Bottom light increased (Kd declined) at most reef/offshore sites throughout the Keys and Marquesas but decreased (Kd increased) in Backcountry, inshore sites along Keys, and Upper Keys in general (*Fig. vii*).

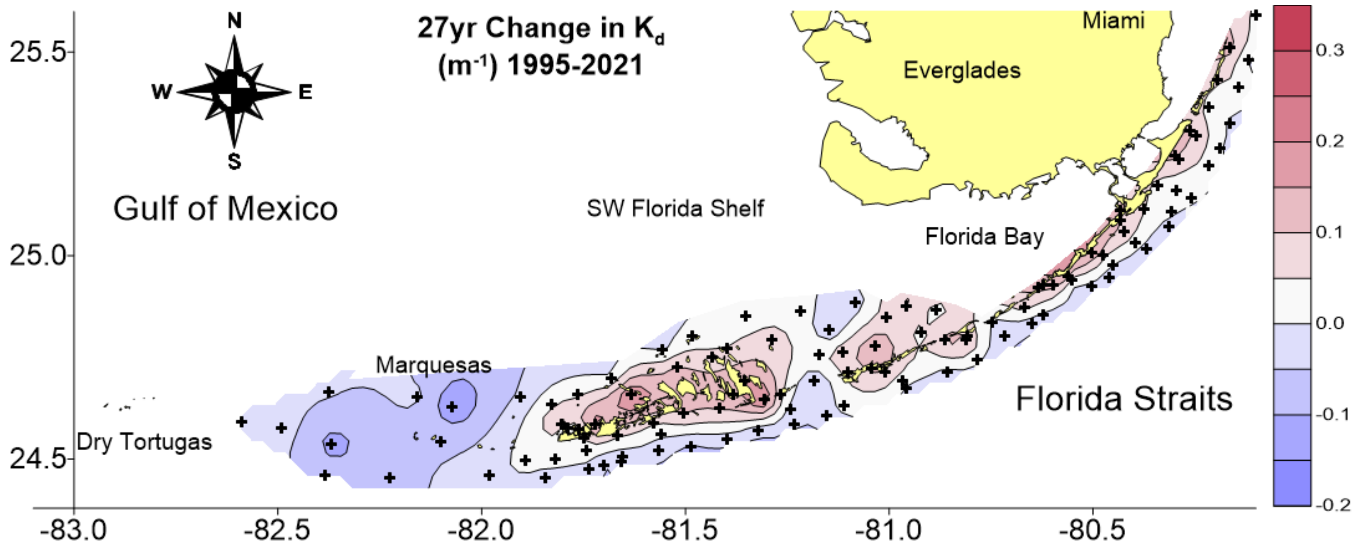

Figure vi. *Total change in K_d in surface waters for 27-year period.*

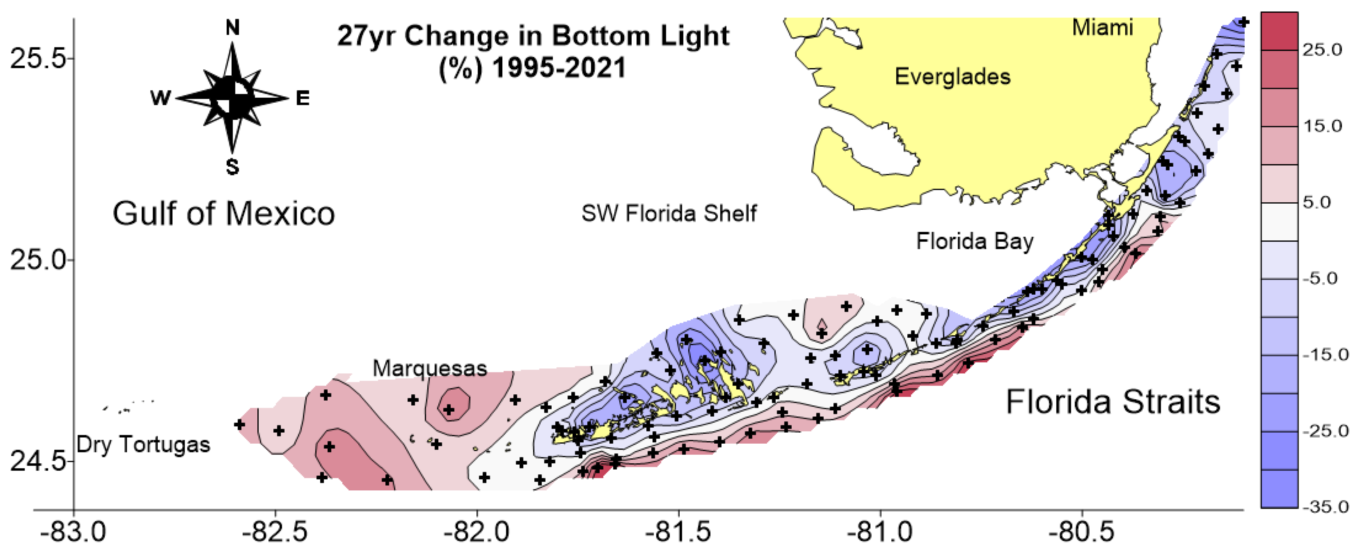

Figure vii. *Total change of incident bottom light for 27-year period.*

Keys-wide declining trends in NH_4^+, NO_3^-, and SRP were detected but were very minor (not shown). Some sites in Islamorada and south of Marquesas show slight increases in NO_3^-. Small declining trends in TP were observed only in surface waters of the Marquesas but increases in TP occurred in all other areas of the FKNMS (Fig viii). The pattern of increase shows consolidation and strengthening from last years's results. These trends need to be watched as we expected TP to decline inshore in response to recent central sewer installation.

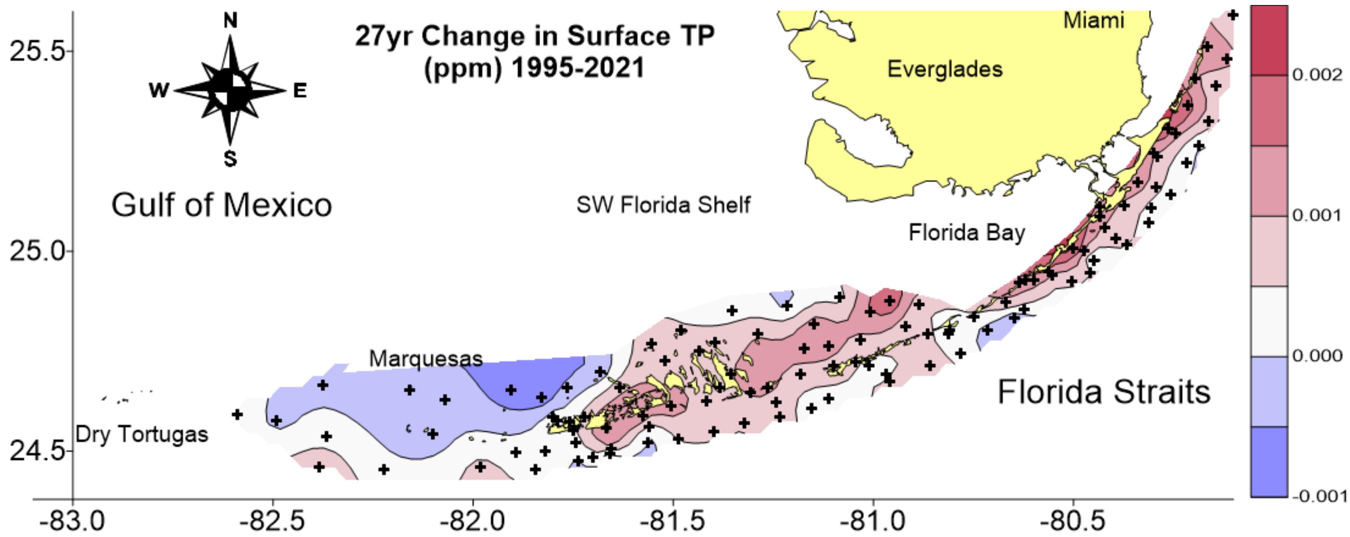

Figure viii. *Total change of TP for 27-year period.*

Chlorophyll *a* (CHLA; Fig ix) patterns resemble the spatial patterns in TP trends, declining in the Marquesas while increasing most everywhere else in the FKNMS (*Fig. ix*). Significant increases for the 27-year record ranged from 0.083 0.279 ppb or 28-68% increase.

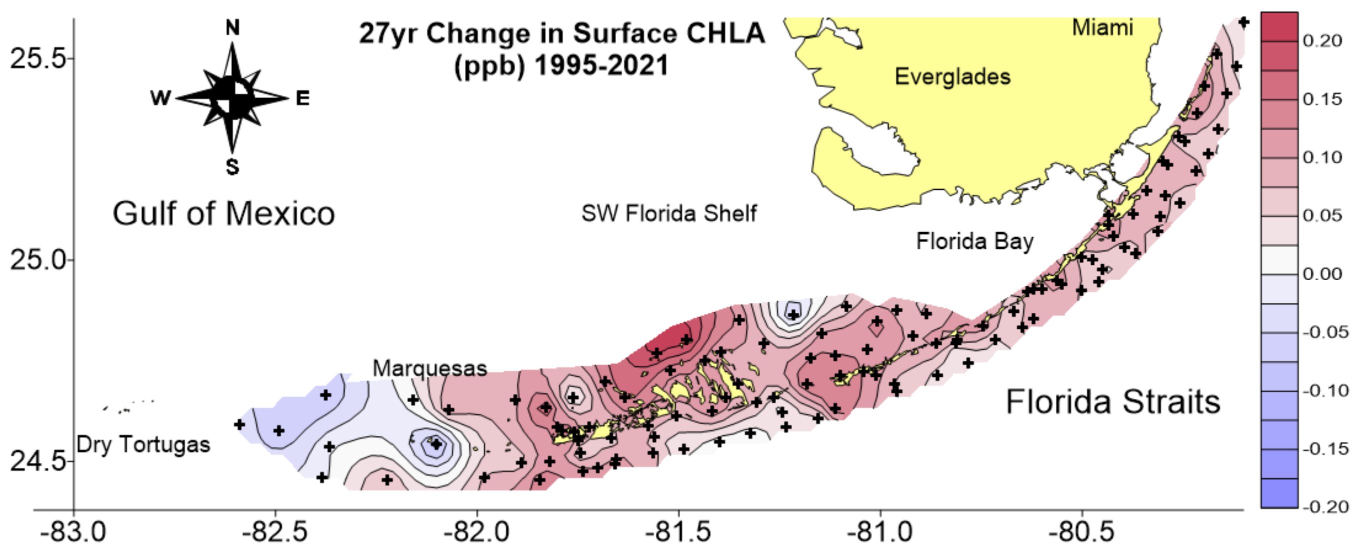

Figure ix. *Total change in CHLA in surface waters for 27-year period.*

The largest sustained trends have been the decline in surface total organic carbon (TOC) and nitrogen (TON) (*Fig. x & xi* respectively). This is part of a regional trend in TOC observed in earlier monitoring on the SW Shelf, Florida Bay, and the Everglades mangrove estuaries. This decline could be considered favorable given that TOC & TON are important components of water color and negatively affect light penetration, but could also be an indication of decreased terrestrial primary production and export. It might also be characteristic of a Gulf-wide trend.

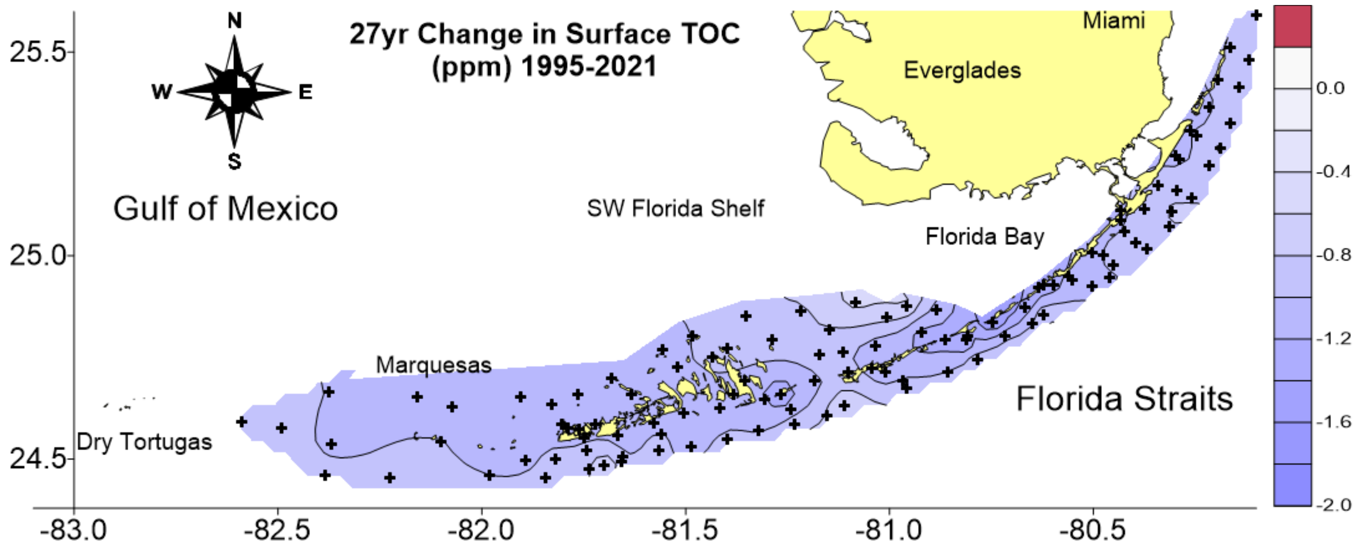

Figure x. *Total change in TOC in surface waters for 27-year period.*

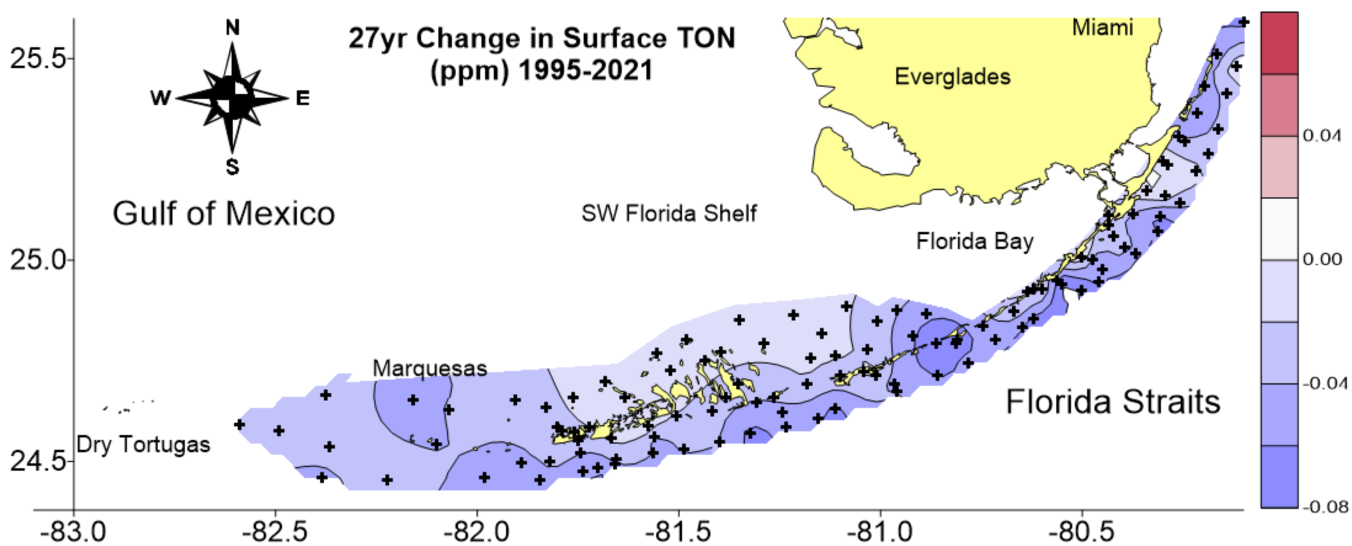

Figure xi. *Total change in TON in surface waters for 27-year period.*

The ratio between dissolved inorganic nitrogen and total phosphorus (DIN:TP) as an indicator for assessing phytoplankton nutrient limitation has also declined overall (*Fig. xii*). This implies that primary production may be becoming more N limited in the FKNMS.

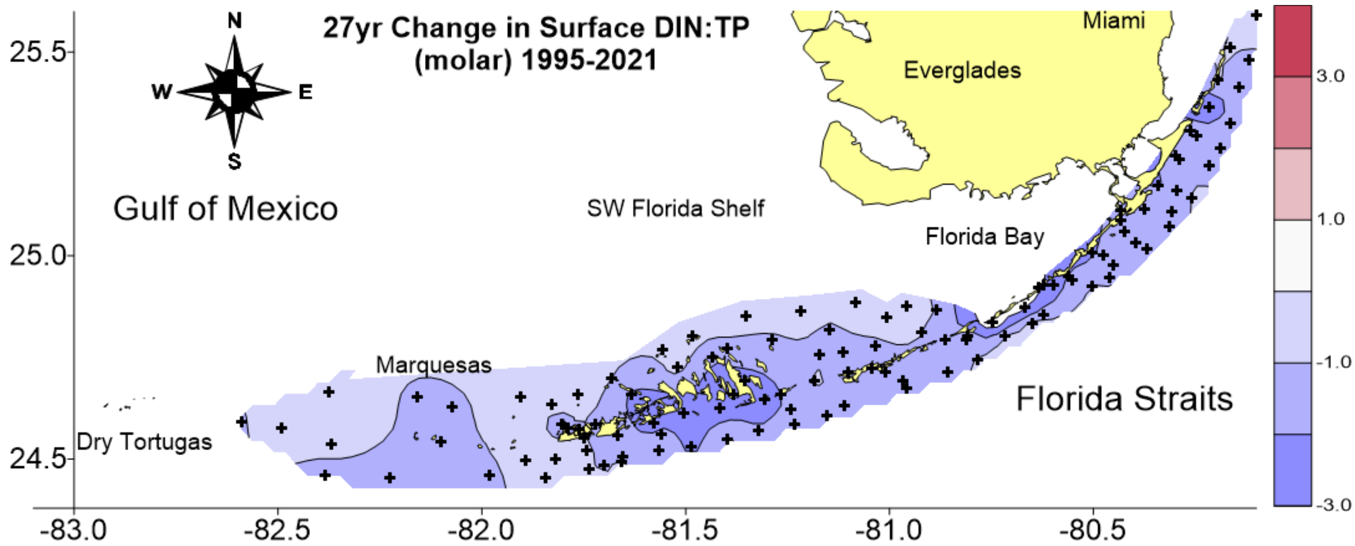

Figure xii. *Total change in DIN:TP ratio in surface waters for 27-year period.*

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 monitoring 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 this project accessible to the public.